ROLLERS AND WHEELS

OBJECTIVE:

You will understand and demonstrate the principle on which rollers and wheels work to help move objects.

INTRODUCTION:

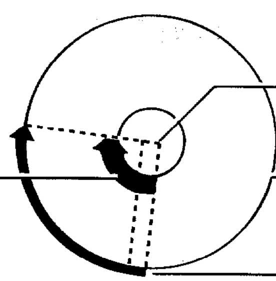
Rollers and wheels are means of reducing friction when dragging large, heavy objects. Rollers are solid cylinders which originally were simply placed under an object to be moved. Wheels, on the other hand, are disk shaped and are usually mounted in a pair, one at either end of an axle.

The origins of rollers are lost in prehistory. Certainly, rollers made of wooden logs would have been used by the ancient Egyptians to drag stone blocks into place when building the pyramids in the third millennium BC. More is known about the origins of the wheel. It is likely that the use of wheels for transportation was not simply a development from the roller but was developed for a different purpose. The first true wheel with axle was probably a potter's wheel, invented in Mesopotamia (now Iraq) in about 3500 BC. It was not long before the wheel was found to be an effective means for carrying lighter loads. It works on the lever principle—the large distance moved by the wheel rim is transmitted as a large force turning the axle over a short distance (see figure 1).

Within Mesopotamia by 3200 BC, solid wooden wheels were used on four-wheeled, two-axled carts pulled by horses. Spoked wheels appeared soon after 2000 BC and could be made lighter and larger than conventional solid wheels. They were gradually improved and refined; iron tires were used to protect and strengthen the rim, and the wheel was made slightly concave to increase its strength and stiffness. A more recent advance has been in the use of pneumatic rubber tires, making it easier for vehicles to travel on uneven surfaces.

The wheel is the key to much of modern engineering; few machines are without wheels or rollers of some type. Almost all vehicles run on wheels, and even those that do not—tanks and bulldozers, for example—run on tracks that are turned by forms of wheel. Pulleys and gears are also modified forms of wheel (see 7.06 and 7.09).

Figure 1



TIME NEEDED:

3/4 hour

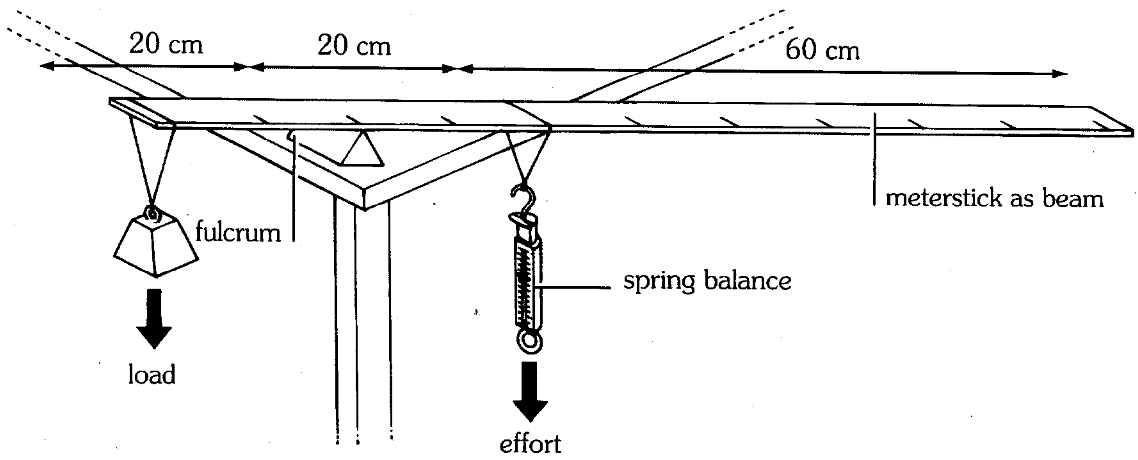
MATERIALS:

Note: You will need a partner for this investigation.

- 4 VHS videocassettes in their boxes
- 12–25mm-diameter metal ring
- masking tape
- spring balance measuring in g
- 6 4-in. lengths of 1/2-in. wooden dowel
- drill (electric or battery operated)
- 2mm drill bit
- workbench and vice
- 4 1/2-in. no. 4 wood screws with domed heads
- 2 lengths of lumber 6 1/2 in. x 3/4 in. x 1/4 in.
- 2 lengths of lumber 4 1/2 in. x 3/4 in. x 1/4 in.
- metric ruler

Note: If using an electric drill, you will need a source of electricity—e.g., a wall outlet.

Figure 1



4. Loop an index finger through the lower ring of the spring balance. Then have your partner release the meterstick. By gently pulling on the spring balance you should be able to keep the meterstick horizontal. Notice what effort (the reading on the spring balance) is needed to keep the meterstick horizontal. Record your findings in the first line of the Data Table, first converting the effort to newtons (N) (1 kg = 10 N).

5. Repeat step 4, but position the spring balance at 40 cm from the fulcrum, then at 60 cm, 80 cm, and 100 cm. In each case, record your findings in the appropriate row of the Data Table.

DATA TABLE

Load (N)	Load-to-fulcrum distance (cm)	Effort (N)	Effort-to-fulcrum distance (cm)
10	20		20
10	20		40
10	20		60
10	20		80
10	20		100

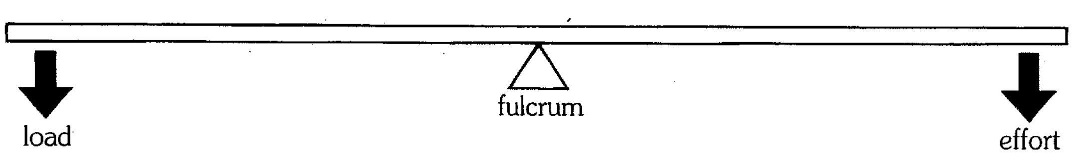
ANALYSIS:

1. Examine the figures in your Data Table. Suggest an equation for determining the effort needed to move the load, expressed in terms of the three other variables in the Data Table.

2. How well do your results agree with the equation you have proposed? If there is some variation, can you suggest why this might be?

3. So far you have been finding out about one type of lever—where the fulcrum is between the load and the effort (see figure 2). This type is called a class 1 lever, and is probably the oldest form of lever.

Figure 2 Class 1 lever



2. Gently pull on the spring balance until the videocassette just begins to move. Then pull gently on the spring balance at a constant speed. Your partner should watch carefully and note the spring balance reading at the point when the box starts to move, and then the reading when the box is being pulled along at a constant speed. Repeat this procedure twice more to get three readings for the start and three readings for the constant movement force. Take an average for each of these three readings. Convert these averages to forces in newtons [effort (newtons) = effort (kg) x 10m/sec^2 (the acceleration due to gravity)]. Enter these values in Part 1 of the Data Table in the row marked Side A.

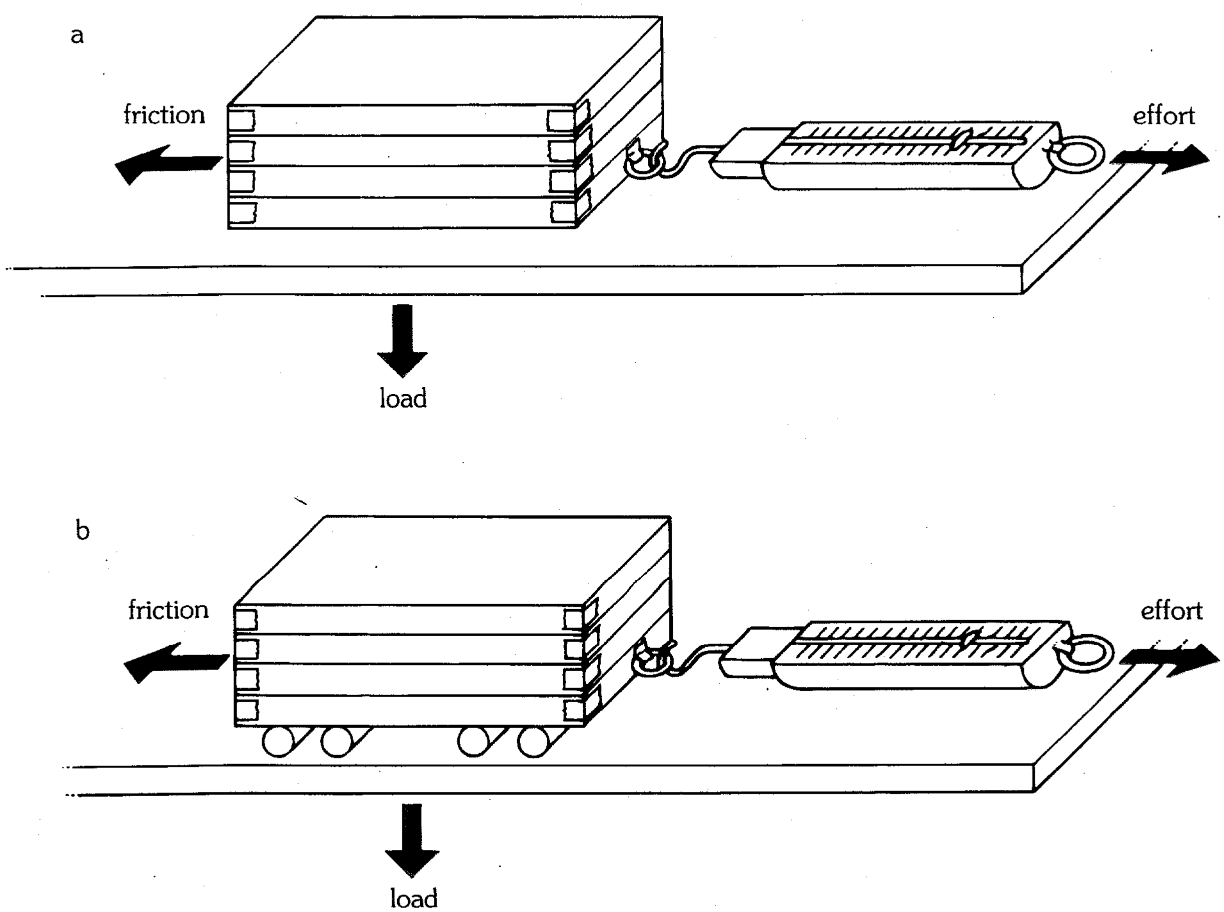
3. Repeat step 2, but with the videocassette box standing first on one edge (see figure 2b) and then the other edge (figure 2c), repositioning the metal ring as required. Again, work out averages for the readings in each case, convert these to newtons, and enter the values in Part 1 of the Data Table in the rows marked Edge B and Edge C.

Part 2—Rollers and wheels

4. Stack four videocassettes, one on top of the other (see figure 3a), and repeat step 2. Again, take three readings, work out the averages, and convert these to newtons. Enter your results in Part 2 of the Data Table in the row marked No Rollers.

5. Repeat step 2, but with the four videocassettes resting on four rollers (figure 3b). Again, take three readings, work out the averages, and convert these to newtons. Enter your results in Part 2 of the Data Table in the row marked On Rollers.

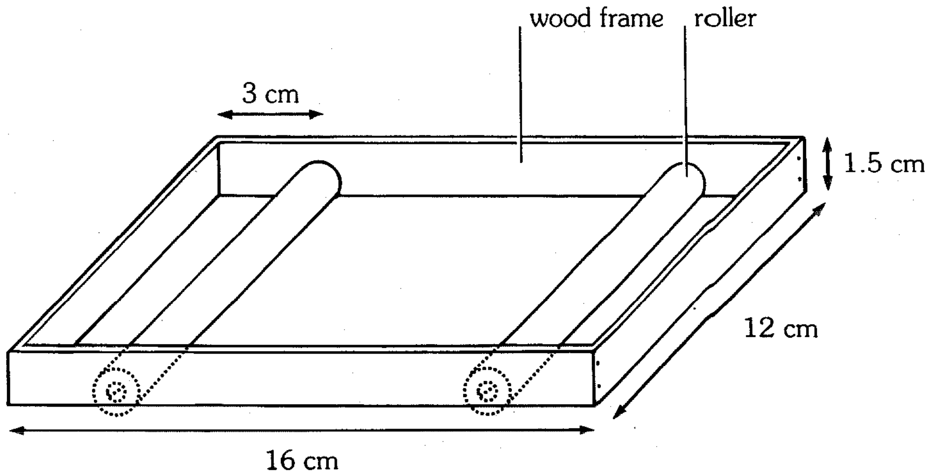
Figure 3



6. Construct a simple wooden frame in which to mount two of the rollers (figure 4). Drill two holes in each of the longer strips of lumber, 3 cm from each end and 0.5 cm from one edge. Glue and nail the two longer lengths of lumber to the shorter lengths to form a rectangular frame.

7. Mount each roller in a vice and drill a 10mm-deep hole in the center of both ends. Use dome-head wood screws to loosely secure the rollers to the wood frame (see figure 4). The rollers should project beyond the edge of the frame and should be free to rotate around their long axis.

Figure 4



8. Place the four videocassettes on the wooden frame and repeat step 2. Enter your results in Part 2 of the Data Table in the row marked On Frame.

DATA TABLE

	Force needed to start load moving (N)	Force needed to keep load moving (N)
Part 1 (one videocassette)		
Side A		
Edge B		
Edge C		
Part 2 (four videocassettes)		
No Rollers		
On Rollers		
On Frame		

ANALYSIS:

1. Friction is a force that acts against movement when two surfaces are in contact. Based on your findings in Part 1:

a) Is friction the same for the different positions of the videocassette (i.e., is it the same regardless of the surface area of contact between the moving surfaces)?

b) Is friction the same when an object starts to move as when it is moving at a constant speed?

2. Based on your findings in Part 2, how much is friction reduced when you use rollers? Calculate your answer as a percentage.

3. What are the advantages of using rollers on axles (in a frame) compared to unmounted rollers?

4. Most wheeled vehicles have four narrow wheels mounted on two axles. What are the advantages of this arrangement compared to simply using mounted rollers?

OUR FINDINGS:

Click on above link to see what we found.