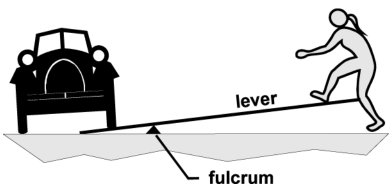
17B Levers and the Human Body

How does a lever work? What types of levers does your body have?

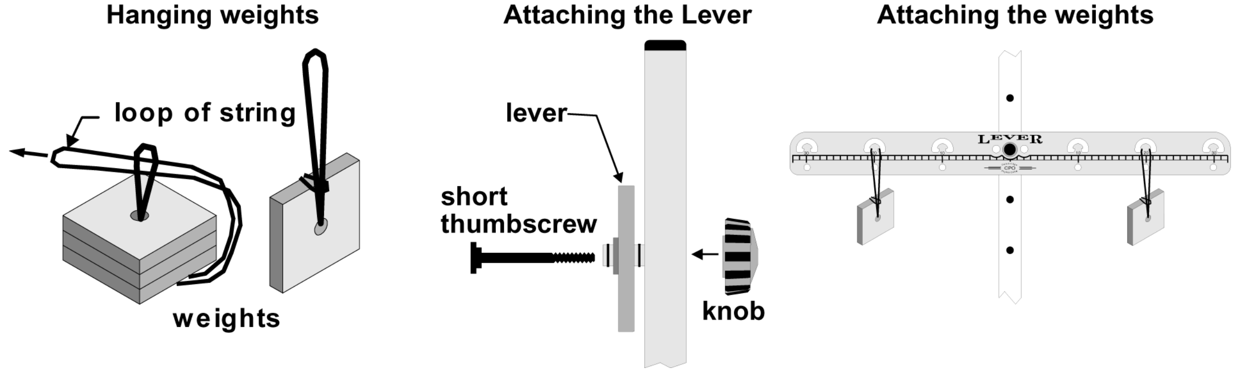
How can you lift up a car—or even an elephant—all by yourself? One way is with a lever. The lever is an example of a simple machine.



Materials

- Lever
- Physics stand
- Force scales
- Weights

1 Setting up the lever



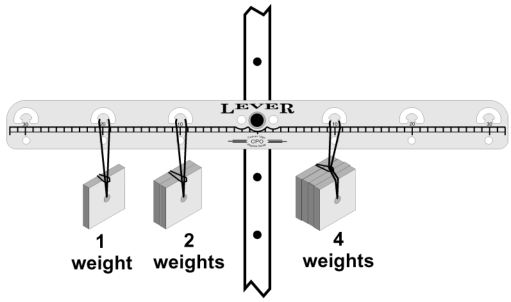
1. Use loops of string to make hangers for the weights. You can put more than one weight on a single string.
2. The weights can be hung from the lever by hooking the string over the center peg in the holes. Make sure that the string is all the way around the peg!

2 Levers in equilibrium

a. The lever is in equilibrium when all the weights on one side balance all the weights on the other side. Hang the weights as shown below. Does the lever balance?

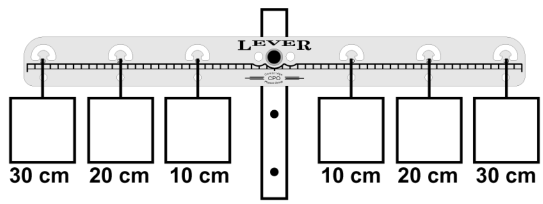
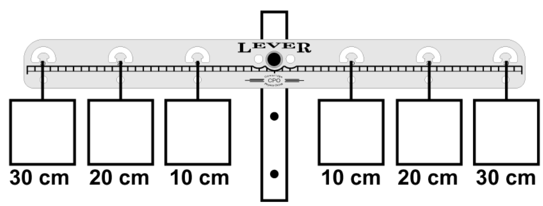
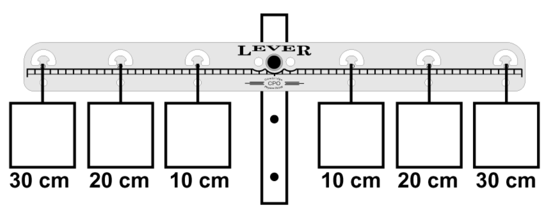
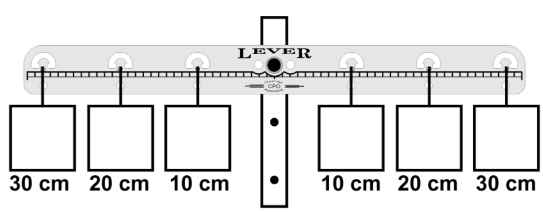
b. What variables can be changed to balance a lever?

c. On the diagram below label the fulcrum, the input arm and the output arm.



3 Trying different combinations to balance the lever

Make different combinations of weights and positions that balance. Use the chart below to write down the numbers of weights you put in each position. If you want to conduct more than four trials, write your results on a separate sheet of paper

Trial #	
Trial #	
Trial #	
Trial #	

4 Determine the mathematical rule for equilibrium

Using the data in the chart above, determine a mathematical rule for levers in equilibrium. Think about the variables in the experiment: *input force*, *output force*, *length of input arm*, and *length of output arm*. First, make some calculations, then write your rule as an equation.

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5 What did you learn?

a. Draw a lever and label these parts: fulcrum, input arm, output arm, input force, and output force.

b. There are two ratios that can be used to determine mechanical advantage in levers. What are the two equations? What is the relationship between the two equations?

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c. In a lever, you can increase the amount of output force by increasing the length of the input arm. When you do this, what must decrease in order to increase output force?

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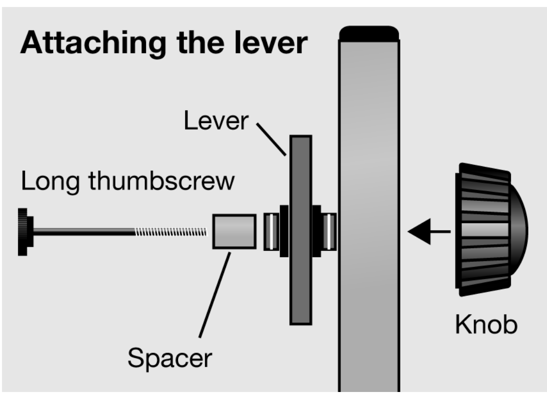
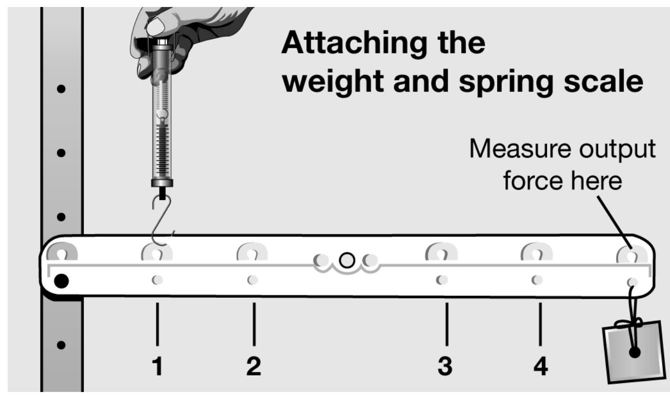
6 The human body

Arms, legs, fingers, toes, the jaw, even the head and neck work like levers. Contracting and extending muscles provide the force to move our levers. Our joints are the fulcrums around which these levers pivot and move. Our bones are the levers themselves. Lets take a look at the human arm and examine how it works like a lever.

Let your left arm hang down by your side. Place the hand of your right arm into the inner part of your elbow. Slowly lift your left arm (palm up) until it is level with the floor. Feel that tissue in your elbow tightening up with your right hand? That is the connective tissue that joins your biceps muscle to the bones of your forearm, the radius and ulna. We can use the physics stand and the lever to make a model of the human arm and measure the forces involved when we lift something.





1. Attach the lever to the stand, but this time use the hole on the left-most side of the lever. Use one of the short thumbscrews. Do not tighten the knob all the way. Leave a little room so the lever can still pivot.
2. Use a loop of string to hang one weight on the right-most side of the lever. Use the green spring scale to measure its force in newtons. This is the output force for the experiment and it will not change. Record the output force in column one of Table 1. Use the same output force for each trial.
3. Measure the output distance, in centimeters, of the lever. The output distance is the distance from the fulcrum to the output force. The output distance will be the same for each trial. Record the output distance in column two of Table 1.
4. For the experiment, you will measure the input force at different distances from the fulcrum. Study the diagram above and then answer the questions in Part 27

Table 1: Input and output data

Trial	Output force (N)	Output distance (cm)	Input force (N)	Input distance (cm)	Mechanical advantage
1					
2					
3					
4					

7 Stop and think

a. Label the fulcrum, output force, output distance, input force, and input distance on the diagram in Part 6.

b. The lever you are testing in this experiment is a model of the human arm. Which part of the lever represents the location of the hand?

c. Predict the position where the mechanical advantage would be greatest and least on the diagram.

8 Doing the experiment

1. Measure the input force at position 1. The input force is the force required to lift the lever up and keep it horizontal. Record your results in the first row, third column of Table 1.
2. Measure the input distance for position 1. Record your results in the first row, fourth column of Table 1.
3. Measure the input force and input distance for the remaining positions and record your results in Table 1.
4. Calculate the mechanical advantage for each trial using the formula below. Record the value for each trial in the last column of Table 1.

$$MA = \frac{\text{output force (N)}}{\text{input force (N)}}$$

9 Analyzing your results

a. At which position is the mechanical advantage greatest? Least?

b. Which trial represents the position of the fulcrum, input force and output force of the human arm?

c. Is the human arm adapted to have the greatest mechanical advantage or the greatest output distance? Explain why the human arm is adapted in this way.

d. Draw a diagram of the human arm lifting a weight. Label fulcrum input and output force, and input and output distance.