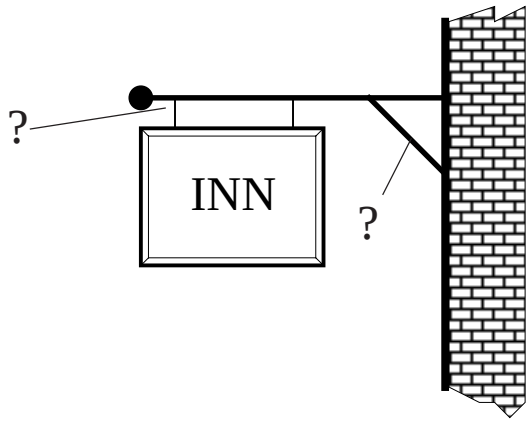
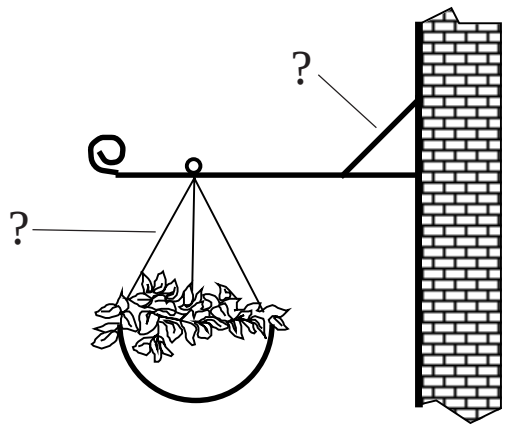
MEASURING FORCE IN STRUTS AND TIES

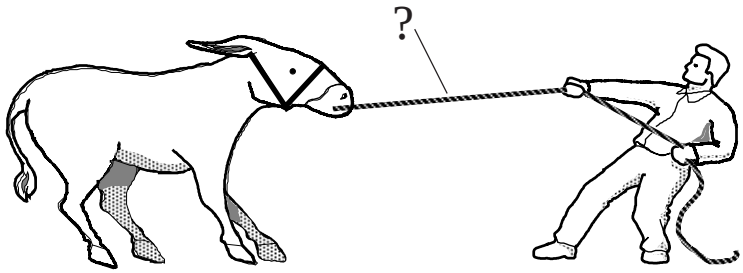
In a structure, the various parts can either be in **compression** (i.e. being squashed) or in **tension**, (i.e. being stretched).

- A member in **compression** is called a **strut**.
- A member in **tension** is called a **tie**.

It is important to know which is which. Label each part marked in the diagrams below as being either in compression or in tension:





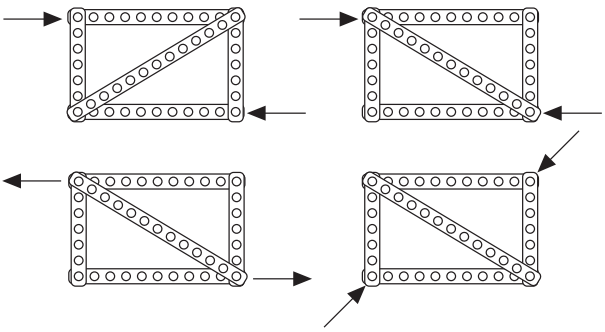


Clearly a cable, rope or wire cannot ever be in compression. Imagine pushing a donkey with its lead rein!

Simple structures can be assembled using drilled strips such as 'Polymek'. Look at each of the following and predict which parts are in compression and which are in tension. What happens when the diagonal strip is left out?

Check your prediction with practical work using a structures kit.

A tie may be replaced by a cable or wire if you are sure it will never be expected to be in compression. Tests on a model may help to establish this.



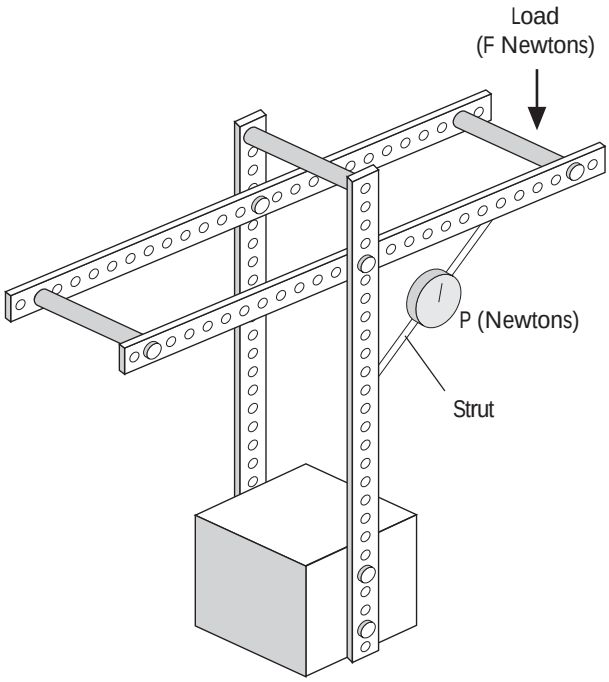
MEASURING FORCE IN A STRUT

You might want to know the loads that your design can safely carry so you can give a guarantee of the strength of your structure. You might even be able to reduce the forces in a particular strut or tie by choosing carefully the angle or the point at which it is connected to the frame. In this way, you may be able to improve the strength of the whole structure. To do this, you need to be able to measure the force in the strut or tie.

Look at the strut in the Structures Research Frame. This is probably the critical point in the structure because it is designed to carry a large force. A question you would have to answer as a designer is 'what forces might this strut have to bear as loads are lifted?'. You will now investigate this.

Investigate how the force in the strut depends on the force of the load.

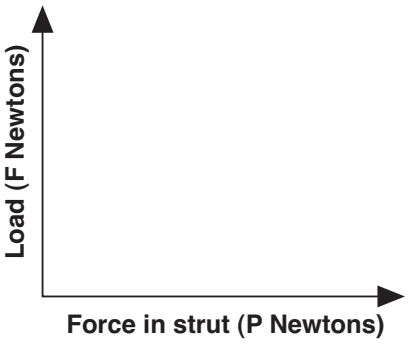
- Call the force in the strut P Newtons.
- Call the force of the load F Newtons.



Practical hints:

- Always apply the load at the same point.
- Collect about ten sets of data.
- Use a wide range of loads.

Make a note of the data you collect in a table. The results of your investigation can be shown on a graph.

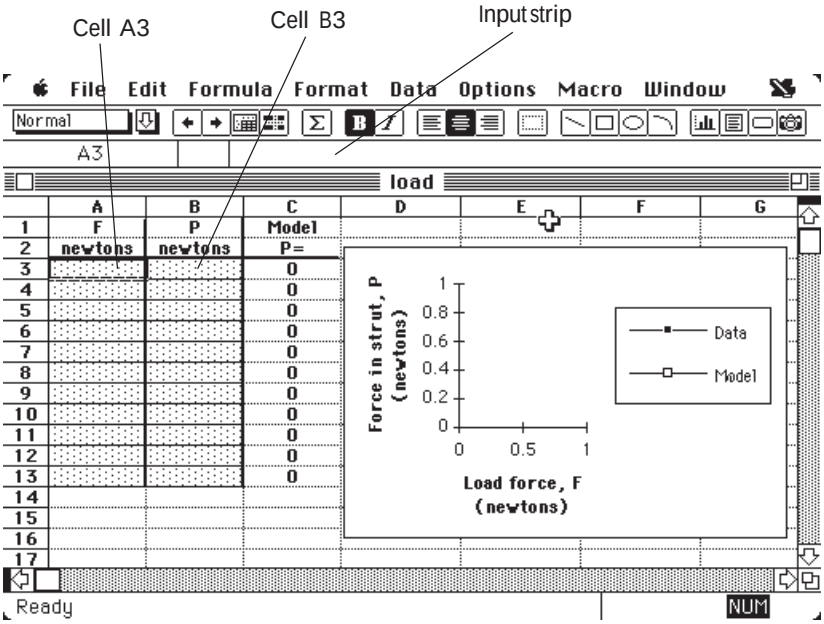


USING A SPREADSHEET TO PREDICT RESULTS

Enter your data into a spreadsheet file. The following instructions will help you:

- Enter your data for F into column A.
- Enter your data for P into column B.
- Enter a formula in column C such as y=2*F.

Make sure that your data pairs match properly.
Your spreadsheet will look something like this:



The model is trying to predict P when you know F. How good is the model at predicting P?

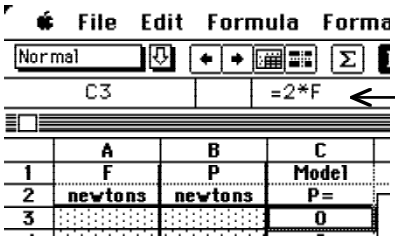
The graph will help you answer this question. One line joins your data pairs (F, P). The other shows the points predicted by the model. If the model is good, the points and lines will lie close together.

INVESTIGATING THE MODEL FOR COMPRESSION

Follow carefully the instructions below to investigate the model used to predict P.

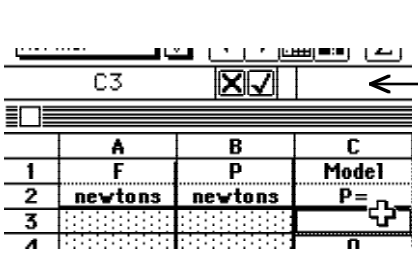
You | **The Computer**

Click on cell C3



The input strip shows the formula that works out P - this is the model

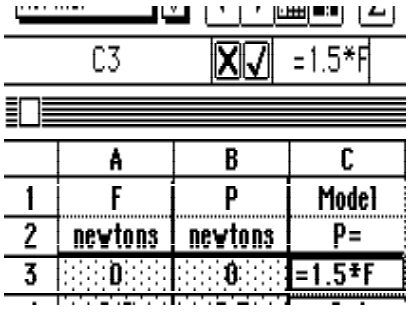
Delete the formula in the input strip. Do this by pressing the <delete> key.



The input strip

The input strip becomes blank

Type in a new model. Try '=1.5*F'



Press the <return> key when you have typed in the formula.

C4 =2*F

	A	B	C
1	F	P	Model
2	newtons	newtons	P=
3	0	0	0
4	0.2	0.3	0.4
5	0.4	0.7	0.8
6	0.6	0.8	1.2
7	0.8	1	1.6
8	1	1.2	2
9	1.2	1.5	2.4
10	1.4	1.8	2.8
11	1.6	2.1	3.2
12	1.8	2.4	3.6
13	2	2.6	4

Notice that the predictions in cells C4-C13 do not change

Copy your model into all of column C

Click on cell C3. Keep the mouse button pressed down and drag down so that cells C3 to C13 are highlighted.

C3 =1.5*F

	A	B	C
1	F	P	Model
2	newtons	newtons	P=
3	0	0	0
4	0.2	0.3	0.4
5	0.4	0.7	0.8
6	0.6	0.8	1.2
7	0.8	1	1.6
8	1	1.2	2
9	1.2	1.5	2.4
10	1.4	1.8	2.8
11	1.6	2.1	3.2
12	1.8	2.4	3.6
13	2	2.6	4

Click on **Edit** on the menu bar. Select **Fill Down** from the **Edit** menu.

Try altering your model in column C so your predictions are as close as possible to the data in column B. Use your graph to help you.

C3 =1.5*F

	A	B	C
1	F	P	Model
2	newtons	newtons	P=
3	0	0	0
4	0.2	0.3	0.3
5	0.4	0.7	0.6
6	0.6	0.8	0.9
7	0.8	1	1.2
8	1	1.2	1.5
9	1.2	1.5	1.8
10	1.4	1.8	2.1
11	1.6	2.1	2.4
12	1.8	2.4	2.7
13	2	2.6	3

New predictions appear in cells C3 to C13

DRAWING CONCLUSIONS ABOUT STRENGTH

Use your model to help you predict forces in the strut for other loads.

- What will P be if F is 5 Newtons?
- What will F be if P is 3 Newtons?
- Test your predictions in practice.

For a given load to be lifted, your formula predicts the force in a strut of the structure. Therefore, if you know the maximum load, you can work out the load the strut must carry. You can then choose a strut which will support this without breaking.

Further investigations will show that the force in the strut depends on the angle at which the strut is connected. Another investigation would tell you where you should connect the strut to reduce the force in the support to a minimum.

Notice that you have assumed that the strut is the most likely to break. To be sure, you would have to investigate every member of the framework. In real structures, engineers do this using large computer programs.