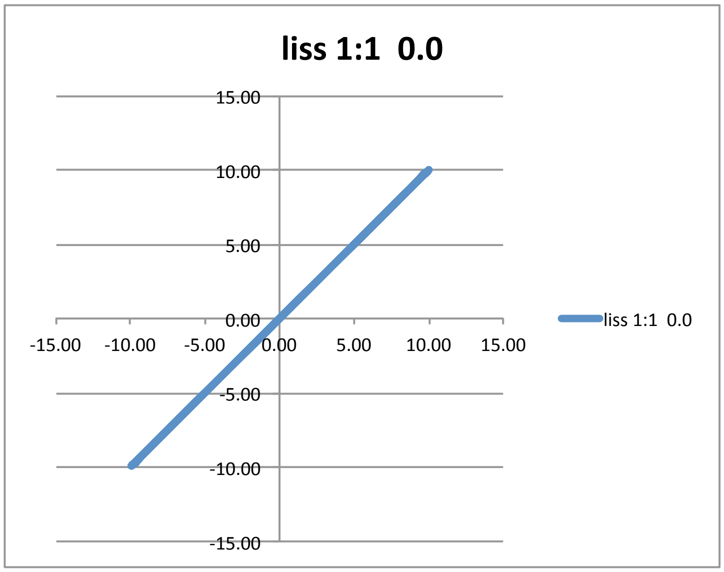

I have on my desk a book on Excel – *Excel for Scientists and Engineers*. Like most books on Excel, it is huge – over 500 pages – and therefore intimidating. The size is unfortunate, in that it probably scares off many people who might find spreadsheet knowledge useful. There are two issues lending heft to the book:

1. Teaching how to use the program requires showing various screens and selection boxes that one will encounter, which fills many pages, even in describing something that may be fairly simple in concept.
2. The book covers many specialized uses of Excel.

Learning Excel is much like learning chess. The basic moves can be learned in an afternoon. Learning the nuances – raising one's game to a higher level – can take longer. However, with just a basic knowledge of chess or Excel, one can immediately begin, and get much satisfaction from the game.

Mouse Clicks

I work on a Mac computer. Like most tech workers, I use a standard three-button mouse, which the Mac understands perfectly well. When I refer to a "right-click" throughout the book, this refers specifically to the three-button mouse, whether on a Windows machine or a Mac. If you happen to be working with the standard Apple mouse, the equivalent to the "right-click" is the Ctrl-click – depressing the **control** key (control or cntrl, not ⌘) while clicking the mouse. A two-finger tap on the trackpad can also work, though you may have to enable it in System Preferences.

Cells

	A	B	C	D
1	π	radius	circumference	area
2	3.14		2πr	πr^2
3		1.00	6.28	3.14
4		2.00	12.57	12.57
5		3.00	18.85	28.27
6		4.00	25.13	50.27
7		5.00	31.42	78.54
8		6.00	37.70	113.10
9		7.00	43.98	153.94
10		8.00	50.27	201.06
11		9.00	56.55	254.47
12		10.00	62.83	314.16
13		11.00	69.12	380.13
14		12.00	75.40	452.39

Figure 1-1 Circle spreadsheet

Have a close look at the preceding spreadsheet. There are rows 1 – 14, and columns A – D. We can refer to any cell by its address in the form ColumnRow. The symbol π is in cell A1. The value we chose to use for π is in the cell below, cell A2. Column B gives the radii of circles, from 1 to 12. Columns C and D give the circumference and area of circles with the given radii.

The good news is that excel did almost all the work. We had to type in the header information in rows 1 and 2 – π, radius, … πr^2 . We had to type in 1 and 2 in the radius column, and formulas in cells C3 and D3. The rest came more or less automatically.

	A	B	C	D
1	π	radius	circumference	area
2	3.14		2πr	πr^2
3		1.00		
4		2.00		
5				

Figure 1-2 Arithmetic series

For this first run, we've entered 3.14 as the value to use for pi. We can go back at any time and use a more accurate value, say 3.1415, and the spreadsheet will automatically recalculate every value dependent on pi. We've also input the first two values to be used for the radius, 1 and 2. If you select both the cells B3 and B4, and then grab the selection box at the bottom right of cell B4 with the cursor, and drag it downward, excel will continue the radius series for you – 3, 4, 5 … as far as you want to drag it. This trick works as long as the numbers are a simple arithmetic series. If you had started with the numbers 3 and 7, excel would continue the series with 11, 15, 19…

	A	B	C	D
1	π	radius	circumference	area
2	3.14		2πr	πr^2
3		1.00		
4		2.00		
5		3.00		
6		4.00		
7		5.00		
8		6.00		
9		7.00		
10		8.00		
11		9.00		
12		10.00		
13		11.00		
14		12.00		

Figure 1-3 Drag to extend arithmetic series

Finally we add the formulas. Every formula begins with =; this lets excel know to do the math. (I have stopped excel from evaluating the formulas here by formatting cells C3 and D3 as text.) There are several things to note:

	A	B	C	D
1	π	radius	circumference	area
2	3.14		2πr	πr^2
3		1.00	=2*A2*B3	=A2*B3^2

Figure 1-4 Entering formulas

- The symbol * means multiply; + means add
- The symbol ^ means raise to a power, so 3^2 is 3 squared, or 9
- The simple B3 cell references are relative references. The B3 in cell C3 points to cell B3, the cell to the left of C3. If the formula is copied to cell C4, then the B3 reference will be changed to B4, so that it will still point to the cell to the left of C4. If you copy this formula to cell Z85, the B3 reference will change to Y85 – it will always point to the cell just to the left.
- The A2 is an absolute cell reference – it always points to cell A2. If the formula is copied to another cell, it will still say A2, and will still point to cell A2. Since A2 holds the value for pi, we want to always point to A2.

- Cell references can be typed in by hand, or entered by clicking inside the referenced cell. If entered by clicking, excel assumes you want a relative reference. You can change to an absolute cell reference by adding the $ signs manually, or by toggling through the possibilities. How one toggles depends on the machine, and perhaps on the version of excel (or other spreadsheet). On my Mac, typing ⌘T causes the toggling. Other machines use F4. Note: you can reference a cell in a different spreadsheet entirely, in which case clicking the cell is the easy way to generate the path information to the other spreadsheet. But be careful; referencing other spreadsheets can lead to your current spreadsheet changing when the other spreadsheet is changed. It is a common way to do things in accounting, where the results of one spreadsheet feed into other spreadsheets.
- When you type in the last character of a formula, end the formula by pressing the enter/return key. If you just move the cursor over to another cell and click, Excel will add that cell to your formula – not what you really wanted.

	A	B	C	D
1	π	radius	circumference	area
2	3.14		2πr	πr^2
3		1.00	6.28	9.87

Figure 1-5 Evaluating formulas

Finally, I've gone back and formatted cells C3 and D3 as "number", and let excel do the math. If we now select both cells, and then grab the selection box at the lower right corner of cell D3, and drag it downwards, Excel will duplicate the formulas in the cells below. The relative cell reference B3 will be changed to point to the radius on the current line. And the cell reference A2 will always to point to A2.

Here is the spreadsheet after dragging the formulas down a couple of lines. If you click on a particular cell, C5 for example, Excel will display the formula for that cell in the header bar above the spreadsheet. (This is the first thing to check when troubleshooting.)

	A	B	C	D
1	π	radius	circumference	area
2	3.14		2πr	πr^2
3		1.00	6.28	3.14
4		2.00	12.56	12.56
5		3.00	18.84	28.26

Figure 1-6 Drag formulas to repeat

If you drag the formulas downward all the way to line 14 (radius = 12), then you will have the spreadsheet shown at the start of the chapter.

Formatting cells

If you select a cell or a range of cells on a spreadsheet and right click (alternately select the Format tab, which will drop down a list of options), then one of the available options is Format Cells. There are many options, more than I want to go through here. Most of the options are fairly self-explanatory. I will mention a few:

1. Number tab – includes options to format numbers (how many decimal places to display, how to display negative numbers, etc.) One of the options hidden in here is "text", which tells excel not to treat the entry as a number at all. Excel will display a text-formatted cell exactly as typed.
   Incidentally, displaying a number with 0 decimal places (so pi would display as 3) does NOT truncate the number. Excel still uses its full 14 decimal places of accuracy in its calculations.
2. Alignment tab – excel gets some funny ideas about whether to display the data on the left side or the right side, or right in the middle of a cell. You can use this to control where it puts cell entries, what to do if the cell text overflows the cell, etc.
3. Font tab – the usual selection of fonts, styles, sizes, notable mainly because this probably is not where you expected to find it.
4. Border – lets you specify line widths for cell boundaries inside your spreadsheet, and on the border of your spreadsheet. This is the final step in preparing a spreadsheet, just before you print it off. Note that the grid lines you see in a new Excel spreadsheet don't print, so you really need to add them here if you want them in the final output.

Functions

Excel has a wealth of built in functions, covering finance, mathematics, and engineering. These are entered as all or part of a formula. If you remember the function abbreviation, you can type it. Alternately you can access all functions by clicking the Insert tab, and selecting Function. This brings up a box with searchable access to all the functions, with their definitions. A few examples:

= SQRT(E44) calculates the square root of whatever is in cell E44

= SUM(B3:B14) calculates the sum of all the entries in the range B3 to B14.

= PI() pi is a special function. If you put anything inside the parentheses, you'll get an error. If you don't put the parentheses there, you'll get an error. But type it as PI(), and you'll get all the decimal places of pi that Excel and your computer can handle, typically 14.

The big picture

If this is new to you, I encourage you to replicate the spreadsheet yourself. For someone with even a little experience in Excel, it is a brief exercise. It may take a bit longer the first time through, but it is easier to spend the time here, where the end results are known in advance, rather than getting bogged down later in a more complex spreadsheet. Maybe you'll have to hunt around to find where to get the symbol for π (Insert tab, Symbol), though of course you could just write pi. Try using the excel value for pi (= PI()), and display everything to 5 decimal places.

Question: Using the excel function PI(), what value do you then get for the area of a circle with a radius of 11, to 5 decimal places? (answer at end of this section)

If you ever expect to refer back to a spreadsheet, then label things, and leave yourself some notes on the spreadsheet itself. Otherwise you'll come back to a big page of numbers, and you'll have to dredge up the formulas to reverse-engineer your own work – often more time-consuming than just doing it over from scratch.

When you are developing a new spreadsheet, don't be timid about using a few extra columns. If you find yourself with a lengthy formula, it would be wise to break it into pieces the first time through. Then you can keep an eye on the calculations, and make sure that each step is giving reasonable results. Then try combining everything into one big formula (if you feel you have to), and make sure the result agrees with your step-by-step calculations. It is too easy for a mistake to hide in a big complicated formula.

Finally, when you run into a problem with a spreadsheet, Google (or whatever search engine you prefer) is your best friend. Excel has online help files, but it is usually faster and easier to Google the problem. A search for "excel cell references mac" will quickly lead to the ⌘T trick for toggling between absolute and relative cell references. If you are stuck on some obscure point, chances are you are the 10,000th person to run into the issue, and an internet search will likely turn up dozens of posts about the problem.

An Aside on Scientific Notation

Scientific notation is covered early in the math curriculum, but it is a topic that is introduced and then seldom used. A student in the sciences is more likely to use scientific notation on an everyday basis. When real quantities are measured, they often are way off the scale of everyday objects. The speed of light is ~$3x10^8$ meters per second. Thirty-two grams of oxygen contains ~6.02×10^{23} molecules of O_2. The mass of the earth is ~5.97×10^{24} kilograms. Moreover, when computers work with these sorts of numbers, they use floating point notation, which is closely related. Bottom line – scientific notation in one form or another is used everyday by workers in science and engineering.

4,650,000 ≡ 4.65×10^6 (≡ means "is the same as". The number is exactly the same, just written in a different format.)

4.65 is called the coefficient; 6 is the exponent.

For scientific notation, Excel will display this as 4.65E+6

Calculators

Most calculators will accept scientific notation. To enter 7.35×10^{12}, one enters:

7.35

EXP (or EE, or something similar)

12

The calculator then displays 7.35E12, which is understood to represent 7.35×10^{12}.

Excel

Excel is flexible in number formatting. It readily handles multiple formats for numbers; we are mostly interested in two formats:

1. Number – which means decimal number, i.e. 37.43 The default is for 2 decimal places, but this can be set larger or smaller as desired.
2. Scientific – which displays 37.43×10^3 as 3.74E+4. Again the default is 2 decimal places, but can be adjusted. And note that the exponent will be adjusted so that the coefficient is always between 1.00 and 9.99…

When a new spreadsheet is opened, all cells have a *General* format, which doesn't specify any particular format for numbers. The format can be changed in any of four ways:

1. Specifically format the cell as *number* (and specify the number of decimal places) – entries will then be displayed in decimal form, for instance 37.43
2. Specifically format the cell as *scientific*, again specifying the number of decimal places – entries will be displayed in scientific notation, i.e. 3.74E+1

3. Enter a number into the cell, and the cell format will match your entry.
    a. Enter 3.7E4. The cell will display 3.70E+4 (default is 2 decimal places)
    b. Enter 37.432. The cell will display 37.43 (default is 2 decimal places)
4. If a decimal number in a cell gets too wide to fit, Excel may switch to scientific notation. Forcing the cell format to *number* may actually increase the width of the cell (and the entire column) to fit in all the digits.

Finally note that a cell displaying ######## usually indicates that a number entry has exceeded the width of the cell. This can be fixed by changing to *scientific*, or by expanding the column width.

You may reformat the cell at any time; scientific notation can be changed to decimal numbers, and vice versa. No data is lost when you change the format. Setting the number of decimal places affects only how many digits are displayed; Excel keeps track of the numbers out to 14 decimal places, regardless of how many you choose to show.

Often you would like to display 2 or perhaps 3 significant digits of the numbers in a table. Suppose you have a table with entries: 1.240, 0.327, 0.00498, and 0.000173. Setting the display to ***number*** with 3 decimal places, the table will show 1.240, 0.327, 0.005, and 0.000 , which illustrates the main shortcoming of the number format. Switching to scientific format, with 3 decimal points, the table will show 1.240E+0, 3.270E-1, 4.980E-3, and 1.730E-4.

Metric System Refinements

One final note: the metric system defines a long list of prefixes to make it easier to talk and write about quantities. With a few exceptions, the ones in common use refer to quantities where the exponent is divisible by three. Using these prefixes implicitly makes use of scientific notation. When an electrical engineer specifies a 22 pF (picofarad) capacitor, she is asking for a 22×10^{-12} farad capacitor. Verbally, the engineer would probably say “22 puff”, and anyone in the industry would know exactly what is intended.

Table 1-1 Metric system prefixes

Exponent	Metric prefix	example	abbreviation
10^{12}	tera-	terawatt	TW
10^{9}	giga-	giga electron volt	GeV
10^{6}	mega-	megawatt	MW
10^{3}	kilo-	kilogram	Kg
10^{2}	hecto-	hectopascal*	hPa
1	no prefix		
10^{-2}	centi-	centimeter**	cm
10^{-3}	milli-	milliliter	ml
10^{-6}	micro-	micrometer	µm, micron (US)
10^{-9}	nano-	nanosecond	ns
10^{-12}	pico-	picofarad	pF

*The hecto- prefix is seldom used. I would have left it out of this table, had I not encountered it in the discussion of barometric pressure, which is now commonly given in hectopascals (abbreviated hPa).
**The centi- prefix is used almost exclusively with meters in the US; a centimeter is a very convenient length for measuring items that you can pick up and handle. But if you asked a US chemist for 12 centiliters of a liquid, he would likely clarify by asking – "You mean 120 milliliters?" Centiliters are encountered somewhat more often outside the US – a standard sized soft drink might be labeled 330 ml, or 33 cl.

Also in the US, lengths in the micrometer range are more often referred to as microns; 1 micron ≡ 1 micrometer. This is especially common in the electronics industry. Years ago, silicon semiconductor features were measured in microns; now they have shrunk below 10 nanometers for digital chips. Traces on printed circuit boards are now as small as 100 microns (1/10 of a millimeter).

Confusingly, a micrometer is also the name of a common measuring device used by machinists. Note however that *micrometer* – the measuring tool – is pronounced differently from *micrometer* – the unit of measurement.

Usage is idiosyncratic. Nanometers, millimeters, kilometers are all commonly used. One might logically think that megameters and gigameters would be useful also, but those terms are almost unknown. Five megameters would be commonly referred to as 5000 kilometers. Distances in the gigameter range are encountered in astronomy, but astronomers have distance measures that predate the metric push to standardization, and they will stick with AUs (astronomical units) and parsecs. (One astronomical unit is roughly the distance from the earth to the sun, ~1.50 x 10^{11} meters. One parsec is 3.086 x 10^{16} meters, or roughly 3.26 light years. The andromeda galaxy is 780 kiloparsecs distant.)

Similarly, one thousand grams is a kilogram, so you might logically expect one million grams to be called a megagram. Nope. It's a thousand kilograms, or a metric ton.

Perhaps the most common everyday usage (some would say misusage) of these prefixes is in the computer/software world. We all know – sort of – that personal computers have memories measured in GB, gigabytes. You should be forgiven if you think that GB means 10^9 bytes. The computer people measure everything in powers of 2, so one KB or kilobyte is 1024 bytes instead of 1000; 1024 is 2^{10}. Summarizing:

Table 1-2 Prefix usage for computer memory

1 kilobyte, or KB	2^{10} bytes	1024 bytes
1 megabyte, or MB	2^{20} bytes	1,048,576 bytes
1 gigabyte, or GB	2^{30} bytes	1,073,741,824 bytes
1 terabyte, or TB	2^{40} bytes	1,099,511,627,776 bytes

The good news is that you're getting a little more than you were expecting, if you thought that a gigabyte was going to be 10^9 bytes.

Note that this power of two usage only applies to memory sizes. If the processor clock speed is 1 GHz (giga-hertz), then that means 1 x 10^9 Hz exactly. And Hz (Hertz) is just a short way of saying cycles per second.

Engineers and scientists think of themselves as Spockishly rational, but as you may be noticing, there is a lot of arcane knowledge (and sometimes even whimsy) lurking in their jargon.

Answer to question: What is the area of a circle with a radius of 11.00, using the Excel function PI() ?

380.13271