Triangle of Forces Board
Student Worksheet

In this experiment you will be using a vector triangle to find the weight of an object.

Theory

It is possible to represent and calculate an unknown force using a vector diagram. If a three force system is in equilibrium, then the resultant force is zero and so the force vectors can be represented as a complete triangle. By knowing two of the forces and the angles between them, it is possible to draw a scale diagram and to measure calculate the third force from the diagram.

You will be using this principle to find the weight of various objects in a system in equilibrium.

Making measurements and observations

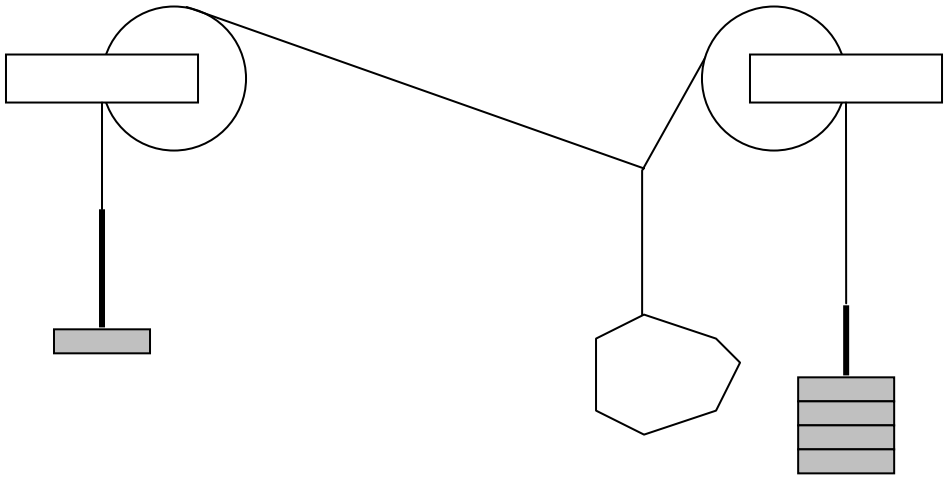
1 Take three equal lengths of thread, each around 0.5 m long. Tie their ends together so that they form a Y shape.

2 Tie one of the objects of unknown weight to the end of one thread and tie a small loop in each end of the other two threads.

3 Clamp the board in a vertical position. Clamp the two pulleys to the large stiff board, one on each side near to the top. The arrangement should be such that the pulleys are between 0.4 m and 0.7 m apart.

4 Attach a clean sheet of white paper to the board behind the pulleys.

5 Loop the two threads with loops over the pulleys and add weights to the end until the object in the middle is supported. The two weights and the object of unknown weight must be in equilibrium. You may need to increase or decrease the weights on each side in order to achieve equilibrium. The arrangement is shown in the diagram below.



6 Record the two weights, making a note of which side of the board they are on.

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7 Trace the lines of the three threads onto the paper on the board. It is very important that you are able to record the angles between the lines accurately. You may find it easier to put dots on the paper behind the threads and then join them up when the paper is removed.

8 Repeat the experiment again for each of the objects of unknown weight.

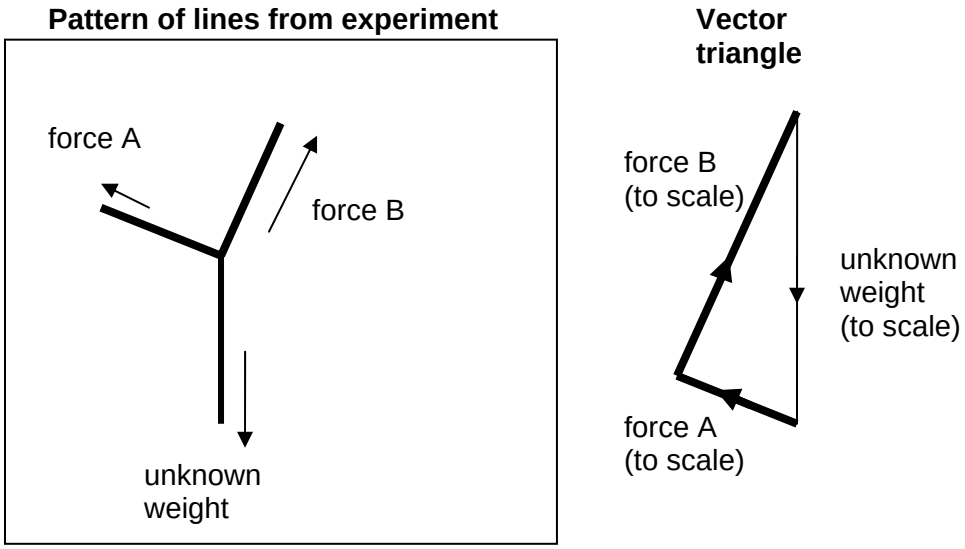
Recording and presenting your data

1 For each object of unknown weight, your results will be the sheet of paper from the forces board.

2 From the lines drawn on the piece of paper, measure the angles between the threads.

3 Construct a triangle of forces. Begin by drawing the two known forces, starting the second force at the end of the arrow representing the first one. The force arrows must have the correct angle between them. You will need to decide on an appropriate scale to use (e.g. 5 cm =1 N): the scale you use will depend upon the weights used.

4 Connect the point at the start of the first force arrow and the point at the end of the second force arrow with a third arrow. The diagram below shows an example of how the lines on the paper are turned into a force triangle.



5 Repeat **1** – **4** to obtain vector diagrams for each of the objects of unknown weight.

Analysing your data

1 Measure the force arrows representing the weight of each the objects of unknown weight.

2 Use the scale to calculate each of the unknown weights.

Evaluation

1 Ask the teacher for the actual weights of the objects. Write a paragraph comparing your results with the actual weights, commenting on the reasons for the differences.

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Teaching Notes

Link to theory

5(d) use a vector triangle to represent forces in equilibrium

Key learning objectives

- To visualise what a vector triangle really means.
- To develop students' skills in manipulating apparatus.

Notes

When students draw vector triangles in their work, they sometimes have difficulty in visualising what the diagram really means. This experiment will give them a clear example and will help them to visualise the meaning of vector triangles in other contexts.

As this experiment is a little fiddly, it is a good chance for students to develop their manual dexterity in manipulating apparatus.

Both of the learning objectives should be stressed to the students before they carry out the experiment. They should also be encouraged to take time in order to get good quality results.

At the end of the activity, students will ask for the actual weights of the three unknown objects. These should be given to them on a card.

Expected results

The students will not produce a great deal of written work. Other than a standard account of the experiment, all they will have is the paper from the experiment, the scale drawings of the vector triangles and the comparison between the experimental results and actual weights.

Possible extension work

Students could be asked to suspend two weights each of 5.0 N from the threads that pass over the pulleys. They could investigate the relationship between the angle between these two threads and the weight suspended from the central thread.

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Technical Notes

Apparatus requirements

1 **Three different objects of unknown weight.** Many objects will be suitable as long as they have weights between about 0.5 N and 5.0 N and they are easy to tie onto a piece of thread.

2 **Two 1.0 N weight hangers and six 1.0 N slotted weights.**

3 **Three A4 sized sheets of white paper.**

4 **Strong wooden board,** about 50 cm × 50 cm.

5 **Two stands, two bosses and two clamps.** These are to hold the board securely in a vertical position.

6 **Two pulleys**. These need to be able to be clamped to the top corners of the board.

7 **Blu-tack** to attach the sheets of paper to the board.

8 **Three pieces of strong thread,** each about 50 cm long.

9 **Card showing the weights of the three objects.** This should be retained by the teacher and not given to the students until the end of the experiment.

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