Advanced Excel: Dates, times and lookup tables

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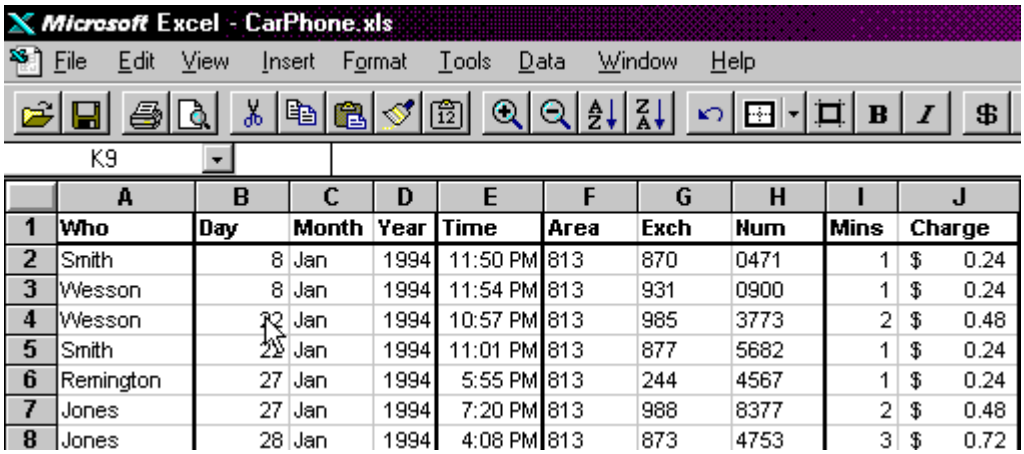
You cover the county commission in Gabalot, R.I. You've been to a few NICAR conferences, and are convinced that the cellular phone logs of commissioners offer a great resource for an enterprising reporter.

So you get copies of four commissioners' cellular phone bills and type them into a spreadsheet.

- Open the worksheet called CarPhone.xls.

What you see is a spreadsheet of four Gabalot commissioners' cellular phone bills. Take a look at the structure. It looks like a database, with fields (columns) and records (rows) of each phone call made.

Zoom in on the area that includes the date and time information. Because of those NICAR conferences, which stress entering each bit of information into its own field, there's a column for the day of the month, the month, the year, and the time. That was wise.



	A	B	C	D	E	F	G	H	I	J
1	Who	Day	Month	Year	Time	Area	Exch	Num	Mins	Charge
2	Smith	8	Jan	1994	11:50 PM	813	870	0471	1	$ 0.24
3	Wesson	8	Jan	1994	11:54 PM	813	931	0900	1	$ 0.24
4	Wesson	22	Jan	1994	10:57 PM	813	985	3773	2	$ 0.48
5	Smith	22	Jan	1994	11:01 PM	813	877	5682	1	$ 0.24
6	Remington	27	Jan	1994	5:55 PM	813	244	4567	1	$ 0.24
7	Jones	27	Jan	1994	7:20 PM	813	988	8377	2	$ 0.48
8	Jones	28	Jan	1994	4:08 PM	813	873	4753	3	$ 0.72

So what are you going to do with all of these phone calls?

If you only wanted to know which telephone numbers are called the most by each commissioner, you probably wouldn't use a spreadsheet at all. Database managers like Access and FoxPro make easy work of counting calls and adding minutes.

But you're looking for something different. How often do commissioners bill taxpayers for personal use of their cellular phones?

One way to examine that question is to examine the individual phone numbers. You'd look for out-of-state calls and calls to known friends or family members. Another way is to look at the timing of the calls.

Of course, knowing whether the commissioners used their phones during normal work hours won't tell you for sure whether the calls were for personal or professional work. Public officials often work well past closing time, on weekends or very early in the morning. But you can get a feel for the patterns by determining what day of the week and what time of day the calls are made. At least you'll be able to ask the commissioners about late night and weekend phone use in your next interview.

This exercise will show you some powerful functions of spreadsheets that can summarize date and time values. You'll use date functions, a lookup table and a pivot table to summarize the cell phone use in this spreadsheet.

Understanding dates and times

Before you start, you have to understand how Excel works with date and time values.

Virtually all personal computer applications treat dates and times in a special way. They display a date or a time that looks like one you recognize, but they are actually storing something very different. In Excel, a date is the number of days since Jan. 1, 1900. Time works the same way. Excel stores a fraction, or decimal representation, of a day. Here's how a spreadsheet sees different values:

What you see:	What a spreadsheet sees:
January 23, 1995	34722
12:05 PM	0.503472
23-Jan-95 12:05 PM	34722.503472

This is a powerful way to think of time for three reasons:

1. No matter how you look at your dates and times, they can be sorted in chronological order. Anyone who's tried to sort a text representation of a date, like "2/1/95," knows how powerful that can be.
2. Excel can keep information about the date. For instance, it knows whether the time is in the afternoon or the morning. It knows that a date is the 25th of December, no matter what year it is. And it knows that January 23, 1995 is a Monday. It stores the day of the week as a number, too: Monday is 2.
3. You can do math on the results. This means that you can add a date to a time. Once you do that, you can find out the number of minutes, days, weeks or months that separate the values. So your spreadsheet will be able to calculate the number of minutes it took for an ambulance to respond to a call, even when the call was made at 11:55 on Saturday night and the response took 20 minutes.

Using number formats

You've probably used number formats in Excel before. When you calculated a percent change, for example, Excel displayed the results as a fraction. In NICAR classes, you mash the "%" format button to convert that number into a percentage that looks right.

You can do the same thing with dates and times. In Excel, you format a number in the Format, Cells, Number dialog box. Special codes tell Excel how to display the date. Here are some ways that Excel can display the value 34722.503472:

Date format	What you see
yyyy	1995
mmmm d, yyyy	January 23, 1995
mm/dd/yy	01/23/95
m/d/yy	1/23/95
dddd, mmm d, yyyy hh:mm AM/PM	Tuesday, Jan 23, 1995 12:05 PM

What day is it?

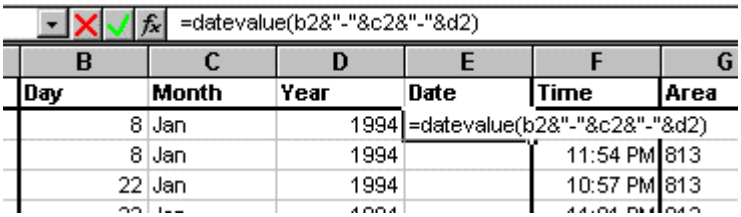
In our cellular phone log, you have to create one of these special date values before you can work with information like the day of the week. You'll use the DATEVALUE() worksheet function to figure it out.

The DATEVALUE() function works on a string of text that looks like a date. So the function command =DATEVALUE("23-Jan-95") would return the value 34722.

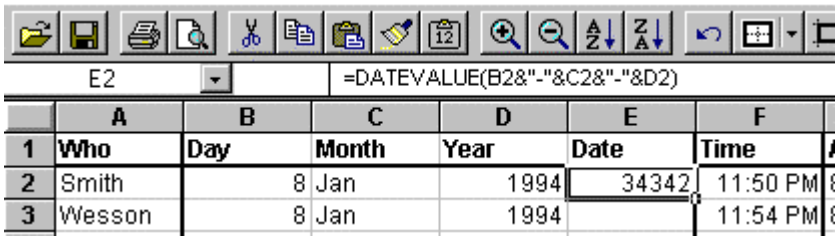
- Select the entire column E. Insert a blank column there. Once it's inserted, select cell E1, type Date and hit enter.

Now there's a problem. Your spreadsheet has the day (8), month (Jan) and year (94) in separate cells. We'll put them together using text operators, separated by dashes, in our formula.

- Move your cursor to cell E2 and select it. Type =datevalue(b2&"-"&c2&"-"&d2)



- and hit enter:

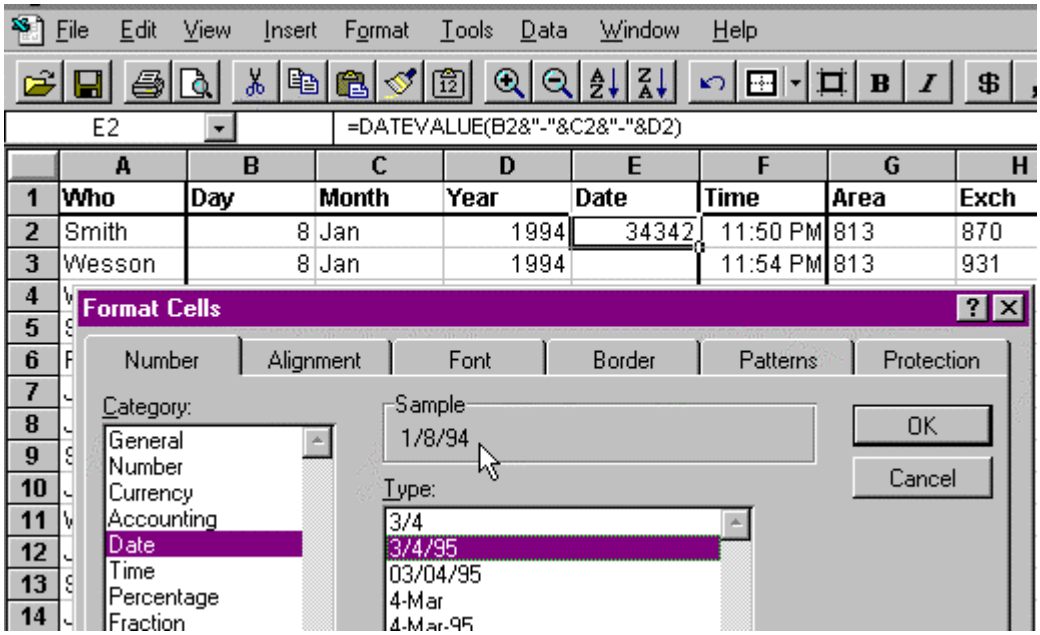


What you've done is create the text string "8-Jan-94" inside the parentheses. Excel can then recognize that string as a date, and has converted it into the number of days since Jan. 1, 1900. (Don't worry if you get a number slightly different than this. There are two date systems. One counts the number of days since 1904, and someone might have put that option onto your computer. As long as you get a number close to this, you've probably done it correctly.)

You'd like to see this number as a date anyway.

- Select column E. Choose Format, Cells from the menu bar, choose the Number tab if it isn't selected already and click on Date within the Category section. Choose the format you like best in the Type section.

In this example, 34342 will become 1/8/94, a format that saves space while giving you all the information you need about your date.

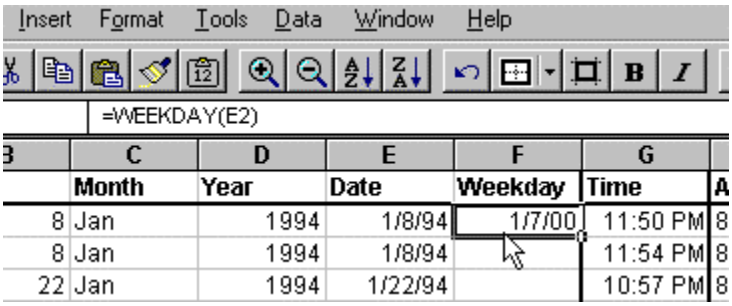


- Copy your new date down through the rest of the rows. You now have a new field that is made up entirely of dates that Excel understands as dates.

We're interested in finding out whether our commissioners use their cell phones on the weekend. Our first step is to figure out what day of the week each call was made.

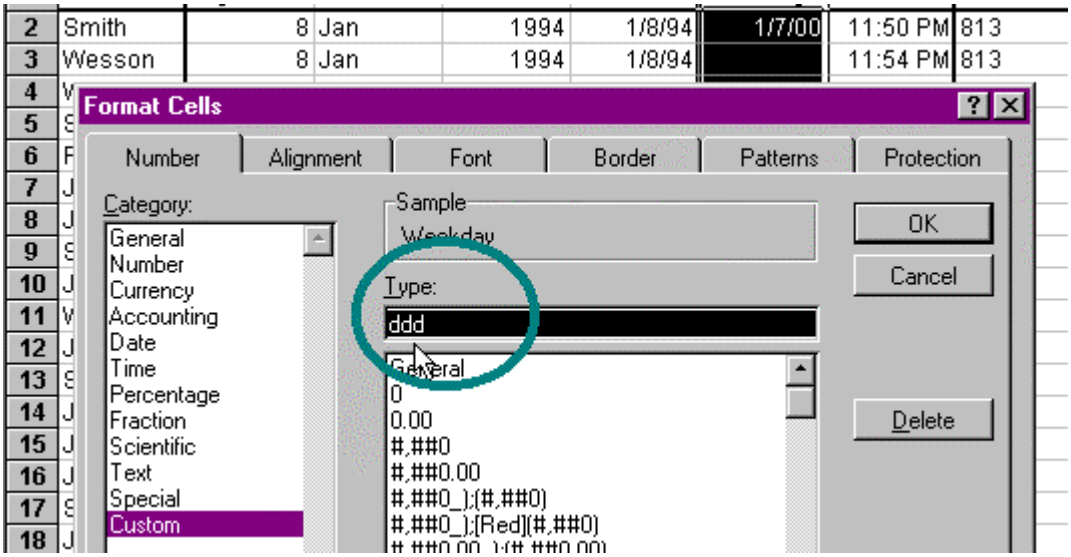
- Select column F and insert another column. Type Weekday in cell F1 and hit enter. Now move your cursor to cell F2, select it and type =weekday(e2) and hit enter.

Oops. You'll see a crazy date something like this:



What happened? When you inserted a new column next to Column E, the spreadsheet assumed you wanted it formatted the same way. It's trying to figure out a date that corresponds to 7, which which is the day of the week that was calculated. Again, all you need is a little formatting help.

- Select column F, choose Format, Cells, Number. Choose Custom under Category and type ddd (for 3-letter days of the week) into the Type box provided:



Now you should see "Sat" in the weekday column, which is the 7th day of the week.

- Select F2 and copy it down through your spreadsheet.

What are your hours?

Commissioners often work long hours. In your town, county commission meetings are held during the day, so you don't have to worry much about night meetings. But how can you tell whether a commissioner is working at night or on weekends?

You can't. But you can set up some rules that will give you a hint about how much time they're spending on the cell phone at times that they're less likely to be working. In Gabalot County, most commissioners get to work around 8:00 a.m., unless they have an early breakfast meeting. They leave around 5:30, unless they have an early evening meeting.

So let's set up some rules about whether they're likely to be working or not:

Before 6:00 a.m., work is doubtful.
Between 6:00 a.m. and 8:00 a.m. it's a tossup.
Between 8:00 a.m. and 5:30 p.m., work is likely.
Between 5:30 p.m. and 7:30 p.m., it's a tossup.
After 7:30 p.m., work is doubtful.

You could probably make a huge formula in your spreadsheet that would test for these conditions. There's an easier way to look up information based on rules like these in a spreadsheet. It's called a *lookup formula*.

The simplest lookup formulas work like telephone directories: Once you find the name of the person you want to call, you glance over and pick up up the corresponding phone number. Anyone who's used a database manager like FoxPro or Access has probably used lookup tables by joining one table of data, like campaign contributions, with details about a field, like PACs.

In this case, you'll use the spreadsheet equivalent of a database join using a formula called VLOOKUP. It looks for your value in another part of the spreadsheet and gives you back the corresponding value from an adjacent column.

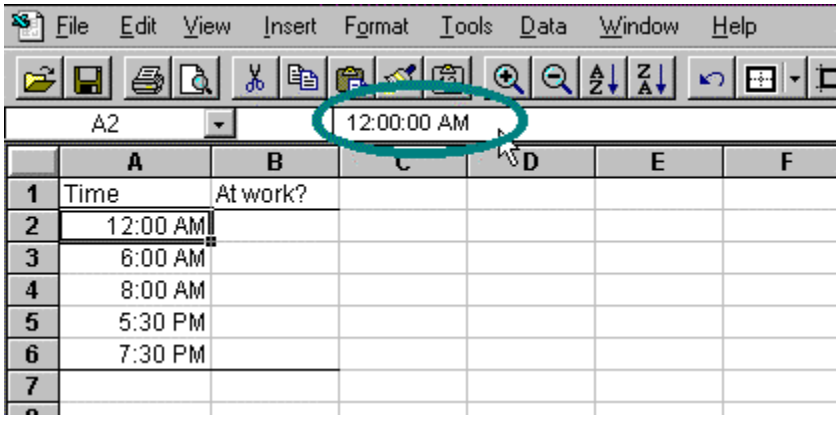
VLOOKUP goes a little further than this simple join. If you've used a database manager, you know that joining two tables requires an exact match. If my Social Security number were off by one digit in one table, the database would treat me as if I didn't exist. That's good. But in this case, we don't want to have to type all of the possible times that commissioners used their phones. Instead, we want to set up slots of time within which the day.

Let's set this up on another worksheet within our CarPhone.XLS workbook. That'll keep it separate from the rest of our analysis.

- Insert a new worksheet by choosing Insert, Worksheet on the menu bar. You'll be taken to a new worksheet named Sheet1 within the same spreadsheet.
- Type in your cutoff hours from the rules above into the first column. Begin with midnight, since that's 0 to a spreadsheet. (Remember, times are actually fractions of a day. So midnight is zero, noon is .5, and 10:00 p.m. is .91 2/3.)

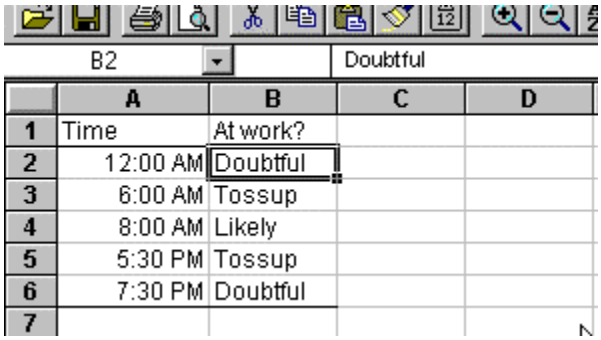
Here's what it should look like when you're done.

(To type a time, just type it in, with a space between the time and the AM or PM indicator. If the formula bar shows extra precision, like 12:00:00 AM instead of 12:00 AM, and if the spreadsheet justifies the number to the right, you've successfully typed in a time.)



VLOOKUP will check each time in your cell phone log against this table. If it doesn't find an exact match, it will give you back the value corresponding to its next lowest value. In this example, 6:30 p.m. will be treated the same way as 5:30 p.m; 7:00 a.m. will be treated as if it's 6:00 a.m

To fill out the lookup table, we'll associate these times with the words Doubtful, Likely, Tossup. This means, for instance, that any time between 6:00 a.m. to 7:59:59 a.m. will be treated as a Tossup.

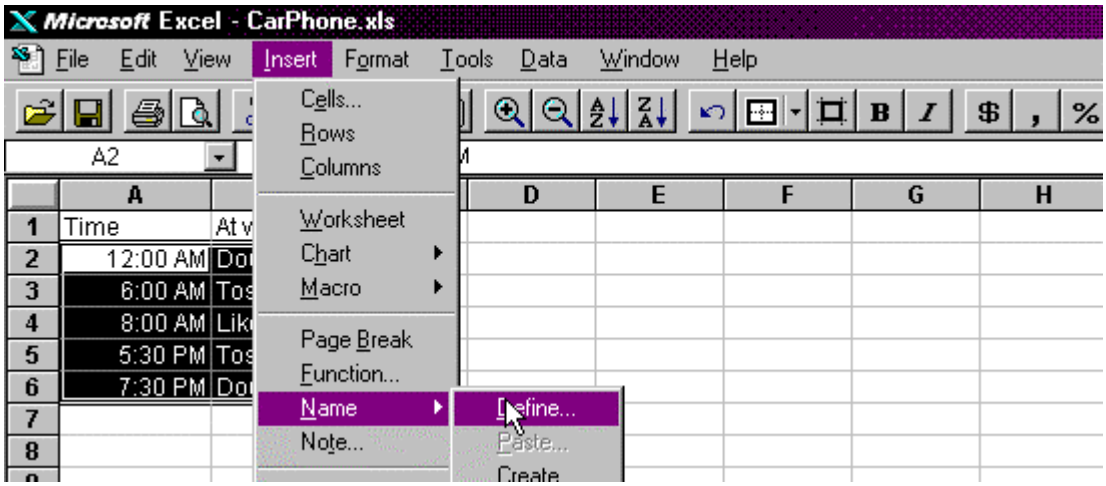


The trick to these kinds of lookups is that your leftmost column – the one you're looking up – must be sorted.

- Just to be sure it's all been typed in correctly, you need to sort your lookup table. Select A1:B6, choose Data, Sort. Then choose Time and Ascending in the first sort area. (If it doesn't look like the table shown above, you've done something wrong. Keep trying until it looks like this table. It must be sorted on the first column for this lookup function to work properly. The worst part is, you'll get an answer but it'll be wrong if it's not sorted.)

Finally, let's make it a little easier on ourselves later by naming this area in the spreadsheet.

- Select cells A2:B6 (the data area of your lookup table). Use the menu command Insert, Name, Define and then type in LkupTime (all one word) in the box provided. From now on, anytime you use the term LkupTime in this spreadsheet, it will refer to this area, or the lookup table.



- Now you're ready to go back to the original database. Choose the tab at the bottom of the worksheet called RawData. (If you can't see it, use the double arrows at the bottom left of the spreadsheet to cycle through the worksheets in this file.)
- Select column H in the original worksheet, and insert a blank column. Type Time Type in column H1, press enter, and select cell H2.

Before you type in the lookup formula, you have to know how it's structured. You'll use the VLOOKUP formula, which tells the spreadsheet to search for your value down a column of sorted values. It's structured like this:

=VLOOKUP(*what*, *where*, *answer*, *how*)

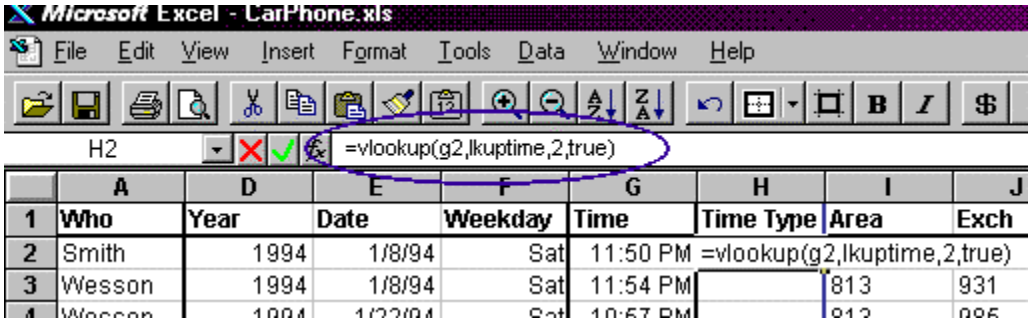
The "*what*" is the value you want looked up. In this case, we want to look up the value in G2, or 11:50 PM.

The "*where*" is where you want to look it up. In this case, we want to look it up in the table we just typed in, which our spreadsheet now recognizes as LkupTime.

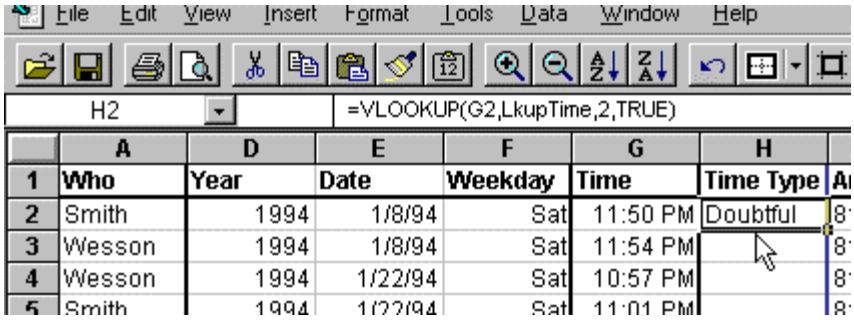
The "*answer*" is the column number in your lookup table that holds the value you want back. We want the only other information in the table, or the corresponding word in column 2 of our table.

And the "*how*" (which is optional) tells the spreadsheet whether you want to check ranges in a sorted table versus an exact match in an unsorted table. This is TRUE for us, since we have a sorted table and want the formula to give us the next lower value if there isn't an exact match on the time. (Use FALSE here if you want to get an error value when there's no exact match or if you can't sort your lookup table for some reason.)

- Type it this formula now: =vlookup(g2,lkuptime,2,true)



- Hit enter, and here is what you get back.



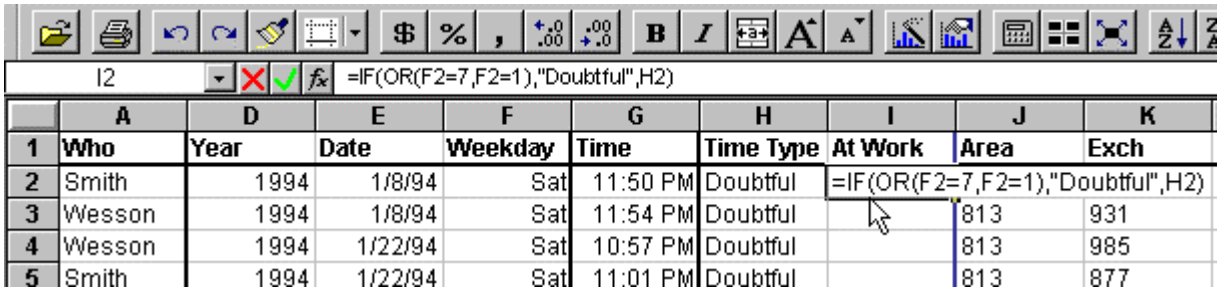
	A	D	E	F	G	H
1	Who	Year	Date	Weekday	Time	Time Type
2	Smith	1994	1/8/94	Sat	11:50 PM	Doubtful
3	Wesson	1994	1/8/94	Sat	11:54 PM	
4	Wesson	1994	1/22/94	Sat	10:57 PM	
5	Smith	1994	1/22/94	Sat	11:01 PM	

- Copy the formula down through your database.

At work or not?

We have one last problem. Scroll through your data, and soon you'll find a case in which we've labeled the commissioner "Likely" to be at work on a Saturday or Sunday. Our last step in setting up our cell phone logs is to put together the day of the week with the time of day.

- Choose column I and insert one last column. Type At Work into cell I1 and hit enter. Select cell I2. Type =if(or(F2=7,F2=1),"Doubtful",H2)



	A	D	E	F	G	H	I	J	K
1	Who	Year	Date	Weekday	Time	Time Type	At Work	Area	Exch
2	Smith	1994	1/8/94	Sat	11:50 PM	Doubtful	=IF(OR(F2=7,F2=1),"Doubtful",H2)		
3	Wesson	1994	1/8/94	Sat	11:54 PM	Doubtful		813	931
4	Wesson	1994	1/22/94	Sat	10:57 PM	Doubtful		813	985
5	Smith	1994	1/22/94	Sat	11:01 PM	Doubtful		813	877

Let's walk through that formula, taking it from the inside out:

OR(F2=7,F2=1) is checking the Weekday column. Even though we've formatted it to tell us the day of the week in words, this column really holds a numerical day of the week, beginning with 1 for Sunday and ending with 7 for Saturday. So this part of the formula checks to see if the value is Saturday (7) or Sunday (1).

The next phrase, "Doubtful," is what we want the formula to give us if either of those two conditions is true. In other words, we doubt a commissioner is at work on Saturday or Sunday. The last part of the formula tells us what to do the rest of the time. We'll assume that if it's not Saturday or Sunday, we'll use the value we figured out in the Time Type column.

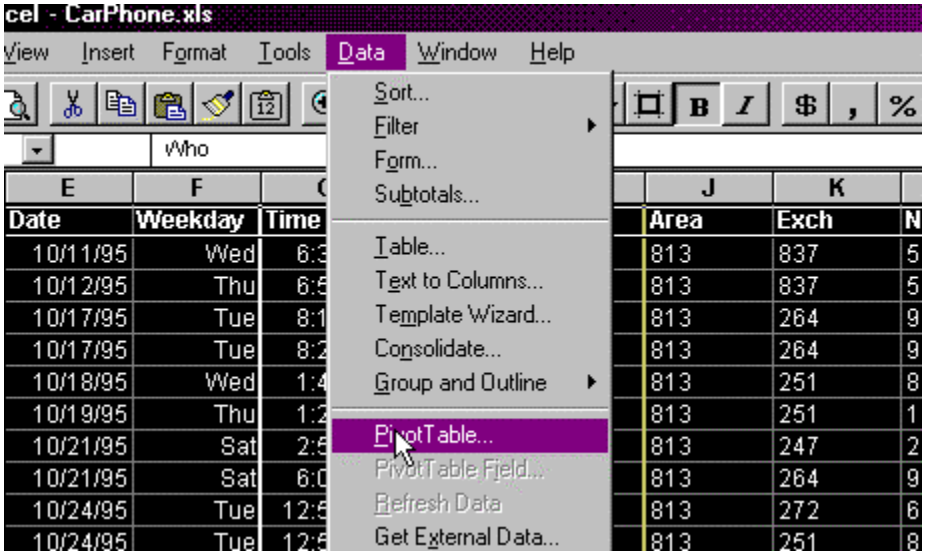
- Go ahead and hit enter if you haven't already, and copy this formula down.

Summarizing your results

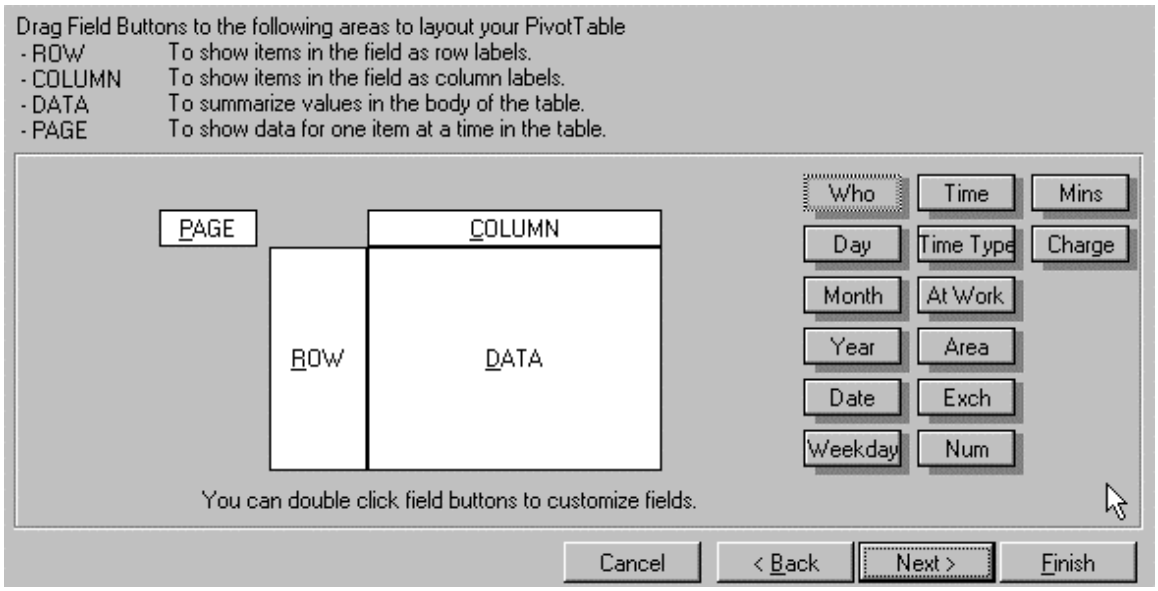
The last step is to summarize your results using one of Excel's most powerful features, the Pivot table. You could skip this part and import your information directly into a database to accomplish something very close to the same thing.

You're going to compute the amount of time that each commissioner spends on the phone during each category of work time: Doubtful, Likely and Tossup. You'll also see what percentage of each commissioner's cell phone use time falls within each category.

- Select your entire database, or the area A1:N400. From the menu, choose Data, PivotTable



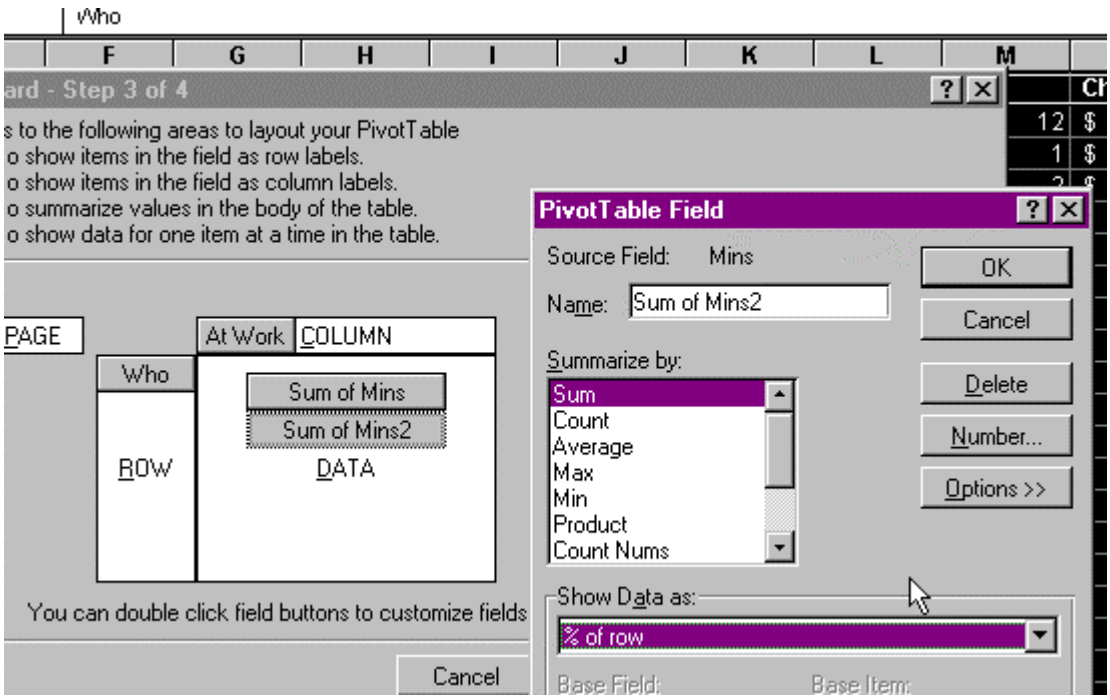
- You'll see the pivot table wizard appear. Make sure the first box has Microsoft Excel List checked. Press the Next> button. The next box should say A1:N400. Press the Next> button again. The third box should look like this:



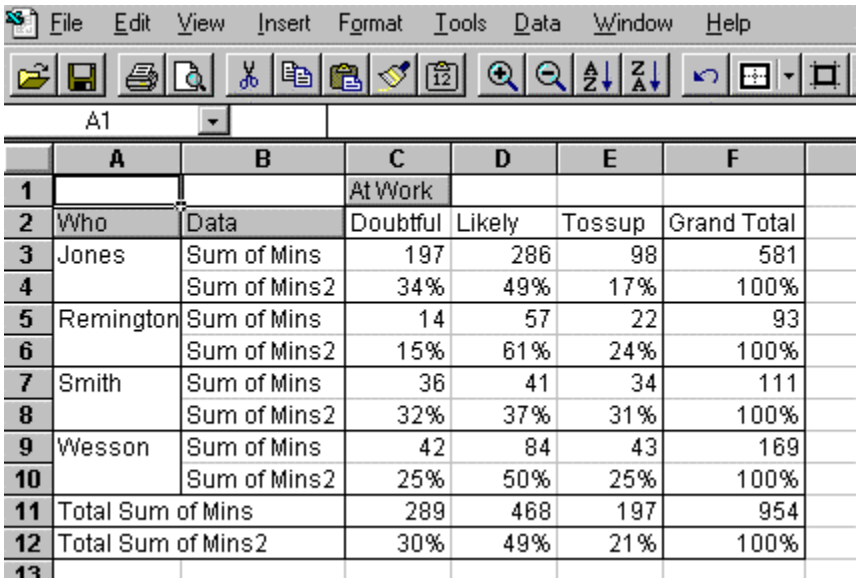
- Drag the Who box to the ROW section. Drag the At Work box to the COLUMN section. This means we'll look at each commissioner (Who) down the left side and the At Work categories across the top.
- Now drag Mins into the Data area. Excel will change this to Sum of Mins. Repeat that last step, dragging another copy of Mins into the DATA area. It should say Sum of Mins2. Double-click that last Sum of Mins2 box. Another dialog box will appear. Choose the Options>> on the lower right corner to give you more control over what will appear in the pivot table.

We're interested in the percent of time each commissioner spent on the phone during doubtful, likely or tossup times and days. Since we'll look at each commissioner across a row, we want to find out the percent of the row in each category.

- Under the Show Data as: box, choose % of row as shown here:



- Finish up the pivot table by pressing OK, then Next>, then Finish on the final screen. Here's how Excel will summarize your data:



	A	B	C	D	E	F
1			At Work			
2	Who	Data	Doubtful	Likely	Tossup	Grand Total
3	Jones	Sum of Mins	197	286	98	581
4		Sum of Mins2	34%	49%	17%	100%
5	Remington	Sum of Mins	14	57	22	93
6		Sum of Mins2	15%	61%	24%	100%
7	Smith	Sum of Mins	36	41	34	111
8		Sum of Mins2	32%	37%	31%	100%
9	Wesson	Sum of Mins	42	84	43	169
10		Sum of Mins2	25%	50%	25%	100%
11	Total Sum of Mins		289	468	197	954
12	Total Sum of Mins2		30%	49%	21%	100%

With four formulas and one table, you've discovered that the Commissioner Jones spends far more time on her cell phone than other commissioners, and that she spends only about half of that time on the phone during regular working hours (not counting holidays).

You probably have some questions for her now.