Levers

Teacher Guide

Purpose of the Investigation

The aim of this investigation is to build and investigate three different classes of lever. Students will learn about how levers work as simple machines and the forces that act on them. Skills such as drawing, comparing designs, critical thinking and applying their findings to real life situations are emphasised.

Risk Management

All schools must have their own risk management procedures and each laboratory will have the required pro formas as it is a legal requirement, but it is incumbent upon the teacher and the lab technician to know and understand all risks associated with the practical.

Aim

To build and investigate three different classes of lever.

Background Information

Simple machine: A basic tool that makes a task easier to do.

Lever: A type of simple machine made of a rigid rod that rotates around a fixed pivot point.

Fulcrum: Another name for the pivot point of a lever.

Load: The force on a lever due to an object's weight. This is the force that must be overcome to make the lever rotate.

Effort: The force applied in order to rotate the lever and lift its load.

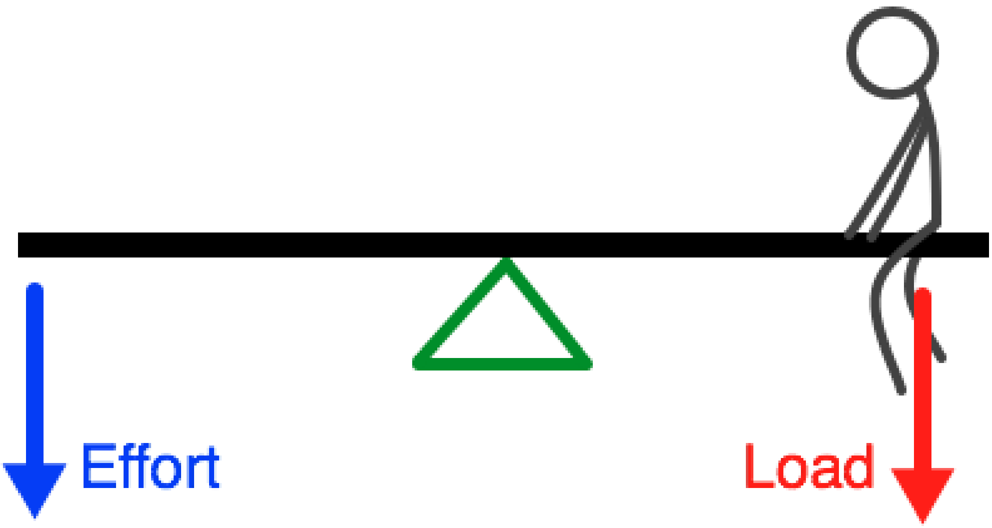
Pre-Practical Question and Example Answer

Using the definitions above and their prior knowledge of levers and forces, have the students answer this question:

The picture below represents a seesaw with a person sitting on one end. In physics, this is called a lever diagram. The triangle shows where the fulcrum of the lever is.

On the diagram, draw an arrow to show the load force due to the person's weight. Draw another arrow to show where you would apply an effort force to lift the person.

Example lever diagram:



Practical

Instructions

Go through the risk management/assessment with your teacher.

Clear the area you will use for your experimental work.

Make sure that all long hair is tied back.

Read through the practical instructions and make sure you understand the requirements.

When you are ready, you can begin.

Materials

- Metre ruler
- 3 x Large butterfly clips
- 1 kg Mass on hook
- Pencil
- Stackable books or blocks

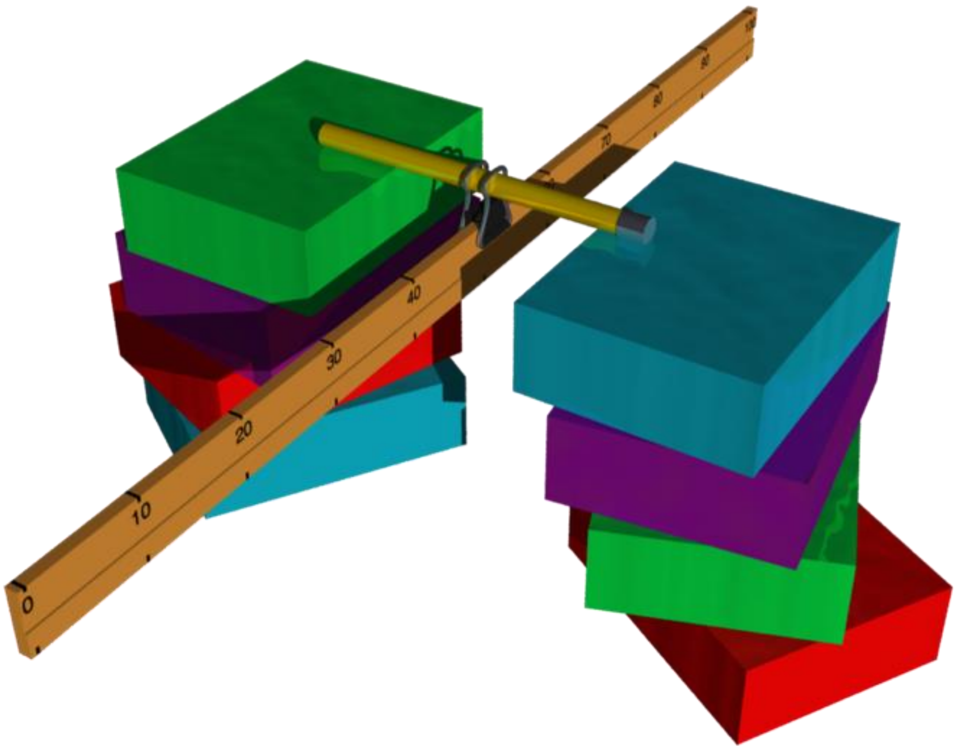
Method

1) Locate the 50 cm mark on the metre ruler. Attach one of the butterfly clips here.

2) Stick the pencil through the metal loops at the top of the butterfly clip. Make sure it can rotate freely.

3) Make two stacks of books on your desk, with a 5 cm gap between them. Each stack should ideally be about 20 cm high.

4) Insert the metre ruler in between your two stacks, so that the pencil balances



on the stacks and supports the weight of the ruler.

5) Attach a second butterfly clip to one end of the ruler. Hang the 1 kg mass from this clip and let it sit on the desk.

First Class Lever: Results Questions and Example Answers

1) **You have just created a first class lever! For your first test, try pushing down on the metre ruler, on the end opposite to where the 1 kg mass is hanging.**

   What happens? Record your observations in the space below:

   Pushing down on the metre ruler causes it to rotate around the pencil like a seesaw. The pushed end on moves down. The other end moves up and lifts the 1 kg mass off the desk.

2) **All levers have a pivot point, which scientists call a fulcrum. Where is the fulcrum for your lever?**

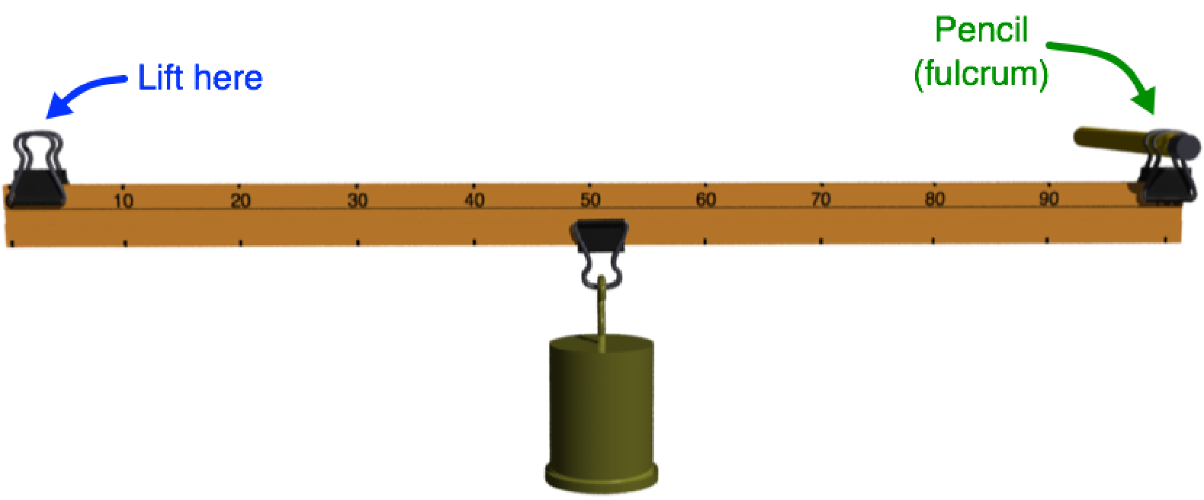
   In this situation, the lever rotates around the pencil held halfway along it. Therefore, the pencil is its fulcrum.

3) **In the space below, draw a diagram to represent your lever. Use a straight line to show the metre ruler and a triangle to show its fulcrum. Also label where the load (weight) and effort forces are applied when you lift the 1 kg mass up.**

   Example lever diagram:

Second Class Lever: Results Questions and Example Answers

Next, build a second class lever. To do this, adjust your setup so that the fulcrum (pencil) is at one end of the metre ruler. Attach the butterfly clip holding to the 1 kg mass to the middle of the ruler. Take your last butterfly clip and put it on the other end of the ruler, opposite the fulcrum.



1) **Try lifting the mass by pulling up on the third butterfly clip. Answer these questions based on what you observe:**

   i. How far does your hand move compared to how far the mass moves?

In this case, the hand has to move about twice as far as the mass does while it's being lifted.

ii. Does it feel easier or harder to lift the mass than in your first test?

It should be somewhat easier to move the mass than in the first test. It requires less force than before.

2) **Now move the butterfly clip you pulled on closer to the mass, but not past it. Try pulling on this clip again to lift the mass.**

i. Does your hand move a greater or smaller distance than before?

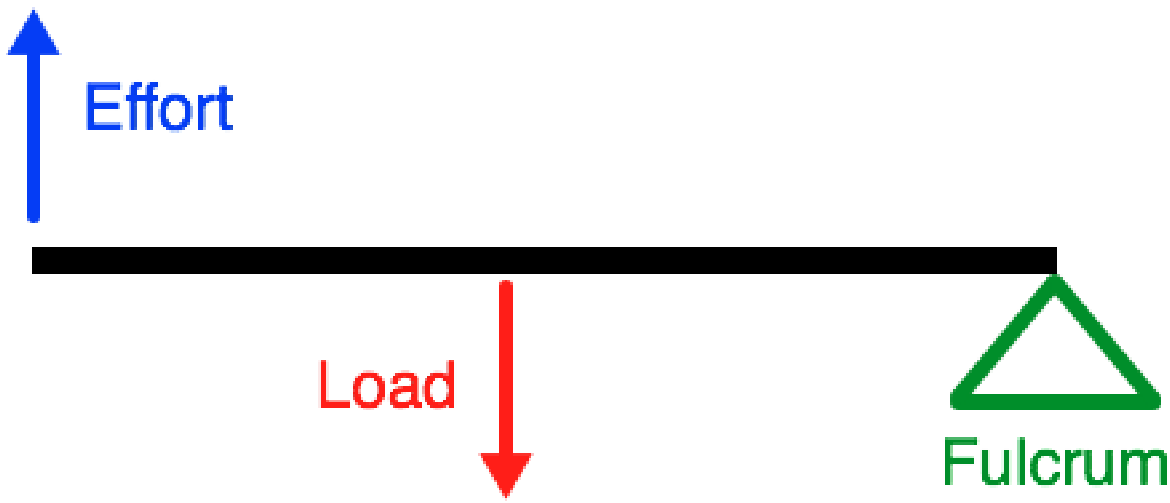
The hand doesn't move as far vertically as it did in the previous test.

ii. Does it feel like you have to pull harder to lift the mass?

Yes. Now that your hand is closer to the lever's fulcrum (the pencil), it feels like you have to work harder to lift the mass up. You are applying more force in this test.

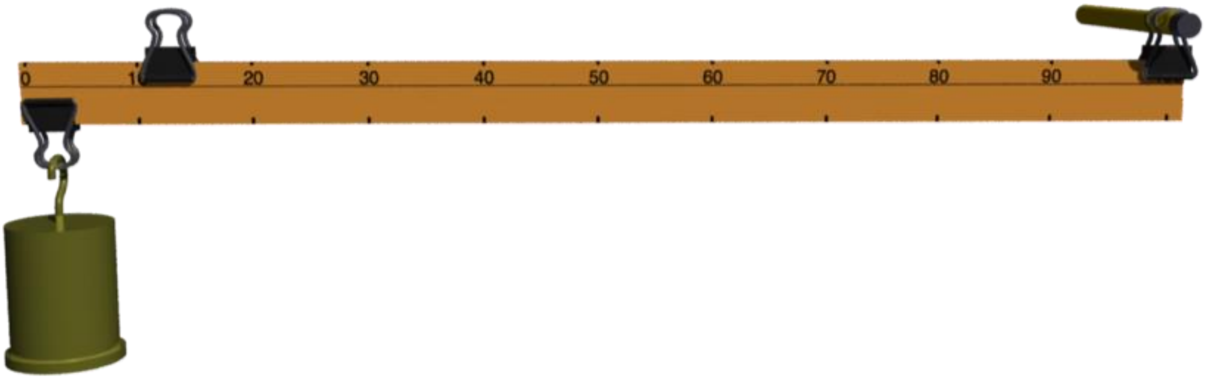
3) **Draw a diagram to represent your second class lever. Use a straight line to show the metre ruler and a triangle to show its fulcrum. Also label where the load and effort forces are applied.**

Example lever diagram:



Third Class Lever: Results Questions and Example Answers

To make a third class lever, move the 1 kg mass and its butterfly clip so that it hangs from the end of the metre ruler. Move the third butterfly clip so that it's closer to the mass than to the fulcrum.



1) **Try lifting the mass by pulling on the third butterfly clip. How far does your hand move compared to how far the mass moves?**

   In this case, the hand doesn't move as far vertically as the mass does.

2) **This time, move the butterfly clip that you pull on close to the fulcrum, away from where the 1 kg mass is hanging. Now pull on the clip to try and lift the mass. Answer these questions based on your observations:**

   i. How far does your hand move compared to how far the mass moves?

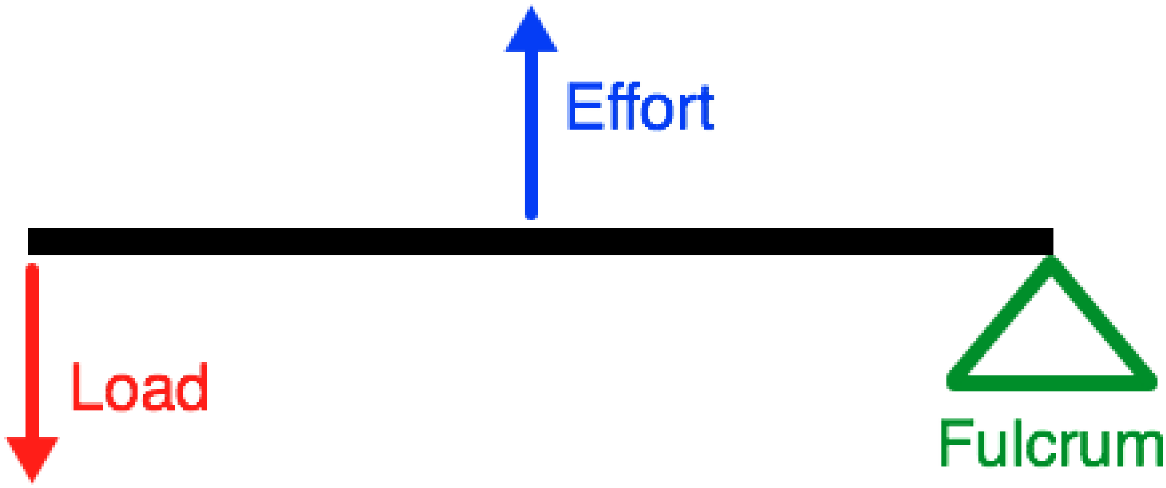
   The hand moves a small distance compared to how far the mass moves. In other words, just a little movement from the hand makes the mass rise high.

   ii. Does it feel easier or harder to lift the mass than in the previous test?

   The mass is much harder to lift than in the previous test! A lot of force is required this time.

3) **Finally, draw a diagram to represent your third class lever. Use a straight line to show the metre ruler and a triangle to show its fulcrum. Also label where the load (weight) and effort forces are applied.**

Example lever diagram:



Discussion Questions and Example Answers

1) **So far you have built, tested and observed a few different levers.**

   For instance, in your second test you used a second class lever, with the load in the middle. You should have found that it was relatively easy to lift the load in this configuration. However, when you applied effort closer to the fulcrum, the task became more difficult.

   Did the same thing happen when you used a third class lever and moved your effort closer to the fulcrum? Do you think this happens for all levers?

   Yes. For both the second class lever and the third class lever, applying effort closer to the fulcrum had the effect of making it harder to lift the load. In other words, a greater effort force had to be applied. This is also true for a first class lever.

   This means that for all three lever classes, applying effort close to the fulcrum means more force is required to lift a load.

2) **When you tested the second class lever, your hand had to move further than the load did. However, you didn't need to apply very much force to lift it up.**

   Compare this with the third class lever, where your hand didn't move as far as the load did, but you had to apply a greater force. Consider the size of the effort force and the distance between your hand and the fulcrum. In the space below, explain how the force and distance are related.

(Hint: Does the effort force increase or decrease when the distance increases?)

When the hand moves further away from the fulcrum of the lever, the distance between them is increased. This has the effect of decreasing the effort force required. The load can be lifted up using less force.

This says something very important about levers and, indeed, all simple machines. There is always a trade-off between force and distance. A user can apply less effort, or move their hand a shorter distance, but they can't do both!

3) **Look back on your experiment and record at least two things that worked well.**

   The aim of the experiment was achieved; qualitative data was gathered and used to make inferences about how levers work.

   The design of the lever was very simple, so this experiment could be repeated in the classroom many times.

4) **Record at least two things that could be improved if you were to do this experiment again.**

   When using the lever, one end of it sometimes hit the surface of the desk. As well as making a loud noise, this limited how far the mass could be lifted. This could be fixed by stacking the books higher, providing more space between the lever and the desk.

   More insight could have been gained by collecting quantitative (numerical) data instead of just qualitative data. For instance, the effort force could have been measured precisely using a spring scale. This would make it possible to create data tables and plot graphs to show the mathematical relationship between distance and force for a lever.

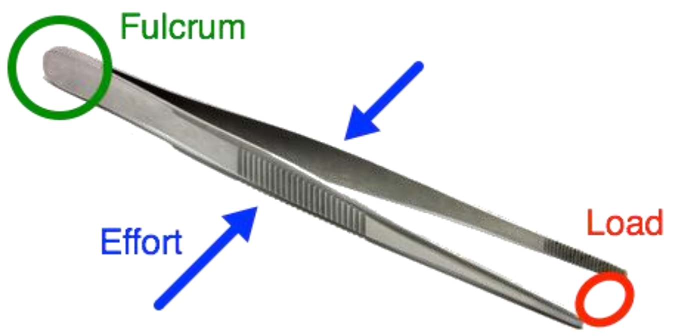
5) **At the beginning of this experiment, you built and tested a first class lever. First class levers have a fulcrum in the middle, with the load and effort applied on either side. A seesaw is an example of this!**

   You concluded that it's harder to lift an object with the lever if you apply effort closer to the fulcrum. Using this information, suggest what you should do to more easily lift a heavy person on a seesaw.

   To make it easier to lift a heavy person, you should move further away from the fulcrum. On a seesaw, this is achieved by sitting further back. You will move further than the other person, but the effort required is less.

6) **Tweezers have a fulcrum at one end and hold a load, like a dead insect, in the other end. You operate them by squeezing and applying effort**

between the fulcrum and the load.

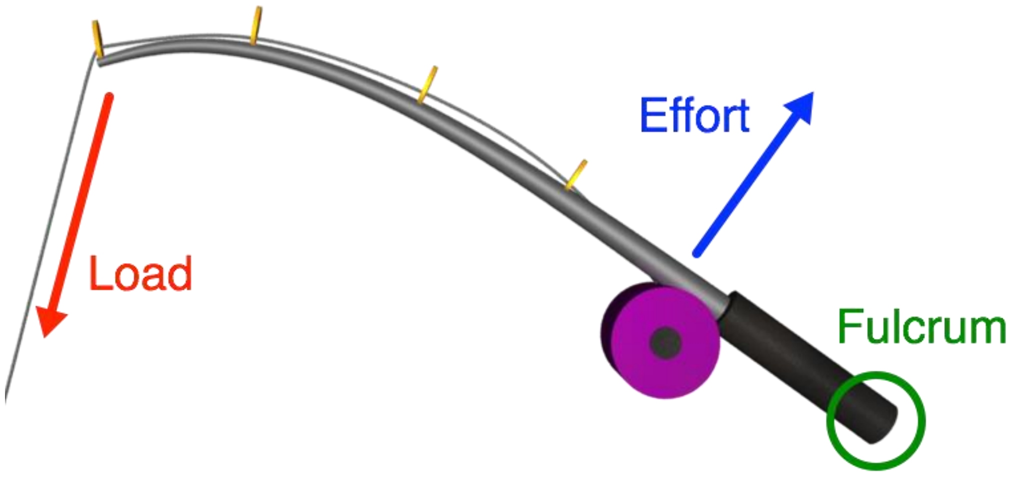


State which class of lever this is an example of. Based on your experimental results, explain whether it's easier to squeeze the tweezers close to or away from their fulcrum.

Tweezers are an example of a third class lever. This is because effort is applied to them between the fulcrum and the load.

In the experiment, you found that it's easier to lift an object with a third class lever if you apply effort further from the fulcrum. Therefore, it is easier to use tweezers if you squeeze them close to where the load is, rather than where the fulcrum is.

7) **A fishing rod is another example of a third class lever. You have to be quite strong to use a fishing rod, because you apply effort very close to where the fulcrum is. The load is the weight of the fish you've caught, which is applied to the thin end of the rod.**



Think back to the third class lever that you built. How far did the load move compared to your hand? Using your findings, consider an advantage of applying effort close to the fishing rod's fulcrum.

When you pull close to the fulcrum of a fishing rod, the end supporting the load moves a great distance. A small movement from your hand creates a large movement at the other end. This means you can pull a fish out of the water and into your boat.

You have to apply a lot of effort force, but the gain in distance is a big advantage for fishing!

Extra for Experts Example Answers

1) **If you aren't touching a lever, it has no effort force applied to it. There is only the fulcrum and the load. As a result, the lever sits still.**

   Why do you need to apply an effort force to make the lever rotate? Use Newton's First Law of Motion to explain your answer.

   Newton's First Law of Motion says that an object at rest will stay at rest until an unbalanced force is applied to it. This is sometimes called the Law of Inertia. The inertia of the load and the lever itself keeps it at rest.

   When you apply an effort force by pulling or pushing on the lever, you're providing the unbalanced force. Therefore the lever is able to move by rotating about its fulcrum.

2) **Newton's Second Law of Motion is often described using an equation: F=ma. It means the net force (F) acting on an object is equal to its mass (m) multiplied by its acceleration (a). Using this formula, explain why you need to apply more effort force to lift a heavier load (mass).**

   (Hint: Assume you want the acceleration of the load to be the same.)

   The equation F=ma shows that net force and mass are proportional. That means that if you increase one of these variables, the other increases by the same factor. That is assuming the acceleration (a) stays the same.

   If the mass of an object increases, so does its weight force, which means it applies a greater load to a lever. Therefore it requires more force to lift the object. In other words, you have to apply more effort!