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Topic: Units and Measurement
Week 1, Day 1

Objective: SWBAT
- Compare and contrast the metric and English systems of measurement
- Identify the SI units
- Convert from one unit of measurement to another

Standards:
S4a
S5a

Materials:
- "Power of Ten" Video
- Reading assignment *"Metric mishap caused loss of NASA orbiter"*(attached)
- Calculator
- Overhead transparency or poster
- Metric ruler,
- VCR, TV Video "Power of Ten"
- "Powers of Ten" worksheet
- Metric worksheet.(attached)

Motivation:
Have students read the article, "Metric mishap caused loss of NASA orbiter". Discuss how this article shows the importance of units.

Aim:

"How do we use the metric system and scientific notation in physics?"

Activities:
1. Place SI units on the board.
2. Show "Power of Ten" video.
3. As students watch the video, have them complete the "Powers of Ten" sheet.

Summary:
Have students answer the following questions;
1. Convert: 40 mm into m
2. Convert: 25 cm into m
3. Convert 250 g into kg
4. What is the height of Mr. Langan to the nearest m?
5. What is the length of a high school physics classroom? 0.01 m 0.1 m 10 m 100 m
6. What is the thickness of a dollar bill? 0.0001 m 0.01 m 0.1 m 10 m
7. Which measurement of an average classroom door is closest to 1 m? thickness width height

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Assessment:
Complete homework assignment sheet.

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Metric mishap caused loss of NASA orbiter

September 30, 1999

Web posted at: 4:21 p.m. EDT (2021 GMT)

In this story: Metric system used by NASA for many years Error points to nation's conversion lag By Robin Lloyd CNN Interactive Senior Writer (CNN) –

NASA lost a $125 million Mars orbiter because a Lockheed Martin engineering team used English units of measurement while the agency's team used the more conventional metric system for a key spacecraft operation, according to a review finding released Thursday. The units mismatch prevented navigation information from transferring between the Mars Climate Orbiter spacecraft team in at Lockheed Martin in Denver and the flight team at NASA's Jet Propulsion Laboratory in Pasadena, California. Lockheed Martin helped build, develop and operate the spacecraft for NASA. Its engineers provided navigation commands for Climate Orbiter's thrusters in English units although NASA has been using the metric system predominantly since at least 1990. No one is pointing fingers at Lockheed Martin, said Tom Gavin, the JPL administrator to whom all project managers report. "This is an end-to-end process problem," he said. "A single error like this should not have caused the loss of Climate Orbiter. Something went wrong in our system processes in checks and balances that we have that should have caught this and fixed it." The finding came from an internal review panel at JPL that reported the cause to Gavin on Wednesday. The group included about 10 navigation specialists, many of whom recently retired from JPL. "They have been looking at this since Friday morning following the loss," Gavin said. The navigation mishap killed the mission on a day when engineers had expected to celebrate the craft's entry into Mars' orbit. After a 286-day journey, the probe fired its engine on September 23 to push itself into orbit. The engine fired but the spacecraft came within 60 km (36 miles) of the planet -- about 100 km closer than planned and about 25 km (15 miles) beneath the level at which the it could function properly, mission members said. The latest findings show that the could function properly, mission members said. The latest findings show that the spacecraft's propulsion system overheated and was disabled as Climate Orbiter dipped deeply into the atmosphere, JPL spokesman Frank O'Donnell said. That probably stopped the engine from completing its burn, so Climate Orbiter likely plowed through the atmosphere, continued out beyond Mars and now could be orbiting the sun, he said. Climate Orbiter was to relay data from an upcoming partner mission called Mars Polar Lander, scheduled to set down on Mars in December. Now mission planners are working out how to relay its data via its own radio and another orbiter now circling the red planet. Climate Orbiter and Polar Lander were designed to help scientists understand Mars' water history and the potential for life in the planet's past. There is strong evidence that Mars was once awash with water, but scientists have no clear answers to where the water went and what drove it away. NASA has convened two panels to look into what led to the loss of the orbiter, including the internal peer review panel that released the Thursday finding. NASA also plans to form a third board -- an independent review panel -- to look into the accident. Metric system used by NASA for many years A NASA document came out several years ago, when the Cassini mission to Saturn was under development, establishing the metric system for all units of measurement, Gavin said. The metric system is used for the Polar Lander mission, as well as upcoming missions to Mars, he said. That review panel's findings now are being studied by a second group -- a special review board headed up by John Casani, which will search for the processes that failed to find the metric to English mismatch. Casani retired from JPL two months ago from the position of chief engineer for the Lab. "We're going to look at how was the data transferred," Gavin said. "How did it originally get into system in English units? How was it transferred? When we were doing navigation and Doppler (distance and speed) checks, how come we didn't find it?" "People make errors," Gavin said. "The problem here was not the error. It was the failure of us to look at it end-to-end and find it. It's unfair to rely on any one person." Lockheed Martin, which failed to immediately return a telephone call for comment, is building orbiters and landers for future Mars missions, including one set to launch in 2001 and a mission that will return some Mars rocks to Earth a few years down the line. It also has helped with the Polar Lander mission, set to land on Mars on December 3 and conduct a 90-day mission studying martian weather. It also is designed to extend a robotic arm that will dig into the nearby martian soil and search for signs of water. NASA managers have said the Polar Lander mission will go on as planned and return answers to the same scientific questions originally planned -- even though the lander will have to relay its data to Earth without help from Climate Orbiter. Error points to nation's conversion lag Lorelle Young, president of the U.S. Metric Association, said the loss of Climate Orbiter brings up the "untenable" position of the United States in relation to most other countries, which rely on the metric system for measurement. She was not surprised at the error that arose. "In this day and age when the metric system is the measurement language of all sophisticated science, two measurements systems should not be used," Young said. "Only the metric system should be used because that is the system science uses," she said. She put blame at the feet of Congress that she said has squeezed NASA's budget to the point that it has no funds to completely convert its operations to metric. "This should be a loud wake-up call to Congress that being first in technology requires funding," she said, "and it's a very important area for the country."

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Metric Conversion Sheet

Table 1. SI base units

SI base units		
Base quantity	Name	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

Scientific Notation Worksheet:

1. Describe the power's of ten

$10^0 = 1$
$10^1 = 10$
$10^2 = 100$
$10^3 = 1,000$
$10^4 = 10,000$
$10^5 = 100,000$
$10^6 = 1,000,000$

$10^{-1} = 0.1$
$10^{-2} = 0.01$
$10^{-3} = 0.001$
$10^{-4} = 0.0001$
$10^{-5} = 0.00001$
$10^{-6} = 0.000001$

2. A power of ten notation with one digit before the decimal.

a) 5000 =
c) 10 =
e) 0.00256 =

b) 0.005 =
d) 3,500,000 =
f) 375 =

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Homework Sheet

Homework: Answer all of the following on this sheet.
Convert into scientific notation:
a) 4000 =
b) 5600 =
c) 0.0065 =
d) 8500 =
e) 0.002 =

Multiply
f) $(8.0 \times 10^5)\ (2.0 \times 10^2) =$
g) $300 \times (6.0 \times 10^3) =$
h) $(2.0 \times 10^{-8})\ (6 \times 10^{-20}) =$
i) $300 \times 60 =$
j) $8000 \times 0.012 =$

Miscellaneous
$A = 6.7 \times 10^{-11}$ $B = 6.6 \times 10^{-34}$ $C = 1.67 \times 10^{-27}$ $D = 3 \times 10^{8}$

k) A x B =

l) C x D =

m) A/B =

n) C/D =

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Physics
Topic: Graphing Motion
Week 1, Day 2

Objective: SWBAT
- Draw a graph
- Determine the relationship of the graph
- Draw a best fitting straight line
- Find the slope of the line

Standards:
S5a
S6a
S7a

Materials:
- Incline plane
- tennis ball
- stopwatch
- meter stick
- graph paper
- handout sheet on graphing motion (attached)

Motivation:
Challenge students to describe how different motions would look in graphical form

Aim:

How do we use graphs to analyze motion in physics?

Activities:
1. Relationships: Draw on the board a graph showing a direct relationship, an inverse relationship, and an inverse square relationship.
2. Perform the demonstration: Allow a car to move at a constant speed. A student records the time of travel over equal distances.
3. Have students create a graph of distance vs. time.
4. Have students complete the handout sheet on graphing.

Summary:
Have students share their graphs with others to see similarities and differences.

Assessment:
Assign data for students to create a graph.

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Graphing Motion Handout Sheet

1) Graph distance vs. time for tennis ball on the incline plane.

S (m)	T (s)
0	
.5	
1.5	
2.0	

2) Draw a graph of s vs. t
3) Find the tangent to each of the points:

V	t

4) Graph v vs. t
5) Draw the best fitting straight line:
6) Find the slope of the graph.
7) Draw a new graph:

Data:

Time (s)	speed m/s
0.033	0.9
0.067	1.2
0.100	1.6
0.130	2.0
0.160	2.1
0.200	2.6
0.230	3.0
0.260	3.2
0.300	3.3
0.330	3.8

8) Graph v vs. t
9) Draw the best fitting straight line:
10) Find the slope of the graph.

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Physics
Topic: Speed and Acceleration
Week 1, Day 3

Objective: SWBAT
- Define speed
- Define instantaneous speed
- Define average speed
- Determine the average speed of an object
- Use the relationship $v = \Delta s/\Delta t$
- Find the distance and the time
- Use the relationship $v = v_f + v_i / 2$

Standards:
S1d
S6b
S6c

Materials:
- overhead projector
- space scene

Motivation:
Ask students to describe how fast they are moving right now. After they answer, "not at all", place the space scene on the overhead and remind them that they are currently on the Earth moving at a great velocity around the Sun.

Aim:

How do we determine the speed and acceleration of an object?

Activities:
1. In collaborative groups of no more than 4 students, have students determine the following;
   a) Determine the speed of an Olympic 100 m dash.
   Given: $s = 100$ m $t = 9.1$ s
   Use the equation $v = \Delta s/\Delta t$

   b) A baseball pitcher throws a baseball at 42 meters per second. If the batter is 18 meters from the pitcher, approximately how much time does it take the ball to reach the batter?

   c) A car travels between the 100 meter and 250 meter highway markers in 10 seconds. What is the average speed of the car?

   d) A ball is thrown by a pitcher that is 20 m (60 ft.) from a batter. If the ball arrives at the plate in 0.5 s. What is the average speed of the ball?

2. In the same collaborative groups, have the students determine the acceleration of each car using the formula, $a = \Delta v \ / \ \Delta t$. The time shows how long it takes the car to go from 0 to 27 m/s (60 mph)

Mazda Miata	8.0 s
VW Beetle	10.0s
Isuzu Amigo	8.1 s
Mercury Cougar	7.9 s

3. A plane must attain a speed of 175 mph (90 m/s). On a recent trip the plane took 30 s to reach take off speed. What is the acceleration of the plane?

Summary:
Have students place answers and mathematical work on the board and discuss the answers with the class.

Assessment:
Students should answer Regents style questions on this subject matter.

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Physics
Topic: Acceleration Due to Gravity
Week 1, Day 4

Objective: SWBAT
- Predict the vertical distance that an object moves over a period of time
- Describe the force of gravity (g)
- Solve computational problems on acceleration due to gravity

Standards:
S1d
S5f
S6c

Materials:
- Paper
- Chalk

Motivation:
On a trip to the Empire State Building the tour guide sometimes mentions that the building is so high 1100 feet = 400 m that a penny if dropped from the building would sink two inches into the pavement. How fast would an object travel if dropped from the top of the Empire State Building?

Aim:

What are the characteristics of the motion of an object undergoing free fall?

Activities:
1. Hold a piece of paper and a piece of chalk. Which one will hit the top of the desk first? Drop the paper and chalk. Fold up the paper and drop it and the chalk.

2. Describe Galileo's thought experiment.
   In a vacuum all objects fall with the same uniform acceleration.

Time (s)	Speed (m/s)
0	0
1	9.8 m/s
2	19.6 m/s
3	29.4 m/s

3. Show graphs of s vs. t, v vs. t and a vs. t for free fall.
4. How could we determine the acceleration of gravity g?
   Pendulum, Free Fall experiment – slope of the graph of v vs. t
5. All experiments agree that the force of gravity (g) is'g' = 9.8 m/s^2
6. Have students work individually or in groups to solve the following problems;

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Problems:

1. A coin drops from the top of the ESB. How fast will it be traveling at the instant before it hits the ground?
   $v_f^2 = v_i^2 + 2\,a\,\Delta s$

2. What is the average speed of the coin?
   $$v = \frac{V_f + V_i}{2}$$

3. A person drops a stone from the top of a cliff. If the stone hits the ground in 5 seconds.
   a) How high is the cliff?

   $\Delta s = v_i\,\Delta t + \frac{1}{2}\,a\,(\Delta t)^2$

   b) What speed will it have at the instant before it hits the ground?

   $v_f^2 = v_i^2 + 2\,a\,\Delta s$

   c) What is the average speed of the stone?

   $$v = \frac{V_f + V_i}{2}$$

Summary:
Have students place their work on the board and discuss the answers with the class.

Assessment:
Students should answer Regents style questions on this subject matter.

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Physics
Topic: Newton's Laws of Motion (1st Law)
Week 1, Day 5

Objective: SWBAT
- Describe Newton's laws of motion.
- Apply Newtonian motion to real world applications.
- Solve computational problems involving Newtonian motion.

Standards:
S1d
S6c

Materials:
- 1 kg mass
- paper

Motivation:
Pull a piece of paper from under a weight.
Demonstrate a car pulling an object.

Aim:

"How did Isaac Newton explain motion?

Activities:

1. Whole group instruction on the work of Sir Isaac Newton.
   a) Isaac Newton (born Christmas Day 1642) put forth a variety of laws which explain why objects move (or don't move) as they do. These three laws have become known as Newton's three laws of motion.
   b) Newton's first law of motion is often stated as: An object at rest will stay at rest and an object in motion will stay in motion with the same speed and in the same direction in a straight line unless acted upon by an unbalanced force.
   The state of motion of an object is maintained as long as the object is not acted upon by an unbalanced force. All objects resist changes in their state of motion – they tend to "keep on doing what they're doing."
2. Have students complete the following scenarios and use these answers to further class discussion.

Question: Have you ever experienced inertia (resisting changes in your state of motion) in an automobile while it is braking to a stop?

Question: What would occur when no seat belt is used when a car is braking?

Draw an illustration of a bus rounding a curve. What will happen to the passengers in the bus?

A plane hits an air pocket. What will happen to the passengers in the plane?

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Summary:

Have students discuss their answers to the real world scenarios. Have students compare and contrast their answers to other students in the class.

Assessment:

Have students describe three real world applications of Newton's 1^{st} law of motion.

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Physics

Topic: Newton's Laws of Motion (2nd and 3rd Law)

Week 2, Day 1

Objective: SWBAT
- Describe Newton's 2nd and 3rd law.
- Use the laws of motion to solve real world problems.
- Compare and contrast the 2nd and 3rd law of motion.

Standards:
S1d
S6c

Materials:
- Apollo 13 video (5 minute blast off sequence)
- Reading on Newton's 3rd Law of motion (attached)

Motivation:
Demonstrate a cart pulling an object.

Aim:

How does force affect the motion of an object?

Activities:
1. Show the 5 minute video section from Apollo 13 and discuss how this relates to Newton's laws of motion.
2. Have students read the excerpt about Newton's laws of motion.
3. Have students answer questions at end of reading. Use these questions to foster class discussion on the topic.

Summary:
Summarize Newton's laws of motions in three simple phrases.

Assessment:
Students should answer Regents type questions on the subject matter.

Newtonian motion

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According to Newton, whenever objects A and B interact with each other, they exert forces upon each other. When you sit in your chair, your body exerts a downward force on the chair and the chair exerts an upward force on your body.

There are two forces resulting from this interaction – a force on the chair and a force on your body. These two forces are called action and reaction forces and are the subject of Newton's third law of motion. "The statement means that in every interaction, there is a pair of forces acting on the two interacting objects. The size of the forces on the first object equals the size of the force on the second object. The direction of the force on the first object is opposite to the direction of the force on the second object.

Forces always come in pairs - equal and opposite action-reaction force pairs. A variety of action-reaction force pairs are evident in nature. Consider the propulsion of a fish through the water. A fish uses its fins to push water backwards. But a push on the water will only serve to accelerate the water. In turn, the water reacts by pushing the fish forwards, propelling the fish through the water. The size of the force on the water equals the size of the force on the fish; the direction of the force on the water (backwards) is opposite the direction of the force on the fish (forwards). For every action, there is an equal (in size) and opposite (in direction) reaction force. Action-reaction force pairs make it possible for fish to swim. Consider the flying motion of birds. A bird flies by use of its wings. The wings of a bird push air down wards. In turn, the air reacts by pushing the bird upwards. The size of the force on the air equals the size of the force on the bird; the direction of the force on the air(downwards) is opposite the direction of the force on the bird (upwards). For every action, there is an equal(in size) and opposite (in direction) reaction. Action-reaction force pairs make it possible for birds to fly. Consider the motion of your automobile to school. An automobile is equipped with wheels which spin backwards. As the wheels the wheels forward. The size of the force on the road equals the size of the force on the wheels (or automobile); the direction of the force on the road (downwards) is opposite the direction of the force on the wheels (upwards). For every action, there is an equal (in size) and opposite (in direction) reaction. Action-reaction force pairs make it possible for automobiles to move.

Check Your Understanding

1. While driving down the road, Anna observed a bug striking the windshield of her car. Quite obviously, a case of Newton's third law of motion. The bug hit the windshield and the windshield hit the bug. Which of the two forces is greater: the force on the bug or the force on the windshield?

2. Rockets are unable to accelerate in space because ...
   a. there is no air in space for the rockets to push off
   b. there is no gravity is in space.
   c. There is no air resistance in space.
   d. ....nonsense! Rockets do accelerate in space.

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Topic: Gravitational and Inertial Mass
Week 2, Day 2

Objective: SWBAT
- Describe the law of universal gravitation.
- Define inertia
- Calculate the gravitational attraction between two objects.

Standards:
S1d
S6c
S4a

Materials:
- mass
- ring stand
- strings,
- kg scale
- overhead projector
- copy of Cavendish experiment sheet

Motivation:
Pull a string from under a 1 kg mass. Which string will break first?

Aim:

How are the mass and distance of two objects related to the gravitational attraction between them?

Activities:

1. Use the demonstration in the motivation to start a class discussion on inertia, weight and mass.
   Which string will break first the top or the bottom string?
   Pull the bottom string quickly.
   What prevented the top string from breaking? The mass prevented the top string from breaking.

2. Use the whole group discussion method t o introduce the following topics.
   The mass prevented the top string from breaking.
   What property does the mass have that it is able to resist the force of the bottom string?
   Define Inertia – The property of a mass that it resists changes in its state of rest or motion.
   Inertia = Mass
   Newton's First Law also called the Law of Inertia
   How can we increase the inertia of an object?
   Describe the difference between mass and weight. Explain the relationship

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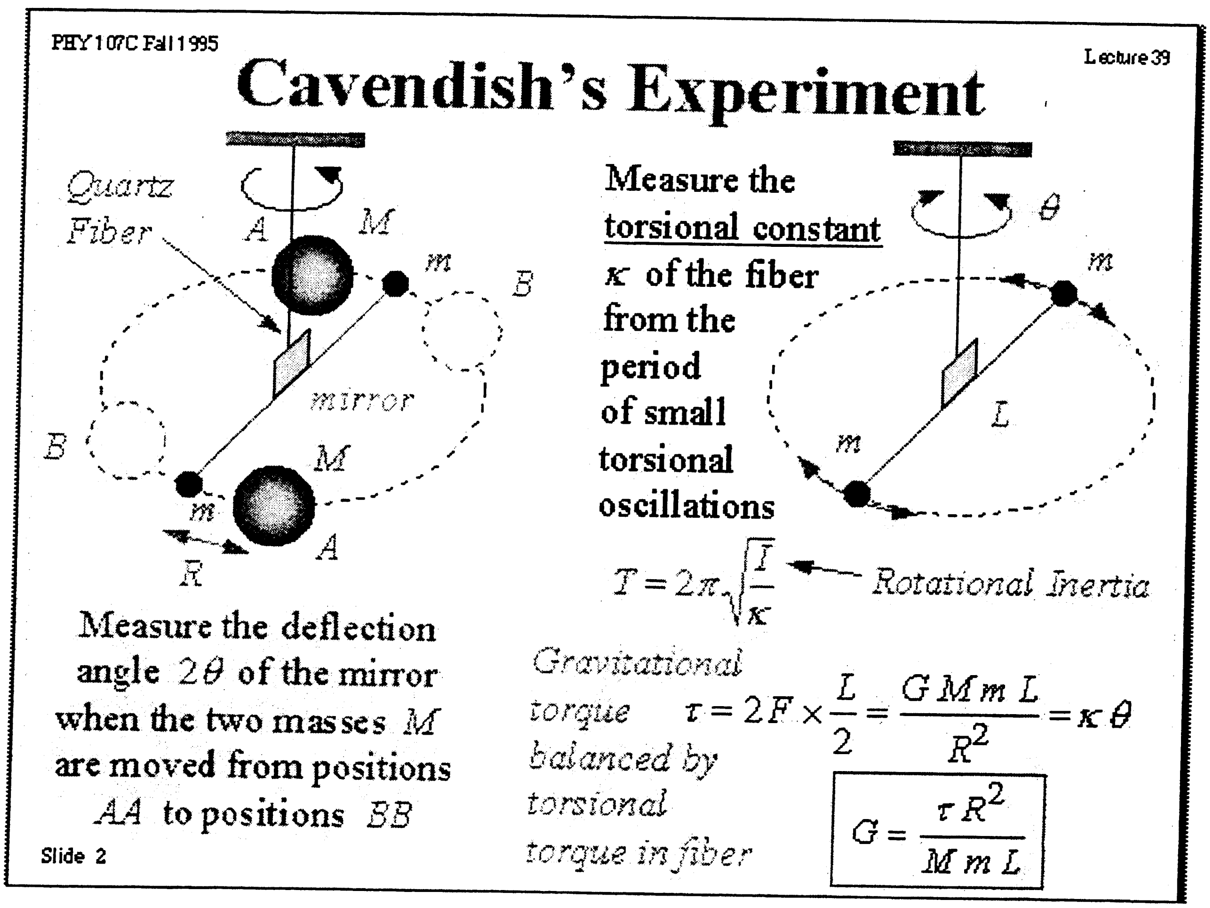
F = m a
w = m g
What is the weight of an average person?
An average sized person is 70 kg or about 150 lbs.
What is the weight of this person on the earth?
W = m g

3. Have students connect to http:// and determine their weight on other planets.
4. Use the Image of Cavendish's experiment to describe how the gravitational constant was discovered

Summary:
Compare and contrast student weights on other worlds.
Assessment:
Students should answer Regents style questions on this subject matter.

Cavendish Experiment



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Topic: Friction, Drag and Net Force
Week 2, Day 3

Objective: SWBAT
- Compare and contrast the frictional force on different objects.
- Measure the frictional force.
- Compare and contrast static and rolling friction

Standards:
S1d
S6c
S4a

Materials:
- Weight
- Newton scale
- Cart
- Smart pulley

Motivation:
Does your weight change in an elevator? Ask students to think about how weight changes in an elevator.

Aim:

How does friction affect the motion of an object?

Activities:
1. Attach a 1 kg cart to a spring balance and pull horizontally on the cart so that it moves at a slow, steady pace.
2. What is the value on the balance? Are the forces balanced or unbalanced?
3. Write a report that explains the results of the lab experiment.

Summary:
Create a chart on the board of results from the experiment and come to conclusions on the questions asked in the activity section.

Assessment:
Have students answer the following questions

1) What is the mass of a 60 kg person on the surface of Mars where the acceleration of gravity is about 1/3 of the earth's gravity. What is this person's weight on Mars?

2) What is the weight of this person on the earth?

3) A 9.8 N object sits on a table. What is the minimum force needed to lift the bag?

4) If a 15 N force is exerted on the bag, what will be its acceleration?

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Physics
Topic: Vectors
Week 2, Day 4

Objective: SWBAT
- Compare and contrast scalar and vector quantities.
- Draw vectors.
- Define and draw resultant vectors.
- Use a protractor to measure angles of vectors.

Standards:
S1d
S6a
S7a

Materials:
- two newton scales
- weight
- string

Motivation:
Hang weight from both scales at different angles to determine the amount of weight on each scale.

Aim:

How do we use vectors to represent magnitude and direction?

Activities:
1. Introduce the concept of vectors to students. Some important concepts are below.
   Definition of a vector: a quantitiy having both a magnitude and a direction
   Definition of a scalar: a quantity having only a magnitude
   Examples of vectors:
   Weight, force, velocity, acceleration, momentum
   Examples of scalars:
   Mass, energy, kinetic energy, work, potential energy, speed, time,
   Draw a vector:
   Draw a vector showing a plane moving at 400 m/s in the direction N.
   Steps:
      Direction
      Scale
      Draw vector to scale
   Draw a diagram showing a vector of 400 m/s W.
   How would a wind affect the plane?
   A tail wind of 100 m/s to the W is blowing. What is the velocity of the plane?
   A headwind of 100 m/s to the E is blowing. What is the velocity of the plane?
   A crosswind of 100 m/s N blows the plane. What is the magnitude and direction of the resultant vector?

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Define resultant.
How do we find the sum of two vectors?
What is the magnitude of the object pulling on the two scales?

Summary:
Place a known weight at he end of two strings at different angles. Have a student measure the angles and have the students predict the weight that should be showing on the two scales.

Assessment:
Students should answer Regents style questions on this topic.

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Physics
Topic: Resolution of Forces
Week 2, Day 5

Objective: SWBAT
- measure the resultant force
- resolve vectors into their components
- resolve vectors using mathematical and graphical analysis

Standards:
S1d
S6a
S7c
S5(a-f)
S7a

Materials:
- Boom apparatus
- Ruler
- Assorted masses
- Scale.
- Resolution of forces activity(attached)
- Protractor

Motivation:
A boom operator needs to know how much weight he can place on his crane if the tension in the cable is a maximum of 1000 N. The angle that the boom makes with the cable is 45 degrees.

Aim:

How do resolve a vector into components?

Activities:
1. Use resolution of forces activity to allow students practice in creating vectors and resolving them into components.

Summary:
Complete analysis questions in class.

Assessment:
Students should answer Regents type questions on this material.

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Title: Resolution of Forces

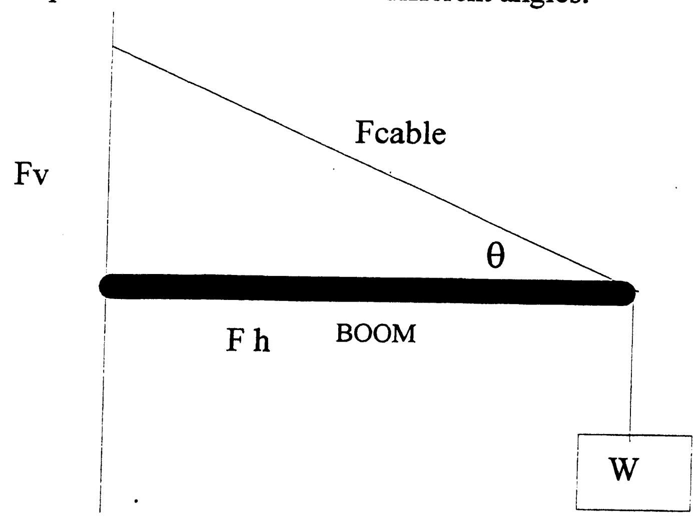
Problem: How can we determine the horizontal and the vertical components of a force?
In this experiment we will determine the horizontal and the vertical components of the forces acting on a cable. We will predict the horizontal and the vertical components of the force after we have determined the tension and the angle θ that the boom makes with the cable.
Using a spring scale we will measure the horizontal and vertical components of the force of the cable.

Materials: boom apparatus; ruler; assorted masses, scale.

Procedure: Determine the tension of the cable using a spring balance. Place that information in the data table. Measure angle θ using a protractor. Measure the horizontal and vertical components of the force using a spring scale

Analysis:

Predict the vertical and the horizontal components of the force on the cable. Use the equations $F_v = F_{cable} \sin\theta$ and $F_h = F_{cable} \cos\theta$.
Repeat this exercise for four different angles.



Data Table

The weight is the measured F vertical
Measured values of the forces on the cart.

Angle	Measured Cable Tension	Measured $F_{horizontal}$	Calculated $F_{horizontal}$	Measured $F_{vertical}$	Calculated $F_{vertical}$

Analysis:

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1. Complete the data table.
2. Show all of the calculations used to predict the vertical and horizontal components of the force on the diagram.
3. Draw a vector diagram to scale showing the forces acting on the boom apparatus.
4. Does your measured values of the F horizontal and F vertical agree with the calculated values.
5. Determine the percent error between the measured $F_{vertical}$ and the calculated $F_{vertical}$. Use the measured $F_{vertical}$ as the standard value in your calculations.

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Topic: Inclined Plane
Week 3, Day 1

Objective: SWBAT
- State the requirements for equilibrium
- Define equilibrium
- Compare and contrast resultant and equillibriant
- Use trigonometry to solve real world problems.

Standards:
S1d
S6a
S5(a-f)
S7a

Materials:
- Cart
- Ruler
- Assorted masses
- Inclined plane
- Scale
- Inclined Plane Activity Sheet

Motivation:
Have two students pull on opposite sides of the rope so that neither student moves. Relate this demonstration to the concept of equilibrium.

Aim:

How do we determine the vertical and horizontal components of an object on an inclined plane?

Activities:
1. Have students complete the inclined plane activity provided with this lesson plan.

Summary:
Use the questions provided on the activity for a class discussion on the topic.

Assessment:
Practice Problems:
1. An explorer walks 13 km due east, then 18 km north, and finally 3 km west. What is his displacement?
2. A motorboat heads due east at 16 m/s across a river that flows due north at 9.0 m/s. What is the resultant velocity?
3. While flying due east at 120 km/h, an airplane is also carried northward at 45 km/h by the wind blowing due north. What is the resultant velocity?
4. A heavy box is pulled across a wooden floor with a rope. The rope makes an angle of 60 degrees with the floor. A force of 75 N is exerted on the rope. What are the horizontal and

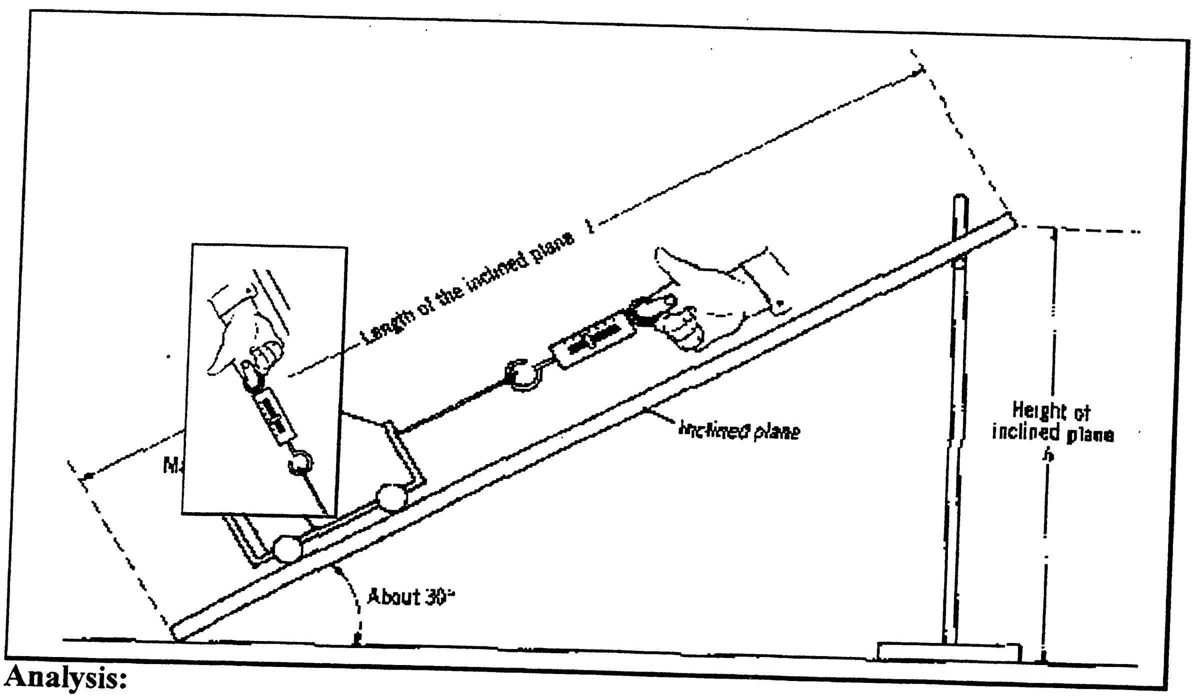
vertical components of the force?

Title: Resolution of Forces - The Inclined Plane

Problem: How can we determine the parallel and the perpendicular components of a force on an inclined plane?
In this experiment we will determine the parallel and the perpendicular components of the forces acting on a cart on an inclined plane. We will predict the parallel and the perpendicular components of the force after we have determined the weight and the angle θ of the incline.
Using a spring scale we will measure the parallel and perpendicular components of the force on the cart.

Materials: Cart; ruler; assorted masses, inclined plane, scale.

Procedure: Determine the weight of the cart using a spring balance. Place that information in the data table. Set up the inclined plane as shown in Fig. 1. Measure angle θ using a protractor. Measure the parallel and perpendicular components of the force on the cart using a spring scale as shown in Fig. 1 Do this by using the spring scale to measure F_{up} and F_{down}. The average value of F_{up} and F_{down} is the parallel component of the force. Place a string on the cart to hold it on the inclined plane, and then lift the cart to determine the perpendicular component of the force on the inclined plane.



Analysis:
Predict the perpendicular and the parallel components of the force on the cart. Use the equations $F_{\perp} = w \sin \theta$ and the $F_{\parallel} = w \cos \theta$.
Repeat this exercise for three different angles.

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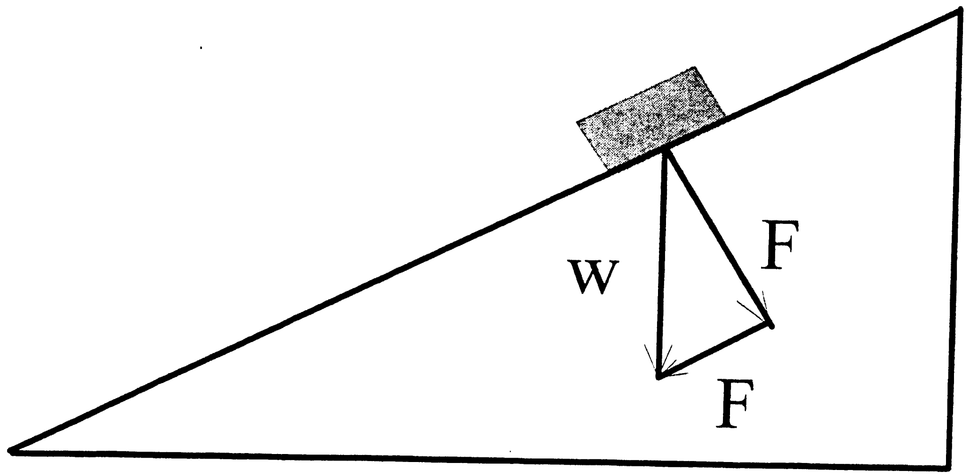

DATA TABLE
Weight = _______ N
Measured values of the forces on the cart.

Angle	F up	Fdown	**F** ⊥	**F**$_{\|\|}$
0				
90				

Analysis:
Predicted value of the perpendicular and parallel components of the force.

Angle	**F** ⊥	**F**$_{\|\|}$
0		
90		

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Conclusion:

6. Complete the data table.
7. Show the calculations used to predict the perpendicular and parallel components of the force on the cart.
8. Draw a diagram showing the forces acting on the cart. $F_{parallel}$, F_N, weight, $F_{\perp}$. Draw this vector diagram to scale using (1 cm = 1 N)
9. The force of friction is $(F_{up} - F_{down})/2$. How does the force of friction affect the results of this experiment.

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Physics

Topic:

Week 3, Day 2

Objective: SWBAT
- Differentiate between horizontal and vertical motion.
- Calculate distance traveled and time in the air.
- Describe the effect of drag on a projectile's motion.

Standards:
S1d
S6a
S4a

Materials:
- Cannon Lab sheet(provided)
- Access to the Internet

Motivation:
Hold one book in your hand at table level and place another book on the edge of the table. Ask students which book will hit the floor first, the one you push of the desk or the one that you drop to the floor?

Aim:

How do we determine the horizontal and vertical velocity of a projectile that is launched horizontally?

Activities:
1. This activity requires Internet access. This activity can be completed in any of the following circumstances;
   - Every student with access to a computer.
   - Computer attached to a television monitor or projector.
   - As an extra credit assignment for students to do at home or in the library.

Summary:
Have students summarize their results in writing.

Assessment:
Students should answer Regents style questions on this subject matter.

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Cannon Lab

Experimental Instructions

http://zebu.uoregon.edu/nsf/cannon.html

(Note: Hit the more button when you run out of ammo!)

Conservation of energy:

1. Set the angle of the cannon to 45 degrees
2. Set the velocity to 30
3. Shoot the cannon and note the distance
4. Double the gravitational acceleration (e.g. move it so it reads -19.6)
5. What must the velocity be set to, in order to cover the same distance as the previous shot. Change the velocity, shoot the cannon until you have determined this. Solution = ________________________
6. Now reset the gravitational acceleration back to -9.8
7. Set the velocity to 40 and the cannon angle to 70
8. Repeat steps 3 thru 6. Solution = ________________________
9. What is the relation between kinetic energy and gravitational acceleration as determined by this experiment?

Angles, Angles, Angles

1. Set gravity to -9.8
2. Set velocity to 50
3. Determine the cannon angle which produces the maximum horizontal distance of the shot
4. What is this angle and why do you think it has this value?

The effects of Drag

1. Set gravity to -9.8
2. Set velocity to 66
3. Shoot the cannon to hit the target.
4. now turn on the atmosphere by clicking the button that says

drag.

5. set the windage to -10 and shoot the cannon and not how far the shot falls from the target

6. set windage to -20,-30,-40 and repeat. Plot (Graph) the distance from target versus wind velocity

The effects of projectile density

1. Keep drag turned on and set wind factor to -20
2. keep velocity at 66; set density to 1.2
3. shoot the cannon and note the distance
4. Decrease the density of the projectile by a factor of 2 (e.g 0.6) and shoot the cannon and note the density .
5. Now decrease density to 0.3 and then 0.15 shooting the cannon at each new value for density
6. Plot the decrease in distance as a function of density
7. Repeat steps 2-6 for windages of -10 and -40

Artillery Tests

In each case you have 4 chances to hit the target

1. Turn off drag if its on
2. set the gavitational acceleration to -15.0
3. hit the target (and record the correct velocity and angle)
4. Turn on drag
5. set windage to -50
6. set density to 0.6
7. Hit the target in 4 tries and record the settings
8. Leave drag on
9. Set gravity to -2
10. set windage to -10
11. set density to 1.2
12. Hit the target in 4 tries and record the settings

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Physics
Topic: Circular Motion
Week 3, Day 3

Objective: SWBAT
- Describe centripetal motion
- Relationship between velocity and revolution
- Explain the relationship between period and frequency

Standards:
S1d
S6c
S4a

Materials:
- Glass tube about 0.15 m long
- Braided nylon line about 1.0 m long
- 2-hole rubber stopper
- 24 iron washers about 0.006 kg each
- Stop watch
- Alligator clip
- Circular motion activity (attached)

Motivation:
Show a video excerpt of the hammer toss competition at the Olympics.

Aim:

How do we determine the centripetal velocity, acceleration and force or an object undergoing circular motion.

Activities:
1. Develop the concept of circular motion with the students. Some important concepts are below

   .Demonstrate how an object that is moving in a circle has a velocity tangent to the circle.
   Describe how the $v_f - v_i = \Delta t$ will have a direction towards the center.
   $V = s/t \quad C = 2\Pi r$
   $V = 2\Pi r/t$
   $a = v/t$
   $a_c = v^2/r$
   Centripetal – means center seeking
   The force takes the same direction as the acceleration.
   $F = ma$
   $F_c = m\,v^2/r$

2. Have students complete the lab activity provided with this lesson.

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Summary:
Go over questions at the end of the activity and use them to spark a class discussion.

Assessment:
Students should answer Regents style questions on this subject matter.

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Title: **Centripetal Force** **Lab#** ____

Problem: What is the relationship between the centripetal force acting on an object moving in a circle of constant radius and the frequency of revolution of the object?
As long as no resultant force acts upon an object in motion it will move in a straight path. To make the object move in a circular path, a force acting toward the center of the circle must be applied to it. This force is called a centripetal force. To keep an object moving in a circle of fixed radius, the centripetal force must change with the velocity of the object. The velocity, in turn, is proportional to the frequency of revolution of the object. In this experiment you are going to study the quantitative relationship between the centripetal force acting on an object and its frequency of revolution.

Materials: Glass tube about 0.15 m long, braided nylon line about 1.0 m long; 2-hole rubber stopper; 24 iron washers about 0.006 kg each; stop watch, alligator clip

Procedure: Securely tie one end of the line to the rubber stopper. Pass the line through the glass tube and attach a bent paper clip to the other end so that iron washers can be slipped on at this end of the string as shown in Fig. 1. Attach an alligator clip to the line to limit the radius of the circular path of the stopper to about 0.50 m. Now add four washers to the line. For each rate of revolution, the radius of the path of the stopper will assume a certain value and the washers will occupy a corresponding vertical position. Whirl the stopper over your head in a horizontal circular path at such a rate that the alligator clip is just pulled up to, but barely touching, the lower end of the glass tube. Adjust the rate of revolution so that the radius of the circular path remains at the constant value permitted by the position of the alligator clip and so that the washers are supported by the motion. The centripetal force furnished by the weight of the washers is now keeping the stopper moving in a selected circle of fixed radius. Have your partner determine how long it takes for the stopper to make 30 revolutions. Find the frequency of the stopper's motion by dividing 30 by the time taken for the 30 revolutions. Practice this technique of measuring the frequency with the radius of the circular path set by the alligator clip at the fixed value.

In this experiment you will keep two factors constant: the mass of the revolving object and the radius of its motion. You will vary the centripetal force applied to the object by adding iron washers to the lower end of the string. Since the washers are similar, the number of washers is proportional to the force they exert and can be used as a measure of the centripetal force. Then you will measure the frequency corresponding to each different centripetal force.

Start with four washers at the bottom of the line and the alligator clip set to allow the stopper to move in a radius of about 0.50 m. Keep the stopper revolving overhead and adjust the rate until the alligator clip is just raised to the bottom of the glass tube and remains motionless there. Measure the time for 30 revolutions and enter it in Table 1.

Now repeat the procedure several times, each time increasing the number of washers used, by 4, until 24 washers are on the line. In each case record the time taken for 30 revolutions.

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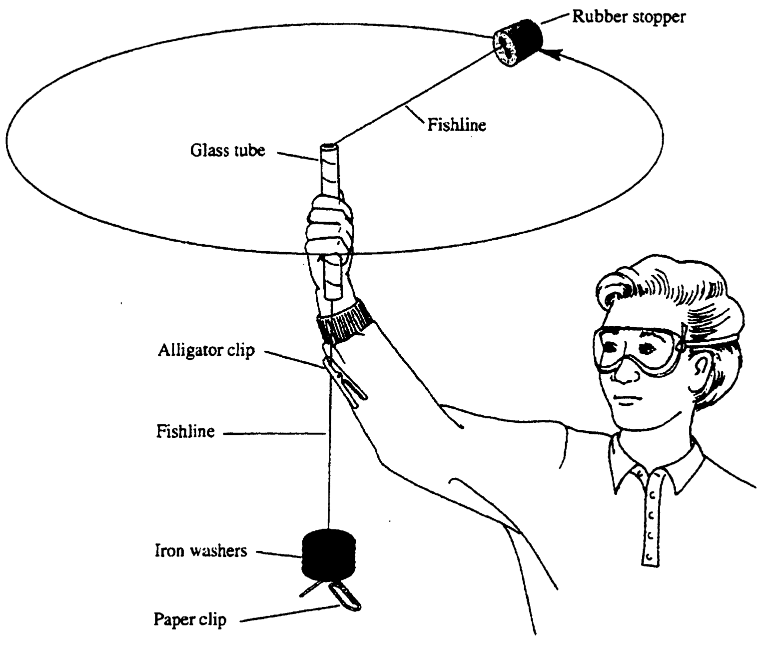

Figure 1

For each trial recorded in Table 1 calculate the frequency of revolution f.

Table 1

Trial 1	Number of Washers	Time for 30 revolutions	Frequency of revolution f (s^{-1})

Calculations:

Calculate the speed of the object for each trial.

1. Determine the Period (the time to make one revolution) from the frequency (number of revolutions per second) using the relationship T = 1/f.
2. Determine the speed from the relationship v = 2Π r /T

Trail	Number of washers	Period of revolution T = 1/f	Speed v = 2Π r /T
1			
2			
3			
4			

Conclusion:

1. Show one sample calculation of the speed.

2. Make a graph of the number of washers vs. v.

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3. Make a graph of the number of washers vs. v^2

4. Does either graph show a direct proportional relationship between the quantities graphed? Explain.

5. What does the experiment indicate to be the relationship between the centripetal force and the speed v?

6. The bob of a pendulum swings through a circular arc of constant radius. At what point of the swing does the cord holding the bob exert the greatest centripetal force on it? Explain.

7. Design an experiment to determine the relationship between f and r when the centripetal force and the mass are held constant.

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Physics
Topic: Kepler's Laws
Week 3, Day 4

Objective: SWBAT
- Calculate periods and velocities of orbiting bodies.
- Describe the relationship between mass and the inverse square of distance.
- Explain the relationship between a planet's period and its distance from the Sun.

Standards:
S1d
S6c
S4a
S3c

Materials:
- Earth Science Reference Tables
- Calculator

Motivation:
Use the Earth Science Reference Tables to discuss with students the different length of years on different planets.

Aim:

How can we use Kepler's Three Laws to explain planetary motion?

Activities:
1. Discuss with the class Kepler's three laws of planetary motion. Some key concepts are shown below.

   Kepler's First Law
   Planets move in elliptical orbits.
   Sun is on the major axis and at one of the foci
   The path of each planet about the Sun is an ellipse with the Sun at one focus.

   Kepler's Second Law
   Equal area in equal times
   Each planet moves so that an imaginary line drawn from the Sun to the planet sweeps out equal areas in equal periods of time.

   Kepler's Third Law
   $R^3/T^2 = K$ where K depends on the mass of the object that is being orbited.

2. Use the Earth Science Reference tables to place a chart of each planet's distance from the Sun (radius) and have students determine the period of revolution using Kepler's 3rd law.

Summary:
Discuss results of activity and compare and contrast the experimental period vs. the actual data

Assessment:

Students should answer Regents style questions on this material.

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Physics
Topic: Momentum
Week 3, Day 5

Objective: SWBAT
- Define momentum
- Calculate momentum using a formula.
- Describe impulse as a change in momentum
- Explain how momentum is conserved.

Standards:
S1d
S6c
S4a
S5(all)

- **Materials:**
- Two carts, at least one with internal spring mechanism
- Set of masses
- Balance
- Several 1-kg masses
- Meter stick
- Stopwatch
- Cord
- Baseball
- Tennis ball
- Apple
- Conservation of momentum activity (attached)

Motivation:
Show the class a baseball, a tennis ball and an apple. Which will have a greater impact?

Aim:

How do we determine the momentum of an object?

Activities:
1. Have students perform the experiment on conservation of momentum.

Summary:
Summarize class results and use discrepancies to initiate class discussion

Assessment:
Students should write a report on real world applications of momentum that they have seen in their lives.

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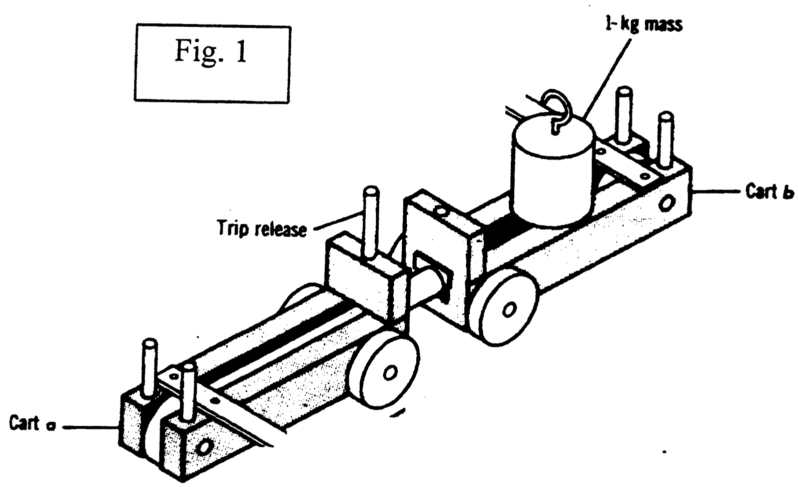
Problem How do the speeds of the fragments of a two-fragment explosion compare with their masses?

The firing of a gun is a two-fragment explosion in which the bullet goes off in one direction and the gun recoils in the opposite direction. How can the speeds of the two fragments of such an explosion be examined and related to their masses? You are going to simulate a two-fragment explosion by releasing a compressed spring between two carts as shown in Fig. 1. You will then measure the speeds and masses of these carts and see how they are related to each other.

Fig. 1



Apparatus Two carts, at least one with internal spring mechanism; set of masses; balance; several 1-kg masses; meter stick; stopwatch, and cord.

Information: To produce a simulated explosion, put the two carts in the middle of the table. Compress the spring in the spring-loaded cart by pushing a dowel rod into the recess and locking it into position against the metal guard. Put the second cart against the first. With a small block strike the trip release sharply to release the compressed exploder spring. Determine the time interval Δt with a stopwatch. Quanitatively compare the speeds of the two carts. Repeat the simulated explosion with a 1-kg mass in one of the carts, and again with a 2-kg mass, and a 3 -kg mass in the second. Let m_a be the total mass of the first cart, m_b the total mass of the second cart, v_a the speed of the first cart, and v_b the speed of the second cart. Then the momentum of the first cart is $m_a v_a$, and that of the second cart is $m_b v_b$. According to the law of conservation of momentum, the combined momentum of the two carts before the explosion must be the same as the combined momentum of the two carts after the explosion. Since neither cart is moving before the explosion, the initial momentum of the two carts is zero. After the explosion, the combined momentum of the two carts is zero. The law of conservation of momentum predicts that the speeds of the two carts will vary inversely with their masses. You are going to check this relationship. Reset the exploder spring and place the two carts against each other. Place the 1-kg load in one cart. Trip the exploder to release the carts. Measure the distance, Δs_a, covered by the unloaded cart in the time Δt measured by the stopwatch. Measure the distance, Δs_b, covered by the loaded cart in the same time. Express both values in meters and record them in Table 1.

Determine the average velocity acquired by each cart. Record these values in Table 1.
With the balance, measure the mass of each cart, m_a and m_b, in kilograms.
Record these in table 1.
Repeat the experiment by adding a 1.0 kg and then a 2.0 kg mass to cart b.

Data:

Table 1

	Cart a			***Cart***		
	ΔS_a	m_a	$v_a = \Delta S_{a/\Delta t}$	ΔS_b	m_b	$v_b = \Delta S_{b/\Delta t}$
Trial 1						
Trial 2						
Trial 3						

Analysis:
Table 2

	Momentum of Cart a $m_a v_a$	Momentum of Cart b $m_b v_b$	% Difference	$\frac{v_a}{v_b}$	$\frac{m_b}{m_a}$
Trial 1					
Trial 2					
Trial 3					

Questions:

Do the measured momenta of the two carts agree accurately with the law of conservation of momentum? If they do not, take the average momentum of the two carts as the best value of the momentum of each and determine the percent difference between the momenta of the two carts.

Does va/vb = mb/ma as predicted? If these ratios are not nearly equal, account for the difference between them.

If both carts had exactly the same mass, how would you expect their velocities to compare with each other? Why?

In the two-fragment explosion that results when a gun is fired, explain why the bullet acquires a high velocity while the gun does not.

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Physics
Topic: Conservation of Momentum
Week 4, Day 1

Objective: SWBAT
- Describe how momentum is conserved in all cases.
- Calculate momentum using a formula.
- Describe impulse as a change in momentum
- Explain how momentum is conserved.

Standards:
S1d
S6c
S4a

Materials:
- Newton's Balls

Motivation:
Use Newton's balls to demonstrate the concept of momentum.

Aim:
How can we use the Law of Conservation of Momentum to determine the mass and speed of objects in motion?

Activities:
Use the demonstration to foster class understanding of the conservation of momentum.
Demonstrate Newton's Balls
Show that one ball causes a ball at the end to move away
$mv = mv$
each ball has the same momentum

Try the above demonstration with two balls
$2mv = 2mv$

Try the above with two balls taped together at the end
$mv = 2m\, v/2$

What conclusion can we make from this demonstration?

Law of Conservation of Momentum – when there is no net external force acting on a system, the total momentum of the system remains constant.
When two bodies interact, the total momentum remains the same.

Summary:

In cooperative groups have students write their conclusion to this demonstration and have each group present their opinion to the class.

Assessment:
Students should answer Regents style questions on this material.

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Physics
Topic: Work and Power
Week 4, Day 2

Objective: SWBAT
- Compare and contrast work and power.
- Use calculations to determine work and power.
- Use the units of power, watts.
- Define mechanical energy.

Standards:
S1d
S6c
S4a

Materials:
- Spring loaded cart
- Different weights
- Inclined Plane
- Ruler
- Calculator

Motivation:
Use students previous knowledge of work to foster a class discussion.

Aim:

How do we determine the amount of work done by a force?

Activities:
1. Have students experiment with carts. Place weight on a cart and use the spring scale to the force on the cart. Move cart some distance on the inclined plane and use the formula to measure the amount of work done. Vary the angle of the plane, weight on cart and distance moved.

Summary:
Have students write their conclusions to this experiment and present them to the class.

Assessment:
Students should answer Regents style questions on this subject matter.

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Physics
Topic: Kinetic and Potential energy
Week 4, Day 3

Objective: SWBAT
- Compare and contrast potential and kinetic energy.
- Calculate potential and kinetic energy.
- Predict the changes in potential and kinetic energy in a closed system.

Standards:
S1d
S4a
S6c

- **Materials:**
- Overhead Projector
- Transparency of the history of the English longbow
- Inclined plane
- Cart
- Meterstick
- 2.5-N spring balance
- Recording timer
- Stopwatch
- Paper tape
- Ring stand
- C-clamp
- 20-N balance
- Platform balance
- Set of masses

Motivation:
Use the history of the English longbow to discuss the transfer of energy from potential to kinetic energy.(attached)

Aim:

How can we determine the kinetic and Potential energy of an object?

Activities:
1. Have students perform experiment on the transfer of energy from potential to kinetic energy.

Summary:
Have students summarize their results and present them to the class.

Assessment:
Allow students some time to present this as a formal laboratory report.

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Potential Energy changed the course of history. From the thirteenth until the sixteenth century, the national weapon of the English army was the longbow. It was this weapon which conquered Wales and Scotland, gave the English their victories in the Hundred Years War, and permitted England to replace France as the foremost military power in Medieval Europe. The longbow was the machine gun of the Middle Ages: accurate, deadly, possessed of a long-range and rapid rate of fire, the flight of its missiles was liken to a storm. Cheap and simple enough for the yeoman to own and master, it made him superior to a knight on the field of battle. Yet, important as this weapon was, most of our present day beliefs concerning it are based upon myth.

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Physics

Topic: Conservation of Energy

Week 4, Day 4

Objective: SWBAT

- Describe the conservation of energy
- Explain the role of friction in the conservation of energy.
- Discuss the different energy transformations in a system.

Standards:

S1d

S6c

S4a

Materials:

- Video of a roller coaster
- Roller coaster handout (attached)

Motivation:

Use the video of a roller coaster to discuss the changes in energy occurring on the ride.

Aim:

How does energy transfer from one form to another?

Activities:

1. Use the roller coaster concept to have students measure the kinetic and potential energies in a system.

Summary:

Have students summarize their results and create a table of data on the blackboard.

Assessment:

Students should answer Regents style questions on this material.

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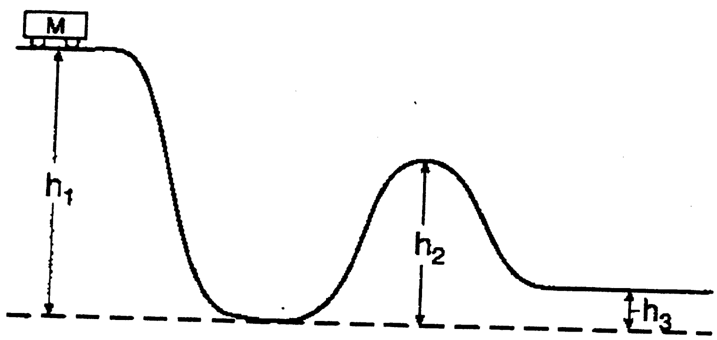
A cart of mass M on a frictionless track starts from rest at the top of a hill having height h_1, as shown in the diagram below.



Roller Coaster

If M = 20 kg
h1 = 10 m h2 = 5 m h3 = 2 m
What is the potential energy at A?
What is the KE at A

	h	Total E	KE	PE
A				
B				
C				
D				

What is the effect of speed on the braking distance of a car?
A car that has a mass of 3000 kg and a speed of 30 m/s.

If the brakes stop the car in 50 m. How much force do the brakes apply?

If the speed is increased to 45 m/s, assuming the same braking force, what will be the braking distance of the car?

As mass is increased, how does this change the braking distance. 6 instead of 1 adds 1000 pounds or about 500 kg.

How do we solve problems involving collisions? (Missing Energy)

What do you observe when there is a car crash?

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Physics
Topic: Hooke's Law
Week 4, Day 5

Objective: SWBAT
- Define elasticity
- Describe Hooke's Law
- Compare the elasticity of a spring to the force applied to it.

Standards:
S1d
S6c
S5(all)
S4a

Materials:
- Steel spring
- Spring support
- Ruler
- Three rings
- Ring stand
- Set of metric masses
- Hooke's Law activity sheet (attached)

Motivation:
Show students how strings can be stretched by placing masses on them.

Aim:

How can we determine the spring constant of a spring?

Activities:
1. Have students complete the experiment attached to this lesson plan.

Summary:
1. Have students present their results to the class.

Assessment:
Students can present their information in a formalized lab report.

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Hooke's Law and Conservation of Potential Energy

Problem: How does the change in the elastic potential energy of an oscillating spring compare with the change in the gravitational potential energy of a mass suspended from it?

Introduction: A mass of 0.5 kg hung from a spring as shown in Fig.-1 will come to rest when the weight of the mass is equal to the tension in the spring. If the mass is then lifted a short distance upward and released, it will oscillate with an up-and-down motion. At the top and bottom positions of its motion it will be at rest. In both positions the mass has potential energy. When the mass is at its highest position, its potential energy is gravitational and is the result of the work done in raising it against the opposition of the earth's gravitational field from the lowest to the highest point of its oscillation. When the mass is at its lowest position, its potential energy is stored in the spring and is the result of the work done against the elastic forces of the spring in stretching it. You are going to measure and compare the change in these two potential energies as the mass goes from its highest to its lowest point. To solve the problem you must measure the loss in gravitational potential Information energy and the gain in the energy stored in the spring as the oscillating mass and m falls the distance from its highest to its lowest position, i.e., the distance h in Fig.-1.

Apparatus: Steel spring; spring support; ruler; three rings; ring stand; set of metric masses

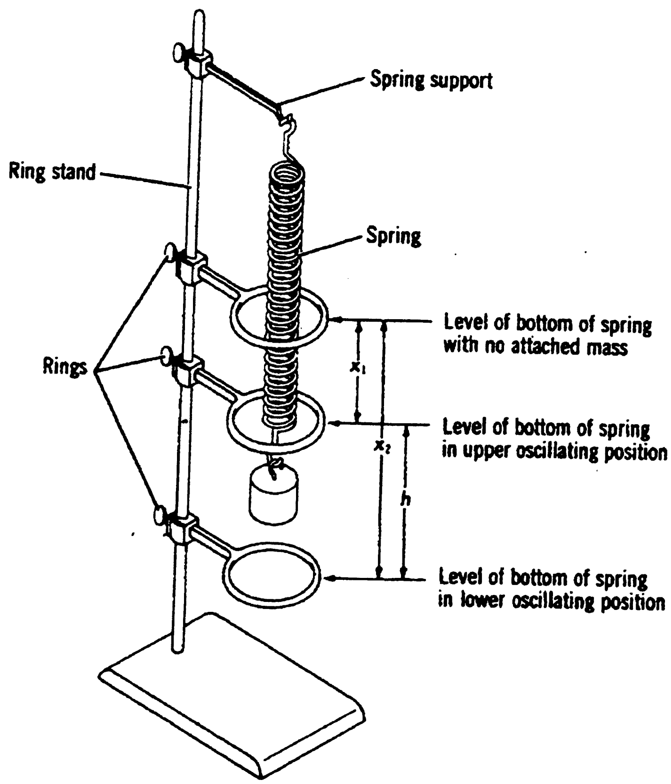

Fig 1

This loss in gravitational potential energy of the mass is $\Delta PE = mg\Delta h$. To find the gain in the potential energy stored in the spring, you must find out how much work was done in stretching the spring. Note the position of the lower end of the spring when no mass is attached to it. Let x_1 be the elongation of the spring when the oscillating mass is in its highest position, and let x_2 be the elongation of the spring when the oscillating mass is in its lowest position. By Hooke's law, the force needed to stretch the spring a distance x_1 is kx_1 and the force needed to stretch the spring a distance x_2 is kx_2, where k is the spring constant. The average force that stretches the spring from x_1 to x_2 is therefore $\frac{1}{2}(kx_1^2 + kx^2)$. Since this average force stretches the spring a distance $x_2 - x_1$, the work done by this force is $\frac{1}{2} k (x_2^2 - x_1^2)$. This work is the gain in potential energy PE stored in the spring and is equal to $PEs = 1/2k(x_2^2 - x_1^2)$ To find this energy you must measure k, x_2, and x_1.

Procedure: First determine the spring constant k. Suspend the spring from a ring stand and fasten a ring on a level with the lower end of the spring as shown in Fig.-1. Hang a mass of 0.25 kg from the spring. Fasten a second ring on a level with the new position of the lower end of the spring. Measure the distance between the upper and lower rings and express it in meters. This is the elongation corresponding to the force exerted by the weight of the 0.25-kg mass. The stretching force is mg = 0.25 kg × 9.8 m/s2 = 2.45 N. Using the same procedure, determine the elongation produced by the series of masses listed in Table-1. Compute the weight of each mass and enter it in the table as the force exerted on the spring. Plot a graph with the elongation in meters as abscissas and the forces in newtons as ordinates. Measure the slope of the graph to determine the spring constant k (k force/elongation). Record the measured value of k in newtons per meter. Gathering the Keep the upper ring (showing the position of the lower end of the spring with Data no mass attached to it) in place throughout the experiment, as shown in Fig.-1. Now hang a 1-kg mass from the spring. Fix a second ring halfway between the position of the mass and the upper ring. Raise the 1-kg mass until the bottom of the spring is on a level with this second ring. Release the mass and, as it oscillates, fix a third ring to indicate the lowest position of the bottom of the spring. Measure the distance x_1 between the top ring and the second ring, and the distance x_2 between the top ring and the lowest ring. Enter these values, expressed in meters, in Table-2. Check the accuracy of your work by restoring the mass to the second ring position and releasing it. See if it oscillates between the second and third rings. If there is time, repeat this procedure using the same mass and a greater amplitude of oscillation by moving the second ring a few centimeters higher than before. If time permits, repeat the procedure using a mass of 0.5 kg instead of 1.0 kg.

Data:

Table 1

Mass kg	Force N	Elongation m
0.00		

Table 2

	Mass (kg)	x_1 (m)	x_2 (m)	$h = x_2 - x_1$ (m)
Trial 1				
Trial 2				
Trial 3				

Analysis of Data:

1. **Graph of F vs X**
2. **Determine the spring constant 'k' from the slope of the best fitting straight line.**
3. Compute PEg = mgh and enter it in Table-3.
4. Compute PEs = ½ $k(x_2^2 - x_1^2)$ and enter it in the table.
5. Compute PEg - PEs.

What conclusion can be drawn by comparing PEg and PEs?

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Table 3:

	PE_g (J)	PE_s (J)	$PE_g - PE_s$ (J)
Trial 1			
Trial 2			
Trial 3			

Conclusions:

1. What reason might there be for expecting that PEg and PEs should be very nearly equal to each other?
2. When the spring is allowed to oscillate for some time, its amplitude becomes smaller until it eventually comes to rest. What is happening to the energy originally stored in the spring?
3. As the mass falls from its highest to its lowest point, its gravitational energy is converted partly into potential energy stored in the spring and partly into kinetic energy. Describe the changes that take place in the kinetic energy of the mass during this fall. Describe the changes that take place in the potential energy during this fall.
4. In Trial 1, compute the value of PEg when the mass reaches a point midway between x_1 and x_2. Compute PEs at this point. How much kinetic energy does the mass have at this point?
5. A ball dropped from a height to the floor loses energy on bouncing back. Design an experiment to determine the relationship between the percent of energy the ball loses after one bounce and the height from which it was dropped.

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Physics
Topic: Introduction to waves
Week 5, Day 1

Objective: SWBAT
- Identify parts of a wave.
- Calculate period, frequency and wavelength.
- Determine the type of wave.

Standards:
S1b
S4a
S6c

Materials:
- Slinky
- Spring
- Overhead
- Ripple Tank

Motivation:
Use slinky to create different types of waves.

Aim:

What are the different types of waves?

Activities:
1. Use the notes below to foster class discussion.

Pulses and waves

Use rope or long coil to demonstrate a pulse and a traveling wave train. (Caution: avoid creating a standing wave.) Pulses and waves are disturbances that move through a medium. Define longitudinal and transverse pulses and waves. Contrast longitudinal and transverse pulse in a long coil. Observe oscillations of marked points along the coil.
Draw a picture of a transverse wave, longitudinal wave and a pulse.
Demonstrate each wave using a slinky and a spring.
Show that the medium does not move.
What does a wave transmit.

Definition of a wave: a wave is a vibratory disturbance that propagates through a material or space.

Waves:
1. Periodic waves

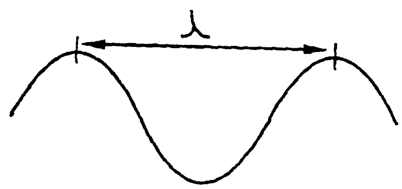
Definition of a transverse wave - the vibratory disturbance in transverse waves is at right angles to the direction of travel of the wave.

Definition of a longitudanal wave- the vibratory disturbance in transverse waves is parrallel to the direction of travel of the wave.

2. Pulses - Definition of a pulse - a pulse is a single vibratory disturbance that that moves

from point to point.

Examples of both kinds of waves in solids, liquids, and gasses.
Characteristics of Waves.
Frequency(f) and period(T). Reciprocals of one another, $T = 1/f$.
Velocity (v) - speed of a wave
Wavelength (λ) - distance between two consecutive points in phase



Phase - points that have the same displacement and the are moving in the same direction are in phase.
Frequency is determined by the source; velocity by the medium. Amplitude. Relate to wave's energy: loudness of sound, brightness of light, destructive impact of water waves.
Phase- define parts of a wave that are in-phase and out-of-phase · * *Phase difference in terms of degrees* *
·* *Two waves: phase difference of 0°, 90 °, 180°, 270°, 360°*
Wave equation.
Establish that $v = f\lambda$, e.g., from diagram of a a wave
Use $\lambda = v/f$ to emphasize that λ is the dependent variable.
SI units: f in s^{-1} or hertz (Hz), λ in m, v in m/s. Problems solving for one variable given the other two. Proportionality's between any pairs of v, f, and λ
$f = 1/T$
Use a wave machine to show how f and T are related
Calculations using $c = f\lambda$
All colors of light have same v, namely c, in air or vacuum.
$c = 3.00 \times 10^8$ m/s
Show electromagnetic spectrum transparency.
Show how f and λ are related
In "material media" (solids, liquids) light has different velocity which are less than c. f is independent of media and depends only on the light source. Therefore, for a given frequency, in different media varies.
Use λ.= c/f to emphasize that λ. is the dependent variable

Summary:
Use collaborative groups to have students summarize their notes and report their findings to the class.
Assessment:
Students should answer Regents style questions.

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Physics
Topic: Properties of Sound
Week 5, Day 2

Objective: SWBAT
- Determine the velocity of sound.
- Use the wave equation to calculate wavelength.
- Identify standing waves.

Standards:
S1b
S4a
S6c

Materials:
- Variable length resonance tube or aluminum cylinder about 45 cm long
- Glass cylinder about 35 cm tall
- Half-meterstick
- Several tuning forks, from 256 to 512 vps
- Large rubber stopper about 5 cm in diameter
- Thermometer

Motivation:
Describe the procedure that students will use to measure the velocity of sound.

Aim:

How do we measure the speed of sound?

Activities:
1. Have students perform the experiment on determining the speed of sound.

Summary:
Place all data on the blackboard and average the results to determine the speed of the sound.

Assessment:
Students should answer Regents style questions on this subject matter.

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Speed of Sound LAB # __________

NAME ______________________________ **Lab Team** _______

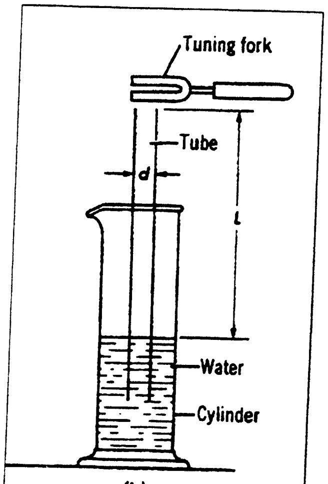
Problem: How can the speed of sound in air be measured? The speed of sound can be measured directly by timing the passage of sound over a long, known distance. To do this with an ordinary watch requires a much longer distance than is available in the laboratory. It is convenient, therefore, to resort to an indirect way of measuring the speed of sound in air by making use of its wave properties. For all waves the following relationship holds,

$$v = f\lambda \qquad (1)$$

where v is the speed of the wave, f is its frequency of vibration, and λ is its wavelength. In this experiment, you are going to measure the wavelength of a sound of known frequency. You will then compute the speed of the sound.

Apparatus Variable length resonance tube or aluminum cylinder about 45 cm long; glass cylinder about 35 cm tall; half-meterstick; several tuning forks, from 256 to 512 vps; large rubber stopper about 5 cm in diameter; thermometer

Procedure: You will use the principle of resonance to determine the wavelength of the sound produced by a tuning fork of known frequency. When a tuning fork is sounded near the open end of a tube closed at the other end, a strong reinforcement of the tuning fork sound will be heard if the air column in the tube is the right length. This reinforcement is known as *resonance.* It is caused by the fact that the waves reflected from the closed end of the tube return to the top in phase with the new direct waves being made by the fork. The direct and reflected waves thus combine their effects. To find the length of the air column that produces resonance for a given tuning fork, it is necessary to vary the length of the tube. Figure-1 shows the method to accomplish this purpose. The metal tube is raised or lowered. In either case, the length of the air column in the tube is changed until the sound intensity is at a



(b)

maximum. For a tube closed at one end, whose diameter is small compared to its length, strong resonance will

occur when the length of the air column is one-quarter of a wavelength, λ/4, of the sound waves made by the tuning fork. A less intense resonance will also be heard when the tube length is 3/4λA, 5/4λ, and so on. Since the shortest tube length for which resonance occurs is L = λ/4, it follows that λ = 4L. Practically, this relationship must be corrected for the diameter d of the tube. This gives

$$\lambda = 4\,(L + 0.3d) \qquad (2)$$

In this experiment λ, L, and d will be measured in meters. Note the room temperature and record this in the table as well. Check your results by repeating these measurements with the same tuning fork. Using several other tuning forks with different frequencies, make the same measurements and record them in the table.

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DATA:

frequency (f) (hz)	Length of Air Column (L) (m)	Diameter of Tube (d) (m)	Wavelength λ (m)	Room Temperature T (°C)	Speed (v) (m/s)

Calculations: Using the values of L and d in Table-1, calculate the value of the wavelength λ from Equation (2). Enter this value of the wavelength in the table. Now, from Equation (1), $v = f\lambda$, calculate the value of the speed of sound in air and record this value in the table for each of the tuning forks used. Average the results, and record your average, together with your reading of the room temperature in Celsius degrees.

To check your results, you can calculate the value of the speed of sound in air from the following relation:

$$v = 331 \text{ m/s} + (0.6 \text{ m/s / C}°)\ T \qquad (3)$$

where T is the temperature in degrees Celsius and 331 m/s is the speed of sound in air at 0°C. Calculate and record your result. Compare the result you obtained by resonance measurement with the calculated value obtained by using Equation (3). Assuming the calculated value is correct.

Results:

1. Use equation (3) to determine the accepted value for the speed of sound.
2. Determine the % error between the accepted value and the experimental value for each trial. Where the result from equation (3) is the accepted value and the result from equation (1) is the experimental value.
3. Show calculations of λ on loose leaf.
4. Determine the mean for all of your measurements of the speed of sound.

Conclusion:

1. How could you use the method and the results of this experiment to determine whether the speed of sound in air depends upon its frequency?
2. What do your results indicate about such a relationship?
3. How could the method of this experiment be used to determine whether the speed of a sound in air depends upon the atmospheric pressure?
4. How could you use the method and the results of this experiment to determine whether the speed of sound in air depends upon its frequency? What do your results indicate about such a relationship?
5. When sound waves pass from air into water, their speed increases by a factor of 4. This means that either the wavelength or the frequency also increases by a factor of 4. Which is it? Explain.
6. An echo results when a sound is reflected from a distant surface such as the wall of a building. Suppose you are standing in an open field 500 meters from a reflecting wall. You have a starting pistol and a stopwatch. How would you use these to measure the speed of sound through the air between the wall and you?

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Physics
Topic: Introduction to Light
Week 5, Day 3

Objective: SWBAT
- Define light.
- Identify parts of the electromagnetic spectrum.
- Describe reflection in a plane mirror

Standards:
S1b
S4a
S6c
S5(all)

Materials:
- Plane mirror
- Pane of clear glass
- Pins
- Ruler
- Light shield
- Mirror supports
- Protractor
- Reflection Experiment (attached)

Motivation:
Use a mirror to have students discuss the appearance of the reflection.

Aim:
How do we find the position of a virtual image in a plane mirror?

Activities:
1. Have students complete the experiment on reflection.

Summary:
Have each group of students summarize their results in writing.

Assessment:
Students should answer Regents style questions on this material.

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Problem: How does the law of reflection enable us to construct the image of an object in a plane mirror? You see an object when rays of light from the object enter your eye. If the rays of light from the object are reflected from a mirror before they enter your eye, you see an image of the object behind the mirror. The position of the image is determined by the *law of reflection.* You are going to use this law to construct the image of an object in a plane mirror. In this way you will predict where the image of the object will be. You are then going to check your predicted image by comparing it with the image seen when the object is actually viewed in a plane mirror.

Apparatus: Plane mirror; pane of clear glass; pins; ruler; light shield; mirror supports; protractor

PART A Straight-line Path of Light Rays As long as a ray of light travels in the same medium, its path is a straight line. To demonstrate this, stand two pins vertically at opposite ends of a sheet of paper. Sight along the surface of the paper from one pin to the other so that the second pin is hidden behind the first pin. You are sighting along the ray of light passing through the points marked by the two pins. Now put a third pin at various distances between the two original pins so that in each case the second and third pins are hidden behind the first. For each position of the third pin, pierce the paper to mark the point where the pin has been. Remove all pins and use a ruler to confirm that all the points are on the same straight line. Then draw the ray passing through all the points pierced by the pins. The fact that light rays travel in straight lines enables you to use the straight edge of a ruler to sight along a light ray.

PART B The Law of Reflection

The law of reflection states that a light ray incident on a plane mirror surface is reflected so that the *angle of reflection is equal to the angle of incidence.* The angle of reflection is the angle between the reflected ray and the normal to the surface. The angle of incidence is the angle between the incident ray and the normal to the surface. You are going to verify this law.

Draw a straight line XY across the middle of a sheet of paper as shown in Fig.-1. Support a plane mirror vertically by fastening it to a rectangular wooden block with a rubber band. Place the mirror so that its silvered surface coincides with the line XY. Note that the silvered reflecting surface of a glass mirror is generally its back surface.

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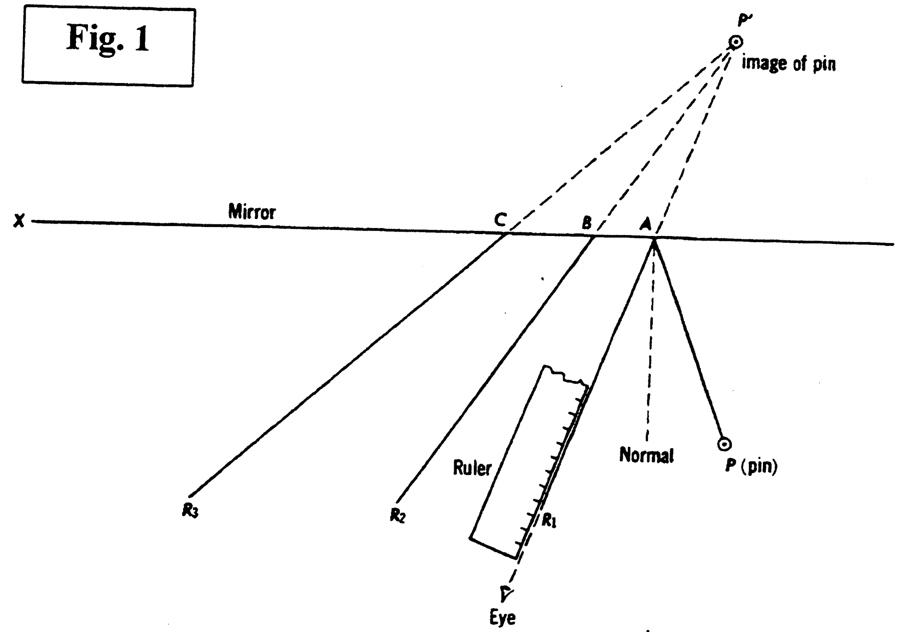
Fig. 1



Put a vertical pin at point P, about 4 cm in front of the mirror. Lay a ruler on the paper about 4 cm to the left of P and sight along its edge at the image of the pin you see in the mirror. The line on which you are sighting is the direction of a reflected ray that seems to come from the image of P. Draw this line along the ruler's edge. Now move the ruler about another 2 cm to the left. Sight along its edge as before and draw the direction of a second reflected ray. Again, move the ruler about 2 cm to the left. Sight along its edge and draw the direction of a third reflected ray. Remove the mirror and pin from the paper. Extend each of the lines representing the reflected rays to the line representing the mirror surface, and label the three reflected rays R_1A, R_2B, R_3C, respectively. (Refer to Fig.-1.) Draw lines *PA, PB,* and *PC.* These are the paths of the incident rays corresponding to the three reflected rays. At A, B, and C draw the normals to *XY* as dotted lines. Now measure the angles of incidence and the corresponding angles of reflection for each of the incident rays and enter their values in Table-1.

Enter the differences between the angles of incidence and reflection. Does your data verify the law of reflection within the limits of experimental error?

Table 1

Incident Ray	Angle of Incidence	Angle of Reflection	Difference
PA			
PB			
PC			

PART C Locating the Image of P

Extend the reflected rays, R_1A, R_2B, and R_3C behind *XY* by dotted lines until they intersect. The point of intersection P' is the position of the image from which the reflected rays seem to come. How does the distance from P to *XY* compare with the distance P' from XY?

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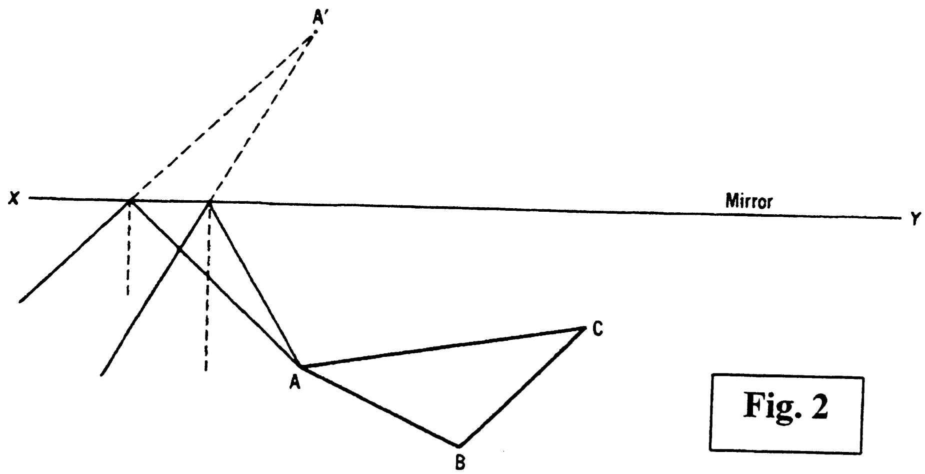

Fig. 2

You will now use the law of reflection to construct and predict the position of an object in a plane mirror. In the middle of a sheet of paper draw line *XY* to represent the mirror, and triangle *ABC* to represent the object as shown in Fig.-2. From vertex A draw two lines to *XY*. These represent incident rays. Where each ray meets *XY* use a protractor to draw the normal and the corresponding reflected ray. Extend the two reflected rays backward. Where they intersect is A', the image of A. Find the images of B and C in the same manner. Then connect A', B', and C' to obtain the image *of ABC.*

Questions 1-3 refer to Part B.

1. How does the distance from P to *XY* compare with the distance P' from XY?
2. What is the relationship between the angle of incidence and the angle of reflection?
3. Does your data verify the law of reflection within the limits of experimental error?

Questions 4 and 5 refer to Part C.

4. Does the appearance of the actual image agree with that of the constructed image? Describe any differences.
5. What are some sources of error for this exercise?

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Physics
Topic: Properties of Light
Week 5, Day 4

Objective: SWBAT
- Describe refraction.
- Determine the index of refraction for an unknown object.
- Draw the path of light rays as it moves from one substance to another.

Standards:
S1b
S6c
S4a
S5(all)

Materials:
- Rectangular glass block
- Pins
- Protractor
- Ruler

Motivation:
Demonstrate the apparent "bending" of a pencil when placed in water.

Aim:

How do light rays bend as they pass through different materials?

Activities:
1. Have students complete the activity on refraction of light.

Summary:
Summarize results in a data table placed on the board.

Assessment:
Have students present their findings in a formalized lab report.

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Speed of Light in Glass NAME ______________________ Lab# ____

Problem: How can the speed of light in glass be determined?
When a ray of light passes obliquely from air into glass, it is *refracted*. The degree to which any particular kind of glass refracts light depends upon a constant called its *index of refraction*. This index is also the ratio of the speed of light in air to the speed of light in that kind of glass. In this experiment you are going to determine the index of refraction of a given sample of glass. Then, knowing the speed of light in air, you will compute its speed in that kind of glass. Actually, both the index of refraction of the glass and the speed of light in it vary somewhat with the wavelength of the incident light. However, the variation is too small to be measured in this experiment. Since you will use white light, the speed you obtain will be the average speed through the glass of all the wavelengths contained in white light.

Apparatus: Rectangular glass block; pins; protractor; ruler

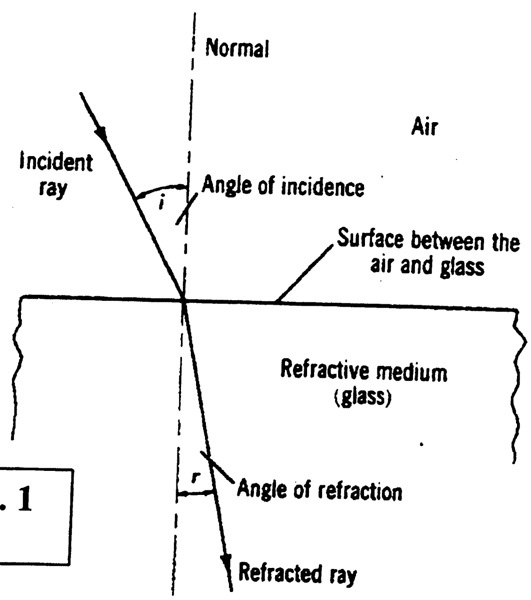

fig. 1

Figure-1 illustrates how a ray of light is refracted on passing from air into a refracting medium like glass. Note that the angle of incidence i and the angle of refraction r are measured with respect to the normal or perpendicular to the surface between the two media. It turns out that, for all angles of incidence, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant. This constant is called the index of refraction of the substance with respect to air. The index of refraction is also known to be equal to the ratio of the speed of light in air v_a to its speed in the substance v_s.

Therefore, $\sin i / \sin r = n$ where n is the index of refraction of the substance sin r with respect to air.

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You will determine n for a given glass block by measuring the angles i and r. Then, since the speed of light in air is known, you will compute the speed of light in the glass block from the relationship,

$$v_s = v_a/n$$

To measure the angles i and r, follow a light ray that passes obliquely from air into the glass block in the following manner. Put the glass block in the middle of a sheet of paper and outline its form as shown in Fig-1. Put the protractor at a point a short distance from the upper left-hand corner of the block. Draw the normal and a second line making an angle of 30° with the normal. This line will mark the path of the incident ray. Set up a pin so that it stands vertically at the point of intersection of the incident ray, the normal, and the glass surface. Set up a second pin so that it stands vertically on the path of the incident ray at a distance of about 5 cm from the first pin. These two pins fix the path of the incident ray. Sight through the glass block along the edge of a ruler as shown in Fig. 35-2 until the two pins appear in a straight line. The ruler indicates the direction of the ray emerging from the glass. With a sharp pencil, draw a line along the edge of the ruler until it meets the outline of the glass block. If this line is accurate, it will come out parallel to the incident ray as shown in Fig.-2. Remove the block and draw a third line joining the incident and the emergent rays. This is the path of the refracted ray. Now measure the angle of refraction with the protractor and enter it in Table -1.

Repeat the above procedure for rays incident at angles starting at 0° and increasing by 10-degree intervals until the angle of incidence is 70°. In each case, measure the angle of refraction and enter it in the table.

For each of the angles of incidence and refraction, look up the corresponding sines and enter them in Table-1. Make a graph plotting the sines of the angles of incidence as ordinates against the sines of the corresponding angles of refraction as abscissas. Draw the straight line that best fits the plotted points and passes through the origin. The slope of this line is the ratio of sin i to sin r and is therefore equal to the index of refraction of the glass with respect to air. Determine the slope by dividing the ordinate of any point on this line by the corresponding abscissa. Record this value and label it n, the index of refraction of the glass block.

Table 1 .

Angle of i	10	20	30	40	50	60	70	80
Angle of r								
sin i								
sin r								

Noting that $n = c/v_s$ where c, is the speed of light in air, 3.00×10^8 m/s, calculate v_s, the speed of light in the glass.

Conclusion:

1. Why should the ray emerging from the glass block come out parallel to the incident ray?

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2. As the angle of incidence increases in equal 10-degree intervals, does the angle of refraction also increase in equal intervals?

3. For what angle of incidence is the angle of refraction a maximum?

4. How can the technique of this experiment be used to determine whether any two different colors of light, such as red light and blue light, travel at the same speed in the glass?

5. Assuming that you have a thin-walled plastic rectangular container, describe a technique suitable for measuring the speed of light in water.

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Physics
Topic: Interference of Waves
Week 5, Day 5

Objective: SWBAT
- Describe constructive and destructive interference.
- Explain the interference pattern shown on a screen as light passes through a diffraction grating.
- Measure the wavelength of the different colors of light

Standards:
S4a
S1b
S6c
S5(all)

Materials:
- Diffraction grating replica having about 5000 lines per centimeter
- Grooved wooden block for mounting diffraction grating
- One ring stand to serve as marker
- Cardboard screen having a vertical slit
- Incandescent lamp
- Monochromatic yellow light source
- Other light sources as available
- Wavelength of light activity (provided)

Motivation:
Pass laser light through a diffraction grating to show the separation of the light into bands.

Aim:

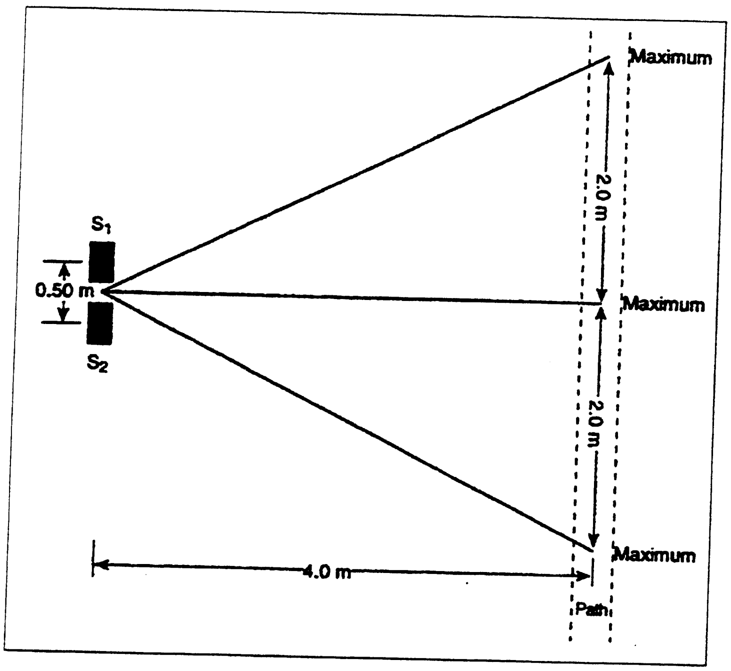
How does the source of waves effect the bending of waves?

Activities:
1. Present the following material to students in whole group discussion.
   Interference - show how the wave pattern changes as the sources move further apart
   define node and antinode
   How does the wavelength effect the bending of the wave
   How does the frequency effect the bending of the wave
   How does the distance d between the two sources effect the bending of the wave.
   How does the distance L effect the bending.

   $x \sim L$
   $x \sim 1/d$
   $x \sim \lambda$
   $\lambda/d = x/L$
   or
   $x = L\lambda/d$
   Illustrate the wave fronts leaving two sources.

Label L, d, x and λ
Interference between waves.
Principle of superposition: waves can pass through each other
And interact as they pass.

Constructive and destructive interference.
Using pulses show the interference between two waves.



2. Complete lab activity on the wavelength of light.

Summary:
Summarize class results on the board. Compare and contrast each group's work. Compare experimental values to accepted values.

Assessment:
Students should answer Regents style questions on this topic.

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MEASUREMENT OF THE WAVELENGTH OF LIGHT

NAME ______________________________ LAB # 2

Problem: How can a diffraction grating be used to measure the wavelength of the light from a source? Light consists of very short wavelengths that require special devices to measure them. The diffraction grating is one such device. Its use depends upon the fact that each wavelength of light passing through a grating is diffracted by an amount that depends upon the wavelength of the light and the separation of the slits of the grating. You are going to measure the angles of diffraction through which light from different sources is bent by a grating. Then, given the separation of the slits of the grating, you will determine the wavelengths of that light.

Apparatus: Diffraction grating replica having about 5000 lines per centimeter; grooved wooden block for mounting diffraction grating; one ring stand to serve as marker; cardboard screen having a vertical slit; incandescent lamp; monochromatic yellow light source, and other light sources as available.

Procedure: A diffraction grating consists of a large number of parallel lines ruled on a plate of glass or other transparent substance. These lines form a series of parallel slits between them. When light from a source passes through the grating, each slit acts like a separate source of light. The waves from each slit interfere with the waves from all other slits after leaving the grating. At all places at which the waves from the different slits arrive in phase, they combine constructively to produce a bright image of the source. As a result, when the light passing through a grating is allowed to fall on a screen, it forms a bright central image flanked by successive pairs of images of decreasing brightness. The images of the pair nearest the center are called first order images; the images of the next pair are called second order images; and so forth. These images can also be seen (as in Fig. 1) by looking directly at the source of light through the grating instead of letting the light fall upon a screen. The images then appear to be in directions exactly opposite to those in which the grating bends the light.

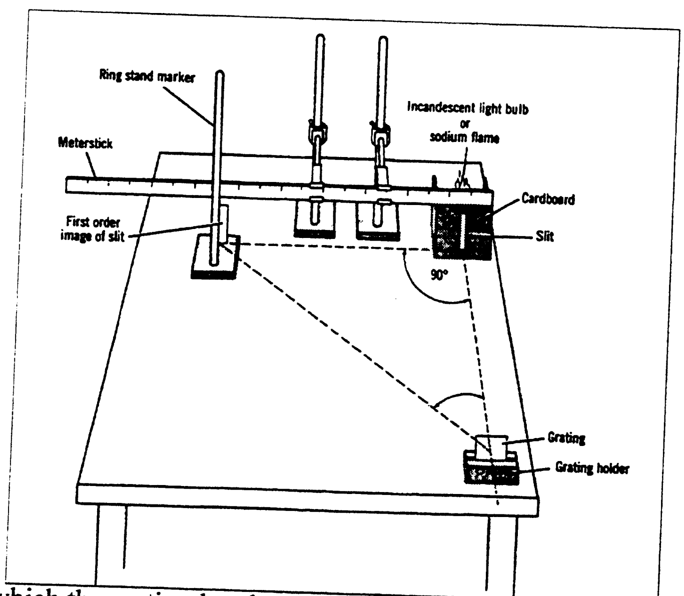

Fig. 1

To understand how the images form, consider Fig. 2 showing monochromatic light of wavelength A passing through two adjacent slits of a grating and falling upon a distant screen. Wherever the light waves from S1 and S2 reach the screen in phase, they will reinforce each other to produce a bright image. Such reinforcement will occur at those points on the screen whose distances are whole multiples of one wavelength.

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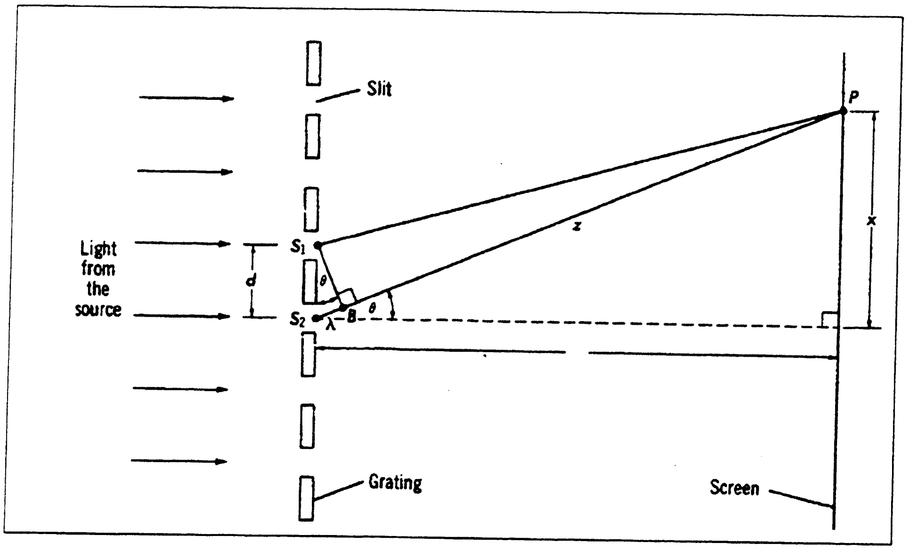

Fig. 2

Now change the light source to the incandescent bulb. Note that each of the first order images is now a complete spectrum. Note which light is diffracted more, the red or the violet. Using the above method, line up the ring stand rod with the extreme red edge of the spectrum and then with the extreme violet edge of the spectrum. For each of these positions, measure and record the corresponding values of x in the table.

DATA:

Light Source	x (m)	L (m)	d (m)	$\lambda = d\,x/L$ (m)

Calculations: Use the equation $\lambda = \frac{d\,x}{L}(1)$ to determine the wavelength of each light source.

$d = 1.86 \times 10^{-6}$ m

Conclusion:

1. A glass prism refracts violet light more than all other visible wavelengths of light. Which color of light is diffracted most by a grating? Explain the difference.

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2. According to Equation (1), how would using a grating with a smaller value of d affect the distance x at which the image appears?

3. The wavelength of the monochromatic yellow sodium light, which you measured in this experiment, is known to be 5.89×10^{-7}. What was your percentage of error in making this measurement?

4. Suppose you do not know the value of the grating constant d for a given grating, but do know that the wavelength of yellow sodium light is 5.89×10^{-7} m. Design an experiment to determine d for the grating.

5. What would happen to the distance X if the distance from the diffraction grating to the light was increased?

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Physics

Topic: Static Electricity

Week 6, Day 1

Objective: SWBAT
- Define static electricity
- Explain how charge moves from one object to another.
- Describe the conservation of charge.

Standards:

S1b

S4a

S6c

Materials:
- Rubber rod
- Fur
- Silk
- Glass rod
- Electroscope
- Internet access

Motivation:

Use rubber rod, fur, silk and glass to charge different objects.

Aim:

How do objects become charged?

Activities:

1. Use notes below to foster a class discussion on static electricity

Development:

Demonstrate - and + charges.

Laws of electrostatics

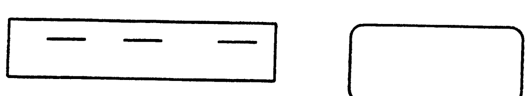
Conservation of charge is a universal law.

Unlike charges attract and like charges repel

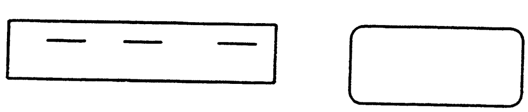
The charging process occurs by an exchange of electrons.

Draw the exchange of electrons between fur and rubber and silk and glass.

Rubber and fur



Glass and silk



Grounding either removes or adds, electrons to the object to neutralize the charge.

Practical applications
photocopy machine lightning electrostatic precipitators lightning rods ground wire in an electrical apparatus

Demonstrate Electroscope. Use the electroscope to show some of the characteristics of static charges.

Conservation of charge
The net charge in a closed system is identical
Pair production is an example of conservation of charge.
If a neutral hard-rubber rod is rubbed with neutral, clean plastic wrap, it can be shown with an electroscope that both are charged, one positive and the other negative.

Elementary charges
Any charge is made up of integral multiples of a minimum charge
proton electron called the elementary charge
The charge of the electron is one negative elementary charge.
The charge of a proton is one positive elementary charge.
1.60×10^{-19} coulomb.

Quantity of charge
The quantity of charge a body
The **coulomb**
1 coulomb = 6.25×10^{18} elementary

2. Have students complete Internet activity on Electrostatics.

Summary:
Have students summarize the results of the demonstrations in a written paper.

Assessment:
Students should answer Regents style questions on this material.

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Electrostatic Simulation Questions

By Gary Richert, Hazelwood Central High School

Introduction to Electrostatics: What is the source of all electric charges? What is the law of static charge: Opposite charges_________, like charges _________? What charge particles exist in the atom? Why are all atoms neutral?

Source for Answers:

http://www.sciencejoywagon.com/physicszone/lesson/07elecst/electro.htm

What is Triboelectricity?

Wearing leather shoes and walking on a wool carpet will cause the person to obtain a _____ charge. Wearing rubber sole shoes will cause the person to obtain a _____ charge.

What is the "Triboelectric Series"?

Rubbing a glass rod with a silk cloth causes each to become charged. Which material is positive? Why?

To give an aluminum rod a positive charge what type of cloth would you rub against it?

For it to have a negative charge, what type of cloth would you use?

Source for Answers:

http://207.10.97.102/physicszone/lesson/07elecst/static/triboele.htm

Why does rubbing a balloon on your head allow it to stick to a wall?

Source for Answers:

http://www.sciencejoywagon.com/physicszone/lesson/07elecst/eleclab/ballrub.htm

What is an electroscope? What is it used for? How does it work?

Source for Answers:

http://www.sciencejoywagon.com/physicszone/lesson/07elecst/eleclab/nerscope.htm

How do you charge an electroscope by contact (conduction)?

Source for Answers:

http://www.sciencejoywagon.com/physicszone/lesson/07elecst/eleclab/escope.htm

How do you charge an electroscope by induction?

Compare and Contrast charging by induction and conduction.

Source for Answers:

http://www.sciencejoywagon.com/physicszone/lesson/07elecst/eleclab/induct.htm

Charging a Pith ball with a rubber or glass rod. What is the charge on a pith ball after being touched by a glass rod? Rubber rod? What method of charging was used - induction or conduction?

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Source for Answers:
http://physics.weber.edu/amiri/director/dcrfiles/electricity/pithBallS.dcr

Losing Charge: How does a charged object lose its charge to the atmosphere?
Source for Answers:
http://www.sciencejoywagon.com/physicszone/lesson/07elecst/static/theft/theft.htm

Lightning Physics: What causes lightning? Which charge moves toward earth? Which charge move toward the clouds? What causes the thunder associated with lightning?
Source for Answers:
http://207.10.97.102/physicszone/lesson/07elecst/lightnin/lightnin.htm

Coulomb's Law: What is Coulomb's Law? State the formula and identify the variables. When the electrostatic force is positive (or negative), what does it indicate about the nature of the force? How is Coulomb's Law similar to Newton's Law of Universal Gravity?
Source for Answers:
http://www.sciencejoywagon.com/physicszone/lesson/07elecst/coulomb/coulomb.htm

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Physics
Topic: Electrical Fields
Week 6, Day 2

Objective: SWBAT
- Draw the electrical field between two charges
- Calculate the electrical field around two charges.
- Compare and contrast gravitational fields and electrical fields.

Standards:
S1b
S4a
S6c

Materials:
- Electroscope
- Pith ball
- Rubber rod
- Glass rod
- Wool
- Fur
- Silk
- Balloons

Motivation:
Use charged rods to cause pith balls to change charge. Charge the electroscope.

Aim:
How do we measure the electrical field around objects?

Activities:
1. Have students charge balloons and attempt to have them "stick" to the wall. Students should create a report, along with their data to explain this phenomenon.

Summary:
Students should summarize the activity in a written paper.

Assessment:
Students should answer Regents style questions on the material

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Physics
Topic: Electrical Current
Week 6, Day 3

Objective: SWBAT
- Identify a serial circuit
- Identify a parallel circuit
- Compare and contrast voltage, current and resistance in both circuits
- Relate voltage, current and resistance (Ohm's Law)

Standards:
S1b
S1d
S6c
S5(all)

Materials:
- Voltage source
- Conducting wires
- Bulbs
- Ammeter
- Voltmeter
- Circuit boards

Motivation:
Set up the series and parallel circuits in front of students

Aim:

How do we measure the electrical current in an electric current?

Activities:
1. Have students complete the lab activity provided with this lesson.

Summary:
1. Summarize student results on the blackboard and compare answers.

Assessment:
Students should complete a formal lab report on this material.

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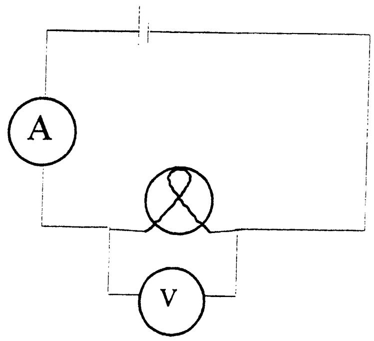
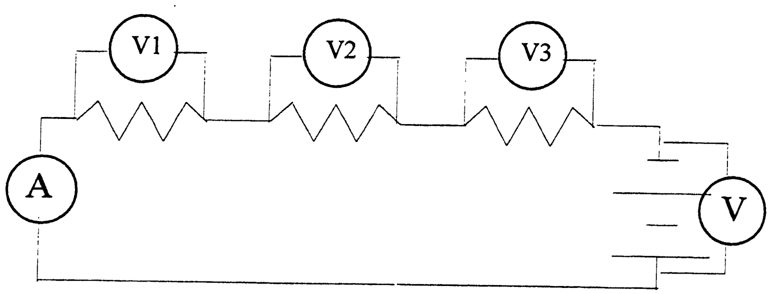
Problem: How does the current and the resistance of a series and parallel circuit change when additional lamps are added?

1. Place a lamp in the socket. Use the circuit below to determine the resistance of each lamp. Complete the table for each lamp.



Resistance	V_T	I_T	R
R1			
R2			
R3			

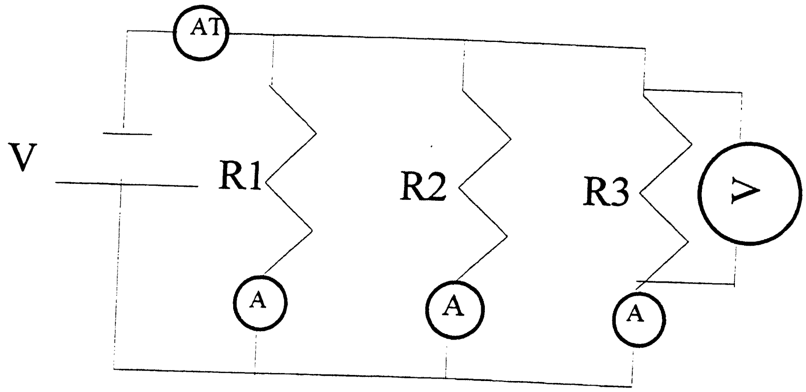
2. Series Circuits: Alternately add one resistor, then two, and then three resistors into a series circuit. Determine the total voltage VT, the total current IT and the total resistance RT for each circuit. Complete the table below:



DATA:

	V_T	I_T	V1	V2	V3	R_T
1						
2						
3						

3. Parallel Circuits. Alternately add one resistor, then two, and then three resistors into a series circuit. Determine the total voltage VT, the total current IT and the total resistance RT for each circuit. Complete the table below:



DATA:

Resistors	VT	IT	RT	V1	V2	V3	I1	I2	I3
1									
2									
3									

Calculations:

Show a sample calculation for each part of this experiment.

Conclusion:

1. What is the effect on the current when additional resistors are added into a series circuit?
2. What is the effect on the current when additional resistors are added to a parallel circuit?
3. Compare the resistance of a parallel circuit to that of a series circuit when all three resistors are added.

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Physics
Topic:
Week 6, Day 4

Objective: SWBAT

- Draw the magnetic field around a magnet
- Explain how different shaped magnets produce different shaped fields.

Standards:
S1b
S4a

Materials:

- Small compass
- Two bar magnets
- Horseshoe magnet
- Iron washer
- Cardboard

Motivation:
Use refrigerator magnets to introduce the concept of magnetism

Aim:

How do we draw magnetic fields?

Activities:
1. Have students complete the activity on drawing magnetic fields.

Summary:
Students should present their information to the class.

Assessment:
Students should answer Regents type questions on this material

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PROBLEM: How can a magnetic field be studied?

INTRODUCTION: A magnet exerts forces on compasses or any other magnets placed in its neighborhood. The space around a magnet in which it exerts these forces is called its *magnetic field of force.* In this experiment you are going to learn how to make a 'map' of a magnetic field that will show the strength and direction of the forces it exerts at every point in its neighborhood.

Small compass; two bar magnets; horseshoe magnet; iron washer; cardboard.

Put a compass at different points around a bar magnet. Note that at each point the compass is acted upon by the magnet and forced to assume a specific direction. The direction in which the north pole of the compass points is said to be the direction of the magnetic field at that point.

You can make a map of the magnetic field around a magnet by drawing a series of lines around it such that the direction of the magnetic field at any point on one of these lines is along the tangent to the line at that point. Each of these lines is called a *line of force.* An infinite number of such lines would be needed to show the magnetic field at every point around the magnet. However, if you draw a sufficiently large sample of the lines of force, you will have an effective picture of the forces that act in the neighborhood of the magnet.

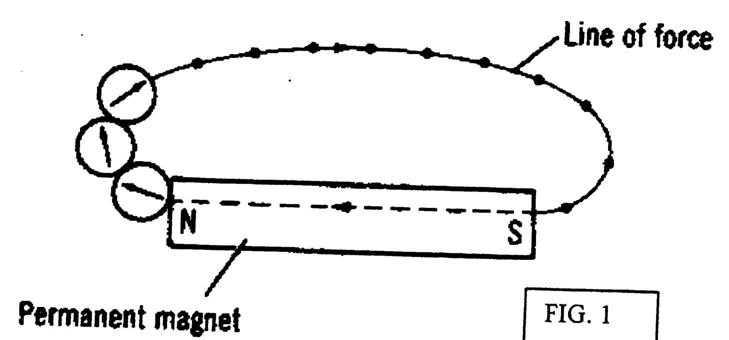

FIG. 1

PROCEDURE: To draw a single line of force around a bar magnet, begin by putting the magnet in the middle of a large sheet of paper and outlining its form on the paper with a pencil. Put a compass at one corner of the north pole of the magnet as shown in Fig. 1. On the paper mark, by dots, the positions of the north and south poles of the compass. Move the compass a little farther from the magnet until the new position of its south pole coincides with the dot marking the previous position of its north pole. Mark the new position of the north pole by a dot. Again move the compass, making its south pole coincide with the new dot, and mark the new position of the north pole by a dot. Continue this process until the compass reaches the south pole of the magnet.

Draw a smooth curve through the dots you have marked from the north to the south pole of the magnet. Complete the curve by joining its ends with a dotted line drawn through the outline of the magnet. See Fig.1. This closed curve is a complete line of force. It is said to begin in the north pole of the magnet, to go to the south pole, and to complete its path through the magnet. Beginning at another point on the north pole of the bar magnet trace a second complete line of force. Using the above method you can trace as many lines of force in a magnetic field as desired.

1. Make a drawing of the observed field around a bar magnet showing about eight lines of force.

2. Line up two bar magnets on a sheet of paper so the N-pole of one is about 10 cm from the S-pole of the other. Mark the outlines of the two poles on the paper. Using the method of tracing single lines of force with a compass, trace four lines of force between the poles. Put arrows on the lines of force to show their direction.

3. Line up two bar magnets on a sheet of paper so that the N-pole of one is about 10 cm from the N-pole of the other. Mark the outline of the facing poles of the two magnets on the paper. Proceed as in *Case 1* to trace two separate lines of force leaving *each* of the facing poles. Stop tracing the lines of force as soon as they begin to turn back toward their own south poles.

4. Cover a horseshoe magnet with a large thin sheet of cardboard. Draw at least eight lines of force of the field.

CONCLUSION:

1. For each of the *Cases 1, 2, 3,* and 4, where are the lines of force most concentrated?

2. How does the field in *Case 2* demonstrate that the lines of force repel each other?

3. What evidence is there in *Case 4* that the field directly between the poles of the horseshoe magnet is much stronger than elsewhere?

4. Why cannot two lines of force in any magnetic field cross each other?

5. List the three rules for drawing a magnetic lines of force.

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Physics
Topic: Mystery Lab
Week 6, Day 5

Objective: SWBAT
- Determine an unknown.
- Use observational skills to solve a problem.
- Use the scientific method to solve a problem.

Standards:
S4a
S6c
S5(all)

Materials:
- One set of black boxes for each student
- Balance

Motivation:
Challenge students to predict what is in a closed shoebox on the teacher's desk.

Aim:

How can we determine the nature and structure of the interior of a 'black box'?

Activities:
1. Have students complete the activity provided with this activity.

Summary:
Show students materials in the black box after experiment.

Assessment:
None required.

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PROBLEM:

How can we determine the nature and structure of the interior of a 'black box'?

INTRODUCTION:

The term 'black box' is used to describe any device or physical system whose internal parts are not accessible to the observer. In some respects all of physics deals with 'black boxes'; for example, the structure of atoms and molecules cannot be directly observed. In earlier experiments, we estimated the size the wavelength of a particular color of visible light by drawing inferences from other data, rather than by measuring the quantity directly. In a similar fashion, in a black box experiment, data is collected from which a model of what is in the box is proposed. That model is then tested by further experiments. Physicists have always used this procedure in constructing models and theories of the real world. The study of black boxes goes directly to the heart of what physicists do. In this experiment, you will examine a sealed box and gather data about it. From that data you will propose a model of the unseen interior of the box. You will then test your model and come to some conclusion about its merits.

MATERIALS:

One set of black boxes for each student; balance

In physics we always make models to help explain what we observe. Most gases are invisible and the properties of their molecules are not observable in any simple, direct manner. However, from the behavior of gases when subjected to changes in pressure or temperature, from their behavior when gases are mixed in a container, and from a host of other observations, a kinetic-molecular theory of gases was developed. When this model was tested, it predicted the behavior of gases quite well up to a point. Further investigation suggested that the forces between molecules, as well as their volumes, neglected in the first model, needed to be taken into account. This required a modification of the early model. Later experiments led to results that required physicists to take account of quantum effects in the model. Thus, models are continuously proposed and then modified in the face of new data. The process seems to have no end, yet it is an intrinsic and essential part of physics.

In this experiment you will examine a box. All the boxes given to the class are identical. **No box is to be opened during the experiment.** All of the boxes contain a number of objects that are nearly identical in weight and size.

PROCEDURE:

Place each of the containers on to a balance and carefully determine the mass of each container. Use the mass of the container and your measurements to determine the mass of each of the objects inside of the container.

DATA:

Box #	Mass 1	Mass 2	Mass 3	Mass 4	Average Mass	Mass of Container	Total Mass of objects inside container	Estimated number of objects in the contain

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CALCULATIONS:

Devise a method to determine the mass of each of the objects inside the container. Describe the procedure that you used and the calculations that you made to determine the mass of the objects inside the container.

CONCLUSION:

1. Describe a famous experiment discussed in class that is similar to the measurements that you made in lab.

2. Define the word model.

3. How is the model that we have of the atom similar to a black box?

4. What are some sources of error in this experiment?