

Building more advanced models in spreadsheets

The following scenario will provide practice in building a more complex model, developing a structured design and use some more sophisticated spreadsheet techniques.

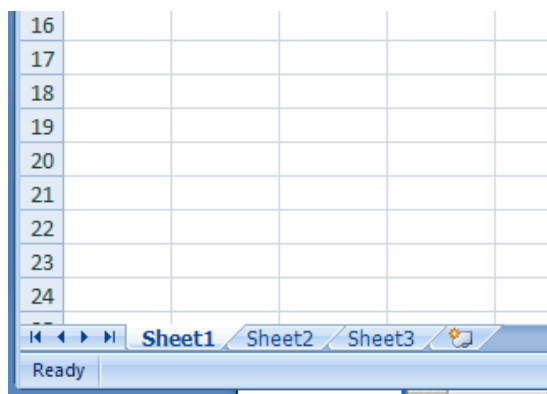
Scenario: A mobile phone company wishes to equip its sales people with a spreadsheet that will suggest the best tariff (i.e. lowest price) for a customer if they provide information about average usage for day, evening and weekend usage.

Starting Excel

To start Excel, select *Excel 2007* from the *Microsoft Office* menu item

Developing a Model

The 'tabs' mechanism in Excel allows several spreadsheet pages to be manipulated concurrently. By using the correct syntax, values and functions in one page or *sheet* can be linked to another.



The number of sheets available in a saved spreadsheet file can vary – the default for most Excel installations is 3 – named Sheet1, Sheet2 and Sheet3 here.

You can increase and decrease the number of sheets as you require – most users still use only the 'topmost' visible sheet which is Sheet1 by default

Using multiple Sheets

It is sensible to place information across the sheets in a structured fashion – the example in this handout will use 3 sheets, however more complex models may require more sheets.

Many simple process models use the sequence *Input*, *Process*, *Output*. In a simple spreadsheet design we can use one sheet for each of these activities - the *Input* sheet could collate the data that will be collected for the system, the *Process* sheet could manipulate the data in some way, whilst the *Output* sheet would display the results of the process. In a real example better names should be chosen to reflect the actual situation being modelled.

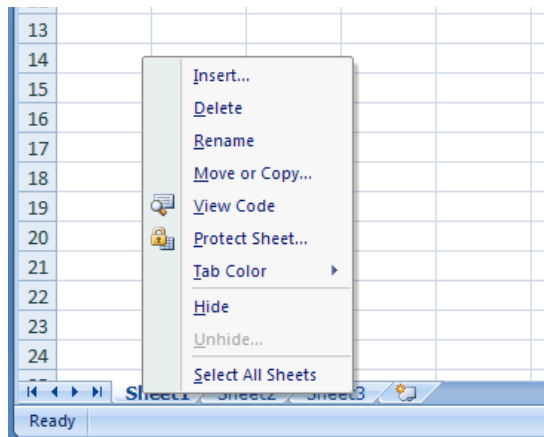
You can use spaces in Sheet names, but this may cause issues later on (when using data from various sheets). This example will use abbreviated names without spaces.

Activity 1: Choosing sensible names for the sheets

To manipulate the sheets, move the cursor over the name of the first sheet *Sheet1* and single press the right mouse button. The *tab* menu items will appear with options for inserting, deleting and renaming sheets along with some others.

Rename the Sheet1 as *custdetails*

Repeat the renaming process twice more – rename Sheet2 as *calcs* and Sheet3 as *recommendations*



This is an example of a *Context Sensitive Menu*. In Excel performing a single right mouse click will give *different* menu items depending upon where the pointer is placed.

Examples: Right Mouse clicking on an individual cell will give cell options (such as formatting and border options) – Right Mouse clicking on a Column heading will give Insert Column / Delete Column options.

The *custdetails* sheet will have some data entry fields for a salesperson to use – information about Customer Name, Address and Average Usage numbers will be entered here.

The *calcs* sheet will have data about different tariffs along with formulas to calculate costs of usage patterns.

The *recommendations* sheet will collate the data from the *custdetails* and *calcs* sheets to provide a printable tariff recommendation.

Creating the input sheet

Activity 2: On the *custdetails* sheet add text so it looks like the design in this screenshot. You will need to type the text into the correct cells for the rest of the handout to be correct (so “Title” must go in cell A4, “Name” must go in A5... No of minutes in a daytime should go in cell A13 etc).

You will also have to alter the column widths and use Bold / Font sizing to create the headings. Right align the text where appropriate.

	A	B	C	D
1	Customer Information			
2				
3	Customer Details			
4	Title			
5	Name			
6	Address			
7				
8				
9	Postcode			
10				
11				
12	Usage statistics (estimates)			
13	No of minutes in a daytime			
14	No of minutes in an evening			
15	No of minutes at the weekend			
16	No of text messages a week			
17				

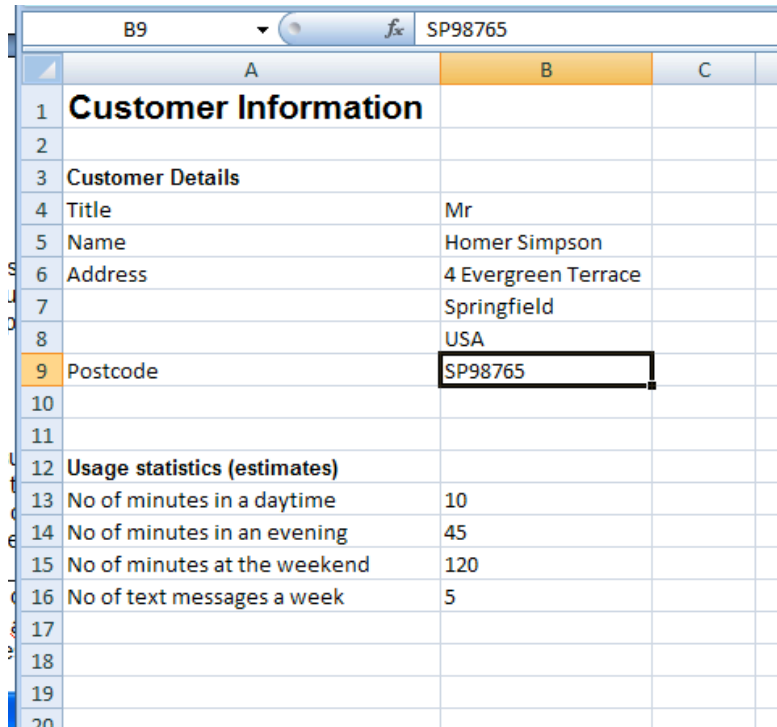
Note that the day and evening figures are PER DAY. Calculations will be used to generate monthly figures on the *calc* sheet.

To assist in building the model we will use some sample data – this will assist in error checking as when calculations are added later the actual results will be viewable (rather than 0's).

Activity 3: Add a sample user as follows

Mr Homer Simpson lives at 4 Evergreen terrace, Springfield, USA, SP98765. He has estimated his usage as 10 minutes in the daytime, 45 minutes in the evening, 120 minutes at the weekend and 5 text messages a week.

For calculations to work, the usage statistics must be entered as a plain number, so '10 minutes' will have to be stored as 10.



The screenshot shows a spreadsheet with the following data:

	A	B	C
1	Customer Information		
2			
3	Customer Details		
4	Title	Mr	
5	Name	Homer Simpson	
6	Address	4 Evergreen Terrace	
7		Springfield	
8		USA	
9	Postcode	SP98765	
10			
11			
12	Usage statistics (estimates)		
13	No of minutes in a daytime	10	
14	No of minutes in an evening	45	
15	No of minutes at the weekend	120	
16	No of text messages a week	5	
17			
18			
19			
20			

Save your spreadsheet

Creating the processing sheet

The *processing* sheet (here called *calcs*) will be used to store base values and perform calculations that would unnecessarily clutter the output sheet. There may also be confidential information that we wouldn't want to save on the output but is required for calculations to be performed.

How the tariffs work in this example

Six different tariffs are offered, payable by monthly subscription. There are different rates for different times of the day (so daytime charges are typically more expensive than evening charges, which are more expensive than weekend charges). There are a number of non-transferable free minutes which varies according to the chosen tariff.

Activity 4: Switch to the *calcs* sheet and add the data from the table so it looks like the screenshot. Remember to use *copy/paste* and the *autofill* technique to speed up the data entry. Ensure that the items are in the same cell addresses as pictured.

F1							
	A	B	C	D	E	F	G
1	Free Minutes						
2			Day	Evening	Weekend		
3	Evening & Weekend 1000		0	500	500		
4	Anytime 30		10	10	10		
5	Anytime 100		33	33	33		
6	Anytime 200		66	66	66		
7	Anytime 500		300	100	100		
8	Anytime 1000		500	250	250		
9							
10		Monthly Cost	Daytime Cost	Evening Cost	Weekend	Text Messages per msg	
11	Evening & Weekend 1000	20	0.29	0.05	0.05	0.12	
12	Anytime 30	15	0.15	0.35	0.15	0.12	
13	Anytime 100	22	0.15	0.35	0.15	0.12	
14	Anytime 200	30	0.12	0.35	0.12	0.12	
15	Anytime 500	50	0.12	0.35	0.12	0.12	
16	Anytime 1000	75	0.12	0.35	0.12	0.12	
17							

Note that Excel represents pounds as a whole number with pence as decimal digits – Excel will assume that 20.34 represents £20 and 34 pence.

Activity 5: Save your work

Adding processing sheet calculations

A calculation of the number of payable minutes used in each period will be required.

Activity 6: In the *calcs* sheet, scroll down to cell A18 and add the columns and rows indicated

	A	B	C	D	E	F
17						
18	Payable Minutes					
19			Day	Evening	Weekend	
20	Evening & Weekend 1000					
21	Anytime 30					
22	Anytime 100					
23	Anytime 200					
24	Anytime 500					
25	Anytime 1000					
26						

The customer will only be charged for minutes when the free minutes for that period have been used up – e.g. Homer indicated that he uses 10 minutes in the day time per day. We will assume 5 working days * 4 weeks = 20 in a month. Hence he would pay for

$$= (10 * 5 * 4) - \text{the free daytime minutes}$$

Hence the formula for cell C20 would be

$$= (\text{B13 from the customer details sheet} * 5 * 4) - \text{C3}$$

When you wish to refer to a cell on another sheet, use this syntax:

sheetname!cellreference

So the formula for cell C20 will be

$$=\text{custdetails!B13} * 20 - \text{C3}$$

A similar formula will be used for weekends, except we will multiply by 4 (4 weekends a month).

Activity 7: Add formulas for the cells C20, D20 and E20. Assume 20 evenings and 4 weekends per month. Calculations for these cells are shown

	A	B	C	D	E	F
17						
18	Payable Minutes					
19			Day	Evening	Weekend	
20	Evening & Weekend 1000		200	400	-20	
21	Anytime 30					
22	Anytime 100					
23	Anytime 200					
24	Anytime 500					
25	Anytime 1000					
26						

We will deal with the issue of negative minutes in the next section.

Using Autofill correctly

One of the major causes of spreadsheet error is the misuse of the *Autofill* technique. In this scenario you may imagine that the values in the remaining cell position can be achieved by dragging the autofill handle to fill cells C21 to C25. This will produce incorrect results.

Activity 8: Click on cell C20, then Autofill cells C21 down to C25. Why are these results incorrect?

	A	B	C	D	E	F
17						
18	Payable Minutes					
19			Day	Evening	Weekend	
20	Evening & Weekend 1000		200	400	-20	
21	Anytime 30		890			
22	Anytime 100		2367			
23	Anytime 200		34			
24	Anytime 500		-300			
25	Anytime 1000		-500			

Examining the formula for cell C21 reveals that Excel has adjusted *both* cell references – the formula for cell C21 is

= custdetails!B14*20-C4

When it should be

= custdetails!B13*20-C4

We require Excel to leave the first cell address as B13, whilst changing the second cell address to values C4, C5 ... etc.

To indicate that a cell address should not change if Autofill is used, Excel uses a concept known as *absolute addressing*. To change a cell address into an absolute address, use the \$ symbol in front of the column and/or row identifier that should never be adjusted.

Examples

- To indicate that no parts of the reference to cell B5 must be adjusted when copied, we would use **\$B\$5**
- To indicate that references to cell B5 can only have the row part adjusted, use **\$B5** (i.e. the '5' can vary to generate lists of cell identifiers like **\$B6**, **\$B7**, **\$B8** ... etc.)
- To indicate that cell B5 can only have the column part adjusted, use **B\$5** (i.e. the 'B' can vary to generate lists of cell identifiers like **C\$5**, **D\$5**, **E\$5**... etc.)
- To indicate that both parts of an address can vary, use the reference as normal, i.e. B5. Excel uses the term *relative addressing*, for cell references that can vary

Activity 9: Correct the formula in cell C20 so it uses absolute addressing for the number of minutes used in the daytime (this should be a fixed address and never vary)

=custdetails!\$B\$13*20-C3

Then use Autofill to generate the formulas for the cells C21..C25

	A	B	C	D	E	F
17						
18	Payable Minutes					
19			Day	Evening	Weekend	
20	Evening & Weekend 1000		200	400	-20	
21	Anytime 30		190			
22	Anytime 100		167			
23	Anytime 200		134			
24	Anytime 500		-100			
25	Anytime 1000		-300			
26						

There is a problem with the calculation in that a low usage can generate negative minutes – if a customer doesn't use all the free minutes available we want the cell to return zero. This can be achieved by using the *if* function.

IF function

Syntax

=if (condition, trueresult, falseresult)

The *if* function allows a cell to return two different results, depending upon a condition. If the condition is true, the *trueresult* is returned, otherwise the *falseresult* is returned.

The condition uses the standard comparison operators =, >, <, <= and >=. To represent labels (which are often called strings) wrap text in double quotes - "this is a string". An empty string is represented by using empty double quotes - ""

Examples

=if(c3>5, 56, 67)	If cell c3 evaluates to a value greater than 5, return the value 56, otherwise return the value 67
=if(b5="some text",78,-89)	If cell b5 contains the text "some text", return the value 78, otherwise return the value -89
=if(b5>=c5, a7, b6+5)	If the contents of cell b5 is greater than or equal to the content of cell c5, return the contents of cell a7, otherwise return the contents of cell b6+5
=if(a2<=100,"Within budget","Over budget")	If the cell a2 contains a value less than or equal to 100, return the text "Within budget" otherwise return "Over budget"
=if(a2=100, sum(b5:b15), "")	If cell a2 evaluates to 100, return the result of adding up the cells between b5 and b15, otherwise return an empty string

To generate a zero if the value is negative, use

=if (cellref > 0, cellref, 0)

Which translates as 'if the cell contains a value greater than 0, return that value, otherwise return 0'.

Activity 10: Change the formula in cell C20 to include the *if* formula

=if (custdetails!\$B\$13*20-C3 > 0, custdetails!\$B\$13*20-C3 ,0)

Then use Autofill to copy the formula into cells C21..C25. The values in cell C24 and C25 should be zero rather than negative

C20 fx =IF(custdetails!\$B\$13*20-C3 > 0,custdetails!\$B\$13*20-C3,0)

Lab2Solution.xlsx

	A	B	C	D	E	F	G
17							
18	Payable Minutes						
19			Day	Evening	Weekend		
20	Evening & Weekend 1000		200	400	-20		
21	Anytime 30		190				
22	Anytime 100		167				
23	Anytime 200		134				
24	Anytime 500		0				
25	Anytime 1000		0				
26							

Activity 11: Correct the formula in cell D20 and E20 by using absolute addressing and an *if* formula, then use *autofill* to copy the values down into D21..E25

The final cell entries should look like this:

C20 fx =IF(custdetails!\$B\$13*20-C3 > 0,custdetails!\$B\$13*20-C3,0)

Lab2Solution.xlsx

	A	B	C	D	E	F	G
17							
18	Payable Minutes						
19			Day	Evening	Weekend		
20	Evening & Weekend 1000		200	400	0		
21	Anytime 30		190	890	470		
22	Anytime 100		167	867	447		
23	Anytime 200		134	834	414		
24	Anytime 500		0	800	380		
25	Anytime 1000		0	650	230		
26							

Activity 12: Save your work

Calculating the call costs

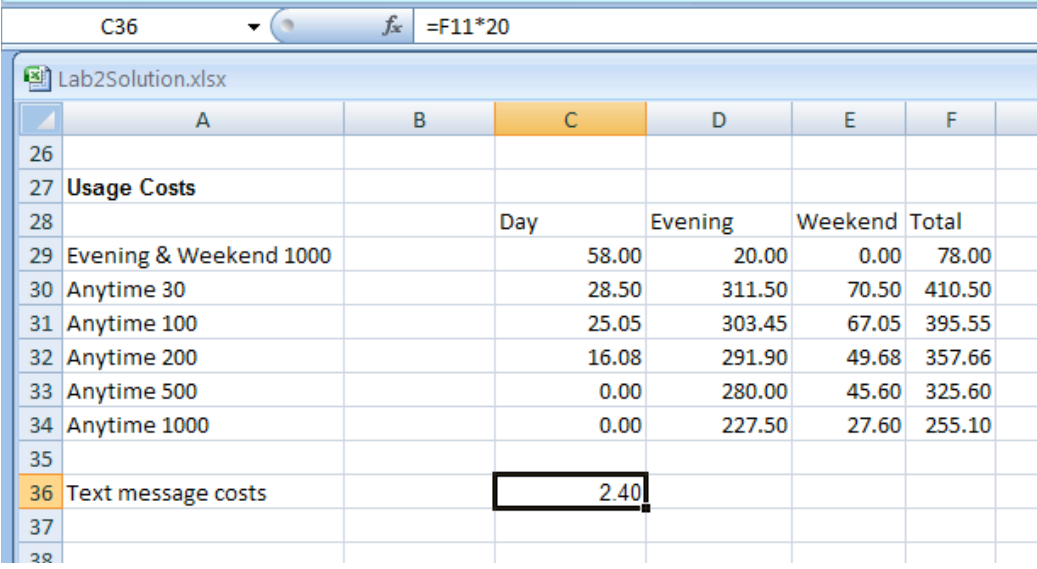
The final section on the *calcs* sheet is an area to calculate the actual call costs. This will be generated by the call cost per minutes * minutes used for each tariff period.

Activity 13: Scroll down to cell A27 and add the Usage costs section

Column C D and E values are generated from *usage minutes * the cost*

Column F is a *total* across each row

The text message costs in a month are derived from: *no of text messages a week * 4 * the cost*



	A	B	C	D	E	F
26						
27	Usage Costs					
28			Day	Evening	Weekend	Total
29	Evening & Weekend 1000		58.00	20.00	0.00	78.00
30	Anytime 30		28.50	311.50	70.50	410.50
31	Anytime 100		25.05	303.45	67.05	395.55
32	Anytime 200		16.08	291.90	49.68	357.66
33	Anytime 500		0.00	280.00	45.60	325.60
34	Anytime 1000		0.00	227.50	27.60	255.10
35						
36	Text message costs		2.40			
37						
38						

Activity 14: Save your work

Creating the Output sheet

The Output sheet (here called *recommendations*) will list the customer details and the tariff cost. Finally a recommendation for the best tariff will be listed along with the estimated monthly costs.

Activity I5: Switch to the *recommendations* sheet and create the following layout

	A	B	C	D	E
1	Analysis of Tariffs				
2					
3	For customer				
4	Address				
5					
6					
7					
8					
9	Customer minutes				
10	Daytime				
11	Evening				
12	Weekend				
13	Total				
14					
15					
16	Text messages				
17					
18					
19		Monthly Rental	Call Costs (Estimate)	Message Costs	Totals
20	Evening & Weekend 1000				
21	Anytime 30				
22	Anytime 100				
23	Anytime 200				
24	Anytime 500				
25	Anytime 1000				
26					
27	Recommendation				
28	Estimated lowest costs for this customer would be				
29	Best Tariff would be				
30					

Activity I6: Save your work

For the *Customer* entry in cell B3, we require a combination of the *title* and *name* values from the *custdetails* sheet.

To combine two text values together use & - this is called concatenation

- "exam"&"ple" would return the value "example"
- A4&A5 would return the value in cell A4 connected to the value in cell A5

If spaces are required between text values, " " can be used (i.e. double quotes with a space between them)

Activity 17:

In cell B3 add a formula to display the title and name separated by a space

```
=custdetails!B4&"
"&custdetails!B5
```

In cell B4 add a formula to display the first line of the address from the *custdetails* sheet

```
=custdetails!B6
```

Use Autofill to create formulas for cells B5 .. B7

In cell B10 add a formula to display the number of minutes used in the daytime per month

```
=custdetails!B13*20
```

Create similar formulas for cell B11 and B12

Add a total formula to cell B13

Add a formula for number of text messages per month to cell B16

	A	B	
1	Analysis of Tariffs		
2			
3	For customer	Mr Homer Simpson	
4	Address	4 Evergreen Terrace	
5		Springfield	
6		USA	
7		SP98765	
8			
9	Customer minutes		
10	Daytime	200	
11	Evening	900	
12	Weekend	480	
13	Total	1580	
14			
15			
16	Text messages	20	
17			

Activity 18: Adding details from the *calcs* sheet

The Monthly rental figures come from cells B11 .. B16 on *calcs* - add a formula to cell B20 to get the monthly charge for the *Evening & Weekend 1000 tariff*

```
=calcs!B11
```

Use Autofill to populate cells B21 .. B25

The call costs figures come from cells F29..F34 on *calcs* – add a formula to cell C20 to get the monthly call costs for the *Evening & Weekend 1000 tariff*

```
=calcs!F29
```

Use Autofill to populate cells C21..C25

The message costs figures come from cell C36 on *calcs* – add a formula to cell D20 to get the monthly message costs for the *Evening & Weekend 1000 tariff*. This must use absolute addressing – why?

```
=calcs!$C$36
```

Use Autofill to populate cells D21..D25

Finally - add a sum formula in cell E20 and autofill down the column

Monthly Rental
£20.00
£15.00
£22.00
£30.00
£50.00
£75.00

Call Costs (Estimate)
£78.00
£410.50
£395.55
£357.66
£325.60
£255.10

Message Costs	Totals
£2.40	£100.40
£2.40	£427.90
£2.40	£419.95
£2.40	£390.06
£2.40	£378.00
£2.40	£332.50

The recommendations section

The final two cells to be filled are lowest costs and recommendations cells.

The lowest cost can be found by looking for the lowest value cell in the range e20..e25. The Excel formula MIN returns the minimum value in a range of cells

Activity 19: In cell C28 add a formula to find the lowest cost

=min(E20:E25)

The recommendation cell should display the name of the best tariff (i.e. the cheapest option). Finding a value based on the value of another cell is called a lookup in Excel and uses one of the *lookup* functions (*lookup*, *vlookup* or *hlookup*). Vlookup requires the columns that will be 'looked up' to be adjacent to each other.

Activity 20: Copy the row labels from cells A20..A25 to cells F20..F25

	A	B	C	D	E	F
19		Monthly Rental	Call Costs(Estimate)	Message Costs	Totals	
20	Evening & Weekend 1000	£20.00	£78.00	2.40	£100.40	Evening & Weekend 1000
21	Anytime 30	£15.00	£410.50	2.40	£427.90	Anytime 30
22	Anytime 100	£22.00	£395.55	2.40	£419.95	Anytime 100
23	Anytime 200	£30.00	£357.66	2.40	£390.06	Anytime 200
24	Anytime 500	£50.00	£325.60	2.40	£378.00	Anytime 500
25	Anytime 1000	£75.00	£255.10	2.40	£332.50	Anytime 1000

Vlookup formula

Syntax:

=lookup(value to be searched for, range of cells containing search value and results, column number to be returned)

In this example we want to look up the value £108.40 in column E (the list of values to be searched). Column F will give us the name of the Lowest tariff for this customer. This is the returned value.

	A	B	C	D	E	F
19		Monthly Rental	Call Costs(Estimate)	Message Costs	Totals	
20	Evening & Weekend 1000	£20.00	£78.00	2.40	£100.40	Evening & Weekend 1000
21	Anytime 30	£15.00	£410.50	2.40	£427.90	Anytime 30
22	Anytime 100	£22.00	£395.55	2.40	£419.95	Anytime 100
23	Anytime 200	£30.00	£357.66	2.40	£390.06	Anytime 200
24	Anytime 500	£50.00	£325.60	2.40	£378.00	Anytime 500
25	Anytime 1000	£75.00	£255.10	2.40	£332.50	Anytime 1000
26						
27	Recommended					
28	Estimated lowest cost					
29	Best Tariff would be					
30						

Diagram illustrating the Vlookup process:

- List of values to be searched:** Points to the range E20:E25 (Totals column).
- Value that will be searched for:** Points to the value £100.40 in cell E20.
- Returned value:** Points to the value "Evening & Weekend 1000" in cell F20.
- List of return values – one of these will be returned:** Points to the range F20:F25 (Tariff names column).

Final activity: Add a lookup formula to cell C29 to return the name of the best tariff:

=vlookup(C28,D20:E25,2)

Save your work