

Musk-o-tawa Chapter Calvinist Cadets
Developed by Lane Smith

Amusement Park Physics for Upper Elementary Students

Expectations:

The Giant Gondola Wheel is a required activity for everyone. Each Group must pick at least 3 additional rides from the following possibilities:

Sea Dragon
Carousel
Wolverine Wildcat
Cork Screw
Shivering Timbers

Mad Mouse
Thunder Hawk
Woodstock Express
Rip cord



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Name _____

Triangle Chart

Triangle	Angle	Height H	Distance D	Ratio h/d	Tangent Angle	Measured Angle
1	A					
2	B					
3	C					

Circle Chart

Circle	Radius R	Diameter D	Circumference C
Circle #1			
Circle #2			

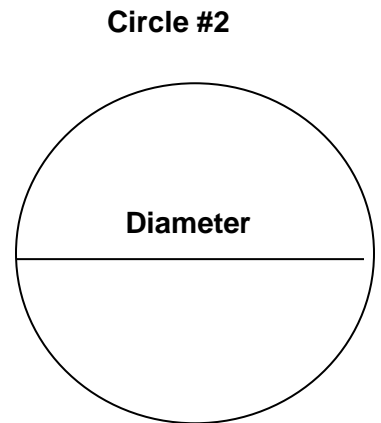
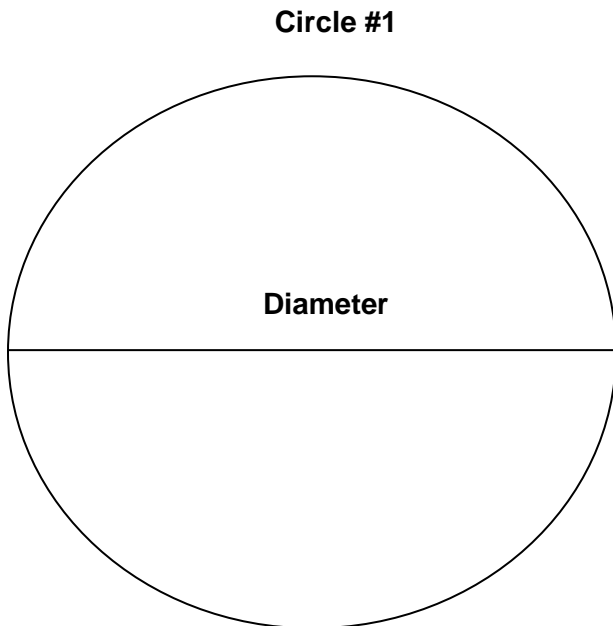
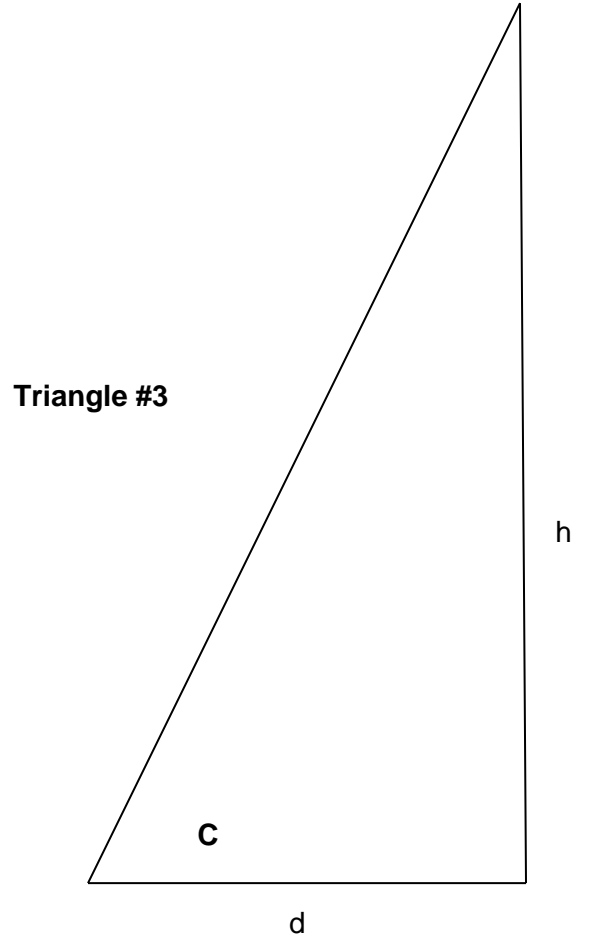
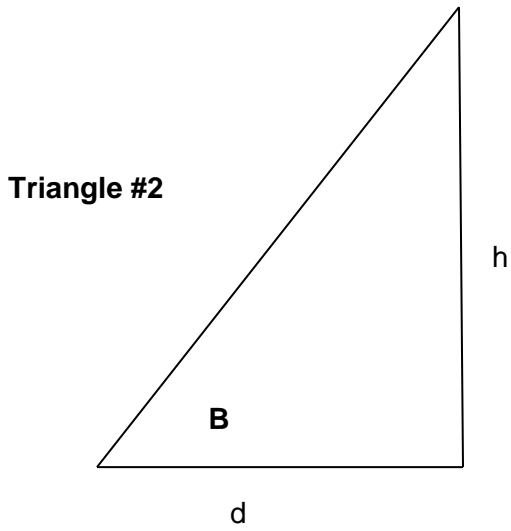
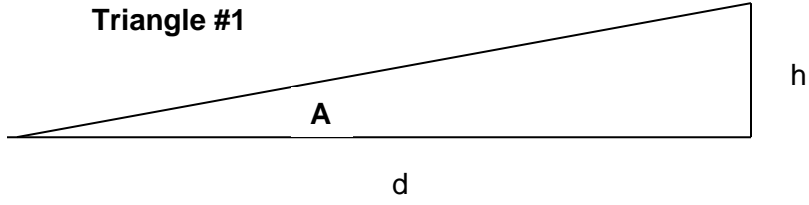
Pacing Chart

Distance of _____ ft.	Number of Paces
Trial #1	
Trial #2	
Average	
Feet/Pace	

Baseline Distance Chart

20 paces _____ feet/pace	
30 paces _____ feet/pace	
20 paces _____ feet/pace	

Triangles and Circles



Tangent Table

Ø-Degrees	h/d-ratio	Ø-Degrees	h/d-ratio	Ø-Degrees	h/d-ratio
1	0.02	31	0.60	61	1.80
2	0.03	32	0.62	62	1.88
3	0.05	33	0.65	63	1.96
4	0.07	34	0.67	64	2.05
5	0.09	35	0.70	65	2.14
6	0.11	36	0.73	66	2.25
7	0.12	37	0.75	67	2.36
8	0.14	38	0.78	68	2.48
9	0.16	39	0.81	69	2.61
10	0.18	40	0.84	70	2.75
11	0.19	41	0.97	71	2.90
12	0.21	42	0.90	72	3.08
13	0.23	43	0.93	73	3.27
14	0.25	44	0.97	74	3.49
15	0.27	45	1.00	75	3.73
16	0.29	46	1.04	76	4.01
17	0.31	47	1.07	77	4.33
18	0.32	48	1.11	78	4.70
19	0.34	49	1.15	79	5.14
20	0.36	50	1.19	80	5.67
21	0.38	51	1.23	81	6.31
22	0.40	52	1.28	82	7.12
23	0.42	53	1.33	83	8.14
24	0.45	54	1.38	84	9.51
25	0.47	55	1.43	85	11.43
26	0.49	56	1.48	86	14.30
27	0.51	57	1.54	87	19.08
28	0.53	58	1.60	88	28.64
29	0.55	59	1.66	89	57.29
30	0.58	60	1.73	90	undefined

Calculation Sheets

Circumference Calculation

Diameter = 2 x radius

Circumference = 3.14 x diameter (C = 3.14 x d)

Example:

Radius is 10.0 inches

Diameter is 20.0 inches

C = 3.14 x d

C = 3.14 x 20.0 inches

C = 62.8 inches

Speed Calculation

Speed = $\frac{\text{distance}}{\text{time}}$

Example: The 20.0 inch wheel spins all the way around in 5.0 seconds.

$$\text{Speed} = \frac{62.8}{5.0 \text{ sec}} = 12.56 \text{ in/sec}$$

Height Calculation

How to determine the height of the item in question:

1. Walk off your base line in feet _____ feet
2. Measure the angle above the base line _____ degrees
3. Determine your tangent ratio from the table _____
4. Calculate the height of the item _____
(tangent ratio x base line = height)

Example: Pace = 2.2 feet per stride
Base line = 30 strides x 2.2 ft = 66 feet
Angle is 35 degrees tan ratio is .70
Height is tan ratio x baseline
Height = .70 x 66 feet = 46 feet

Making Measurements

TIME

The times that are required to work out the problems can easily be measured using a watch with a second hand or a digital watch with a stopwatch mode. When measuring the period of a ride that involves harmonic or circular motion, measure the time for several repetitions of the motion, then divide by the number of repetitions. This will give a better estimate of the period of motion than just measuring one repetition. You may want to measure the time two or three times and then average them.

DISTANCE

Since you cannot interfere with the normal operation of the rides, you will not be able to directly measure heights, diameters, etc. All but a few of the distances can be measured remotely using the following methods. They will give you a reasonable estimate. Try to keep consistent units, i.e. meters, centimeters, etc., to make calculations easier.

Pacing

Determine the length of your stride by walking at your normal rate over a measured distance. Divide the distance by the number of steps and you get an average distance per step. Knowing this, you can pace off horizontal distances.

Triangulation

For measuring height by triangulation, an astrolabe such as that shown in figure b can be constructed. You can practice this with the school flagpole before coming to the park.

Suppose the height (h_1) of the Corkscrew must be determined:

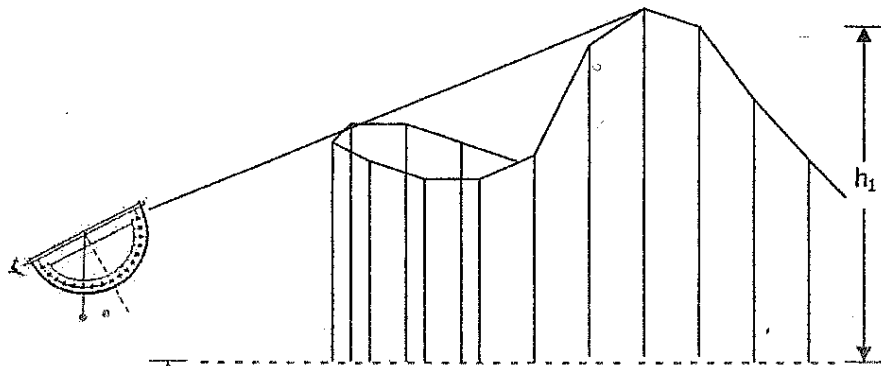
1. Measure the distance between you and the ride. You can pace off the distance:

Distance d : _____

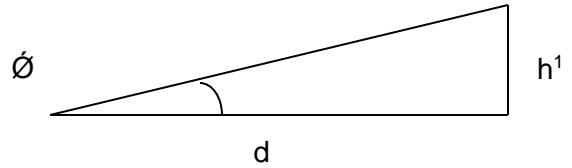
2. Take a sighting at the highest point of the ride.

3. Read off the angle of elevation:

Angle of elevation _____



$$h^1 = d (\tan \emptyset)$$



4. Look up the tangent value for the angle measured:

Tangent value _____

ANGLE	TANGENT	ANGLE	TANGENT	ANGLE	TANGENT
5	.09	35	.70	65	2.14
10	.18	40	.84	70	2.75
15	.27	45	1.00	75	3.73
20	.36	50	1.19	80	5.67
25	.47	55	1.43	85	11.43
30	.58	60	1.73	90	57.29

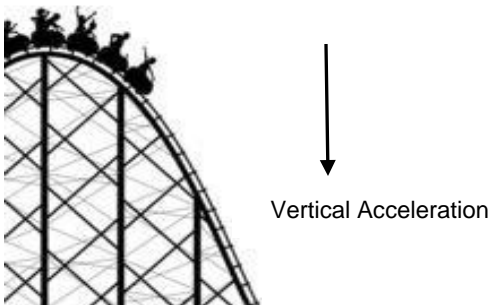
5. Multiply tangent value by the distance from the ride: $h^1 =$ _____

ACCELERATION

Accelerometers are designed to record the g forces felt by a passenger. Accelerometers are usually oriented to provide force data perpendicular to the track, longitudinally along the track.

Accelerometers are calibrated in g's. A reading of 1 g equals an acceleration of 9.8 m/s^2 . As you live on Earth, you normally experience 1 g of acceleration vertically (no g's laterally or longitudinally). Listed below are the sensations of various g forces. These are rough estimates, but may be helpful in estimating accelerations on the various rides.

Accelerometer Reading	Sensation
+3.0 g	3 times heavier than normal (maximum g's pulled by space shuttle).
+2.0 g	Twice normal weight.
+1.0 g	Normal weight.
+0.5 g	½ normal weight.
+0.0 g	Weightlessness (no force between rider and coaster).
-0.5 g	½ normal weight, but directed away from the coaster seat



Team Names: _____

Data Sheet

Giant Gondola Wheel
(Required activity)

baseline _____ feet
 angle _____ degrees
 height _____ feet
 time _____ sec.
 speed _____ feet/sec

Sea Dragon

time _____ sec.
 speed _____ feet/sec
 highest g A B C D E
 lowest g A B C D E

Carousel

diameter _____ feet
 time _____ sec
 speed _____ feet/sec

Ride	Baseline feet	Angle Degree	Ratio	Height feet	Time Sec	Speed Feet/sec	Highest "g"	Lowest "g"
Wolverine Wildcat								
Cork Screw								
Shivering Timbers								
Mad Mouse								
Thunder Hawk								
Woodstock Express								
Rip Cord								

Giant Gondola Wheel

Measure the height (diameter):

1. Walk off your baseline _____ feet
2. Measure the angle above the baseline _____ degrees
3. Determine your tan ratio from the table _____
4. Calculate the height of the Gondola wheel

Tangent ratio x baseline = height

$$\text{_____} \times \text{_____} = \text{height}$$

Height is the diameter

Diameter _____ feet

Circumference = 3.14 x diameter

Circumference _____ feet

Time to rotate once around

Rotation time _____ sec

Speed = $\frac{\text{circumference}}{\text{time}}$

Speed _____ feet/sec



Sea Dragon

The length of the sea dragon boat is _____ 44 _____ feet

Measure the time for the dragon to pass through the frame _____ sec

Speed = $\frac{\text{dragon length}}{\text{Time}}$ _____ feet

Where is the highest “g” force? (choose from below) _____

Where is the lowest “g” force? (choose from below) _____

A	At the top of the swing
B	At the bottom of the swing
C	Half way up the swing
D	Three quarters up the swing
E	One quarter up the swing



Carousel

Walk off the diameter of the carousel _____ feet

Circumference = $3.14 \times \text{diameter}$ circumference _____ feet

Measure the time for one rotation _____ sec

Speed = $\frac{\text{circumference}}{\text{time}}$ _____ feet/sec



Wolverine Wildcat Roller Coaster

Determine height of the highest hill:

1. Walk off your baseline _____ feet
2. Measure the angle above the baseline _____ degrees
3. Determine your tan ratio from the table _____
4. Calculate the height

Tan ratio x baseline = height

_____ x _____ = _____ feet

Determine speed of train:

The length of the coaster train is _____ 40 _____ feet

Measure the time for the train to pass _____ sec

Speed = $\frac{\text{coaster length}}{\text{Time}}$ _____ feet/sec

Where do you get the highest “g” force? (choose from below) _____

Where do you get the lowest “g” force? (choose from below) _____

A	Top of highest hill
B	Bottom of highest hill
C	Half way down the highest hill
D	Three quarters down the highest hill
E	One quarter down the highest hill



Cork Screw Roller Coaster

Determine height of the highest hill:

1. Walk off your baseline _____ feet
2. Measure the angle above the baseline _____ degrees
3. Determine your tan ratio from the table _____
4. Calculate the height –
Tan ratio x baseline = height
_____ x _____ = _____ feet

Determine speed of train:

The length of the coaster train is _____ 56 _____ feet

Measure the time for the train to pass _____ sec

Speed = $\frac{\text{coaster length}}{\text{Time}}$ _____ feet/sec

“g” force:

Where do you get the highest “g” force?
(Select option from those below) _____

Where do you get the lowest “g” force?
(Select option from those below) _____

- A. Top of highest hill
- B. Bottom of highest hill
- C. Half way down the highest hill
- D. Three quarters down from the highest hill
- E. One quarter down from the highest hill



Shivering Timbers Roller Coaster

Determine height of the highest hill:

1. Walk off your baseline _____ feet
2. Measure the angle above the baseline _____ degrees
3. Determine your tan ratio from the table _____
4. Calculate the height –
Tan ratio x baseline = height
_____ x _____ = _____ feet

Determine speed of train:

The length of the coaster train is _____ 42 _____ feet

Measure the time for the train to pass _____ sec

Speed = $\frac{\text{coaster length}}{\text{Time}}$ _____ feet/sec

“g” force:

Where do you get the highest “g” force?
(Select option from those below)

Where do you get the lowest “g” force?
(Select option from those below)

- A. Top of highest hill
- B. Bottom of highest hill
- C. Half way down the highest hill
- D. Three quarters down from the highest hill
- E. One quarter down from the highest hill



Mad Mouse Roller Coaster

Determine height of the highest hill:

1. Walk off your baseline _____ feet
2. Measure the angle above the baseline _____ degrees
3. Determine your tan ratio from the table _____
4. Calculate the height –
Tan ratio x baseline = height
_____ x _____ = _____ feet

Determine speed of train:

The length of the coaster train is _____ 7.0 _____ feet

Measure the time for the train to pass _____ sec

Speed = $\frac{\text{coaster length}}{\text{Time}}$ _____ feet/sec

“g” force:

Where do you get the highest “g” force?
(Select option from those below) _____

Where do you get the lowest “g” force?
(Select option from those below) _____

- A. Top of highest hill
- B. Bottom of highest hill
- C. Half way down the highest hill
- D. Three quarters down from the highest hill
- E. One quarter down from the highest hill



Thunder Hawk Roller Coaster

Determine height of the highest hill:

1. Walk off your baseline
2. Measure the angle above the baseline
3. Determine your tan ratio from the table
4. Calculate the height –

Tan ratio x baseline = height

_____ x _____ = _____ feet

_____ feet

_____ degrees

Determine speed of train:

The length of the coaster train is

_____ 48 _____ feet

Measure the time for the train to pass

_____ sec

Speed = $\frac{\text{coaster length}}{\text{Time}}$

_____ feet/sec

“g” force:

Where do you get the highest “g” force?
(Select option from those below)

Where do you get the lowest “g” force?
(Select option from those below)

- A. Top of highest hill
- B. Bottom of highest hill
- C. Half way down the highest hill
- D. Three quarters down from the highest hill
- E. One quarter down from the highest hill



Woodstock Express Roller Coaster

Determine height of the highest hill:

1. Walk off your baseline _____ feet
2. Measure the angle above the baseline _____ degrees
3. Determine your tan ratio from the table _____
4. Calculate the height –
Tan ratio x baseline = height
_____ x _____ = _____ feet

Determine speed of train:

The length of the coaster train is _____ 21 _____ feet

Measure the time for the train to pass _____ sec

Speed = $\frac{\text{coaster length}}{\text{Time}}$ _____ feet/sec

“g” force:

Where do you get the highest “g” force?
(Select option from those below)

Where do you get the lowest “g” force?
(Select option from those below)

- A. Top of highest hill
- B. Bottom of highest hill
- C. Half way down the highest hill
- D. Three quarters down from the highest hill
- E. One quarter down from the highest hill



Rip Cord Giant Swing

Determine height of the back pole:

16

5. Walk off your baseline _____ feet
6. Measure the angle above the baseline _____ degrees
7. Determine your tan ratio from the table _____
8. Calculate the height –
Tan ratio x baseline = height
_____ x _____ = _____ feet

Determine speed of the falling person:

- Time for the person to fall from top to bottom _____ sec
- Average speed = $\frac{\text{distance}}{\text{time}}$ = _____ feet/sec

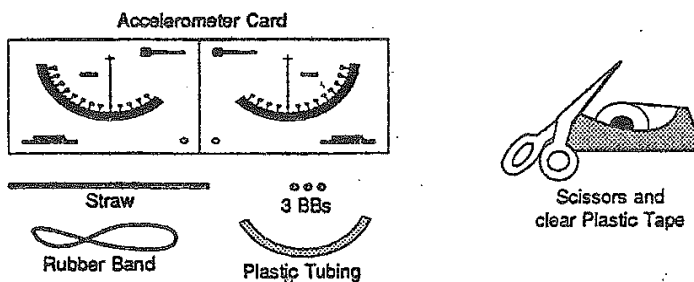


Constructing the Horizontal Accelerometer

Step 0

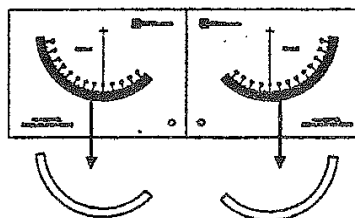
Materials Needed:

- Accelerometer Card
- Plastic Tubing (at least 13.5 cm)
- BBs (3)
- Straw
- Scissors
- Clear Plastic Tape
- Rubber Band



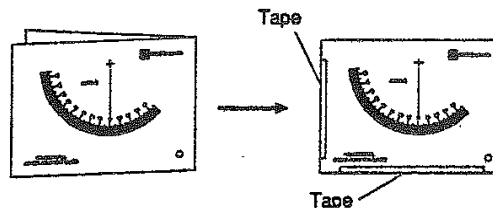
Step 1

- Remove the cutouts from each side of the Accelerometer Card.



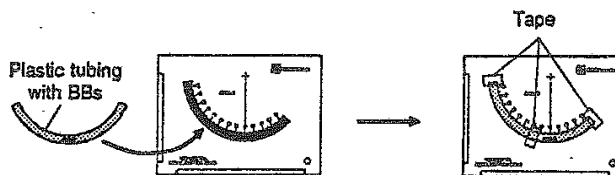
Step 2

- Fold the Accelerometer Card.
- Tape the side and bottom of the two halves together.



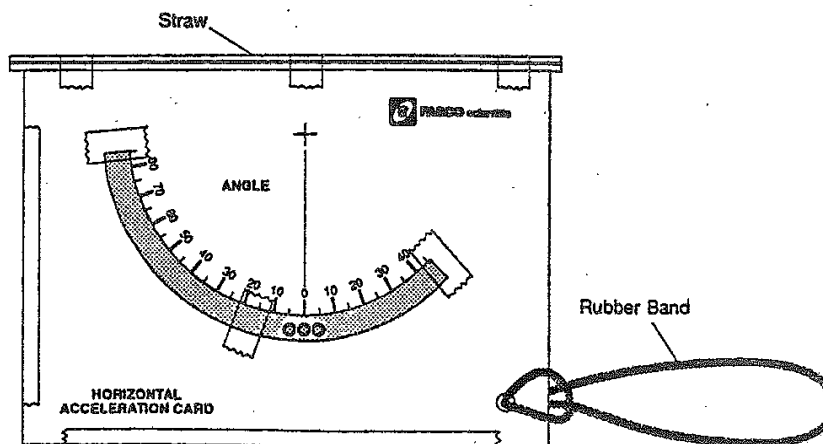
Step 3

- Cut the plastic tubing to fit the Accelerometer Card (15.3 cm).
- Place three BBs in the tube.
- Fit the tube into the card.
- Tape the tube to the card on both sides.



Step 4

- Tape the straw to the top of the Accelerometer Card.
- Secure the rubber band to the hole in the card, as shown. It serves as a lanyard.

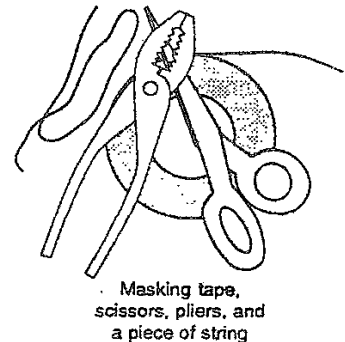
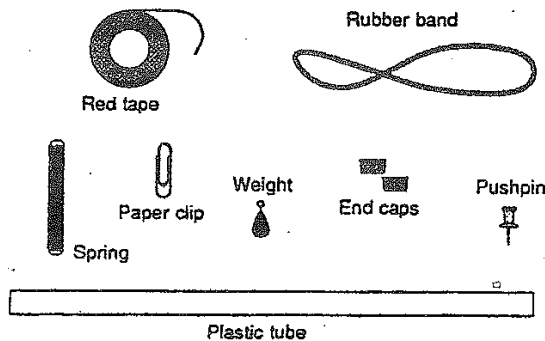


Constructing the Vertical Accelerometer

Step 0

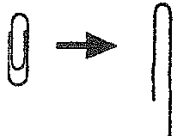
Materials Needed:

- Plastic tube
- Spring
- Red tape
- Rubber band
- Paper clip
- Weight
- End caps
- Masking tape, scissors, and pliers



Step 1

- Unbend the paper clip.



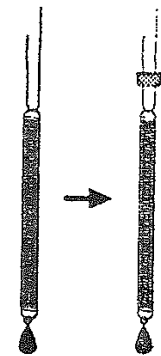
Step 2

- Use the pushpin to poke two holes in one of the plastic end caps.



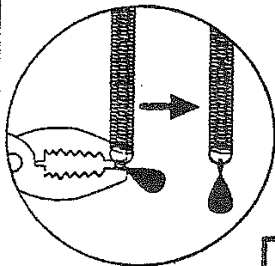
Step 3

- Attach the weight to the spring and suspend both from the paper clip.
- Push the paper clip through the holes in the end cap.



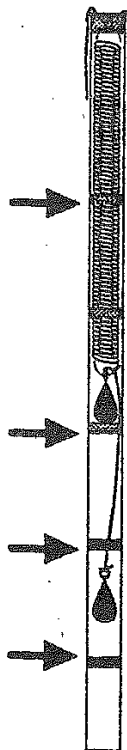
Step 4

- Using the pliers, crimp the brass ring of the weight.



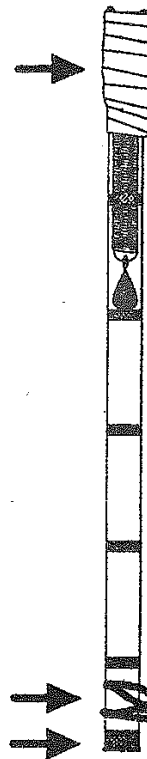
Step 6

- Tie a second weight on a string and suspend it, as well, from the spring.
- Place a second piece of red tape around the tube, again aligned with the bottom of the first weight.
- Remove the string and the second weight.
- Place additional pieces of tape around the tube, with equal spacing between the pieces.



Step 7

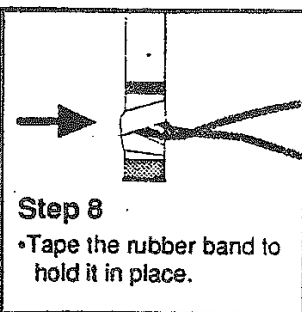
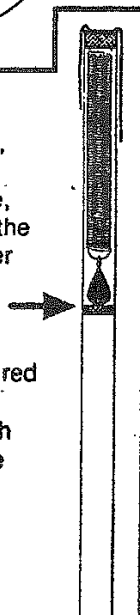
- Wrap masking tape around the ends of the paper clip.



- Secure the rubber band to the bottom of the tube as a lanyard.
- Place the other end cap on the bottom of the tube.

Step 5

- Insert the spring, weight, and end cap into the tube, and bend down the ends of the paper clip.
- Hold the tube vertically. Place a piece of red tape around the tube, aligned with the bottom of the weight.



Step 8

- Tape the rubber band to hold it in place.