Chapter 1

Getting Started

"How many @#$%ˆ&* cars *are* there?"
(the author, stuck in yet another endless traffic jam)

I've asked myself this question any number of times when I'm in a traffic jam with no end in sight, just immobile cars as far as the eye can see. This has happened to me in the United States, Canada, England and France over the past few years; you've undoubtedly had similar experiences somewhere.

So how many cars are there? You might wonder about the number on the road ahead, or in the town you live in, or the total in your home country.

Stop right now! Don't reach for your computer or your phone; don't ask Siri or Alexa. Imagine that you're in a situation where you simply can't ask. Perhaps your traffic jam is out in the countryside where there is no cell service, or you're on a plane without Internet connectivity, or maybe you're in an interview where a prospective employer wants to see whether you can think for yourself.

Figure 1.1: How many cars *are* there?

Your job is to figure out sensible answers on your own, without consulting any other sources—in other words, to come up with an *estimate*. Dictionary.com defines the noun *estimate* as "an approximate judgment or calculation, as of the value, amount, time, size, or weight of something," and the verb as "to form an approximate judgment or opinion regarding the worth, amount, size, weight, etc., of." That's exactly what you should do first.

Make your own estimate first.

As a specific example, let's estimate the number of cars in the United States. The way we approach this would be the same in other parts of the world, though the details might well be different.

It's often easiest to work from the bottom up, starting from something concrete that you know or have experience with, then build on that to the general situation. I would start with my own experience: there are three people in my immediate family, and we each have one car. If it were that simple—one car per person—then we're done. The population of the US today is around 330 million, so there are 330 million cars. And for many purposes, that estimate would be entirely adequate.

A rough estimate is often good enough.

Notice that our estimate came from two things: personal experience and knowledge of a single fact, the approximate population of the country. As we'll see in the rest of the book, we can make remarkably good estimates without detailed knowledge, but in the end, we do have to know something.

The more you know, the better your estimates.

330 million is probably too high, since many people don't have cars—children up to some age like 18 or 20, elderly people who no longer drive, and of course those who live in big cities where parking is expensive and public transportation is good. On the other side, some people will have more than one car, but that's likely to be much less common.

Taking such factors into account, we can refine the estimate of 330 million. If more than half of the population in the US has a car, perhaps even two thirds or three quarters, that leads to a more refined estimate of 200 to 250 million cars.

Refine your estimate if necessary.

Don't forget the "if necessary" part. Very often, a rough answer is entirely adequate, and sometimes there's no way to get information that would make it possible to refine anyway. We'll see plenty of examples of that along the way, and Chapter 13 offers some advice and a chance to practice.

We'll also see examples where people claim more knowledge and more accuracy than they could possibly have; that's a sign of something sketchy going on. If you've done your own estimation before accepting someone else's values, you'll be alert for such situations.

If we now turn to a computer or phone, we can compare our estimate to other sources. For instance, Wikipedia says that "there were an estimated 263.6 million registered passenger vehicles in the United States in 2015." The top Google hit is a story from the *Los Angeles Times* that says 253 million cars. Our estimate is certainly close to those, which is an encouraging sign.

Independent estimates should be similar.

Consensus is a good sign, unless everyone is making the same error. If two independently created estimates are significantly different, however, something is awry and at least one of them is wrong.

Now that we have a decent value for the number of cars, we can think about related questions. For example, how many miles does a typical car get driven in a year? How long does it last? How many cars are sold each year? How much does it cost to own a car?

How many miles does a car travel in a year? As above, it's useful to start with personal experience or observation. For instance, suppose you or some family member commutes to work 20 miles each way. That's 200 miles in a week, and thus about 10,000 miles in a 50-week year. Again, there will be a lot of variability: some people will have longer commutes, while others will have shorter, and still others will use public transportation. Short weeks and vacation trips and who knows what else will change the estimate to some extent, but many of these effects will average out.

Too big and too small tend to average out.

My auto insurance policy says that the premium for each of the family cars is based on an average of 27 miles per day, which on the surface is a strange number. But 365 times 27 is 9,855, which is close to 10,000. I suspect that this is not a coincidence: the insurance company knows that 10,000 miles per year is a good representative value.

How long does a car last? I've owned quite a few cars over the years, tending to drive them until they really start to fall apart; my last one was 17 years old and had 180,000 miles. I probably hang on longer than the norm, so we might choose a round number, say 100,000 miles or 10 years, though this is definitely a rough estimate. What about people who lease a new car every few years? When they upgrade, someone else will acquire a lightly used car, and it will go on to a typical lifetime, so 10 years is still reasonable.

How many new cars are sold each year? If there are 250 million cars and each lasts 10 years, then one tenth of them, or about 25 million, must be replaced each year; if instead they last 15 years, then 16 or 17 million will be replaced.

This is an example of a kind of conservation law: a car that reaches the end of its life will generally be replaced by a new one. Of course that assumes a steady state, which isn't true with a growing population or fluctuating economic conditions, but it's a reasonable assumption for getting started. Chapter 7 talks more about conservation laws.

Conservation: what goes in must come out.

How much does it cost to own a car? For practice, you might estimate how much per mile it costs to drive. This includes variable costs like fuel, fixed costs like insurance, unpredictable costs like repairs, and the money you'll need for a new car when the old one dies.

You may have noticed that for all of the estimates above, we used no arithmetic operations more complicated than multiplication and division, and we rounded off numeric values ruthlessly to make the computations easy.

Multiplication, division and approximate arithmetic are good enough.

This will be true of the rest of the book as well—we're not doing "mathematics," but elementary-school arithmetic in a really relaxed way. Chapter 12 has a more extended discussion of arithmetic, with some shortcuts and rules of thumb to make it easier.

I've written this chapter mostly in terms of cars, which may not be of direct interest to you. But even if not, in later chapters we'll see that the approaches and techniques are applicable to any situation where you have to estimate something from incomplete information. Most of the time, you can get a value by looking it up, but you will be much better off if, before you resort to a search engine, you make your own estimate. It won't take long and you'll quickly get good at it. Practice will arm you for a lifetime of being wary about what people are telling you. If you have already thought about some numeric value and have done a bit of easy arithmetic, it's much less likely that someone can put something over on you.

A note on units

Given the accident of where I live, the majority of the examples in this book come from American sources. I'm not too worried about this fact; any part of the world will have similar stories.

I'm more concerned that the units of measure in many examples—lengths, weights, capacities—are expressed in "English" units because the US is almost unique in not adopting the metric system, and still uses English units for pretty much all weights and measures. Readers who are not familiar with feet, pounds and gallons may sometimes be perplexed by unfamiliar units. I've tried to alleviate this when possible, but failing to get the units right is often the point of the story.

Meanwhile, here's a list of the most common English units that appear in the book, with approximate conversions to and from metric units.

1 inch = 2.54 cm	1 cm = 0.3937 inches
1 foot = 12 inches = 30.48 cm	1 meter = 3.28 feet
	= 39.37 inches
1 yard = 3 feet = 0.9144 meters	1 meter = 1.09 yards
1 mile = 5,280 feet = 1,609 meters	1 km = 0.62 miles
	= 3,281 feet
1 ounce = 28.3 grams	1 gram = 0.035 ounces
1 pound = 16 ounces = 453.6 grams	1 kg = 2.204 pounds
1 ton = 2,000 pounds = 907.2 kg	1 metric ton = 1,000 kg
	= 2,204 pounds
1 US pint = 16 fluid ounces = 0.47 liters	1 liter = 2.11 US pints
1 gallon = 4 quarts = 8 pints = 3.79 liters	1 liter = 0.26 gallons
	= 1.06 quarts

1 acre = 0.405 hectares	1 hectare = 2.47 acres
1 square mile = 640 acres	1 hectare = 0.0039 square miles
1 Fahrenheit degree = 5/9 Celsius degrees	1 Celsius degree = 1.8 Fahrenheit degrees

If you look at these conversions carefully, you can see some handy approximations:

1 meter ~ 1 yard
1 kilogram ~ 2 pounds
1 liter ~ 1 quart
1 Celsius degree ~ 2 Fahrenheit degrees

These are all within 10 percent of the true values. If you really need more accuracy, then add these adjustment factors:

1 meter ~ 1 yard + 10%
1 kilogram ~ 2 pounds + 10%
1 liter ~ 1 quart + 5%
1 Celsius degree ~ 2 Fahrenheit degrees – 10%

The adjusted values are all within about 1 percent of the true values, which will almost always be good enough for making estimates.