Common Sense Mathematics
Extra Exercises

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Contents

About These Extra Exercises

You will find here extra exercises for *Common Sense Mathematics*. Some just didn't fit in the book. Others are suggestions that you can turn into exercises. Some we wrote after the first edition went to press.

A few of those that used to be here have been copied to the second edition, but remain here too for reference purposes. Old exercises deleted from the first edition are archived here, with their original exercise numbers, so you can keep using them if you wish.

We will periodically update this document and post the latest version at `commonsensemathemaics.net` .

If you have invented exercises you'd like to share, let us know and we will include them.

Exercise numbering here begins where the numbers in each chapter left off.

Exercises marked [S] have solutions, which you will find in the solutions manual.

If you want to modify or format these exercises yourself you can cut from the LaTeX source at the end of this document.

Chapter 1

Calculating on the Back of an Envelope

Exercise 1.8.2. [S] Dropping out.

In his May 17, 2010 op-ed column in *The New York Times* Bob Herbert noted that the dropout rate for American high school students was one every 26 seconds. [R1]
{R1}

Is this number reasonable?

Exercise 1.8.7. [S] Health care costs for the uninsured.

On March 22, 2012 Linda Greenhouse wrote in *The New York Times* that the average cost of a family insurance policy increased by $1,000 a year because health care providers needed to recover $43 billion annually for health care costs of the uninsured. [R2]
{R2}

(a) What it the annual cost per United States resident for medical care for the uninsured?

(b) Estimate (or research) how much an average person spends each year buying food at the grocery store (do not include restaurant purchases). Compare your answer to your answer from the previous question about the cost of medical care.

(c) Estimate (or research) the number of uninsured people, and then estimate the cost per uninsured person for medical care. Does your answer make sense to you?

Exercise 1.8.13. [S] The popularity of social networks.

From *The New York Times*, June 28, 2011:

> In May [2011], 180 million people visited Google sites, including YouTube, versus 157.2 million on Facebook, according to comScore. But Facebook users looked at 103 billion pages and spent an average of 375 minutes on the site, while Google users viewed 46.3 billion pages and spent 231 minutes. [R3]
{R3}

(a) How many webpages did the average Facebook user visit? How many webpages did the average Google user visit?

(b) On average, how many webpages per day in May did a Facebook user visit? Compare this to the average number of webpages per day for the Google user.

(c) On average, who spent more time on each page, the Facebook user or the Google user?

(d) Think about your own web behavior. Do these numbers seem reasonable to you?

Exercise 1.8.15. [S] Greek debt.

In her September 26, 2011 *New York Times* review of Michael Lewis's book *Boomerang* Michiko Kakutani noted that Lewis said Greek debt of $1.2 trillion amounted to about $250,000 for each working Greek. [R4]
{R4}

(a) Use Lewis's statement to estimate the population of working Greeks at the time he wrote the article.

(b) Use the web to find the national debt and population of Greece (for 2011 if you can, now if you can't).

(c) Do the answers to the previous two parts of this exercise agree? If not, what might explain any differences?

(d) Compare Greek per capita national debt to that in the United States.

(e) Here's a political question: is large national debt a bad thing? You can find both "yes" and "no" answers on the web. Here's one place to start: `www.npr.org/templates/story/story.php?storyId=99927343` .

Exercise 1.8.24. [U][C] Drivers curb habits as cost of gas soars.

In *The Boston Globe* on April 21, 2011 you could read that

> [F]amilies are quickly adapting [to increasing gas prices] by carpooling, combining errands to save trips, and curtailing weekend outings, according to organizations that track gasoline consumption. Still, the US Energy Department projects that the average US household will pay $825 more for gas this year than in 2010.
>
> NPD Group Inc., a market research firm, estimates that consumers bought roughly 128 million fewer gallons of gasoline in March than a year earlier. [R5]
> {R5}

Combine reasonable estimates for the increase in gasoline prices, the number of miles driven annually and the average fuel economy of cars to decide whether the $825 figure in the quotation makes sense.

Exercise 1.8.27. [S] Counting car crashes.

The National Safety Council estimates that "21 percent of [automobile] crashes or 1.2 million crashes in 2013 involve talking on handheld and hands-free cell phones." [R6]
{R6}

(a) Use the data in the quote to estimate the total number of crashes in the U.S. in 2013.

(b) Check your answer with a web search.

(c) If crashes were evenly distributed across the population, how many would you expect in your community? Does your answer seem reasonable?

Exercise 1.8.39. [U] e-reading.

In December, 2014 Amazon offered a Kindle e-reader with

> **Storage:** 16GB (10.9GB available to user) or 32GB (25.1GB available to user), or 64 GB (53.7GB available to user)

(a) Compare the percentage of storage available to the user for each of these options.

(b) Estimate the number of e-books you could store on the 64 GB Kindle.

(c) Estimate the size of *Common Sense Mathematics* in MB.

Exercise 1.8.40. [U] Personal storage.

(a) How many bytes of storage are there on the hard drive of your computer (or tablet or smartphone, or some device you use regularly)? Is that best measured in megabytes or gigabytes?

(b) If you have a thumb drive or flash memory stick, what's its capacity?

Exercise 1.8.41. [U] Backing up the Library of Congress.

How many 200 gigabyte computer memories would you need to store the books in the Library of Congress?

Exercise 1.8.43. [R][S] Data glut.

In the article from *The Boston Globe* on February 24, 2003 with the long headline

> Data glut as gene research yields information counted in terabytes. Researchers struggle to visualize and process it while technology businesses scramble to profit from it.

you could read that

{R7}
> [Peter Sorger's] bioengineering lab produces a terabyte of data in a typical month. [R7]

(a) At what rate in bytes per minute is the lab producing data? Write your answer with the appropriate metric prefix and the appropriate level of precision.

(b) If the lab has been producing data from the time the article appeared to the present, how much has accumulated now?

(c) When will a petabyte of data have accumulated? Do you believe your prediction?

(d) When will an exabyte of data have accumulated?

x:zettabytes}

Exercise 1.8.45. [U][C] Zettabytes redux.

On August 6, 2011 Kari Kraus wrote in *The New York Times* that

> We generate over 1.8 zettabytes of digital information a year. By some estimates, that's nearly 30 million times the amount of information contained in all the books ever published. [R8]

{R8}

Are the two estimates in this quotation (1.8 million zettabytes, 30 million times . . .) consistent with each other?

Exercise 1.8.47. [U]

In the article "The impact of free-ranging domestic cats on wildlife of the United States" in January 2013 in *Nature Communications* Scott R. Loss, Tom Will and Peter P. Marra offered an

> . . . estimate that free-ranging domestic cats kill 1.4-3.7 billion birds and 6.9-20.7 billion mammals annually. Un-owned cats, as opposed to owned pets, cause the majority of this mortality. [R9]

{R9}

Make sense of those numbers. Consider kills per cat or kills per day, or kills per day in your community.

Exercise 1.8.63. [U][N] How many backspaces?

From

blog.stephenwolfram.com/2012/03/the-personal-analytics-of-my-life/

> For many years, I've captured every keystroke I've typed, now more than 100 million of them . . .
> There are all kinds of detailed facts to extract: like that the average fraction of keys I type that are backspaces has consistently been about 7% (I had no idea it was so high!). [R10]

{R10}

Lots of other stuff here too.

Exercise 1.8.64. [U][R] Goldman Settles With S.E.C. for $550 Million.

That's what *The New York Times* reported on July 15, 2010. How much is that per person in the United States?

Exercise 1.8.65. [N] Recycling.

The February 28, 2009 issue of *The Economist* has enough information on waste and recycling to generate as many Fermi problems as you can imagine. And there are ideas there that could lead to interesting possible term papers, if you still need ideas. See www.economist.com/opinion/displaystory.cfm?story_id=13135349 .

In this special report:

- Talking rubbish
- You are what you throw away
- Down in the dumps
- Modern landfills
- The science of waste
- The value of recycling
- Waste and money
- Tackling waste
- Sources and acknowledgments

Exercise 1.8.66. [U] Cheerio.

Here's an exercise and its solution from a student.

> How many boxes of Cheerios are sold each year?
> If 1 person out of 30 (10,483,000 out of U.S. population: 314,490,000) had a 2oz bowl (8 servings per box) of Cheerios 3 times a week during a year, that would equal 220,143,000 pounds or boxes (Cheerios happen to come in one pound boxes).

Critique the solution.

Exercise 1.8.67. [U][N] Overhaul the tax code.

From *The New York Times*, January 9, 2013:

> In her legally required annual report to Congress, the national taxpayer advocate, Nina E. Olson, estimated that individuals and businesses spend about 6.1 billion hours a year complying with tax-filing requirements. That adds up to the equivalent of more than three million full-time workers, or more than the number of jobs on the entire federal government's payroll. [R11]

{R11}

(a) Check the arithmetic: does 6.1 billion hours a year "add up to the equivalent of more than three million full-time workers"?

(b) How many federal employees are there? Estimate or use the web to find out. Compare your answer to three million.

(c) The IRS estimates how long it takes an individual to prepare and file annual income taxes. They may also give an estimate for how much time a business needs to comply with tax-filing requirements. Find these estimates and see if they help you verify Olson's claim of 6.1 billion hours.

Exercise 1.8.68. [U][N] Sticky fingers.

> As of July 2018, the FBI's Next Generation Identification (NGI) conducts more than 300,000 tenprint record searches per day against more than 140 million computerized fingerprint records (both criminal and civil applicant records). [R12]

{R12}

Exercise 1.8.69. [U] No strings.

January 2011: The inner flap of the Celestial Seasonings Mint Magic Tea box tells this story:

> Ever wonder why . . .
> no string and tag?
> Our unique pillow style tea bag is the result of our commitment to doing what's best for the environment. Because these natural fiber tea bags don't need strings, tags, staples or individual wrappers we're able to save more than 3.5 million pounds of waste from entering landfills every year! [R13]

{R13}

(a) Is that claim reasonable?

(b) If you find it unreasonable, or a close call, compose a letter to send to the company explaining your puzzlement and asking perhaps humorously but certainly politely for an explanation or a correction.

(c) If your letter really pleases you, consider sending it to Celestial Seasons — you can find an address at `www.celestialseasonings.com`.

Exercise 1.8.70. [S][W] Too many plastic bags.

A January 2018 post at *Rate it Green* website stated that "Worldwide, an estimated 4 billion plastic bags end up as litter each year. Tied end to end, the bags could circle the Earth 63 times". [R14]

{R14}

(a) Are the numbers "4 billion plastic bags" and "circle the Earth 63 times" consistent?

(b) Use an estimate of the population of the United States and some common sense to estimate how many plastic bags are used in the United States each year. Use your answer to show that the 4 billion plastic bag claim is too small by several orders of magnitude.

(c) Confirm your U.S. estimate with a web search.

Exercise 1.8.71. [N] Losing lots.

An article in *The Economist* on September 10, 2011 noted that

> Walmart . . . has moved on to health, with a campaign that has already caused associates to lose a combined 200,000 lbs of weight. [R15]

{R15}

Put that number in context. Can you make sense of it?

Exercise 1.8.72. [U] No T means more pollution.

In *The Boston Globe* on April 11, 2009 reporter Matt Viser wrote that

> Marc Draisen, executive director of the Metropolitan Area Planning Council, said the MBTA plan "would be nothing short of a disaster for the Greater Boston area."
>
> He estimated that the reduction in services would result in 25 million new automobile trips per year with 119 million additional miles traveled and 6 million extra gallons of gas consumed. [R16]

{R16}

(a) How long (on average) is each of the new automobile trips?

(b) How many gallons of gas (on average) will each trip use?

(c) What is the average fuel economy (in miles/gallon and in gallons/(100 miles)) for these trips?

(d) Is Draisin's estimate of 25 million new automobile trips reasonable?

[Hint] Consider estimating how many trips per week per person this represents.

Exercise 1.8.73. [U] Snapple facts.

(a) What are "Snapple facts"?

(b) Find some Snapple facts on the web and figure out whether they are believable.

Exercise 1.8.74. [U][N] Google learns a lot each day.

On December 18, 2012, Pamela Jones Harbour wrote in *The New York Times* that

> [Google] creates as much data in two days — roughly 5 exabytes — as the world produced from the dawn of humanity until 2003, according to a 2010 statement by Eric Schmidt, the company's chairman. [R17]

{R17}

Exercise 1.8.75. [U] Stolen coins.

In 2007 R. J. Gibson blogged about a retiree charged with stealing coins and tokens from the Massachusetts Bay Transportation Authority, (MBTA, "the T") caught when the T switched from tokens to Charlie Cards and Charlie Tickets.

The Boston Globe reported that when investigators went to his home "ldots they found more than $40,000 in coins and tokens . . . stashed in 17 plastic jugs, each large enough to hold 5 gallons." [R18]

{R18}

(a) Estimate how many coins and tokens it would take to total $40,000.

(b) Check your estimate by thinking about whether those coins and tokens would fit into 17 five gallon jugs.

(c) Estimate the weight of these coins and tokens.

Exercise 1.8.76. [U][N] Keep the cap.

From Joan Wickersham's op-ed in *The Boston Globe*, March 4, 2011, written as an open letter to a nonprofit environmental group:

> This week you also sent me your magazine, as well as another solicitation for money. Taken all together, you sent me a total of 1.25 pounds of stuff in the past week alone. Browsing your website, I found a handy carbon footprint calculator, which I was able to use to see how much your mailings may be contributing to global warming.
>
> Assuming you shower all your 1,000,000 members with this same 1.25 pounds of attention when they pay their annual dues, you fill at least three Boeing 747s with thank-you gifts and mailings, thus creating, by a conservative estimate, between 1,800 and 2,000 tons of carbon dioxide. [R19]

{R19}

Verify Wickersham's estimates in the second paragraph.

Exercise 1.8.77. [U] Up and down the ladder.

An April 21, 2011 article in *The Boston Globe* reported that

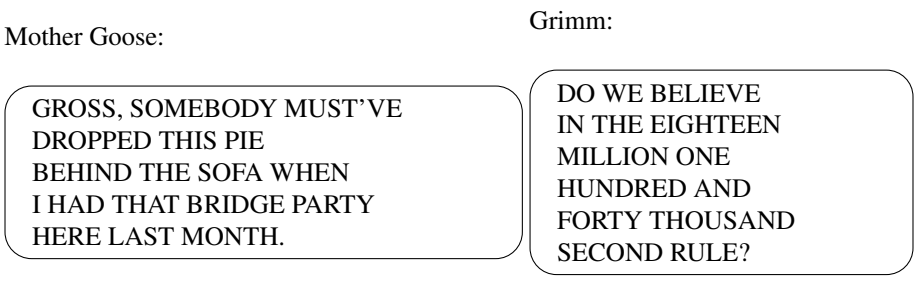
> Volker Kraft's apple sapling sported just 18 eggs when he first decorated it for Easter in 1965. Decades later, the sturdy tree is festooned with 9,800 eggs, with artful decorations that include sequins and sea shells.
>
> . . .
>
> Kraft needs two weeks and countless trips up and down his ladder to hang the eggs. [R20]

{R20}

The trips aren't countless, even if Kraft didn't count them. Estimate how many trips in how many hours.

Exercise 1.8.78. [S] The 18 million second rule.

Here are the dialog boxes for a cartoon that appeared in *The Boston Globe* on Sunday, November 6, 2011. You can see the original at `www.grimmy.com/comics.php?sel_dt=2011-11-06` . [R21]
{R21}



(a) What is the five second rule?

(b) Check Grimm's (approximate) arithmetic. Is he in the right ballpark?

Exercise 1.8.79. Powers of ten.

Consider watching the famous "Powers of 10" film, available at `www.eamesoffice.com/the-work/powers-of-ten/` .

We showed it in class once but our students didn't find it as interesting as we do. Much as we like it, we haven't used it since.

Exercise 1.8.80. [S] A self-checkout way of life.

Business Wire reported on a 2008 study by the research company IHL Group that claimed that "The average American woman could lose 4.1 lbs a year simply from resisting the urge to purchase impulse items such as chocolate candies, chips and soda once they [*sic*] are in the checkout line."

The study said that impulse purchases among were 32.1 percent lower at self-checkout lines compared to staffed ones. [R22]
{R22}

Think about the claim that the average American woman could lose 4.1 pounds a year by not buying items such as candy in the checkout line.

Is that claim reasonable?

Exercise 1.8.81. [U][N][W] Mapping the brain.

On July 16, 2012 Carolyn Johnson reported in *The Boston Globe* that

> When Sebastian Seung read that each day people around the world spend 600 years collectively playing Angry Birds, he saw not a huge waste, but a big opportunity. . . .
>
> By Seung's calculations, tracing all the neural connections in a cubic millimeter of brain would take one person working around the clock 100,000 years. Aided by the computer programs his lab has been building, that task would be slightly more doable, requiring 1,000 years of work. . . .
>
> But, he said, "if we were 1 percent as fun [as Angry Birds], we could do this in a year." [R23]
{R23}

Exercise 1.8.82. [N] The Nine Billion Names of God.

Read that classic short science fiction story by Arthur C. Clarke at `downlode.org/Etext/nine_billion_names_of_god.html` .

Exercise 1.8.83. [N] Food safety.

On June 21, 2011 Mark Bittman wrote in *The New York Times* about budget cuts in food safety programs. The article is at `opinionator.blogs.nytimes.com/2011/06/21/no-food-safety-in-these-numbers`

There's lots of food for quantitative thought here.

Exercise 1.8.84. [S] How much television?

At the Wikipedia page `en.wikipedia.org/wiki/Cognitive_Surplus` you can read that Clay Shirky claims that people spend 200 billion hours a year watching TV. [R24] (You can see an interesting visual depiction of this information at `www.informationisbeautiful.net/2010/cognitive-surplus-visualized/` [R25]) On July 22, 2010, Hiawatha Bray wrote in *The Boston Globe*:

> My trouble is I don't watch enough television. If I burned through the national average, watching 35 hours a week, I would probably love Hulu Plus, the new pay-to-play video service. [R26]

Do these two estimates of the amount of time we spend watching TV agree?

Exercise 1.8.85. [N] Exabytes of storage.

On February 11, 2011 the BBC reported on a study om *Science* on the the accumulated amount of information mankind has collected and stored: 295 exabytes by 2007.

> That is the equivalent of 1.2 billion average hard drives.
> ...
> "If we were to take all that information and store it in books, we could cover the entire area of the US or China in 13 layers of books," Dr. Martin Hilbert of the University of California told the BBC's Science in Action.
> ...
> The same information stored digitally on CDs would create a stack of discs that would reach beyond the moon, according to the researchers. [R27]

Exercise 1.8.86. [U][S] Metric history.

(a) The metric prefix kilo was invented along with the metric system. When was that?

(b) The need for larger numbers grew with time. When were the prefixes mega ... zetta invented?

Exercise 1.8.87. [U][N] The 1940 census.

On April 2, 2012 National Public Radio's *All Things Considered* aired an interview with Susan Cooper, head of publicity for the National Archives, about the release on the web of data from the 1940 census.

> COOPER: This is our first online release of census material and we released 16 terabytes of census material and this is, by far, the largest release of digital material that the National Archives has ever had.
> SIEGEL: What was your past record?
> COOPER: We released 250 megabytes of Nixon grand jury transcripts, and so there's a huge leap from 250 megabytes to 16 terabytes. [R28]

Unfortunately, these bytes are microfilm images of census forms. That means they're not searchable. For our quantitative reasoning purposes it means we can't use the number of bytes to estimate the amount of information collected.

Exercise 1.8.88. [N] Save your data with DNA.

> The raw storage capacity of DNA is staggering compared with even the most advanced electronic or magnetic storage systems. It is theoretically possible to store an exabyte of information, if it were coded into DNA, in the volume of a grain of sand. An exabyte is roughly equivalent to 200 million DVDs. [R29]

{R29}

Exercise 1.8.89. [S] Put down your telephohe.

On November 15, 2015 the online *Metro* magazine published an article on cellphone use that quoted Gauthier Peyrouzet, founder of Digital Detox Holidays, saying "A smartphone owner picks up their phone more than 1,500 times a week." The article went on to assert "There's nothing we should be doing 1,500 times a week except breathing, so take the holiday season as your chance to break the cycle." [R30]

{R30}

(a) Is Peyrouzet's "more than 1,500 times a week" reasonable?

(b) Is the article's assumption that we breath 1,500 times a week reasonable?

(c) Track down and comment on the source of Peyrouzet's claim.

Exercise 1.8.90. [U][N] Chicken from farm to table.

> In fairness, the chicken companies excel at producing cheap food, with the price of chicken falling by at least half in real terms since 1930. Chicken is cheap partly because companies have tinkered with genetics so that a baby chick burgeons in five weeks to a full-size bird with an enormous breast. By my calculations, if humans grew that explosively, a baby at five weeks would weigh almost 300 pounds. [R31]

{R31}

Exercise 1.8.91. [U][S] Queueing at the airport.

On May 2, 2016 reader NY Renters Alliance commented in *The New York Times* that

> Last year, terrorists killed zero people on airplanes, at the cost of at least 228 lifetimes spent waiting in lines, not to mention the increased death toll due to driving long distances instead of flying. [R32]

{R32}

Is 228 lifetimes in the right ballpark?

Exercise 1.8.92. [U] No one at the wheel.

In an AP report in *The Boston Globe* on May 15, 2016 you could read that "Vehicles traveled a record 3.1 trillion miles in the United States last year." [R33]

{R33}

Can you make sense of this estimate?

Exercise 1.8.93. [U][S] Too many plastic bags.

In a letter to the editor of *The Boston Globe* on June 18, 2016, Newton City Councilor Alison Leary wrote that

> The City of Newton passed a plastic bag ban last year, and I conservatively estimate that we are diverting 2 million to 3 million bags a month from entering our waste stream, contaminating our recycling bins, and contributing to litter. [R34]

{R34}

Is her estimate reasonable? Is it conservative?

[Hint] Newton has about 100,000 people.

Exercise 1.8.94. [U] Lots of molecules

In a footnote in Bill Bryson's *A Short History of Nearly Everything* he writes about Avogadro's number: 6.02×10^{23} that

> Chemistry students have long amused themselves by computing just how large a number it is, so I can report that it is equivalent to the number of popcorn kernels needed to cover the United States to a depth of nine miles, or cupfuls of water in the Pacific Ocean, or soft drink cans that would, evenly stacked, cover the Earth to a depth of 200 miles. An equivalent number of American pennies would be enough to make every person on Earth a dollar trillionaire. It is a big number. [R35]

{R35}

Check the chemistry students' claims.

Exercise 1.8.95. [U][S] How big is a rally?

On October 17, 2016 *The Boston Globe* quoted Bob Shrum on Hillary Clinton: "She's talking to 80 million people in those debates, and that's worth 200 rallies." [R36]

{R36}

Is this a reasonable estimate?

Exercise 1.8.96. [U] Eggs.

An editorial in *The Boston Globe* on October 17. 2017 began with this paragraph:

> The average American eats roughly 150 shell eggs a year, and a referendum on the Massachusetts ballot this November that would require better treatment for hens is expected to raise retail prices for consumers in the Commonwealth by between 1 and 5 cents per shell egg. If those projections are even roughly accurate, the initiative would translate into an additional cost of maybe $10 per Massachusetts resident per year — and probably less. [R37]

{R37}

Later that week in a news article *The Boston Globe* reported that

> Both sides agree that the price of eggs will almost certainly go up if the measure passes. But its backers, which include the Humane Society of the United States and the MSPCA, say the uptick will probably be a penny an egg.
>
> Opponents, however, see potential increases of 80 cents or more per dozen — a shift that would have an outsize impact on the lowest-income families. [R38]

{R38}

Identify the estimates in these paragraph. Are they consistent? Are they convincing?

Exercise 1.8.97. [U][N] Pennies add up.

On November 6. 2016 you could read in *The New York Times* that

> Soda taxes are on the ballots in San Francisco and Oakland, Calif., and spending to persuade citizens to vote for or against them has topped $50 million, enough to buy every person in those two cities about 40 cans of Coke. [R39]

{R39}

Exercise 1.8.98. [U][N] How many jobs?

> No, Mr. Trump didn't "stand up" to Carrier — he seems to have offered it a bribe. And we're talking about a thousand jobs in a huge economy; at the rate of one Carrier-size deal a week, it would take Mr. Trump 30 years to save as many jobs as President Obama did with the auto bailout; it would take him a century to make up for the overall loss of manufacturing jobs just since 2000. [R40]

{R40}

Exercise 1.8.99. [N] Pasta for all. On January 3, 2017 *The New York Times* reported that

> Every year, an Italian eats on average about 60 pounds of pasta (compared with about 20 pounds for an American). Although Italian farmers grow an enormous amount of durum wheat — four million tons annually — they cannot meet the domestic pasta industry's demand, which requires five million tons or more. [R41]

{R41}

Ideas for questions

- You can estimate the population of Italy from these data.
- Estimate the size of a serving of pasta?

Exercise 1.8.100. [U] How to save a year and half.

In the January 16, 2017 *The New Yorker* Ben Pasternak is quoted on why he has six identical pairs of Zanerobe black plants: "You can save, like, a year and a half of your life if your outfit is pre-chosen. We did the math." [R42]

{R42}

Exercise 1.8.101. [N] What's in a game?

> "The average mobile game is a team of about 20 people, and it takes an average of about 18 months," said Michael Pachter, research analyst at Wedbush Securities in Los Angeles. Assuming an industry-average salary of about $100,000 per year, Pachter said, a high-quality mobile game can be brought to market for around $5 million. That's far less than the cost of building a major multiplayer title, which could easily require 300 or more developers to create the software. [R43]

{R43}

Exercise 1.8.102. [U] Retro data storage.

At `retrocomputing.stackexchange.com/questions/5652/why-are-punch-card-readers-no-longer-in-use` you can read the question

> When you think about it, punch cards are the safest way to backup data for long term storage.
>
> They are not influenced by magnetic fields and their data (the holes) don't fade over time. They are also less sensitive to heat than most backup media I can think of.
>
> Their biggest advantage should be that they are future-proof. Try reading an old computer backup tape or diskette (pick any size). Even if the data signal hasn't faded you probably cannot retrieve the data without some major effort.
>
> Punch cards are easy enough to read and don't have proprietary encoding issues.
>
> If you wanted to read your grandfather's punch cards (or: your grandson wanted to read yours) it should be easy enough to create a card reader.
>
> It may not be ideal for graphics, but data - e.g. a family tree or government records — would be much safer if stored on punch cards in a fire-proof box.
>
> How come punch cards are not used (or not very popular) for long-term backups? [R44]

{R44}

(a) What are punch cards?

(b) How many bytes of data can you store on a punch card?

(c) Estimate how many punch cards would be required to store the text of *Common Sense Mathematics*.

(d) Read the answers online to this question. Confirm some of the estimates you find there.

Exercise 1.8.103. [U][N] Returning to L. L. Bean.

{R45}

> L.L. Bean officials said the company has lost $250 million on returned items in the last five years, with the number of returns doubling in that period. The annual losses on these items alone were "equal to the amount of revenue generated from Bean boot sales," they said. [R45]

Chapter 2

Units and Unit Conversions

Exercise 2.9.5. [S] The penny stops here.

On June 4, 2008 *The Seattle Times* reported on MIT physicist Jeff Gore's research on the cost of a penny. He estimated that dealing with pennies makes transactions take two to two and a half seconds longer, costing each of us four hours every year. At $15 per hour "that's $15 billion a year lost nationwide annually." [R46]
{R46}

(a) How many cash transactions per person per year involving pennies did Gore assume when he made his estimate?

(b) On the average, how many cash transactions per day does each of these people participate in?

(c) How many people did Gore assume were making those transactions?

(d) Use the answers to these questions to decide whether Gore's estimate of $15 billion worth of wasted time is reasonable.

Exercise 2.9.9. [S][C] Global warming opens Arctic for Tokyo-London undersea cable.

On January 21, 2010 *The Seattle Times* carried an Associated Press report about plans to connect London and Tokyo by an underwater cable through the Northwest Passage, in order to reduce the time a message takes to 88 milliseconds from 140 milliseconds. "The proposed system would nearly cut in half the time it takes to send messages from the United Kingdom to Asia." [R47]
{R47}

(a) Estimate the distance from London to Tokyo via the Northwest Passage.

(b) Use that estimate to estimate the speed of the transmission signal, in appropriate units.

(c) Compare the speed of transmission to the speed of light.

Exercise 2.9.19. [R] The national debt.

According to the United States Department of the Treasury, the national debt on January 1, 2013 was $\$16,432,730,050,569.12 \approx$ \$16.5 trillion.

(a) Estimate the average share of the debt for each person in the United States on January 1, 2013.

(b) By some estimates, the debt increases an average of just over $2.5 billion per day. Use the web to find the current national debt of the United States and comment on the accuracy of those estimates.

(c) Find the current population of the United States and update the average share of the debt for each person.

(d) Choose a different country and use the web to find its current national debt. Estimate the average share of the debt for each person in that country and compare this to what you calculated for the United States.

Exercise 2.9.25. [S][C] Apple's app store.

A March 2012 press release from the Apple Corporation heralded the 25 billionth download from their App Store.

> . . . by the users of the more than 315 million iPhone®, iPad® and iPod touch®devices worldwide. [R48]

{R48}

(a) Find out when the App Store opened, and calculate the rate at which apps have been downloaded since then, assuming the rate was constant. Choose units that best express your answer: apps/year? apps/day? apps/second?

(b) Find estimates for the number of devices (phones, tablets, pads, pods) sold. Use those estimates to estimate the number of apps per device.

(c) Do you think these rates have been constant since the store opened?

Exercise 2.9.44. [R][U] Stressing your calculator.

(a) How many digits are there in the largest number your calculator can display normally?

(b) When you ask it for a number bigger than that does it switch to scientific notation or complain?

[Hint] To make a number larger than what the calculator can display you can't just enter it from the keypad. Try multiplying together two numbers each of which is nearly as large as possible.

Exercise 2.9.45. [U] Gold.

In a comment in *The New York Times* online on December 23, 2013, Adam wrote that

> "Gold has no real practical use except making jewelry and filling cavities and the like." Not true. Gold has many industrial uses, and it coats the terminals of the best high-fidelity electrical connections. A ton of cell phones contains about 300 grams of gold — just 300 parts per million by weight, but there are a lot of cell phones. [R49]

{R49}

(a) Is Adam's "ton" a metric ton or an English ton?

(b) How much gold is there in one cell phone? Write your answer in grams using an appropriate metric prefix.

(c) Estimate the number of cell phones in the world.

(d) Estimate the amount of gold in the world's cell phones.

Exercise 2.9.46. [U][S] Expensive solar energy.

In an article headlined "Solar use will push energy costs up in Mass. 20-year rise put at $1 billion" in *The Boston Globe* on February 12, 2014 you could read that the added cost for residential customers would be about $1 to $1.50 more a month. [R50]
{R50}

(a) Use the data to estimate the number of residential customers in Massachusetts.

(b) Is your answer to the previous question a reasonable approximation of the actual number? If not, what might explain the discrepancy?

(c) The headline and the quote convey the same information, but with very different psychological content. In one the added cost seems enormous, in the other insignificant. Write a letter to the editor politely criticizing the way the *Globe* presented the numbers.

Exercise 2.9.71. What does it cost to go green?

One way to save energy is to install solar panels to cover all or part of your roof. Solar panels are expensive, but there are some clever ways to reduce or eliminate the cost. In this project, you will act as a consultant to a homeowner who is thinking of installing solar panels. Your job is to figure out how much of the roof will be covered and what the options are for paying for it. Make sure you look at the option of the homeowner paying for the panels up front, using rebates and credits, and calculate how long it will take to earn that back through reduced electricity costs. Use information from your local area for this, and state your assumptions clearly.

(a) Estimate the area of the roof where the panels will be installed. Solar panels work best when placed on south-facing roofs, so work that into your calculation.

(b) Do some research about options for installing solar panels. One approach is to sign a long-term contract with a solar services provider to purchase the power that the panels generate. Or a homeowner could apply for a grant to cover some of the cost. The federal government also allows homeowners to take a tax credit of up to 30% of the cost of installing panels. There are other options and it's your job to look into them.

(c) Write a proposal for the customer that outlines the different options. For each option, calculate the up-front costs and the long-term costs (or benefits).

(d) What would you recommend? Write a clear recommendation, justifying your answer with the data you have found and calculated.

Exercise 2.9.72. Fire and ice.

In 2013, the Northwest campus of Wayne County Community College District installed a thermal energy cooling system. This system consists of large water-filled tanks. The water in the tanks is frozen at night, when electricity is less expensive, and used in the cooling system during the day. The college installed its tanks underground in a space between two buildings, measuring approximately 60 by 90 feet.

(a) Standard cooling tanks (from the Calmac corporation, for example, at `www.calmac.com/products/icebankc_specs.asp` are 89 inches wide, 91 inches long and 69.5 inches tall. Use this information to determine the maximum number of tanks that the college could install in that space. Make a sketch of the layout of the installation.

(b) Another type of tank from the same company is cylindrical, measuring 48 inches tall and with a diameter of 73.75 inches. How many tanks of this style could be installed in the space? Sketch the layout of the installation.

Exercise 2.9.73. [U] Back in the saddle again.

{R51} Bradley Wiggins won the km Tour de France, cycling 3,497 km in 87 hours 34 minutes 47 seconds. [R51]

(a) What was his average speed, in km/hour?

(b) What was his average speed, in mi/hour?

(c) Did he travel as far as the distance from Maine to Florida? If not, how far would he have gone on that route?

(d) Did he travel as far as the distance from California to New York? If not, how far would he have gone on that route?

Exercise 2.9.74. [U] Waltons' fortune.

From a 2012 article in *Mother Jones* headlined "To Match Walton Heirs' Fortune, You'd Need to Work at Walmart for 7 Million Years":

> Just how rich are the Waltons? According to the latest edition of the Forbes 400, released yesterday, the six wealthiest heirs to the Walmart empire are together worth a staggering $115 billion.
> ...
> The average Walmart worker earns just $8.81 an hour. At that wage, the union-backed Making Change at Walmart campaign calculates that a Walmart worker would need:
>
> - 7 million years to earn as much wealth as the Walton family has (presuming the worker doesn't spend anything)
> - 170,000 years to earn as much money as the Walton family receives annually in Walmart dividends
> - 1 year to earn as much money as the Walton family earns in Walmart dividends every three minutes.

{R52} [R52]

(a) Verify the calculations in this quote.

(b) What is the average annual salary of a Walmart worker?

Exercise 2.9.75. [U] The 2012 Nobel prize in physics.

Serge Haroche and David J. Wineland won that prize for experimental work in quantum physics. One of their experiments built an optical clock.

> The precision of an optical clock is better than one part in 10^{17} which means that if one had started to measure time at the beginning of the universe in the Big Bang about 14 billion years ago, the optical clock would only have been off by about five seconds today. [R53]

{R53}

Check the arithmetic in this paragraph: does one part in 10^{17} work out to five seconds in 14 billion years?

Exercise 2.9.76. [S] Keeping Wikipedia solvent.

This appeal appeared in December 2012 on the Wikipedia website:

> Dear Wikipedia readers: We are the small non-profit that runs the #5 website in the world. We have only 150 staff but serve 450 million users, and have costs like any other top site. To protect our independence, we'll never run ads. We take no government funds. We run on donations. We just need 0.3% of readers to donate an average of about $30. We're not there yet. Please help us forget fundraising and get back to Wikipedia.
>
> If everyone reading this gave the price of a cup of coffee, our fundraiser would be done within an hour. If Wikipedia is useful to you, take one minute to keep it online another year by donating whatever you can today. [R54]

{R54}

(a) Use the data in the first paragraph to estimate Wikipedia's fundraising goal. Is your answer believable?

(b) Estimate the percentage of the fundraising goal that goes toward staff salaries.

(c) Use the data in the second paragraph to estimate the number of users who visit Wikipedia in an hour. (The average cost of a cup coffee on campus is $2.00.) For a little bit of extra credit, spend no more than five minutes on the internet to see if you can confirm your estimate

Exercise 2.9.77. [U] Claim your money, please!

One of the authors received this in email:

> I am thompson Cole the newly appointed United Nations Inspection Agent in JFK Airport New York. During our Investigation, we discovered An abandoned shipment on your name through a Diplomat from London. which was transferred to our facility here in JF Kennedy Airport and when scanned it revealed an undisclosed sum of money in a Metal Trunk Box weighing approximately 55kg each.
>
> I beleived each of the boxes will contain more that $4M or above in each and the consignment is still left in storage house till today through a registered shipping Company, Courier Dispatch Service Limited a division of Tran guard LTD. The Consignment are two metal box with weight of about 55kg each (Internal dimension: W61 x H156 x D73 (cm). Effective capacity: 680 L.)Approximately.

Mr. thompson Cole goes on to ask for identification, and offers to "bring it by myself to avoid any more trouble. But we will share it 70% for you and 30% for me. But you have to assure me of my 30%."

(a) Does a box with the dimensions specified contain approximately 680 liters?

(b) What denominations (bills or coins) would you expect to find inside to make a total of $4M?

(c) Does a weight of 55kg seem reasonable for that box full of money?

(d) What things about the email make you suspicious?

Exercise 2.9.78. [U] Cleaning up Everest.

> Nepal's government announced on March 3 that it would require every climber returning from the summit of Mount Everest to bring back at least 18 pounds of garbage, the first concerted effort to eliminate the estimated 50 tons of trash that has been left on the mountain over the past six decades. The waste includes empty oxygen bottles, torn tents and discarded food containers. [R55]

{R55}

(a) How many people would have to bring back 18 pounds of garbage to eliminate those 50 tons?

(b) Estimate how many years it would take to bring back the garbage if everyone who made it to the top did what he or she should.

(c) The quotation says only people who reach the summit would be required to bring back garbage. Answer the previous question if everyone on each expedition had to do that.

[Hint] Use the web to find out enough about the history of Mount Everest expeditions to estimate the average number of climbers and the average number of people who actually reach the summit each year.

Exercise 2.9.79. [U][N] Digital photography.

> The relative increase in detail resulting from an increase in resolution is better compared by looking at the number of pixels across (or down) the picture, rather than the total number of pixels in the picture area. For example, a sensor of 2560×1600 sensor elements is described as "4 megapixels" ($2560 \times 1600 = 4,096,000$). Increasing to 3200×2048 increases the pixels in the picture to 6,553,600 (6.5 megapixels), a factor of 1.6, but the pixels per cm in the picture (at the same image size) increases by only 1.25 times. A measure of the comparative increase in linear resolution is the square root of the increase in area resolution, i.e., megapixels in the entire image. [R56]

{R56}

Exercise 2.9.80. [S] The flight of the honeybee.

An article in the April 28, 2009 edition of *The New York Times* quotes Dr. Anna Dornhaus:

> A honeybee is less than an inch long. If it flies 20 kilometers that equals 787,400 body lengths. If we say a human is two meters tall, then in human terms, that would be like traveling 394 kilometers and back, possibly several times a day. [R57]

{R57}

(a) Use the figures she provided to determine the body length of a honeybee. Is she correct in stating that it is "less than an inch"?

(b) Is Dr. Dornhaus's estimate of "394 kilometers and back" as the human equivalent of the honeybee's 20 kilometers reasonable?

Exercise 2.9.81. [S] Cheers from the (no) peanut gallery.

The Boston Globe reported on June 12, 2011 that 3,000 bags of peanuts sold at Fenway would lead to a half ton of scattered shells. [R58]

{R58}

(a) How many ounces of shells are there in each bag of peanuts?

(b) About what fraction of the weight of a bag of peanuts are the shells?

(c) Are the numbers in this quotation reasonable?

Exercise 2.9.82. [S] Please cut your nails.

In *The Human Age* author Diane Ackerman writes "A human fingernail grows about 1 nanometer per second." [R59]

{R59}

Check her claim by estimating how often you trim your nails.

Exercise 2.9.83. [U][N] Crime in London then and now.

In *Sherlock Holmes and New Scotland Yard* Philip Dalton wrote about information Sir Robert Mark, the Commissioner of Police for London, presented at the 1974 Annual Dinner of the Sherlock Holmes Society:

> The Report of the Commissioner of Police of the Metropolis [London] for 1890 reveals that 15,264 police officers were available to police an area of 688.31 square miles and that the total of serious offenses (down the scale from murder to forgery and counterfeiting) was 18,815.
>
> Provisional figures for 1974 show that 20,055 police officers were available to police an area of 788 square miles, and that the total number of indictable crimes (fairly comparable with the serious crimes of 1890) was 413,516.
>
> ...
>
> [Holmes] would appreciate the irony in the fact that the internal combusiton engine has presented the Metropolitan Police with a massive problem; how massive can be gauged from the fact that of 1974's indictable crime total of 413,516, no fewer than 134,836 concern autocrime — taking and drving away or theft from motor vehicles. To that, one might point out to Holmes, can be added more than 600 road deaths and some 53,000 injuries in London, compared with 144 deaths and 5,500 injuries in 1890. Although it might seem that the road accident problem was relatively small in 1890, it was in fact causing the Commissioner much concern, especially since many of the casualties were children riding illegally on the backs of carts. [R60]

{R60}

Questions should probably ask about per capita rates (research the populations) and percentage change. Maybe this exercise belongs in the next chapter.

Exercise 2.9.84. [U] Currency conversion in 1927.

On the cover of *Common Sense Mathematics* in the upper right corner of *The New York Herald* front page reporting Lindbergh's flight you can read that

Dollar in Paris	20fr. 34 1/2c.
Dollar in London	4s. 2d.
Pound in Paris	194fr. 09c.

French francs (fr) are divided into 100 cents (sou). English money is measured in pounds, shillings (s, 20 to the pound) and pence (d, 12 to the shilling).

(a) Calculate the conversion rates in dollars per pound, pounds per franc, and francs per dollar.

(b) Explain why the product of your three answers to the previous question should be 1.

(c) Check to see whether the product is 1. If it's not, try to explain why. One possibility: we misread the cover image. Perhaps if you squint you can see it better.

Exercise 2.9.85. [U] CNN does not know when to divide.

Timothy Delworth noted this quote from CNN in a piece on the proposed Dakota Access Pipeline:

> After the pipeline is completed, it would shuttle 470,000 barrels of crude oil a day, according to developer Energy Access Partners. That's more than 19.7 million gallons of crude oil a day — or enough to make 374.3 million gallons of gasoline per day. [R61]

{R61}

(a) Does "460,000 barrels of oil" match "more than 19.7 million gallons of oil"?

(b) How much crude oil would the pipeline shuttle in a year?

(c) Clearly 19.7 million gallons of crude oil can't produce 374.3 million gallons of gasoline. What did CNN get wrong? There's a hint at `www.eia.gov/tools/faqs/faq.cfm?id=327&t=9` .

(d) Will completing this pipeline make a large contribution to our nation's need for gasoline?

Exercise 2.9.86. [U] Binge watching.

{R62} Can you believe that Vine celebrated its third birthday on January 24th [2016]? According to Tubular, over 39M videos have been uploaded to the platform in that time, generating 765 billion views. Here's to the next 3 years! [R62]

Unfortunately, that was wishful thinking, because on October 27, 2016, Twitter announced that it would be shutting down Vine: its app where people can upload videos which are only six seconds long.

(a) What's the total length of all Vine videos, as of Jan 24, 2016?

(b) How many times (on average) was each video viewed?

(c) Calculate the average rate at which users uploaded videos, in uploads per day, per hour and per minute. Which version would you choose to report?

(d) Answer the previous question for video views.

(e) Estimate the number of videos uploaded between January 24 and October 27 2016.

(f) If it was someone's job to watch every Vine video, could they complete the task? If you think not, estimate how many people it would take.

Exercise 2.9.87. [N] Saffron

{R63} Top-shelf saffron, almost all of it imported, sells for $16-20 per gram in grocery stores — or roughly $500 per ounce. [R63]

{R64} At $19 a gram and $100,000 of estimated revenue per acre, saffron also has a chance to be uniquely profitable in Vermont. [R64]

Exercise 2.9.88. [N] Stalled in traffic

INRIX press release: `inrix.com/press-releases/scorecard-us/`

All the data: `inrix.com/scorecard/`

Scientific American discussion" `www.scientificamerican.com/article/traffic-gridlock-is-linked-to-more-crime/`

The Boston Globe: Typical Boston commuter spent 2.5 days in traffic last year

`https://www.bostonglobe.com/metro/2017/02/23/typical-boston-commuter-spent-equivalent-days-sitting-traffic-last-year/J9SwUJibjBhiySQOfZQViN/story.html`

Exercise 2.9.89. [N] Ten penny nails.

You can buy ten penny nails at your local hardware store. They're about three inches long. Why ten pennies? An article on the website of the Manchester, Massachusetts Glasgow Steel Nail company tells the story

> Although many different handmade nails were in use at the time [15th century England] which had specific names, a large proportion were named simply by the number of pence paid for a hundred nails.
>
> For example, four penny nails were those of which a hundred were purchased for 4d. (The 'd' stands for pence in the days when sterling was denominated in pounds, shillings and pence — £s d).
>
> . . .
>
> For those that would like to work out the true cost today, the article tell us that the medieval penny would have been the equivalent of around 1s 6d in value in 1915. Government sources suggest that prices have risen over 61 fold since 1914, so a medieval penny might be worth around £4.50 today. [R65]

{R65}

Exercise 2.9.90. [S][U] The back of the batter's box.

In *The Boston Globe* on June 16, 2015 Stan Grossfeld quoted umpire Ted Barrett saying

> the back line of the batter's box is the first to be erased. That's from guys looking for an extra millisecond to track a 98-mile-per-hour fastball. [R66]

{R66}

Does the ball take a millisecond to travel the width of the stripe at the end of the batter's box?

Exercise 2.9.91. [U][N] Waste disposal.

A question at skeptics.stackechange.com (`skeptics.stackexchange.com/questions/38844/do-solar-panels-create-300-times-more-toxic-waste-per-unit-of-energy-than-nuclea` asks

> Do solar panels create 300 times more toxic waste per unit of energy than nuclear-power plants?

That question was prompted by the article "Study Claims Discarded Solar Panels Create More Toxic Waste Than Nuclear Plants " on slashdot (`hardware.slashdot.org/story/17/07/01/0442203/study-claims-discarded-solar-panels-create-more-toxic-waste-than-nuclear-plants`) which reports on the *National Review* story "Discarded solar panels are piling up all over the world, and they represent a major threat to the environment." (`www.nationalreview.com/article/449026/solar-panel-waste-environmental-threat-clean-energy`) which refers in turn to the that to the original source "A Clean Energy's Dirty Little Secret" from an organization called "Environmental Progress". `www.environmentalprogress.org/big-news/2017/6/21/are-we-headed-for-a-solar-waste-crisis`

Exercise 2.9.92. [S] Rain, rain go away.

On September 2, 2018 a headline in *The Washington Post* said that hurricane Harvey "unloaded 33 trillion gallons of water in the U.S."

(a) If that rain fell evenly across the whole continental United States how deep would it be?

(b) How deep would the water be if it all fell on your state?

Exercise 2.9.93. [U] Maple cream.

The label on the jar of Maple Cream from Ben's Sugar Shack in Temple, NH reads

Net Wt. 1 lb, * 453.59g

What's wrong with this unit conversion? What should it say?

Exercise 2.9.94. [U][S] Apples for sale.

What's the best deal in Figure 2.1?

fig:deal

Figure 2.1: Apples for sale [R67]

{R67}

Exercise 2.9.95. [U][S] Can you believe what you see?

In the November 12 issue of *The New Yorker* Joshua Rothman wrote about Medifor's video fraud detection systems. ("Medifor" is short for "Media Forensics").

> Ideally, such systems would be integrated into YouTube, Facebook, and other social-media platforms, where they could flag synthesized content. The problem is speed. Each day, five hundred and seventy-six thousand hours of video are uploaded to YouTube; MediFor's systems have a "range of run-times from less than a second to "tens of seconds" or more. [R68]

{R68}

The last sentence of this quote is unclear. It seems to suggest that it might take between one and one hundred seconds of computer time to check an hour of video for fraud. Use that as an assumption in answering the following queations.

(a) How many hours of computer time would it take to check a day's worth of YouTube uploads?

(b) How many computers would you need in order to check a day's worth of uploads on the day they appear.

Chapter 3

Percentages, Sales Tax and Discounts

Exercise 3.8.7. [S][C][W] New taxes?

On January 14, 2013 *The Boston Globe* reported that Massachusetts could raise $1 billion a year by increasing the income tax rate from 5.25 to 5.66 percent. [R69]
{R69}

(a) Find the 2013 taxable income in Massachusetts.

(b) Find the total revenue from this income tax at the 5.25 percent rate.

(c) Compare your answer to the state budget. Are the numbers consistent?

[Hint] Look up the Massachusetts budget for 2013, and the percentage of revenue that comes from this personal income tax.

Exercise 3.8.77. [N][C] Fantasy sports.

On September 24, 2015 Neil Irwin wrote in *The New York Times* about the economics of fantasy sports.

> 1.3 percent of fantasy players paid $9,100 in entry fees on average, accounting for 23 percent of all entry fees and 77 percent of all profits.
>
> While they earned a 27 percent return on their "investments," the 80 percent of bettors who counted as small fish, spending $49 each, lost about half their money. [R70]
{R70}

Exercise 3.8.78. [S] Living without a cellphone.

On September 28, 2012 *The Wall Street Journal* reported that

> In the second quarter, the number of cellphone subscribers on contract plans rose just 0.5% from the year before, to 217 million, according to UBS AG. The number of prepaid customers grew about 11% to 74 million. [R71]
{R71}

(a) What percentage of the people using cellphones has prepaid service now?

(b) How many subscribers had contract plans in the second quarter of 2011 ("the year before")?

(c) How many prepaid customers were there in the second quarter of 2011?

(d) How did the percentage of people using a prepaid service rather than a contract plan change in the last year?

Exercise 3.8.79. [W][R][S] Doublespeak.

In his "Letter from Rangoon" in the August 25, 2008 issue of *The New Yorker* George Packer wrote:

> The minister of planning ... gave a long speech that attempted to rebut Petrie's remarks, using the U.N.'s own statistics. "Some of it was really funny," Petrie recalls. "He said, for example, 'The U.N. states that a third of the children under five are malnourished. That's absolutely not true. It's 31.2 per cent. The U.N. states that three-quarters of an average family's income is used on food. That's actually not true. It's 68.7 per cent.' He was using our statistics to say there was no poverty — that everything was fine." [R72]

{R72}

(a) Where is Rangoon?

(b) The quote describes how Myanmar's minister of planning tried to rebut the conclusions of a U.N. report. Do you think he succeeded?

(c) Why did Petrie think the attempt was "really funny"?

(d) Estimate the number of malnourished children in Myanmar in 2008.

(e) (optional) What is doublespeak? What's the origin of the term? Is the minister of planning's response doublespeak?

Exercise 3.8.80. [C][U] Colleges and the numbers game

On February 4, 2008 Ralph Whitehead Jr. wrote in *The Boston Globe* that

> The share of the nation's 18-year-olds who are from households where no adult holds a four-year degree is 60 percent. If Princeton looked like America, its first-generation number would be 60 [percent], not 11. Its number is about one-fifth of a representative number. Blacks make up 12 percent of America. If Princeton's enrollment represented one-fifth of black America, the black share of its students would be under 2 percent. If it did the same for women, the female share of its students would be under 10 percent. [R73]

{R73}

We find these numbers quite confusing. Can you figure out what Whitehead is trying to say? This exercise might make an interesting class discussion. Assign it first, then build a class around student solutions.

Exercise 3.8.81. [U][N] ADHD.

The web page `www.cdc.gov/ncbddd/adhd/data.html/` from the Centers for Disease Control (CDC) reports this data on Attention-Deficit Hyperactivity Disorder (ADHD):

> The American Psychiatric Association states in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) that 3%-7% of school-aged children have ADHD. However, studies have estimated higher rates in community samples.
>
> Parents report that approximately 9.5% or 5.4 million children 4-17 years of age have ever been diagnosed with ADHD, as of 2007.

> The percentage of children with a parent-reported ADHD diagnosis increased by 22% between 2003 and 2007.
>
> Rates of ADHD diagnosis increased an average of 3% per year from 1997 to 2006 and an average of 5.5% per year from 2003 to 2007.
>
> Boys (13.2%) were more likely than girls (5.6%) to have ever been diagnosed with ADHD. [R74]

{R74}

(a) Make sense of these statistics.

(b) Read and comment on Bronwen Hruska's opinion piece *Raising the Ritalin Generation* at `www.nytimes.com/2012/08/19/opinion/sunday/raising-the-ritalin-generation.html`

Exercise 3.8.82. [N] Low income smokers.

On November 8, 2012 an article in *The New York Times* headlined "Poor Smokers in New York State Spend 25% of Income on Cigarettes, Study Finds" (`www.nytimes.com/2012/09/20/nyregion/poor-smokers-in-new-york-state-spend-25-of-income-on-cigarettes-study-says.html`) reported on a study in *PLOS one*.

The discussion at Andrew Gelman's blog (`andrewgelman.com/2012/09/poor-smokers-in-new-york-state-spend-25-of-income-on-cigarettes-study-finds/\#comments` is a gem, dissecting the assumptions behind the headline and the study.

Exercise 3.8.83. [U] Organic foods.

In 2012 The U. S. Department of Agriculture said that the retail market for organic foods was $31.4 billion in 2011 — 4.2 percent of all retail food sales. The amount was only $3.6 billion in 1997. [R75]

{R75}

(a) Use these figures to find total retail food sales in 2011.

(b) Estimate total annual retail food sales as a Fermi problem.

(c) Are your answers in the same ballpark?

Exercise 3.8.84. [S] Gasoline in Europe.

In *The New York Times* on July 20, 2011 reader Robin Foor commented on the article *Bipartisan Plan for Budget Deal Buoys President*:

> The tax on a gallon of gas in Germany is more than $3.
> . . .
> The US per gallon tax on gasoline is 18.4 cents per gallon, which it has been since 1993.
> . . .
> In 1993 gasoline cost $1.16 per gallon. The 18.4 cents per gallon tax was 15.9 percent of the value of a gallon of gas. Today gas is about $3.70 a gallon. Equivalent tax at 15.9 percent is 58.7 cents per gallon. The increased tax of 40.3 per gallon would fund fixing the road. [R76]

{R76}

(a) Check the percentage calculations in this quote.

(b) Correct the writing errors in the last sentence.

(c) Verify as many of the historical quantitative claims as you can.

Exercise 3.8.85. [S] Fare increases at the T.

On Sunday, February 19, 2012 *The Boston Globe* reported that

> . . . [The MBTA] provides 1.3 million rides each weekday
> . . .
> The proposed increases — a one-way subway ride, now $1.70 with the reloadable CharlieCard and $2 with paper CharlieTicket, could rise to as much as $2.40 and $3, respectively — would be the largest by percentage since 1949,
> . . .
> the advisory group said fares should rise no more than 25 percent, acknowledging the need for more money but wary of pricing people off the system. Such a fare increase would generate about $80 million . . . [R77]

{R77}

(a) Compare the proposed increases in CharlieCard and CharlieTicket fares, in absolute and relative terms.

(b) Estimate how much extra revenue would be generated in a year from weekday rides if CharlieCard and CharlieTicket fares increased by just 25%.

(c) Compare your answer to the assertion in the quotation that a 25% increase in fares would yield $80 million in new revenue.

(d) What was the percent increase in T fares in 1949?

Exercise 3.8.86. [S] Natural born drillers.

On March 16, 2012 Paul Krugman wrote in *The New York Times*

> Employment in oil and gas extraction has risen more than 50 percent since the middle of the last decade, but that amounts to only 70,000 jobs, around one-twentieth of 1 percent of total U.S. employment. So the idea that drill, baby, drill can cure our jobs deficit is basically a joke. [R78]

{R78}

(a) Use the data in the quotation to estimate total U.S. employment.

(b) Use the data here (not a web search!) to estimate oil and gas industry employment in 2005.

Think carefully first about what the 70,000 oil industry jobs represents. There are several possibilities. Write them down; then decide which you think is right, and why.

(c) Use the web to check your estimate.

Exercise 3.8.87. [S] Math at camp.

On July 27, 2011 *The New York Times* reported from a math camp for middle school kids who like mathematics

> In a Bard classroom one afternoon, it seemed for a moment that Arturo Portnoy had stumped everyone. Dr. Portnoy . . . posed this question: "The length of a rectangle is increased by 10 percent and the width is decreased by 10 percent. What percentage of the old area is the new area?" [R79]

{R79}

What's the answer to Portnoy's question?

Exercise 3.8.88. [S] Paying for a Picasso.

On May 12, 2012 *The New York Times* reported that

> Picasso's "Femme Assise Dans un Fauteuil," a 1941 portrait of Dora Maar, the artist's muse and lover, posed in a chair . . . went for $26 million, or $29.2 million with fees." [R80]

{R80}

Earlier, the article described how Sotheby's computes fees: "Final prices include the buyer's commission to Sotheby's: 25 percent of the first $50,000; 20 percent of the next $50,000 to $1 million and 12 percent of the rest."

Check that the explanation about how the commission was computed does in fact match the data in the quotation about fees.

Exercise 3.8.89. [S] The prison population.

In *The New York Times* on May 31, 2011 you could read that

> Every year America spends close to $66 billion to keep people behind bars. But almost 500,000 of the 2.3 million prisoners aren't convicts; rather, they are accused individuals awaiting trial. [R81]

{R81}

(a) What percentage of the population is behind bars?

(b) How does that percentage compare to the percentages in other countries?

(c) How much does it cost to incarcerate a prisoner for a year?

(d) Can you verify the $66 billion and 2.3 million figures in this quotation?

Exercise 3.8.90. [N] Who presided over debt increase?

At `www.politifact.com/truth-o-meter/statements/2011/may/19/nancy-pelosi/nancy-pelosi-posts-questionable-chart-debt-accumul/` you can read Louis Jacobson's post on May 19, 2011 titled "Nancy Pelosi posts questionable chart on debt accumulation by Barack Obama, predecessors".

Deconstructing that chart is a good exercise.

Exercise 3.8.91. [S] Biking to work in Boston.

On October 26, 2015 you could read in *The Boston Globe* that

> The number of Boston residents who regularly commute by bicycle has more than tripled in a decade, according to data from the US Census Bureau.
>
> An estimated 8,100 workers regularly pedaled themselves to their jobs last year, up from 2,300 in 2005, according to the bureau's American Community Survey, which was released last month.
>
> The percentage of Bostonians traveling to work by bike also more than doubled, from 0.9 percent to 2.4 percent during that 10-year span. [R82]

{R82}

Exercise 3.8.92. [S] Raise the cap?

On November 19, 2015 *The Boston Globe* asked its readers "Should the state raise the cap on charter schools?" The following Sunday the paper reported the results of the online poll:

No: 56.72% (38 votes) Yes: 43.28% (29 votes)

(a) Check the percentage calculations.

(b) Criticize the way those percentages are reported.

(c) How reliable is this poll as a measure of the public's opinions on the question?

Exercise 3.8.93. [U] What a deal!

Figure 3.1 suggests a 100% discount. Is it?

GE TL-26604 NiMH Cordless Phone Battery
by Jasco
Be the first to review this item

List Price: $832.99
Price: $3.75 **Free shipping** for Prime members when buying this Add-on Item. Details
You Save: $829.24 (100%)

In Stock.
Want it tomorrow, April 12? Add it to a qualifying order within 33 mins and choose **One-Day Shipping** at checkout. Details
Sold by Sale Stores and Fulfilled by Amazon. Gift-wrap available.

- Simply compare shape, size and connector position
- 1.2V, 1300mAh, NiMH
- Pack of 2 batteries

Add-on Item

This item is available because of the Add-on program
The Add-on program allows Amazon to offer thousands of low-priced

fig:amazondeal

{R83} Figure 3.1: 100% discount! [R83]

Exercise 3.8.94. [S] Take me out to the ball game.

According to the United States Census Bureau, which recently announced its annual [2015] estimates for major American cities, New York has reached a record high of 8,550,405 residents. That increase from last year's high of 8,495,405 makes the city's total population large enough to fill Yankee Stadium about 170 times, or Citi Field about
{R84} 205 times. [R84]

(a) By what percentage did the population of New York increase?

(b) By what amount did the population of New York increase?

(c) Use the information given above to calculate the seating capacity of Citi Field.

(d) Could Yankee Stadium accommodate the increase in the population of New York?

Exercise 3.8.95. [S] Suicide statistics.

On April 22, 2016 *The New York Times* reported on a study saying that suicide in the United States rose by 24 percent from 1999 to 2014.

> The increases . . . lifted the nation's suicide rate to 13 per 100,000 people, the highest since 1986. The rate rose by 2 percent a year starting in 2006, double the annual rise in the earlier period of the study. In all,
{R85} 42,773 people died from suicide in 2014, compared with 29,199 in 1999. [R85]

(a) Are 42,773 suicides and 13 per 100,000 people in 2014 consistent?

(b) The suicide rate in 2006 was 11.1 per 100,000 people. If as stated, the rate has risen 2 percent each year since 2006, does that lead to a rate of 13 per 100,000 in 2014? not?.

(c) If the suicide rate continues to increase at 2% per year, in what year will it reach 22 per 100,000?

Exercise 3.8.96. [U][S] Private elevators.

In May of 2016 Beth Teitel wrote in *The Boston Globe* that

> The number of residential elevators in single-family homes has increased by 40 percent over the past five years in Massachusetts, according to Stephen Sampson, the state's chief elevator inspector. In March, there were about 2,070 "residential" — or roughly 15-square-foot — elevators in owner-occupied
{R86} single-family homes in Massachusetts. [R86]

(a) How many owner-occupied single-family homes had elevators in 2011?

(b) Estimate the percentage of residents of Boston who lived in single-family homes with elevators in 2016.

(c) How many people would fit in one of these elevators?

Exercise 3.8.97. [U][N] Should you watch out for alligators?

> Over all, incidents like the Disney attack remain very rare despite Florida's growth in recent decades. The state's wildlife agency says the frequency of unprovoked bites — currently about seven a year — has been increasing about 3 percent each year. But the odds of a resident being seriously injured during an unprovoked alligator encounter are roughly one in 2.4 million. [R87]

{R87}

Exercise 3.8.98. [N][U] How rich is J. K. Rowling?

In *The New York Times* article "In the Chamber of Secrets: J.K. Rowling's Net Worth" on November 24, 2016 you could read that:

> To start with the obvious, there's the source of her wealth: The seven Harry Potter books have sold an estimated 450 million copies, with estimated total revenue of $7.7 billion. At a standard 15 percent author's royalty, she would have earned $1.15 billion. [R88]

{R88}

Many more question ideas in the rest of the article.

Exercise 3.8.99. [N][S] How much fraud in food stamps?

A *Washington Post* story headlined "Fox News wonders whether we should cancel food stamps because 0.09% of spending is fraudulent" started with these words:

> A bit over 44 million Americans participate in the government's Supplemental Nutrition Assistance Program, more commonly referred to as food stamps. That's a higher number than in most years past, representing about 13.7 percent of the U.S. population, but it's down from the high of 47.6 million in 2013, 14.9 percent of the population that year.
>
> What's incensing Fox News, though, is that 2016 saw a record-high level of fraud in the system, with $70 million wasted. The network hosted a discussion Tuesday morning with a simple conceit: Should the program therefore be ended? [R89]

{R89}

To days later:

> Fox News has retracted a Tuesday story that claimed "an all-time high" for food stamp fraud.
>
> "We reported that back in 2016 $70 [billion] were wasted on food stamp fraud," Fox News contributor Abby Huntsman said on Friday's " Fox and Friends."
>
> "That was actually incorrect. The latest information from 2009 to 2011 shows the fraud at 1.3 percent, which is approximately $853 million for each of those three years. Nationally food stamp trafficking is on the decline. So sorry about that mistake." [R90]

{R90}

Exercise 3.8.100. [U] Incarceration

> While the United States has less than 5 percent of the world's population, it houses nearly a quarter of the world's prisoners. Our prison and jail population has quintupled since the 1970s, even as crime rates are near historic lows, and American taxpayers spend some $80 billion per year on incarceration. [R91]

{R91}

American League

EAST	W	L	PCT.	GB
Tampa Bay	1	0	1.000	—
Baltimore	0	0	—	½
Boston	0	0	—	½
Toronto	0	0	—	½
New York	0	1	.000	1

fig:dayone

Figure 3.2: Standings very early in the season [R93]

{R93}

(a) Do you have enough information to estimate the number of prisoners in the United States?

(b) If your answer to the previous question is "yes", make the estimate and check your answer with a web search. If it's "no" then find an estimate in at least two independent place on the web.

(c) Use your estimate of the number of prisoners in the United States to figure out the number of prisoners in the world.

(d) What is the average annual cost for incarcerating one prisoner in the United States?

Exercise 3.8.101. [S][U] An opening day no-hitter.

Roger Angell writes about this riddle:

> Name the only major-league game in which the players on one side all ended up with the same averages they'd begun with. [R92]

{R92}

He says the answer is the no-hitter Bob Feller threw on opening day in 1940: the Chicage players began and ended with batting average .000.

Explain why that's not quite correct.

Figure 3.2 provides a hint. It shows the American League East standings at the start of the 2017 season when two teams have played and the others haven't yet.

Exercise 3.8.102. [U][C] Traffic fatalities up?

An article headlined "The number of pedestrians, cyclists and drivers killed in L.A. traffic rose sharply in 2016" began:

> Traffic deaths in Los Angeles rose sharply despite a high-profile campaign by Mayor Eric Garcetti and other city leaders to eliminate fatal traffic crashes.
>
> In 2016, the first full year that Garcetti's Vision Zero policy was in effect in L.A., 260 people were killed in traffic crashes on city streets, an increase of almost 43% over the previous year. [R94]

{R94}

Later in the article you could read that Seleta Reynolds, the L.A. Transportation Department's general manager, "cited an increase in driving as one reason for the rising number of fatalities. Car sales and car registrations have risen in Southern California, driven by a strong economy and low gas prices."

This article was discussed in Andrew Gelman's blog at `andrewgelman.com/2017/04/03/no-evidence-providing-drivers-licenses-unauthorized-immigrants-california-decreases-traffic-safety/` . There you can find a link to an Associated Press report that began

WASHINGTON: Pedestrian deaths are climbing faster than motorist fatalities, reaching nearly 6,000 deaths last year — the highest total in more than two decades, according to an analysis of preliminary state data released Thursday.

Increased driving due to an improved economy, lower gas prices and more walking for exercise and environmental reasons are some of the likely reasons behind the estimated 11 per cent spike in pedestrian fatalities in 2016. The figures were prepared for the Governors Highway Safety Association, which represents state highway safety offices. [R95]

{R95}

(a) How many traffic fatalities were there in Los Angeles in 2015?

(b) How many pedestrian traffic fatalities were there in the United States in 2015?

(c) What data would you need to compare these two fatality rates since one is for all traffic deaths and the other for pedestrian traffic deaths.

(d) Explain how Reynolds' observation might change the perceptions these article raise. What data would you need to calculate the fstality rates in deaths per mile driven?

Exercise 3.8.103. [U][N] Taxes down, spending up.

During the 1990s, state taxes amounted to roughly 6.7 cents of every dollar earned in Massachusetts. These days, it's more like 5.9 cents. And if that doesn't sound like a big change, it adds up to something like 3.5 billion no-longer-collected dollars every year — more than enough to resolve the budget woes.

Compare that with the big driver on the other side of the ledger: the rise in health care spending, particularly on Medicaid. This, too, is a very big and very real fiscal challenge. In the late 1990s, less than 20 percent of the state budget went to Medicaid (known here as MassHealth); these days, it's over 35 percent. And while about half of those expenses are reimbursed by the federal government, the state's share is swelling, too.

Had these health care costs not exploded — but merely grown at the same rate as the rest of the Massachusetts economy — it would have freed up about $2.5 billion every year. That's a big number, by any metric, but a good deal smaller than the $3.5 billion cost of tax reductions.

So that's the big picture. Tax cuts drained away money, health care spending absorbed a growing portion of the remaining funds, and the result is a budget that's been out of balance for over a decade. [R96]

{R96}

The first paragraph makes an easy question on percentages. You have enough information to find the total taxable dollars and the total tax collected. Then you can check those with a web search or ask about per capita amounts.

[U][S] Thumb on the scale.

Exercise 3.8.104. A dishonest dealer sells his goods at the cost price but still earns a profit of 25% by underweighing . What weight does he use for a kilogram?

Exercise 3.8.105. [U][N] Tax cuts for whom?

The [Urban-Brookings Tax Policy Center] analysis showed that the proposed Trump tax cuts would lift after-tax income for the top 1 percent of taxpayers by at least 11.5 percent (or an average annual tax cut of $175,000), compared with a barely perceptible 1.3 percent for taxpayers in the middle (or $760 in average tax savings). [R97]

{R97}

Exercise 3.8.106. [U][N] Eat less beef, save the planet.

On March 18, 2018 *The New York Times* published an opinion piece advocating a carbon tax on the CO_2 emissions from the production of various kinds of meat and dairy foods. Figure 3.3 displays some of the numbers. The price increases reflect the maximum impact after a $247.83 tax per ton of CO_2 emitted.

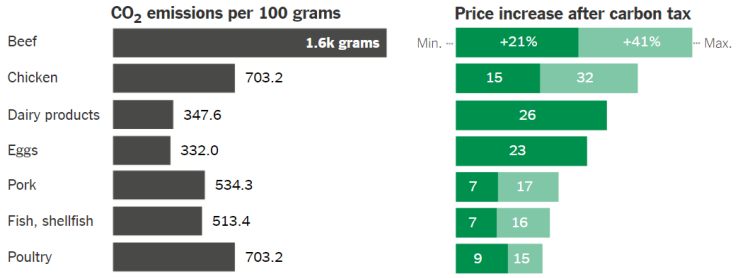


fig:meat

{R98} Figure 3.3: The cost of carbon [R98]

(a) Check that the price increases correspond to the carbon emissions for each product.

(b) Explain the lengths of the two part bars in the chart on the right.

(c) Read the article.

Exercise 3.8.107. [U][N] Harry Potter on Broadway

https://www.nytimes.com/2018/04/14/theater/harry-potter-broadway.html

Was it a huge increase?

[U]

Exercise 3.8.108. [U][S] Counting fraudulent immigration claims. On June 18, 2018 *The New York Times* reported that Kirstjen Nielsen, the secretary of homeland security said "between October and February, there was a 315 percent increase in the number of undocumented immigrants 'fraudulently' using 'unaccompanied alien children' to pose as a family unit in order to enter the United States. "

In the next paragraph you could read that

> The large percentage that Ms. Nielsen cited refers to a sliver of overall data: During that time frame, there were 191 cases of fraudulent family claims reported, up from 46 cases for all of 2017, when more than 303,000 crossing attempts were recorded. [R99]

{R99}

Exercise 3.8.109. [U][S] Finding subjects

On July 28, 2018 Gina Kolata reported in *The New York Times* on the difficulty finding subjects for clinical trials of prospective Alzheimer's drugs.

> There are more than 100 Alzheimer's studies looking for a whopping 25,000 participants, Mr. Dwyer said.
>
> To begin filling them all, 37.5 million patients in the right age group would first have to be informed. Ten percent would be referred to a trial site for screening.
>
> Just 4 percent will move forward with an evaluation, and of these, just over 17 percent will drop out, given the current rate, leaving roughly 125,000 to be screened. And with an 80 percent screening failure rate, that leaves 25,000 participants of the 37.5 million who were first informed.
>
> The numbers make it clear: There's no way scientists are going to find 25,000 participants for all of the Alzheimer's trials that have been approved. [R100]

{R100}

The second and third paragraphs say that 10 percent of the patients would be referred for screening and that four percent would move forward.

It's not clear what that means. The four percent might be four out of every hundred people referred for screening, or it might be four percent and not ten percent of the original 37.5 million.

Which of these interpretations matches Kolata's calculation?

Exercise 3.8.110. [U][S] Should drivers complain?

In *The Boston Globe* on August 8, 2018, Patrick Marvin, a spokesman for the MassDOT, defended the Commonwealth's electronic toll collection system with the quote

> The Massachusetts Department of Transportation has processed nearly 900 million transactions since transitioning to All Electronic Tolling in October 2016 and components of the system are designed to be more than 99.9% accurate. [R101]

{R101}

(a) About how many toll collection errors were made?

(b) Estimate the number of toll collection errors per day.

(c) Is that good performance?

Exercise 3.8.111. [U][S] Discounts for centenarians

On August 26, 2018 the website `www.georgetakei.com` reported that

> Western Montana resident Helen Self just celebrated her 109th birthday, and she knew exactly where she wanted to celebrate with her friends and family.
>
> The Montana Club in Missoula offers a special discount for patrons based on their age; the older you are, the bigger the discount.
>
> For example, a person celebrating their 21st birthday would be entitled to a 21% discount.
>
> . . .
>
> Self didn't go overboard with her order. For her celebratory dinner, self ordered some shrimp. Her bill wound up earning her around $1.30. [R102]

{R102}

How much did her meal cost (before the discount)?

Exercise 3.8.112. [U][S] Please pay for the ride.

On December 4, 2018 *The New York Times* reported on fare evasion:

> The Metropolitan Transportation Authority expects to lose about $215 million this year from fare evasion on the subway and buses, officials said during a presentation to the agency's board. About 208,000 people ride the subway each day without paying — nearly 4 percent of all subway riders during the fourth quarter of this year.
>
> . . .
>
> Fare evasion on buses is even worse. About 348,000 people take the bus every day without paying — about 16 percent of all bus riders. [R103]

{R103}

(a) Use the data in the quotation to estimate the number of daily subway and bus passengers in New York.

(b) Do your answers to the preceding question make sense?

(c) Estimate the average subway and bus fare.

Exercise 3.8.113. [U][S] An expensive shutdown.

On January 9, 2019 *Politico* reported on the probable cost of a government shutdown:

> Estimates from President Donald Trump's chief economist peg the cost to the overall U.S. economy at about $1.2 billion for each week the shutdown persists. While that's just 0.05 percentage points off the GDP growth rate, it could be among the factors complicating the administration's aspiration of reaching sustained 3 percent growth. [R104]

{R104}

So the difference is between a growth rate of 3% per year and 3.05$ per year. That 0.05% is $1.2 billion means the GDP is

Chapter 4

Inflation

Exercise 4.8.10. [S] Holiday Pops.

Adjust the calculations in Exercise **??** to take into account inflation from 2009 to 2012.

Exercise 4.8.15. [U][R][A] When is a raise not a raise?

Your employment contract calls for a 3% annual raise. If the inflation rate is 4.2%, what is your effective "raise"?

Exercise 4.8.28. [N] The federal minimum wage.

At `www.peri.umass.edu/fileadmin/pdf/resources/Minimum_Wage_petition_website.pdf` you can read a July 2013 open letter from dozens of economists advocating an increase in the federal minimum wageto $10.50 per hour.

The essay suggests lots of good quantitative reasoning questions: check their arithmetic, verify their estimates, put their conclusions in a personal context, ...

Exercise 4.8.29. [S] Kids are expensive.

On June 23, 2012, you could read on the *Dallas Morning News* website that

> In 1960] the cost of raising a child was just over $25,000 for middle-income families. That would be $191,720 today when adjusted for inflation. [R105]

{R105}

(a) Use the inflation calculator to check this inflation assertion.

(b) Has the cost of raising a child increased faster or slower than inflation? Does that question even make sense?

[Hint] You will have to think about whether $190K was enough to raise a child in 2012.

Exercise 4.8.30. [N] Salvaged silver.

On July 18, 2012 ABC News reported that the Tampa, FL company Odyssey Marine Exploration, Inc. announced that it had recovered 48 of a possible 240 tons of silver from the Gairsoppa, a World War II shipwreck.

> The recovery is being made under a contract awarded by the U.K. government, which will keep 20 percent of the cargo's value, estimated to be in the tens of millions of dollars. The Gairsoppa became U.K. property after the government paid the owners of the ship an insurance sum of £325,000 in 1941. Records indicate the silver was valued at £600,000 in 1941. [R106]

{R106}

Possible questions:

(a) some routine percentage calculations.

(b) value of silver then and now? did it match inflation rate?

(c) currency conversion.

Exercise 4.8.31. [U][C] Cutting the Pentagon's budget.

In an August 9, 2010 article in *The New York Times* headlined "Making Good on Pledge, Gates Outlines Military Cuts" you could read than

> Mr. Gates is calling for the Pentagon's budget to keep growing in the long run at 1 percent a year after inflation, plus the costs of the war. It has averaged an inflation-adjusted growth rate of 7 percent a year over the last decade (nearly 12 percent a year without adjusting for inflation), including the costs of the wars. So far, Mr. Obama has asked Congress for an increase in total spending next year of 2.2 percent, to $708 billion — 6.1 percent higher than the peak under the Bush administration. [R107]

{R107}

(a) Make sense of these numbers.

Some readers were confused, and said so:

> Unless I missed something in this article, there are no cuts at all if the overall budget is increasing 1% above inflation. This is a shell game.

(b) What is a shell game?

Exercise 4.8.32. [N] Half-pennies. At `factually.gizmodo.com/the-u-s-killed-the-half-penny-when-it-was-worth-what-a-1639266183` Alissa Walker wrote an article titled "The U.S. killed the half-penny when it was worth what a dime is today". There you can read that

> The half-cent had a short life, as currency goes. It was only produced by the U.S. Mint from 1793 to 1857. The coins featured the head of a nameless "Miss Liberty" (one of the few females on our currency). At the time it was first minted, many Americans made about a dollar a day, and might have been able to purchase a pound of potatoes for 1.5 cents. But as prices went up, the half-cent was quickly proven to be useless. It was retired, and most of the coins were scrapped for their copper.
>
> ...
>
> According to the Consumer Price Index, the 1857 half-cent would have been worth 14 whole cents in 2014 dollars. [R108]

{R108}

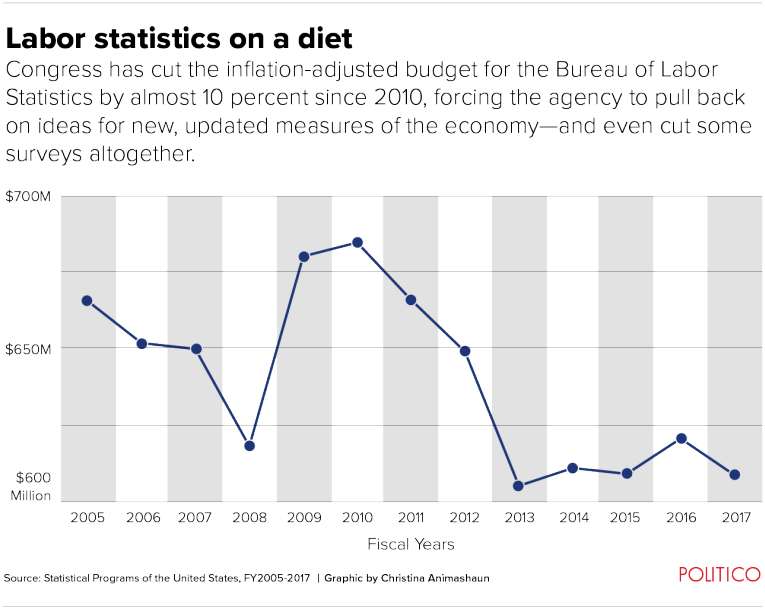


fig:laborstatistics

Figure 4.1: Labor ststistics on a diet [R110]

{R110}

Exercise 4.8.33. [N] It all depends on where you live.

The federal government has begun using the data collected to calculate the Consumer Price Index to report on regional differences in the cost of various goods and services. They conclude that

> The "real value" of a dollar is highest in Mississippi ($115.30), Arkansas ($114.30), Alabama ($113.90), South Dakota ($113.60) and Kentucky ($112.70). It buys the least in the District of Columbia ($84.70), Hawaii, New York ($86.40), New Jersey ($87.30), California ($89) and Maryland ($90.70). [R109]

{R109}

There are many more good numbers in the full article.

Exercise 4.8.34. [U] Labor statistics on a diet.

Figure 4.1 shows the budget for the Bureau of Labor Statistics for the years 2005-2017.

(a) Is the "almost 10% cut" since 2010 correct?

(b) Why does the 2010 budget seem to be about seven times the 2017 budget? Redraw the graph so that the 10% drop is visible but less dramatic. (A careful sketch will do; later you will learn how to draw the graph in Excel.)

(c) The numbers in the graph are inflation adjusted. Find out for which year the actual budget number appears. (It's probably 2017 but may not be.) Then find the actual dollar values for 2010 and 2017 and calculate the percent change.

Exercise 4.8.35. [U]

Figure 4.2 shows the increase in airline revenue from fees charged for checked bags.

(a) Calculate the percent increase in fees collected for checked bags between 2000 and 2016.

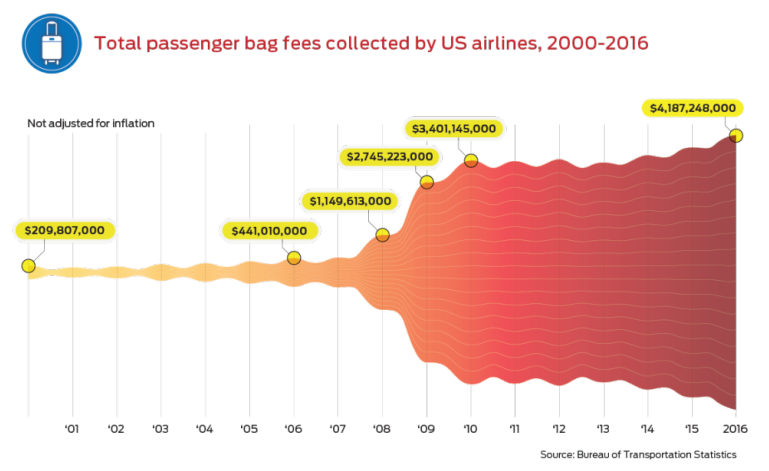


fig:baggagefees

{R111} Figure 4.2: Fees for checked bags [R111]

(b) Redo the previous calculation after adjusting for inflation.

(c) Measure the height of the colored area for each of the years 20006, 2008 and 2016. Do the percentage increases in height match the percentage increases in fees?

(d) What might the wavy top and bottom of the colored area mean?

Exercise 4.8.36. [U][N] Package delivery.

In a post at *Politico* in March, 2018, you could find out that

> The Postal Service reported delivering fewer than 900 million packages in 2008, which amounted to $1.8 billion in revenue. That was a pittance for the agency, which raked in $75 billion that year. Come 2017, USPS reported more than 5.7 billion parcels which reaped $19.5 billion, about 28 percent of USPS' $65 billion in annual revenue. [R112]

{R112}

Confirming/understanding order of magnitude of these totals.

Possible questions: percentage changes in cost per package, in revenue and in fraction of revenue from package delivery, adjusting for inflation.

This exercise combines reasoning about percentages, unit costs and inflation.

Exercise 4.8.37. [U][N] Another old Apple

On September 27, 2018 *The Boston Globe* reported that

> A computer built in the 1970s that helped launch the personal computer age as well as a trillion-dollar company has sold for $375,000. [R113]

{R113}

Exercise **??** reports on a similar sale earlier. You can read there that the computer sold for $666 in

Compare the prices.

Chapter 5

Average Values

Exercise 5.7.2. [S] Fundraising.

On October 20, 2011 the Elizabeth Warren campaign provided *The Boston Globe* with the data we used to draw Figure 5.1. The first bar in the chart shows the total dollar contributions to her campaign, broken down according to where the money came from (Massachusetts vs. out of state). The second bar shows the total number of donors, broken down the same way.

(a) What was the average donation (per donor)?

(b) What was the average donation from Massachusetts?

(c) What was the average donation from outside Massachusetts?

(d) Check that calculating appropriate weighted average of your answers in parts (b) and (c) gives the answer you found in (a).

Exercise 5.7.10. [S][C] Regional differences in the CPI.

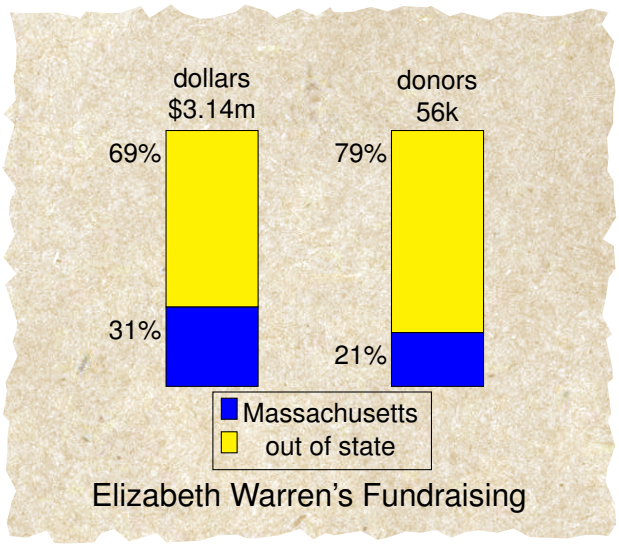
We saw in Section **??** that the average 2006-2007 inflation rate for the northeast urban consumer was 2.58% while the national average was 2.85%.

(a) Estimate the fraction of the population of the United States that counts as urban in the northeast.

(b) Use your estimate to estimate the average inflation rate for the rest of the country.

Exercise 5.7.21. [U][N] Improving reading skills.

On June 29, 2010 the *Cape Cod Times* reported that "Almost half of Massachusetts third-graders are not proficient readers."



{R114} Figure 5.1: Where did the money come from? [R114] fig:warrenfundraising

> Last year, 65 percent of low-income third grade students scored below proficient on the MCAS reading test. And overall, the percentage of third-graders receiving below-proficient scores has hovered around 40 percent over the last decade. [R115]

{R115}

There's a weighted average hidden here. If we knew either the percentage of low-income third graders in the population or the percentage of non-low-income students who scored below proficient we could find the other percentage.

Exercise 5.7.22. [S] A wage freeze.

The Boston Globe reported on February 25, 2009 in its "New England in Brief" column that

> Faculty members at the Boston and Amherst campuses of the University of Massachusetts have agreed to a three-year contract that freezes their wages for the current academic year. . . . The new contract raises salaries by 1.5 percent in the coming academic year and 3.5 percent the following year. . . . At UMass-Amherst, full professors earn an average of $117,000 a year. Faculty members earn an average of $90,000, according to university data. [R116]

{R116}

(a) What was the average Amherst full professor's salary in the 2009-2010 academic year?

(b) What is the percentage increase in faculty salaries over the life of the contract?

(c) There was no raise in 2009, so the salaries then were the same as they were the year before. What is the buying power of a faculty member's $90K salary in 2009, in 2008 dollars?

(d) Suppose 30% of the faculty at Amherst were full professors. What was the average salary of the other 70%?

Chapter 6

Income Distribution — Spreadsheets, Charts, and Statistics

Exercise 6.12.28. [U] Income growth.

On April 26, 2014 *The Boston Globe* reported that 2012 per capita income in Massachusetts grew to $49,354, up 3.2% from 2008, after adjusting for inflation.

(a) How much was Massachusetts per capita income in 2008, in 2012 dollars?

(b) How much was Massachusetts per capita income in 2008, in 2008 dollars?

(c) This income figure is an average. Is it a mean, a median or a mode? Explain how you know.

(d) Estimate the total 2012 income for Massachusetts.

[Hint] If you don't know what "per capita" means, look it up.

Exercise 6.12.36. [U] Car and truck prices.

The article on new car and truck prices that we studied in first asserts that

> . . . the average price of a new vehicle in the second quarter [of 2008] fell 2.3 percent from a year earlier to $25,632 . . .

and later

> The result is the average new vehicle now costs less than 40 percent of an average household's median annual income, the analysts said, whereas from 1991 to 2007, it would cost more than half of the median income. [R117]

{R117}

Verify as much of this last assertion as you can.

Exercise 6.12.37. [U][A] Enrollments.

The final enrollment report for the past year at an unnamed small college provided the following information about students: 450 freshmen, 421 sophomores; 400 juniors and 511 seniors.

(a) Create an Excel spreadsheet containing this data. Label the columns appropriately.

(b) Ask Excel to calculate the total number of students enrolled during the past year. Label this result.

(c) Create a properly labeled bar chart of the student data.

(d) A corrected enrollment report noted that there were 419 juniors. Make that adjustment in your spreadsheet and check that the other information (total number of students, bar chart) is correctly updated.

(e) Using this new information, ask Excel to calculate the percentage of students who are freshmen, sophomores, juniors and seniors. Copy and paste so that you type as few formulas as possible.

(f) Create a new bar chart displaying the percentages.

(g) Convert your bar chart to a pie chart.

Exercise 6.12.38. [U][A] SAT percentiles.

A student received this notification on his college entrance exam:

English Language Arts:	77th percentile
Mathematics:	88th percentile

Explain this report in everyday language.

[Hint] Your answer might begin "More than three quarters of the students taking this test . . . "

Exercise 6.12.39. [U] Comparing the states.

You can do this exercise using Excel, or with properly documented research. (Your instructor may specify one method or the other.)

Find the mean, median and mode for the populations of the 50 states.

Display the answers to the previous question on a properly labeled histogram. Discuss your findings — is the distribution skewed?

Redo parts (a) and (b) for the areas of the states.

Redo parts (a) and (b) for the population densities (people per square mile).

Exercise 6.12.40. [N] Jellybean margin of error.

`andrewgelman.com/2011/08/that_xkcd_carto/`

Exercise 6.12.41. [U] Reputation on stack exchange.

Stackexchange.com (`stackexchange.com`) is a network of online question and answer websites. Users who post questions and provide answers earn reputation based on community feedback. Table 6.1 shows the number of

Reputation	Users
100,000+	97
50,000+	297
25,000+	938
10,000+	3,249
5,000+	6,874
3,000+	11,150
2,000+	15,650
1,000+	24,867
500+	34,857
200+	45,107
1+	1,478,007
All sites	

Reputation	Users
100,000+	2
50,000+	14
25,000+	24
10,000+	60
5,000+	91
3,000+	132
2,000+	179
1,000+	281
500+	395
200+	591
1+	18,417
TEX— LATEX	

tackexchange}

Table 6.1: Stackexchange reputation

users with reputations in certain ranges on January 6, 2013 for all stackexchange sites and for the particular site `tex.stackexchange.com/` where the authors have asked and answered questions about the TEXsoftware used to prepare the manuscript for *Common Sense Mathematics*.

Estimate the mode, median and mean for each distribution. This is subtle in several ways. The bucket sizes vary. Data at the top and bottom end of the range are very scarce. Ask about sensitivity to the assumptions made there about the actual means for the top and bottom categories.

Exercise 6.12.42. [U] Deceptive pie charts.

Build the pie chart from .

(a) Experiment with the pie chart features to make it look like the managers' salaries are the largest. You can't actually change the data to do this — you need to use the 3D and other pie chart features to make it look like the managers' salaries are large.

(b) Play around with different types of charts in Excel. Find a chart type and an effect (3D, most likely) that really distorts the data.

Exercise 6.12.43. [U][C] River lengths.

There should be a good Benford's law exercise somewhere, maybe here. But spending time on this peculiar phenomenon is probably not worth the time it takes away from other more useful topics.

At `en.wikipedia.org/wiki/List_of_rivers_by_length` Wikipedia offers a chart of 163 major rivers, organized by length.

(a) Construct a bar chart with nine categories, using the first digit of the length of the river to determine the category.

You might expect all the bars to be the same height, since there are nine possible starting digits. But they're not. In fact, there are no rivers longer than 6000 km.

The fact that for the short rivers there are more whose length begins with small digits is an instance of *Benford's law*. You can look up more about it if you're curious.

(b) Use Excel to create new columns with river lengths measured in yards, in feet and in inches. Draw each of those bar charts. Discuss what you see.

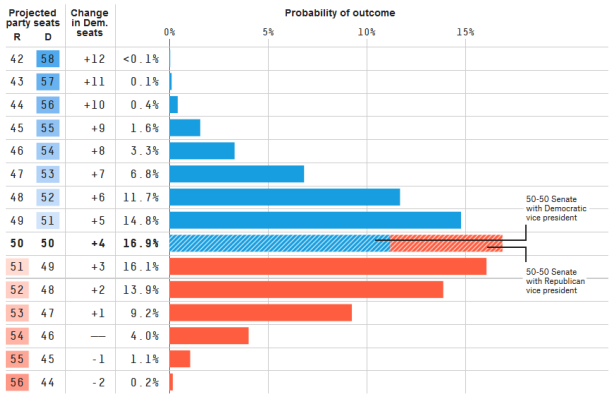


fig:senate2016

{R118} Figure 6.2: The fight for the Senate [R118]

Exercise 6.12.44. Fight for the Senate (2016).

A graph like the one in Figure 6.2 appeared in Nate Silver's 538 website on November 7, 2015. The y-axis displays the number of seats held by each party, the x-axis the probability of that outcome.

Nate Silver constructed this histogram by imagining (simulating) many thousands of elections and recording the percentage of time each Democratic/Republican split occurred.

(a) What is the most likely number of Democratic senators?

(b) What number of Democratic senators represents the mode of this distribution?

(c) What is the probability that there are more than 50 Democratic senators?

(d) What number of Democratic senators is the median of this distribution?

(e) If you had the complete list of all Nate Silver's imagined elections and sorted it by the number of Democratic senators, how many Democratic Senators would there be in the middle election on that list?

(f) Use Excel to compute the (weighted) average number of Democratic senators for these imagined elections.

(g) What actually happened in the election?

Exercise 6.12.45. [N] Boston's payroll.

This histogram appeared in *The Boston Globe* on February 14, 2017.

{R120} The raw data are available on the web. There's an anonymized copy at `Boston14Payroll.xlsx` [R120] .

The histogram and the spreadsheet suggest many possible questions. Some suggestions:

(a) Estimate bar heights from the graphic.

(b) Estimate median and mean, with Excel or otherwise.

(c) Discuss how you would report the mode in order to convey the most information.

(d) Check the estimates of the median and mean by looking at the raw data.

(e) Check estimates of the bar heights by reconstructing the histogram from the raw data.

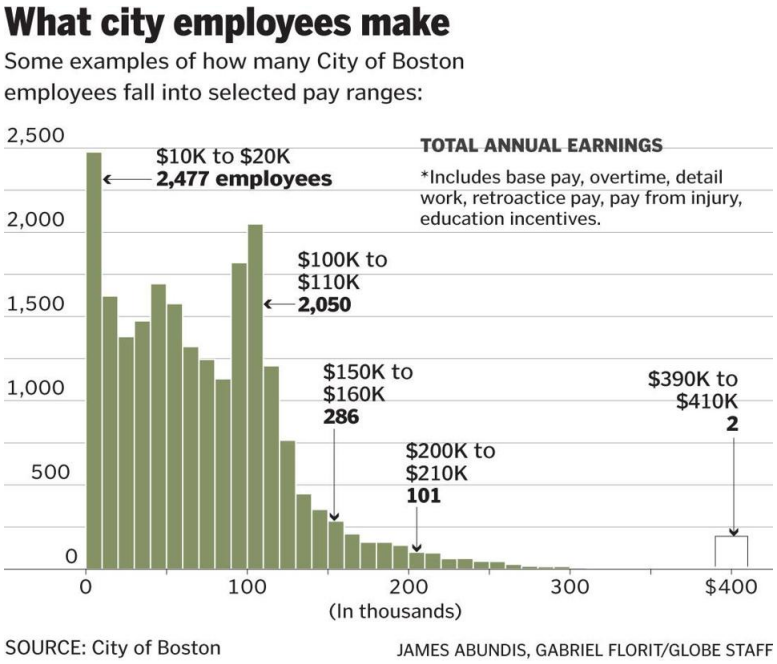


fig:bostonpayroll

{R119} Figure 6.3: Boston Municipal Payroll [R119]

IQ	Percentile	% population in bracket	number of people	average IQ	weighted votes	share of weighted votes
150	0.9995709	0.04%	42911.6534	150	6436748.01	0.06%
140	0.9961696	0.34%	340130.8591	145	49318974.57	0.49%
130	0.9772499	1.89%	1891963.691	135	255415098.3	2.55%
120	0.9087887	6.85%	6846121.994	125	855765249.2	8.56%
110	0.7475075	16.13%	16128118.54	115	1854733632	18.55%
100	0.5	24.75%	24750753.29	105	2598829095	25.99%
90	0.2524925	24.75%	24750753.24	95	2351321558	23.51%
80	0.0912113	16.13%	16128118.54	85	1370890076	13.71%
70	0.0227501	6.85%	6846121.994	75	513459149.5	5.13%
60	0.0038304	1.89%	1891963.691	65	122977639.9	1.23%
50	0.0004291	0.34%	340130.8591	55	18707197.25	0.19%
40	3.169E-05	0.04%	39743.0499	45	1788437.246	0.02%
30	1.532E-06	0.00%	3015.3698	35	105537.943	0.00%
20	4.832E-08	0.00%	148.402	25	3710.05	0.00%
10	9.9E-10	0.00%	4.7327	15	70.9905	0.00%
0	0	0.00%	0.099	5	0.495	0.00%

fig:iqvoting

{R121} Figure 6.4: Votes weighted by IQ [R121]

Ask the usual questions: mode, median, mean. Bimodality is interesting.

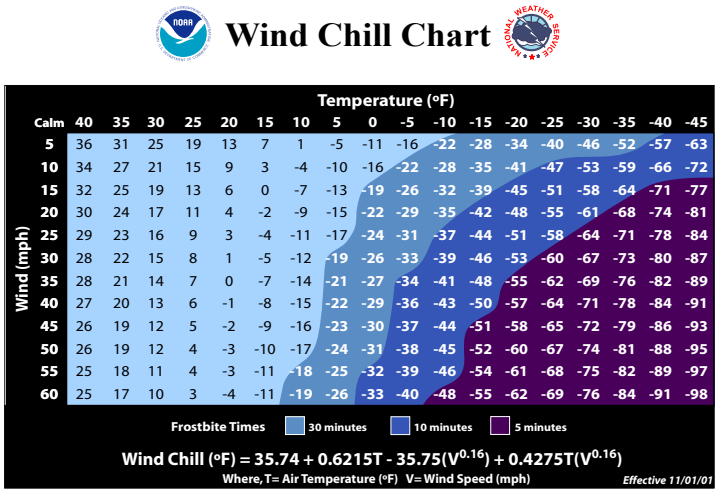
Exercise 6.12.46. [N] Votes weighted by IQ.

An answer to the question "What would be the possible issues with an IQ based voting system?" at `worldbuilding.stackexchange.com/questions/83199/what-would-be-the-possible-issues-with-an-iq-based-voting-system` offers this:

> If you're giving everyone exactly as many votes as their IQ — the effect on the actual vote doesn't appear to be very much at all. See the table in [Figure 6.4] for a population of 100 million to illustrate — the vote share for IQ 120 + is slightly higher than with a normal democracy, but the fact there are exponentially fewer people in these higher intelligence brackets means that the linear multiplier on their vote weight has less and less of an effect.

The comments are interesting too.

Exercise 6.12.47. [U][N] How cold is it really?



{R122} Figure 6.5: Calculating the Wind Chill [R122] fig:windchill

Figure!6.5 shows the National Weather Service calculation for how cold it feels in terms of the temperature and the speed of the wind.

The formula there came from research done by Maurice Bluestein; you can read the story in his obituary at `www.nytimes.com/2017/09/14/science/maurice-bluestein-who-modernized-the-wind-chill-index-dies-at-76.html`

There's a spreadsheet you can play with at `windchill.xlsx` .

The New York Times

Exercise 6.12.48. [U][W][N] "Average" household wealth.

On December 8, 2017 you could read in a Associated Press Report in *The Boston Globe* headlined "Surging stocks lift US wealth, yet most still trail '07 peak" that

> Surging stock prices and steady increases in home values powered American household wealth to $96.9 trillion this fall, the Federal Reserve said Thursday. The gains, however, aren't widely shared.
>
> . . .
>
> In 2016, the latest figures available, median household wealth was still 34 percent below its prerecession, 2007 level. Average household wealth, meanwhile, fully recovered from the downturn and was 7 percent higher last year. The average figure is pulled up by very wealthy families.
>
> While average household wealth reached $667,600 in 2016, net worth for the median household was just $78,100. [R123]

{R123}

Note: There's even enough information here to determine the number of households - for a sanity check.

Note: Is this a place for a discussion of the difference between wealth and income?

Exercise 6.12.49. [U] Median age vs. mean age?

On September 9, 2018 Dante Ramos wrote in *The Boston Globe* that

{R124} According to research by Portland State University in Oregon, the median age of voters in a Boston mayoral election is 51, more than 14 years older than the average adult in the city. [R124]

(a) Why is it correct to use the median age rather than the average (mean) age in this report?

(b) Why is it better to write "older than tha average adult" rather than "greater than the average adult's age"?

(c) Think of a situation where it would be more useful to know that mean age rather than the median age.

Chapter 7

Electricity Bills and Income Taxes — Linear Functions

Exercise 7.8.23. [U] Your total federal tax bill.

Modify the graph in Figure **??** to show how total tax and the effective tax rate for (income tax + Social Security) depends on income.

Exercise 7.8.39. [U][C][N] Does virtual save energy?

> MOST PEOPLE take for granted the Earth-friendly nature of electronic communication. Paperless, ink-free, no shipping supplies, no gas for transportation: the environmental benefits of virtual communication are obvious. But the reality is more complicated, at least according to a growing number of concerned technology experts and scientists. Vast stockpiles of digital data waste energy, too.
>
> Everyday emails aren't to blame. But large photo and video attachments, cluttered inboxes, and massive email forwards may be. Some analysts estimate that emailing a 4.7-megabyte attachment — the equivalent of four large digital photos — can use as much energy as it takes to boil about 17 kettles of water. The problem is magnified when large emails are forwarded to many people and left in inboxes undeleted. As long as emails remain in your inbox, the data they create is physically stored somewhere.
>
> And that's where the problems arise: The total amount of digital storage worldwide is approaching 1 zettabyte, or 1 million times the contents of the Earth's largest library. Currently, that information is archived on equipment with a mass equivalent to 20 percent of Manhattan. Global data storage is expected to reach 35 zettabytes by 2020, which means more equipment, land, and energy. The information industry already accounts for approximately 2 percent of global carbon dioxide emissions. That's the same amount as the airline industry blasts into the atmosphere. Coupled with the rapid increase in stored data, it's an unsustainable scenario.
>
> Technology firms must create systems that store data with less energy, and governments should provide incentives for them to do so. Just as important, consumers must demand products that save energy, and use websites like Flickr and MediaFire that allow them to share large files without emailing. Better still, they could consider keeping some of those embarrassing photos and home videos to themselves. [R125]

{R125}

Exercise 7.8.40. [U][N] Green gas?

Robert Bryce's op-ed in *The New York Times* on June 7, 2011 (`www.nytimes.com/2011/06/08/opinion/08bryce.html`) has lots of interesting numbers about the costs in steel and land area for solar and wind electricity generation.

Exercise 7.8.41. [U][N] Every little bit counts.

On March 5, 2012 *The Boston Globe* reported on the Ocean Renewable Power Company's plans to install tidal powered generators in Maine:

> The first unit capable of powering 20 to 25 homes will be hooked up to the grid this summer, and four more units will be installed next year at a total cost of $21 million . . .
>
> Eventually, Ocean Renewable hopes to install more units to bring its electrical output to 4 megawatts.

{R126} [R126]

Exercise 7.8.42. [S][A] Compact fluorescent bulbs.

Consumers are being encouraged to replace ordinary light bulbs with compact fluorescent bulbs. (CFLs). Soon they will be required to.

(This exercise should be updated to discuss LED bulbs too, and to use real rather than invented numbers.)

A CFL uses less energy than an ordinary incandescent bulb that produces the same amount of light, but it costs more to buy. This table provides data with which you can compare the two.

bulb	initial cost	power
ordinary	$2.00	100 watts
CFL	$9.00	25 watts

Suppose electricity costs $0.20 per kwh.

You can use pencil and paper, a calculator or Excel to do the arithmetic.

(a) Write a linear equation with which you can calculate the total cost C of using the ordinary bulb for H hours.

(b) What is the slope of that equation (with its units)?

(c) What is the intercept of that equation (with its units)?

(d) How much would it cost to buy the ordinary bulb and use it for 1000 hours?

(e) Write a linear equation with which you can calculate the total cost C of using the CFL for H hours.

(f) How much would it cost to buy the CFL and use it for 1000 hours?

(g) How long would you have to use the CFL to make it worth having paid the higher purchase price?

Are the five numbers given in this exercise reasonable?

What does "incandescent" mean? Why are incandescent light bulbs called that?

Exercise 7.8.43. [U][S] Not flying to London.

In *The New York Times* on April 25, 2011 you could read that

{R127}

> You can save so much energy by not flying to London [to collaborate with a coworker] that it will run a rack of computers for a year. [R127]

Estimate the energy costs of flying to London and running a rack of computers for a year to see if they are of the same order of magnitude.

[Hint] If you're a physicist you can make these estimates with your common knowledge. If you're not, you can put together reliable information from the web. Try searching for the energy cost of flying an airplane and the energy cost of running a computer.

Exercise 7.8.44. [S] Express lane?

In *The Boston Globe* on November 27, 2015 you could read that

{R128}

> Amid the holiday grocery shopping madness, every line feels like the wrong one. And yet, some are wronger than others. Given equally capable cashiers, you are often better off bypassing the express lane. Research conducted at a large, unnamed, California grocery store found that while each item adds 3 seconds to the check-out time, it takes 41 seconds for a person to move through the line even before their items are added to the tally. Bottom line: The big time-consumers are not the items, but the small talk and the paying, says Dan Meyer, who has a doctorate in math education from Stanford University. [R128]

Suppose you have 10 items in your cart, so you are allowed to use the express lane. How much longer must the line there be (compared to the regular lane) to make the wait in the regular lane less?

[Hint] The answer depends one the relative lengths of the lines, not on the absolute difference in the lengths.

You can answer that question with any strategy that makes sense to you, as long as you explain what you're thinking. If you need a starting place, one way is to follow these steps:

(a) Write the linear equation showing how the time it takes a shopper to check out depends on the number of items in her cart. What are the slope and intercept, with their units?

(b) Suppose shoppers in the express lane buy 6 items (on average), while those in the regular lane buy about 20. Write a linear equation for each line showing your waiting time depends on the number of shoppers ahead of you.

(c) Now work on the main question — which line should you join when you have 10 items in your cart? How much longer must the express lane line be to make the wait on the regular lane line less?

Exercise 7.8.45. [U] LED lightbulb.

Figure 7.1 shows the specifications for an LED bulb that costs $11.00. It's meant to replace a 60 watt incandescent bulb that costs about a dollar.

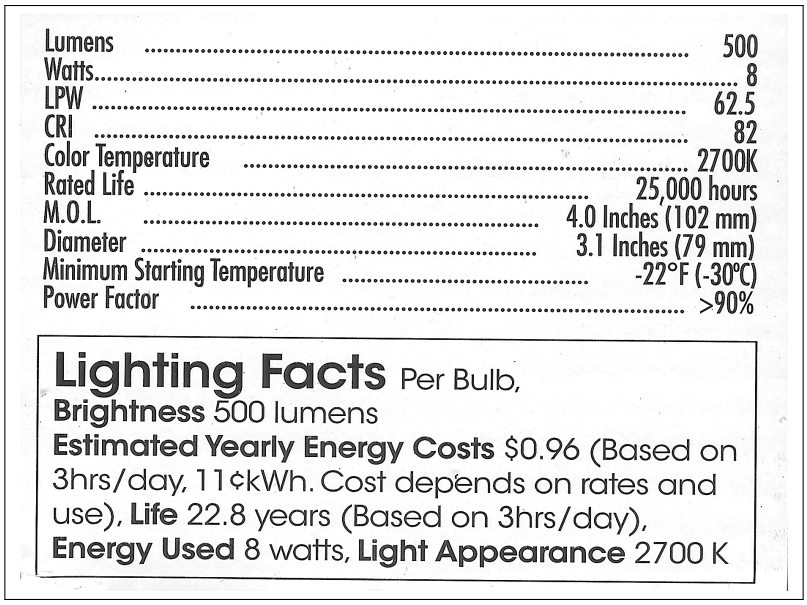
(a) Check the claimed Estimated Yearly Energy Cost.

(b) Check that the Rated Life agrees with the claimed 22.8 year Life.

(c) How long will it take for the LED bulb to be cheaper overall than the incandescent bulb (counting both the initial cost and the cost of the electricity to run it) ?

(d) What does the acronym "LPW" stand for? Has it been computed correctly?

(e) What do the words "LED" and "incandescent" mean?



{fig:ledbulb} Figure 7.1: Light bulb specs

Exercise 7.8.46. [S] Kilowatt hours per day.

Professor Sir David Mackay's obituary in *The Telegraph* observed that

> [His] genius was to express all forms of power consumption and production in a single unit of measurement — kilowatt hours per day (kWh/d). A 40 watt lightbulb, kept switched on all the time, uses one kWh/d, while driving the average car 50km a day consumes 40 kWh/d. [R129]

{R129}

(a) Confirm that keeping a 40 watt lightbulb left switched on all day would use 1 kilowatt hour of energy.

(b) According to MacKay, "The amount of energy saved by switching off the phone charger [for a day] is exactly the same as the energy used by driving an average car for one second." How many people would have to switch of their cell phone chargers in a day to save as much energy as driving a car 50 km?

(c) Mackay claims that switching your cell phone charger off for one year saves as much energy as is needed for one hot bath. How many kilowatt hours per day does it take to heat that bath water? water?

(d) What did MacKay mean when he stated that gestures like turning of your cell phone charger were akin to "bailing out the Titanic with a teaspoon"? Do you agree?

Exercise 7.8.47. [N] The Rosenfeld.

From *The New York Times* January 27 obituary of physicist Arthur Rosenfeld:

> [In 2010] a group of scientists proposed a unit of measurement in his name. The "Rosenfeld," they said, should refer to annual electricity savings of three billion kilowatt-hours — enough to eliminate the need for a coal plant. [R130]

{R130}

Exercise 7.8.48. [U][N] Fuel economy in square meters?

physics.stackexchange.com/questions/325733/why-can-fuel-economy-be-measured-in-square-meters

> The fact that the gallon (or liter) is a volume is really irrelevant. What we're really measuring is distance per energy unit. It's just handy that all kinds of gasoline have pretty close to the same energy content for a given volume (about 32.8 kWh/gal, per Google), and technology/commerce makes it convenient to measure & sell liquids by volume. (But other liquid fuels, say ethanol or diesel, have kWh/volume, so we get different mpg from them.) So plug in the kWh/gal figure into your math, and get miles/kWh :-)

And of course

`what-if.xkcd.com/11/`

Exercise 7.8.49. [N][W] Home solar power. From *The Boston Globe* on May 28, 2017:

> The median price per watt of capacity for systems financed through the Mass Solar Loan Program is $4, and the median installation size is 8.1 kilowatts. Those numbers suggest a new solar system could easily run more than $30,000.
>
> Fortunately, several programs can help defray the costs. Federal tax incentives allow you to take a credit worth 30 percent of the cost of the installation. Massachusetts also offers a tax credit of 15 percent of the remaining cost after the federal incentive has been subtracted, with a maximum value of $1,000.
>
> Together, these credits could reduce the cost of a $30,000 system to roughly $20,000 — still a pretty hefty total. [R131]

{R131}

Exercise 7.8.50. [U][N] What does a butcoin cost?

On January 22, 2018 you could read in *The New York Times* that

> . . . the computer power needed to create each digital token consumes at least as much electricity as the average American household burns through in two years . . . [R132]

{R132}

There are more question opportunities later in the article.

Exercise 7.8.51. [U][N] What is fair?

In March 2018 *The New York Times* published an opinion piece headlined "A Billionaire and a Nurse Shouldn't Pay the Same Fine for Speeding"

> If Mark Zuckerberg and a janitor who works at Facebook's headquarters each received a speeding ticket while driving home from work, they'd each owe the government the same amount of money. Mr. Zuckerberg wouldn't bat an eye.
>
> The janitor is another story.
>
> For people living on the economic margins, even minor offenses can impose crushing financial obligations, trapping them in a cycle of debt and incarceration for nonpayment. In Ferguson, Mo., for example, a single $151 parking violation sent a black woman struggling with homelessness into a seven-year odyssey of court appearances, arrest warrants and jail time connected to her inability to pay. [R133]

{R133}

> Read the article and the reader's comments. If you were to post a comment at the website what would you say? You might consider comparing the fine structure to the graduated income tax.

Exercise 7.8.52. [U][N] Capturing fog.

On June 7, 2018 *The Boston Globe* reported on an MIT project to capture the water in fog.

Varanasi said a typical 600-megawatt power plant consumes as much water annually as a city of 100,000 people, losing 750 million gallons to the air, 20 to 30 percent of which would be fog droplets.

Varanasi envisions his system capturing 150 million gallons from the hypothetical plant. Varanasi didn't go into the details of what the system installation and operation would cost but said it would need just $10,000 in electricity to run. [R134]

{R134}

(a) Estimate or search to find out how much water 100,000 people use annually.

At their website water.usgs.gov/edu/qa-home-percapita.html the USGS says that "Estimates vary, but each person uses about 80-100 gallons of water per day."

Calculating with 350 days per year 100,000 people use between 2.8 and 3.5 billion gallons per year.

(b) What fraction of the water consumed by the power plant is lost?

750 million is one fourth of 3.5 billion, so about 25 percent of the water is lost.

I wonder where the other $3/4$ goes.

(c) What fraction of the lost water would this system capture?

150 million is one fifth of 750 million.

(d) What is the cost in electricity to capture one gallon of the water?

$$\frac{\$10,000}{150 \times 10^6 \text{ gallons}} = 0.00007 \frac{\$}{\text{gallon}}$$

Chapter 8

Climate Change — Linear Models

Exercise 8.5.19. [U][N] Heart attack risk

At the website `my.americanheart.org/professional/StatementsGuidelines/Prevention-Guidelines_UCM_457698_SubHomePage.jsp` you can download a spreadsheet with which to predict your risk of a heart attack. You fill in some values (like your age, blood pressure and cholesterol count) and the spreadsheet tells you your risk.

There's a local copy at `HeartAttackRiskEstimator.xls` .

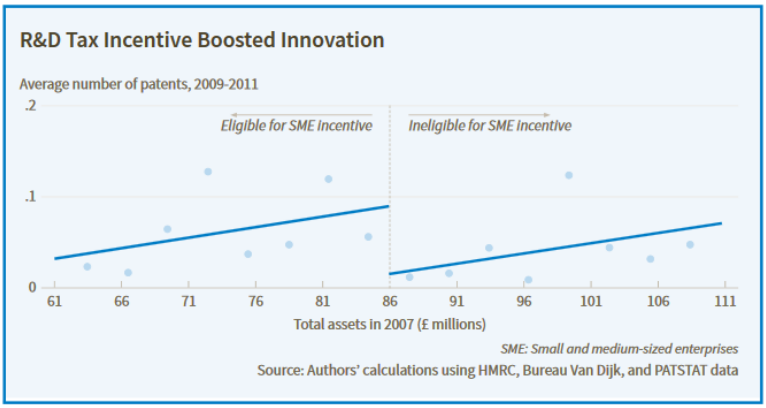
The formulas it uses are hidden, but you can figure out something about them by experimenting.

For example, try filling in all the fields, then vary the total cholesterol count while keeping all the other values the same. Record the results in another spreadsheet, and produce a graph showing how risk depends on that variable. Is it linear? Approximately linear?

Do the same for some of the other variables.

Exercise 8.5.20. [U][N] R&D grants boost patents.

Figure!8.1 shows a regression line



`fig:randdpatents`

{R135} Figure 8.1: Tax incentives for reearch.[R135]

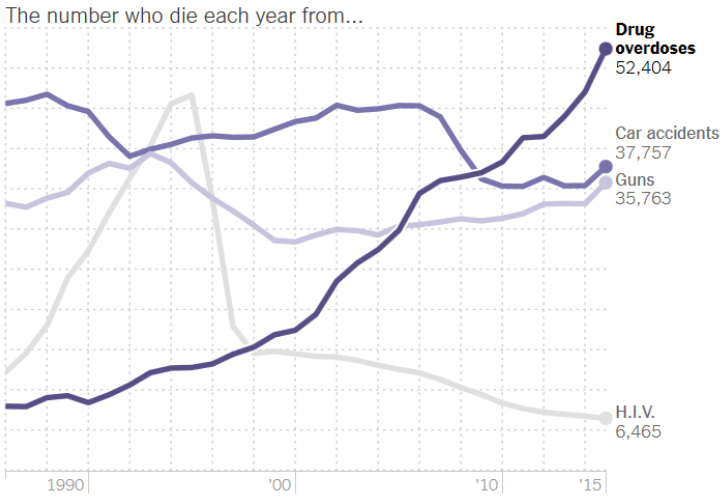


fig:fourtrends

Figure 8.2: Four trends. [R136]

{R136}

Are these regression lines convincing? The authors think not, but draw them anyway.

Exercise 8.5.21. [N] Prediction is hard.

On April 14, 2017 *The New York Times* presented the graphs in Figure 8.2 after offering readers the opportunity to predict what they would look like given only the date up to 1990.

This quote is particularly telling:

> In 2015, more Americans died from drug overdoses than from car accidents and gun homicides combined.

Exercise 8.5.22. [U][C][S] Project gigaton.

Fred Krupp, the president of the Environmental Defense Fund, wrote about industrial initiatives to reduce carbon dioxide emissions:

> With Project Gigaton, Walmart and its suppliers are committing to a "moon shot" goal — removing a gigaton of greenhouse gas emissions from the company's global supply chain by 2030. That's more than the annual emissions of Germany. It's the equivalent of taking 211 million cars off the road every year. In a word, it's transformational. [R137]

{R137}

The EPA says

> A typical passenger vehicle emits about 4.7 metric tons of carbon dioxide per year. This assumes the average gasoline vehicle on the road today has a fuel economy of about 21.6 miles per gallon and drives around 11,400 miles per year. Every gallon of gasoline burned creates about 8,887 grams of CO_2.
> `www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle-0`

(a) Check that the two quotations agree about the amount of carbon dioxide emitted the average gasoline vehicle emits in a year.

(b) Where do you think Mr. Krupp got his 211 million car estimate? Critique it.

(c) Estimate, or look up, the number of cars on the road in the United States. Compare that number to the 211 million that the gigaton project would take off the road. What does your comparison tell you?

(d) If you know some chemistry, figure out how much carbon there is in a gallon of gasoline.

Chapter 9

Compound Interest — Exponential Growth

Exercise 9.7.37. [S][U] From *Swan Boats at Four*, a novel by George V. Higgins:

> Rutledge said "In other words, if we'd painted over that damned picture in the summer of nineteen seventy-eight, we would've made the club, and ourselves individually, liable for a hundred thousand bucks, plus interest at, say, an average of seven percent per annum, compounded for thirty-four years. . . ."
> "Offhand," [David] said, "I can't even imagine how much that would've been."
> "At the time, I couldn't either," Rutledge said, " . . . so we looked it up — I don't mean we figured it out. . . . I don't recall the exact figure, but it came out to around a million and a half dollars." [R138]

{R138}

David is a banker. He would know the Rule of 70 and figure it out offhand, without pencil and paper. Higgins should have known that.

(a) Use the Rule of 70 to decide whether Rutledge was right when he said the figure was "around a million and a half dollars".

(b) Calculate the answer.

Exercise 9.7.38. [S] So many words!

On December 1, 2012 R. Alexander Bentley and Michael J. O'Brien wrote in *The New York Times* that

> [F]or the last 300 years, the number of words published annually grew exponentially by about 3 percent per year. From about 20 million words for 1700, the annual word count grew to several trillion for 2000. [R139]

{R139}

(a) Check the authors' arithmetic.

(b) If the growth continues at the same rate how many words will be published in the year 3000?

(c) How much confidence do you have in your prediction?

Exercise 9.7.39. [S] World population.

According to a Harvard School of Public Health press release the world's population has grown slowly for most of human history. It took until 1800 for the population to hit 1 billion. However, in the past half-century, population jumped from 3 to 7 billion. In 2011, approximately 135 million people will be born and 57 million will die, a net increase of 78 million people.

(a) By what percent did world population increase in 2011?

(b) Write the equation for a mathematical model for world population growth for years since 2011 if the annual net increase seen in 2011 remains constant for the remainder of the century. (Use 7 billion as the 2011 population.)

(c) Write the equation for a mathematical model for world population growth for years since 2011 if the annual percentage increase seen in 2011 remains constant for the remainder of the century. (Use 7 billion as the 2011 population.)

(d) Construct an Excel spreadsheet predicting world population for the years through 2100 using both models. Graph both predictions on the same chart.

(e) The table below gives the United Nations high estimate for world population growth during the remainder of this century.

Year	Population (billions)
2011	7
2025	8.5
2050	10.6
2100	15.8

Which of your models most closely matches the UN high estimate?

Exercise 9.7.40. [N] Making it into the Hall of Fame.

On January 12, 2013, Nate Silver wrote in his blog at *The New York Times* that individual voting totals for the baseball Hall of Fame seemed to increase by about ten percent each year.

> Thus, a player who received 10 percent of the vote in his first year would be expected to receive about 11 percent on his second try, while a player who got 50 percent of the vote would go up to 55 percent. [R140]

{R140}

Explain why this is exponential growth. Look up the original. Make some projections.

Exercise 9.7.41. [U][N] Save another one percent.

The interactive web based calculator provided by *The New York Times* at `www.nytimes.com/interactive/2010/03/24/your-money/one-pct-more-calculator.html` suggests many questions about savings, compound interest and inflation.

Exercise 9.7.42. [U][N] The London olympics.

On July 22, 2012 *The Boston Globe* wrote about the third Olympic games to be hosted by London:

> The Games have grown geometrically during the past 104 years — from 2,023 athletes representing 22 countries competing in 109 events in 24 sports in 1908 to 4,064 athletes, 59 countries, 136 events, and 19 sports in 1948 to 10,500 athletes, 204 countries, 302 events and 37 sports in 2012. [R141]

{R141}

Note: “geometric” is a synonym for “exponential”.

Possible questions: find exponential regression curves for the numbers of athletes, countries and events.

Exercise 9.7.43. [U][N] Radioactive waste.

The web site `www.nirs.org/factsheets/hlwfcst.htm` we quoted earlier offers much more information about radioactive waste.

Ask and answer some interesting Fermi problems suggested by the data there. You could consider what it says about a nuclear power plant near you.

We could construct the Fermi problems based on this radioactive waste data ourselves, and ask the students to solve them. But by this time in the course we hope they can start from the numbers and create their own.

Exercise 9.7.44. [U][N] Payday loans 2016.

> People who borrow money against their paychecks are generally supposed to pay it back within two weeks, with substantial fees piled on: A customer who borrows $500 would typically owe around $575, at an annual percentage rate of 391 percent. [R142]

{R142}

Many more juicy numbers in the article.

Exercise 9.7.45. [U][N] Was this a good deal on a mortgage?

On July 6, 2016 Max Jacob posted this question at `money.stackexchange.com/questions/66978/was-this-a-good-deal-on-a-mortgage` .

> I just graduated college last year, and was looking to buy a house. Clearly I wouldn’t be able to buy it outright, so I was thinking of getting a mortgage. I have a steady job ($55,000 annual before taxes) and an okay credit score (740). Here’s the deal that a mortgage consultant gave me:
>
> $2,000 per month for 30 years on a $300,000 home (he didn’t mention any other fees)
>
> It seems terrible to me because it comes out to a total of $720,000 over that 30-year period. I’m completely new to the concept, so maybe I’m just being naive. [R143]

{R143}

Possible uses: classroom discussion, group homework assignment, think about the answers informative answers at the site, appended here.

From user Aganju (`money.stackexchange.com/users/35405/aganju` :

> That seems a very bad offer, it borders on fraud.
>
> In the current US economy, you should be able to get between 3 and 4 % APR (and that number is what you should look at). That means that for 300000 over 30 years, you’d pay $1265 to $1432 per month.
>
> If you are able to pay more than that monthly rate, you should go for less than 30 years - 20, 15, 10, whatever you can afford - but don’t overextend yourself.
>
> Google “mortgage calculator” to do your own calculations.

From user quid (`money.stackexchange.com/users/22881/quid` :

> I’m calculating that to about a 7% apr, which given loan rates available today seems a bit high.
>
> I wouldn’t get too caught up on what that equates to over the life of the loan. There are a lot of forces in play over a 30 year period, namely the time value of money. 30 years from now a dollar will be less valuable in real terms due to the forces of inflation. At 2% per year in inflation today’s $1 will be worth about $0.55 in 30 years.

From user keshlam (money.stackexchange.com/users/12439/keshlam):

> Some part of the payment is probably also going for tax escrow, insurance payments, probably PMI if you aren't putting at least 20% down. Get a complete breakdown of the costs.
>
> Remember to budget for upkeep.
>
> And please see past discussion of why buying a home at this point in your career/life may be very, very premature.

Exercise 9.7.46. [U][R][S] Get rich quick.

Tad Friend wrote in the October 10, 2016 issue of *The New Yorker* that

> YC's gold standard for revenue growth is ten percent a week, which compounds to 142x a year. [R144]

{R144}

Check his calculation.

Exercise 9.7.47. [U][N] Double, double, . . .

In April, 2017 Tad Friend wrote in *The New Yorker* that

> Progress in computers, or anyway in semiconductors, has been subject to Moore's Law, the exponential flywheel that has doubled capacity every two years. In linear progress, after thirty iterations you've advanced thirty steps; in exponential progress, you've advanced 1.07 billion steps. Our progress in mapping the human genome looked like it was linear — and then was revealed, once the doublings grew significant, as exponential. [R145]

{R145}

(a) Where does that 1.07 billion come from?

(b) Question about Moore's Law?

Exercise 9.7.48. [U] Free meat!

On July 2, 2017 *The Boston Globe* published an article about bioengineered meat grown from animal stem cells.

> Steve Myrick, vice president of business development at Memphis [Meets], said the company is now producing beef, chicken, and duck in stainless steel tanks for roughly $2,400 per pound. That'a lot cheaper than it was even a year ago, and the price is falling about 15 to 20 percent per month, as the company improves yields and finds less expensive nutrients. [R146]

{R146}

(a) Estimate the cost "a year ago".

(b) When will the cost be competitive with what meat sells for in your local market?

Exercise 9.7.49. [U] Payday loans 2017.

On October 5. 2017 *The New York Times* reported that the Consumer Financial Protection Bureau announced new rules applicable to payday loans. The article read (in part)

> Currently, a cash-strapped customer might borrow $400 from a payday lender. The loan would be due two weeks later — plus $60 in interest and fees. That is the equivalent of an annual interest rate of more than 300 percent, far higher than what banks and credit cards charge for loans.

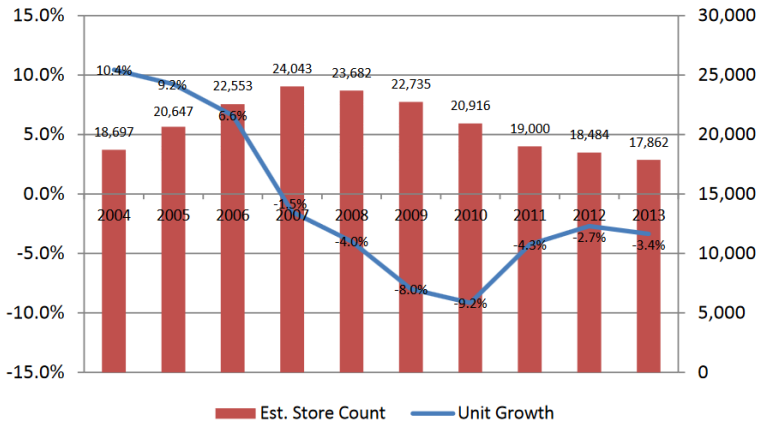


fig:paydayloanstores

{R148} Figure 9.1: Payday Loan Stores 2004-2013 [R148]

...

The payday-lending industry is vast. There are now more payday loan stores in the United States than there are McDonald's restaurants. The operators of those stores make around $46 billion a year in loans, collecting $7 billion in fees. Some 12 million people, many of whom lack other access to credit, take out
{R147} the short-term loans each year, researchers estimate. [R147]

(a) Verify the interest calculation in the first paragraph of the quotation.

(b) Are the assertions in the second paragraph reasonable? The data in Figure 9.1 should help answer this question.

Exercise 9.7.50. [U][N] R&D in China.

China is the clearest example. Since 2000, China's spending on research and development has grown by an average of 18 percent each year, while ours grew by only 4 percent. This has placed China a decisive second in R & D expenditures behind the United States, where the government and private sector together invest far more than any other country. Even so, the share of R & D funded by the federal government
{R149} declined to about 25 percent from just over 30 percent from 2010 to 2015. [R149]

Exercise 9.7.51. [U][S] Endangered apes.

On April 26, 2018 *The Washington Post* summarized a study from the journal *Science Advances* that reported

...estimates that there were 361,900 gorillas and 128,700 chimpanzees as of 2013. That's about one-third more gorillas and one-tenth more chimpanzees than previous surveys estimated, though those calculations were performed differently and were not designed to count the animals across their entire range.

That is the good news. Now the bad: Researchers found that gorilla populations are dropping faster than they believed, at a rate of nearly 3 percent per year, said Fiona Maisels, a conservation scientist with the Wildlife Conservation Society and the University of Stirling in Scotland. At this rate, half of the world's
{R150} gorillas could be gone by about 2040, she said. [R150]

(a) How many gorillas and chimpanzees were estimated in the previous surveys?

(b) This article updates numbers from 2013. Estimate the gorilla population in 2018, when this study was published.

(c) Is Dr. Maisel's prediction about the 2040 gorilla population reasonable?

fig:connectedhomes

{R152} Figure 9.2: Connected Homes, 2015-2017 [R152]

Exercise 9.7.52. [U] An extra percentage point.

On May 22, 2018 *The Boston Globe* reported that

> Over the past 18 months, the average rate on 30-year fixed mortgages has climbed a full percentage point, which translates into an additional $100,000 in interest over the life of a $500,000 loan. [R151]

{R151}

(a) Verify this assertion.

(b) Does the difference in interest paid depend on the actual mortgage rate, or only on the increase?

Exercise 9.7.53. [U] The Internet of Things.

Figure **??** shows the growth of U. S. households with devices like appliances connected to the internet.

(a) Is the 31% compound annual growth rate correct?

(b) Estimate when every home in the United States will be connected.

Exercise 9.7.54. [U][W][N] 5 miilion Bostonians?

On August 19, 2019 Martin Finucane wrote in *The Boston Globe* that in 1900 Globe reporter Thomas F. Anderson reported a prediction that Boston's population would be 5,251,330 in 2000. [R153]

{R153}

The original article said

> This population is estimated on the rate of increase of the last 20 years, and on the same basis (the population according to the census of 1900 being 560,892), the figures for consecutive 10-year periods will probably be as follows. . .

The current story continued

> Anderson then cited a series of population figures that appeared to reflect an approximately 25 percent increase per decade for 100 years [. . . because he] had just seen the population of the city explode by 54 percent from 1880 to 1900.

$1.25^2 = 1.5625$

$1.25^{10} = 9.31$

$560,000 * 1.25^10 \approx 5,200,000$

Chapter 10

Borrowing and Saving

Exercise 10.6.17. [N][U] The debit card trap.

On August 20, 2009 *The New York Times* editorialized that

> A study by the Center for Responsible Lending, a nonpartisan research and policy group, describes what it calls the "overdraft domino effect." One college student whose bank records were analyzed by the center made seven small purchases including coffee and school supplies that totaled $16.55 and was hit with overdraft fees that totaled $245.
>
> Some bankers claim the system benefits debit card users, allowing them to keep spending when they are out of money. But interest rate calculations tell a different story. Credit card companies, for example, were rightly criticized when some drove up interest rates to 30 percent or more. According to a 2008 study by the F.D.I.C., overdraft fees for debit cards can carry an annualized interest rate that exceeds 3,500 percent. [R154]

{R154}

We haven't made up any questions yet to go with this interesting quote.

Exercise 10.6.18. [S] Regulating the credit card industry.

The Boston Globe reported on May 13, 2009 on the Senate's deliberations on credit card rules.

One change, since signed into law, requires lendsrs to apply payments first to the part of the balance with the highest interest rates.

A second change, proposed as an amemndment by Senator Bernie Sanders (Independent, Vermont) would limit interest rates to 15%. [R155]

{R155}

Suppose a credit card user has a balance of $100 at 24% for purchases and $1000 at 0% for a debt she transferred from another credit card. She makes no new purchases, and pays off her loan at the rate of $100 per month.

(a) When will her loan be paid off and how much interest will she have paid under the 2009 rules — payments are applied to the purchases balance first.

(b) Under the new rules, which are now law?

(c) If Sanders' amendment had passed? (It didn't.)

Exercise 10.6.19. [N] Reward cards.

In *The Boston Globe* on December 18, 2009, Candice Choi wrote about credit card reward programs:

`www.boston.com/business/personalfinance/articles/2009/12/18/rewards_cards_may_be_a_bit_less_rewarding_after_you_consider_the_higher_fees/.`

Exercise 10.6.20. [U] Smoke and mirrors.

A visitor at `money.stackexchange.com` asks

> I'm reading about Household International's fraudulent mortgage interest rate. According to Michael Lewis, Household disguised a 15 year, fixed-rate loan as a thirty-year loan. The sales would offer to replace a client's existing $67,300 mortgage (8.5% interest rate) with a bigger but seemingly cheaper one: $86,300 at an "effective rate" of 7.6%. The sales pitch goes something like this: "If I can put together a loan that pays out like a 7.579%-a-year loan, but has a total term of 18.63 years — would you be interested?"
>
> Can someone explain how exactly does the trick work? How did the sales misrepresent the 7.6% interest rate, which is seemingly lower than the client's existing 8.5% interest rate? [R156]

{R156}

The original story is at `www.forbes.com/forbes/2002/0902/062.html` .

The stackexchange site has an answer that can be checked with the mortgage calculator spreadsheet.

Exercise 10.6.21. [U][N] Paying for credit.

In the June 26, 2018 edition of *The New York Times* you could read that

> In addition to annual fees, interest charges and other, more mysterious fees that consumers pay, credit card companies also levy fees on merchants: usually a flat fee per sale and a commission of 2 percent to 3.5 percent or more. If you spend $200 at a store and use a credit card, you could be sending as much as $7 of that payment to the credit card company.
>
> Merchants, no fools, pass those fees on to consumers by making their products more expensive. This yields a credit card "tax" that everyone pays (even those, usually the poor, who don't have credit cards).
>
> There is no reason to expect credit card companies to offer their services free. But the credit card tax paid by American retailers and consumers is the highest in the world. Credit card "swipe" fees account for an estimated $42 billion every year in the United States. The Europeans pay less, because they see this as an obvious market failure and limit the commission to 0.3 percent, meaning that you would pay 60 cents instead of $7 in fees for that $200 purchase. [R157]

{R157}

Chapter 11

Probability — Counting, Betting, Insurance

tteryhistory}

Exercise 11.9.8. [U] 1996 was a long time ago.

> Lotteries rank first among the various forms of gambling in terms of gross revenues: total lottery sales in 1996 totaled $42.9 billion. 1982 gross revenues were $4 billion, representing an increase of 950% over the preceding 15 years, 1982-1996.
>
> Lotteries have the highest profit rates in gambling in the U.S.: in 1996, net revenues (sales minus payouts, but not including costs) totaled $16.2 billion, or almost 38% of sales. They are also the largest source of government revenue from gambling, in 1996 netting $13.8 billion, or 32% of money wagered,
{R158} for governments at all levels. [R158]

The quotation that starts the section on lotteries in the first edition of *Common Sense Mathematics* comes to us courtesy of the University of North Texas CyberCemetery:

> The University of North Texas Libraries and the U.S. Government Printing Office, as part of the Federal Depository Library Program, created a partnership to provide permanent public access to the Web sites and publications of defunct U.S. government agencies and commissions. This collection was named the
{R159} "CyberCemetery" by early users of the site. [R159]

The bookkeeping[1] for analyzing these numbers is

$$\text{total from ticket sales} = \text{ prizes awarded } + \text{ overhead } + \text{ net revenue to state.}$$

In 1996 gross revenues — that is, ticket sales, dollars bet — were $42.9 billion.

The $16.2 billion in the second paragraph is "sales − payouts", so the payouts must be $\$42.9 - \$16.2 = \$26.7$ billion. Then

$$\frac{\text{payouts}}{\text{sales}} = \frac{\$26.7 \text{ billion}}{\$42.9 \text{ billion}} = 0.622377622 \approx 62\%$$

so for each lottery dollar in 1996, players got back (on average) a little more than 62 cents in prize money. That is the fair price of a one dollar ticket. The other 38 cents is the 38% of sales that count as total revenue for the government —

[1] One of our favorite words. We don't know another with three double letters in a row.

the $16.2 billion not returned to bettors as prizes. Some of that money was overhead. After subtracting that, the net revenue available for other use was $13.2 billion.

Update the numbers from that quote (go back to) so that you can rewrite the paragraph referring to a much more recent year than 1996.

[Hint] Consider starting at `www.census.gov/govs/state/10lottery.html` . There may be a better site that gives you totals, or lets you download directly into a spreadsheet.

Exercise 11.9.15. [U] What you're counting counts.

(a) What is the probability that a random word in English begins with the letter "t"?

This is a question with several answers, which depend on how you select your "random word". You might count the words that begin with "t" in the dictionary. You might count those words in a newspaper, or on a website. There may be answers to the question on the web.

Estimate the answer in several ways. Do the various assumptions lead to approximately equal answers?

(b) "e" is the most commonly used letter in English. What is the probability that a random letter in an English text is "e"?

Attack this question as you did the previous one.

(c) What is "etaion shrdlu" and where does it come from?

Exercise 11.9.16. [S] What is wrong with this estimate?

The following report appeared in the Offline column of *The New York Times* business section on March 8, 2008, where "Cubicle Coach" Marie Claire, says "take a chance" when considering whether to hire the ordinary candidate or one

> . . . who has the potential to be great, but has an equal chance of being awful?
> "You have a 66.7 percent chance of a positive result," the coach writes. "Yes, the unknown could flop, but she could also a) do as well as the known, or b) actually be a star." [R160]

{R160}

(a) What assumption is Claire making that leads her to her estimate of 66.7%?

(b) Suppose Claire is correct when she assumes that the probabilities of great and awful are equal. Show that the chance of a positive result (great, or just OK) is somewhere between 50% and 100%.

Ben Bolker suggests analyzing this hiring dilemma using a payoff matrix, with utilities associated with each state (awful, ok, great). Then we could compute an expected value for each action (hire known, hire unknown) in terms of the various probability and payoff assumptions. This would be cool in Excel.

Exercise 11.9.24. [U][N] Savings accounts with benefits.

On January 15, 2014 Tina Rosenberg blogged at *The New York Times* that

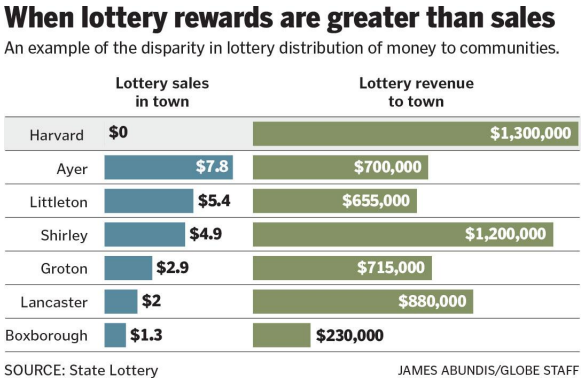


fig:lottertowns

{R162} Figure 11.1: Who really wins? [R162]

> Lotteries aren't usually considered part of the solution to our savings crisis. They're usually cited as a big part of the problem. Lotteries offer the worst odds in legal gambling — about 55 percent of what people pay for tickets is paid out in prizes. Yet we spend an average of $540 per household on lottery tickets every year — about $100 more than we spend on milk or beer. That is disproportionately spent by African-Americans, who spend five times as much on lottery tickets per person than whites, and the very poor. People with a household income of less than $10,000 a year who play the lottery spend $597 a year on tickets. [R161]

{R161}

Read further for the savings strategy ....

Exercise 11.9.25. [U] Who really wins the lottery?

Figure **??** appeared in *The Boston Globe* on February 25, 2017.

(a) The graphic does not show the units for the dollars in the sales column. Figure out what the $7.8 for Ayer represents.

(b) Note that the bars in the sales column are shorter than the bars in the revenue column. What wrong conclusion does this misleading graphic suggest?

(c) Calculate the cost of the lottery in each town in units (dollar of tickets bought) per (dollar of lottery revenue). Why are all but the first of these numbers less than 1?

(d) Why might it be more informative to report the cost of the lottery in units (dollar of lottery revenue) per (dollar of tickets bought)? Do that.

(e) How do those figures compare to the statewide cost? (Look at an earlier exercise where you worked out the fair price of a dollar ticket.)

Exercise 11.9.26. [U][N] Mass Lottery redux.

On August 31, 2017 Yvonne Abraham wrote in *The Boston Globe* that

> We seem to be especially dippy here in Massachusetts, where we buy more lottery tickets per capita than anywhere in the nation — a whopping $746 per person in fiscal 2017. The 5*billionwespentongamesofchancein*2017*returnedabout*1 billion to cities and towns. For every dollar spent on Powerball tickets, Massachusetts collects 42 cents. Its share of Wanczyk's winnings was $24 million. We'd be sunk without those revenues. [R163]

{R163}

(a) Compare these figures with those in previous exercises.

(b) Is it reasonable or correct to say that the state's share of Wanczyk's *winnings* was $24 million?

Chapter 12

Break the Bank — Independent Events

Exercise 12.7.21. [N] What are the chances of six double-yolkers?

www.bbc.co.uk/news/magazine-16118149

Exercise 12.7.22. [N] Gladwell and success.

From Andrew Gelman's blog: andrewgelman.com/2013/10/11/gladwell-vs-chabris-david-vs-goliath/

> Here's another example. A few years ago, I criticized the following passage from Gladwell:
>
> > It's one thing to argue that being an outsider can be strategically useful. But Andrew Carnegie went farther. He believed that poverty provided a better preparation for success than wealth did; that, at root, compensating for disadvantage was more useful, developmentally, than capitalizing on advantage.
>
> I argued that Gladwell was making a statistical fallacy:
>
> > At some level, there's got to be some truth to this: you learn things from the school of hard knocks that you'll never learn in the Ivy League, and so forth. But . . . there are so many more poor people than rich people out there. Isn't this just a story about a denominator? Here's my hypothesis:
> > Pr (success given privileged background) is much greater than Pr (success given humble background) .
> > Number of people with privileged background is much less than number of people with humble background.
> > Multiply these together, and you might find that many extremely successful people have humble backgrounds, but it does not mean that being an outsider is actually an advantage.

The comments on that post are worth reading!

Exercise 12.7.23. [U][N] Is failure to predict a crime?

This oped from *The New York Times* has an interesting discussion of the difficulty working with small probabilities for rare events.

urlwww.nytimes.com/2012/10/27/opinion/a-failed-earthquake-prediction-a-crime.html

Exercise 12.7.24. [U] Russian roulette.

(a) What is Russian roulette?

(b) What is the probability of surviving 1, 2, 3, 4, 5 or 6 rounds?

Exercise 12.7.25. [N] Are small schools better?

The article "Evidence That Smaller Schools Do Not Improve Student Achievement" at `www.pdkmembers.org/members_online/publications/Archive/pdf/k0612wai.pdf` discusses a data interpretation error like that in the cancer cluster section to argue that the Gates Foundation focus on small schools is a mistake.

Exercise 12.7.26. [U] NBA draft top pick? In *The Boston Globe* on May 16. 201y you could read that

> The draft pick Boston will receive from the Brooklyn Nets has the best lottery odds of any pick. It has a 25 percent chance of turning into the No. 1 choice, a 21.5 percent chance of being No. 2, a 17.8 percent chance of being No. 3 and a 35.7 percent chance of being No. 4. It cannot fall beyond that.
>
> In the last six years, the team with the best lottery odds received either the No. 1 or No. 2 pick each time. That seemed a bit startling, considering there is just a 46.5 percent chance of that happening each year.
>
> So I crunched some numbers and found that the odds of that happening six years in a row were approximately 1 in 98. And if the Celtics continued the streak and made it seven years in a row, they will have defied odds of about 1 in 212.
>
> So Boston should prepare for heartbreak once again, right? Well, not quite. [R164]

{R164}

(a) Verify the calculations.

(b) Why "not quite"? What are the 2017 odds?

Chapter 13

How Good Is That Test?

Exercise 13.7.15. [U][N] HIV testing.

Read the City of New York Department of Health and Mental Hygeine Advisory #20 at `www.nyc.gov/html/doh/downloads/pdf/cd/08md20.pdf` .

Build the two way contingency tables based on the data there, and discuss the consequences of the data.

Exercise 13.7.16. [N] Mad cow disease.

Bovine Spongiform Encephalopathy(BSE) is a disease fatal to people who eat infected beef products.

Here is a paragraph from the United States Department of Agriculture website on screening for BSE:

> After the first confirmation of BSE in an animal in Washington State in December 2003, USDA evaluated its BSE surveillance efforts in light of that finding. We determined that we needed to immediately conduct a major surveillance effort to help determine the prevalence of BSE in the United States. Our goal over a 12-18 month period was to obtain as many samples as possible from the segments of the cattle population where we were most likely to find BSE if it was present. This population was cattle exhibiting some signs of disease. We conducted this enhanced surveillance effort from June 2004 - August 2006. In that time, we collected a total of 787,711samples and estimated the prevalence of BSE in the United States to be between 4-7 infected animals in a population of 42 million adult cattle. We consequently modified our surveillance efforts based on this prevalence estimate to a level we can monitor for any potential changes, should they occur. Our statistical analysis indicated that collecting approximately 40,000 samples per year from the targeted cattle population would enable us to conduct this monitoring. [R165]

{R165}

Exercise 13.7.17. [N] Correlation and causation.

This question and and answers at the statistics stackexchange site has nice examples. The answers are written using conditional probabilities but can be rewritten as contingency tables.

`stats.stackexchange.com/questions/283133/relationships-between-correlation-and-causation`

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 \protect \chapter {Calculating on the Back of an Envelope}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{1}
\begin{MoreExercises}{1.8}

\begin{exx}{\hassolution\sref{heartbeats}\gref{verify}\gref{estimate}
\gref{round}} Dropping out.

In his May 17, 2010 op-ed column in \theTimes{}
Bob Herbert noted that the dropout rate for American high school
students was one every 26 seconds.%
\begin{csmr}
B. Herbert,
A Very Bright Idea,
\theTimes{} (May 17, 2010),
\url{www.nytimes.com/2010/05/18/opinion/18herbert.html} \access{July
  20, 2015}.
\csmrcomment{Paraphrase. no permission necessary.}
\end{csmr}

Is this number reasonable?

\begin{sol}

Is this number reasonable?

Here's a student solution.

\begin{quotation}
If the average high school dropout rate was 1 student per 26 seconds,
then (with 31,536,000 seconds in a year) this would mean there would
be about 1,212,923 dropouts each year: $31,536,000/26 = 1212923.07692$
This seems to be a reasonable number as different sources say the
number could be about 1.5 million or so. For example the 2010 Fact
Sheet for the Alliance for Excellent Education lists the number as 1.3
million students.
\end{quotation}

Rounder numbers would be better. With 30 million seconds per year and
one student dropout per 30 seconds I get about 1 million dropouts a
year.
```

```
\url{nces.ed.gov/fastfacts/display.asp?id=65} says that there
are about 15 million high school students in the United States. That means
about one in every ten drops out. That seems high to me.

\end{sol}
\end{exx}

\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{6}
\begin{MoreExercises}{1.8}
\begin{exx}{\hassolution\sref{heartbeats}\gref{verify}
\gref{estimate}\gref{round}\gref{mentalestimate}}
Health care costs for the uninsured.

On March 22, 2012 Linda Greenhouse wrote in \theTimes{} that
the average cost of a family insurance policy increased by \$1,000 a
year because health care providers needed to recover
\$43 billion annually for health care costs of the uninsured.%
\begin{csmr}
L. Greenhouse, Never Before,
\theTimes{} (March 21, 2012),
\url{opinionator.blogs.nytimes.com/2012/03/21/never-before/}
\access{July 20, 2015}.
\csmrcomment{Short paraphrase}
\end{csmr}

\begin{abcd}

\item
What it the annual cost per United States resident
for medical care for the uninsured?

\item
Estimate (or research) how much an average person spends each year
buying food at the grocery store (do not include restaurant
purchases).  Compare your answer to your answer from the previous
question about the cost of medical care.

\item
Estimate (or research) the number of uninsured people, and then
estimate the cost per uninsured person for medical care. Does your
answer make sense to you?

\end{abcd}

\begin{sol}
\begin{abcd}

\item
What it the annual cost per United States resident
for medical care for the uninsured?
```

```
I need to compute
\begin{equation*}
\frac{43 \text{ billion dollars}}{300 \text{ million people}}.
\end{equation*}

I'll round the 43 to 45 to make the arithmetic easier and compensate
some for underestimating the population. Then I have
\begin{equation*}
\frac{45 \text{(9 zeros) dollars}}{3 \text{ (8 zeros) people}}
=  150 \frac{\$}{\text{person}}
\end{equation*}
for the annual cost of covering the uninsured.

\item
Estimate (or research) how much an average person spends each year
buying food at the grocery store (do not include restaurant
purchases).  Compare your answer to your answer from the previous
question about the cost of medical care.

A person probably spends about \$50 per week for food at the
supermarket. (This is a very rough estimate. There's lots of fast food
consumed, which I'm not supposed to count. Most food is bought by
families, so it's hard to get individual estimates.) At 50 weeks per
year that comes to about \$2,500 per year per person.

The \$150 per year to cover the uninsured is $\$150/\$2500 = 0.06 = 6\%$ of the
cost of food at the market. That's a surprisingly large fraction.

For a sanity check I googled ``cost of food per month'' and found the
US Department of Agriculture web site

\url{www.cnpp.usda.gov/sites/default/files/usda_food_plans_cost_of_food/CostofFoodNov2012.pdf}
The numbers there are in the same ballpark as my estimates.

If this estimate is right then the annual cost for food is
about 15 times the  annual cost for medical care for an
uninsured person.  I could say this another way: the annual cost
for medical care is about one-fifteenth of the annual cost for groceries.

\item
Estimate (or research) the number of uninsured people, and then
estimate the cost per uninsured person for medical care. Does your
answer make sense to you?

I've been paying attention to recent (2012) debates about medical care
costs. I think I remember that about 20\% of the population (60 million
people) are uninsured.

The \$4.3 billion spread out among 60 million people will give an
answer five times larger than the one I got when I spread it out among
all 300 million people (in 2012)
--- $5 \times \$150 \approx \$750$. That's a
reasonable number for the average cost of shifted medical care costs for an
uninsured person for a year --- some people need no care, some have
```

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much more expensive treatment.

Then I checked the web. In June of 2012 CNN reported on the web
\url{www.cnn.com/2012/06/27/politics/btn-health-care/index.html}:
``49.9 million --- The number of uninsured Americans in 2010. That's
16.3\% of the total population.''
So my estimate is good enough.
\end{abcd}

\end{sol}
\end{exx}

\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{12}
\begin{MoreExercises}{1.8}
\begin{exx}{\hassolution\sref{secondsalive}\gref{round}
\gref{mentalestimate}\gref{conversions}}
The popularity of social networks.
\index{Google}

From \theTimes, June 28, 2011:

\begin{quotation}
In May [2011], 180 million people visited Google sites,
including YouTube,
versus 157.2 million on \myindex{Facebook}, according to comScore. But
Facebook users looked at 103 billion pages and spent an average of 375
minutes on the site, while Google users viewed 46.3 billion pages and spent
231 minutes.%
\begin{csmr}
C. C. Miller,
Another Try by Google to Take On Facebook
\theTimes{} (June 28, 2011),
\url{www.nytimes.com/2011/06/29/technology/29google.html}
\access{July 20, 2015}.
\csmrcomment{Snippet from the Times - 50 words. Fair use.}
\end{csmr}
\end{quotation}

\begin{abcd}
\item How many webpages did the average Facebook user visit?  How many
  webpages did the average Google user visit?

\item  On average, how many webpages per day in May did a Facebook user
  visit?  Compare this to the average number of webpages per day for
  the Google user.

\item On average, who spent more time on each page, the Facebook user
  or the Google user?

\item  Think about your own web behavior.  Do these numbers seem
  reasonable to you?
```

```
\end{abcd}

\begin{sol}

\begin{abcd}
\item How many webpages did the average Facebook user visit?  How many
  webpages did the average Google user visit?

For Facebook,
\begin{equation*}
\frac{103 \text{ billion pages}}{157.2 \text{ million users}}
\approx 650 \frac{\text{pages}}{\text{user}}.
\end{equation*}

I did the division using the Google calculator. The answer there was
655.216284987 but it makes no sense to write more than the first three
digits, since the numbers I started with have only three digits of
precision.

For Google,
\begin{equation*}
\frac{46.3 \text{ billion pages}}{180 \text{ million users}}
\approx 260 \frac{\text{pages}}{\text{user}}.
\end{equation*}

\item  On average, how many webpages per day in May did a Facebook user
  visit?  Compare this to the average number of webpages per day for
  the Google user.

May has 31 days, so I will divide each of the numbers in my previous
answer by 31.
Facebook users visited about $655/31 \approx 21$ pages per day, Google
users visited about $257/31 \approx 8$ pages per day. That's about one
third as many.

\item On average, who spent more time on each page, the Facebook user
  or the Google user?

For this one I need to calculate (total minutes)/(total pages).
The viewing times are for each user, so to get the total minutes I
have to multiply.

Facebook:
\begin{equation*}
\frac{ 375 \frac{\text{minutes}}{\text{user}} \times 157 \text{
    million users}}{103 \text{ billion pages}}
\approx
0.6 \frac{\text{minutes}}{\text{page}},
\end{equation*}
or just over half a minute per page.
Google:
\begin{equation*}
\frac{ 231 \frac{\text{minutes}}{\text{user}} \times 180 \text{
    million users}}{46.3 \text{ billion pages}}
```

```
\approx
0.9 \frac{\text{minutes}}{\text{page}}.
\end{equation*}
That's one and one half times as much as the Facebook users spent.

\item  Think about your own web behavior.  Do these numbers seem
  reasonable to you?

I don't use Facebook. I use Google a lot --- probably more than eight
pages a day. Some pages I just scan; some I really read. I think my
average time is more than a minute per page.
\end{abcd}

\end{sol}

\end{exx}

\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{14}
\begin{MoreExercises}{1.8}
\begin{exx}{\hassolution\sref{secondsalive}\gref{verify}\gref{estimate}
\gref{mentalestimate}\gref{conversions}} Greek debt.

In her September 26, 2011 \emph{New York Times}
review of Michael Lewis's book
\emph{Boomerang} Michiko Kakutani noted that Lewis said
Greek debt of \$1.2 trillion amounted to about \$250,000
% CHANGE deleted dollars
for each working Greek.%
\begin{csmr}
M. Kakutani,
Touring the Ruins of the Old Economy,
\theTimes{} (September 26, 2011),
\url{www.nytimes.com/2011/09/27/books/boomerang-by-michael-lewis-review.html}
\access{July 0, 2015}.
\csmrcomment{paraphrase}
\end{csmr}

\begin{abcd}

\item Use Lewis's  statement to estimate the population of working
  Greeks at the time he wrote the article.

\item Use the web to find the national debt and population of Greece
  (for 2011 if you can, now if you can't).

\item Do the answers to the previous two parts of this exercise agree?
  If not, what might explain any differences?

\item Compare Greek per capita national debt to that in the United
States.

\item Here's a political question: is large national debt a bad thing?
```

```
  You can find both ‘‘yes’’ and ‘‘no’’ answers on the web.
Here’s one place to start:
\url{www.npr.org/templates/story/story.php?storyId=99927343}.
\end{abcd}
\begin{sol}

\begin{abcd}

\item Use Lewis’s  statement to estimate the population of working
  Greeks at the time he wrote the article.

I’ve been given two numbers:
%
\begin{equation*}
\text{Total debt: } \$1.2 \text{ trillion}
\end{equation*}
and
\begin{equation*}
\frac{\$250,000}{\text{working Greek}}.
\end{equation*}
%
I need to find the number of working Greeks.
I’m sure I have to divide one of these by the other. To make sure I
get it right, I will use the units:
%
\begin{equation*}
\frac{\$1.2 \text{ trillion}}{\text{unknown number of working Greeks}}
=
\frac{\$250,000}{\text{working Greek}}.
\end{equation*}
%
I can solve that. Just cross multiply and then divide:
%
\begin{equation*}
\text{number of working Greeks}
=
\frac{1.2 \text{ trillion}}{250,000}
= 4,800,000
\approx 5 \text{ million}.
\end{equation*}

\item Use the web to find the national debt and population of Greece
  (for 2011 if you can, now if you can’t).

Wikipedia (OK to use here) says there were about 10.8 million Greeks
in 2011. Wikipedia again: the national debt in 2011 was about 355
billion Euros.

In 2011 the Euro was worth about \$1.33, varying from month to month.
(\url{useconomy.about.com/od/inflation/p/Euro-To-Dollar-Conversion.htm})
At that rate 355 billion Euros was about \$475 billion.

\item Do the answers to the previous two parts of this exercise agree?
  If not, what might explain any differences?
```

```
The Greek debt in my previous answer is about 1/3 of the \$1.2 trillion
reported in Michael Lewis'  book. I have no idea why these numbers
don't agree.

\item Compare Greek per capita national debt to that in the United
States.

``per capita'' means ``per person''. Using Lewis' figures Greek debt
in 2011 was
\begin{equation*}
\frac{\$1.2 \text{ trillion}}{10.8 \text{ million people}}
=
111,111.111111 \frac{\$}{\text{person}},
\end{equation*}
%
according to the Google calculator. But most of those $1$s are
nonsense (even though they are pretty). Greek debt was about \$100,000
per person.

In the United States in September 2014 the national debt was about
\$17.8 trillion; that works out to about \$56,000 per person, or about
half the Greek value.

\item Here's a political question: is large national debt a bad thing?
  You can find both ``yes'' and ``no'' answers on the web.
Here's one place to start:
\url{www.npr.org/templates/story/story.php?storyId=99927343}.

Waiting for good student answers here.
\end{abcd}

\end{sol}
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{23}
\begin{MoreExercises}{1.8}

\begin{exx}{\untested\complex\sref{heartbeats}
\gref{verify}\gref{estimate}\gref{conversions}}
Drivers curb habits as cost of gas soars.

In \theGlobe{} on April 21, 2011 you could read that

\begin{quotation}
[F]amilies are quickly adapting [to increasing gas prices]
by carpooling, combining errands to save
trips, and curtailing weekend outings, according to organizations that
track gasoline consumption. Still, the US Energy Department projects
that the average US household will pay \$825 more for gas this year
than in 2010.

NPD Group Inc., a market research firm, estimates that consumers
```

```
bought roughly 128 million fewer gallons of gasoline in March than a
year earlier.%
\begin{csmr}
E. Ailworth,
Drivers curb habits as cost of gas soars (April 21, 2011 ),
\url{www.boston.com/business/personalfinance/articles/2011/04/21/drivers_curb_habits_as_cost_of_gas_soar
\access{July 20, 2015}.
\csmrcomment{This is a longish quote in an exercise. OK sinc Boston Globe}
\end{csmr}
\end{quotation}

Combine reasonable estimates for the increase in gasoline prices, the
number of miles driven annually and the average fuel economy of cars
to decide whether the \$825 figure in the quotation makes sense.
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{26}
\begin{MoreExercises}{1.8}
\begin{exx}{\hassolution\sref{heartbeats}\gref{verify}\gref{estimate}}
Counting car crashes.

The National Safety Council estimates that
``21 percent of [automobile] crashes or 1.2 million crashes in 2013
involve talking on  handheld and hands-free cell phones.''%
\begin{csmr}
Annual Estimation of Cell Phone Crashes 2013,
National Safety Council,
\url{www.minnesotasafetycouncil.org/traffic/DistractedDriving/Attributable-Risk-Summary.pdf}
\access{February 24, 2019}.
\end{csmr}

\begin{abcd}

\item Use the data in the quote to estimate the total number of
  crashes in the U.S. in 2013.

\item Check your answer with a web search.

\item If crashes were evenly distributed across the population, how
many would you expect in your community? Does your answer seem
reasonable?

\end{abcd}

\begin{sol}

\begin{abcd}

\item Use the data in the quote to estimate the total number of
  crashes in the U.S. in 2013.

We need to know the number that 1.2 million is 21\% of. That's
%
```

```
\begin{equation*}
\frac{1.2 \text{ million}}{0.21}= 5.7 \text{ million}.
\end{equation*}

\item Check your answer with a web search.

The next page on the website that's the source of this quotation says
there were 5,687,000 crashes in 2013.

\item If crashes were evenly distributed across the population, how
many would you expect in your community? Does your answer seem
reasonable?

For a quick estimate, I'll use 6 million crashes for 300 million
people (in 2013), so 6 crashes for each 300 people. That's one crash
for every 50 people.

I live in Newton, Massachusetts, population about 100 thousand. At one
accident for every 50 people that would mean about 2,000 accidents, or
about five per day. That number sounds reasonable to me.

\end{abcd}

\end{sol}
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{38}
\begin{MoreExercises}{1.8}
\begin{exx}{\untested\sref{kilomega}
\gref{round}\gref{largemetric}\gref{conversions}}
e-reading.

In December, 2014 Amazon offered a Kindle e-reader with
\index{e-reader}\index{Kindle}

\begin{quotation}
\textbf{Storage:}
16GB (10.9GB available to user) or 32GB (25.1GB
available to user), or 64 GB (53.7GB available to user)
\end{quotation}

\begin{abcd}
\item Compare the percentage of storage available to the user for each
  of these options.

\item Estimate the number of e-books you could store on the 64 GB
  Kindle.

\item Estimate the size of \commonsense{} in MB.
\end{abcd}
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{8}
```

```
\protect \setcounter {Exc}{39}
\begin{MoreExercises}{1.8}
\begin{exx}{\untested\sref{kilomega}\gref{round}\gref{largemetric}
\gref{conversions}}
  Personal storage.

\begin{abcd}
\item How many bytes of storage are there on the hard drive of your
computer (or tablet or smartphone, or some device you use regularly)?
Is that best measured in megabytes or gigabytes?

\item If you have a thumb drive or flash memory stick, what's its
capacity?

\end{abcd}
\end{exx}

\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{40}
\begin{MoreExercises}{1.8}
\begin{exx}{\untested\sref{kilomega}\gref{round}
\gref{largemetric}\gref{conversions}}
Backing up the Library of Congress.

How many 200 gigabyte computer memories
would you need to store the books in the Library of Congress?
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{42}
\begin{MoreExercises}{1.8}
\begin{exx}{\routine\hassolution\sref{kilomega}\gref{round}\gref{mentalestimate}\gref{largemetric}\gref{
Data glut.

In the article from \theGlobe{} on February 24, 2003 with the long
headline

\begin{quotation}
Data glut as gene research yields information counted in terabytes.
Researchers struggle to visualize and process it while technology
businesses scramble to profit from it.
\end{quotation}

you could read that

\begin{quotation}
[Peter Sorger's] bioengineering lab produces a terabyte of
data in a typical month.%
\begin{csmr}
J. Dodge,
Data Glut as Gene Research Yields Information Counted in Terabytes
Researchers Struggle to Visualize and Process It,
\theGlobe{} (February 24, 2003),
```

```
Online source no longer accessible.
\end{csmr}
\end{quotation}

\begin{abcd}

\item At what rate in bytes per minute is the lab producing data?
Write your answer with the appropriate metric prefix and the
appropriate level of precision.

\item If the lab has been producing data from the time the article
appeared to the present, how much has accumulated now?

\item When will a petabyte of data have accumulated? Do you believe
your prediction?

\item When will an exabyte of data have accumulated?

\end{abcd}

\begin{sol}

\begin{abcd}

\item At what rate in bytes per minute is the lab producing data?
Write your answer with the appropriate metric prefix and the
appropriate level of precision.

The Google calculator says
\gc{
1 (terabyte per month) = 25 086 358.9 bytes per minute
}
so the answer to the question is about 25 megabytes per minute.

It's wrong to report the rest of the digits (086,358.9) in
the answer.

I can also do the problem without the Google calculator:
%
\begin{align*}
\frac{1 \text{ terabyte}}{\text{month}}
\times
\frac{1 \text{ month}}{30 \text{ days}}
\times
\frac{1 \text{ day}}{24 \text{ hours}}
\times
\frac{1 \text{ hour}}{60 \text{ minutes}}
\times
\frac{10^{12} \text{ bytes}}{\text{terabyte}}
 = & 23,148,148.1 \frac{\text{bytes}}{\text{minute}} \\
 \approx & 25 \frac{\text{megabytes}}{\text{minute}}.
\end{align*}

\item If the lab has been producing data from the time the article
```

```
appeared to the present, how much has accumulated now?

I am answering this question in February 2011. It's been
96 months since February 2003. Call it 100
months for ease of computation. Then the answer is about 100 terabytes
of data.

\item When will a petabyte of data have accumulated? Do you believe
your prediction?

A petabyte is 1,000 times a terabyte, so it will take 1,000 months to
accumulate that data. That's about 83 years. 83 years from year 2003 is
year 2086.

I don't think you can reliably predict this kind of technology for
that long.

\item When will an exabyte of data have accumulated?

Exa is 1,000 times peta, so it will take 83,000 years.
No point planning that far ahead.

\end{abcd}

\end{sol}

\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{44}
\begin{MoreExercises}{1.8}
\begin{exx}[zettabytes]{\untested\complex\gref{largenumbers}\sref{kilomega}
\gref{largemetric}\gref{conversions}}%
Zettabytes redux.

On August 6, 2011 Kari Kraus wrote in \theTimes{} that

\begin{quotation}
We generate over 1.8 zettabytes of digital information a
year. By some
estimates, that's nearly 30 million times the amount of information
contained in all the books ever published.%
\begin{csmr}
K. Kraus,
When Data Disappears
\theTimes{} (August 6, 2011),
\url{www.nytimes.com/2011/08/07/opinion/sunday/when-data-disappears.html}
\access{July 20, 2015}.
\csmrcomment{29 words. fair use.}
\end{csmr}
\end{quotation}

Are the two estimates in this quotation (1.8 million zettabytes, 30
million times \ldots) consistent with each other?
```

```
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{46}
\begin{MoreExercises}{1.8}
\begin{exx}{\untested\sref{heartbeats}\gref{verify}\gref{estimate}}


In the article ‘‘The impact of free-ranging domestic cats on wildlife
of the   United States’’ in
January 2013 in \emph{Nature Communications} Scott R. Loss, Tom Will
and Peter P. Marra
%CHANGE  wrote that
offered an
%
\begin{quotation}
\ldots estimate that free-ranging domestic cats kill
1.4-3.7 billion birds and 6.9-20.7 billion mammals annually. Un-owned
cats, as opposed to owned pets, cause the majority of this mortality.%
\begin{csmr}
S. R. Loss, T. Will, P. P. Marra, The impact of free-ranging domestic
cats on wildlife of the United States, \emph{Nature Communications} \bf{4}
(2013) 1396-1403, doi:10.1038/ncomms2380.
\url{www.nature.com/ncomms/journal/v4/n1/full/ncomms2380.html}
\access{July 16, 2015}.
Quoted with permission.
\csmrcomment{27 words from a scientific publication - fair use. Maura
  has permission anyway.}
\end{csmr}
\end{quotation}

Make sense of those numbers. Consider kills per cat or kills per
day, or kills per day in your community.
\end{exx}

\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{62}
\begin{MoreExercises}{1.8}

\begin{exx}{\untested\needsquestions}
How many backspaces?

From

\url{blog.stephenwolfram.com/2012/03/the-personal-analytics-of-my-life/}

\begin{quotation}
For many years, I’ve captured every keystroke I’ve
  typed, now more than 100 million of them \ldots

There are all kinds of detailed facts to extract: like that the
average fraction of keys I type that are backspaces has consistently
```

```
been about 7\% (I had no idea it was so high!).%
\begin{csmr}
S. Wolfram,
The Personal Analytics of My Life,
(March 8, 2012),
\url{blog.stephenwolfram.com/2012/03/the-personal-analytics-of-my-life/}
\access{July 20, 2015}.
\csmrcomment{51 words from a blog. fair use, or we can delete the question}
\end{csmr}
\end{quotation}

Lots of other stuff here too.

\end{exx}

 \begin{exx}{\untested\routine}\sref{heartbeats}
Goldman Settles With S.E.C. for \$550 Million.
\index{Goldman Sachs}

That's what \theTimes{} reported on July 15, 2010.  How much is that per
person in the United States?

\end{exx}



\begin{exx}{\needsquestions\sref{carbonfootprints}}
Recycling.

The February 28, 2009 issue of \emph{The Economist} has enough
information on waste \index{Economist, The@\emph{Economist, The}}
and \myindex{recycling} to generate as many Fermi problems as you can
imagine. And there are ideas there that could lead to interesting
possible term papers, if you still need ideas.
See \url{www.economist.com/opinion/displaystory.cfm?story_id=13135349}.

In this special report:
\begin{itemize}
    \item Talking rubbish
    \item You are what you throw away
    \item Down in the dumps
    \item Modern landfills
    \item The science of waste
    \item The value of recycling
    \item Waste and money
    \item Tackling waste
    \item Sources and acknowledgments
\end{itemize}
\end{exx}


\begin{exx}{\untested}\sref{trees}
Cheerio.
```

```
Here's an exercise and its solution from a student.

\begin{quotation}
How many boxes of
\myindex{Cheerios} are sold each year?

If 1 person out of 30 (10,483,000 out of U.S. population: 314,490,000)
had a 2oz bowl (8 servings per box) of Cheerios 3 times a week during
a year, that would equal 220,143,000 pounds or boxes (Cheerios happen
to come in one pound boxes).
\end{quotation}

Critique the solution.

\end{exx}

\begin{exx}{\untested\needsquestions\sref{trees}}
Overhaul the tax code.

From \theTimes{}, January 9, 2013:

\begin{quotation}
In her legally required annual report to Congress, the national
taxpayer advocate, Nina E. Olson, estimated that individuals and
businesses spend about 6.1 billion hours a year complying with
tax-filing requirements. That adds up to the equivalent of more than
three million full-time workers, or more than the number of jobs on
the entire federal government's payroll.%
\begin{csmr}
C. Rampell,
I.R.S.'s Taxpayer Advocate Calls for a Tax Code Overhaul,
\theTimes{} (January 9, 2013),
\url{www.nytimes.com/2013/01/09/business/irss-taxpayer-advocate-calls-for-a-tax-code-overhaul.html}
\access{July 20, 2015}.
\csmrcomment{57 words. could easily paraphrase}
\end{csmr}
\end{quotation}

\begin{abcd*}
\item  Check the arithmetic:  does 6.1 billion hours a year ``add up to the
  equivalent of more than
three million full-time workers''?
\item  How many federal employees are there?  Estimate or use the web
to find out.  Compare your answer to three million.
\item  The IRS estimates how long it takes an individual to prepare
and file annual income taxes.  They may also give an estimate for
how much time a business needs to comply with tax-filing requirements.
Find these estimates and see if they help you verify Olson's claim of
6.1 billion hours.
\end{abcd*}

\end{exx}
```

```
\begin{exx}{\untested\needsquestions\sref{secondsalive}\gref{estimate}
\gref{largenumbers}\gref{conversions}}
Sticky fingers.
\index{FBI}\index{fingerprints}

\begin{quotation}
As of July 2018, the FBI's Next Generation Identification (NGI)
conducts more than 300,000 tenprint record searches per day against
more than 140 million computerized fingerprint records (both criminal
and civil applicant records).
\begin{csmr}
The History of Fingerprints,
\url{onin.com/fp/fphistory.html}
\url{onin.com/fp/IAI_2018_FBI_NGI_Update_McKinsey.pdf}
\end{csmr}
\end{quotation}
%\figurefile{FBIfingerprints-page-6.pdf}
%Tenprint Rapsheet Request (TPRS)

\end{exx}

\begin{exx}{\untested\sref{heartbeats}\gref{verify}
\gref{estimate}\gref{mentalestimate}}
No strings.

January 2011: The inner flap of the Celestial Seasonings Mint Magic
Tea box tells this story:

\begin{quotation}
\noindent
Ever wonder why \ldots \\
no string and tag?

\noindent
Our unique pillow style tea bag is the result of our commitment to
doing what's best for the environment. Because these natural fiber tea
bags don't need strings, tags, staples or individual wrappers we're
able to save more than 3.5 million pounds of waste from entering
landfills every year!%
\begin{csmr}
Celestial Seasonings Mint Magic
Tea box.
\csmrcomment{if we need permission I'm sure they'll grant it for the
  free publicity.}
 \end{csmr}
\end{quotation}

\begin{abcd}

\item Is that claim reasonable?

\item If you find it unreasonable, or a close call, compose a letter
to send to the company explaining your puzzlement and
asking perhaps humorously but certainly politely for an explanation or
```

```
a correction.

\item If your letter really pleases you, consider sending it to
Celestial Seasons --- you can find an address at
\url{www.celestialseasonings.com}.

\end{abcd}

\end{exx}

\begin{exx}{\hassolution\worthy\sref{secondsalive}\gref{verify}
\gref{estimate}\gref{round}\gref{largenumbers}}
Too many \myindex{plastic bags}.

A January 2018 post at \emph{Rate it Green} website stated that
``Worldwide, an estimated 4 billion plastic bags end up as litter each
year.  Tied end to end, the bags could circle the Earth 63 times''.
\begin{csmr}
E. Howe,
Plastic vs. Reusable Bags: Which Bag Is Best?,
\emph{Rate it Green}
January 18, 2017,
  \url{www.rateitgreen.com/green-building-articles/plastic-vs-reusable-bags-which-bag-is-best/59}
 \access{July 25, 2019}
\end{csmr}

\begin{abcd}

\item Are the numbers ``4 billion plastic bags'' and ``circle the
Earth 63 times'' consistent?

\item Use an estimate of the population of the United States and some
  common sense to estimate how many plastic bags are used in the
  United States each year. Use your answer to show that the 4 billion
  plastic bag claim is too small by several orders of magnitude.

\item Confirm your U.S. estimate with a web search.

\end{abcd}
\begin{sol}

\begin{abcd}
\item Are the numbers ``4 billion plastic bags'' and ``circle the
Earth 63 times'' consistent?

Suppose a plastic bag is about a foot long.  There are about 5,000
feet in a mile, so four billion feet is 800,000 miles. I know that the
distance around the earth at the equator is 25,000 miles.  Then
800,000/25,000 = 800/25 = 32. So my estimate says the bags would go
around the equator 32 times, not 63. If I started with the assumption
that bags were two feet long I'd get the answer the
article claims. But the number is in the right ballpark.

\item Use an estimate of the population of the United States and some
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common sense to estimate how many plastic bags are used in the United
States each year. Use your answer to show that
the 4 billion plastic bag claim is too small by several orders of magnitude.

I'll use 300 million for the 2018 population (it was actually about
10\%larger).
Off the top of my head: 300 million people each using 10 plastic bags
a week for 50 weeks would mean 150,000 million plastic bags a year for
the U.S. That's 150 billion, which is two orders of magnitude more than
the 4 billion the article claims for the whole world. And I think 10
bags per week is a low estimate.

Since I am uncomfortable claiming the post was wrong, I will
check my work by reasoning backwards from the number there.  Say we use a
quarter of the plastic bags in the world (even though we're just 1/20th
of the population).  That would be 1 billion per year for us, or just
over three per year per person (since $3 \times 300$ million is just
short of a billion). I am sure we use more than three bags per person
per year!

\item Confirm your U.S. estimate with a web search.

I googled
\gc{
How Many Plastic Bags do we Use Each Year?
}
and found this 2018 estimate from
\url{www.earthday.org/2018/03/29/fact-sheet-single-use-plastics/}

\begin{quotation}
It is estimated that 4 trillion plastic bags are used worldwide
annually. Only 1\% of plastic bags are returned for recycling.[6]
Americans throw away 100 billion plastic bags
annually. That's about 307 bags per person! All that
waste can be eliminated by switching to reusable
shopping bags.
\end{quotation}

That means the 4 billion bag in the original quotation is
about \emph{two
  orders of magnitude} too small!

Lots of other websites report this 4 trillion plastic bags estimate.
I suspect they are all relying on the same original source.
\end{abcd}

\end{sol}

\end{exx}


\begin{exx}{\needsquestions\sref{secondsalive}\gref{verify}
\gref{estimate}\gref{round}}
Losing lots.
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An article in \emph{The Economist} on September 10, 2011 noted that
\index{Economist, The@\emph{Economist, The}}
\index{Walmart}

\begin{quotation}
Walmart \ldots has moved on to health, with a campaign that
has already caused associates
to lose a combined 200,000 lbs of weight.%
\begin{csmr}
Got talent?,
\emph{The Economist} (September 10, 2011),
\url{www.economist.com/node/21528436}
\access{July 20, 2015}.
\csmrcomment{23 words from a 2600 word article. fair use.}
\end{csmr}
\end{quotation}

Put that number in context. Can you make sense of it?
\end{exx}

\begin{exx}{\untested\sref{heartbeats}
\gref{verify}\gref{estimate}\gref{round}\gref{mentalestimate}}
No T means more pollution.
\index{MBTA}\index{pollution}

In \theGlobe{} on April 11, 2009 reporter Matt Viser wrote that

\begin{quotation}
Marc Draisen, executive director of the Metropolitan Area
Planning
Council, said the MBTA plan ‘‘would be nothing short of a disaster for
the Greater Boston area.’’

He estimated that the reduction in services would result in 25 million
new automobile trips per year with 119 million additional miles
traveled and 6 million extra gallons of gas consumed.%
\begin{csmr}
M. Viser,
Plan to cut T services draws ire, criticism,
\theGlobe{} (April 11, 2009)
\url{www.boston.com/news/local/massachusetts/articles/2009/04/11/plan_to_cut_t_services_draws_ire_critic
\access{July 20, 2015}.
\csmrcomment{57 words, could be shortened. Let's see what happens with
  Globe permissions generally.}
\end{csmr}
\end{quotation}

\begin{abcd*}

\item How long (on average) is each of the new automobile trips?

\item How many gallons of gas (on average) will each trip use?
```

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\item What is the average fuel economy (in miles/gallon and in
gallons/(100 miles)) for these trips?

\item Is Draisin's estimate of 25 million new automobile trips
reasonable?
\end{abcd*}

\begin{hint}
Consider estimating how many trips per week per person
this represents.
\end{hint}

\end{exx}


\begin{exx}{\untested}\sref{trees}
Snapple facts.
\index{snapple fact}

\begin{abcd}
\item What are ``Snapple facts''?

\item Find some Snapple facts on the web and figure out whether they
  are believable.
\end{abcd}

\end{exx}


\begin{exx}{\untested\needsquestions}\sref{carbonfootprints}
\myindex{Google} learns a lot each day.

On December 18, 2012,  Pamela Jones Harbour wrote in \theTimes{} that

\begin{quotation}
[Google] creates as much data in two days --- roughly 5
exabytes --- as the world produced from the dawn of humanity until
2003, according to a 2010 statement by Eric Schmidt, the company's
chairman.%
\begin{csmr}
P. J. Harbour,
The Emperor of All Identities,
\theTimes{} (December 18, 2012)
\url{www.nytimes.com/2012/12/19/opinion/why-google-has-too-much-power-over-your-private-life.html}
\access{July 20, 2015}.
\csmrcomment{35 words. OK for a Times snippet (fair use)}
\end{csmr}
\end{quotation}

\end{exx}


\begin{exx}{\untested\sref{heartbeats}\gref{estimate}\gref{round}
\gref{mentalestimate}\gref{conversions}}
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Stolen coins.

In 2007 R. J. Gibson blogged about a
retiree charged with stealing coins and tokens from
the Massachusetts Bay Transportation Authority,
(\myindex{MBTA}, ‘‘the T’’) caught when the T  switched from tokens to
\myindex{Charlie Card}s and Charlie Tickets.

\theGlobe{} reported  that when investigators
went to his home ‘‘ldots they found more than \$40,000 in coins and tokens
\ldots stashed in 17 plastic jugs, each large enough to hold 5
gallons.’’%
\begin{csmr}
R. J. Gibson,
‘‘Not That Guy’’ (March 6, 2007),
\url{rjgibson.blogspot.com/2007/03/not-that-guy.html}.
\access{October 4, 2015}.
The source in \theGlobe{}
is no longer available on the web.
\csmrcomment{short enough for fair use in any case}
\end{csmr}


\begin{abcd}

\item Estimate how many coins and tokens it would take to total
\$40,000.

\item Check your estimate by thinking about whether those coins and
tokens would fit into 17 five gallon jugs.

\item
Estimate the weight of these coins and tokens.

\end{abcd}
\end{exx}

\begin{exx}{\untested\needsquestions\sref{heartbeats}\gref{verify}\gref{estimate}\gref{round}\gref{conve
Keep the cap.

From Joan Wickersham’s op-ed in \theGlobe, March 4, 2011, written as
an open letter to a nonprofit environmental group:

\begin{quotation}
This week you also sent me your magazine, as well as another
solicitation for money. Taken all together, you sent me a total of
1.25 pounds of stuff in the past week alone. Browsing your website, I
found a handy carbon footprint calculator, which I was able to use to
see how much your mailings may be contributing to global warming.

Assuming you shower all your 1,000,000 members with this same 1.25
pounds of attention when they pay their annual dues, you fill at least
three Boeing 747s with thank-you gifts and mailings, thus creating, by
a conservative estimate, between 1,800 and 2,000 tons of carbon
```

```
dioxide.%
\begin{csmr}
J. Wickersham,
Keep the cap,
\theGlobe{} (March 4, 2011),
\url{www.boston.com/bostonglobe/editorial_opinion/oped/articles/2011/03/04/keep_the_cap}
\access{July 20, 2015}.
Quoted with permission.
\csmrcomment{nice ‘‘yes’’ from Wickersham}
\end{csmr}
\end{quotation}
\index{Boeing 747}

Verify Wickersham’s estimates in the second paragraph.
\end{exx}

\begin{exx}{\untested\sref{heartbeats}\gref{verify}\gref{estimate}}
Up and down the ladder.

An April 21, 2011 article in \theGlobe{} reported that

\begin{quotation}
Volker Kraft’s apple sapling sported just 18 eggs when he first
decorated it for Easter in 1965. Decades later, the sturdy tree is
festooned with 9,800 eggs, with artful decorations that include
sequins and sea shells.

\ldots

Kraft needs two weeks and countless trips up and down his ladder to
hang the eggs.%
\begin{csmr}
Tree in Germany boasts 9,800 eggs,
Associated Press reported in \theGlobe{} (April 21, 2011),
\url{www.boston.com/news/world/europe/articles/2011/04/21/tree_in_germany_boasts_9800_eggs/},
\access{July 20, 2015}.
\csmrcomment{51 words - fair use from Globe}
\end{csmr}
\end{quotation}

The trips aren’t countless, even if Kraft didn’t count them. Estimate
how many trips in how many hours.
\end{exx}


\begin{exx}{\hassolution\sref{heartbeats}\gref{verify}\gref{estimate}}
  The 18 million second rule.
\index{Mother Goose and Grimm@\emph{Mother Goose and Grimm}}

Here are the dialog boxes for a
cartoon that appeared in \theGlobe{} on Sunday, November 6, 2011.
You can  see the original at
\url{www.grimmy.com/comics.php?sel_dt=2011-11-06}.%
\begin{csmr}
```

```
M. Peters,
Mother Goose and Grimm,
\url{www.grimmy.com/comics.php?sel_dt=2011-11-06}.
\csmrcomment{Quoting text from a cartoon but not using the image
  should not need permission ...}
\end{csmr}

\begin{center}
\begin{minipage}{2.7in}
\noindent
\raggedright
Mother Goose:
\vspace{0.1in}
\begin{center}
\begin{mdframed}[roundcorner=10pt]
\parbox[t]{2.5in}{
GROSS, SOMEBODY MUST'VE\\
DROPPED THIS PIE\\
BEHIND THE SOFA WHEN\\
I HAD THAT BRIDGE PARTY\\
HERE LAST MONTH.
}
\end{mdframed}
\end{center}

\end{minipage}
%\begin{minipage}{2.7in}
\begin{minipage}{2.0in}
\noindent
\raggedright
Grimm:
\vspace{0.1in}
\begin{center}
\begin{mdframed}[roundcorner=10pt]
\parbox[t]{1.6in}{
DO WE BELIEVE\\
IN THE EIGHTEEN\\
MILLION ONE \\
HUNDRED AND\\
FORTY THOUSAND\\
SECOND RULE?
}
\end{mdframed}
\end{center}

\end{minipage}
\end{center}

\begin{abcd}

\item What is the \myindex{five second rule}?

\item
Check Grimm's (approximate) arithmetic. Is he in the right ballpark?
```

```
\end{abcd}

%\figfile{MotherGooseAndGrimm.jpg}
%\begin{figure}
%\centering
%\includegraphics[height=60mm]{\thefigurefilename}
%\caption{The 18 million second rule} \label{fig:MotherGooseAndGrimm}
%\figsource{\theGlobe, Sunday, November 6, 2011.
%\url{www.grimmy.com/}}
%\figcomment{The cost is probably prohibitive. We've extracted the text
%which is enough for the problem, though less fun. Could we include at
%least a link to the comic? What permissions if any would text or link
%call for?}
%\end{figure}
%\figfile{}

\begin{sol}

\begin{abcd}
\item What is the \myindex{five second rule}?

According to Wikipedia,
\url{en.wikipedia.org/wiki/Five-second_rule},
a reasonable reference for this kind of thing,

\begin{quotation}
A common superstition, the five-second rule states that food dropped
on the ground will not be contaminated with bacteria if it is picked
up within five seconds of being dropped. Some may earnestly believe
this assertion, whereas other people employ the rule
as a polite social fiction to prevent their having to forgo eating
something that dropped.
\end{quotation}

\item
Check Grimm's (approximate) arithmetic. Is he in the right ballpark?

The Google calculator says that
\gc{
one month = 2 629 743.83 seconds
}
so Grimm's arithmetic is way off. 2.7 million seconds and 18 million
seconds are not of the same order of magnitude.

\end{abcd}


\end{sol}


\end{exx}
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\begin{exx}{\sref{kilomega}\gref{largemetric}}
Powers of ten.
\index{Eames}

Consider watching the famous ‘‘Powers of 10’’ film, available at
\url{www.eamesoffice.com/the-work/powers-of-ten/}.

We showed it in class once but our students
didn’t find it as interesting as we do. Much as we like it, we haven’t
used it since.
\end{exx}


\begin{exx}{\hassolution\sref{carbonfootprints}\gref{verify}\gref{estimate}}
A self-checkout way of life.

Business Wire reported on a 2008 study by the research company IHL
Group that claimed that ‘‘The average American woman could
lose 4.1 lbs a year simply from resisting the urge to purchase
impulse items such as chocolate candies, chips and soda once they
[\emph{sic}] are in the checkout line.’’

The study said that impulse purchases among were 32.1 percent lower at
self-checkout lines compared to staffed ones.%
\begin{csmr}
\url{www.businesswire.com/news/home/20070906005261/en/Women-Lose-4.1-lbs-Simply-Avoiding-Impulse\#.VhGO-
\access{October 4, 2015}.
\csmrcomment{20 words and some paraphrase}
\end{csmr}

Think about the claim that the
average American woman could lose 4.1 pounds a year by not buying
items such as candy in the checkout line.

Is that claim reasonable?

\begin{sol}

  At
  \url{fdc.nal.usda.gov/fdc-app.html\#/food-details/169592/nutrients}
  the USDA says that a 2.6 ounce dark chocolate bar about 406
calories.

Now I need to know how calories in food are converted to pounds of
weight on a person. The website
\url{convertunits.com} tells me that 4.1 pounds (of weight) is
equivalent to 14,350 calories.

If a shopper (I really question why it’s a woman in the article, but
that’s a different issue) buys a chocolate bar each week, that’s about
$ 50\times 400 =20,000$ calories, so it’s close enough. A different
calculation with chips would be worthwhile for comparison, but I
usually see candy at the checkout, not chips.
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```
\end{sol}

\end{exx}


\begin{exx}{\untested\needsquestions\worthy\gref{verify}
\gref{estimate}\sref{carbonfootprints}}
Mapping the brain.
\index{Angry Birds}

On July 16, 2012 Carolyn Johnson reported in \theGlobe{} that

\begin{quotation}
When Sebastian Seung read that each day people around the world spend
600 years collectively playing Angry Birds, he saw not a huge waste,
but a big opportunity. \ldots

By Seung's calculations, tracing all the neural connections in a cubic
millimeter of brain would take one person working around the clock
100,000 years. Aided by the computer programs his lab has been
building, that task would be slightly more doable, requiring 1,000
years of work. \ldots

But, he said, ``if we were 1 percent as fun [as Angry Birds], we could
do this in a year.''%
\begin{csmr}
C. Y. Johnson,
Scientist's game helps map the brain,
\theGlobe{}
(July 16, 2012)
\url{bostonglobe.com/metro/2012/07/15/mit-scientists-crowdsource-effort-map-connections-brain/v1CEwhwl90
\access{July 20, 2015}.
\end{csmr}
\end{quotation}

\end{exx}

\begin{exx}{\needsquestions\sref{carbonfootprints}}
The Nine Billion Names of God.

Read that classic short science fiction story by Arthur C. Clarke
\index{Clarke, Arthur C.} at
\url{downlode.org/Etext/nine_billion_names_of_god.html}.

\end{exx}


\begin{exx}{\needsquestions}
Food safety.

On June 21, 2011 Mark Bittman wrote in \theTimes{} about budget cuts in
food safety programs. The article is at
\url{opinionator.blogs.nytimes.com/2011/06/21/no-food-safety-in-these-numbers
}
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There's lots of food for quantitative thought here.
\index{food safety}

\end{exx}


\begin{exx}{\hassolution\gref{verify}\gref{estimate}
\gref{mentalestimate}\sref{carbonfootprints}}
How much television?

At the Wikipedia page
\url{en.wikipedia.org/wiki/Cognitive_Surplus} you can read that Clay Shirky
claims that people spend 200 billion hours a year watching TV.%
\begin{csmr}
Cognitive Surplus,
Wikipedia,
\url{en.wikipedia.org/wiki/Cognitive_Surplus}
\access{July 31, 2015}.
\csmrcomment{no permission needed}
\end{csmr}
(You can see an interesting visual depiction of this
information at
\url{www.informationisbeautiful.net/2010/cognitive-surplus-visualized/}%
\begin{csmr}
Cognitive Surplus visualized
(July 19 2010),
\url{www.informationisbeautiful.net/2010/cognitive-surplus-visualized/}
\access{July 31, 2015}.
\csmrcomment{Just a pointer here in the text, so no permission required.}
\end{csmr}
)
On July 22, 2010, Hiawatha Bray\index{Bray, Hiawatha} wrote in \theGlobe:

\begin{quotation}
My trouble is I don't watch enough television. If I burned
through the national average, watching 35 hours a week, I would
probably love Hulu Plus, the new pay-to-play video service.%
\begin{csmr}
H. Bray,
Hulu Plus for TV gurus,
\theGlobe{} (July 22, 2010),
\url{www.boston.com/business/technology/articles/2010/07/22/tv_gurus_will_enjoy_hulus_new_pay_service/}.
\access{July 20, 2015}.
\end{csmr}
\end{quotation}

Do these two estimates of the amount of time we spend watching TV agree?

\begin{sol}
I will convert the data in the first paragraph to hours per person per
week, and see whether the answer is about 35.

If I start with the estimate that 2/3 of the approximately 300 million
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people in the United States in 2010 were adults, then 200 billion
hours per year divided by 200 million adults means 1000 hours per year
per adult. There are about 50 weeks in a year, so that becomes 20
hours per adult per week.

Bray's estimate is nearly twice that.
They do have the same order
of magnitude, but when counting hours in front of a TV set the
difference between 20 hours per week and 35 hours per week matters.

Bray's figure is more recent, by two years. Maybe people are watching
a lot more television now, but I don't think that explains the
discrepancy.

I think that with a lot more digging around on the web I could find
more information about the amount of television adults watch, but what
I've said so far is good enough for this question.

\end{sol}

\end{exx}

\begin{exx}{\needsquestions\gref{verify}\gref{round}\gref{mentalestimate}
\gref{largenumbers}\gref{conversions}\sref{kilomega}}
Exabytes of storage.
\index{exabyte}\index{BBC}

On February 11, 2011 the BBC reported on a study om \emph{Science} on
the the accumulated amount of information mankind has collected and
stored:
295  exabytes by 2007.

\begin{quotation}
That is the equivalent of 1.2 billion average hard drives.

\ldots

``If we were to take all that information and store it in books, we
could cover the entire area of the US or China in 13 layers of books,''
Dr. Martin Hilbert of the University of California told the
BBC's Science in Action.

\ldots

The same information stored digitally on CDs would create a stack of
discs that would reach beyond the moon, according to the researchers.%
\begin{csmr}
J. Stewart,
Global data storage calculated at 295 exabytes,
BBC World Service (February 11, 2011),
\url{www.bbc.co.uk/news/technology-12419672}
\access{July 26, 2015}.
\csmrcomment{78 words fair use}
\end{csmr}
```

```
\end{quotation}

\end{exx}

\begin{exx}{\untested\hassolution\sref{kilomega}\gref{largemetric}}
Metric history.

\begin{abcd}
\item  The metric prefix kilo was invented along with the metric
system. When was that?

\item The need for larger numbers grew with time. When
were the prefixes mega \ldots zetta invented?
\end{abcd}

\begin{sol}
\begin{abcd}
\item  The metric prefix kilo was invented along with the metric
system. When was that?

1795, in France, right after the French Revolution.

\item The need for larger numbers grew with time. When
were the prefixes mega \ldots Zetta invented?

The Wikipedia entry at
\url{en.wikipedia.org/wiki/SI_prefix}
refers to meetings of the
\myindex{General Conference on Weights and Measures} which certified
mega, giga and tera in 1960, peta and exa in 1975 and zetta and yotta
in 1991.
\end{abcd}

\end{sol}

\end{exx}

\begin{exx}{\untested\needsquestions\sref{kilomega}\gref{largemetric}\gref{conversions}\sref{kilomega}}
The 1940 census.

On April 2, 2012 National Public Radio's \emindex{All Things
Considered} aired an interview with Susan Cooper,
head of publicity for the National Archives, about the release on the
web of data from the 1940 census.

\begin{quotation}
COOPER:
This is our first online release of census material and we
released 16 terabytes of census material and this is, by far, the
largest release of digital material that the National Archives has
ever had.

SIEGEL: What was your past record?
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```
COOPER: We released 250 megabytes of Nixon grand jury transcripts, and
so there's a huge leap from 250 megabytes to 16 terabytes.%
\begin{csmr}
Rush For 1940 Census Data Jams Archives' Website,
National Public Radio (April 2, 2012),
\url{www.npr.org/2012/04/02/149866207/rush-for-1940-census-data-jams-archives-website}
\access{July 20, 2015}
\end{csmr}
\end{quotation}

Unfortunately, these bytes are microfilm images of census forms. That
means they're not searchable. For our quantitative reasoning purposes
it means we can't use the number of bytes to estimate the amount of
information collected.

\end{exx}

\begin{exx}{\needsquestions}
Save your data with DNA.

\begin{quotation}
The raw storage capacity of DNA is staggering compared with even the
most advanced electronic or magnetic storage systems. It is
theoretically possible to store an exabyte of information, if it were
coded into DNA, in the volume of a grain of sand. An exabyte is
roughly equivalent to 200 million DVDs.%
\begin{csmr}
J. Markoff,
Data Storage on DNA Can Keep It Safe for Centuries,
\emph{The New York Times}, December 3, 2015,
\url{www.nytimes.com/2015/12/04/science/data-storage-on-dna-can-keep-it-safe-for-centuries.html}
\access{December 6, 2015}/
\end{csmr}
\end{quotation}

\end{exx}

\begin{exx}{\hassolution}
Put down your telephohe.

On November 15, 2015 the online \emph{Metro} magazine published an
article on cellphone use that quoted
Gauthier Peyrouzet, founder of Digital Detox Holidays, saying
``A smartphone owner picks up their phone more than 1,500 times a
week.'' The article went on to assert ``There's nothing we should be
doing 1,500 times a week except breathing, so take the holiday season
as your chance to break the cycle.''%
\begin{csmr}
E. Noel and E. Kis,
The holiday season is the best time for a digital detox,
\emph{Metro} (November 15, 2015),
\url{www.metro.us/lifestyle/the-holiday-season-is-the-best-time-for-a-digital-detox/zsJokp---T2FLuPkw2IS
\access{December 17, 2015}.
\end{csmr}
```

```
\begin{abcd}

\item Is Peyrouzet's ``more than 1,500 times a week'' reasonable?

\item Is the article's assumption that we breath 1,500 times a week
  reasonable?

\item Track down and comment on the source of Peyrouzet's claim.

\end{abcd}

\begin{sol}

\begin{abcd}

\item Is Peyrouzet's ``more than 1,500 times a week'' reasonable?

1,500 times per week is about 200 times per day, or 20 times per hour
for ten hours. That's once every three minutes. It's once every six
minutes if I imagine using the phone twenty hours a day. So I think
Peyrouzet's estimate is possible for an addicted user, but too large
for an average user.

\item Is the article's assumption that we breath 1,500 times a week
  reasonable?

We breathe all night too. Using 25 hours per day (for ease of
arithmetic) 200 breaths per day is about 40 breaths per hour. That's
less than one per minute. You can hold your breath for a minute (it's
hard without practice) but that's way too small for a regular rate.

Wikipedia says adults breath 12--18 times per minute, which is about
150,000 breaths per week. That's two orders of magnitude off.

\item Track down and comment on the source of Peyrouzet's claim.

I searched the web. Peyrezout seems to have gotten his data at
\url{www.theonlinerocket.com/sexandlove/2015/02/11/social-media-changes-how-people-find-dates-check-up-o
where you can read that

\begin{quotation}
In a week, the average smartphone owner picks up their phone more than
1,500 times a week, the marketing agency TecMark discovered in a study
that observed phone usage of 2,000 people.
\end{quotation}

I found the survey results on the company website at
\url{www.tecmark.co.uk/smartphone-usage-data-uk-2014/}:

\begin{quotation}
Tecmark survey finds average user picks up their smartphone 221 times
a day.
\end{quotation}
```

```
So people quoting this result have converted the daily rate to a
weekly rate.

If I wanted to explore further, I could download the survey data as an
Excel spreadsheet. There are answers there from 2,000 people.


\end{abcd}

\end{sol}

\end{exx}

\begin{exx}{\untested\needsquestions}
Chicken from farm to table.

\begin{quotation}
In fairness, the chicken companies excel at producing cheap food, with
the price of chicken falling by at least half in real terms since
1930. Chicken is cheap partly because companies have tinkered with
genetics so that a baby chick burgeons in five weeks to a full-size
bird with an enormous breast. By my calculations, if humans grew that
explosively, a baby at five weeks would weigh almost 300 pounds.%
\begin{csmr}
N. Kristof,
Animal Cruelty or the Price of Dinner?
\emph{The New York Times},
April 17, 2016,
\url{www.nytimes.com/2016/04/17/opinion/sunday/animal-cruelty-or-the-price-of-dinner.html}
\access{April 17, 2016}
\end{csmr}
\end{quotation}

\end{exx}

\begin{exx}{\untested\hassolution}
Queueing at the airport.

On May 2, 2016 reader NY Renters Alliance commented in \theTimes\ that

\begin{quotation}
Last year, terrorists killed zero people on airplanes, at the cost of
at least 228 lifetimes spent waiting in lines, not to mention the
increased death toll due to driving long distances instead of flying.
\begin{csmr}
Comment on J. Mouawadmay,
Catching a Flight? Budget Hours, Not Minutes, for Security,
\emph{The New York Times}, May 2, 2016,
\url{www.nytimes.com/2016/05/03/business/airport-security-lines.html}
\access{May 3, 2016}.pppp
\end{csmr}
\end{quotation}
```

```
Is 228 lifetimes in the right ballpark?

\begin{sol}

I started by assuming that 300 million people in the US make one
flight each (on average - many don't fly at all, some lots.
Suppose the average wait for security is an hour.
There are about 8,000 hours in a year. Call that $10^4$ to make the
arithmetic easy. Then we have $3*10^8/10^4 = 3,000$ years of
waiting. An average lifetime of 60 years would mean 500 lifetimes. So
228 seems to be the right order of magnitude.

I wonder how the commenter arrived at a 228, with three significant
digits.

The website \url{www.rita.dot.gov/bts/press_releases/bts015_15} says
about 850 million passengers per year, so my first assumption was
small by a factor of three.

\url{www.thrillist.com/travel/nation/the-busiest-airports-in-america-ranked-by-security-wait-time}
suggests that average wait times are much less than an hour --- maybe
only 20 minutes, so I get the factor of three back.
\end{sol}



\end{exx}

\begin{exx}{\untested}
No one at the wheel.

In an AP report in \theGlobe{} on May 15, 2016 you could read that
``Vehicles traveled a record 3.1 trillion miles in the United States
last year.''
\begin{csmr}
J. Lowy,
Will robot cars drive traffic congestion off a cliff?
\theGlobe{},  May 15, 2016,
\url{www.bostonglobe.com/business/2016/05/15/will-robot-cars-drive-traffic-congestion-off-cliff/nHFfzLTi
\access{May 16, 2016}.
\end{csmr}

Can you make sense of this estimate?
\end{exx}


\begin{exx}{\untested\hassolution}
Too many plastic bags.\index{plastic bags}

In a letter to the editor of \theGlobe{} on June 18, 2016, Newton City
Councilor Alison Leary wrote that

\begin{quotation}
The City of Newton passed a plastic bag ban last year, and I
```

```
conservatively estimate that we are diverting 2 million to 3 million
bags a month from entering our waste stream, contaminating our
recycling bins, and contributing to litter.
\begin{csmr}
A. Leary,
Statewide ban on plastic bags is what we need,
letter to the editor of \theGlobe{},
June 18, 2016,
\url{www.bostonglobe.com/opinion/letters/2016/06/17/statewide-ban-plastic-bags-what-need/sAllQImjtKpO9aw
\access{June 18, 2016}.
\end{csmr}
\end{quotation}

Is her estimate reasonable? Is it conservative?

\begin{hint}
Newton has about 100,000 people.
\end{hint}

\begin{sol}
2 to 3 million plastic bags per month in a city of 100,000 is between
20 and 30 per month per person. That's just under one per day. A trip
to the grocery store could easily count for three or four, so that
estimate seems OK for adults who shop. It might be too high on
average because there are kids and not everyone shops regularly. So I
think the estimate is in the right ballpark (not what I thought when I
first read the question) but I don't think it's a ``conservative''
estimate.
\end{sol}

\end{exx}

\begin{exx}{\untested}
Lots of molecules
\index{Avogadro's number}
\index{Bryson, Bill}
\index{popcorn}

In a footnote in Bill Bryson's \emph{A Short History of Nearly
  Everything} he writes about Avogadro's number: $6.02 \times 10^{23}$
that

\begin{quotation}
Chemistry students have long amused themselves by computing just how
large a number it is, so I can report that it is equivalent to the
number of popcorn kernels needed to cover the United States to a depth
of nine miles, or cupfuls of water in the Pacific Ocean, or soft
drink cans that would, evenly stacked, cover the Earth to a depth of
200 miles. An equivalent number of American pennies would be enough to
make every person on Earth a dollar trillionaire. It is a big number.%
\begin{csmr}
B. Bryson,
\emph{A Short History of Nearly Everything},
Broadway Books, New York, 2003, p. 105.
```

```
\end{csmr}
\end{quotation}

Check the chemistry students' claims.

\end{exx}


\begin{exx}{\untested\hassolution}
How big is a rally?

On October 17, 2016 \theGlobe{} quoted Bob Shrum on
Hillary Clinton:
``She's
talking to 80 million people in those debates, and that's worth 200
rallies.''%
\begin{csmr}
M. Levenson,
Clinton keeps the public schedule light in home stretch,
\theGlobe,   October 17, 2016,
\url{www.bostonglobe.com/news/politics/2016/10/16/hillary-clinton-shuns-spotlight-donald-trump-spirals/u
\access{October 17, 2016}.
\end{csmr}

Is this a reasonable estimate?

\begin{sol}
80 million people at 200 rallies would mean 400 thousand people per
rally. I think that's way too big.
\end{sol}


\end{exx}

\begin{exx}{\untested}
Eggs.

An editorial in \theGlobe{} on October 17. 2017 began with this
paragraph:

\begin{quotation}
The average American eats roughly 150 shell eggs a year, and a
referendum on the Massachusetts ballot this November that would
require better treatment for hens is expected to raise retail prices
for consumers in the Commonwealth by between 1 and 5 cents per shell
egg. If those projections are even roughly accurate, the initiative
would translate into an additional cost of maybe \$10 per Massachusetts
resident per year --- and probably less.%
\begin{csmr}
Endorsement: Yes on Question 3,
\theGlobe{},
October 17. 2017,
\url{www.bostonglobe.com/opinion/editorials/2016/10/16/endorsement-yes-question/CbaF6Z4wx45oH1E22Ayx3L/s
\access{October 17. 2017}.
```

```
\end{csmr}
\end{quotation}

Later that week in a news article \theGlobe{} reported that

\begin{quotation}
Both sides agree that the price of eggs will almost certainly go up if
the measure passes. But its backers, which include the Humane Society
of the United States and the MSPCA, say the uptick will probably be a
penny an egg.

Opponents, however, see potential increases of 80 cents or more per
dozen --- a shift that would have an outsize impact on the lowest-income
families.%
\begin{csmr}
J. Miller,
Cage-free egg fight heats up on TV,
\theGlobe{}, October 20, 2016,
\url{www.bostonglobe.com/metro/2016/10/20/cage-free-egg-fight-heats/QmwLOYpT2SabU6cxp24qFP/story.html}
\access{October 21, 2016}.
\end{csmr}
\end{quotation}

Identify the estimates in these paragraph. Are they consistent?
Are they convincing?
\end{exx}

%\begin{exx}{\untested\needsquestions}
%Billions of trees.
%
%In October 2016 Baba Brinkman\index{Brinkman, Baba} wrote
%
%\begin{quotation}
%Hi Ethan,
%
%Thanks for keeping me updated! I haven't planted trees in
%several years since I moved to New York in 2011, but I still keep in
%touch with the culture back in Canada. Here's a page on the company
%website that lists all the planters who have personally planted more
%than a million trees. You have to go to fifth page to find me, since
%it's listed from highest to lowest number!
%\url{www.brinkmanreforestation.ca/millionaires-club?}
%
%All my best,
%
%Baba
%\end{quotation}
%
%At that website you can read
%
%\begin{quotation}
%With great pride we confirm that our long line of planters across
%Canada, Panama and Costa Rica have collectively planted over 1.25
%billion trees. We honour all treeplanters who have restored forests
```

```
%with us over the last 45 years, many of whom are members of the
%Brinkman Millionaire's Club for personally having planted over a
%million trees by hand!
%\begin{csmr}
%Millionaire's Club,
%\url{www.brinkmanreforestation.ca/millionaires-club?},
%\access{October 26, 2016}.
%\end{csmr}
%
%There's a tree counter on the site that updates continuously. On
%October 30, 2016 at 8:59 am (Eastern Daylight Time) it showed
%\begin{center}
%1274674337.
%\end{center}
%One minute later it ended with the digits 397.
%\end{quotation}
%\end{exx}
%
\begin{exx}{\untested\needsquestions}
Pennies add up.

On November 6. 2016 you could read in \theTimes{} that

\begin{quotation}
Soda taxes are on the ballots in San Francisco and Oakland, Calif.,
and spending to persuade citizens to vote for or against them has
topped \$50 million, enough to buy every person in those two cities
about 40 cans of Coke.%
\begin{csmr}
M. Sanger-Katz,
Most Expensive Thing on California's Ballot: A One-Cent Soda Tax,
\emph{The New York Times},
November 6, 2016,
\url{www.nytimes.com/2016/11/07/upshot/a-bay-area-soda-tax-fight-is-drawing-big-bucks.html}
\access{November 7, 2016}.
\end{csmr}


\end{quotation}
\end{exx}


\begin{exx}{\untested\needsquestions}
How many jobs?

\begin{quotation}
No, Mr. Trump didn't ``stand up'' to Carrier --- he seems to have offered
it a bribe. And we're talking about a thousand jobs in a huge economy;
at the rate of one Carrier-size deal a week, it would take Mr. Trump
30 years to save as many jobs as President Obama did with the auto
bailout; it would take him a century to make up for the overall loss
of manufacturing jobs just since 2000.%
\begin{csmr}
P. Krugman,
```

```
Seduced and Betrayed by Donald Trump,
\emph{The New York Times}, December 2, 2016,
\url{www.nytimes.com/2016/12/02/opinion/seduced-and-betrayed-by-donald-trump.html}
\access{December 2, 2016}.
\end{csmr}
\end{quotation}


\end{exx}

\begin{exx}{\needsquestions}
Pasta for all.
\index{pasta}
On January 3, 2017 \theTimes{} reported that

\begin{quotation}
Every year, an Italian eats on average about 60 pounds of pasta
(compared with about 20 pounds for an American). Although Italian
farmers grow an enormous amount of durum wheat --- four million tons
annually --- they cannot meet the domestic pasta industry's demand,
which requires five million tons or more.%
\begin{csmr}
N. Czarjan,
Pastas With a New Selling Point: They're All Italian
\emph{The New York Times}, January 3, 2017,
\url{www.nytimes.com/2017/01/03/dining/pasta-100-percent-italian-wheat.html}
\access{January 8, 2017}.
\end{csmr}
\end{quotation}

Ideas for questions
\begin{itemize}
\item You can estimate the population of Italy from these data.

\item Estimate the size of a serving of pasta?
\end{itemize}

\end{exx}

\begin{exx}{\untested}
How to save a year and half.

In the January 16, 2017 \emph{The New Yorker} Ben Pasternak is quoted
on why he has six identical pairs of Zanerobe black plants:
``You can save, like, a year and a half of your life if your outfit is
pre-chosen. We did the math.''%
\begin{csmr}
C. Bethea,
Meet Monkey's Teen-Age Founders,
\emph{The New Yorker},  January 16, 2017,
\url{www.newyorker.com/magazine/2017/01/16/meet-monkeys-teen-age-founders}
\access{January 11. 2017}.
\end{csmr}
```

```
\end{exx}

\begin{exx}{\needsquestions}
What's in a game?
\index{video games}
\begin{quotation}
``The average mobile game is a team of about 20 people, and it takes
  an average of about 18 months,'' said Michael Pachter, research
  analyst at Wedbush Securities in Los Angeles.
Assuming an industry-average salary of about \$100,000 per year,
Pachter said, a high-quality mobile game can be brought to market for
around \$5 million. That's far less than the cost of building a major
multiplayer title, which could easily require 300 or more developers
to create the software.%
\begin{csmr}
H. Bray,
Turbine mobilizes to catch changing videogame market,
\theGlobe, January 17, 2017,
\url{www.bostonglobe.com/business/2017/01/16/turbine-mobilizes-catch-changing-video-game-market/6Gksikeg
\access{January 17, 2017}.
\end{csmr}
\end{quotation}
\end{exx}


\begin{exx}{\untested}
Retro data storage.
\index{punch card}

At
\url{retrocomputing.stackexchange.com/questions/5652/why-are-punch-card-readers-no-longer-in-use}
you can read the question

\begin{quotation}
When you think about it, punch cards are the safest way to backup data
for long term storage.

They are not influenced by magnetic fields and their data (the holes)
don't fade over time. They are also less sensitive to heat than most
backup media I can think of.

Their biggest advantage should be that they are future-proof. Try
reading an old computer backup tape or diskette (pick any size). Even
if the data signal hasn't faded you probably cannot retrieve the data
without some major effort.

Punch cards are easy enough to read and don't have proprietary
encoding issues.

If you wanted to read your grandfather's punch cards (or: your
grandson wanted to read yours) it should be easy enough to create a
card reader.

It may not be ideal for graphics, but data - e.g. a family tree or
```

```
government records --- would be much safer if stored on punch cards in a
fire-proof box.

How come punch cards are not used (or not very popular) for long-term
backups?
\begin{csmr}
D. Schoemann,
Why are punch card readers no longer in use?,
\emph{retrocomputing.stackexchange.com}, February 6, 2018,
\url{retrocomputing.stackexchange.com/questions/5652/why-are-punch-card-readers-no-longer-in-use}
\access{February 7, 2018}.
\end{csmr}
\end{quotation}

\begin{abcd}
\item What are punch cards?

\item How many bytes of data can you store on a punch card?

\item Estimate how many punch cards would be required to store the
text of \commonsense .

\item Read the answers online to this question. Confirm some of the
  estimates you find there.
\end{abcd}
\end{exx}

\begin{exx}{\untested\needsquestions}
Returning to L. L. Bean.
\index{L. L. Bean}

\begin{quotation}
L.L. Bean officials said the company has lost \$250 million on returned
items in the last five years, with the number of returns doubling in
that period. The annual losses on these items alone were ‘‘equal to the
amount of revenue generated from Bean boot sales,’’ they said.
\begin{csmr}
J, Nanos,
L.L. Bean dropping its unlimited returns policy,
\theGlobe,
February 09, 2018,
\url{www.bostonglobe.com/business/2018/02/09/bean-dropping-its-unlimited-returns-policy/LEc2iLzayaJxxFDk
\access{February 10, 2018}.
\end{csmr}

\end{quotation}
\end{exx}


\end{MoreExercises}
 \protect \chapter {Units and Unit Conversions}
\protect \setcounter {section}{9}
\protect \setcounter {Exc}{4}
\begin{MoreExercises}{2.9}
```

```
\begin{exx}
{\hassolution}{\sref{ratetimedistance}\gref{units}\gref{scientificnotation}}
The penny stops here.

On June 4, 2008
\emph{The Seattle Times} reported on MIT physicist Jeff Gore's
research on the cost of a penny. He estimated that dealing with
pennies makes transactions take two to two and a half seconds longer,
costing each of us four hours every year. At \$15 per hour
``that's  \$15 billion a year lost nationwide annually.''%
\begin{csmr}
J. Scott Orr, Does keeping the penny still make sense?, Newhouse News
Service, \emph{The Seattle Times}, (2006),
\url{community.seattletimes.nwsource.com/archive/?date=20060604&slug=penny04}
\access{July 17, 2015}.
\csmrcomment{10 words of direct quote plus a paraphrase. Fair use.}
\end{csmr}

\begin{abcd}

\item How many cash transactions per person per year involving pennies
  did Gore assume when he made his estimate?

\item On the average, how many cash transactions per day does each of
  these people participate in?

\item How many people did Gore assume were making those transactions?

\item Use the answers to these questions to decide whether Gore's
  estimate of \$15 billion worth of wasted time is reasonable.

\end{abcd}

\begin{sol}


\begin{abcd}

\item How many cash transactions per person per year involving pennies
  did Gore assume when he made his estimate?

  Four hours is $4 \times 3,600 = 14,400$ seconds. If each transaction
  takes two   seconds, that's 7,200 transactions per person per
  year. If each takes   two and a half seconds, that's 5,760 per
  year. So Gore was assuming  between 6 and 7 thousand transactions
  per person per year.

\item On the average, how many cash transactions per day does each of
  these people participate in?

Rounding for easy arithmetic,
%
\begin{equation*}
7000 \frac{\text{transactions}}{\text{year}}
```

```
\times
\frac{1 \text{ year}}{350 \text{ days}}
= 20 \frac{\text{transactions}}{\text{day}}.
\end{equation*}

\item How many people did Gore assume were making those transactions?

Gore says the cost is \$15 billion dollars per year if people's time
is worth \$15 per hour. That means he's working with a billion hours
of wasted time. At four hours per person, a quarter of a billion
people are wasting that time. That's 250 million, or about 2/3 of the
population of the U.S.

\item Use the answers to these questions to decide whether Gore's
  estimate of \$15 billion worth of wasted time is reasonable.

I think 250 million people doing 20 transactions per day is too
large. The 250 million is too large because there are lots of people
(children, in particular) who don't use cash on a daily basis. Many grownups
buy their coffee with a debit card.
I think 20 cash transactions a day is too large too. It's a lot of
going from store to store every day of the year.

I'd be more comfortable with \$1.5 billion instead of \$15 billion.
\end{abcd}

\end{sol}

\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{9}
\protect \setcounter {Exc}{8}
\begin{MoreExercises}{2.9}
\begin{exx}{\hassolution\complex\sref{ratetimedistance}\gref{units}
\gref{metricprefixes}\gref{scientificnotation}}
Global warming opens Arctic for Tokyo-London undersea cable.
\index{global warming}

On January 21, 2010 \emph{The Seattle Times} carried an Associated
Press report about plans to connect London and Tokyo by  an underwater
cable through the Northwest Passage, in order to reduce the time a
message takes to 88 milliseconds from 140 milliseconds.
``The proposed system would nearly cut in half the time it takes to send
messages from the United Kingdom to Asia.''%
\begin{csmr}
D. Joling,
Global warming opens Arctic for
Tokyo-London undersea cable,
\emph{The Seattle Times} (January 21, 2010),
%\url{www.seattletimes.com/nation-world/global-warming-opens-arctic-for-tokyo-london-undersea-cable/}
\access{July 17, 2015}.
\csmrcomment{21 words plus paraphrase. fair use}
\end{csmr}
```

```
\begin{abcd*}

\item Estimate the distance from London to Tokyo via the Northwest
Passage.

\item Use that estimate to estimate the speed of the transmission
signal, in appropriate units.

\item Compare the speed of transmission to the speed of light.

\end{abcd*}

\begin{sol}
\begin{abcd*}

\item Estimate the distance from London to Tokyo via the Northwest
Passage.

I'll start with a guess. I know it's 3,000 miles across the United
States. If you went from London to Tokyo via the U.S. you'd have to
cross the Atlantic and then the Pacific, so I'd guess that would be on
the order of 10,000 miles.  But the Earth is round, and the whole
point of the quotation is that the route that goes up near the North
Pole is shorter. How about 6,000 miles?

Now I'll look it up. I googled
\gc{
distance from london to tokyo
}
and was told 5,936 miles --- but the map there showed that was the
land route over Europe and Asia. I need the polar route.

The link at \url{www.distance.to/Tokyo/London} shows the same
overland route, but on a map. That map actually shows the flight path
curving up toward the North Pole to take advantage of the curvature of
the Earth. I zoomed out on the map and imagined the route over the top
of North America. I'll estimate that as 8,000 miles.

Students will not be happy with this crude procedure, but it's not
worth their time or mine to try to do better.

\item Use that estimate to estimate the speed of the transmission
signal, in appropriate units.

  This is actually pretty easy. The signal travels 8,000 miles in 88
  milliseconds. I decided to use miles/second for my answer.
The Google calculator tells me
\gc{
(8000 miles) per (88 milliseconds) =
90 909.0909 miles per second
}
which is about 90 thousand miles per second.

\item Compare the speed of transmission to the speed of light.
```

```
The speed of light (in a vacuum) is about 186,000 miles per second
(something I just happen to know) so the speed of transmission is
about half the speed of light.

You should get the same answer if you work everything out in metric
units.
\end{abcd*}

\end{sol}
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{9}
\protect \setcounter {Exc}{18}
\begin{MoreExercises}{2.9}
\begin{exx}{\routine\sref{unitprices}\gref{units}\gref{unitpricing}}
The \myindex{national debt}.

According to the United States Department of the Treasury, the
national debt on January 1, 2013 was
$\$16,432,730,050,569.12 \approx \$16.5$ trillion.

\begin{abcd}
\item  Estimate the average share of the debt for each person in the
United States on January 1, 2013.

\item  By some estimates, the debt increases an average of just over
\$2.5 billion per day.  Use the web to find the current national debt
of the United States and comment on the accuracy of those estimates.

\item Find the current population of the United States and
update the average share of the debt for   each person.

\item  Choose a different country and use the web to find its current
  national debt.  Estimate the
average share of the debt for each person in that country and compare
this to what you calculated for the United
States.
\end{abcd}

\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{9}
\protect \setcounter {Exc}{24}
\begin{MoreExercises}{2.9}
\begin{exx}{\hassolution\complex\sref{unitprices}\gref{unitpricing}
\gref{googlecalculatorunits}}
Apple's app store.

A March 2012 press release from the Apple Corporation heralded the 25 billionth
download from their App Store. \index{Apple}\index{iPhone}

\begin{quotation}
\ldots by the users of the more than
```

```
315 million iPhone\textregistered, iPad\textregistered{} and
iPod touch\textregistered devices worldwide.%
\begin{csmr}
Apple Press release,
Apple's App Store Downloads Top 25 Billion,
\url{images.apple.com/pr/library/2012/03/05Apples-App-Store-Downloads-Top-25-Billion.html}
\access{July 27, 2015}.
\csmrcomment{18 words fair use}
\end{csmr}
\end{quotation}

\begin{abcd}

\item Find out when  the App Store opened, and calculate the rate at
which apps have been downloaded since then, assuming the rate was
constant. Choose units that best express your answer: apps/year?
apps/day? apps/second?

\item Find estimates for the number of devices (phones, tablets, pads,
pods) sold. Use those estimates to estimate the number of apps per
device.

\item
Do you think these rates have been constant since the store opened?

\end{abcd}

\begin{sol}

\begin{abcd}
\item Find out when  the App Store opened, and calculate the rate at
which apps have been downloaded since then, assuming the rate was
constant. Choose units that best express your answer: apps/year?
apps/day? apps/second?

Several web sources date the opening of the first App Store as
May, 2001. It's about 11 years from then until this quote
appeared in March 2012.

(Several students found different opening dates for various kinds of
Apple stores. Those answers are acceptable too, as long as they are
documented.)

I asked Google for
\gc{
25 billion (dollars per 11 years) in (dollars per day)
}
and was told
\gc{
(25 billion U.S. dollars) per (11 years) = 6 222 521.06 U.S. dollar per day
}
so apps/day isn't a good way to answer this question. I'll try per
minute:
\gc{
```

```
(25 billion U.S. dollars) per (11 years) = 4 321.19518 U.S. dollar per
minute
}
which is about 4,000 apps per minute.

That sounds like a lot to me!

\item Find estimates for the number of devices (phones, tablets, pads,
pods) sold. Use those estimates to estimate the number of apps per
device.

The headline
\headline{Apple by the numbers: 84M iPads, 400M iOS devices, 350M
iPods sold}
at
{\def\UrlBreaks{\do\-\do\s}%
\url{news.cnet.com/8301-13579_3-57511323-37/apple-by-the-numbers-84m-ipads-400m-ios-devices-350m-ipods-s
from September 12, 2012 gives me the ballpark figure I want:
$84 + 400 + 350 = 834 \approx 800$ million devices.
That's
\begin{equation*}
\frac{ 25 \times 10^9 \text{ apps}}{800 \times 10^6 \text{ devices}}
\approx 30 \frac{\text{apps}}{\text{device}}.
\end{equation*}
\item
Do you think these rates have been constant since the store opened?

The rate of sales in apps/minute has surely not been constant. It was
much larger in 2012 than 11 years earlier, since there was just one
store then, and far fewer devices.

The rate in apps/device is probably larger too, since many
more kinds of popular apps were developed in the intervening years.
\end{abcd}

\end{sol}
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{9}
\protect \setcounter {Exc}{43}
\begin{MoreExercises}{2.9}
\begin{exx}{\routine\untested\sref{railroad}
\gref{googlecalculatorunits}\gref{scientificnotation}}
Stressing your calculator.

\begin{abcd}

\item How many digits are there in the largest number your calculator
can display normally?

\item When you ask it for a number bigger than that does it switch to
scientific notation or complain?
\end{abcd}
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\begin{hint}
To make a number larger than what the calculator can display you
can't just enter it from the keypad. Try multiplying together two
numbers each of which is nearly as large as possible.
\end{hint}

\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{9}
\protect \setcounter {Exc}{44}
\begin{MoreExercises}{2.9}
\begin{exx} {\untested}
Gold.

In a comment in \theTimes{} online on December 23, 2013, Adam wrote that

\begin{quotation}
``Gold has no real practical use except making jewelry and
  filling cavities and the like.'' Not true. Gold has many industrial
  uses, and it coats the terminals of the best high-fidelity
  electrical connections. A ton of cell phones contains about 300
  grams of gold --- just 300 parts per million by weight, but there are
  a lot of cell phones.%
\begin{csmr}
P. Krugman,
Bits and Barbarism, \theTimes{} (December 22, 2013),
\url{www.nytimes.com/2013/12/23/opinion/krugman-bits-and-barbarism.html}
\access{July 18, 2015}.
\csmrcomment{61 words is short enough for a Times fair use
  snippet. Could paraphrase if necessary but I'd rather not.}
\end{csmr}
\end{quotation}

\begin{abcd}

\item Is Adam's ``ton'' a metric ton or an English ton?

\item How much gold is there in one cell phone? Write your answer in
  grams  using an appropriate metric prefix.

\item Estimate the number of cell phones in the world.

\item Estimate the amount of gold in the world's cell phones.
\end{abcd}
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{9}
\protect \setcounter {Exc}{45}
\begin{MoreExercises}{2.9}
\begin{exx}{\untested\hassolution}
Expensive solar energy.

In an article headlined ``Solar use will push energy costs up in
Mass. 20-year rise put at \$1 billion'' in \theGlobe{} on February 12,
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2014 you could read that the added cost for residential customers
would be about \$1 to \$1.50 more a month.%
\begin{csmr}
J. Fitzgerald, Solar use will push energy costs up in Mass.,
\theGlobe{} (February 12, 2014)
\access{July 18, 2015}.
\csmrcomment{paraphrase, not direct quote}
\end{csmr}

\begin{abcd}
\item Use the data to estimate the number of residential
  customers in Massachusetts.

\item Is your answer to the previous question a reasonable
  approximation of the actual number? If not, what might explain the
  discrepancy?

\item The headline and the quote convey the same information, but with
  very different psychological content. In one the added cost seems
  enormous, in the other insignificant.
  Write a letter to the editor politely criticizing the way the
  \emph{Globe} presented the numbers.
\end{abcd}

\begin{sol}


\begin{abcd}
\item Use the data to estimate the number of residential
  customers in Massachusetts.


At a dollar a month each residential customer would pay an extra \$12
per year. At \$1.50 per month the extra cost would be \$18 per year.
Over 20 years that adds up to between \$240 and \$360 per
customer. Working with \$300 per customer it would take about 3.3
million customers to push energy costs up by \$1 billion.

\item Is your answer to the previous question a reasonable
  approximation of the actual number? If not, what might explain the
  discrepancy?

The population of Massachusetts in 2014 was about 6 million. My
estimate for the number of residential customers is just about half
that. I think it's in the right ballpark.

\item The headline and the quote convey the same information, but with
  very different psychological content. In one the added cost seems
  enormous, in the other insignificant.
  Write a letter to the editor politely criticizing the way the
  \emph{Globe} presented the numbers.

One such letter appeared the next day:
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\begin{quotation} The headline on the front page of the Globe
  yesterday was alarmist and misleading.

(‘‘Solar use will push energy costs up in Mass. | 20-year rise put at
  \$1 billion,’’ Page A1, Feb. 12).

When I read just two paragraphs into the article, I found that the
monthly rise in a typical electric bill would be \$1 to \$1.50. For most
of your readers, this is a trivial amount. With a huge benefit, we
should be pursuing solar energy for all we’re worth.

I sympathize with those for whom this increase might be a problem, but
perhaps even they would be glad to help contribute to cleaner, safer
energy.

Linda Given

Somerville

\end{quotation}

\end{abcd}

\end{sol}
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{9}
\protect \setcounter {Exc}{70}
\begin{MoreExercises}{2.9}

\begin{exx}{\gref{areaandvolume}\sref{areaandvolume}}
What does it cost to go green?

One way to save energy is to install solar panels to cover all or part
of your roof.  Solar panels are expensive, but there are some clever
ways to reduce or eliminate the cost.  In this project, you will act
as a consultant to a homeowner who is thinking of installing solar
panels.  Your job is to figure out how much of the roof will be
covered and what the options are for paying for it.  Make sure you
look at the option of the homeowner paying for the panels up front,
using rebates and credits, and calculate how long it will take to earn
that back through reduced electricity costs.  Use information from
your local area for this, and state your assumptions clearly.

\begin{abcd}
\item Estimate the area of the roof where the panels will be
installed.  Solar panels work best when placed on south-facing
roofs, so work that into your calculation.
\item  Do some research about options for installing solar panels.
One approach is to sign a long-term contract
with a solar services provider to purchase the power that the panels
generate.  Or a homeowner could apply for a grant to cover some of the
cost.  The federal government also allows homeowners to take a tax
credit of up to 30\% of the cost of installing panels. There are other
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options and it's your job to look into them.
\item  Write a proposal for the customer that outlines the different
options.  For each option, calculate the up-front costs and the
long-term costs (or benefits).
\item  What would you recommend?  Write a clear recommendation,
justifying your answer with the data you have found and calculated.
\end{abcd}
\end{exx}

\begin{exx}{\sref{areaandvolume}\gref{areaandvolume}\gref{units}}
Fire and ice.

In 2013, the Northwest campus of Wayne County Community College
District installed a thermal energy cooling system.
This system consists of large water-filled tanks.  The water in the
tanks is frozen at night, when electricity is less expensive, and used
in the cooling system during the day.  The college installed its tanks
underground in a space between two buildings, measuring approximately
60 by 90 feet.

\begin{abcd}
\item Standard cooling tanks (from the Calmac corporation, for
example, at \url{www.calmac.com/products/icebankc_specs.asp}
are 89 inches wide, 91 inches long and 69.5 inches tall.
Use this information to determine the maximum number of tanks that the
college could install in that  space.  Make a sketch of the layout of
the installation.

\item Another type of tank from the same company is cylindrical,
  measuring 48 inches tall and with a diameter of 73.75 inches.  How
  many tanks of this style could be installed in the space?  Sketch
  the layout of the installation.
\end{abcd}
\end{exx}

\begin{exx}{\untested\sref{ratetimedistance}\gref{units}}
Back in the saddle again.
\index{Tour de France}

Bradley Wiggins won the km Tour de France, cycling 3,497 km
in 87 hours 34 minutes 47 seconds.%
\begin{csmr}
2012 Tour de France, Wikipedia,
\url{en.wikipedia.org/wiki/2012_Tour_de_France}
\access{August 23, 2015}.
\csmrcomment{No permission needed}
\end{csmr}

\begin{abcd*}
\item What was his average speed, in km/hour?

\item What was his average speed, in mi/hour?

\item Did he travel as far as the distance from Maine to Florida?
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If not, how far would he have gone on that route?

\item Did he travel as far as the distance from California to New York?
If not, how far would he have gone on that route?

\end{abcd*}

\end{exx}

\begin{exx}{\untested}
Waltons' fortune.
\index{Walmart}
\index{Mother Jones@\emph{Mother Jones}}

From a 2012 article in \emph{Mother Jones} headlined
``To Match Walton Heirs' Fortune, You'd Need to Work at
Walmart for 7 Million Years'':

\begin{quotation}
Just how rich are the Waltons? According to the latest
edition of the Forbes 400, released yesterday, the six wealthiest
heirs to the Walmart empire are together worth a staggering \$115
billion.

\ldots

The average Walmart worker earns just \$8.81 an hour. At that wage, the
union-backed Making Change at Walmart campaign calculates that a
Walmart worker would need:

\begin{itemize}
\item     7 million years to earn as much wealth as the Walton family
has (presuming the worker doesn't spend anything)

\item  170,000 years to earn as much money as the Walton family
receives annually in Walmart dividends

\item 1 year to earn as much money as the Walton family earns in
Walmart dividends every three minutes.%
\begin{csmr}
J. Harkinson,
To Match Walton Heirs' Fortune, You'd Need to Work at Walmart for 7
Million Years,
\emph{Mother Jones} (September 20, 2012),
\url{www.motherjones.com/mojo/2012/09/sam-waltons-fortune-walmart-employees-7-million-years}
\access{July 18,2015}.
Quoted with permission.
\csmrcomment{email from Mother Hones says this is just fine}
\end{csmr}
\end{itemize}
\end{quotation}

\begin{abcd}
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\item Verify the calculations in this quote.

\item What is the average annual salary of a Walmart worker?
\end{abcd}
\end{exx}


\begin{exx}{\untested}
The 2012 Nobel prize in physics.
\index{Nobel prize}

Serge Haroche and David J. Wineland won that prize for
experimental work in quantum physics. One of their experiments built
an \myindex{optical clock}.
\index{Nobel Prize}

\begin{quotation}
The precision of an optical clock is better than one part
in $10^{17}$ which means that if one had started to measure time at
the beginning of the universe in the Big Bang about 14 billion years
ago, the optical clock would only have been off by about five seconds today.%
\begin{csmr}
Quantum optics work wins physics Nobel,
\emph{photonics.com},
\url{www.photonics.com/Article.aspx?AID=52530}
\access{July 25, 2019}.
\end{csmr}
\end{quotation}

Check the arithmetic in this paragraph: does one part in $10^{17}$
work out to five seconds in 14 billion years?

\end{exx}


\begin{exx}{\hassolution}
Keeping \myindex{Wikipedia} solvent.

This appeal appeared in December 2012 on the Wikipedia website:

\begin{quotation}
Dear Wikipedia readers: We are the small non-profit that
  runs the \#5 website in the world. We have only 150 staff but serve
  450 million users, and have costs like any other top site. To
  protect our independence, we'll never run ads. We take no government
  funds. We run on donations. We just need 0.3\% of readers to donate
  an average of about \$30. We're not there yet. Please help us forget
  fundraising and get back to Wikipedia.

If everyone reading this gave the price of a cup of coffee, our
fundraiser would be done within an hour. If Wikipedia is useful to
you, take one minute to keep it online another year by donating
whatever you can today.%
\begin{csmr}
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Wikipedia fundraising announcement (December, 2012).
\csmrcomment{I think anything from wikipedia is OK}
\end{csmr}
\end{quotation}

\begin{abcd}
\item
Use the data in the first paragraph to estimate Wikipedia's
fundraising goal. Is your answer believable?


\item Estimate the percentage of the fundraising goal that goes toward
staff salaries.

\item Use the data in the second paragraph to estimate the number of
users who visit Wikipedia in an hour. (The average cost of a cup
coffee on campus is \$2.00.) For a little bit of extra credit, spend no
more than five minutes on the internet to see if you can confirm your
estimate

\end{abcd}

\begin{sol}
\begin{abcd}
\item
Use the data in the first paragraph to estimate Wikipedia's
fundraising goal. Is your answer believable?

\begin{equation*}
0.3\% \times 450 \text{ million users }
\times
\frac{\$30}{\text{user}}
= \$40,500,000
\approx \$40 \text{ million}.
\end{equation*}

That sounds reasonable to me.

\item Estimate the percentage of the fundraising goal that goes toward
staff salaries.

I suspect that the 150 employees running this important web site are
pretty highly trained in technical matters, so I will estimate their
average annual salary as \$100K. Then it will take \$15,000,000 to cover
salaries. That's $\$15,000,000/\$400,000,000 = 0.375 \approx 38\%$ or
about one third of their fundraising goal

If you estimate the average annual salary as just \$50K then the
fraction is closer to 20\%, or one fifth.

Any answer in this range makes sense to me.

The rest of the money is for ``costs like any other top site'' ---
things like computers and office space.
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```
\item Use the data in the second paragraph to estimate the number of
users who visit Wikipedia in an hour. (The average cost of a cup
coffee on campus is \$2.00.) For a little bit of extra credit, spend no
more than five minutes on the internet to see if you can confirm your
estimate

It would take 20 million \$2 contributions to raise
\$40,000,000, so that's the number of hourly visits if their estimate
is right.

According to
\url{meta.wikimedia.org/wiki/Wikimedia_in_figures_-_Wikipedia}

\begin{quotation}
In June 2007 a one-time measurement was made of number of visitors to
all Wikimedia projects combined \ldots [which resulted in]
an average view rate of more than 2500 Wikimedia pages per second, 24
hours per day.
\end{quotation}

That converts to a rate of 9 million pages per hour, which is in the
same ballpark as my estimate.

\end{abcd}


\end{sol}

\end{exx}

\begin{exx}{\untested \gref{areaandvolume}\gref{estimate}\sref{metricsystem2}}
Claim your money, please!
\index{spam}

One of the authors received this in email:

\begin{quotation}
I am thompson Cole the newly appointed United Nations
Inspection Agent in JFK Airport New York. During our Investigation, we
discovered An abandoned shipment on your name through a Diplomat
from London. which was transferred to our facility here in JF Kennedy
Airport and when scanned it revealed an undisclosed sum of money in
a Metal Trunk Box weighing approximately 55kg each.

I beleived each of the boxes will contain more that \$4M or above in
each and the consignment is still left in storage house till today
through a registered shipping Company, Courier Dispatch Service
Limited a division of Tran guard LTD. The Consignment are two metal
box with weight of about 55kg each (Internal dimension: W61 x H156 x
D73 (cm). Effective capacity: 680 L.)Approximately.
\end{quotation}

Mr. thompson Cole goes on to ask for identification, and offers to
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``bring it by myself to avoid any more trouble. But we will share it
70\% for you and 30\% for me. But you have to assure me of my 30\%.''

\begin{abcd}
\item Does a box with the dimensions specified contain approximately
  680 liters?

\item What denominations (bills or coins) would you expect to find
inside to make a total of \$4M?

\item Does a weight of 55kg seem reasonable for that box full of
  money?

\item What things about the email make you suspicious?
\end{abcd}
\end{exx}

\begin{exx}{\untested}
Cleaning up \myindex{Everest}.

\begin{quotation}
Nepal's government announced on March 3 that it would
  require every climber returning from the summit of Mount Everest to
  bring back at least 18 pounds of garbage, the first concerted effort
  to eliminate the estimated 50 tons of trash that has been left on
  the mountain over the past six decades. The waste includes empty
  oxygen bottles, torn tents and discarded food containers.%
\begin{csmr}
G. Harrismarch, Local-Guide Requirement Considered for Nepal Peaks,
\theTimes{} (March 27, 2014),
\url{www.nytimes.com/2014/03/28/world/asia/nepal-considering-local-guide-requirement-for-peaks.html}
\access{July 18, 2015}.
\csmrcomment{64 words. Short enough for fair use, but we could delete
  the whole exercise and little would be lost.}
\end{csmr}
\end{quotation}

\begin{abcd}
\item How many people would have to bring back 18 pounds of garbage to
  eliminate those 50 tons?

\item Estimate how many years it would take to bring back the garbage
  if everyone who made it to the top did what he or she should.

\item The quotation says only people who reach the summit would be
  required to bring back garbage. Answer the previous question if
  everyone on each expedition had to do that.
\end{abcd}

\begin{hint}
Use the web to find out enough about the history of Mount
Everest expeditions to estimate the average number of climbers and the
average number of people who actually reach the summit each year.
\end{hint}
```

```
\end{exx}



\begin{exx}{\untested\needsquestions}
Digital photography.
\index{digital photography}

\begin{quotation}
The relative increase in detail resulting from an increase in
resolution is better compared by looking at the number of pixels
across (or down) the picture, rather than the total number of pixels
in the picture area. For example, a sensor of $2560 \times 1600$ sensor
elements is described as ``4 megapixels'' ($2560 \times 1600 =
4,096,000)$. Increasing to $3200 \times 2048$ increases the pixels in the
picture to 6,553,600 (6.5 megapixels), a factor of 1.6, but the pixels
per cm in the picture (at the same image size) increases by only 1.25
times. A measure of the comparative increase in linear resolution is
the square root of the increase in area resolution, i.e., megapixels
in the entire image.%
\begin{csmr}
Digital photography,
Wikipedia,
\url{en.wikipedia.org/wiki/Digital_photography}
\access{July 18, 2015}.
\csmrcomment{wikipedia - public enough}
\end{csmr}
\end{quotation}
\end{exx}

\begin{exx}{\hassolution\sref{railroad}\gref{units}
\gref{metricprefixes}\gref{googlecalculatorunits}}
The flight of the honeybee\index{honeybee}.

An article in the April 28, 2009 edition of \theTimes{}
quotes Dr. Anna Dornhaus:

\begin{quotation}
A honeybee is less than an inch long. If it flies 20
kilometers that equals 787,400 body lengths.  If we say a human is two
meters tall, then in human terms, that would be like traveling 394
kilometers and back, possibly several times a day.%
\begin{csmr}
A. Conover, To Fathom a Colony's Talk and Toil, Studying Insects One
by One,
\theTimes{} ( April 27, 2009 ),
\url{www.nytimes.com/2009/04/28/science/28prof.html}
\access{July 18, 2015}.
\csmrcomment{46 words fair use snippet}
\end{csmr}
\end{quotation}

\begin{abcd}
```

```
\item
Use the figures she provided to determine the body length of a
honeybee.  Is she correct in stating that it is ‘‘less than an inch’’?

\item
Is Dr. Dornhaus’s estimate of ‘‘394 kilometers and back’’ as the
human equivalent of the honeybee’s 20 kilometers reasonable?
\end{abcd}

\begin{sol}
\begin{abcd}

\item
Use the figures she provided to determine the body length of a
honeybee.  Is she correct in stating that it is ‘‘less than an inch’’?

The Google calculator tells me that 20 kilometers = 787,401.575
inches. If each body length were less than an inch then 787,400 of
them would be less than 20 kilometers (by just a little bit), so she’s
not quite right.

She might have arrived at her answer by first converting kilometers to
miles: 20 kilometers = 12.4274238 miles. If she rounded before
converting to inches she’d get 12.427 miles = 787,374.72 inches. That
would be consistent with her assertion.

She should probably have said ‘‘just about an inch’’ instead of ‘‘less
than an inch.’’


\item
Is Dr. Dornhaus’s estimate of ‘‘394 kilometers and back’’ as the
human equivalent of the honeybee’s 20 kilometers reasonable?

394 kilometers is 394,000 meters, which is 394,000 body lengths per
round trip for a 2 meter tall person. That’s just about half the
number of body lengths flown by the bee. So ‘‘possibly several times a
day’’ should be ‘‘twice a day.’’
\end{abcd}

\end{sol}

\end{exx}

\begin{exx}{\hassolution\sref{ratetimedistance}\gref{units}}
Cheers from the (no) peanut gallery.
\index{peanuts}\index{Fenway Park}

\theGlobe{} reported on June 12, 2011 that 3,000 bags of peanuts sold at
Fenway would lead to a half ton of scattered shells.%
\begin{csmr}
A. Ryan,
Cheers from (no) peanut gallery,
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\theGlobe{} (June 12, 2011),
\url{www.boston.com/lifestyle/health/articles/2011/06/12/with_ban_allergic_red_sox_fans_cheer_breathe/}
\access{July 18, 2015}.
\csmrcomment{Paraphrased.}
\end{csmr}

\begin{abcd}
\item How many ounces of shells are there in each bag of peanuts?

\item About what fraction of the weight of a bag of peanuts are the
  shells?

\item Are the numbers in this quotation reasonable?
\end{abcd}

\begin{sol}

\begin{abcd}
\item How many ounces of shells are there in each bag of peanuts?
\begin{equation*}
\frac{\frac{1}{2} \text{ ton}}{3000 \text{ bags}}
\times \frac{ 2000 \text{ pounds}}{\text{ton}}
\times \frac{16 \text{ ounces}}{\text{pound}}
=
5.333\ldots \frac{\text{ounces}}{\text{bag}}
\approx
5 \frac{\text{ounces}}{\text{bag}}
\end{equation*}

\item About what fraction of the weight of a bag of peanuts are the
shells?

A bag of peanuts probably weighs eight ounces. I think it's
reasonable that the weight is more than half shells.

\item Are the numbers in this quotation reasonable?

  Fenway Park seats about 30,000 people. If ten percent of them bought
peanuts that would be 3,000 bags. I can believe that estimate.
\end{abcd}
\end{sol}
\end{exx}

\begin{exx}{\hassolution} Please cut your nails.

In \emph{The Human Age} author Diane Ackerman writes ``A human
fingernail grows about 1 nanometer per second.''%
\begin{csmr}
D. Ackerman,
\emph{The Human Age},
W. W. Norton \& Company, 2014,
p. 175.
\end{csmr}
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```
Check her claim by estimating how often you trim your nails.

\begin{sol}
I asked the Google calculator for
\gc{
1 nanometer per second in inches per month
}
and found that it's about 0.1 inches per month.
That sounds about right to me. I trim my nails three or four times a
month.

Truth in advertising. I actually asked first for inches per day. The
answer was too small to understand. The same thing happened with
inches per week. Inches per month turned out to be useful.

\end{sol}
\end{exx}

\begin{exx}{\untested\needsquestions\sref{unitprices}}
Crime in London then and now.

In \emph{Sherlock Holmes and New Scotland Yard}
\index{Holmes, Sherlock} Philip Dalton wrote about information
Sir Robert Mark, the Commissioner  of Police for London, presented at
the 1974 Annual Dinner of the Sherlock Holmes Society:

\begin{quotation}
The Report of the Commissioner of Police of the Metropolis [London] for 1890
reveals that 15,264 police officers were available to police an area
of 688.31 square miles and that the total of serious offenses (down
the scale from murder to forgery and counterfeiting) was 18,815.

Provisional figures for 1974 show that 20,055 police officers were
available to police an area of 788 square miles, and that the total
number of indictable crimes (fairly comparable with the serious crimes
of 1890) was 413,516.

\ldots

[Holmes] would appreciate the irony in the fact that the internal
combusiton engine has presented the Metropolitan Police with a
massive problem; how massive can be gauged from the fact that of
1974's indictable crime total of 413,516, no fewer than 134,836
concern autocrime --- taking and drving away or theft from motor
vehicles. To that, one might point out to Holmes, can be added more
than 600 road deaths and some 53,000 injuries in London, compared with
144 deaths and 5,500 injuries in 1890. Although it might seem that the
road accident problem was relatively small in 1890, it was in fact
causing the Commissioner much concern, especially since many of the
casualties were children riding illegally on the backs of carts.%
\begin{csmr}
P. Dalton,
Sherlock Holmes and New Scotland Yard,
in \emph{Beyond Baker Street},
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M. Harrison (ed),
The Bobbs-Merrill Company, Inc, New York, 1976,
pp 76-77.
\end{csmr}
\end{quotation}

Questions should probably ask about per capita rates (research the
populations) and percentage change. Maybe this exercise belongs in the
next chapter.
\end{exx}

\begin{exx}{\untested}
Currency conversion in 1927.

On the cover of \commonsense{} in the upper right corner of
\emph{The New York Herald} front page reporting Lindbergh's flight you
can read that

\begin{center}
\begin{tabular}{lr}
\toprule
Dollar in Paris & 20fr. 34 1/2c. \\
Dollar in London & 4s. 2d. \\
Pound in Paris & 194fr. 09c. \\
\bottomrule
\end{tabular}
\end{center}

French francs (fr) are divided into 100 cents (sou). English
money is measured in pounds, shillings (s, 20 to the pound) and pence
(d, 12 to the shilling).

\begin{abcd}
\item Calculate the conversion rates in dollars per pound, pounds per
  franc, and francs per dollar.

\item Explain why the product of your three answers to the previous
  question should be 1.

\item Check to see whether the product is 1. If it's not, try to
  explain why. One possibility: we misread the cover image. Perhaps if
  you squint you can see it better.
\end{abcd}
\end{exx}

\begin{exx}{\untested}
CNN does not know when to divide.

Timothy Delworth noted this quote from CNN in a piece on the proposed
Dakota Access Pipeline:
\index{Delworth, Timothy}
\index{oil pipeline}
\index{CNN}
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\begin{quotation}
After the pipeline is completed, it would shuttle 470,000 barrels of
crude oil a day, according to developer Energy Access Partners. That's
more than 19.7 million gallons of crude oil a day --- or enough to make
374.3 million gallons of gasoline per day.
\begin{csmr}
H. Yan,
Dakota Access Pipeline: What's at stake?
CNN, September 7, 2016,
\url{www.cnn.com/2016/09/07/us/dakota-access-pipeline-visual-guide/index.html}
\access{September 8, 2016}.
\end{csmr}
\end{quotation}

\begin{abcd}

\item Does ``460,000 barrels of oil'' match
``more than 19.7 million gallons of oil''?

\item How much crude oil would the pipeline shuttle in a year?

\item
Clearly 19.7 million gallons of crude oil can't produce 374.3 million
gallons of gasoline. What did CNN get wrong?  There's a hint at
\url{www.eia.gov/tools/faqs/faq.cfm?id=327&t=9}.

\item Will completing this pipeline make a large contribution to
our nation's need for gasoline?

\end{abcd}
\end{exx}

\begin{exx}{\untested}
Binge watching.
\index{Vine}

\begin{quotation}
Can you believe that Vine celebrated its third birthday on January
24th [2016]? According to Tubular, over 39M videos have been uploaded to the
platform in that time, generating 765 billion views. Here's to the
next 3 years!%
\begin{csmr}
Best Branded Vines \& Instagram Videos,
TubularInsights.com,
\url{tubularinsights.com/best-branded-vines-instagram-videos/\#ixzz4PKkPz18l}
\access{November 7, 2016}.
\end{csmr}
\end{quotation}

Unfortunately, that was wishful thinking, because on October 27, 2016,
Twitter announced that it would be shutting down Vine: its app where
people can upload videos which are only six seconds long.

\begin{abcd}
```

```
\item What's the total length of all Vine videos, as of Jan 24, 2016?

\item How many times (on average) was each video viewed?

\item Calculate the average rate at which users uploaded videos, in
  uploads per day, per hour and per minute. Which version would you
  choose to report?

\item Answer the previous question for video views.

\item Estimate the number of videos uploaded between January 24 and
  October 27 2016.

\item If it was someone's job to watch every Vine video, could
  they complete the task? If you think not, estimate how many people
  it would take.
\end{abcd}

\end{exx}

\begin{exx}{\needsquestions}
Saffron\index{saffron}

\begin{quotation}
Top-shelf saffron, almost all of it imported, sells for \$16-20 per gram
in grocery stores --- or roughly \$500 per ounce.%
\begin{csmr}
J. B, Baird,
Rare saffron could thrive in VT, prof says,
Burlington Free Press, November 5 2016,
\url{www.burlingtonfreepress.com/story/news/2016/11/05/rare-saffron-thrive-vermont/93052418/}
\access{December 27, 2016}
\end{csmr}
\end{quotation}

\begin{quotation}
At \$19 a gram and \$100,000 of estimated revenue per acre, saffron also
has a chance to be uniquely profitable in Vermont.
\begin{csmr}
B. MacQuarrie,
I. Thomas,
Could an exotic spice from Iran help Vt. farmers?,
\theGlobe{},December 20, 2016,
\url{www.bostonglobe.com/metro/2016/12/20/saffron-crop-could-spice-agriculture/BgoyCyqs5pdffokVXBhlNJ/st
\access{December 27, 2016}
\end{csmr}
\end{quotation}
\end{exx}

\begin{exx}{\needsquestions}
Stalled in traffic

INRIX press release:
\url{inrix.com/press-releases/scorecard-us/}
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All the data:
\url{inrix.com/scorecard/}

\emph{Scientific American} discussion''
\url{www.scientificamerican.com/article/traffic-gridlock-is-linked-to-more-crime/}


\theGlobe{}:
Typical Boston commuter spent 2.5 days in traffic last year

\url{https://www.bostonglobe.com/metro/2017/02/23/typical-boston-commuter-spent-equivalent-days-sitting-

\end{exx}

\begin{exx}{\needsquestions}
Ten penny nails.

You can buy ten penny nails at your local hardware store. They're
about three inches long. Why ten pennies? An article on the website of
the Manchester, Massachusetts Glasgow Steel Nail company tells the story

\begin{quotation}
Although many different handmade nails were in use at the time [15th
century England] which had specific names, a large proportion were
named simply by the number of pence paid for a hundred nails.

For example, four penny nails were those of which a hundred were
purchased for 4d. (The 'd' stands for pence in the days when sterling
was denominated in pounds, shillings and pence --- \textsterling s
d).

\ldots

For those that would like to work out the true cost today, the article
tell us that the medieval penny would have been the equivalent of
around 1s 6d in value in 1915.  Government sources suggest that prices
have risen over 61 fold since 1914, so a medieval penny might be worth
around \textsterling{}4.50 today.%
\begin{csmr}
``The Penny Nail'',
Glasgow Steel Nail,
\url{www.glasgowsteelnail.com/nailnames.htm}
\access{March 22, 2017}.
\end{csmr}
\end{quotation}

\end{exx}

\begin{exx}{\hassolution\untested}
The back of the batter's box.
\index{Fenway Park}
\index{baseball}
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In \theGlobe{} on June 16, 2015 Stan Grossfeld quoted umpire Ted
Barrett saying
\begin{quotation}
the back line of the batter's box is the first to be
erased. That's from guys looking for an extra millisecond to track a
98-mile-per-hour fastball.%
\begin{csmr}
S. Grossfeld,
Thinking inside the (batter's) box at Fenway,
\theGlobe{}, June 16, 2017,
\url{www.bostonglobe.com/sports/redsox/2017/06/16/thinking-inside-batter-box-fenway/PMDhKueeIESuf0IMPf1z
\access{June 19, 2017}.
\end{csmr}
\end{quotation}

Does the ball take a millisecond to travel the width of the stripe at
the end of the batter's box?

\begin{sol}
Google says 98 miles per hour is 1.72 inches per millisecond. Two
inches is probably about right for the width of the stripe.
\end{sol}
\end{exx}

\begin{exx}{\untested\needsquestions}
Waste disposal.

A question at skeptics.stackechange.com
(\url{skeptics.stackexchange.com/questions/38844/do-solar-panels-create-300-times-more-toxic-waste-per-u
}
asks
\begin{quotation}
Do solar panels create 300 times more toxic waste per unit of energy
than nuclear-power plants?
\end{quotation}

That question was prompted by the article
``Study Claims Discarded Solar Panels Create More Toxic Waste Than
Nuclear Plants `` on slashdot
(\url{hardware.slashdot.org/story/17/07/01/0442203/study-claims-discarded-solar-panels-create-more-toxi
which reports on the \emph{National Review}
story ``Discarded solar panels are piling up all
over the world, and they represent a major threat to the
environment.''
(\url{www.nationalreview.com/article/449026/solar-panel-waste-environmental-threat-clean-energy})
which refers in turn to the that to the original source
``A Clean Energy's Dirty Little Secret''
from an organization called
``Environmental Progress''.
\url{www.environmentalprogress.org/big-news/2017/6/21/are-we-headed-for-a-solar-waste-crisis}
\end{exx}


\begin{exx}{\hassolution}
```

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Rain, rain go away.
\index{hurricane Harvey}

On September 2, 2018 a headline in \emph{The Washington Post} said
that hurricane Harvey ‘‘unloaded 33 trillion gallons of water in the U.S.’’

\begin{abcd}
\item If that rain fell evenly across the whole continental United
  States how deep would it be?

\item How deep would the water be if it all fell on your state?
\end{abcd}

\begin{sol}
\begin{abcd}
\item If that rain fell evenly across the whole continental United
  States how deep would it be?

 A google search tells me

\begin{quotation}
Together, the 48 contiguous states and Washington, D.C. occupy a
combined area of 3,119,884.69 square miles.
\end{quotation}

Since I have only two significant figures to work with in the 33
trillion gallons I’ll round to $3.1 \times 10^6$ square miles. That’s
$8.6 \times 10^{13}$ square feet (Google again).

Google also tells me 33 gallons is 4.4 cubic feet.

Then 4.4 trillion cubic feet, which is $4.4 \times 10^{12}$ cubic feet,
will cover
$8.6 \times 10^{13}$ square feet to a depth of
$4.4/86 \approx 1/20$ of a foot, or about half an inch.

\item How deep would the water be if it all fell on your state?

I’ll answer for Massachusetts. Its area is 10,555 square miles. That’s
about
$10,555/3,119,884.69 = 0.00338313785 \approx 0.34\%$ of the area of the
continental United States. So spreading that water over just
Massachusetts would be about 300 times as deep, so about 150 inches or
12 feet.
\end{abcd}

\end{sol}

\end{exx}

\begin{exx}{\untested}
Maple cream.

The label on the jar of Maple Cream from Ben’s Sugar Shack in Temple,
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NH reads
\begin{center}
Net Wt. 1 lb, * 453.59g
\end{center}

What's wrong with this unit conversion? What should it say?

\begin{sol}
Two decimal places (five significant figures) is much too
precise. Better to say 450g.
\end{sol}
\end{exx}

\begin{exx}{\untested\hassolution}
Apples for sale.

What's the best deal in Figure~\ref{fig:deal}?
\index{apples}

\figfile{unitpricingdeal.png}
\begin{figure}
\centering
\includegraphics[height=50mm]{\thefigurefilename}
\begin{csmr}[Apples for sale\label{fig:deal}]
Ad on the internet, February 12, 2018.
\end{csmr}
\end{figure}
\figfile{}

\begin{sol}
$\$2.00/\text{apple}$
is a better deal than
$\$2.50/\text{apple}$, unless you need just two apples.
\end{sol}
\end{exx}

\begin{exx}{\untested\hassolution}
Can you believe what you see?

In the November 12 issue of \emph{The New Yorker} Joshua Rothman wrote
about Medifor's video fraud detection systems. (``Medifor'' is short for
``Media Forensics'').

\begin{quotation}
Ideally, such systems would be
integrated into YouTube, Facebook, and other social-media platforms,
where they could flag synthesized content. The problem is speed. Each
day, five hundred and seventy-six thousand hours of video are uploaded
to YouTube; MediFor's systems have a ``range of run-times from less
than a second to ``tens of seconds'' or more.%
\begin{csmr}
J. Rothman,
In the Age of A.I., Is Seeing Still Believing?
\emph{The New Yorker}, November 12, 2018, p. 576,
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```
\url{www.newyorker.com/magazine/2018/11/12/in-the-age-of-ai-is-seeing-still-believing}
\access{November 18, 2018}.
\end{csmr}
\end{quotation}

The last sentence of this quote is unclear. It seems to suggest that
it might take between one and one hundred seconds of computer time to
check an hour of video for fraud. Use that as an assumption in
answering the following queations.

\begin{abcd}
\item How many hours of computer time would it take to check a day's
  worth of YouTube uploads?

\item How many computers would you need in order to check a day's
  worth of uploads on the day they appear.
\end{abcd}

\begin{sol}

\begin{abcd}
\item How many hours of computer time would it take to check a day's
  worth of YouTube uploads?

576,000 seconds is 160 hours. That's how long it would take at one
second of testing per hour of video. It would take 100 times as long,
or 16,000 hours at 100 seconds per hour of video.

\item How many computers would you need in order to check a day's
  worth of uploads on the day they appear.

160 hours is 6.7 days, so 7 computers running essentially nonstop
would do the work at one second per hour of video. At 100 seconds per
hour you would need 670 computers.

I thought these numbers would be larger.
\end{abcd}

\end{sol}
\end{exx}
%\begin{exx}
%
%  http://www.sacred-texts.com/hin/sbe15/sbe15117.htm
%
%305:4 While the sun goes round Meru in a day and a night, the breath
%performs 21,000 breathings, or, more exactly, 21,600. M. reads
%bahirâtmagatyâ.
%
%\end{exx}

%Day length, leap years, leap seconds
%\begin{exx}
%\rul{en.wikipedia.org/wiki/Earth%27s_rotation}
```

```
%Atomic clocks show that a modern day is longer by about 1.7
%milliseconds than a century ago,[1] slowly increasing the rate at
%which UTC is adjusted by leap seconds.
%
% Dennis D. McCarthy; Kenneth P. Seidelmann (18 September 2009). Time:
% From Earth Rotation to Atomic Physics. John Wiley &
% Sons. p. 232. ISBN 978-3-527-62795-0.
%
%\end{exx}
\end{MoreExercises}
 \protect \chapter {Percentages, Sales Tax and Discounts}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{6}
\begin{MoreExercises}{3.8}
\begin{exx}{\hassolution\complex\worthy\sref{percentagepoints}\gref{percentagestrategies}}
  New taxes?

On January 14, 2013 \theGlobe{} reported that
Massachusetts could raise \$1 billion a year by increasing the
income tax rate from 5.25 to 5.66 percent.%
\begin{csmr}
M. Levenson and E. Moskowitz,
Patrick expected to seek increased income tax,
\theGlobe{} (January 16, 2013),
\url{bostonglobe.com/metro/2013/01/16/patrick-set-propose-income-tax-increase/V2PY3WnBElmKrmi3aHptkN/sto
\access{July 18, 2015}.
\csmrcomment{Paraphrase, no permission needed}
\end{csmr}

\begin{abcd}
\item
Find the 2013 taxable income in Massachusetts.

\item
Find the total revenue from this income tax at the 5.25 percent rate.

\item Compare your answer to the state budget. Are the numbers
  consistent?

\end{abcd}

\begin{hint}
Look up the Massachusetts budget for 2013, and the percentage of
revenue that comes from this personal income tax.
\end{hint}

\begin{sol}

\begin{abcd}
\item
Find the 2013 taxable income in Massachusetts.

The words and numbers there tell me
\begin{equation*}
```

```
\text{new revenue} = 0.0566 \times \text{(taxable income)}
\end{equation*}
and
\begin{equation*}
\text{current revenue} = 0.0525 \times \text{(taxable income)} .
\end{equation*}

The article says that increasing the rate would raise \$1
billion. That suggests that \$1 billion is the difference
between the two revenues. Then
\begin{equation*}
\$1 \text{ billion} = (0.0566 - 0.0525) \times \text{(taxable income)}
\end{equation*}
so
\begin{equation*}
\text{(taxable income)}
= \frac{\$1 \text{ billion}}{0.0041} = \$244\text{ billion}.
\end{equation*}


\item
Find the total revenue from this income tax at the 5.25 percent rate.

Then tax collected at the current rate of 5.25\% is
\begin{equation*}
  0.0525 \times \$244 \text{ billion} \approx \$13 \text{ billion}.
\end{equation*}


\item Compare your answer to the state budget. Are the numbers
  consistent?

The Massachusetts 2013 budget was about \$34 billion (several websites
confirm this). At \url{www.mass.gov/informedma/revenue/} I
discovered that 23\% of revenue comes from personal income tax.
23\% of \$34 billion is about \$8 billion, which is less than my
estimate above but in the same ballpark.

\end{abcd}
\end{sol}
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{76}
\begin{MoreExercises}{3.8}


\begin{exx}{\needsquestions\complex}
Fantasy sports.

On September 24, 2015 Neil Irwin wrote in \theTimes{} about the
economics of fantasy sports.

\begin{quotation}
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```
1.3 percent of fantasy players paid \$9,100 in entry fees on average,
 accounting for 23 percent of all entry fees and 77 percent of all
 profits.

While they earned a 27 percent return on their ‘‘investments,’’ the 80
percent of bettors who counted as small fish, spending \$49 each, lost
about half their money.%
\begin{csmr}
N. Irwin,
Daily Fantasy Sports and the Hidden Cost of America’s Weird Gambling
Laws,
The New York Times (September 24, 2015),
\url{www.nytimes.com/2015/09/27/upshot/daily-fantasy-sports-and-the-hidden-cost-of-americas-weird-gambli
\access{October 17, 2015}.
\csmrcomment{57 words fair use}
\end{csmr}
\end{quotation}

\end{exx}
%
\begin{exx}{\hassolution\gref{oneplustrick}}
Living without a \myindex{cellphone}.

On September 28, 2012 \emph{The Wall Street Journal} reported that
\index{Wall Street Journal, The@\emph{Wall Street Journal, The}}

\begin{quotation}
In the second quarter, the number of cellphone subscribers
on contract plans rose just 0.5\% from the year before, to 217
million, according to UBS AG. The number of prepaid customers
grew about 11\% to 74 million.%
\begin{csmr}
A. Troianovski,
Living Without a Cellphone,
\emph{The Wall Street Journal} (September 27, 2012),
\url{online.wsj.com/article/SB10000872396390444549204578022641193306214.html}
\access{July 27, 2015}.
\csmrcomment{38 words could be paraphrased but probably just fair use
  as is}
\end{csmr}
\end{quotation}

\begin{abcd}
\item What percentage of the people using cellphones has prepaid
service now?

\item How many subscribers had contract plans in the second quarter of
2011 (‘‘the year before’’)?

\item How many prepaid customers were there in the second quarter of 2011?

\item How did the percentage of people using a prepaid service rather
than a contract plan change in the last year?
\end{abcd}
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```
\begin{sol}

\begin{abcd}

\item What percentage of the people using cellphones has prepaid
service now?

The percentage is
\begin{equation*}
\frac{74}{74 + 217} = 0.254295533 \approx 25\%.
\end{equation*}
It makes no sense to keep more than two significant digits.

\item How many subscribers had contract plans in the second quarter of
2011 (``the year before'')?

This is a place where the 1+ trick comes in handy. Since the current
number is 0.5\% more than last year's number,
\begin{equation*}
1.005 \times 217 = \text{last year's number}
\end{equation*}
so
\begin{equation*}
\text{last year's number} =
\frac{217}{1.005} = 215.920398.
\end{equation*}
Almost all those digits are nonsense. The answer is about 216 million.

\item How many prepaid customers were there in the second quarter of 2011?

I used the same method and calculated $74/1.11 =66.6666667 \approx 67$
million.

\item What percentage of the people using cellphones had prepaid
service last year?

The percentage of people using a prepaid service last year was
\begin{equation*}
\frac{67}{67 + 216} = 0.236749117 \approx 24\% .
\end{equation*}

\item How did the percentage of people using a prepaid service rather
than a contract plan change in the last year?

The percentage increased by about one percentage point from
24\% to 25\%. Not much at all.

\end{abcd}

\end{sol}

\end{exx}
\begin{exx}{\worthy\routine\hassolution}
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```
Doublespeak.
\index{doublespeak}

In his ‘‘Letter from Rangoon’’ in the August 25, 2008 issue of
\theNewYorker{} George Packer wrote:
\index{Rangoon}

\begin{quotation}
The minister of planning \ldots gave a long speech that attempted to
rebut Petrie’s remarks, using the U.N.’s own statistics. ‘‘Some of it
was really funny,’’ Petrie recalls. ‘‘He said, for example, ’The
U.N. states that a third of the children under five are
malnourished. That’s absolutely not true. It’s 31.2 per cent. The
U.N. states that three-quarters of an average family’s income is used
on food. That’s actually not true. It’s 68.7 per cent.’ He was using
our statistics to say there was no poverty --- that everything was
fine.’’%
\begin{csmr}
G. Packer,
Drowning,
\emph{The New Yorker} (August 25, 2008),
\url{www.newyorker.com/reporting/2008/08/25/080825fa_fact_packer}
\access{July 21, 2015},
\csmrcomment{97 words. Hard to paraphrase, but possible if
  necessary. I’d really rather not}
\end{csmr}
\end{quotation}

\begin{abcd*}

\item Where is Rangoon?

\item The quote describes how Myanmar’s minister of planning tried to
rebut the conclusions of a U.N. report. Do you think he succeeded?

\item Why did Petrie think the attempt was ‘‘really funny’’?

\item Estimate the number of malnourished children in Myanmar in 2008.

\item (optional) What is doublespeak? What’s the origin of the term?
Is the minister of planning’s response doublespeak?
\end{abcd*}

\begin{sol}

\begin{abcd*}

\item Where is Rangoon?

Rangoon, now known as Yangon, is the largest city in Myanmar (formerly
known as Burma). It used to be the capital.

\item The quote describes how Myanmar’s minister of planning tried to
rebut the conclusions of a U.N. report. Do you think he succeeded?
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```
No, I don't think so. The report is describing how much poverty there
is in Myanmar. All the minister can do to contradict the report is to
criticize the perfectly reasonable approximations it uses to describe
the situation in words. 31.2 percent rounds to one third, 68.7 percent is
nearly three quarters.

\item Why did Petrie think the attempt was ``really funny''?

The minister was nitpicking the numbers but refusing to acknowledge
what they meant.

\item Estimate the number of malnourished children in Myanmar in 2008.

According to
\url{www.indexmundi.com/burma/population.html} the population
of Myanmar(Burma) in 2008 was 47,758,180, or approximately 48
million. The site says the numbers come from estimates made by the
U.S. Census Bureau. I see no reason to doubt this figure. Since
Myanmar is a very poor country, and poor countries tend to have a
disproportionate fraction of small children, I'll estimate that 20\%
of the population, or about 10 million, are children. That would mean
about three and a half million undernourished children.

\item (optional) What is doublespeak? What's the origin of the term?
Is the minister of planning's response doublespeak?

According to \url{dictionary.reference.com/browse/doublespeak},
doublespeak is ``evasive, ambiguous language that is intended to
deceive or confuse.'' I think the minister's comment qualifies.

They say the source of the word might be an analogy to
``doublethink''. That cool word, meaning
``the act of simultaneously accepting two mutually contradictory
beliefs as correct'' (according to Wikipedia, which in this case is
trustworthy) was invented by George Orwell in his novel \emph{1984}.
\index{Orwell, George}
\end{abcd*}

\end{sol}
\end{exx}


\begin{exx}{\complex\untested}Colleges and the numbers game

On February 4, 2008 Ralph Whitehead Jr. wrote in \theglobe{} that

\begin{quotation}
The share of the nation's 18-year-olds who are from households where no
adult holds a four-year degree is 60 percent. If Princeton looked like
America, its first-generation number would be 60 [percent], not
11. Its number is about one-fifth of a representative number. Blacks
make up 12 percent of America. If Princeton's enrollment represented
one-fifth of black America, the black share of its students would be
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under 2 percent. If it did the same for women, the female share of its
students would be under 10 percent.%
\begin{csmr}
R. Whitehead Jr.,
Colleges and the numbers game,
\theGlobe{} (February 4, 2008),
\url{www.boston.com/news/education/higher/articles/2008/02/04/colleges_and_the_numbers_game/}
\access{July 21, 2015}.
\csmrcomment{Globe so OK}
\end{csmr}
\end{quotation}

We find these numbers quite confusing. Can you figure out what
Whitehead is trying to say?
\begin{teacher}
This exercise might make an interesting class discussion. Assign it
first, then build a class around student solutions.
\end{teacher}

\end{exx}


\begin{exx}{\untested\needsquestions}
ADHD.

The web page
\url{www.cdc.gov/ncbddd/adhd/data.html/} from the
\myindex{Centers for Disease Control} (\myindex{CDC}) reports this
data on \myindex{Attention-Deficit Hyperactivity Disorder}
(\myindex{ADHD}):

\begin{quotation}
\item
The American Psychiatric Association states in the
Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) that
3\%-7\% of school-aged children have ADHD.  However, studies have
estimated higher rates in community samples.

\item  Parents report that approximately 9.5\% or 5.4 million children
4-17 years of age have ever been diagnosed with ADHD, as of 2007.

\item The percentage of children with a parent-reported ADHD diagnosis
increased by 22\% between 2003 and 2007.

\item Rates of ADHD diagnosis increased an average of 3\% per
year from 1997 to 2006 and an average of
5.5\% per year from 2003 to 2007.

\item Boys (13.2\%) were more likely than girls (5.6\%) to have
ever been diagnosed with ADHD.%
\begin{csmr}
Attention-Deficit / Hyperactivity Disorder (ADHD),
Centers for Disease Control and Prevention,
\url{www.cdc.gov/ncbddd/adhd/data.html/}
```

```
\access{July 27, 2015}.
\csmrcomment{Federal website no permission needed}
\end{csmr}
\end{quotation}

\begin{abcd}

\item Make sense of these statistics.

\item Read and comment on Bronwen Hruska's opinion piece
\headline{Raising the Ritalin Generation} at
\url{www.nytimes.com/2012/08/19/opinion/sunday/raising-the-ritalin-generation.html}
\end{abcd}
\end{exx}
%\marginpar{Needs a reference, and questions.}

\begin{exx}{\needsquestions}
Low income smokers.

On November 8, 2012 an article in
\theTimes{} headlined ``Poor Smokers in New York State Spend 25\% of Income on
Cigarettes, Study Finds''
(\url{www.nytimes.com/2012/09/20/nyregion/poor-smokers-in-new-york-state-spend-25-of-income-on-cigarette
reported on a study in \emph{PLOS one}.

\index{Gelman, Andrew}
The discussion at Andrew Gelman's blog
(\url{andrewgelman.com/2012/09/poor-smokers-in-new-york-state-spend-25-of-income-on-cigarettes-study-fi
is a gem, dissecting the assumptions behind the headline and the
study.

\end{exx}

\begin{exx}{\untested}
Organic foods.
\index{organic food}

In 2012 The U. S. Department of Agriculture said that the retail
market for organic foods was \$31.4 billion in 2011 --- 4.2 percent of
all retail food sales. The amount was only \$3.6
billion in 1997.%
\begin{csmr}
Organic food hardly healthier, study suggests,
Associated Press reported on CBS News (September 4, 2012),
\url{www.cbsnews.com/8301-204_162-57505328/organic-food-hardly-healthier-study-suggests/}
\access{July 21, 2015}.
\csmrcomment{39 word paraphrase no permission needed}
\end{csmr}

\begin{abcd}

\item Use these figures to find total retail food sales in 2011.

\item Estimate total annual retail food sales as a Fermi problem.
```

```
\item Are your answers in the same ballpark?
\end{abcd}


\end{exx}


\begin{exx}{\hassolution\sref{partvswhole}
\gref{percentagestrategies}}
Gasoline in Europe.

In \theTimes{} on July 20, 2011 reader Robin Foor commented on the article
\headline{Bipartisan Plan for Budget Deal Buoys President}:

\begin{quotation}
The tax on a gallon of gas in Germany is more than
\$3.

\ldots

The US per gallon tax on gasoline is 18.4 cents per gallon, which it
has been since 1993.

 \ldots

In 1993 gasoline cost \$1.16 per gallon. The 18.4 cents per gallon tax
was 15.9 percent of the value of a gallon of gas. Today gas is about
\$3.70 a gallon. Equivalent tax at 15.9 percent is 58.7 cents per
gallon. The increased tax of 40.3 per gallon would fund fixing the
road.%
\begin{csmr}
R. Foor comment on J. Calmes and J. Steinhauer,
Bipartisan Plan for Budget Deal Buoys President,
\theTimes{} (July 19, 2011),
\url{www.nytimes.com/2011/07/20/us/politics/20fiscal.html}
\access{August 28, 2015}.
\csmrcomment{91 words fair use}
\end{csmr}
\end{quotation}

\begin{abcd}
\item Check the percentage calculations in this quote.

\item Correct the writing errors in the last sentence.

\item Verify as many of the historical quantitative claims as you can.
\end{abcd}

\begin{sol}
\begin{abcd}
\item Check the percentage calculations in this quote.

$0.159 \times 1.16 = 0.18444$ so the 18.4 cents per gallon claim is
```

```
right.

$0.159 \times 3.70 = 0.5883$ rounds to 58.8 cents per gallon. I don't
know how \theTimes{} came up with 58.7 cents per gallon.

\item Correct the writing errors in the last sentence.

The last sentence is missing the ``cents'' in cents per gallon and an
``s'' at the end of road. What's worse is that it mixes up the new
value of the tax with the increase in the tax. It should read

\begin{quotation}
The increase in tax to 58.7 cents per gallon would fund fixing the
roads.
\end{quotation}

or

\begin{quotation}
The increase in tax of 40.3 cents per gallon would fund fixing the
road.
\end{quotation}

\item Verify as many of the historical quantitative claims as you can.

\emph{Der Spiegel}, a well known German magazine, reported in its
English language web page on April 5. 2012, that

\begin{quotation}
Tax authorities apply a set tax rate to every liter (quarter gallon)
of fuel --- 47.40 cents for diesel fuel, for example, and 65.45 cents
for gas.%
\begin{csmr}
A. Jung,
Berlin's Oil Bonanza: Hefty Gas Taxes Fill Up Germany's Coffers,
\emph{Spiegel Online International} (April 5, 2012),
\url{www.spiegel.de/international/germany/high-german-fuel-taxes-have-been-a-bonanza-for-government-a-82
\access{August 23, 2015}.
\csmrcomment{28 words fair use}
\end{csmr}
\end{quotation}

I assume that's U.S. cents, not hundredths of a Euro. Since four times
65.45 cents is more than three dollars, \theTimes{} is right.

Many web sites confirm the 18.4 cents per gallon tax. (For example,
\url{taxfoundation.org/article/federal-gasoline-excise-tax-rate-1932-2008}.)

Many web sites confirm the total 1993 cost of (approximately) \$1.16
per gallon. The graph at
\url{flowingdata.com/2008/08/08/watch-the-rise-of-gasoline-retails-prices-1993-2008/}
is cool.
\end{abcd}
```

```
\end{sol}
\end{exx}

\begin{exx}{\hassolution\sref{oneplus}
\gref{absolutevsrelativechange}\gref{percentagestrategies}}
Fare increases at the T.
\index{MBTA}
\index{Charlie Card}

On  Sunday, February 19, 2012 \theGlobe{} reported that

\begin{quotation}
\ldots [The MBTA] provides 1.3 million rides each weekday

\ldots

The proposed increases --- a one-way subway ride, now \$1.70 with the
reloadable CharlieCard and \$2 with paper CharlieTicket, could rise to
as much as \$2.40 and \$3, respectively --- would be the largest by
percentage since 1949,

\ldots

the advisory group said fares should rise no more than 25
percent, acknowledging the need for more money but wary of pricing
people off the system.
Such a fare increase would generate about \$80 million
\ldots%
\begin{csmr}
E. Moskowitz,
Top official favors fare hike over service cut,
\theGlobe{} (February 19, 2012),
\url{bostonglobe.com/metro/2012/02/19/top-official-favors-fare-hike-over-service-cut/D08UlBCew6682ddN4FI
\access{July 21,, 2015}.
\csmrcomment{Globe OK}
\end{csmr}
\end{quotation}

\begin{abcd}
\item
Compare the proposed increases in CharlieCard and
CharlieTicket fares, in absolute and relative terms.

\item
Estimate how much extra revenue would be generated in a year from
weekday rides if CharlieCard and CharlieTicket fares increased by just
25\%.

\item
Compare your answer to the assertion in the quotation that a 25\%
increase in fares would yield \$80 million in new revenue.

\item What was the percent increase in T fares in 1949?
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```
\end{abcd}

\begin{sol}

\begin{abcd}
\item
Compare the proposed fares to the current fares in absolute and
relative terms.

The CharlieCard fare will go up \$0.70 (the absolute change). Since
$\$2.40/\$1.70 = 1.41176471$ that's about a 40\% increase.

The corresponding increases for the CharlieTicket fares are \$1
(absolute change) and 50\% (relative change).

\item
Estimate how much extra revenue would be generated in a year from
weekday rides if CharlieCard and CharlieTicket fares increased by just
25\%, as proposed in the last part of the quotation.

There are  52 weeks per year and 5 weekdays per week, so 260 days on
which extra fare is collected. There are 1.3 million riders each
weekday, so $260 \times 1.3 = 338$ million weekday rides.

Now I need to know how much more money per ride would come from a 25\%
increase in the fare. For CharlieCards that would be $0.25 \times
\$1.70 = \$0.43$. For CharlieTickets it would be $0.25 \times \$2.00 =
\$0.50$. If I assume about half the riders use cards and the other
half use tickets I can estimate about \$0.48 extra per ride. Then then
increase in revenue would be
\begin{equation*}
338 \text { million rides} \times
0.48 \frac{\$}{\text{ ride}}
\approx \$162 \text{ million}.
\end{equation*}

\item
Compare your answer to the assertion in the quotation that a 25\%
increase in fares would yield \$80 million in new revenue.

If my calculation is correct, that 25\% increase would collect about
double the \$80 million claimed. I wonder why.

\item What was the percent increase in T fares in 1949?

In 1949, the MBTA proposed a 5 cent increase in the charge for
customers exiting trains above ground.
This fare increase prompted the composition of the song
``M.T.A.'' (or ``Charlie on the M.T.A.''  as
most people refer to it) about a fictional subway rider named Charlie
who was doomed to ride forever because he didn't have that nickel to
get off of the T.  The MBTA website \url{www.mbta.com/about_the_mbta/history/?id=19582}
has a short description. When the MBTA introduced plastic fare
cards they named them ``Charlie cards''.
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The Kingston Trio made the song famous in 1959.

\end{abcd}


\end{sol}

\end{exx}

\begin{exx}{\hassolution\sref{oneplus}
\gref{absolutevsrelativechange}\gref{percentagestrategies}}
Natural born drillers.

On March 16, 2012 Paul Krugman\index{Krugman, Paul} wrote in \theTimes{}

\begin{quotation}
Employment in oil and gas
extraction has risen more than 50 percent since the middle of the last
decade, but that amounts to only 70,000 jobs, around one-twentieth of
1 percent of total U.S. employment. So the idea that drill, baby,
drill can cure our jobs deficit is basically a joke.%
\begin{csmr}
P. Krugman,
Natural Born Drillers,
\theTimes{} (March 15, 2012),
\url{www.nytimes.com/2012/03/16/opinion/krugman-natural-born-drillers.html}
\access{July 21, 2015}.
\csmrcomment{54 words fair use}
\end{csmr}
\end{quotation}

\begin{abcd}
\item  Use the data in the quotation to estimate total
U.S. employment.

\item Use the data here (not a web search!) to estimate oil and gas
  industry employment in 2005.

Think carefully first about what the 70,000 oil industry jobs
represents. There are several possibilities. Write them down; then
decide which you think is right, and why.

\item  Use the web to check your estimate.
\end{abcd}

\begin{sol}

\begin{abcd}
\item Use the data in the quotation to estimate total
U. S. employment.


\item Use the data here (not a web search!) to estimate oil and gas
```

```
  industry employment in 2005.

Think carefully first about what the 70,000 oil industry jobs
represents. There are several possibilities. Write them down; then
decide which you think is right, and why.

The quotation says ‘‘risen more than 50 percent since the middle of the last
decade, but that amounts to only 70,000 jobs’’. I can’t tell whether
the 70,000 is the amount that employment \emph{rose} or the number of
jobs \emph{after the increase}.

\item Use the web to check your estimate.
\end{abcd}


\end{sol}
\end{exx}

\begin{exx}{\hassolution\sref{oneplus}\gref{percentagestrategies}
\gref{oneplustrick}}
Math at camp.

On July 27, 2011 \theTimes{} reported from a math camp for middle
school kids who like mathematics

\begin{quotation}
In a Bard classroom one afternoon, it seemed for a moment
that Arturo Portnoy had stumped everyone. Dr. Portnoy \ldots
posed this question: ‘‘The length of a rectangle is increased by 10
percent and the width is decreased by 10 percent. What percentage of
the old area is the new area?’’%
\begin{csmr}
R. Cromidas,
A Sleepaway Camp Where Math Is the Main Sport,
\theTimes{} (July 27, 2011),
\url{www.nytimes.com/2011/07/28/nyregion/a-sleepaway-camp-for-low-income-ny-math-whizzes.html}
\access{July 21, 2015}.
\csmrcomment{50 words fair use}
\end{csmr}
\end{quotation}

What’s the answer to Portnoy’s question?

\begin{sol}
The crucial mathematics is $1.1 \times 0.9 = 0.99$ --- the new area is
99\% of the original.

If you’re uncomfortable with just the 1+ trick, work it out for a
square that’s 10 inches on each side, with an area of 100 square inches.

\end{sol}

\end{exx}
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```
\begin{exx}{\hassolution\sref{redsoxtix}\gref{percentagestrategies}}
Paying for a Picasso.
\index{Picasso, Pablo}
\index{Sotheby}

On May 12, 2012 \theTimes{} reported that

\begin{quotation}
Picasso's ``Femme Assise Dans un Fauteuil,'' a 1941
  portrait of Dora Maar, the artist's muse and lover, posed in a chair
  \ldots went for \$26 million, or \$29.2 million with fees.''%
\begin{csmr}
C. Vogel,
'The Scream' Is Auctioned for a Record \$119.9 Million,
\theTimes{} (May  2, 2012),
\url{www.nytimes.com/2012/05/03/arts/design/the-scream-sells-for-nearly-120-million-at-sothebys-auction.
\access{July 21, 2015}.
\csmrcomment{33 words fair use}
\end{csmr}
\end{quotation}

Earlier, the article described how Sotheby's computes fees:
``Final prices include the
buyer's commission to Sotheby's: 25 percent of the first \$50,000; 20
percent of the next \$50,000 to \$1 million and 12 percent of the rest.''

Check that the explanation about how the commission was
computed does in fact match the data in the quotation about
fees.

\begin{sol}
Sotheby's buyer's commission on a \$26 million sale is

\begin{center}
%\begin{tabular}{lS[table-format=7.0]}
\begin{tabular}{lr}
\toprule
25\% of  \$50,000    &   \$12,500 \\
20\% of \$950,000    &   \$190,000 \\
12\% of \$25 million &   \$3,000,000 \\
\midrule
total & \$3,202,500 \\
\bottomrule
\end{tabular}
\end{center}

When I add that total to the \$26 million
sale price I do get the article's \$29.2 million, plus an extra
\$2,500. I guess \$2,500 is just \myindex{chump change} in this game.

\end{sol}

\end{exx}
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\begin{exx}{\hassolution\sref{partvswhole}
\gref{percentagestrategies}}
The \myindex{prison population}.

In \theTimes{} on May 31, 2011 you could read that

\begin{quotation}
Every year America spends close to \$66 billion to keep
people behind bars. But almost 500,000 of the 2.3 million prisoners
aren't convicts; rather, they are accused individuals awaiting trial.%
\begin{csmr}
S. Baradaran,
The Right Way to Shrink Prisons,
\theTimes{} (May 30, 2011),
\url{www.nytimes.com/2011/05/31/opinion/31baradaran.html}
\access{July 21, 2015}.
\csmrcomment{32 words fair use}
\end{csmr}
\end{quotation}

\begin{abcd}
\item What percentage of the population is behind bars?

\item How does that percentage compare to the percentages in other countries?

\item How much does it cost to incarcerate a prisoner for a year?

\item Can you verify the \$66 billion and 2.3 million figures in this
quotation?

\end{abcd}

\begin{sol}


\begin{abcd}
\item What percentage of the population is behind bars?

I want two significant digits for the U.S. population, so my usual
estimate of 300 million won't do. I looked up the population on
September 24, 2012 at
\url{www.census.gov/popclock/}
  and found 314,445,535.

\begin{equation*}
\frac{2.3 \text{ million prisoners}}{314 \text{ million people}}
= 0.0073 = 0.73\%.
\end{equation*}

\item How does that percentage compare to the percentages in other countries?

I googled ``prison population by country'' and found the Wikipedia
page at
```

```
\url{en.wikipedia.org/wiki/List_of_countries_by_incarceration_rate}.
There the United States is at the top of the list. The rate of 730
inmates per 100,000 people confirms my answer to the previous question.

Wikipedia got all its numbers from the International Centre for Prison
Studies (\url{www.prisonstudies.org/}); I never quote Wikipedia
without looking to see where it got its information.

\item How much does it cost to incarcerate a prisoner for a year?

\begin{equation*}
\frac{\$ 66 \times 10^9}{2.3 \times 10^6 \text{ prisoners}}
= 29,000 \frac{\$}{\text{prisoner}}
\end{equation*}
(rounded to two significant digits).

\item Can you verify the \$66 billion and 2.3 million figures in this
quotation?

The Wikipedia article above verifies the number of prisoners.

On April 22, 2012 CBS News reported on a study from
``the non-partisan Vera Institute of Justice'' that said (in part)
that ``Our epidemic of incarceration costs us taxpayers \$63.4 billion
a year.'' That's in the same ballpark as the \$66 billion figure above.
I didn't check further, but could have if I'd needed to.
\end{abcd}

\end{sol}

\end{exx}

\begin{exx}{\needsquestions}
Who presided over debt increase?

At
\url{www.politifact.com/truth-o-meter/statements/2011/may/19/nancy-pelosi/nancy-pelosi-posts-questionabl
you can read Louis Jacobson's post on May 19, 2011 titled
``Nancy Pelosi posts questionable chart on debt accumulation by Barack
Obama, predecessors''.

Deconstructing that chart is a good exercise.

\end{exx}

\begin{exx}{\hassolution}
Biking to work in Boston.

On October 26, 2015 you could read in \theGlobe{} that

\begin{quotation}
The number of Boston residents who regularly commute by bicycle has
more than tripled in a decade, according to data from the US Census
Bureau.
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```
An estimated 8,100 workers regularly pedaled themselves to their jobs
last year, up from 2,300 in 2005, according to the bureau's American
Community Survey, which was released last month.

The percentage of Bostonians traveling to work by bike also more than
doubled, from 0.9 percent to 2.4 percent during that 10-year span.%
\begin{csmr}
M, Rocheleau,
Biking to work increasingly popular in Boston, census shows,
\theGlobe{} (October 20, 2015),
\access{October 26, 2015}
\end{csmr}
\end{quotation}

\begin{sol}
\begin{abcd}
\item Use the data in this quote to estimate the total number of
  Boston commuters in 2005 and 2015.

The number of commuters in 2005 was
%
\begin{equation*}
\frac{2,300}{0.009} = 255555.555 \dots \approx 260,000.
\end{equation*}
%
The figure for 2015 was
\begin{equation*}
\frac{8,100}{0.024} = 337500.0 \approx 340,000.
\end{equation*}

\item Use your answer for 2015 to estimate the fraction of the
  population of Boston that commutes to work. Do you think your
  estimate is reasonable?

There were about 650,000 Bostonians in 2015. My calculations suggest
that about half of them commute to work.

That's reasonable. One half seems about right --- of course it's not exact.
In households with several young adults, everyone will commute. In
households with kids the fraction of commuters will be a lot less than
half. The census data may include people who commute to Boston from
suburbs like Brookline of Cambridge.

\item Explain how the number of cyclists could triple while the
  percentage just doubled.

This happened because the total number of commuters increased, by
about 30\%: $340,000/260,000 \approx 1.3$.
\end{abcd}

\end{sol}

\end{exx}
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\begin{exx}{\hassolution}
Raise the cap?

On November 19, 2015 \theGlobe{} asked its readers
‘‘Should the state raise the cap on charter schools?’’
The following Sunday the paper reported the results of the online
poll:

\begin{center}
No: 56.72\% (38 votes) \hspace{0.5in} Yes: 43.28\% (29 votes)
\end{center}

\begin{abcd}
\item Check the percentage calculations.

\item Criticize the way those percentages are reported.

\item How reliable is this poll as a measure of the public’s opinions
  on the question?
\end{abcd}
\end{exx}

\begin{exx}{\untested}
What a deal!

Figure~\ref{fig:amazondeal} suggests a 100\% discount. Is it?

\figfile{amazondeal.png}
\begin{figure}
\centering
\includegraphics[width=4in]{\thefigurefilename}
\begin{csmr}[100\% discount!\label{fig:amazondeal}]
D. Streitfeld,
Some Online Bargains May Only Look Like One,
Amazon screen capture reproduced from \emph{The New York Times},
April 13, 2016,
\url{www.nytimes.com/2016/04/14/technology/some-online-bargains-may-only-look-like-one.html}
\access{April 17, 2016}.
\end{csmr}
\end{figure}
\figfile{}

\end{exx}

\begin{exx}{\hassolution}
Take me out to the ball game.

According to the United States Census Bureau, which recently announced
its annual [2015] estimates for major American cities, New York has reached a
record high of 8,550,405 residents. That increase from last
year’s high of 8,495,405 makes the city’s total population large
enough to fill Yankee Stadium about 170 times, or Citi Field about 205
times.%
```

```
\begin{csmr}
 A. Levine,
New York Today: A Bigger Apple,
\emph{The New York Times},  March 30, 2016,
\url{www.nytimes.com/2016/03/30/nyregion/new-york-today-citys-census-numbers-population.html}
\access{April 28, 2016}.
\end{csmr}

\begin{abcd}
\item By what percentage did the population of New York increase?

\item By what amount did the population of New York increase?

\item Use the information given above to calculate the seating
  capacity of Citi Field.

\item Could Yankee Stadium accommodate  the  increase in the
  population of New York?
\end{abcd}


\begin{sol}
\begin{abcd}
\item By what percentage did the population of New York increase?

\begin{equation*}
\frac{ 8,550,405}{ 205 } = 1.00647408805
\end{equation*}
so the increase was about 0.65 percent.

\item By what amount did the population of New York increase?
%
\begin{equation*}
8,550,405 - 8,495,405 = 55,000
\end{equation*}
%
It's a weird coincidence that produces such a round number.

\item Use the information given above to calculate the seating
  capacity of Citi Field.

\begin{equation*}
\frac{ 8,550,405}{ 205 } = 41709.2926829 \approx 41,700.
\end{equation*}

Just to check: Wikipedia (\url{en.wikipedia.org/wiki/Citi_Field}
confirms this answer.

\item Could Yankee Stadium accommodate  the  increase in the
  population of New York?

I could use the same method to find the capacity of Yankee Stadium and
see if the answer is larger than 55,000 but I'll do it differently. I
know how many more times it will fill Citi than the Stadium, so
```

```
%
\begin{equation*}
\frac{205}{170} \times 41,700 = 50285.2941176 \approx 50,300,
\end{equation*}
so no, they wouldn't fit.

\end{abcd}


\end{sol}
\end{exx}

\begin{exx}{\hassolution}
Suicide statistics.

On April 22, 2016 \theTimes{}
reported on a study saying that suicide in the United States
rose by 24 percent from 1999 to 2014.

\begin{quotation}
The increases \ldots lifted the nation's suicide
rate to 13 per 100,000 people, the highest since 1986. The rate rose
by 2 percent a year starting in 2006, double the annual rise in the
earlier period of the study. In all, 42,773 people died from suicide
in 2014, compared with 29,199 in 1999.%
\begin{csmr}
S. Tavernis,
U.S. Suicide Rate Surges to a 30-Year High,
\emph{The New York Times}, April 22, 2016,
\url{www.nytimes.com/2016/04/22/health/us-suicide-rate-surges-to-a-30-year-high.html}
\access{May 2, 2016}.
\end{csmr}
\end{quotation}

\begin{abcd}
\item Are 42,773 suicides and 13 per 100,000 people in 2014
  consistent?

\item  The suicide rate in 2006 was 11.1 per 100,000 people. If as
  stated, the rate has risen 2 percent each year since 2006, does that
  lead to a rate of 13 per 100,000 in 2014?
  not?.

\item If the suicide rate continues to increase at 2\% per year, in
  what year will it reach 22 per 100,000?
\end{abcd}

\begin{sol}

\begin{abcd}
\item Are 42,773 suicides and 13 per 100,000 people in 2014
  consistent?

The population of the United States in 2014 was
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```
about 318 million people (source: various websites). Then
%
\begin{equation*}
\frac{42,773 \text{ suicides}}{318,000,000 \text{ people}}
= 0.00013 \frac{\text{suicides}}{\text{person}}.
\end{equation*}

Moving the decimal point five places confirms 13 suicides per 100,000
people.

\item  The suicide rate in 2006 was 11.1 per 100,000 people. If as
  stated, the rate rose 2 percent each year since 2006, does that
  lead to a rate of 13 per 100,000 in 2014?

Eight years of increase from 11.1 at 2\% per year leads to
\begin{equation*}
1.02^8 \times 11.1 = 13.0
\end{equation*}
so the assertion is correct.

If you forget that successive percentage increases are like compound
interest and think that 8 years of increase at 2\% per year is 16\% overall
then you find
\begin{equation*}
1.16 \times 11.1 = 12.88
\end{equation*}
which is not quite 13, but does round to 13.

\item If the suicide rate continues to increase at 2\% per year, in
  what year will it reach 22 per 100,000?

The fastest way to get a quick answer is to use the rule of 70, since
22 is just about twice 11.1. The rule says 2\$ compounded interest
doubles principal in 35 years. 35 years from 2006 is 2041.

Just to check:
\begin{equation*}
11.1 \times 1.02^{35} = 22.2.
\end{equation*}

I don't have much faith in that as a prediction.
\end{abcd}

\end{sol}

\end{exx}

\begin{exx}{\untested\hassolution}
Private elevators.
\index{elevators, private}

In May of 2016 Beth Teitel wrote in \theGlobe{} that

\begin{quotation}
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The number of residential elevators in single-family homes has
increased by 40 percent over the past five years in Massachusetts,
according to Stephen Sampson, the state's chief elevator inspector. In
March, there were about 2,070 ``residential'' --- or roughly
15-square-foot --- elevators in owner-occupied single-family homes in
Massachusetts.%%
\begin{csmr}
B. Teitell,
The rich are different. They have home elevators,
\theGlobe{}, May 10, 2016,
\url{www.bostonglobe.com/lifestyle/2016/05/10/the-rich-are-different-than-you-and-they-have-home-elevato
\access{May 11, 2016}.
\end{csmr}
\end{quotation}

\begin{abcd}
\item How many owner-occupied single-family homes had elevators in
  2011?

\item Estimate the percentage of residents of Boston who lived in
  single-family homes with elevators in 2016.

\item How many people would fit in one of these elevators?

\end{abcd}

\begin{sol}
\begin{abcd}
\item How many owner-occupied single-family homes had elevators in
  2011?

I want the number $E$ (for elevators) which when increased by 40\%
gives me 2,070.  Then
\begin{equation*}
1.4E = 2,070
\end{equation*}
so
\begin{equation*}
E = \frac{2,070}{1.4} = 1478.57142857 \approx 1,480
\end{equation*}
elevators.

The article actually says there were 1,474. Then
\begin{equation*}
\frac{2,070}{1,474} = 1.40434192673 \approx 1.40
\end{equation*}
does indeed indicate a 40\% increase.

\item Estimate the percentage of residents of Boston who lived in
  single-family homes with elevators in 2016.

The population of Boston in 2016 was about 660,000. If I estimate
three people per household that's 220,000 households. The fraction
with private elevators is thus
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\begin{equation*}
\frac{2,070}{220,000} \approx \frac{2,000}{220,000} = \frac{1}{110}
\approx 0.009
\end{equation*}
or just under one percent.

\item How many people would fit in one of these elevators?

  15 square feet is about 3 feet by 5 feet or 4 feet square. Two people
would be a little crowded.

\end{abcd}

\end{sol}

\end{exx}

\begin{exx}{\untested\needsquestions}
Should you watch out for alligators?
\index{alligators}

\begin{quotation}
Over all, incidents like the Disney attack remain very rare despite
Florida's growth in recent decades. The state's wildlife agency says
the frequency of unprovoked bites --- currently about seven a year --- has
been increasing about 3 percent each year. But the odds of a resident
being seriously injured during an unprovoked alligator encounter are
roughly one in 2.4 million.%
\begin{csmr}
A.  C. Revkin,
The Peril that Lurks as People and Reptiles Flourish in Florida,
\emph{The New York Times}, June 15, 2016,
\url{dotearth.blogs.nytimes.com/2016/06/15/the-peril-that-lurks-as-people-and-reptiles-flourish-in-flori
\access{June 15, 2016}.
\end{csmr}
\end{quotation}
\end{exx}

\begin{exx}{\needsquestions\untested}
How rich is J. K. Rowling?
\index{Rowling, J. K.}
\index{Potter, Harry}

In \theTimes{} article
``In the Chamber of Secrets: J.K. Rowling's Net Worth''
on November 24, 2016 you could read that:

\begin{quotation}
To start with the obvious, there's the source of her wealth: The seven
Harry Potter books have sold an estimated 450 million copies, with
estimated total revenue of \$7.7 billion. At a standard 15 percent
author's royalty, she would have earned \$1.15 billion.%
\begin{csmr}
 J. B. Stewart,
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In the Chamber of Secrets: J.K. Rowling's Net Worth,
\emph{The New York Times},
 November. 24, 2016,
\url{www.nytimes.com/2016/11/24/business/in-the-chamber-of-secrets-jk-rowlings-net-worth.html}
\access{November 24, 2016}.
\end{csmr}
\end{quotation}

Many more question ideas in the rest of the article.

\end{exx}

\begin{exx}{\needsquestions\hassolution}
How much fraud in food stamps?

A \emph{Washington Post} story headlined ``Fox News wonders whether we
should cancel food stamps because 0.09\% of spending is fraudulent''
started with these words:

\begin{quotation}
A bit over 44 million Americans participate in the government's
Supplemental Nutrition Assistance Program, more commonly referred to
as food stamps. That's a higher number than in most years past,
representing about 13.7 percent of the U.S. population, but it's down
from the high of 47.6 million in 2013, 14.9 percent of the population
that year.

What's incensing Fox News, though, is that 2016 saw a record-high
level of fraud in the system, with \$70 million wasted. The network
hosted a discussion Tuesday morning with a simple conceit: Should the
program therefore be ended?%
\begin{csmr}
P. Bump,
Fox News wonders whether we should cancel food stamps because 0.09\%
of spending is fraudulent,
\emph{The Wasbington Post},
 December 28, 2016,
\url{www.washingtonpost.com/news/the-fix/wp/2016/12/28/fox-news-wonders-if-we-should-cancel-food-stamps-
\access{January 1. 2017}.
\end{csmr}

\end{quotation}

To days later:

\begin{quotation}
Fox News has retracted a Tuesday story that claimed ''an all-time high''
for food stamp fraud.

``We reported that back in 2016 \$70 [billion] were wasted on food
stamp fraud,'' Fox News contributor Abby Huntsman said on Friday's ``
Fox and Friends.''

``That was actually incorrect. The latest information from 2009 to 2011
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shows the fraud at 1.3 percent, which is approximately \$853 million
for each of those three years. Nationally food stamp trafficking is on
the decline. So sorry about that mistake.''
\begin{csmr}
  J. Concha,
Fox News retracts claim food stamp fraud at 'all-time high',
\emph{The Hill}, December 30, 2016,
\url{https://thehill.com/homenews/media/312213-fox-news-retracts-claim-food-stamp-fraud-at-all-time-high
\access{July 27, 2019}.
\end{csmr}
\end{quotation}


\end{exx}

\begin{exx}{\untested}
Incarceration\index{incarceration}\index{prison}

\begin{quotation}
While the United States has less than 5 percent of the world's
population, it houses nearly a quarter of the world's prisoners. Our
prison and jail population has quintupled since the 1970s, even as
crime rates are near historic lows, and American taxpayers spend some
\$80 billion per year on incarceration.%
\begin{csmr}
 D. Scharfenberg,
Why we should free violent criminals,
\theGlobe, February 5, 2017,
\url{www.bostonglobe.com/ideas/2017/02/05/why-should-free-violent-criminals/HK8zo5OMtsMjhhQuXySuDM/story
\access{February 5, 2017}.
\end{csmr}
\end{quotation}

\begin{abcd}
\item Do you have enough information to estimate the number of
  prisoners in the United States?
\item If your answer to the previous question is ``yes'', make the
  estimate and check your answer with a web search.
 If it's ``no'' then find an estimate in at least two independent
  place on the web.
\item Use your estimate of the number of prisoners in the United
  States to figure out the number of prisoners in the world.
\item What is the average annual cost for incarcerating one prisoner
  in the United States?
\end{abcd}
\end{exx}


\begin{exx}{\hassolution\untested}
An opening day no-hitter.

Roger Angell writes about this riddle:
\index{Angell, Roger}
\index{no-hitter}
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\index{batting average}

\begin{quotation}
Name the only major-league game in which the players on one side all
ended up with the same averages they'd begun with.%
\begin{csmr}
R. Angell,
\emph{This Old Man},
Doubleday, New York, p. 109.
\end{csmr}
\end{quotation}

He says the answer is the no-hitter Bob Feller threw on opening day in
1940: the Chicage players began and ended with batting average
$.000$.

Explain why that's not quite correct.

Figure~\ref{fig:dayone} provides a hint. It shows the American League
East standings at the start of the 2017 season when two teams have
played and the others haven't yet.

\figfile{standingsdayone.png}
\begin{figure}
\centering
\includegraphics[width=2.5in]{\thefigurefilename}
\begin{csmr}[Standings very early in the season\label{fig:dayone}]
American League East standings,
\theGlobe{},
April 3, 2017.
\end{csmr}
\end{figure}
\figfile{}

\begin{sol}
A player's batting average is
\begin{equation*}
\frac{\text{number of hits}}{\text{number of at-bats}} .
\end{equation*}
Before the game began hitters had no at bats, so this fraction looked
like ``$0/0$'' and was undefined. It wasn't .000.
\end{sol}
\end{exx}

\begin{exx}{\untested\complex}
Traffic fatalities up?

An article headlined
``The number of pedestrians, cyclists and drivers killed in L.A. traffic
rose sharply in 2016'' began:

\begin{quotation}
Traffic deaths in Los Angeles rose sharply despite a high-profile campaign by Mayor Eric Garcetti and o
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In 2016, the first full year that Garcetti's Vision Zero policy was in
effect in L.A., 260 people were killed in traffic crashes on city
streets, an increase of almost 43\% over the previous year.%
\begin{csmr}
L. Nelson and D. Smith,
The number of pedestrians, cyclists and drivers killed in L.A. traffic
rose sharply in 2016,
\emph{The Los Angeles Times}. April 2, 2017,
\url{www.latimes.com/local/lanow/la-me-ln-2016-traffic-deaths-20170403-story.html}
\access{April 4, 2017}.
\end{csmr}
\end{quotation}

Later in the article you could read that Seleta Reynolds, the
L.A. Transportation Department's general manager,
``cited an increase in driving as one reason for the rising number of
fatalities. Car sales and car registrations have risen in Southern
California, driven by a strong economy and low gas prices.''

This article was discussed in Andrew Gelman's blog at
\url{andrewgelman.com/2017/04/03/no-evidence-providing-drivers-licenses-unauthorized-immigrants-californ
\index{Gelman, Andrew}
There you can find a link to an Associated Press report
that began

\begin{quotation}
WASHINGTON: Pedestrian deaths are climbing faster than motorist
fatalities, reaching nearly 6,000 deaths last year --- the highest total
in more than two decades, according to an analysis of preliminary
state data released Thursday.

Increased driving due to an improved economy, lower gas prices and
more walking for exercise and environmental reasons are some of the
likely reasons behind the estimated 11 per cent spike in pedestrian
fatalities in 2016. The figures were prepared for the Governors
Highway Safety Association, which represents state highway safety
offices.%
\begin{csmr}
Associated Press,
6,000 US pedestrians killed in 2016, cellphone use cited,
\emph{New StraitsTimes}, March 40, 2017,
\url{www.nst.com.my/news/2017/03/225575/6000-us-pedestrians-killed-2016-cellphone-use-cited}
\access{April 4, 2017}
\end{csmr}
\end{quotation}

\begin{abcd}
\item How many traffic fatalities were there in Los Angeles in 2015?

\item How many pedestrian traffic fatalities were there in the United
  States in 2015?

\item What data would you need to compare these two fatality rates
  since one is for all traffic deaths and the other for pedestrian traffic
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  deaths.

\item Explain how Reynolds' observation might change the perceptions
  these article raise. What data would you need to calculate the
  fstality rates in deaths per mile driven?
\end{abcd}
\end{exx}

\begin{exx}{\untested\needsquestions}
Taxes down, spending up.

\begin{quotation}
During the 1990s, state taxes amounted to roughly 6.7 cents of every
dollar earned in Massachusetts. These days, it's more like 5.9
cents. And if that doesn't sound like a big change, it adds up to
something like 3.5 billion no-longer-collected dollars every year ---
more than enough to resolve the budget woes.

Compare that with the big driver on the other side of the ledger: the
rise in health care spending, particularly on Medicaid. This, too, is
a very big and very real fiscal challenge. In the late 1990s, less
than 20 percent of the state budget went to Medicaid (known here as
MassHealth); these days, it's over 35 percent. And while about half of
those expenses are reimbursed by the federal government, the state's
share is swelling, too.

Had these health care costs not exploded --- but merely grown at the
same rate as the rest of the Massachusetts economy --- it would have
freed up about \$2.5 billion every year. That's a big number, by any
metric, but a good deal smaller than the \$3.5 billion cost of tax
reductions.

So that's the big picture. Tax cuts drained away money, health care
spending absorbed a growing portion of the remaining funds, and the
result is a budget that's been out of balance for over a decade.
\begin{csmr}
E. Horowitz,
The next recession could make the state budget deficit explode,
\theGlobe{}, April 21, 2017,
\url{www.bostonglobe.com/news/politics/2017/04/20/the-next-recession-coud-make-state-budget-deficit-expl
\access{April 21, 2017}.
\end{csmr}
\end{quotation}

The first paragraph makes an easy question on
percentages. You have enough information to find the total taxable
dollars and the total tax collected. Then you can check those with a
web search or ask about per capita amounts.

\end{exx}{\untested\hassolution}
Thumb on the scale.

\begin{exx}
A dishonest dealer sells his goods at the cost price but still earns a
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profit of 25\% by underweighing . What weight does he use for a kilogram?

\begin{sol}
Suppose his cost is \$1 per kilo. He wants to make \$1.25 per kilo
when he sells stuff, but tell his customers they are paying \$1 per
kilo.

If he sells $1/1.25 = 0.8$ kilos (800 grams) for $1$ he's actually
charging the $\$1.25$ per kilo.
\end{sol}
\end{exx}

\begin{exx}{\untested\needsquestions}
Tax cuts for whom?

\begin{quotation}
The [Urban-Brookings Tax Policy Center] analysis showed
that the proposed Trump tax cuts would lift after-tax income for the
top 1 percent of taxpayers by at least 11.5 percent (or an average
annual tax cut of \$175,000), compared with a barely perceptible 1.3
percent for taxpayers in the middle (or \$760 in average tax savings).
\begin{csmr}
Editorial,
The False Promises in President Trump's Tax Plan,
\theTimes{}, September 3, 2017,
\url{www.nytimes.com/2017/09/02/opinion/sunday/trump-republicans-tax-reform.html}
\access{September 9, 2017}
\end{csmr}
\end{quotation}
\end{exx}

\begin{exx}{\untested\needsquestions}
 Eat less beef, save the planet.
\index{carbon tax}
\index{climate change}
\index{beef}

On March 18, 2018 \theTimes{} published an opinion piece
advocating a carbon tax on the \cotwo{} emissions from the production of
various kinds of meat and dairy foods. Figure~\ref{fig:meat}
displays some of the numbers.
The price increases reflect the maximum impact after a \$247.83 tax per ton
of \cotwo{} emitted.

\figfile{meat-tax-carbon.png}
\begin{figure}
\centering
\includegraphics[width=4in]{\thefigurefilename}
\begin{csmr}[The cost of carbon\label{fig:meat}]
 R. Conniff,
The Case for a Carbon Tax on Beef,
\emph{The New York Times}, March 17, 2018,
\url{www.nytimes.com/2018/03/17/opinion/sunday/carbon-tax-on-beef.html}
\access{March 18, 2018}
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\end{csmr}
\end{figure}
\figfile{}

\begin{abcd}
\item Check that the price increases
correspond to the carbon emissions for each product.

\item Explain the lengths of the two part bars in the chart on the
  right.

\item Read the article.
\end{abcd}
\end{exx}


\begin{exx}{\untested\needsquestions}
Harry Potter on Broadway
\index{Harry Potter}

https://www.nytimes.com/2018/04/14/theater/harry-potter-broadway.html

Was it a huge increase?
\end{exx}{\untested}


\begin{exx}{\untested\hassolution}
  Counting fraudulent immigration claims.
  \index{immigration}
  \index{Nielsen, Kirstjen}
%AND SEE
%
%\url{www.nytimes.com/2018/06/18/us/politics/nielsen-family-separation-factcheck.html}
%
On June 18, 2018 \theTimes{} reported that
Kirstjen Nielsen, the secretary of homeland security said
``between October and February,
there was a 315 percent increase in the number of undocumented
immigrants 'fraudulently' using 'unaccompanied alien children' to pose
as a family unit in order to enter the United States. ''

In the next paragraph you could read that

\begin{quotation}
The large percentage that Ms. Nielsen cited refers to a sliver of
overall data: During that time frame, there were 191 cases of
fraudulent family claims reported, up from 46 cases for all of 2017,
when more than 303,000 crossing attempts were recorded.%
\begin{csmr}
K. Rogers and E. Sullivan,
Trump Repeats Assertion That Democrats Are to Blame for Separating
Children at Border,
\emph{The New York Times},
June 18. 2018,
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\url{www.nytimes.com/2018/06/18/us/politics/trump-immigration-germany-merkel.html}
\access{June 18, 2018}.
\end{csmr}
\end{quotation}

\begin{sol}
\begin{abcd}
\item Is the increase from 46 to 191 an 315 percent increase?
%
\begin{equation*}
\frac{191}{46} = 4.15
\end{equation*}
so the increase is indeed 315\%.

\item How might Ms. Neilsen have legitimately reported an increase
  more than double
  that 315\%?

\item The 191 fraudulent cases reported represent less than half a
  year. The number for a full year 2018 might end up at about $2
  \times   191 =   382$. How could Ms. Neilsen use that in order to
  report legitimately that the increase was 730\%?

If the number of fraudulent cases was more than twice 191 then
the ratio of current to historical cases would be more than
$2 \times 4.15 = 8.3$ and
thus the increase would be more than 730 percent.

\item What percentage of the crossing attempts in 2017 involved a
  fraudulent family claim?
%
To answer that I need to divide the number of fraudulent claims by the
number of crossing attempts.
\begin{equation*}
\frac{46}{303,000}
= 0.00014
\end{equation*}
which is 14 one-thousandths of a percent.

\item If the number of crossing attempts in 2018 remained the same as
the number in 2017   while the number of fraudulent cases grew to $2
\times 191 = 382$ what would the percentage of fraudulent cases be?

That percentage would be
\begin{equation*}
\frac{382}{303,000}
= 0.00116
\end{equation*}

That's 116  one-thousandths of a percent --- more than 8 times what it
was.

\item What is the increase in fraudulent claims measured in
  \emph{percentage points}?
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That's just
\begin{equation*}
0.00116 - 0.00014 = 0.00101
\end{equation*}
or just about one-onethousandth of a percentage point.
\end{abcd}


\end{sol}
\end{exx}


\begin{exx}{\untested\hassolution}
Finding subjects
\index{Alzheimer's disease}

On July 28, 2018 Gina Kolata reported
in \theTimes{}
on the difficulty finding
subjects for clinical trials of prospective Alzheimer's drugs.

\begin{quotation}
There are more than 100 Alzheimer's studies looking for a whopping
25,000 participants, Mr. Dwyer said.

To begin filling them all, 37.5 million patients in the right age
group would first have to be informed. Ten percent would be referred
to a trial site for screening.

Just 4 percent will move forward with an evaluation, and of these,
just over 17 percent will drop out, given the current rate, leaving
roughly 125,000 to be screened. And with an 80 percent screening
failure rate, that leaves 25,000 participants of the 37.5 million who
were first informed.

The numbers make it clear: There's no way scientists are going to find
25,000 participants for all of the Alzheimer's trials that have been
approved.%
\begin{csmr}
G. Kolata,
For Scientists Racing to Cure Alzheimer's, the Math Is Getting Ugly,
\emph{The New York Times}, July 23, 2018,
\url{www.nytimes.com/2018/07/23/health/alzheimers-treatments-trials.html}
\access{July 23, 2018}
\end{csmr}
\end{quotation}

The second and third paragraphs say that 10 percent of the patients
would be referred for screening and that four percent would move
forward.

It's not clear what that means. The four percent might be four out of
every hundred people referred for screening, or it might be four
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percent and not ten percent of the original 37.5 million.

Which of these interpretations matches Kolata's calculation?

\begin{sol}
  The first interpretation yields
  \begin{equation*}
  0.1 * 0.04 * 0.83 * 0.2 * 37.5 million = 24,900 \approx 25,000
  \end{equation*}
  the second is just
  \begin{equation*}
  0.04 * 0.83 * 0.2 * 37.5 million = 249,000
  \end{equation*}
so the first is what Kolata used. The second is an order of magnitude
too large.
\end{sol}

\end{exx}

\begin{exx}{\untested\hassolution}
Should drivers complain?
\index{electronic toll collection}

In \theGlobe{} on August 8, 2018,
Patrick Marvin, a spokesman for the MassDOT, defended the
Commonwealth's  electronic toll collection system with the quote

\begin{quotation}
The Massachusetts Department of Transportation has processed nearly
900 million transactions since transitioning to All Electronic Tolling
in October 2016 and components of the system are designed to be more
than 99.9\% accurate.%
\begin{csmr}
T. Andersen,
Governor LePage's office defends attack on Mass. toll system for
'harassment' of Maine drivers,
\theGlobe{}, August 7, 2018,
\url{www.bostonglobe.com/metro/2018/08/07/maine-gov-lepage-office-defends-attack-mass-toll-system-for-bu
\access{August 8, 2018}.
\end{csmr}
\end{quotation}

\begin{abcd}
\item About how many toll collection errors were made?
\item Estimate the number of toll collection errors per day.
\item Is that good performance?
\end{abcd}

\begin{sol}
\begin{abcd}

\item About how many toll collection errors were made?

In the worst case the system was just 99.9\% accurate, so 0.001\% of
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the transactions went wrong somehow.

One tenth of one percent of 900 million is 900 thousand.

\item Estimate the number of toll collection errors per day.

The data cover not quite three years, from October 2016 to August
2018. So I'll use 900 days.

That means there were about 1,000 errors per day.

\item Is that good performance?

Well, it depends. A thousand drivers a day complaining about toll
collection malfunction could be pretty annoying for the drivers and
for the Department of Transportation. Perhaps most of the errors go
unnoticed so few complaints are filed.

\end{abcd}
\end{sol}

\end{exx}

\begin{exx}{\untested\hassolution}
Discounts for centenarians

On August 26, 2018 the website \url{www.georgetakei.com}
reported that

\begin{quotation}
Western Montana resident Helen Self just celebrated her 109th
birthday, and she knew exactly where she wanted to celebrate with her
friends and family.

The Montana Club in Missoula offers a special discount for patrons
based on their age; the older you are, the bigger the discount.

For example, a person celebrating their 21st birthday would be
entitled to a 21\% discount.

\ldots

Self didn't go overboard with her order. For her celebratory dinner,
self ordered some shrimp. Her bill wound up earning her around \$1.30.
\begin{csmr}
K. Mochizuki,
109-Year-Old Woman Uses Loophole To Make Restaurant Pay Her To Eat
There On Her Birthday,
August 26, 2018,
\url{www.georgetakei.com/109-year-old-montana-club-2599313319.html?utm_content=inf_10_4221_2&tse_id=INF_
\access{September 9, 2018}.
\end{csmr}
\end{quotation}
\end{exx}
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How much did her meal cost (before the discount)?

\begin{sol}
She earned back 9\% of her bill, so the bill was
\begin{equation*}
\frac{\$1.30}{0.09} \approx \$14.40.
\end{equation*}
\end{sol}

\begin{exx}{\untested\hassolution}
Please pay for the ride.

On December 4, 2018 \theTimes{} reported on fare evasion:

\begin{quotation}
The Metropolitan Transportation Authority expects to lose about \$215
million this year from fare evasion on the subway and buses, officials
said during a presentation to the agency's board. About 208,000 people
ride the subway each day without paying --- nearly 4 percent of all
subway riders during the fourth quarter of this year.

\ldots

Fare evasion on buses is even worse. About 348,000 people take the bus
every day without paying --- about 16 percent of all bus riders.%
\begin{csmr}
E. G. Fitzsimmons,
Fare Evasion Is Skyrocketing on New York City's Subway. Here's Why.
\emph{The New York Times},
December 4, 2018,
\url{www.nytimes.com/2018/12/04/nyregion/fare-evasion-new-york-city-subways.html}
\access{December 4, 2018}.
\end{csmr}
\end{quotation}


\begin{abcd}
\item Use the data in the quotation to estimate the number of daily subway
  and bus passengers in New York.

\item Do your answers to the preceding question make sense?

\item Estimate the average subway and bus fare.

\end{abcd}

\begin{sol}
\begin{abcd}
\item Use the data in the quotation to estimate the number of daily subway
  and bus passengers in New York.

For the subway:
$$
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\frac{208,000 \text{ people}}{0.04} = 5.2 \text{ million people}.
$$

For the bus:
$$
\frac{348,000 \text{ people}}{0.16} = 2.32 \text{ million people}.
$$

\item Do your answers to the preceding question make sense?

New York has about 9 million people. If a third of them take the bus
or subway twice a day to work or school the total ridership would be
about 6 millon. That's the same order of magnitude as the sum of my
answers to the previous questions.

\item Estimate the average subway and bus fare.

The \$215 million yearly loss is from subway and bus riders. That corresponds
to $208,000 + 248,000 = 456,000$ lost fares per day. So the average
fare seems to be
$$
\frac{\$215,000,000 \text{/year}}{456,000 \text{ rides/day}}
\times
\frac{1 \text{ year}}{365 \text{ days}}
\approx
\frac{ \$1.30}{\text{ride}},
$$
which makes sense.


\end{abcd}
\end{sol}

\end{exx}

%WORKING ON THIS WITH BEN
\begin{exx}{\untested\hassolution\sref{percentagepoints}}
  An expensive shutdown.
  \index{government shutdown}

On January 9, 2019 \emph{Politico} reported on the probable cost of a
government shutdown:

\begin{quotation}
Estimates from President Donald Trump's chief economist peg the cost
to the overall U.S. economy at about \$1.2 billion for each week the
shutdown persists. While that's just 0.05 percentage points off the
GDP growth rate, it could be among the factors complicating the
administration's aspiration of reaching sustained 3 percent growth.
\begin{csmr}
V. Guida,
Shutdown's economic damage: \$1 billion a week,
Politico,
January 9, 2019,
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\url{www.politico.com/story/2019/01/09/shutdowns-economic-damage-1-billion-a-week-1071609}
\access{January 10, 2019}.
\end{csmr}
\end{quotation}

\begin{sol}
\begin{abcd}
\item Use the data in this quote to estimate the U.S. GDP.

  Since \$1.2 billion is 0.05\% of the GDP, the GDP is
\begin{equation*}
 \frac{\$1.2 \text{ billion}}{0.0005} = \$2.4 \text{ trillion}
\end{equation*}
but that's off by an order of magnitude.
\end{abcd}
\end{sol}
So the difference is between a growth rate of 3\% per year and 3.05\$
per year. That 0.05\% is \$1.2 billion means the GDP is

\end{exx}


\end{MoreExercises}
 \protect \chapter {Inflation}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{9}
\begin{MoreExercises}{4.8}
\begin{exx}{\hassolution\sref{inflationrate}\gref{cpicalculator}
\gref{adjustforinflation}\gref{reinforcepercentages}}
Holiday Pops.

Adjust the calculations in \exref{HolidayPops} to take into account
inflation from 2009 to 2012.

\begin{sol}
The Bureau of Labor Statistics inflation calculator tells me that the
inflation rate from 2009 to 2012 was 7\%.

Calculating in 2012 dollars, the 2009 Pops revenue of \$4.9m would be
$1.07 \times \$4.9\text{m} = \$5.24\text{m}$. Thus the increase to
\$5.8m was only $5.8/5.24 = 1.106$, or 11\%, not 18\%.

I could have done the calculation without going back to the data,
using the 1+ trick to take inflation into account:
$1.18/1.07 = 1.103$, which corresponds to 10\%. The answer doesn't
match exactly because the 18\% is a rounded figure.

It's wrong to subtract the 7\% from 18\% to get 11\%, even though
that gives the right answer in this case.

The rest of the solution is similar. You fill in the details.

You'll find that ticket prices actually fell, since they went
up by three or four percent when inflation was seven percent.
```

```
\end{sol}
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{14}
\begin{MoreExercises}{4.8}
%\begin{exx}{\untested\routine\artificial\sref{indexraise}}
\begin{exx}{\untested\routine\artificial\sref{indexraise}
\gref{adjustforinflation}\gref{reinforcepercentages}}
When is a raise not a raise?

Your employment contract calls for a 3\% annual raise.  If the
inflation rate is 4.2\%, what is your effective ‘‘raise"?
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{27}
\begin{MoreExercises}{4.8}


\begin{exx}{\needsquestions\sref{minimumwage}
\gref{adjustforinflation}
\gref{verify}\gref{estimate}}
The federal \myindex{minimum wage}.

At
\url{www.peri.umass.edu/fileadmin/pdf/resources/Minimum_Wage_petition_website.pdf}
you can read a July 2013 open letter from dozens of economists
advocating an increase in the federal minimum wageto \$10.50 per hour.

The essay suggests lots of good quantitative reasoning questions:
check their arithmetic, verify their estimates, put their conclusions
in a personal context, \ldots .

\end{exx}

\begin{exx}
{\hassolution\sref{inflationrate}\gref{adjustforinflation}
\gref{reinforcepercentages}}
Kids are expensive.

On June 23, 2012, you could read on  the \emph{Dallas Morning News }
website that

\begin{quotation}
In 1960] the cost of raising a child was just
over \$25,000 for middle-income families. That would be \$191,720 today
when adjusted for inflation.%
\begin{csmr}
Middle-income family spends \$235,000 to raise baby,
\emph{The Dallas Morning News} (June 23, 2012),
\url{www.dallasnews.com/business/headlines/20120623-middle-income-family-spends-235000-to-raise-baby.ece
\access{July 22, 2015}.
\csmrcomment{25 words fair use}
```

```
\end{csmr}
\end{quotation}

\begin{abcd}
\item Use the inflation calculator to check this inflation assertion.

\item Has the cost of raising a child increased faster or slower than
  inflation? Does that question even make sense?

\end{abcd}

\begin{hint}
You will have to think about whether \$190K was enough to raise a child
in 2012.
\end{hint}

\begin{sol}
\begin{abcd}
\item Use the inflation calculator to check this inflation assertion.

The inflation calculator tells me \$193,913.85 for the 2012 value of
\$25,000 in 1960. That's a little larger than the
\$191,720 reported in the newspaper. That article appeared in June, so
maybe I should check the 2011 inflation result. OK, that's
\$189,982.26, which is a little low. Perhaps if I dug deeper I could
find the midyear data and see whether it matches the article, but my
time is worth more than it would take me to do that digging.

\item Has the cost of raising a child increased faster or slower than
  inflation? Does that question even make sense?

There's really no way to answer this question without data about what
expenses were counted in the 1960 report. Even with the data I'd have
to quantify the changes in what one had to buy to raise a kid. And I'd
have to wonder about whether the \$25,000 figure was itself adjusted
for inflation during the 18 years that child was considered a child.

On the whole, I think this kind of article is a headline grabbing
waste of time and energy.
\end{abcd}

\end{sol}
\end{exx}


\begin{exx}{\needsquestions\gref{percentagestrategies}\gref{units}
\gref{adjustforinflation}}
Salvaged silver.

On July 18, 2012 ABC News reported that the Tampa, FL company Odyssey
Marine Exploration, Inc. announced that it had recovered 48 of a
possible 240 tons of silver from the Gairsoppa, a World War II shipwreck.

\begin{quotation}
```

```
The recovery is being made under a contract awarded by the
U.K. government, which will keep 20 percent of the cargo's value,
estimated to be in the tens of millions of dollars. The Gairsoppa
became U.K. property after the government paid the owners of the ship
an insurance sum of \textsterling{}325,000 in 1941. Records indicate
the silver was valued at \textsterling{}600,000 in 1941.%
\begin{csmr}
A. Harish,
48 Tons of Silver Recovered From World War II Shipwreck,
World News reported on ABC News (July 18, 2012),
\url{abcnews.go.com/International/record-setting-silver-recovery-made-world-war-ii/story?id=16806534\#.U
\access{July 22, 2015}.
\csmrcomment{69 words fair use}
\end{csmr}
\end{quotation}

Possible questions:

\begin{abcd*}
\item some routine percentage calculations.
\item value of silver then and now? did it match inflation rate?
\item currency conversion.
\end{abcd*}


\end{exx}


\begin{exx}{\untested\complex\sref{inflationrate}\gref{adjustforinflation}\gref{reinforcepercentages}}
Cutting the Pentagon's budget. \index{Pentagon}

In an August 9, 2010 article in \theTimes{} headlined ``Making Good on
Pledge, Gates Outlines Military Cuts'' you could read than

\begin{quotation}
Mr. Gates is calling for the Pentagon's budget to keep
growing in the
long run at 1 percent a year after inflation, plus the costs of the
war. It has averaged an inflation-adjusted growth rate of 7 percent a
year over the last decade (nearly 12 percent a year without adjusting
for inflation), including the costs of the wars. So far, Mr. Obama has
asked Congress for an increase in total spending next year of 2.2
percent, to \$708 billion --- 6.1 percent higher than the peak under the
Bush administration.%
\begin{csmr}
T. Shanker ande C. Drew,
Pentagon Faces Growing Pressures to Trim Budget,
\theTimes{} (July 22, 2010),
\url{www.nytimes.com/2010/07/23/us/politics/23budget.html}
\access{July 22, 2015}.
93 words. If not fair use I'll delete this question, which appears
\csmrcomment{only in the instructor's manual, not the printed
  text. But I'd like to
keep it.}
```

```
\end{csmr}
\end{quotation}

\begin{abcd*}

\item Make sense of these numbers.

\suspend{abcd*}

Some readers were confused, and said so:

\begin{quotation}
Unless I missed something in this article, there are no
cuts at all if
the overall budget is increasing 1\% above inflation. This is a shell
game. \index{shell game}%
\end{quotation}

\resume{abcd*}

\item What is a shell game?
\index{shell game}
\end{abcd*}

\end{exx}

\begin{exx}{\needsquestions}
Half-pennies.
\index{half-penny}
At
\url{factually.gizmodo.com/the-u-s-killed-the-half-penny-when-it-was-worth-what-a-1639266183}
Alissa Walker wrote an article titled
``The U.S. killed the half-penny when it was worth what a dime is
today''. There you can read that

\begin{quotation}
The half-cent had a short life, as currency goes. It was only produced
by the U.S. Mint from 1793 to 1857. The coins featured the head of a
nameless ``Miss Liberty'' (one of the few females on our currency). At
the time it was first minted, many Americans made about a dollar a
day, and might have been able to purchase a pound of potatoes for 1.5
cents. But as prices went up, the half-cent was quickly proven to be
useless. It was retired, and most of the coins were scrapped for their
copper.

\ldots

According to the Consumer Price Index, the 1857 half-cent would have
been worth 14 whole cents in 2014 dollars.%
\begin{csmr}
A. Walker,
The U.S. killed the half-penny when it was worth what a dime is today,
Factually, September 25, 2014,
\url{factually.gizmodo.com/the-u-s-killed-the-half-penny-when-it-was-worth-what-a-1639266183}
```

```
\access{July 27, 2016}
\end{csmr}
\end{quotation}

\end{exx}

\begin{exx}{\needsquestions}
It all depends on where you live.

The federal government has begun using the data collected to calculate
the Consumer Price Index to report on regional differences in the cost
of various goods and services. They conclude that

\begin{quotation}
The ‘‘real value’’ of a dollar is highest in Mississippi (\$115.30), Arkansas
(\$114.30), Alabama (\$113.90), South Dakota (\$113.60) and Kentucky
(\$112.70). It buys the least in the District of Columbia (\$84.70),
Hawaii, New York (\$86.40), New Jersey (\$87.30), California (\$89) and
Maryland (\$90.70).%
\begin{csmr}
N. Chokshi,
What \$100 Can Buy, State by State,
\emph{The New York Times}, August 8, 2016,
\url{www.nytimes.com/2016/08/09/business/what-100-can-buy-state-by-state.html}
\access{August 13, 2016}.
\end{csmr}
\end{quotation}

There are many more good numbers in the full article.
\end{exx}

\begin{exx}{\untested}
Labor statistics on a diet.

Figure~\ref{fig:laborstatistics} shows the budget for the Bureau of
Labor Statistics for the years 2005-2017.

\figfile{labor-statistics-on-diet.png}
\begin{figure}
\centering
\includegraphics[width=4in]{\thefigurefilename}
\begin{csmr}[
Labor ststistics on a diet\label{fig:laborstatistics}]
Labor ststistics on a diet,
Politico
\url{static.politico.com/9e/14/6859028642f38041b3f926652674/labor-statistics-on-diet.png}
\access{October 15, 2017}.
\csmrcomment{Permission requested}
\end{csmr}
\end{figure}
\figfile{}

\begin{abcd}
\item Is the ‘‘almost 10\% cut’’ since 2010 correct?
```

```
\item Why does the 2010 budget seem to be about seven
  times the 2017 budget? Redraw the graph so that the 10\% drop is
  visible but less dramatic. (A careful sketch will do; later you will
  learn how to draw the graph in Excel.)

\item The numbers in the graph are inflation adjusted. Find out for
  which year the actual budget number appears. (It's probably 2017 but
  may not be.) Then find the actual dollar values for 2010 and 2017
  and calculate the percent change.
\end{abcd}
\end{exx}

\begin{exx}{\untested}

Figure~\ref{fig:baggagefees} shows the increase in airline revenue
from fees charged for checked bags.

\figfile{baggagefees.png}
\begin{figure}
\centering
\includegraphics[width=4in]{\thefigurefilename}
\begin{csmr}[
Fees for checked bags\label{fig:baggagefees}]
America's vanishing triplets,
Politico,
\url{www.politico.com/agenda/story/2017/10/11/5-interesting-datasets-000545?lo=ap_e1}
\access{October 15, 2017}.
\csmrcomment{Permission requested}
\end{csmr}
\end{figure}
\figfile{}

\begin{abcd}

\item Calculate the percent increase in fees collected for checked
  bags between 2000 and 2016.

\item Redo the previous calculation after adjusting for inflation.

\item Measure the height of the colored area for each of the years
  20006, 2008 and 2016. Do the percentage increases in height
  match the percentage increases in fees?

\item What might the wavy top and bottom of the colored area mean?

\end{abcd}

\end{exx}

\begin{exx}{\untested\needsquestions}
Package delivery.
\index{USPS}
\index{Postal Service}
```

```
In a  post at \emph{Politico} in March, 2018, you could find out that

\begin{quotation}
The Postal Service reported delivering fewer than 900 million packages
in 2008, which amounted to \$1.8 billion in revenue. That was a
pittance for the agency, which raked in \$75 billion that year. Come
2017, USPS reported more than 5.7 billion parcels which reaped \$19.5
billion, about 28 percent of USPS' \$65 billion in annual revenue.%
\begin{csmr}
K. Kosar,
What Trump should have said about Amazon and the Post Office,
\emph{Politico}, March 31, 2018,
\url{www.politico.com/agenda/story/2018/03/31/what-trump-should-have-said-about-amazon-and-the-post-offi
\access{February 17, 2019}
\end{csmr}
\end{quotation}

Confirming/understanding order of magnitude of these totals.

Possible questions: percentage changes in cost per package,  in
revenue and in fraction of revenue from package delivery, adjusting
for inflation.

\begin{teacher}
This exercise combines reasoning about percentages, unit costs and
inflation.
\end{teacher}
\end{exx}

\begin{exx}{\untested\needsquestions}
Another old Apple
\index{Apple}

On September 27, 2018 \theGlobe{} reported that

\begin{quotation}
A computer built in the 1970s that helped launch the personal computer
age as well as a trillion-dollar company has sold for \$375,000.%
\begin{csmr}
Associated Press,
Apple computer built in 1970s sells for \$375,000 at auction,
\theGlobe, September 27, 2018,
\url{www.bostonglobe.com/business/2018/09/26/apple-computer-built-sells-for-auction/DHmSyfIPjt1aQiilkv7C
\access{September 27, 2018}.
\end{csmr}
\end{quotation}


\exref{applecomputer} reports on a similar sale earlier. You can read
there that the computer sold for \$666 in

Compare the prices.
```

```
\end{exx}


\end{MoreExercises}
 \protect \chapter {Average Values}
\protect \setcounter {section}{7}
\protect \setcounter {Exc}{1}
\begin{MoreExercises}{5.7}
\begin{exx}{\hassolution\sref{avgtests}\gref{weightedaverage}}
Fundraising.

On October 20, 2011 the Elizabeth Warren campaign provided \theGlobe{}
with the data we used to draw Figure~\ref{fig:warrenfundraising}.
The first bar in the chart shows the total dollar contributions to her
campaign, broken down according to where the money came from
(Massachusetts vs. out of state).  The second bar shows the total
number of donors, broken down the same way.

\figfile{WarrenFundRaising.pdf}
\begin{figure}
\centering
\includegraphics[width=4in]{\thefigurefilename}
\begin{csmr}[Where did the money come from?\label{fig:warrenfundraising}]
Data from M. Arsenault,
Out-of-state donations filling Warren's campaign coffers,
\theGlobe{} (October 20, 2011),
\url{www.bostonglobe.com/metro/2011/10/19/out-state-donations-filling-elizabeth-warren-campaign-coffers/
\access{July 22, 2015}.
\csmrcomment{redrawn from Globe data no permission needed}
\end{csmr}
\end{figure}
\figfile{}

\begin{abcd*}
\item What was the average donation (per donor)?

\item What was the average donation from Massachusetts?

\item What was the average donation from outside Massachusetts?

\item Check that calculating appropriate weighted average of your
  answers in parts (b) and (c) gives the answer you found in (a).

\end{abcd*}

\begin{sol}
\begin{abcd*}
\item What was the average donation (per donor)?

\begin{equation*}
\frac{\$3.14 \text{ million}}{56,131 \text{ donors}}
\approx
\frac{\$56 }{\text{donor}}.
\end{equation*}
```

```
The calculator says 55.9405676 but it's wrong to report the pennies
and fractions of a penny.

\item What was the average donation from Massachusetts?

Before I even do any arithmetic I see that Massachusetts provided
about 30\% of the total from only about 20\% of the donors. That means
the average Massachusetts contribution will have to be more than
$\$56$.

\begin{equation*}
\frac{0.31 \times \$3.14 \text{ million}}{0.21 \times 56,131 \text{ donors}}
\approx
\frac{\$83 }{\text{donor}} .
\end{equation*}

\item What was the average donation from outside Massachusetts?

\begin{equation*}
\frac{0.69 \times \$3.14 \text{ million}}{0.79 \times 56,131 \text{ donors}}
\approx
\frac{\$49 }{\text{donor}}.
\end{equation*}

This is of course smaller than the overall average.

\item Check that calculating appropriate weighted average of your
  answers in parts (b) and (c) gives the answer you found in (a).

When I weight the average contributions by the fraction of donors from
inside and outside Massachusetts I get
\begin{equation*}
0.21 \times \$83 + 0.79 \times \$49 = \$56.
\end{equation*}
That checks.
\end{abcd*}

\end{sol}
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{7}
\protect \setcounter {Exc}{9}
\begin{MoreExercises}{5.7}
\begin{exx}{\hassolution\complex\sref{cpiredux}
\gref{cpi}\gref{weightedaverage}\gref{modifyaverage}}
Regional differences in the CPI.
\index{Consumer Price Index}

We saw in Section~\ref{sec:cpi2006}
that the average 2006-2007
inflation rate for the
%CHANGE Northeast
northeast urban consumer was 2.58\% while the national average was
```

```
2.85\%.

\begin{abcd}
\item Estimate the fraction of the population of
%CHANGE Northeast
the United States that counts as urban in the northeast.

\item Use your estimate to
estimate the average inflation rate for the rest of the country.

\end{abcd}

%\begin{hint}
%Estimate the percentage of the U.S. population that's urban in the
%northeast by treating it as a Fermi problem. Combine reliable data you
%find on the net with some common sense.
%
%When you have that percentage (call it $W$ for the moment) you can
%express the overall average inflation rate of 2.85\% as a weighted
%average of the urban northeast rate (2.58\%) with the weight $W$ and the
%unknown inflation rate for the rest of the country with weight $100\%
%- W$.
%\end{hint}
%
\begin{sol}

\begin{abcd}
\item Estimate the fraction of the population of the United States
that counts as urban in the northeast.

This is hard. I need to worry both about what counts as northeast and
what counts as urban.

Google isn't helping a lot (maybe I'm not searching well.) Here's what
I found out.

Wikipedia lists the top 20 U.S. population centers as of 2008.
(\url{en.wikipedia.org/wiki/Demographics_of_the_United_States}).
Three of those are in the northeast: New York (19 million),
Philadelphia (5.8 million) and Boston (4.5 million). That adds up to
about 30 million. But other reasonably large cities like Providence
and Buffalo aren't counted at all. Not Pittsburgh, either.

A little more searching led me to a list of all the U.S. urban areas,
with their populations in year 2000.
\url{en.wikipedia.org/wiki/List_of_United_States_urban_areas}

There I find (in addition to
New York, Philadelphia and Boston): Pittsburgh (1.7 million), Buffalo
(1 million), Bridgeport Connecticut (0.9 million), Springfield MA and
Albany NY(0.6 million each), and then probably another dozen or so
smaller ones further down the list. I'm getting tired. I will estimate
that these places add another 10 million to my list. So, finally, I
estimate 40 million urban dwellers in the Northeast. Using 300 million
```

```
for the total population (remember we're talking about 2006) I
estimate that about 40 million out of 300 million or 13\% of the
population lived in Northeast urban areas.

\item Use your estimate to
estimate the average inflation rate for the rest of the country.

Let $x$ stand for the unknown average inflation rate in the rest of
the country. 87\% of the population experiences that inflation rate,
while 13\% in the northeast experience 2.58\% inflation. Then I can
compute the overall average inflation rate (which is 2.85\%) as a
weighted average:
\begin{equation*}
0.87x + 0.13 \times 2.58 = 2.85.
\end{equation*}
I will solve this for $x$. Before I do the algebra, I see that the
answer $x$ should be more than 2.85, but, since the $x$ has much more
weight than the 2.58, $x$ will be much closer to 2.85 than 2.58 is.

The algebra tells me
\begin{equation*}
x = \frac{ 2.85 - 0.13 \times 2.58}{0.87} = 2.89034483 \approx
2.89.
\end{equation*}
So the average inflation rate in the rest of the country was 2.89\%
\end{abcd}

\end{sol}
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{7}
\protect \setcounter {Exc}{20}
\begin{MoreExercises}{5.7}

\begin{exx}{\untested\needsquestions\sref{avgtests}\gref{weightedaverage}}
Improving reading skills.
\index{MCAS}

On June 29, 2010 the  \emph{Cape Cod Times} reported that
``Almost half of Massachusetts third-graders are not proficient readers.''

\begin{quotation}
Last year, 65 percent of low-income third grade students
  scored below proficient on the MCAS reading test. And overall, the
  percentage of third-graders receiving below-proficient scores has
  hovered around 40 percent over the last decade.%
\begin{csmr}
Turn the page,
\emph{The Cape Cod Times} (June 29,, 2010),
\url{www.capecodonline.com/apps/pbcs.dll/article?AID=/20100629/OPINION/6290319}
\access{July 22, 2015}.
\end{csmr}
\end{quotation}
```

```
There's a weighted average hidden here.  If we knew either the
percentage of low-income third graders in the population or the
percentage of non-low-income students who scored below
proficient we could find the other percentage.

\end{exx}



\begin{exx}{\hassolution\sref{improvingaverages}\gref{weightedaverage}
\gref{modifyaverage}}
A \myindex{wage freeze}.

\theGlobe{} reported on February 25, 2009 in its ``New England in Brief''
column that

\begin{quotation}
Faculty members at the Boston and Amherst campuses of the
University of Massachusetts have agreed to a three-year contract that
freezes their wages for the current academic year. \ldots The new
contract raises salaries by 1.5 percent in the coming academic year
and 3.5 percent the following year. \ldots At UMass-Amherst, full
professors earn an average of \$117,000 a year. Faculty members earn an
average of \$90,000, according to university data.%
\begin{csmr}
New England in brief,
Some UMass unions agree to wage freeze,
\theGlobe{} (February 25, 2009),
\url{www.boston.com/news/local/massachusetts/articles/2009/02/25/flu_cases_reach_seasonal_high_in_mass/}
\access{July 28, 2015}.
\end{csmr}
\end{quotation}

\begin{abcd}

\item
What was the average Amherst full professor's salary in the
2009-2010 academic year?

\item
What is the percentage increase in faculty salaries over the life of
the contract?

\item There was no raise in 2009, so the salaries then were the same as
they were the year before.
What is the buying power of a faculty member's \$90K salary in
2009, in 2008 dollars?

\item Suppose 30\% of the faculty at Amherst were full professors. What
was the average salary of the other 70\%?

\end{abcd}
```

```
\begin{sol}

\begin{abcd}

\item
What was the average Amherst full professor's salary in the
2009-2010 academic year?

Using the 1+ trick is the fastest way to do the problem: in 2010 the
average UMass-Amherst full professor salary was
$1.015 \times \$117,000 = \$118,755$.

You can also find the answer by figuring out the raise and then adding
it to the base salary.

\item
What is the percentage increase in faculty salaries over the life of
the contract?

To compute the effect of successive raises of 1.5\% and 3.5\% I
multiplied $1.015 \times 1.035 = 1.050525$. The result corresponds to
a raise of 5.0525\%. I know I couldn't just add the two percentage raises
to get 5\%, but the difference in this case is pretty small: just over
\$50 --- a dollar a week --- on a salary of \$100K.

\item There was no raise in 2009, so the salaries then were the same as
they were the year before.
What is the buying power of a faculty member's \$90K salary in
2009, in 2008 dollars?

The inflation calculator tells me \$90K in 2009 was worth
\$90,321 in 2008 dollars. So although there was no raise, professors
were actually a little better off because the economic meltdown that
year led to a little \emph{deflation}.

\item Suppose 30\% of the faculty at Amherst were full professors. What
was the average salary of the other 70\%?

The \$90K average is a weighted average of the salaries of the
full professors (weight 30\%) and that of the rest of the faculty
(weight 70\%). So I need to solve the equation
\begin{equation*}
0.7 x + 0.3 \times \$117K = \$90K
\end{equation*}
for $x$. The answer is about \$78,400.

\end{abcd}

\end{sol}

\end{exx}

\end{MoreExercises}
 \protect \chapter {Income Distribution --- Spreadsheets, Charts, and Statistics}
```

```
\protect \setcounter {section}{12}
\protect \setcounter {Exc}{27}
\begin{MoreExercises}{6.12}
\begin{exx}{\untested}
Income growth.

%Raw data from
%www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=4#reqid=70&step=27&isuri=1&7028=-1&7083=lev
%

On April 26, 2014 \theGlobe{} reported that 2012 per capita income in
Massachusetts grew to \$49,354, up 3.2\% from 2008, after adjusting
for inflation.

\begin{abcd}
\item How much was Massachusetts per capita income in 2008, in 2012
  dollars?

\item How much was Massachusetts per capita income in 2008, in 2008
  dollars?

\item This income figure is an average. Is it a mean, a median or a
  mode? Explain how you know.


\item Estimate the total 2012 income for Massachusetts.

\end{abcd}

\begin{hint}
If you don't know what ``per capita'' means, look it up.
\end{hint}

\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{12}
\protect \setcounter {Exc}{35}
\begin{MoreExercises}{6.12}


\begin{exx}{\untested\sref{mmm}\gref{skew}}
Car and truck prices.

The article on new car and truck prices that we studied in
\sref*{weightsmatter} first asserts that

\begin{quotation}
\ldots
the average price of a new
vehicle in the second quarter [of 2008] fell 2.3 percent from a year
earlier to \$25,632 \dots
\end{quotation}

and later
```

```
\begin{quotation}
The result is the average new vehicle now costs less than
40 percent of an average household's median annual income, the analysts said,
whereas from 1991 to 2007, it would cost more than half of the median
income.%
\begin{csmr}
New car prices fall at fastest rate ever,
Associated Press reported in \theGlobe{} (September 5, 2008)
\url{www.boston.com/business/articles/2008/09/05/new_car_prices_fall_at_fastest_rate_ever}
\access{July 22,, 2015}.
\csmrcomment{Globe, OK}
\end{csmr}
\end{quotation}

Verify as much of this last assertion as you can.
\end{exx}



\begin{exx}{\untested\artificial\sref{barcharts}\gref{excelroutine}
\gref{excelwhatif}\gref{excelchart}}
Enrollments.

The final enrollment report for the past year at an unnamed small
college provided the following information about students:  450
freshmen,  421 sophomores; 400 juniors and
511 seniors.

\begin{abcd*}
\item Create an Excel spreadsheet containing this data.  Label the
columns appropriately.

\item  Ask Excel to calculate the total number of students enrolled
during the past year.  Label this result.

\item  Create a properly labeled bar chart of the student data.

\item  A corrected enrollment report noted that there were 419
juniors.  Make that adjustment in your spreadsheet and check that the
other information (total number of students, bar chart) is correctly
updated.

\item  Using this new information, ask Excel to calculate the
percentage of students who are freshmen, sophomores, juniors and
seniors. Copy and paste so that you type as few formulas as possible.

\item Create a new bar chart displaying the percentages.

\item  Convert your bar chart to a pie chart.

\end{abcd*}
\end{exx}
```

```
\begin{exx}{\untested\artificial\sref{percentiles}\gref{percentiles}}
\myindex{SAT} percentiles.

A student received this notification on his college entrance exam:

\begin{center}
\begin{tabular}{ll}
English Language Arts: & 77th percentile  \\
Mathematics:   & 88th percentile
\end{tabular}
\end{center}

Explain this report in everyday language.

\begin{hint}
Your answer might begin ``More than three quarters of the students
taking this test \ldots''
\end{hint}

\end{exx}

\begin{exx}{\untested\sref{mmm}\gref{excelaverages}}
Comparing the states.

You can do this exercise using Excel, or with properly documented
research. (Your instructor may specify one method or the other.)

\item Find the mean, median and mode for the populations of the 50
states.

\item Display the answers to the previous question on a properly
labeled histogram. Discuss your findings --- is the distribution
skewed?

\item Redo parts (a) and (b) for the areas of the states.

\item Redo parts (a) and (b) for the population densities
(people per square mile).

\end{exx}

\begin{exx}{\needsquestions\sref{marginoferror}\gref{descriptivestatistics}}
Jellybean margin of error.
\index{jellybeans}

\url{andrewgelman.com/2011/08/that_xkcd_carto/}
\index{xkcd}
\end{exx}


\begin{exx}{\untested\sref{averagesfromhistograms}\gref{excelchart}
\gref{weightedaverage}\gref{histograms}\gref{histogramaverages}}
Reputation on \myindex{stack exchange}.
```

```
Stackexchange.com (\url{stackexchange.com}) is a network of online
question and answer websites. Users who post questions and provide
answers earn reputation based on community
feedback. Table~\ref{table:stackexchange} shows the number of users
with reputations in certain ranges on January 6, 2013 for all
stackexchange sites and for
the particular site \url{tex.stackexchange.com/}
where the authors have asked and answered questions about the \TeX{}software
used to prepare the manuscript for \commonsense.


Estimate the mode, median and mean for each distribution. This is
subtle in several ways. The bucket sizes vary. Data at the top and
bottom end of the range are very scarce. Ask about sensitivity to the
assumptions made there about the actual means for the top and bottom
categories.

\begin{table}
\centering
\begin{minipage}{2.3in}
  \centering
\begin{tabular}{rS[table-format=7.0]}
\toprule
Reputation & {Users} \\
\midrule
100,000+ &97 \\
50,000+ &297 \\
25,000+ &938 \\
10,000+ &3,249 \\
5,000+ &6,874 \\
3,000+ &11,150 \\
2,000+ &15,650 \\
1,000+ &24,867 \\
500+ &34,857 \\
200+ &45,107 \\
1+ &1,478,007 \\
\bottomrule
\end{tabular}
\par
All sites
\end{minipage}
\begin{minipage}{2.3in}
  \centering
\begin{tabular}{rS[table-format=5.0]}
\toprule
Reputation & {Users} \\
\midrule
100,000+ &2 \\
50,000+ &14 \\
25,000+ &24 \\
10,000+ &60 \\
5,000+ &91 \\
3,000+ &132 \\
```

```
2,000+ &179 \\
1,000+ &281 \\
500+ &395 \\
200+ &591 \\
1+ &18,417 \\
\bottomrule
\end{tabular}
\par
\TeX --- \LaTeX{}
\end{minipage}
\caption{Stackexchange reputation}
\label{table:stackexchange}
\tablesource{  \url{stackexchange.com/leagues/1/week/stackoverflow/2012-12-30?sort=reputationchange&page
\url{stackexchange.com/leagues/29/week/tex/2012-12-30?sort=reputationchange}
}
\end{table}

\end{exx}

\begin{exx}{\untested\sref{piecharts}\gref{excelchart}}
Deceptive pie charts.
\index{pie chart}

Build the pie chart from \sref*{piecharts}.

\begin{abcd}
\item Experiment with the pie chart features to make it look like the
  managers' salaries are the largest.   You can't actually change the
  data to do this --- you need to use the 3D and other pie chart
  features to make it look like the managers' salaries are
  large. \item  Play around with different types of charts in Excel.
  Find a chart type and an effect (3D, most likely) that really
  distorts the data.
\end{abcd}
\end{exx}



\begin{exx}{\untested\complex\sref{histograms}
\gref{excelchart}\gref{histograms}}
River lengths.

\begin{teacher}
There should be a good Benford's law exercise somewhere, maybe
  here. But spending time on this peculiar phenomenon is probably not
  worth the time it takes away from other more useful topics.
\end{teacher}

At \url{en.wikipedia.org/wiki/List_of_rivers_by_length}
Wikipedia offers a chart of 163 major rivers, organized by length.

\begin{abcd}

\item
```

```
Construct a bar chart with nine categories, using the first digit of
the length of the river to determine the category.

You might expect all the bars to be the same height,
since there are nine possible starting digits. But they're not. In
fact, there are no rivers longer than 6000 km.

The fact that for the short rivers there are more whose length begins
with small digits is an instance of \emindex{Benford's law}. You can
look up more about it if you're curious.

\item Use Excel to create new columns with river lengths measured in
  yards, in feet and in inches. Draw each of those bar charts. Discuss
  what you see.
\end{abcd}

\end{exx}

\begin{exx}{\sref{averagesfromhistograms}
\gref{histogramaverages}\gref{histograms}}
Fight for the Senate (2016).

A graph like the one in Figure~\ref{fig:senate2016}
appeared in Nate Silver's 538 website
on November 7, 2015.\index{Silver, Nate}
The $y$-axis displays the number of seats held by each
party, the $x$-axis the probability of that outcome.

\figfile{538SenatePrediction.png}
\begin{figure}
\centering
\includegraphics[width=3.5in]{\thefigurefilename}
\begin{csmr}[The fight for the Senate\label{fig:senate2016}]
Screen capture,
\url{projects.fivethirtyeight.com/2016-election-forecast/senate/?ex_cid=2016-forecast}
\access{November 7, 2016}.
\end{csmr}
\end{figure}
\figfile{}

Nate Silver constructed this histogram by imagining
(simulating) many thousands of elections and recording the percentage
of time each Democratic/Republican split occurred.
%We estimated the percentages in his chart and entered them
%in the spreadsheet
%\link{Oct31SenateProjection.xlsx} so you don't have to type them
%yourself. (We rounded the really tiny percentages to zero.)
%Use Excel whenever it's most
%convenient for you.
%
\begin{abcd}
\item What is the most likely number of Democratic senators?

\item What number of Democratic senators represents the mode of this
```

```
distribution?

\item What is the probability that there are more than 50
Democratic senators?

\item What number of Democratic senators is the median of this
distribution?

\item If you had the complete list of all Nate Silver's imagined
elections and sorted it by the number of Democratic senators, how many
Democratic Senators would there be in the middle election on that
list?

\item Use Excel to compute the (weighted) average number of Democratic
senators for these imagined elections.

\item What actually happened in the election?

\end{abcd}

\end{exx}

\begin{exx}{\needsquestions}
Boston's payroll.

This histogram appeared in \theGlobe{} on February 14, 2017.

\figfile{Boston14payroll_graphic.jpg}
\begin{figure}
\centering
\includegraphics[width=4in]{\thefigurefilename}
\begin{csmr}[Boston Municipal Payroll\label{fig:bostonpayroll}]
\url{www.bostonglobe.com/metro/2017/02/14/police-detective-tops-boston-payroll-with-total-over/6PaXwTAHZ
\access{February 14, 2017}.
\end{csmr}
\end{figure}
\figfile{}

The raw data are available on the web. There's an anonymized copy
at \link{Boston14Payroll.xlsx}%
\begin{csmr}
City of Boston,
Employee Earnings Report 2014,
\url{data.cityofboston.gov/Finance/Employee-Earnings-Report-2014/4swk-wcg8}
\access{February 21, 2017}.
\end{csmr}.

The histogram and the spreadsheet suggest many possible
questions. Some suggestions:

\begin{abcd}
\item Estimate bar heights from the graphic.

\item Estimate median and mean, with Excel or otherwise.
```

```
\item Discuss how you would report the mode in order to convey the
  most information.

\item Check the estimates of the median and mean by looking at the raw
  data.

\item Check estimates of the bar heights by reconstructing the histogram
  from the raw data.

\end{abcd}
Ask the usual questions: mode, median, mean. Bimodality is
interesting.

\end{exx}

\begin{exx}{\needsquestions}
Votes weighted by IQ.
\index{IQ}
\index{voting}

An answer to the question ‘‘What would be the possible issues with an
IQ based voting system?’’ at
\url{worldbuilding.stackexchange.com/questions/83199/what-would-be-the-possible-issues-with-an-iq-based-
offers this:

\begin{quotation}
If you’re giving everyone exactly as many votes as their IQ --- the
effect on the actual vote doesn’t appear to be very much at all. See
the table in
[Figure~\ref{fig:iqvoting}] for a population of 100 million to
illustrate --- the
vote share for IQ 120 + is slightly higher than with a normal
democracy, but the fact there are exponentially fewer people in these
higher intelligence brackets means that the linear multiplier on their
vote weight has less and less of an effect.
\end{quotation}

The comments are interesting too.

\figfile{IQVoting.png}
\begin{figure}
\centering
\includegraphics[width=4in]{\thefigurefilename}
\begin{csmr}[Votes weighted by IQ\label{fig:iqvoting}]
\url{worldbuilding.stackexchange.com/questions/83199/what-would-be-the-possible-issues-with-an-iq-based-
\access{June 12, 2017}.
\end{csmr}
\end{figure}
\figfile{}

\end{exx}

\begin{exx}{\untested\needsquestions}
```

```
How cold is it really?
\index{wind chill factor}

Figure!\ref{fig:windchill} shows  the National Weather Service
calculation for how cold it feels
in terms of the temperature and the speed of the wind.

The formula there came from research done by
Maurice Bluestein; you can read the story in his obituary at
\url{www.nytimes.com/2017/09/14/science/maurice-bluestein-who-modernized-the-wind-chill-index-dies-at-76

There's a spreadsheet you can play with at \link{windchill.xlsx}.

\theTimes{}
\figfile{windchillchart3.pdf}
\begin{figure}
\centering
\includegraphics[width=4in]{\thefigurefilename}
\begin{csmr}[Calculating the Wind Chill\label{fig:windchill}]
\url{www.nws.noaa.gov/om/cold/wind_chill.shtml}
\access{September 15, 2017}.
\end{csmr}
\end{figure}
\figfile{}


\end{exx}

\begin{exx}{\untested\worthy\needsquestions}
``Average'' household wealth.

On December 8, 2017 you could read in a  Associated Press Report in
\theGlobe{} headlined
``Surging stocks lift US wealth, yet most still trail '07 peak'' that

\begin{quotation}
Surging stock prices and steady increases in home values powered
American household wealth to \$96.9 trillion this fall, the Federal
Reserve said Thursday. The gains, however, aren't widely shared.

\ldots

In 2016, the latest figures available, median household wealth was
still 34 percent below its prerecession, 2007 level. Average household
wealth, meanwhile, fully recovered from the downturn and was 7 percent
higher last year. The average figure is pulled up by very wealthy
families.

While average household wealth reached \$667,600 in 2016, net worth for
the median household was just \$78,100.
\begin{csmr}
C. Rugaber,
``Surging stocks lift US wealth, yet most still trail '07 peak'',
Associated Press,
```

```
\theGlobe, December 8, 2017,
\url{www.bostonglobe.com/business/2017/12/07/surging-stocks-lift-wealth-yet-most-still-trail-peak/DSb0ih
\access{December 8, 2017}.
\end{csmr}
\end{quotation}

Note: There's even enough information here to determine the number of
households - for a sanity check.

Note: Is this a place for a discussion of the difference between
wealth and income?
\end{exx}

\begin{exx}{\untested}
Median age vs. mean age?

On September 9, 2018 Dante Ramos wrote in \theGlobe{} that

\begin{quotation}
According to research by Portland State University in Oregon, the
median age of voters in a Boston mayoral election is 51, more than 14
years older than the average adult in the city.
\begin{csmr}
D. Ramos,
Young voters, claim your power,
\theGlobe, September 9, 2018,
\url{www.bostonglobe.com/opinion/2018/09/07/for-millennials-power-there-for-taking/NITLEtmQtk4Ecubk7Xhoz
\access{September 9, 2018}
\end{csmr}
\end{quotation}
\end{exx}

\begin{abcd}
\item
Why is it correct to use the median age rather than the average (mean)
age in this report?

\item
Why is it better to write ``older than tha average adult'' rather than
``greater than the average adult's age''?

\item Think of a situation where it would be more useful to know that
  mean age rather than the median age.
\end{abcd}
\end{MoreExercises}
 \protect \chapter {Electricity Bills and Income Taxes --- Linear Functions}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{22}
\begin{MoreExercises}{7.8}
\begin{exx}{\untested\sref{taxes}\gref{directproportion}
\gref{linearexcel}\gref{incometax}}
Your total federal tax bill.

Modify the graph in Figure~\ref{fig:effectivetax} to show how total
```

```
tax and the effective tax rate for (income tax + Social Security)
depends on income.

\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{8}
\protect \setcounter {Exc}{38}
\begin{MoreExercises}{7.8}



\begin{exx}{\untested\complex\needsquestions}
Does virtual save energy?

\begin{quotation}
MOST PEOPLE take for granted the Earth-friendly nature of
  electronic communication. Paperless, ink-free, no shipping supplies,
  no gas for transportation: the environmental benefits of virtual
  communication are obvious. But the reality is more complicated, at
  least according to a growing number of concerned technology experts
  and scientists. Vast stockpiles of digital data waste energy, too.

Everyday emails aren't to blame. But large photo and video
attachments, cluttered inboxes, and massive email forwards may
be. Some analysts estimate that emailing a 4.7-megabyte attachment ---
the equivalent of four large digital photos --- can use as much energy
as it takes to boil about 17 kettles of water. The problem is
magnified when large emails are forwarded to many people and left in
inboxes undeleted. As long as emails remain in your inbox, the data
they create is physically stored somewhere.

And that's where the problems arise: The total amount of digital
storage worldwide is approaching 1 zettabyte, or 1 million times the
contents of the Earth's largest library. Currently, that information
is archived on equipment with a mass equivalent to 20 percent of
Manhattan. Global data storage is expected to reach 35 zettabytes by
2020, which means more equipment, land, and energy. The information
industry already accounts for approximately 2 percent of global carbon
dioxide emissions. That's the same amount as the airline industry
blasts into the atmosphere. Coupled with the rapid increase in stored
data, it's an unsustainable scenario.

Technology firms must create systems that store data with less energy,
and governments should provide incentives for them to do so. Just as
important, consumers must demand products that save energy, and use
websites like Flickr and MediaFire that allow them to share large
files without emailing. Better still, they could consider keeping some
of those embarrassing photos and home videos to themselves.%
\begin{csmr}
Don't forward those photos
\theGlobe{} (September 7, 2010),
\url{www.boston.com/bostonglobe/editorial_opinion/editorials/articles/2010/09/07/dont_forward_those_phot
\access{July 23, 2015}.
\csmrcomment{This is a really long quote with lots of numbers, no
```

```
  questions yet. Since we have blanket permission from the Globe for
  this kind of material, we can quote it here.}
\end{csmr}
\end{quotation}

\end{exx}

\begin{exx}{\untested\needsquestions}
Green gas?

Robert Bryce's op-ed in \theTimes{} on
June 7, 2011
(\url{www.nytimes.com/2011/06/08/opinion/08bryce.html})
has lots of interesting numbers about the costs in steel and land area
for solar and wind electricity generation.

\end{exx}

\begin{exx}{\untested\needsquestions}
Every little bit counts.

On March 5, 2012 \theGlobe{} reported on the
Ocean Renewable Power Company's plans to install tidal powered
generators in Maine:
\index{tidal power}

\begin{quotation}
The first unit capable of powering 20 to 25 homes will be
hooked up to
the grid this summer, and four more units will be installed next year
at a total cost of \$21 million \ldots

Eventually, Ocean Renewable hopes to install more units to bring its
electrical output to 4 megawatts.%
\begin{csmr}
D. Sharp,
Maine company ready to install tidal power unit,
Associated Press reported in \theGlobe{}  (March 05, 2012),
\url{www.bostonglobe.com/business/2012/03/05/maine-company-ready-install-tidal-power-unit/daJ3ivfrUNUnHe
\access{July 23, 2015}.
\csmrcomment{Globe so OK}
\end{csmr}
\end{quotation}

\end{exx}


\begin{exx}{\hassolution\artificial\sref{comparelinear}\gref{linearfunctions}\gref{slopeintercept}}
Compact fluorescent bulbs.

Consumers are being encouraged to replace ordinary light bulbs
with compact fluorescent bulbs.\index{compact fluorescent bulb}
(CFLs). Soon they will be required to.
```

```
(This exercise should be updated to discuss LED bulbs too, and to use
real rather than invented numbers.)

A CFL uses less energy than an ordinary
incandescent bulb that produces the same amount of light, but it costs
more to buy. This table provides data with which you can
compare the two.

\begin{center}
\begin{tabular}{ccc}
\toprule
bulb & initial cost & power \\
\midrule
ordinary & \$2.00 & 100 watts \\
CFL & \$9.00 & 25 watts \\
\bottomrule
\end{tabular}
\end{center}

Suppose electricity costs \$0.20 per kwh.

You can use pencil and paper, a calculator or Excel to do the
arithmetic.

\begin{abcd}

\item Write a linear equation with which you can calculate the total
cost $C$ of using the ordinary bulb for $H$ hours.

\item What is the slope of that equation (with its units)?

\item What is the intercept of that equation (with its units)?

\item How much would it cost to buy the ordinary bulb and use it for
1000 hours?

\item Write a linear equation with which you can calculate the total
cost $C$ of using the CFL for $H$ hours.

\item How much would it cost to buy the CFL and use it for
1000 hours?

\item How long would you have to use the CFL to make it worth having
paid the higher purchase price?
\end{abcd}

\item Are the five numbers given in this exercise reasonable?

\item What does ``incandescent'' mean? Why are incandescent light
bulbs called that?

\begin{sol}
```

```
\begin{abcd}
\item Write a linear equation with which you can calculate the total
cost $C$ of using the ordinary bulb for $H$ hours.

\begin{equation*}
C = 2.00 + 0.1\times 0.20 H .
\end{equation*}
\item What is the slope of that equation (with its units)?

The slope is 0.02 \$/hour, or 2 cents/hour.

\item What is the intercept of that equation (with its units)?

The intercept is \$2.00.

\item How much would it cost to buy the ordinary bulb and use it for
1000 hours?
\begin{equation*}
C = \$2.00 + 0.02 \frac{\$}{\text{hour}}\times 1000 \text{ hours}
= \$22.00.
\end{equation*}
\item Write a linear equation with which you can calculate the total
cost $C$ of using the CFL for $H$ hours.

\begin{equation*}
C = 9.00 + 0.025\times 0.20 H .
\end{equation*}

\item How much would it cost to buy the CFL and use it for
1000 hours?

\begin{equation*}
C = \$9.00 + 0.005 \frac{\$}{\text{hour}}\times 1000 \text{ hours }
= \$14.00.
\end{equation*}

\item How long would you have to use the CFL to make it worth having
paid the higher purchase price?

From my previous work, the answer will be less than 1000 hours. I can
find the exact time by algebra or by trial and error. It turns out to
be 467 or about 500 hours. That makes sense --- the CFL costs a penny
and a half less per hour to run, which means it will take about 500
hours to save the \$7 difference in initial cost.

\item Are the five numbers given in this exercise reasonable?

Waiting for student input.

\item What does ``incandescent'' mean? Why are incandescent light
bulbs called that?

``Incandescent'' means
``giving off light because it's hot''. That's just how ordinary old
```

```
fashioned light bulbs work. There's a thin filament (wire) inside that
heats up and glows.

\end{abcd}

\end{sol}

\end{exx}


\begin{exx}{\untested\hassolution\sref{energypower}\gref{energyandpower}}
Not flying to London.

In \theTimes{} on April 25, 2011 you could read that

\begin{quotation}
You can save so much energy by not flying to London [to collaborate
  with a coworker] that it will run a rack of computers for a year.%
\begin{csmr}
J. Markoff,
Digging Deeper, Seeing Farther: Supercomputers Alter Science,
\theTimes{} (April 25, 2011),
\url{www.nytimes.com/2011/04/26/science/26planetarium.html}
\access{July 23, 2015}.
\csmrcomment{22 words fair use}
\end{csmr}
\end{quotation}

Estimate the energy costs of flying to London and running a rack of
computers for a year to see if they are of the same order of
magnitude.

\begin{hint}
If you're a physicist you can make these estimates with your common
knowledge. If you're not, you can put together reliable information
from the web. Try searching for the energy cost of flying an airplane
and the energy cost of running a computer.
\end{hint}
\begin{sol}
From \url{www.inference.phy.cam.ac.uk/withouthotair/c5/page_35.shtml}:

\begin{quotation}
Imagine that you make one intercontinental trip per year by plane. How
much energy does that cost?

A Boeing 747-400 with 240,000 litres of fuel carries 416 passengers
about 8,800 miles (14,000 km). And fuel's calorific value is 10 kwh
per litre. (We learned that in Chapter 3.) So the energy cost of one
full-distance roundtrip on such a plane, if divided equally among the
passengers, is
\begin{equation*}
\frac{2 \times 240,000 \text{ litre}}{416 \text{ passengers}}
  \times 10 \text{ kwh/litre} \approx  12,000 \text{ kwh per passenger}.
\end{equation*}
```

```
If you make one such trip per year, then your average energy consumption
per day is
\begin{equation*}
\frac{12,000 \text{ kwh}}{365 {\text{ days}}}
\approx  33 \text{ kwh/day}.
\end{equation*}
\end{quotation}

The round trip airline distance from Boston to London is about 6,500
miles, so that trip will cost somewhat less than the trip above,
figure 24 kwh/day.

At (say) 100 watts to run a computer (that's the right order of
magnitude) you use about 2,400 watt-hours or 2.4 kwh in a day. So 24
kwh will power ten computers for a day. That's a pretty small
rack, but the order of magnitude is right.

\end{sol}
\end{exx}

\begin{exx}{\hassolution}
Express lane?

In \theGlobe{} on November 27, 2015 you could read that

\begin{quotation}
Amid the holiday grocery shopping madness, every
line feels like the wrong one. And yet, some are wronger than
others. Given equally capable cashiers, you are often better off
bypassing the express lane. Research conducted at a large, unnamed,
California grocery store found that while each item adds 3 seconds to
the check-out time, it takes 41 seconds for a person to move through
the line even before their items are added to the tally. Bottom line:
The big time-consumers are not the items, but the small talk and the
paying, says Dan Meyer, who has a doctorate in math education from
Stanford University.
\begin{csmr}
B. Teitel,
17 holiday blunders (and how to avoid them),
\theGlobe{}, November 27, 2015,
\url{www.bostonglobe.com/lifestyle/2015/11/27/the-mistakes-you-make-this-holiday-season-and-how-avoid-th
\access{November 30, 2015}.
\end{csmr}
\end{quotation}

Suppose you have 10 items in your cart, so you are allowed to use the
express lane. How much longer must the line there be (compared to the
regular lane) to make the wait in the regular lane less?

\begin{hint}
The answer depends one the relative lengths of the lines, not on the
absolute difference in the lengths.
\end{hint}
```

```
You can answer that question with any strategy that makes sense
to you, as long as you explain what you're thinking. If you need a
starting place, one way is to follow these steps:

\begin{abcd}
\item Write the linear equation showing
  how the time it takes a shopper to check out depends on the number
  of items in her cart. What are the slope and intercept, with their
  units?

\item Suppose shoppers in the express lane buy 6 items (on
  average), while those in the regular lane buy about 20.
Write a linear equation for each line  showing your waiting time
depends on the number of shoppers ahead of you.


\item Now work on the main question --- which line should you join
  when you have 10 items in your cart? How much longer must the
  express lane line be to make the wait on the regular lane line less?

\end{abcd}

\begin{sol}


\begin{abcd}
\item Write the linear equations showing
  how the time it takes a   shopper to check out depends on the number
  of items in her cart. What are the slope and intercept, with their
  units?

Let $T$ be the time (in seconds) and $I$ the number of items in the
cart. Then the equation for checkout time is
%
\begin{equation*}
T = 3I + 41 .
\end{equation*}

The slope is 3 seconds/item and the intercept is 41 seconds.

\item Suppose shoppers in the express line buy 6 items (on
  average), while those in the regular line buy about 20.
Write the linear equations showing your waiting time in each
  line depends on the number of shoppers ahead of you.

Using my answer to (a) I see that I will have to wait
3*6 + 41 = 59 seconds for each customer ahead of me in the express
line, so
%
\begin{equation*}
W = 59C ,
\end{equation*}
%
where $W$ is the waiting time in seconds and $C$ is the number of
```

```
customers ahead of me. The slope is 59 seconds per customer. The
intercept is 0 since if I'm first in line there's no wait.

The equation for the regular line has slope
3*20 + 41 = 101 seconds per customer:
%
\begin{equation*}
W = 101C .
\end{equation*}

\item Now work on the main question --- which line should you join
  when you have 10 items in your cart? How much longer must the
  express line be to make the wait on the regular line less?

My first thought is that the single seconds in 59 and 101 are a
distraction, and I will approximate them by 60 and 100 seconds. That
means the wait behind 5 customers on the regular line is the same as
the wait behind 3 customers on the express line --- 300 seconds (5
minutes). To decide which line to join I would mentally
count the customers in groups of 5 in the express
line and groups of 3 in the regular line.

With arithmetic: if the number of customers on the
express line is more than 5/3 = 1.7 times the number of customers on
the regular line, it's better to wait on the regular line.

I can reach the same answer with algebra. Let $R$ be the humber of
customers on the regular line and $E$ the number on the express
line. Then I want the regular line when
%
\begin{equation*}
61E > 101R
\end{equation*}
which is the same as
\begin{equation*}
E > \frac{101R}{61} = \frac{101}{81}R \approx 1.7 R.
\end{equation*}
%\end{hint}
\end{abcd}

\end{sol}

\end{exx}

\begin{exx}{\untested}
LED lightbulb.

Figure~\ref{fig:ledbulb} shows the specifications for an LED bulb that
costs \$11.00. It's meant to replace a 60 watt incandescent bulb that
costs about a dollar.

\figfile{ledbulb.png}
\begin{figure}
\centering
```

```
\framebox{
  \includegraphics[width=4in]{\thefigurefilename}
}
\caption{Light bulb specs}
\label{fig:ledbulb}
\end{figure}
\figfile{}

\begin{abcd}
\item Check the claimed Estimated Yearly Energy Cost.

\item Check that the Rated Life agrees with the claimed 22.8 year
  Life.

\item How long will it take for the LED bulb to be cheaper overall
  than the incandescent bulb
  (counting both the initial cost and the cost of the electricity to
  run it) ?

\item What does the acronym ``LPW'' stand for? Has it been computed
  correctly?

\item What do the words ``LED'' and ``incandescent'' mean?

\end{abcd}

\end{exx}

\begin{exx}{\hassolution}
Kilowatt hours per day.

Professor Sir David Mackay's
\index{MacKay, David}
obituary in \emph{The Telegraph} observed that

\begin{quotation}
  [His] genius was to express all
forms of power consumption and production in a single unit of
measurement --- kilowatt hours per day (kWh/d). A 40 watt lightbulb,
kept switched on all the time, uses one kWh/d, while driving the
average car 50km a day consumes 40 kWh/d.
\begin{csmr}
Professor Sir David MacKay, physicist --- obituary,
\emph{The Telegraph}, April 15, 2016,
\url{www.telegraph.co.uk/obituaries/2016/04/15/professor-sir-david-mackay-physicist--obituary/}
\access{May 1, 2016}.
\end{csmr}
\end{quotation}

\begin{abcd}

\item Confirm that keeping a 40 watt lightbulb left switched on all
  day would use 1 kilowatt hour of energy.
```

```
\item According to MacKay, ``The amount of energy saved by switching off
  the phone charger [for a day] is exactly the same as the energy used
  by driving an average car for one second.'' How many people would
  have to switch of their cell phone chargers in a day to save as much
  energy as driving a car 50 km?

\item Mackay claims that switching your cell phone charger off for
  one year saves as much  energy as is needed for one hot bath. How
  many kilowatt hours per day does it take to heat that bath water?
  water?

\item What did MacKay mean when he stated that gestures like turning
  of your cell phone charger were akin to ``bailing out the Titanic
  with a teaspoon''? Do you agree?

\end{abcd}

\begin{sol}
\begin{abcd}

\item Confirm that keeping a 40 watt lightbulb left switched on all
  day would use 1 kilowatt hour of energy.

\begin{equation*}
40 \text{ watts} \times 24 \text{ hours} = 960 \text{ watt-hours}
\approx 1 \text{ kilowatt-hour}.
\end{equation*}

\item According to MacKay, ``The amount of energy saved by switching off
  the phone charger [for a day] is exactly the same as the energy used
  by driving an average car for one second.'' How many people would
  have to switch of their cell phone chargers in a day to save as much
  energy as driving a car 50 km?

I know from the quote that it takes one kilowatt-hour to drive a car 50
km. To figure out how much energy it takes to drive it for one second
I need to estimate the speed of the car. To make the arithmetic easy
I'll assume it's driving 50 km/hour (about 30 miles/hour). So the car
needs 1 kilowatt-hour to drive for an hour.

MacKay says that each phone charger's energy savings could drive the
car for a second, so it would take turning about 3,600 of them off for
a day to save the energy to drive the car 50 km.

\item MacKay claims that switching your cell phone charger off for
  one year saves as much  energy as is needed for one hot bath. How
  many kilowatt-hours of energy does it take to heat that bath water?

Switching off the cell phone charger for a day saves 1/3,600 of a
kilowatt-hour. Multiplying by (approximately) 360 days per year leads
to a savings of 0.1 kilowatt-hours. So that's how much energy it takes
to heat the bath water.

\item What did MacKay mean when he stated that gestures like turning
```

```
  of your cell phone charger were akin to ‘‘bailing out the Titanic
  with a teaspoon’’? Do you agree?

He means that the gesture is just a gesture, and won’t make any
difference when it comes to solving the real problem --- saving the
titanic or conserving energy. I agree with the conclusion. I do wonder
if he thought about this quantitatively --- how many people with
teaspoons would it take to bail out the Titanic?
\end{abcd}

\end{sol}

\end{exx}

\begin{exx}{\needsquestions}
The Rosenfeld.
\index{Rosenfeld, Robert}

From \theTimes{} January 27 obituary of physicist Arthur Rosenfeld:
\begin{quotation}
[In 2010] a group of scientists proposed a unit of measurement
in his name. The ‘‘Rosenfeld,’’ they said, should refer to annual
electricity savings of three billion kilowatt-hours --- enough to
eliminate the need for a coal plant.
\begin{csmr}
K. Galbraith,
Arthur Rosenfeld, Zealous Champion of Energy Efficiency, Dies at 90,
\emph{The New York Times}, January 27, 2017,
\url{www.nytimes.com/2017/01/27/science/arthur-rosenfeld-dead-energy-efficiency.html}
\access{February 8, 2017}.
\end{csmr}
\end{quotation}

\end{exx}

\begin{exx}{\untested\needsquestions}
Fuel economy in square meters?

\url{physics.stackexchange.com/questions/325733/why-can-fuel-economy-be-measured-in-square-meters}

\begin{quotation}
The fact that the gallon (or liter) is a volume is really
irrelevant. What we’re really measuring is distance per energy
unit. It’s just handy that all kinds of gasoline have pretty close to
the same energy content for a given volume (about 32.8 kWh/gal, per
Google), and technology/commerce makes it convenient to measure \&{} sell
liquids by volume. (But other liquid fuels, say ethanol or diesel,
have kWh/volume, so we get different mpg from them.) So plug in the
kWh/gal figure into your math, and get miles/kWh :-)
\end{quotation}

And of course

\url{what-if.xkcd.com/11/}
```

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\index{xkcd}

\end{exx}

\begin{exx}{\needsquestions\worthy}
Home solar power.
\index{solar power}
From \theGlobe{} on May 28, 2017:

\begin{quotation}
The median price per watt of capacity for systems financed through the
Mass Solar Loan Program is \$4, and the median installation size is 8.1
kilowatts. Those numbers suggest a new solar system could easily run
more than \$30,000.

Fortunately, several programs can help defray the costs. Federal tax
incentives allow you to take a credit worth 30 percent of the cost of
the installation. Massachusetts also offers a tax credit of 15 percent
of the remaining cost after the federal incentive has been subtracted,
with a maximum value of \$1,000.

Together, these credits could reduce the cost of a \$30,000 system to
roughly \$20,000 --- still a pretty hefty total.%
\begin{csmr}
S. Shemkus,
Home solar power becomes a brighter prospect for many,
\theGlobe{}, May 28, 2017,
\url{www.bostonglobe.com/business/2017/05/28/shedding-light-home-solar-systems/2eZClXIj20e36yha8v2dwN/st
\access{June 1, 2017}.
\end{csmr}

\end{quotation}
\end{exx}

\begin{exx}{\untested\needsquestions}
What does a butcoin cost?
\index{bitcoin}

On January 22, 2018 you could read in \theTimes{} that

\begin{quotation}
\ldots the computer power needed to create each digital token consumes at
least as much electricity as the average American household burns
through in two years \ldots%
\begin{csmr}
N. Popperjan,
There Is Nothing Virtual About Bitcoin's Energy Appetite,
\emph{The New York Times},
January 21, 2018,
\url{www.nytimes.com/2018/01/21/technology/bitcoin-mining-energy-consumption.html}
\access{January 22, 2018}
\end{csmr}
\end{quotation}
```

```
There are more question opportunities later in the article.
\end{exx}

\begin{exx}{\untested\needsquestions}
What is fair?
\index{fair}
\index{Zuckerberg, Mark}
\index{parking ticket}

In March 2018
\theTimes{} published an opinion piece headlined
``A Billionaire and a Nurse Shouldn't Pay the Same Fine for Speeding''

\begin{quotation}
If Mark Zuckerberg and a janitor who works at Facebook's headquarters
each received a speeding ticket while driving home from work, they'd
each owe the government the same amount of money. Mr. Zuckerberg
wouldn't bat an eye.

The janitor is another story.

For people living on the economic margins, even minor offenses can
impose crushing financial obligations, trapping them in a cycle of
debt and incarceration for nonpayment. In Ferguson, Mo., for example,
a single \$151 parking violation sent a black woman struggling with
homelessness into a seven-year odyssey of court appearances, arrest
warrants and jail time connected to her inability to pay. %
\begin{csmr}
A. Schierenbeck
A Billionaire and a Nurse Shouldn't Pay the Same Fine for Speeding,
\emph{The New York Times}, March  15, 2018,
\url{www.nytimes.com/2018/03/15/opinion/flat-fines-wealthy-poor.html}
\access{March 17, 2018}.
\end{csmr}

Read the article and the reader's comments. If you were to post a
comment at the website what would you say? You might consider
comparing the fine structure to the graduated income tax.
\end{quotation}
\end{exx}


\begin{exx}{\untested\needsquestions}
Capturing fog.\index{fog}

On June 7, 2018 \theGlobe{} reported on an MIT project to capture the
water in fog.

\begin{quotation}
Varanasi said a typical 600-megawatt power plant consumes as much
water annually as a city of 100,000 people, losing 750 million gallons
to the air, 20 to 30 percent of which would be fog droplets.

Varanasi envisions his system capturing 150 million gallons from the
```

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hypothetical plant. Varanasi didn't go into the details of what the
system installation and operation would cost but said it would need
just \$10,000 in electricity to run.%
\begin{csmr}
M. Finucane,
MIT says new system captures water in fog,
\theGlobe, June 8, 2018,
\url{www.bostonglobe.com/metro/2018/06/08/mit-says-new-system-could-someday-allow-people-have-nice-cold-
\access{June 16, 2018}
\end{csmr}
\end{quotation}

\begin{abcd}
\item Estimate or search to find out how much water 100,000 people use
  annually.

At their website \url{water.usgs.gov/edu/qa-home-percapita.html} the
  USGS says that  ``Estimates vary, but each person uses about 80-100
  gallons of water   per day.''

  Calculating with 350 days per year 100,000 people use between
  2.8 and 3.5 billion gallons per year.

\item What fraction of the water consumed by the power plant is lost?

 750 million is one fourth of 3.5 billion, so about 25 percent of the
 water is lost.

 I wonder where the other $3/4$ goes.

\item What fraction of the lost water would this system capture?

  150 million is one fifth of 750 million.

\item What is the cost in electricity to capture one gallon of the
  water?

  \begin{equation*}
    \frac{\$10,000}{150 \times 10^6 \text{ gallons}}
         =
         0.00007 \frac{\$}{\text{gallon}}
\end{equation*}
\end{abcd}
\end{exx}
\end{MoreExercises}
 \protect \chapter {Climate Change --- Linear Models}
\protect \setcounter {section}{5}
\protect \setcounter {Exc}{18}
\begin{MoreExercises}{8.5}

%\begin{exx}{\untested\sref{climatechange}\gref{regression}}
%Visiting the White House.
%\index{White House}
%
```

```
%On April 15 2012 \theTimes{} published
%Figure~\ref{fig:VisitWhiteHouseNYTimesChart.jpg}
%
%\begin{figure}
%\centering
%\includegraphics[height=60mm]{\here/VisitWhiteHouseNYTimesChart.jpg}
%\caption{Odds of an invitation to the White House}
%\label{fig:VisitWhiteHouseNYTimesChart.jpg}
%\figsource{
%\url{www.nytimes.com/2012/04/15/us/politics/white-house-doors-open-for-big-donors.html}}
%\end{figure}
%
%Fit a linear trendline to this data to predict the size of donation
%that would guarantee an invitation to visit the White House.
%
%You can do this with a ruler and get a good-enough approximate
%answer. No need to put the data into Excel.
%\end{exx}
%

\begin{exx}{\untested\needsquestions}
Heart attack risk
\index{heart attack risk}

At the website
\url{my.americanheart.org/professional/StatementsGuidelines/Prevention-Guidelines_UCM_457698_SubHomePage
you can download a spreadsheet with which to predict your risk of a
heart attack. You fill in some values (like your age, blood pressure
and cholesterol count) and the spreadsheet tells you your risk.

There's a local copy at \link{HeartAttackRiskEstimator.xls}.

The formulas it uses are hidden, but you can figure out something
about them by experimenting.

For example, try filling in all the fields, then vary the total
cholesterol count while keeping all the other values the same.
Record the results in another spreadsheet, and produce a graph showing
how risk depends on that variable. Is it linear? Approximately linear?

Do the same for some of the other variables.

\end{exx}

\begin{exx}{\untested\needsquestions}
R\&D grants boost patents.

Figure!\ref{fig:randdpatents} shows a regression line
\figfile{RandDvsPatents.png}
\begin{figure}
\centering
\includegraphics[width=4in]{\thefigurefilename}
\begin{csmr}[Tax incentives for reearch.\label{fig:randdpatents}]
A. Dechezlepr\^{e}tre \emph{et. al.}
```

```
Do Tax Incentives for Research Increase Firm Innovation?,
NBER Working Paper 22405,
\emph{The NBER Digest} (National Bureau of Economic Research),
September, 2016,
\url{http://www.nber.org/digest/sep16/sep16.pdf}
\access{March 17, 2017}.
\end{csmr}
\end{figure}
\figfile{}

Are these regression lines convincing? The authors think not, but draw
them anyway.

\end{exx}

\begin{exx}{\needsquestions}
Prediction is hard.

On April 14, 2017 \theTimes{} presented the graphs in
Figure~\ref{fig:fourtrends} after offering readers the opportunity to
predict what they would look like given only the date up to 1990.

\figfile{fourtrends.png}
\begin{figure}
\centering
\includegraphics[width=4in]{\thefigurefilename}
\begin{csmr}[Four trends.\label{fig:fourtrends}]
J. Katz,
You Draw It: Just How Bad Is the Drug Overdose Epidemic?,
\emph{The New York Times}, April 14, 2017,
\url{www.nytimes.com/interactive/2017/04/14/upshot/drug-overdose-epidemic-you-draw-it.html}
\access{April 15, 2017}.
\end{csmr}
\end{figure}
\figfile{}

This quote is particularly telling:

\begin{quotation}
In 2015, more Americans died from drug overdoses than from car
accidents and gun homicides combined.
\end{quotation}

\end{exx}
\begin{exx}{\untested\complex\hassolution}
Project gigaton.
\index{project gigaton}
\index{greenhouse gas}

Fred Krupp, the president of the Environmental Defense Fund, wrote
about industrial initiatives to reduce carbon dioxide emissions:

\begin{quotation}
With Project Gigaton, Walmart and its suppliers are committing to a
```

```
``moon shot'' goal --- removing a gigaton of greenhouse gas emissions from
the company's global supply chain by 2030. That's more than the annual
emissions of Germany. It's the equivalent of taking 211 million cars
off the road every year. In a word, it's transformational.
\begin{csmr}
F. Krupp,
Upping The Ante On Corporate Climate Leadership --- By A Gigaton,
\emph{Forbes},
April 21, 2017,
\url{www.forbes.com/sites/edfenergyexchange/2017/04/19/upping-the-ante-on-corporate-climate-leadership-b
\access{April 21, 2017}.
\end{csmr}
\end{quotation}

The EPA says

\begin{quotation}
A typical passenger vehicle emits about 4.7 metric tons of carbon
dioxide per year. This assumes the average gasoline vehicle on the
road today has a fuel economy of about 21.6 miles per gallon and
drives around 11,400 miles per year. Every gallon of gasoline burned
creates about 8,887 grams of \cotwo{}.
\url{www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle-0}
\end{quotation}

\begin{abcd}
\item Check that the two quotations agree about the amount of
  carbon dioxide emitted the average gasoline vehicle emits in a year.

\item Where do you think Mr. Krupp got his 211 million  car estimate?
  Critique it.

\item Estimate, or look up, the number of cars on the road in the
  United States. Compare that number to the 211 million that the
  gigaton project would take off the road. What does your comparison
  tell you?

\item If you know some chemistry, figure out how much carbon there is
  in a gallon of gasoline.

\end{abcd}

\begin{sol}
\begin{abcd}
\item Check that the two quotations agree about the amount of
  carbon dioxide emitted the average gasoline vehicle emits in a year.

``Giga'' is $10^9$, or one billion.
I divided 1 billion tons of emissions per year by 211 million cars to
get 4.7 tons of emissions per car per year.

\item Where do you think Mr. Krupp got his 211.   car estimate?
  Critique it.
```

```
I suspect Krupp looked up the emissions figure at this EPA site
and divided:
\begin{equation*}
\frac{10^9 \text{ metric tons}}{4.7 \text{ metric tons per car}}
= 212765957.447 \text{ cars}.
\end{equation*}

Of course those fractions of cars are nonsense. This should be rounded.
I don't know why Krupp has 211 million rather
than 213 million, but even that much precision is too much. Since
all you know is one significant digit in ``1 gigaton'' a better
estimate would be ``about 200 million cars''.

\item Estimate, or look up, the number of cars on the road in the
  United States. Compare that number to the 211 million that the
  gigaton project would take off the road. What does your comparison
  tell you?

At
\url{en.wikipedia.org/wiki/Passenger\_vehicles\_in\_the\_United\_States\#Total\_number\_of\_vehicles} Wi
\begin{quotation}
According to the Bureau of Transportation Statistics for 2012, there
were 254,639,386 registered vehicles. Of these, 183,171,882 were
classified as ``Light duty vehicle, short wheel base,'' \ldots
\end{quotation}

That suggests that the 211 million cars the project would take off the
road is just about all the cars! Something is wrong!

Perhaps it's the ``per year'' that's the problem. The gigaton project
hopes to prevent that much carbon dioxide emission between now and 13
years from now. If you want to count those savings in ``cars off the
road per year'' you should divide the 211 milion by 13 years. That'ss
till a pretty big saving: about 10\% of the emissions caused by cars.

\item If you know some chemistry, figure out how much carbon there is
  in a gallon of gasoline.

The EPA says that burning a gallon of gasoline creates about 8900
grams of \cotwo{}. That molecule contains two oxygen atoms with atomic
weight 16 and one carbon atom with atomic weight 12, so the amount of
carbon in that much \cotwo{} is $(12/44)\times 8900 = 2400$ grams, so
about 2.4 kg.

\end{abcd}

The link at \url{www.chargepoint.com/files/420f05004.pdf} has slightly
different numbers for lots of these quantities. It's dated 2005. The
chemistry hasn't changed since then, but fuel economy has, and so may
the carbon content of gasoline.
\end{sol}
\end{exx}

\end{MoreExercises}
```

```
 \protect \chapter {Compound Interest --- Exponential Growth}
\protect \setcounter {section}{7}
\protect \setcounter {Exc}{36}
\begin{MoreExercises}{9.7}
\begin{exx}{\hassolution\untested}
From \emph{Swan Boats at Four}, a novel by George V. Higgins:

\begin{quotation}
Rutledge said ‘‘In other words, if we’d painted over that damned
picture in the summer of nineteen seventy-eight, we would’ve made the
club, and ourselves individually, liable for a hundred thousand bucks,
plus interest at, say, an average of seven percent per annum,
compounded for thirty-four years. \ldots’’

‘‘Offhand,’’ [David] said, ‘‘I can’t even imagine how much that
would’ve been.’’

‘‘At the time, I couldn’t either,’’ Rutledge said, ‘‘ \ldots so we
looked it up --- I don’t mean we figured it out. \ldots I don’t
recall the exact figure, but it came out to around a million and a
half dollars.’’%
\begin{csmr}
George V. Higgins,
\emph{Swan Boats at Four},
Henry Holt and Company, 1995,
pp. 198-199.
\end{csmr}
\end{quotation}

David is a banker. He would know the Rule of 70 and figure it out
offhand, without pencil and paper. Higgins should have known that.

\begin{abcd}

\item  Use the Rule of 70 to decide whether Rutledge was right
  when he said the figure was ‘‘around a million   and a half dollars’’.

\item Calculate the answer.

\end{abcd}

\begin{sol}
\begin{abcd}

\item  Use the Rule of 70 to decide whether Rutledge was right
  when he said the figure was ‘‘around a million   and a half dollars’’.

The rule tells me that seven percent interest doubles
a debt in ten years. In twenty years it will quadruple, in
thirty it will be eight times as large. So the \$100,000 would be
\$800,000 after 30 years. It would be \$1,600,000 after 40
years. That’s barely over a million and a half, so I don’t think
it would be a million and a half after just 34 years.
```

```
\item Calculate the answer.

\begin{equation*}
100,000 \times 1.07^{34} = 997811.353702
\end{equation*}
%
so the \$100,000 debt would grow to just about a million dollars in 34
years.
\end{abcd}

\end{sol}

\end{exx}

\begin{exx}{\hassolution}
So many words!

On December 1, 2012 R. Alexander Bentley and Michael J. O'Brien
wrote in \theTimes{} that

\begin{quotation}
[F]or the last 300 years, the number of words published
  annually grew exponentially by about 3 percent per year. From about
  20 million words for 1700, the annual word count grew to several
  trillion for 2000.%
\begin{csmr}
R. A. Bentley and M. J.O'Brien,
The Buzzwords of the Crowd,
\theTimes{}
(December 1, 2012),
\url{www.nytimes.com/2012/12/02/opinion/sunday/science-and-buzzwords.htm}
\access{July 23, 2015}.
\csmrcomment{37 words fair use}
\end{csmr}
\end{quotation}

\begin{abcd}
\item Check the authors' arithmetic.

\item If the growth continues at the same rate how many words will be
published in the year 3000?

\item How much confidence do you have in your prediction?
\end{abcd}


\begin{sol}

\begin{abcd}
\item Check the authors' arithmetic.

The coolest way to do this is with the rule of 70. A 3\% annual
increase has a doubling time of $70/3 \approx 25$ years. The question
asks about $300$ years of growth, which would be $12$ doublings.
```

```
But to get from 20 million to 20 trillion you must multiply by $10^6$.
Since $2^{10} \approx 1,000$, that's 20 doublings. It would take 19
doublings to get to 10 trillion, and 16 to get to 1 trillion. So 12 is
not enough.

You can, of course, solve this problem the boring way with some arithmetic:
\begin{equation*}
(20 \text{ million})\times (1.03)^{300} \approx 140,000 \text{ million}
= 140 \text{ billion}.
\end{equation*}
That's at least an order of magnitude short of ``several trillion''.

To get to 2 trillion you'd need 19 doublings in 300 years. That's a
doubling time of about 16 years. Then the rule of 70 says you'd have
to have had an annual  growth rate of about 4.3\%.

\item If the growth continues at the same rate how many words will be
published in the year 3000?

Another 100 years at 4.3\% would be about 6 more doublings, so each
trillion words would grow to $2^6 = 64$ trillion.

\item How much confidence do you have in your prediction?

Not much!

\end{abcd}

\end{sol}

\end{exx}
\begin{exx}{\hassolution}
World population.
\index{world population}

According to a Harvard School of Public Health press release
the world's population has grown slowly for most of human history. It
took until 1800 for the population to hit 1 billion. However, in the
past half-century, population jumped from 3 to 7 billion. In 2011,
approximately 135 million people will be born and 57 million will die,
a net increase of 78 million people.

\begin{abcd}
\item By what percent did world population increase in 2011?

\item Write the equation for a mathematical model for world population
growth for years since 2011 if the annual net increase seen in 2011
remains constant for the remainder of the century. (Use 7 billion as
the 2011 population.)

\item Write the equation for a mathematical model for world population
growth for years since 2011 if the annual percentage increase seen in
2011 remains constant for the remainder of the century. (Use 7 billion
```

```
as the 2011 population.)

\item Construct an Excel spreadsheet predicting world population for
the years through 2100 using both models. Graph both predictions on
the same chart.

\item The table below gives the United Nations high estimate for
world population growth during the remainder of this century.

\begin{center}
\begin{tabular}{cS[table-format=2.1]}
\toprule
Year & {Population} \\
     & {(billions)} \\
\midrule
2011 & 7 \\
2025 & 8.5 \\
2050 & 10.6 \\
2100 & 15.8 \\
\bottomrule
\end{tabular}
\end{center}

Which of your models most closely matches the UN high estimate?
\end{abcd}

\begin{sol}
\begin{abcd}
\item By what percent did world population increase in 2011?

The percentage increase was
\begin{equation*}
\frac{78 \times 10^6}{7 \times 10^{9}}
=
0.01114285714
\approx 1.1\%.
\end{equation*}

\item Write the equation for a mathematical model for world population
growth for years since 2011 if the annual net increase seen in 2011
remains constant for the remainder of the century. (Use 7 billion as
the 2011 population.)

Let $Y$ be the number of years since 2011 and $P$ the world
population, in billions. Then the equation is
\begin{equation*}
P = 7 + 0.078Y.
\end{equation*}

\item Write the equation for a mathematical model for world population
growth for years since 2011 if the annual percentage increase seen in
2011 remains constant for the remainder of the century. (Use 7 billion
as the 2011 population.)
```

```
With the same variables as above, the exponential equation is
\begin{equation*}
P = 7 \times (1.011)^Y.
\end{equation*}

\item Construct an Excel spreadsheet predicting world population for
the years through 2100 using both models. Graph both predictions on
the same chart.

\item The table below gives the United Nations' high estimate for
world population growth during the remainder of this century.

Which of your models most closely matches the UN high estimate?

I've added the predictions to the table. Numbers are in billions. The
last two columns show the relative errors in the predictions.

\begin{center}
\begin{tabular}{c
S[table-format=2.1]
S[table-format=2.2]
S[table-format=2.2]
S[table-format=1.2]
S[table-format=1.2]
}
\toprule
Year & {UN} & {linear} & {exp} & {lin/UN} & {exp/UN} \\
\midrule
2011 & 7.0  & 7.00  & 7.00  & 1.00 & 1.00 \\
2025 & 8.5 & 8.19 & 8.17 & 0.96 & 0.99 \\
2050 & 10.6 & 10.32 & 10.78 & 0.97 & 1.02 \\
2100 & 15.8 & 14.57 & 18.77 & 0.92 & 1.19 \\
\bottomrule
\end{tabular}
\end{center}

The linear and exponential predictions are both pretty close for the
first half of the 21st century. By 2100 the linear prediction is
8\% lower than the UN's, the exponential prediction 19\% higher.
\end{abcd}

\end{sol}

\end{exx}
\begin{exx}{\needsquestions}
Making it into the \myindex{Hall of Fame}.

On January 12, 2013, Nate Silver \index{Silver, Nate} wrote in his
blog at \theTimes{} that individual voting totals for the baseball
Hall of Fame seemed to increase by about ten percent each year.

\begin{quotation}
Thus, a player who received 10 percent of the vote in his first year
would be expected to receive about 11 percent on his second try, while
```

```
a player who got 50 percent of the vote would go up to 55 percent.%
\begin{csmr}
N. Silver,
In Cooperstown, a Crowded Waiting Room,
\theTimes{}
(January 12, 2013),
\url{fivethirtyeight.blogs.nytimes.com/2013/01/12/in-cooperstown-a-crowded-waiting-room/}
\access{July 23, 2015}.
\csmrcomment{42 words fair use}
\end{csmr}
\end{quotation}

Explain why this is exponential growth. Look up the original. Make
some projections.

\end{exx}


\begin{exx}{\untested\needsquestions}
Save another one percent.

The interactive web based calculator provided by \theTimes{} at
\url{%
www.nytimes.com/interactive/2010/03/24/your-money/one-pct-more-calculator.html
}
suggests many
questions about savings, compound interest and inflation.


\end{exx}

\begin{exx}{\untested\needsquestions}
The \myindex{London olympics}.

On July 22, 2012 \theGlobe{} wrote about the third Olympic games to be
hosted by London:

\begin{quotation}
The Games have grown geometrically during the past 104
years --- from 2,023 athletes representing 22 countries competing in
109 events in 24 sports in 1908 to 4,064 athletes, 59 countries, 136
events, and 19 sports in 1948 to 10,500 athletes, 204 countries, 302
events and 37 sports in 2012.%
\begin{csmr}
J. Powers,
London ready to complete Olympic triple play,
\theGlobe{} (July 22, 2012),
\url{www.bostonglobe.com/sports/2012/07/22/london-ready-complete-olympic-triple-play/iaAdNViKdg53AyrkHM0
\access{July 23, 2015}.
\csmrcomment{Globe, OK}
\end{csmr}
\end{quotation}

Note: ‘‘geometric’’ is a synonym for ‘‘exponential’’.
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Possible questions: find exponential regression curves for the numbers
of athletes, countries and events.

\end{exx}

\begin{exx}{\untested\needsquestions\sref{exponentialdepreciation}
\gref{exponentialgrowth}}
Radioactive waste.
\index{radioactive waste}

The web site \url{www.nirs.org/factsheets/hlwfcst.htm} we
quoted earlier offers much more information about radioactive waste.
\index{radioactive waste}\index{plutonium}

Ask and answer some interesting Fermi problems suggested by the data there.
You could consider what it says about a nuclear power
plant near you.%

We could construct the Fermi problems based on this radioactive waste
data ourselves, and ask the students to solve them. But by this time
in the course we hope they can start from the numbers and create their
own.

\end{exx}

\begin{exx}{\untested\needsquestions}
Payday loans 2016.
\index{payday loan}

\begin{quotation}
People who borrow money against their paychecks are generally supposed
to pay it back within two weeks, with substantial fees piled on: A
customer who borrows \$500 would typically owe around \$575, at an
annual percentage rate of 391 percent.
\begin{csmr}
S. Cowley,
Payday Loans' Debt Spiral to Be Curtailed,
\emph{The New York Times}, June 2, 2016,
\url{www.nytimes.com/2016/06/02/business/dealbook/payday-borrowings-debt-spiral-to-be-curtailed.html}
\access{June 2, 2016}.
\end{csmr}
\end{quotation}

Many more juicy numbers in the article.

\end{exx}

\begin{exx}{\untested\needsquestions}
Was this a good deal on a mortgage?

On July 6, 2016 Max Jacob posted this question at
\url{money.stackexchange.com/questions/66978/was-this-a-good-deal-on-a-mortgage}.
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\begin{quotation}
I just graduated college last year, and was looking to buy a
house. Clearly I wouldn't be able to buy it outright, so I was
thinking of getting a mortgage. I have a steady job (~\$55,000 annual
before taxes) and an okay credit score (~740). Here's the deal that a
mortgage consultant gave me:

\$2,000 per month for 30 years on a \$300,000 home (he didn't mention
any other fees)

It seems terrible to me because it comes out to a total of \$720,000
over that 30-year period. I'm completely new to the concept, so maybe
I'm just being naive.%
\begin{csmr}
Was this a good deal on a mortgage?
\url{money.stackexchange.com/questions/66978/was-this-a-good-deal-on-a-mortgage}
\access{July 6, 2016}.
\end{csmr}
\end{quotation}

Possible uses: classroom discussion, group homework assignment, think
about the answers informative answers at the site, appended here.

From user Aganju
(\url{money.stackexchange.com/users/35405/aganju}:
\begin{quotation}
That seems a very bad offer, it borders on fraud.

In the current US economy, you should be able to get between 3 and 4
\% APR (and that number is what you should look at). That means that
for 300000 over 30 years, you'd pay \$1265 to \$1432 per month.

If you are able to pay more than that monthly rate, you should go for
less than 30 years - 20, 15, 10, whatever you can afford - but don't
overextend yourself.

Google ``mortgage calculator'' to do your own calculations.
\end{quotation}

From user quid
(\url{money.stackexchange.com/users/22881/quid}:
\begin{quotation}
I'm calculating that to about a 7\% apr, which given loan rates
available today seems a bit high.

I wouldn't get too caught up on what that equates to over the life of
the loan. There are a lot of forces in play over a 30 year period,
namely the time value of money. 30 years from now a dollar will be
less valuable in real terms due to the forces of inflation. At 2\% per
year in inflation today's \$1 will be worth about \$0.55 in 30 years.
\end{quotation}

From user keshlam
(\url{money.stackexchange.com/users/12439/keshlam}):
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```
\begin{quotation}
Some part of the payment is probably also going for tax escrow,
insurance payments, probably PMI if you aren't putting at least 20\%
down. Get a complete breakdown of the costs.

Remember to budget for upkeep.

And please see past discussion of why buying a home at this point in
your career/life may be very, very premature.
\end{quotation}

\end{exx}

\begin{exx}{\untested\routine\hassolution}
Get rich quick.

Tad Friend wrote in the October 10, 2016 issue of  \thenewyorker{}
that
\begin{quotation}
YC's gold standard for revenue growth  is ten percent a week, which
compounds to 142x a year.%
\begin{csmr}
T. Friend,
Adding a Zero,
\emph{The New Yorker},
October 10, 2016, p. 77.
\end{csmr}
\end{quotation}

Check his calculation.

\begin{sol}
He's right. The Google calculator tells me
\begin{equation*}
1.1^{52} = 142.042931984
\end{equation*}
which will multiply any starting amount by 142.
\end{sol}
\end{exx}

\begin{exx}{\untested\needsquestions}
Double, double, $\ldots$

In April, 2017 Tad Friend wrote in \emph{The New Yorker} that

\begin{quotation}
Progress in computers, or anyway in
semiconductors, has been subject to Moore's Law, the exponential
flywheel that has doubled capacity every two years. In linear
progress, after thirty iterations you've advanced thirty steps; in
exponential progress, you've advanced 1.07 billion steps. Our progress
in mapping the human genome looked like it was linear --- and then was
revealed, once the doublings grew significant, as exponential.
\begin{csmr}
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T. Friend,
Silicon Valley's Quest to Live Forever,
\emph{The New Yorker}, April 3, 2017,
\url{www.newyorker.com/magazine/2017/04/03/silicon-valleys-quest-to-live-forever}
\access{April 20, 2017}.
\end{csmr}
\end{quotation}

\begin{abcd}
\item Where does that 1.07 billion come from?
%Answer: It's $2^{30}$.

\item Question about Moore's Law?
\end{abcd}
\end{exx}


\begin{exx}{\untested}
Free meat!

On July 2, 2017 \theGlobe{} published an article about bioengineered
meat grown from animal stem cells.

\begin{quotation}
Steve Myrick, vice president of business development at Memphis
[Meets], said the company is now producing beef, chicken, and duck in
stainless steel tanks for roughly \$2,400 per pound. That'a lot cheaper than it
was even a year ago, and the price is falling about 15 to 20 percent
per month, as the company improves yields and finds less expensive
nutrients.%
\begin{csmr}
D. Scharfenberg,
I'm a vegetarian. Bring on the lab-grown meat,
\theGlobe, July 2, 2017,
\url{ostonglobe.com/ideas/2017/06/29/vegetarian-bring-lab-grown-meat/M8s2vNYxiYZsusZPM8fF8K/story.html}
\access{July 2, 2017}.
\end{csmr}
\end{quotation}

\begin{abcd}
\item Estimate the cost ``a year ago''.

\item When will the cost be competitive with what meat sells for in
  your local market?
\end{abcd}
\end{exx}


\begin{exx}{\untested}
Payday loans 2017.
\index{payday loan}
\index{McDonalds}

On October 5. 2017 \theTimes{} reported that the
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 Consumer Financial Protection Bureau announced new rules applicable
 to payday loans. The article read (in part)

\begin{quotation}
Currently, a cash-strapped customer might borrow \$400 from a payday
lender. The loan would be due two weeks later --- plus \$60 in interest
and fees. That is the equivalent of an annual interest rate of more
than 300 percent, far higher than what banks and credit cards charge
for loans.

\ldots

The payday-lending industry is vast. There are now more payday loan
stores in the United States than there are McDonald's restaurants. The
operators of those stores make around \$46 billion a year in loans,
collecting \$7 billion in fees. Some 12 million people, many of whom
lack other access to credit, take out the short-term loans each year,
researchers estimate.
\begin{csmr}
S. Cowley,
Payday lending faces tough new restrictions by consumer agency,
\emph{The New York Times},  October 5, 2017,
\url{www.nytimes.com/2017/10/05/business/payday-loans-cfpb.html}
\access{October 6, 2017}.
\end{csmr}
\end{quotation}

\begin{abcd}
\item Verify the interest calculation in the first paragraph of the
  quotation.

\item Are the assertions in the second paragraph reasonable?
The data in Figure~\ref{fig:paydayloanstores} should help answer this
question.

\figfile{paydayloanstores.png}
\begin{figure}
\centering
\includegraphics[width=4in]{\thefigurefilename}
\begin{csmr}[Payday Loan Stores 2004-2013\label{fig:paydayloanstores}]
J. Hecht,
Alternative Financial Services, February 27, 2014, slide 31,
\url{cfsaa.com/Portals/0/cfsa2014_conference/Presentations/CFSA2014_THURSDAY_GeneralSession_JohnHecht_St
\access{October 5, 2017}.
\end{csmr}
\end{figure}
\figfile{}

\end{abcd}
\end{exx}

%HarryPotterLoan.jpg
%At 239.45% APR, this is evidently equivalent to a payday lender.
```

```
\begin{exx}{\untested\needsquestions}
R\&D in China.
\index{China}
\index{R\&D}

\begin{quotation}
China is the clearest example. Since 2000, China's spending on
research and development has grown by an average of 18 percent each
year, while ours grew by only 4 percent. This has placed China a
decisive second in R \& D expenditures behind the United States, where
the government and private sector together invest far more than any
other country. Even so, the share of R \& D funded by the federal
government declined to about 25 percent from just over 30 percent from
2010 to 2015.%
\begin{csmr}
M. Zuberjan,
Falling Short on Science,
\emph{The New York Times}, January 26, 2018,
\url{www.nytimes.com/2018/01/26/opinion/falling-short-on-science.html}
\access(January 26, 2018)
\end{csmr}

%
\end{quotation}

\end{exx}

\begin{exx}{\untested\hassolution}
Endangered apes.

On April 26, 2018 \emph{The Washington Post} summarized a study from
the journal \emph{Science Advances} that reported

\begin{quotation}
\ldots
estimates that there were 361,900 gorillas and 128,700 chimpanzees as
of 2013. That's about one-third more gorillas and one-tenth more
chimpanzees than previous surveys estimated, though those calculations
were performed differently and were not designed to count the animals
across their entire range.

That is the good news. Now the bad: Researchers found that gorilla
populations are dropping faster than they believed, at a rate of
nearly 3 percent per year, said Fiona Maisels, a conservation
scientist with the Wildlife Conservation Society and the University of
Stirling in Scotland. At this rate, half of the world's gorillas could
be gone by about 2040, she said.%
\begin{csmr}
D. Main,
Vast survey finds far more gorillas in Africa than previously believed
- and some bad news, too,
\emph{The Washington Post},
April 26, 2018,
\url{www.washingtonpost.com/news/animalia/wp/2018/04/26/vast-survey-finds-far-more-gorillas-in-african-f
```

```
\access{April 30, 2018}
\end{csmr}
\end{quotation}

\begin{abcd}
\item How many gorillas and chimpanzees were estimated in the previous
  surveys?

\item This article updates numbers from 2013. Estimate the gorilla
  population in 2018, when this study was published.

\item Is Dr. Maisel's prediction about the 2040 gorilla population
  reasonable?
\end{abcd}

\begin{sol}
\begin{abcd}
\item How many gorillas and chimpanzees were estimated in the previous
  surveys?

``One third more gorillas'' means that
\begin{equation*}
\frac{4}{3} \times \text{previous estimate} = 361,900
\end{equation*}
so
\begin{equation*}
\text{previous estimate} = \frac{3}{4} \times 361,900
=271,425 \approx 270,000 \text{ gorillas}.
\end{equation*}
A similar calculation says the previous estimate was about 117,00
chimpanzees.

\item This article updates numbers from 2013. Estimate the gorilla
  population in 2018, when this study was published.

Given three percent per year decrease the 2018 gorilla population is
about
\begin{equation*}
270,000 \times 0.97^5 \approx 232,000 .
\end{equation*}

\item Is Dr. Maisel's prediction about the 2040 gorilla population
  reasonable?

The rule of 70 says that the half life of a population declining at a
rate of $3$ percent per year is about $70/3 \approx 23$ years. Since
2040 is 22 years from now Dr. Maisel's prediction is reasonable.
\end{abcd}

\end{sol}
\end{exx}

\begin{exx}{\untested}
An extra percentage point.
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On May 22, 2018 \theGlobe{} reported that

\begin{quotation}
Over the past 18 months, the average rate on 30-year fixed mortgages
has climbed a full percentage point, which translates into an
additional \$100,000 in interest over the life of a \$500,000 loan.%
\begin{csmr}
E. Horowitz,
Gas and mortgages are getting expensive again. Welcome to a normal
economy,
\theGlobe, May 22, 2018.
\url{www.bostonglobe.com/business/2018/05/22/gas-and-mortgages-are-getting-expensive-again-welcome-norma
\access{May 24, 2018}.
\end{csmr}
\end{quotation}

\begin{abcd}
\item Verify this assertion.

\item Does the difference in interest paid depend on the actual
  mortgage rate, or only on the increase?
\end{abcd}
\end{exx}

\begin{exx}{\untested}
The Internet of Things.
\index{internet of things}

Figure~\ref{fig:connectedHomes} shows the growth of U. S. households
with devices like appliances connected to the internet.


\figfile{connectedHomes.png}
\begin{figure}
\centering
\includegraphics[width=4in]{\thefigurefilename}
\begin{csmr}[Connected Homes, 2015-2017\label{fig:connectedhomes}]
There's No Place Like [ A CONNECTED ] Home,
McKinsey\&Company,
\url{www.mckinsey.com/spContent/connected_homes/index.html}
\access{June 23, 2018}.
\end{csmr}
\end{figure}
\figfile{}

\begin{abcd}
\item Is the $31\%$ compound annual growth rate correct?

\item Estimate when every home in the United States will be connected.
\end{abcd}
\end{exx}

\begin{exx}{\untested\worthy\needsquestions}
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5 miilion Bostonians?

On August 19, 2019 Martin Finucane wrote in \theGlobe{} that
in 1900 Globe reporter Thomas F. Anderson reported a prediction that
Boston's population would be 5,251,330 in 2000.%
\begin{csmr}
M. Finucane,
5.2 million people crammed into Boston? In 1900, some of the best
minds thought it was a possibility,
theGlobe, August 19, 2018,
\url{www.bostonglobe.com/metro/2018/08/19/million-people-crammed-into-boston-some-best-minds-thought-was
\access{August 19, 2018}.
\end{csmr}

The original article said
\begin{quotation}
This population is estimated on the rate of increase of the last 20
years, and on the same basis (the population according to the census
of 1900 being 560,892), the figures for consecutive 10-year periods
will probably be as follows. . .
\end{quotation}

The current story continued

\begin{quotation}
Anderson then cited a series of population figures that appeared to
reflect an approximately 25 percent increase per decade for 100
years [\ldots because he] had just seen the population of the city
explode by 54 percent from 1880 to 1900.
\end{quotation}

$1.25^2 = 1.5625$

$1.25^{10} = 9.31$

$560,000 * 1.25 ^10 \approx 5,200,000$
\end{exx}

\end{MoreExercises}
 \protect \chapter {Borrowing and Saving}
\protect \setcounter {section}{6}
\protect \setcounter {Exc}{16}
\begin{MoreExercises}{10.6}

\begin{exx}{\needsquestions\untested}
The debit card trap.
\index{debit card}

On August 20, 2009 \theTimes{} editorialized that

\begin{quotation}
A study by the Center for Responsible Lending, a
nonpartisan research and policy group, describes what it calls the
``overdraft domino effect.'' One college student whose bank records
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were analyzed by the center made seven small purchases including
coffee and school supplies that totaled \$16.55 and was hit with
overdraft fees that totaled \$245.

Some bankers claim the system benefits debit card users, allowing them
to keep spending when they are out of money. But interest rate
calculations tell a different story. Credit card companies, for
example, were rightly criticized when some drove up interest rates to
30 percent or more. According to a 2008 study by the F.D.I.C.,
overdraft fees for debit cards can carry an annualized interest rate
that exceeds 3,500 percent.%
\begin{csmr}
Editorial,
 Debit Card Trap,
\theTimes{} (August 19, 2009),
\url{www.nytimes.com/2009/08/20/opinion/20thu1.html}
\access{July 24, 2015}.
\end{csmr}
\end{quotation}

We haven't made up any questions yet to go with this interesting quote.

\end{exx}


\begin{exx}{\hassolution\sref{apr}\gref{creditcards}
\gref{periodicpayment}\gref{compounding}}
Regulating the credit card industry.

\theGlobe{} reported on May 13, 2009 on the Senate's deliberations on
credit card rules.

One change, since signed into law, requires lendsrs to apply payments
first to the part of the balance with the highest interest rates.

A second change, proposed as an amemndment by Senator Bernie Sanders
\index{Sanders, Bernie}
(Independent, Vermont) would limit interest rates to 15\%.%
\begin{csmr}
J. Plungis,
Senate might consider cap on card interest rates,
Bloomberg News report in \theGlobe{} (May 13, 2009),
\url{www.boston.com/business/personalfinance/articles/2009/05/13/senate_might_consider_cap_on_card_inter
\access{July 24, 2015}.
\csmrcomment{paraphrase}
\end{csmr}

Suppose a credit card user has a balance
of \$100 at 24\% for purchases and  \$1000 at 0\% for a debt she
transferred from another credit card. She
makes no new purchases, and pays off her loan at the rate of \$100 per
month.

\begin{abcd}
```

```
\item
When will her loan be paid off and how much interest will she
have paid under the 2009 rules --- payments are applied to the
purchases balance first.

\item
Under the new rules, which are now law?

\item If Sanders' amendment had passed? (It didn't.)
\end{abcd}

\begin{sol}

\begin{abcd}

\item
When will her loan be paid off and how much interest will she
have paid under the 2009 rules --- payments are applied to the
purchases balance first.

Under the 2009 rules it will take her 10 months to pay off the
\$1,000 transfer. During that time her \$100 balance will have been
accruing interest at the rate of 2\% per month. Then she will
owe $\$100 (1.02)^{10} = \$121.90$. (I could have found the same answer
with the spreadsheet.) Then she will pay that off in two months, so
she'll have one month's interest on the unpaid balance of \$21.90:
another $0.02 \times \$21.90 =
\$0.44$. Her total interest payments will be $\$21.90 + \$0.44 =
\$22.34$ .

\item
Under the new rules she will pay off the high interest part of her
bill in the  first month, with no interest charge, and then the rest
in 10 months, again with no interest charge.

\item If Sanders's amendment had passed her interest rate would be capped at
15\% annually, so if she pays off the zero interest balance first her
unpaid balance will become $100 \times (1 + 0.15/12)^{10} = 113.23$. The
last interest charged will be just $(0.15/12)\times 13.23 = 0.17$ for
a total interest payment of \$113.40.

She'll pay no interest if she pays off the purchases first.
\end{abcd}

\end{sol}
\end{exx}

\begin{exx}{\needsquestions\sref{creditcard}\gref{creditcards}}
Reward cards.
\index{reward program}

In \theGlobe{} on December 18, 2009, Candice Choi wrote about
credit card reward programs:
```

```
\url{www.boston.com/business/personalfinance/articles/2009/12/18/rewards_cards_may_be_a_bit_less_rewardi

\end{exx}

\begin{exx}{\untested}
Smoke and mirrors.

A visitor at \url{money.stackexchange.com} asks

\begin{quotation}
I'm reading about Household International's fraudulent mortgage
interest rate. According to Michael Lewis, Household disguised a 15
year, fixed-rate loan as a thirty-year loan. The sales would offer to
replace a client's existing \$67,300 mortgage (8.5\% interest rate) with
a bigger but seemingly cheaper one: \$86,300 at an ``effective rate''
of 7.6\%. The sales pitch goes something like this: ``If I can put
together a loan that pays out like a 7.579\%-a-year loan, but has a
total term of 18.63 years --- would you be interested?''

Can someone explain how exactly does the trick work? How did the sales
misrepresent the 7.6\% interest rate, which is seemingly lower than
the client's existing 8.5\% interest rate?%
\begin{csmr}
user59667,
If I can put together a loan that pays out like a 7.579\%-a-year loan,
but has a total term of 18.63 years would you be interested?,
money.stackexchange.com, July 19, 2017,
\url{money.stackexchange.com/questions/81940/if-i-can-put-together-a-loan-that-pays-out-like-a-7-579-a-y
\access{July 20, 2017}.
\end{csmr}

\end{quotation}

The original story is at
\url{www.forbes.com/forbes/2002/0902/062.html}.

The stackexchange site has an answer that can be checked with the
mortgage calculator spreadsheet.

\end{exx}


\begin{exx}{\untested\needsquestions}
Paying for credit.

In the June 26, 2018 edition of \theTimes{} you could read that

\begin{quotation}
In addition to annual fees, interest charges and other, more
mysterious fees that consumers pay, credit card companies also levy
fees on merchants: usually a flat fee per sale and a commission of 2
percent to 3.5 percent or more. If you spend \$200 at a store and use a
credit card, you could be sending as much as \$7 of that payment to the
credit card company.
```

```
Merchants, no fools, pass those fees on to consumers by making their
products more expensive. This yields a credit card ‘‘tax’’ that everyone
pays (even those, usually the poor, who don’t have credit cards).

There is no reason to expect credit card companies to offer their
services free. But the credit card tax paid by American retailers and
consumers is the highest in the world. Credit card ‘‘swipe’’ fees
account for an estimated \$42 billion every year in the United
States. The Europeans pay less, because they see this as an obvious
market failure and limit the commission to 0.3 percent, meaning that
you would pay 60 cents instead of \$7 in fees for that \$200 purchase.%
\begin{csmr}
T. Wu,
The Supreme Court Devastates Antitrust Law,
\emph{The New York Times},
June 26, 2018,
\url{www.nytimes.com/2018/06/26/opinion/supreme-court-american-express.html}
\access{June 26, 2018}
\end{csmr}
\end{quotation}
\end{exx}

\end{MoreExercises}
 \protect \chapter {Probability --- Counting, Betting, Insurance}
\protect \setcounter {section}{9}
\protect \setcounter {Exc}{7}
\begin{MoreExercises}{11.9}
\begin{exx}[lotteryhistory]{\untested\sref{lotteries}\gref{expectedvalue}}
1996 was a long time ago.

\begin{quotation}
Lotteries rank first among the various forms of gambling in
terms of gross revenues: total lottery sales in 1996 totaled \$42.9
billion. 1982 gross revenues were \$4 billion, representing an increase
of 950\% over the preceding 15 years, 1982-1996.

Lotteries have the highest profit rates in gambling in the U.S.: in
1996, net revenues (sales minus payouts, but not including costs)
totaled \$16.2 billion, or almost 38\% of sales. They are also the
largest source of government revenue from gambling, in 1996 netting \$13.8
billion, or 32\% of money wagered, for governments at all levels.%
\begin{csmr}
National Gambling Impact Study Commission, Lotteries.
\url{govinfo.library.unt.edu/ngisc/research/lotteries.html}
\access{July 17, 2015}.
\csmrcomment{This is an archived federal document. I’m sure we don’t
  need permission.}
\end{csmr}
\end{quotation}


The quotation that starts the section on lotteries in the first
edition of \commonsense{} comes to us
```

```
courtesy of the University of North Texas \myindex{CyberCemetery}:

\begin{quotation}
The University of North Texas Libraries and the
U.S. Government Printing Office, as part of the Federal Depository
Library Program, created a partnership to provide permanent public
access to the Web sites and publications of defunct U.S. government
agencies and commissions. This collection was named the
‘‘CyberCemetery’’ by early users of the site.%
\begin{csmr}
CyberCemetery,
\url{govinfo.library.unt.edu/}
\access{July 24, 2015}.
\csmrcomment{I’m sure we don’t need permission for this.}
\end{csmr}
\end{quotation}


The \myindex{bookkeeping}%
\footnote{One of our favorite words. We don’t know another with three
double letters in a row.}
for analyzing these numbers is
\begin{equation*}
\text{total from  ticket sales} =
\text{ prizes awarded }
+ \text{ overhead }
+ \text{ net revenue to state}.
\end{equation*}

In 1996 gross revenues --- that is, ticket sales, dollars bet --- were
\$42.9 billion.

%CHANGE (not) The $-$ below should stay, not become em dash ---
The \$16.2 billion in the second paragraph is ‘‘sales $-$ payouts’’, so
the payouts must be $\$42.9 - \$16.2 = \$26.7$ billion. Then
\begin{equation*}
\frac{\text{payouts}}{\text{sales}}
=
\frac{\$26.7 \text{ billion}}{\$42.9 \text{ billion}}
= 0.622377622
\approx 62\%
\end{equation*}
so for each lottery dollar in 1996, players got back (on average) a
little more than 62 cents in prize money. That is the fair price of a
one dollar ticket. The other 38 cents is the 38\% of sales that count
as total revenue for the government --- the
\$16.2 billion not returned to bettors as prizes. Some of that money
was overhead. After subtracting that, the net revenue available for
other use was \$13.2 billion.

Update the numbers from that quote (go back to \sref*{lotteries}) so
that you can rewrite the paragraph referring
to a much more recent year than 1996.
```

```
\begin{hint}
Consider starting at
\url{www.census.gov/govs/state/10lottery.html}. There may be a
better site that gives you totals, or lets you download directly into
a spreadsheet.
\end{hint}

\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{9}
\protect \setcounter {Exc}{14}
\begin{MoreExercises}{11.9}
\begin{exx}{\untested}What you're counting counts.

\begin{abcd}
\item What is the probability that a random word in English begins
with the letter ``t''?

This is a question with several answers, which depend on how you
select your ``random word''. You might count the words that begin
with  ``t'' in the dictionary. You might count those words in a
newspaper, or on a website. There may be answers to the question on
the web.

Estimate the answer in several ways. Do the various assumptions lead
to approximately equal answers?

\item ``e'' is the most commonly used letter in English. What is the
  probability that a random letter in an English text is ``e''?

Attack this question as you did the previous one.

\item What is ``etaion shrdlu'' and where does it come from?

\end{abcd}
\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{9}
\protect \setcounter {Exc}{15}
\begin{MoreExercises}{11.9}
\begin{exx}{\hassolution\sref{equallylikely}\gref{combinatorics}}
What is wrong with this estimate?

The following report appeared in the Offline column of \theTimes{}
business section on March 8, 2008, where
 ``Cubicle Coach'' Marie Claire, says ``take a chance'' when
considering whether to hire the ordinary candidate or one

\begin{quotation}
\ldots who has the potential to be great, but has an equal chance of being
awful?

``You have a 66.7 percent chance of a positive result,'' the coach
writes. ``Yes, the unknown could flop, but she could also a) do as well
```

```
as the known, or b) actually be a star.''%
\begin{csmr}
P. B. Brown,
Avoiding a Problem C.E.O.,
\theTimes{} (March 8, 2008),
\url{www.nytimes.com/2008/03/08/business/08offline.html}
\access{July 29, 2015}.
\csmrcomment{52 words fair use}
\end{csmr}
\end{quotation}

\begin{abcd}

\item What assumption is Claire making that leads her to her estimate
  of 66.7\%?

\item Suppose Claire is correct when she assumes that the
probabilities of great and awful are equal.  Show that the chance of a
positive result (great, or just OK) is somewhere between 50\% and 100\%.

\end{abcd}

\begin{teacher}
Ben Bolker \index{Bolker, Benjamin} suggests analyzing this hiring
dilemma using a payoff matrix, with utilities associated with each
state (awful, ok, great). Then we could compute an expected value for
each action (hire known, hire unknown) in terms of the various
probability and payoff assumptions. This would be cool in Excel.
\end{teacher}

\begin{sol}

\begin{abcd}

\item What assumption is Claire making that leads her to her estimate
  of 66.7\%?

There are three alternatives: safe bet, risky and a flop, risky and
outstanding. Claire is assuming each is equally likely. In 2/3 if the
cases you end up with someone who can do the job. Claire counts that
as a ``positive result''.


\item Suppose Claire is correct when she assumes that the
probabilities of great and awful are equal.  Show that the chance of a
positive result (great, or just OK) is somewhere between 50\% and 100\%.


Assume ``great'' and ``awful'' are equally likely in the risky
category and think about the probability of that category. If it's 1
(no ordinary candidates) then half the time you have a satisfactory
outcome. If it's 0 (no risky candidates) then you're sure to have a
satisfactory outcome.
```

```
\end{abcd}

\end{sol}

\end{exx}
\end{MoreExercises}
\protect \setcounter {section}{9}
\protect \setcounter {Exc}{23}
\begin{MoreExercises}{11.9}

\begin{exx}{\untested\needsquestions}
Savings accounts with benefits.

On January 15, 2014 Tina Rosenberg blogged at \theTimes{} that

\begin{quotation}
Lotteries aren't usually considered part of the solution
to our savings crisis. They're usually cited as a big part of the
problem. Lotteries offer the worst odds in legal gambling --- about 55
percent of what people pay for tickets is paid out in prizes. Yet we
spend an average of \$540 per household on lottery tickets every year ---
about \$100 more than we spend on milk or beer. That is
disproportionately spent by African-Americans, who spend five
times as much on lottery tickets per person than whites, and the very
poor. People with a household income of less than \$10,000 a year who
play the lottery spend \$597 a year on tickets.%
\begin{csmr}
T. Rosenberg,
Playing the Odds on Saving,
\theTimes{} (January 15, 2014),
\url{opinionator.blogs.nytimes.com/2014/01/15/playing-the-odds-on-saving/}
\access{July 24, 2015}.
\csmrcomment{114 words from a Times blog. I'd like to keep it here -
  in the instructor's manual. It's shorter than the Strogatz quote
  that counts as fair use.}
\end{csmr}
\end{quotation}

Read further for the savings strategy \dots{}.
\end{exx}


\begin{exx}{\untested}
Who really wins the lottery?

Figure~\ref{fig:lotterytowns} appeared in \theGlobe{} on February 25,
2017.

\figfile{lotterytowns.jpg}
\begin{figure}
\centering
\includegraphics[width=3in]{\thefigurefilename}
\begin{csmr}[Who really wins?\label{fig:lottertowns}]
 S. Murphy,
```

```
Should a town that doesn't sell lottery tickets take in less lottery
revenue?
\theGlobe{}, February 24, 2017,
\url{www.bostonglobe.com/metro/2017/02/24/critics-call-for-sales-count-lottery-aid-formula/zKAJmO93Wcg9P
\access{February 26, 2017}.
\end{csmr}
\end{figure}
\figfile{}

\begin{abcd}

\item The graphic does not show the  units for
  the dollars in the sales column. Figure out what the \$7.8 for Ayer
  represents.

\item Note that the bars in the sales column are
  shorter than the bars in the revenue column. What wrong conclusion
  does this misleading graphic suggest?

 \item Calculate the cost of the lottery in each town in units
(dollar of tickets bought)   per (dollar of lottery revenue).
Why are all but the first of
  these numbers less than $1$?

\item Why might it be more informative to report the cost of the
  lottery in units (dollar of lottery revenue) per (dollar of tickets
  bought)? Do that.

\item How do those figures compare to the statewide cost? (Look at an
  earlier exercise where you worked out the fair price of a dollar
  ticket.)
\end{abcd}
\end{exx}

\begin{exx}{\untested\needsquestions}
Mass Lottery redux.
\index{lottery, Massachusetts}

On August 31, 2017 Yvonne Abraham wrote in \theGlobe{} that

\begin{quotation}
We seem to be especially dippy here in Massachusetts, where we buy
more lottery tickets per capita than anywhere in the nation --- a
whopping \$746 per person in fiscal 2017. The $5 billion we spent on
games of chance in 2017 returned about $1 billion to cities and
towns. For every dollar spent on Powerball tickets, Massachusetts
collects 42 cents. Its share of Wanczyk's winnings was \$24
million. We'd be sunk without those revenues.
\begin{csmr}
Y. Abraham,
I can't stop thinking about Mavis Wanczyk. And that's what the Lottery
wants,
\theGlobe{}, August 31, 2017,
\url{www.bostonglobe.com/metro/2017/08/30/mavis-mind/v9A3QKcF20iVhV6Li6QJpO/story.html}
```

```
\access{August 31, 2017}.
\end{csmr}
\end{quotation}

\begin{abcd}
\item Compare these figures with those in previous exercises.

\item Is it reasonable or correct to say that the state's share of Wanczayk's
  \emph{winnings} was \$24 million?
\end{abcd}

\end{exx}

%
%\begin{quotation}
%  For   starters,  the United States as a whole made
%  \$66,788,035,000 in
%income generated from all of the states' respective
%lotteries. \$42,278,889,000 of this was used for prizes,
%\$3,180,173,000
%was expended on administration, and \$21,352,759,000 was the total
%proceeds remaining.
%\begin{csmr}
%M. Brown,
%Did We Get Lucky? LendEDU's Lottery Study \& Report,
%lendedu.com,
%August 31, 2018,
%\url{lendedu.com/blog/lottery-study-report/}
%\access{March 14, 2019}.
%\end{csmr}
%\end{quotation}
%
%www.statista.com/statistics/215265/sales-of-us-state-and-provincial-lotteries/
% In 2016, sales of state lotteries reached approximately 80.55 billion
% U.S. dollars, up from 73.87 billion the previous year.
%In 2016, the state with the highest lottery sales was New York, with
%around 9.7 billion U.S. dollars in sales. In the same year, state
%lotteries transferred a profit of 22.57 billion U.S. dollars to state
%and local governments.

%The payoff rules for state lotteries are very complex, and vary widely
%from game to game. It's hard to think about the fair price of any
%particular ticket but with the data in
%the quote we can compute the expected average return on each dollar
%bet. That number, which will be less than a dollar, is the fair price.
%
%Players spent $\$66.8$ billion on tickets. States returned $\$42.3$
%billion in prizes. (That is how the numbers should have been
%reported. The rest of the digits can't be guaranteed, and make the
%paragraph harder to read.)
%
%The average return was thus
%\begin{equation*}
%  \frac{42.3 \text{ billion prize dollars}}
```

```
%       {66.8 \text{ billion purchase dollars}}
%       = 0.633
%         \frac{\text{prize dollars}}
%       {\text{purchase dollar}} .
%\end{equation*}
%The fair price for a one dollar ticket is just over 63 cents.
%
%With that figure we can estimate the probability of winning when we
%know the prize structure. For example, if there's a single million
%dollar payout then the people running the lottery will have to sell
%\begin{equation*}
%\frac{ \$1,000,000}{0.633\  \$/\text{ticket}} \approx 1,600,000
%\text{ dollar tickets}
%\end{equation*}
%in order to pay out 63\% in winnings. Therefore the odds
%that yours is a winning ticket are 1:1,600,000. To say that another
%way: you would have to buy about 1.6 million one dollar tickets to win the
%million dollar prize.
%
%
%
\end{MoreExercises}
 \protect \chapter {Break the Bank --- Independent Events}
\protect \setcounter {section}{7}
\protect \setcounter {Exc}{20}
\begin{MoreExercises}{12.7}

\begin{exx}{\needsquestions}
What are the chances of six double-yolkers?

\url{www.bbc.co.uk/news/magazine-16118149}

\end{exx}
\begin{exx}{\needsquestions}
  Gladwell and success.

From Andrew Gelman's blog:
\url{andrewgelman.com/2013/10/11/gladwell-vs-chabris-david-vs-goliath/}
\index{Gelman, Andrew}
\index{Gladwell, Malcolm}

\begin{quotation}
Here's another example. A few years ago, I criticized the following
passage from Gladwell:

\begin{center}
\begin{minipage}{0.7\textwidth}
It's one thing to argue that being an outsider can be
strategically useful. But Andrew Carnegie went farther. He
believed that poverty provided a better preparation for success
than wealth did; that, at root, compensating for disadvantage was
more useful, developmentally, than capitalizing on advantage.
\end{minipage}
\end{center}
```

```
I argued that Gladwell was making a statistical fallacy:

\begin{center}
\begin{minipage}{0.7\textwidth}
    At some level, there's got to be some truth to this: you learn
    things from the school of hard knocks that you'll never learn in
    the Ivy League, and so forth. But \ldots there are so many more
    poor people than rich people out there. Isn't this just a story
    about a denominator? Here's my hypothesis:

    Pr (success given privileged background) is much greater than Pr
    (success given humble     background) .

    Number of people with privileged background is much less than
    number of     people with humble background.

    Multiply these together, and you might find that many extremely
    successful people have humble backgrounds, but it does not mean
    that being an outsider is actually an advantage.
\end{minipage}
\end{center}

\end{quotation}

The comments on that post are worth reading!
\end{exx}



%
%\begin{exx}{\needsquestions}
%The pregnancy probability.
%\index{pregnancy}
%
%Figure~\ref{fig:Pregnancy} appeared in the \emph{Deseret News}
%on August 6, 2012.
%
%\figfile{Pregnancy.jpg}
%\begin{figure}
%\centering
%\framebox{
%\includegraphics[height=70mm]{\thefigurefilename}
%}
%\caption{Odds of conceiving}
%\figsource{www.deseretnews.com/article/765595049/Mathematician-plots-pregnancy-probability.html,
%  updated April 30 2015, visited June 19, 2015}
%\label{fig:Pregnancy}
%\end{figure}
%\figfile{}
%
%\end{exx}

\begin{exx}{\untested\needsquestions}
```

```
Is failure to predict a crime?

This oped from \theTimes{} has an interesting discussion of the
difficulty working with small probabilities for rare events.

url{www.nytimes.com/2012/10/27/opinion/a-failed-earthquake-prediction-a-crime.html}

\end{exx}

\begin{exx}{\untested}
\myindex{Russian roulette}.

\begin{abcd}
\item What is Russian roulette?

\item What is the probability of surviving 1, 2, 3, 4, 5 or 6 rounds?
\end{abcd}

\end{exx}

\begin{exx}{\needsquestions}
Are small schools better?

The article ‘‘Evidence That Smaller Schools Do Not Improve Student
Achievement’’ at
\url{www.pdkmembers.org/members_online/publications/Archive/pdf/k0612wai.pdf}
discusses a data interpretation error like that in the cancer cluster
section to argue that the Gates Foundation focus on small schools is a
mistake.

\end{exx}

\begin{exx}{\untested}
NBA draft top pick?
\index{gambler's fallacy}\index{NBA draft}\index{Boston Celtics}
In \theGlobe{} on May 16. 201y you could read that

\begin{quotation}
The draft pick Boston will receive from the Brooklyn Nets has the best
lottery odds of any pick. It has a 25 percent chance of turning into
the No. 1 choice, a 21.5 percent chance of being No. 2, a 17.8 percent
chance of being No. 3 and a 35.7 percent chance of being No. 4. It
cannot fall beyond that.

In the last six years, the team with the best lottery odds received
either the No. 1 or No. 2 pick each time. That seemed a bit startling,
considering there is just a 46.5 percent chance of that happening each
year.

So I crunched some numbers and found that the odds of that happening
six years in a row were approximately 1 in 98. And if the Celtics
continued the streak and made it seven years in a row, they will have
defied odds of about 1 in 212.
```

```
So Boston should prepare for heartbreak once again, right? Well, not
quite.%
\begin{csmr}
A, Himmelsbach,
Celtics have best lottery odds, but there are long odds, too,
\theGlobe{}. May 15, 2017,
\url{www.bostonglobe.com/sports/celtics/2017/05/15/celtics-have-best-odds-but-there-are-long-odds-too/l1
\access{May 16, 2017}.
\end{csmr}
\end{quotation}

\begin{abcd}
\item Verify the calculations.

\item Why ‘‘not quite’’? What are the 2017 odds?
\end{abcd}

\end{exx}


\end{MoreExercises}
 \protect \chapter {How Good Is That Test?}
\protect \setcounter {section}{7}
\protect \setcounter {Exc}{14}
\begin{MoreExercises}{13.7}

\begin{exx}{\untested\needsquestions\sref{falsepos}\gref{contingencytable}}
HIV testing. \index{HIV}

Read the City of New York Department of Health and Mental Hygeine
Advisory \#20 at
\url{www.nyc.gov/html/doh/downloads/pdf/cd/08md20.pdf}.

Build the two way contingency tables based on the data there, and
discuss the consequences of the data.

\end{exx}

\begin{exx}{\needsquestions\sref{falsepos}\gref{falsepositives}}
Mad cow disease\index{mad cow disease|see {Bovine Spongiform Encephalopathy}}.

Bovine Spongiform Encephalopathy(BSE)
is a disease fatal to people who eat infected beef products.

Here is a paragraph from the United States Department of Agriculture
website on screening for BSE:

\begin{quotation}
After the first confirmation of BSE in an animal in Washington State
in December 2003, USDA evaluated its BSE surveillance efforts in light
of that finding. We determined that we needed to immediately conduct a
major surveillance effort to help determine the prevalence of BSE in
the United States. Our goal over a 12-18 month period was to obtain as
many samples as possible from the segments of the cattle population
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where we were most likely to find BSE if it was present. This
population was cattle exhibiting some signs of disease. We conducted
this enhanced surveillance effort from June 2004 - August 2006. In
that time, we collected a total of 787,711samples and estimated the
prevalence of BSE in the United States to be between 4-7 infected
animals in a population of 42 million adult cattle. We consequently
modified our surveillance efforts based on this prevalence estimate to
a level we can monitor for any potential changes, should they
occur. Our statistical analysis indicated that collecting
approximately 40,000 samples per year from the targeted cattle
population would enable us to conduct this monitoring.%
\begin{csmr}
BSE (Mad Cow Disease) Ongoing Surveillance Information Center,
U.S. Department of Agriculture,
\url{www.usda.gov/wps/portal/usda/usdahome?contentid=BSE_Ongoing_Surveillance_Information_Center.html}
\access{November 15, 2015}.
\end{csmr}
\end{quotation}
\end{exx}

\begin{exx}{\needsquestions}
Correlation and causation.
\index{correlation}\index{causation}

This question and and answers at the statistics stackexchange site has
nice examples. The answers are written using conditional probabilities
but can be rewritten as contingency tables.

\url{stats.stackexchange.com/questions/283133/relationships-between-correlation-and-causation}

\end{exx}
\end{MoreExercises}
```