

National Science Teacher's Association

Knott's Berry Farm Field Trip

Teachers Guide

We hope you have found this guide to be helpful in planning your own outing. Teachers borrow from many sources and among these the following are thankfully acknowledged:

Knott's Berry Farm Physics Day

http://www.exploratorium.edu/math_explorer/

<http://quest.arc.nasa.gov/space/teachers/microgravity/2accel.html>

Copies of this brochure can be downloaded at:

<http://fremonths.org>



Dear Teachers

Welcome to the National Science Teacher's Association (NSTA) Field Trip to Fun with Physics at Knott's Berry farm. We hope you have both an educational and a fun day. This booklet contains many fun activities that you can use in organizing your own field trip to your local amusement park.

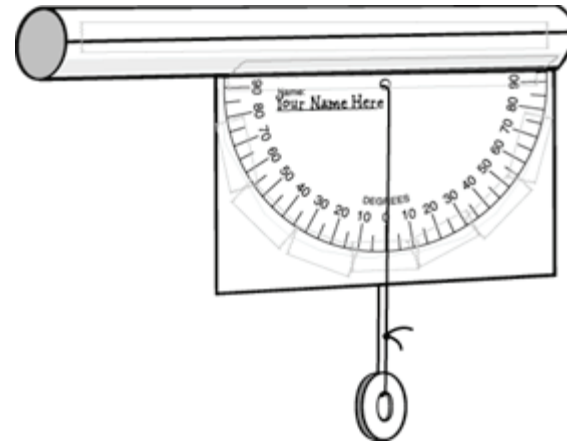
The activities in this book have been grouped into the three school age categories. Elementary school teachers will find age appropriate activities featured in Fun Time with Physics sections. Middle school teachers will find their activities under the Thrill Time with Physics section and high school teachers will find their activities under Extreme Fun with Physics.

This booklet also has cutout templates for having your students make their own measuring instruments. Also in this booklet are a few words of Physics's big ideas for describing the forces and velocities at any amusement park.

Have a great time at Knotts and have Fun with Physics!

Step 5

Roll a sheet of paper into a cylinder that's $8\frac{1}{2}$ " long and about 1 inch across. Put tape on the seam so the paper stays rolled, then tape this cylinder to the card along the straight edge of the protractor. One end of the cylinder should line up with the edge of the card.



Making Your Inclinometer

Here's how to make a tool that you can use to measure how tall something is—or how high a rocket or kite flies.

What Do I Need?

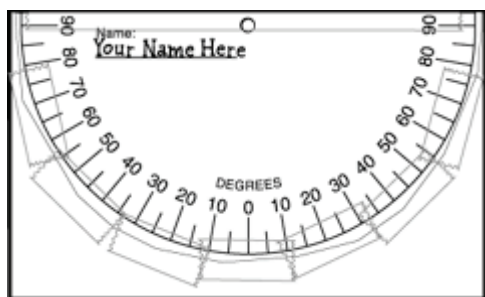
- Copies of Protractor for Inclinometer
- Scissors
- Clear tape
- A 3" x 5" card
- A hole punch
- 50 cm of string
- A washer or other small weight with a hole in it
- A sheet of 8 1/2" x 11" paper

Step 1

Print out a protractor. Cut very carefully on the straight line on one edge of the protractor. Protractor for Inclinometers

Step 2

Tape the protractor to the 3" x 5" card so that the straight side of the protractor matches up with the long side of the card.



Step 3

Use the hole punch to punch a hole through the circle on the protractor.

Step 4

Push one end of the string through the hole and through the washer. Tie the two ends of the string together making a loop on which the washer can slide freely.

Stuff Required for Making Scientific Measurements

To make the most of your day of physics you will need the following pieces of equipment:

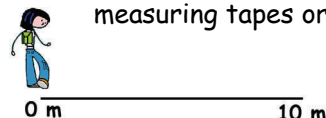
Pencil & notebook	Stop watch 0.01 sec.
Vertical Accelerometer	Horizontal accelerometer
Inclinometer	Calculator

When making measurements work in teams of two, three, or four. One team member should plan to keep track of the "stuff" while others stand in line for the ride.

Before coming to the park you should discuss the measurements you will need to make and calibrate your equipment. Measurement suggestions and useful equations are included in this guide. If a line for one ride is too long, go to another ride.

Measurement Suggestions and Helpful Formulae

find distances use string knotted at known intervals, cloth measuring tapes or your known pace length.

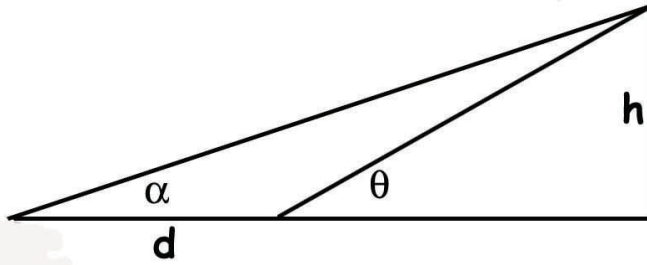


when measuring speeds find a location that parallels the tracks and take several readings to find the average value.



find heights you will measure the angles from your eye to the height at two locations in line of sight along a measured distance between the two angles. Have someone help you read the angle on the inclinometer because very slight errors in reading angles

cause major errors in calculations.



$$h = d \frac{\sin \theta \sin \alpha}{\sin(\theta - \alpha)}$$

observer height

when using accelerometers, be sure to have them secured around your wrist so there is no possibility that they may come loose to hurt yourself or others.

Other Useful Formulae:

Distance

Linear, average $x = vD t$ Free Fall, distance $x = \frac{1}{2}gt^2$

Energy

Kinetic Energy $KE = \frac{1}{2}mv^2$ Potential Energy $PE = mgD h$

Gravity

Free Fall, velocity $v = gt$

Momentum

Momentum $p = mv$ Impulse / momentum $Ft = mv$

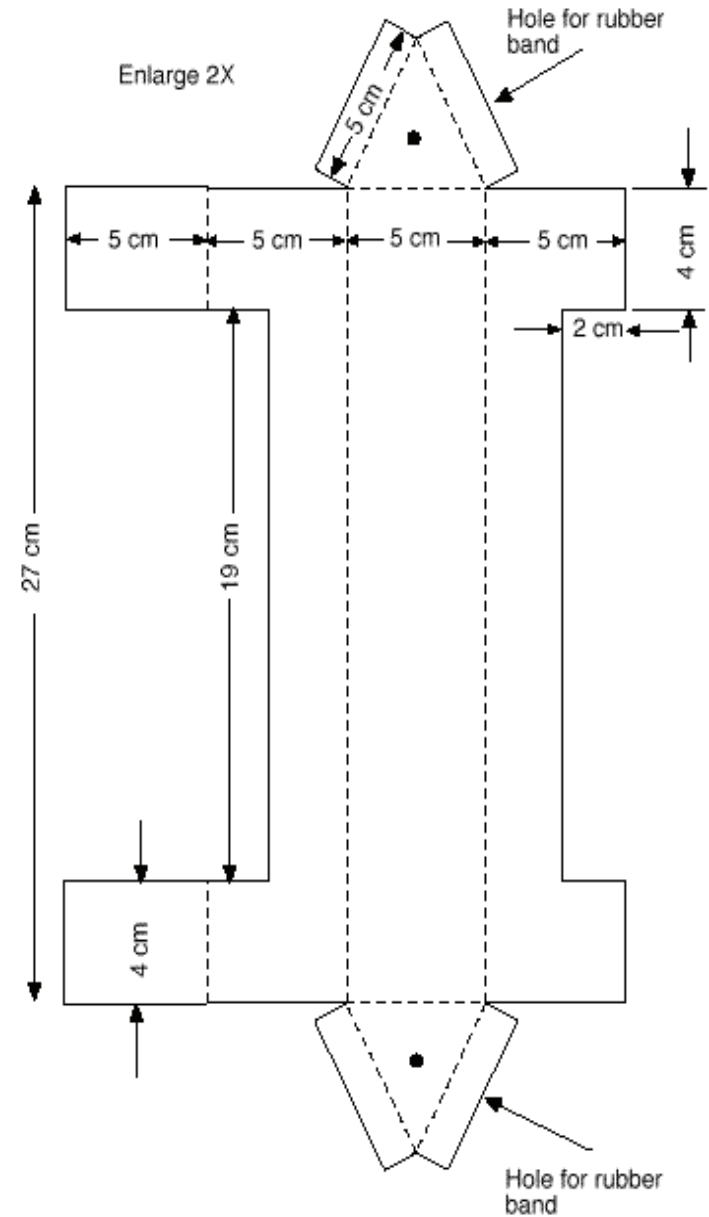
Rotary Motion

Tangential velocity $v = r\omega$ Centripetal force $F = \frac{mv^2}{r}$

Work

Work $W = Fd$ $W = D KE$

Accelerometer Box Pattern



triangle. While stretching the band, slip the free end through the second hole and tie it to a second paper clip.

8. Set the triangular box on its side so the window is up. Slide the weight so it is in the middle of the elastic band. Put a dab of hot glue on each end of the weight where the elastic band enters the holes.

9. If the elastic band sags inside the box, roll the elastic around one of the paper clips until it is snug. Then tape the paper clip in place. Tape the other triangular end in place.

Calibrating the Accelerometer:

1. Stand the accelerometer on one end. Using a pencil, mark one side of the accelerometer next to the middle of the weight.

2. Identify this mark as 1 g.

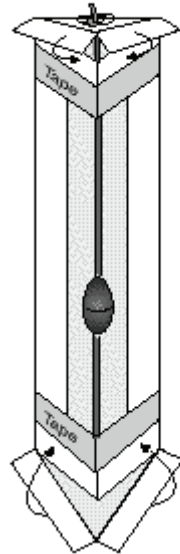
3. Using a small paper clip as a hook, hang a second weight on the first. Again, mark the middle of the first weight on the accelerometer.

4. Identify this mark as 2 g. Repeat this step with a third weight and identify the mark as 3 g.

5. Remove the two extra weights and stand the accelerometer on its other end. Repeat the marking procedure and identify the marks as -1 g, -2 g, and -3 g.

6. The final step is to mark the midway position between 1 and -1 g. Identify this place as 0 g. The accelerometer is completed.

Fold ends after rubber band and weight are attached. The two flaps on each end are folded to the outside.



Using a Horizontal Accelerometer

Step 1

Loop the accelerometer to your wrist using the lanyard.

Step 2

Hold the accelerometer so that the upper side is horizontal and the weight swings freely in the direction you are moving.

Step 3

Measure the change of the angle the string makes with the protractor while being accelerated. The table below gives the number of g's recorded by the device.

Angle	G's
10	0.17
20	0.36
30	0.57
40	0.84
45	1.00
50	1.19
60	1.73
70	2.74



The use of the horizontal accelerometer requires some caution for the most accurate readings. The top surface of the accelerometer must be level. If the upper edge is not level, then the accelerometer is reading your angle of incline. Wind loads must be considered. Rushing wind can blow the weight in different directions. Both of these conditions will result erroneous readings.

Using a Vertical Accelerometer

Step 1

Loop the accelerometer to your wrist using the lanyard.

Step 2

Hold the accelerometer so that it is in the same axis as the acceleration you are measuring. In other words, when measuring vertical acceleration, hold the accelerometer vertically. When measuring forward and backward acceleration, hold it in a forward and backward position.

Step 3

The rubber band is non-linear. This means that it stretches more at high g 's than at low g 's. Therefore readings at 1 g are harder to see because of the limited travel of the indicator. Readings at 3 g 's are much easier to see.



Acceleration means that there is a change in the velocity of the object for any given time. Under constant speed conditions the velocity is not changing, therefore the acceleration is zero. The car itself may be traveling at a high rate of speed but if not changing speed it will register no acceleration. This is always a question a kid would ask. They will say they are going very fast and yet the instruments read zero.



The accelerometer must be held in-line with the axis being measured. If it is not in-line then the instrument will measure the vector sum of the accelerations.

Making a Vertical Accelerometer

Materials and Tools

- * Lightweight poster board (any color)
- * 3 "drilled egg" lead fishing sinkers, 1 ounce size
- * Masking tape
- * Rubber band, #19 size
- * 4 small paper clips
- * Scissors
- * Straightedge
- * Ballpoint pen
- * Pattern
- * Hot glue (low temperature)

Building the Accelerometer:

1. Trace the pattern for the accelerometer on a piece of poster board. Cut out the pattern.

2. Use a ruler and a ballpoint pen to draw the fold lines on the poster board in the same place they are shown on the pattern.

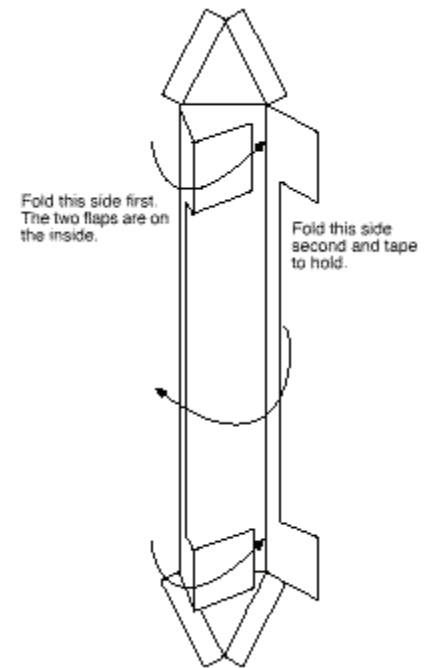
3. As you draw the lines, apply pressure to the poster board. This will make the poster board easier to fold.

4. Fold the two long sides up as shown in the first illustration.

5. The left side with the tabs is folded over first. The right side is folded second. This makes a long triangle shape. Use tape to hold the sides together.

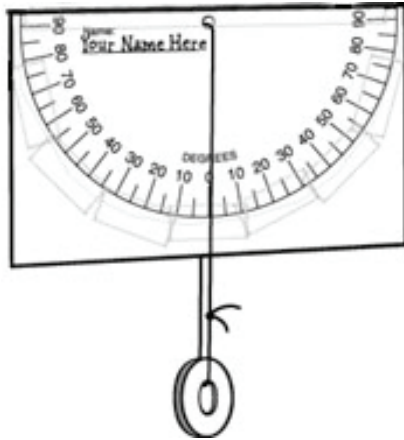
6. Punch a small hole in one of the end triangles. Cut the rubber band to make one long elastic band. Tie one end of the band to a small paper clip. Thread the other end through the hole.

7. Slip the lead weight on the band. Punch a hole in the other end



Step 4

Push one end of the string through the hole and through the washer. Tie the two ends of the string together making a loop on which the washer can slide freely.



Notes and Sketches

Using a Inclinometer

Step 1

Look through the end of the tube that sticks out from the card. You can look through the tube or sight along the top of the tube. It's your choice.

Step 2

Look at something that's at eye level. Ask a friend to read the angle where the string crosses the protractor. If your inclinometer is level, the string should cross the protractor at about 0 degrees.

Step 3

Look through the tube at the top of something tall. Ask your friend to read the angle where the string crosses the protractor. When you look at something above your head, the inclinometer tilts. The string crossing the protractor marks the angle of the tilt of the inclinometer. Take a few steps toward the tall thing and check the angle on your inclinometer again. What happens to the angle on your inclinometer?

Step 4

Rather than having your friend read the angle for you, look through the tube and pinch the string against the card to hold it in place. Then take the tube away from your eye and read the angle on the protractor. Have your friend watch you do this and tell you if you move the string and change the angle. Try this a few times, until you can do it without changing the angle.

Step 6

Look at the top of the object through your inclinometer and determine what angle your inclinometer measures. Write down this angle.

Step 7

Take the distance measurements and use the proper angles in the formulas given earlier.

Fun Day With Physics
Activities for Elementary School Kids
(below 48" height, 85 lbs weight)

Merry-Go-Round

The Merry-Go-Round is a great place to get the kids started in learning the principles of Physics. Two of Physics' "Big Ideas" can be demonstrated on this ride.



Force

Everyone has experienced centrifugal force. That is the force that throws you out as you go into a turn. The kids can discover that that force depends upon the radius of the turn. A smaller radius will produce a lower force while a greater radius produces a greater force. A horizontal accelerometer can be used for this activity.

Up and Down Acceleration

The up-down motion of the merry-go-round can be measured by using a very sensitive vertical accelerometer. Follow the instructions in this booklet and use a thin rubber band. The forces here will be very small, but they can still be read with the proper equipment.

Other Rides

Other rider are available for smaller children. Most amusement parks offer whole areas for the elementary school Physics student. These two big ideas can be adapted to the other rides as well. Look around, Physics is everywhere. Challenge your students to find it!

Making Your Horizontal Accelerometer

The construction of the horizontal accelerometer is similar to the inclinometer. Instructions for building both are included in this guide.

What Do I Need?

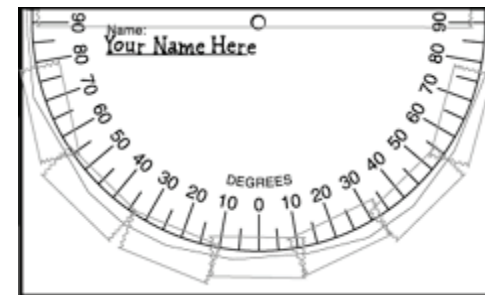
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- Scissors
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Step 3

Use the hole punch to punch a hole through the circle on the protractor.

Equipment Needed: Inclinator, stopwatch, accelerometer, and measuring tape



1. Estimate the length of the Silver Bullet train.

L = _____ m

2. What is the minimum power of the motor which lifts the Silver Bullet and riders to the top of the first incline? (Assume the Silver Bullet has a mass of 10,000 kg and each rider averages 73.0 kg.)

Power, min. _____ HP

3. Calculate the increase in speed resulting from the initial drop 33.2 m (109 ft.).

Speed Increase _____ m/s

4. Estimate the angular velocity, ω , of the Silver Bullet as it travels through the lower elevated spiral.

Angular Velocity _____ rad/sec

5. Estimate the radius of the lower elevated spiral and calculate anticipated centripetal acceleration.

Radius _____ m

Centripetal Acceleration, a_c _____ m/s^2

Bumper Cars

Bumper cars can give the beginning Physics students some lessons on Newton's Laws of Motion and some principles of momentum and impact. Make sure that the student is old enough to be safely in control of the bumper car. Some times this activity works better when two riders are in the car. One can be the driver while the other is the observer/scientist.



Wheeler Dealer Bumper Cars

1. Which of Newton's Laws is best used to describe what happens most between the bumper cars?

2. Where do the cars get their power?

3. What is the purpose of the rubber bumpers on the cars?

4. Observe a collision and describe it using conservation of momentum concepts

Thrill Day With Physics
 Activities for Middle School Kids
 (above 48" height, 85 lbs weight)

Middle school kids can be more adventuresome at the amusement park. Pay heed to the height and weight requirements posted by most amusement parks. Sometimes children of middle school age will be too short to partake of all activities. This can lead to disappointment. Honesty is always the best policy. Tell them of these limits and have activities in which they can participate.

Be sure to investigate the water rides for these kids. Water rides generally have lower forces, and because of this have fewer restraint requirements.

Big Ideas in Middle School Physics

Middle school Physics can introduce the student to many concepts and ideas. Acceleration and forces experienced during rides are places to start exploring. Students can be introduced to periodic motions, velocities and rotation.

Sample Activities

Have the students undertake across-the-curriculum activities. Before the trip have them look up the history of amusement parks. Have them look up the history of the Ferris wheel. (It was invented to upstage the Eiffel Tower in Paris!).

Include some math into your activities. Some simple calculations can be done in finding the velocities of the various rides. Simple geometry exercises can give the curious student the tools he/she needs to calculate the height of the many rides.

Be prepared for the many questions that will follow a trip to the amusement park!

Equipment Needed: Inclinator, stopwatch, accelerometer, measuring tape, Acceleration sensor



1. Estimate the height of the cover on the top of the first lift.

$q_1 =$ $q_2 =$ $b =$

$h =$ _____ m

2. Estimate the speed in m/s of the outbound coaster as it crosses over Grand Avenue (the street outside of the main gates).

Distance used =

Time =

$v_{avg} =$ _____ m/s

3. Determine your acceleration as you go down the first hill and explain how you found it.

*Questions 1 & 2 are to be completed in the parking area of the park **BEFORE** you enter or **AFTER** you leave.*

Equipment Needed: Inclinometer, stopwatch, accelerometer, and measuring tape

1. Estimate the height (in meters) of the last car when it reaches its highest point on the track.



$$q_1 =$$

$$q_2 =$$

$$b =$$

$$h = \text{_____} \text{ m}$$

2. Calculate the average speed of the last car on the train during the first descent.

distance used =

time used =

$$v_{\text{avg}} = \text{_____} \text{ m/sec}$$

3. Knott's Berry Farm gives the maximum speed obtained by the train as 22.4m/s. Assuming all the train's potential energy is transferred to kinetic energy, what is its theoretical maximum speed

$$v_{\text{theoretical}} = \text{_____} \text{ m/sec}$$

4. Measure the acceleration as you go through the bottom of the loop.

$$a = \text{_____} \text{ m/sec}^2$$

Equipment Needed: Inclinometer, stopwatch, accelerometer, measuring tape



1. Measure the angle of the drop path and the drop time.

$$q = \text{_____}$$

2. Estimate the height of the drop. (Explain how you did this.)

$$h = \text{_____} \text{ m}$$

3. Determine the theoretical acceleration along the drop path if there was no water and no friction.

$$a = \text{_____} \text{ m/sec}^2$$

4. Measure the acceleration on the drop path using an accelerometer.

$$a = \text{_____} \text{ m/sec}^2$$

5. Compare the measured and the theoretical acceleration.

Equipment Needed: Inclinometer, stopwatch, accelerometer, and measuring tape

DRAGON SWING

1. Using an accelerometer, measure the centripetal acceleration experienced at the bottom of the arc of the Dragon Swing.

$$a = \text{_____} \text{ m/sec}^2$$

2. Estimate the length of the pendulum "arm" or "radius of the rotation of the ship" (in meters). Explain how you did this.

$$L = \text{_____} \text{ m}$$

3. Assuming mechanical energy is conserved, calculate the speed of the ship at the bottom of the swing.

$$v = \text{_____} \text{ m/sec}$$

4. Using the centripetal acceleration (using v and r) calculate the theoretical acceleration at the bottom of the swing.

$$a = \text{_____} \text{ m/sec}^2$$

5. Compare the measured acceleration from question #1 and the theoretical acceleration

Extreme Day With Physics Activities for High School Kids

High school kids can have the best Physics experience at the amusement park. Why? Because they have the full run of the park and they have the Physics skills to perform most activities.

Big Ideas in High School Physics

The biggest idea in high school Physics is that we live in a 3-D world. Every force felt, every velocity experienced is the vector sum of our 3-dimensional world. Students should understand that while actions in some directions might be ignored, to simplify calculations, they nevertheless exist. Impulse and momentum are other big ideas to observe. Both are velocity dependent. The transformation of energy, from Kinetic to Potential and back again are clearly demonstrated at the amusement park. The concepts of Work and Power can also be explored. Power is time dependent while work is not, often times the kids have a difficult time making this distinction.

Measuring 3-axis acceleration.

This is one measurement that creates excitement. Acceleration always results in a force. An active ride can pull and tug the rider in different directions at the same time. The best way to get this information is by prior planning. The activity must be given in advance and the responsibilities must be clearly defined. One team member will have the assignment to the readings at pre-designated locations. All readings must be made at this exact point. Later the results may be summed vectorally. The resultant is the force felt by the rider.