21 Tension

Purpose

To introduce the concept of tension in a string

Required Equipment/Supplies

3 large paper clips
3 large identical rubber bands
1 m of strong string
500-g hook mass
ring stand
spring scale
ruler
marking pen

Discussion

When you put bananas on a hanging scale at the supermarket, a spring is stretched. The greater the weight of the bananas (the force that is exerted), the more the spring is stretched. Rubber bands act in a similar way when stretched. For stretches that are not too great, the amount of the stretch is directly proportional to the force.

If you hang a load from a string, you produce a tension in the string and stretch it a small amount. The amount of tension can be measured by attaching the top end of the string to the hook of a spring scale hanging from a support. The scale will register the tension as the sum of the weights of the load and the string. The string's weight is usually small enough to be neglected, so the tension is simply the weight of the load.

Is this tension the same all along the string? To find the tension at the lower end of the string you could place a second scale there, but the weight of the added scale would increase the tension in the top scale. You need a scale with a tiny mass. Since a rubber band stretches proportionally with the force, you could use it to measure the tension at the lower end of the string. Its tiny weight will not noticeably affect the reading in the top scale. In this activity, you will use rubber bands to investigate the tensions at different places along short and long strings supporting the same load.

Procedure

Step 1: Without stretching them, place three identical large rubber bands flat on a table. Carefully mark two ink dots 1 cm apart on each of the rubber bands.

Mark rubber bands.

Cut string.

Step 2: Cut a 1-meter string into 2 lengths of 25 cm each, and 1 length of 50 cm. Tie each end of each string into a loop.

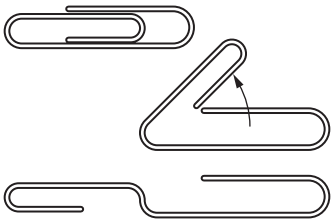


Fig. A

Step 3: Bend the paper clips into double hooks, as shown in Figure A.

Step 4: Suspend the spring scale from the top of a ring stand such that it extends over the edge of the table. Place one end of a rubber band over the scale hook. Suspend the 500-g load from the lower end of the rubber band as shown in Figure B. Note that the weight of the load stretches both the rubber band and the spring inside the spring scale.

While the load is suspended, measure and record the distance between the ink marks on the rubber band. Also record the reading on the spring scale.

distance between marks = _____

tension (scale reading) = _____

3-rubber-band stretch

Step 5: With the use of paper-clip hooks, repeat the previous step using three rubber bands connected as shown in Figure C. Measure the stretch of the three bands. Record your results.

distance between marks of top band = _____

distance between marks of middle band = _____

distance between marks of bottom band = _____

tension (spring-scale reading) = _____

Hang load from one band and string.

Step 6: Disconnect the load and two of the rubber bands. Using a paper-clip hook, connect one end of a 25-cm length of string to the remaining rubber band. Suspend the load on the other end of the string, as shown in Figure D. Record the spring-scale reading and the distance between the marks of the rubber band.

tension (spring-scale reading) = _____

distance between marks of band = _____

Hang load from string and two bands.

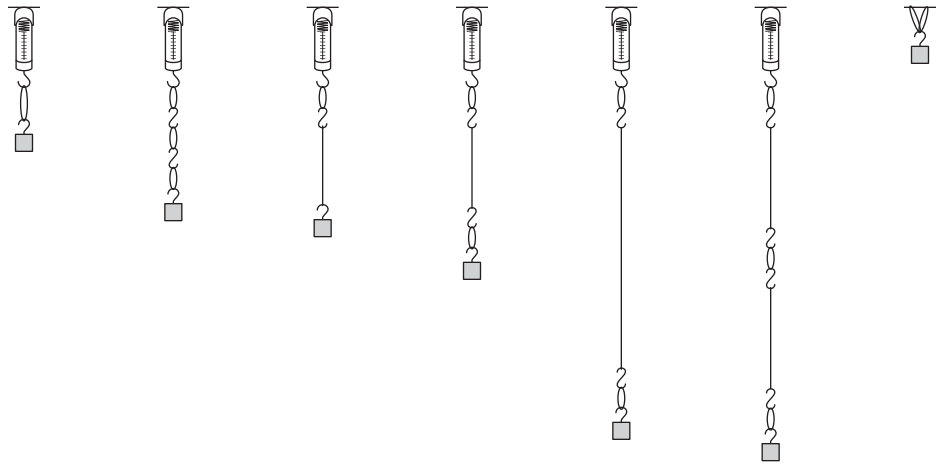
Step 7: Using a paper-clip hook, insert a rubber band between the lower end of the string and the load, as shown in Figure E. While you are attaching the bottom rubber band, mentally predict the amount of stretch of the added band. Compare the tensions at the top and the bottom of the string by measuring the stretches of the two rubber bands. Record your findings.

distance between marks of top band = _____

distance between marks of bottom band = _____

Name Period Date

Fig. B Fig. C Fig. D Fig. E Fig. F Fig. G Fig. H



Step 8: Repeat Step 7 using the 50-cm piece of string, as shown in Figure F, to see whether the tension in the string depends on the length of the string. Make a mental prediction before you measure and record your findings.

Repeat using longer string.

distance between marks of top band = _____

distance between marks of bottom band = _____

Step 9: Repeat the previous step, substituting two 25-cm pieces of string joined by paper-clip hooks with a rubber band in the middle (as shown in Figure G) for the 50-cm string. This arrangement is to compare the tension at the middle of a string with the tension at its ends. While you are substituting, mentally predict how far apart the ink marks will be. After your prediction, measure and record your findings.

Add rubber band between two strings.

distance between marks of top band = _____

distance between marks of middle band = _____

distance between marks of bottom band = _____

Analysis

1. Does the length of the string have any effect on the reading of the spring scale? What evidence can you cite?

_____

_____

_____

_____

_____

2. Does the tension in the string depend on the length of the string? What evidence can you cite?

3. How does the tension at different distances along a stretched string compare? What evidence can you cite?

4. How much would each rubber band stretch if the 500-g load were suspended by two side-by-side bands as shown in Figure H? Make your prediction, and then set up the experiment. Explain your result.

predicted stretch = _____

actual stretch = _____