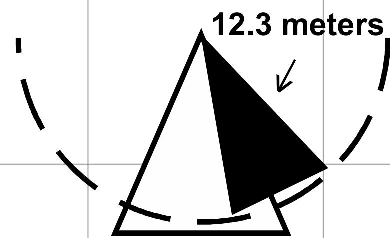

SEABREEZE PHYSICAL SCIENCE

The Science of Fun: Hands-on Learning Program

Developed in cooperation with
Greece Athena Middle School Rochester, NY

Seabreeze AMUSEMENT PARK®

Rochester NY

Welcome to the Seabreeze Physical Science Program

This hands-on learning program is designed for the middle school physical science class level, and was created by science teachers at Greece Athena Middle School in Rochester NY. Educators are encouraged to use any or all lab exercises within this document as you see fit, and to let us know if you have any questions or comments on ways to improve the program. If you'd like to create another exercise or educational program and share it with us, we would welcome it! Have fun sharing with your students the Physical Science of Fun.

Test Questions

There are ten questions for each of the seven rides included in this packet. These multiple choice questions are based on observations of the rides, therefore, the ride need not be taken for the questions to be answered. It's suggested that no more than two students should work together.

A chaperone can be stationed at each of the test rides to answer any questions the students might have and to administer the test - or a central location can be established where the students can go for help and to take their test. Six or more answers should be correct to successfully complete the objectives covered on the ride. Before attempting the next series, the teacher (chaperone) will discuss the questions which were missed.

The test questions are found on the pages that follow, along with the test key and a chart of the rides and related concepts.

Newton's Law of Motion In-Class Exercises

Several in-school laboratory exercises on Newton's Law of Energy are found in the back of this workbook. They can be incorporated into the forces and motion section of the curriculum.

References

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Sumners, Carolyn; "Falling Up"; "Science Activities"; February/March 1985; pp 9-11.

Unterman, Nathan A.; " Amusement Park Physics"; J. Weston Walch, Publisher; PO Box 658, Portland ME 04104-0658; 1990.

Walker, Jearl; "Roll'em"; "Science World"; April 7, 1989; pp 17-19.

Glossary

Acceleration:

Rate of increase in speed and/or change in direction of motion. Newton's Second Law of Motion: Whenever an unbalanced force acts on an object, acceleration results. The amount of acceleration depends on two things: the amount of force and the mass of the object. Force = Mass in grams x acceleration in m/sec.

Circumference:

Distance around the outside of a circle.

Centripetal force:

Any force that keeps an object moving in a circular path. (i.e. gravity for a planet moving around the sun, friction for a car going around a turn etc.)

Conservation of momentum:

The total momentum that exists within a system before a collision equals the total momentum in that system after a collision.

Conservation of energy:

A system's energy can be neither created or destroyed. It can only change from one form to another (i.e. Mechanical to Electrical)

Deceleration:

Negative acceleration.

Energy (forms):

The ability for an object to do work. (Different forms of energy are light, heat, magnetic, nuclear, electrical, mechanical and chemical.)

Energy (kinds):

Different kinds of energy are potential and kinetic.

Distance:

Space between two points.

Doppler Effect:

Sound is louder when the source is approached than when going away from it.

Force:

A pull or push.

Force of gravity:

Effect of the attraction between two objects. The force is dependent upon the mass of the objects and the space between the objects.

Friction:

Opposing force at the surface between two objects. The amount of friction depends upon the amount of surface area and the texture of the surface.

"g" force:

Force felt by a person; the force felt by a person on Earth is 1 g. Between 0 g and 1g a person feels lighter than normal; over 1 g, the person feels heavier than usual. On Earth every kilogram feels a gravitational force of about 9.8 newtons.

Glossary (cont'd.)

Height:

Distance above the ground.

Inertia:

Tendency of matter to remain at rest or moving at a constant velocity. Newton's first Law of Motion states that an object at rest tends to stay at rest; an object moving at a constant velocity remains at a constant velocity unless there is an unbalanced force applied to the object.

Kinetic energy:

The energy an object possesses due to its motion.

Momentum:

Measure of how difficult it is to stop a moving object or change its direction. Momentum depends upon the mass and velocity of the object. The greater the mass; the greater the velocity. The greater the velocity; the larger the force to change the object's direction. Momentum = Mass x velocity.

Negative acceleration:

Decreasing an objects speed.

Positive acceleration:

Increasing an objects speed.

Potential energy:

A form of stored energy.

Power:

The amount of push or pull which moves an object through a distance during a given amount of time. Power = Work in newton meters divided by time in seconds.

Rotational motion:

Movement around a central point.

Speed (real):

The distance covered in a given amount of time. Speed = Distance in meters time in seconds.

Speed (apparent):

Distance which appears to be covered between two points which is dependent upon the observer's location.

Time:

An interval between events.

Velocity:

Speed in a given direction, distance covered in a specific time in a given direction.

Weight:

The measurement of the force of gravity in newtons.

Weightlessness:

A condition in which you feel no forces; 0 g.

Work:

The amount of force which causes an object to change its position. Work = Force in newtons x distance in meters.

SEABREEZE PHYSICAL SCIENCE IN-PARK EXERCISE

BUMPER CARS

1. The bumper cars have rubber bumpers because
   (1) it is cheap
   (2) it absorbs much of the impact
   (3) it reduces the sound

2. The cars get their energy from
   (1) a gasoline engine
   (2) momentum from previous collisions on a frictionless floor
   (3) The electrical circuit that is formed between the ceiling, car and the floor

3. The electrical sparks from the ceiling are from
   (1) friction
   (2) faulty wiring
   (3) The electrical circuit that is formed between the ceiling, car, and floor causes and electrical current to flow.

4. We do not see the exhaust coming from the bumper cars as we do from real cars because
   (1) the exhaust comes out beneath the car
   (2) It is changed into an invisible gas
   (3) the power for the car comes from electrical energy and not from gasoline combustion

5. If the power suddenly stops, the car
   (1) continues moving in the same direction until friction brings it to rest
   (2) stops suddenly
   (3) changes direction until friction brings it to rest

6. If the floor is made of ice instead of metal, when the power suddenly stops, the car would
   (1) slide farther
   (2) not slide as far
   (3) moves the same distance it comes to rest

7. If you hit a car ahead of you, your body
   (1) moves backward
   (2) moves forward
   (3) moves with the car

8. If the car ahead of you goes faster than you in the same direction, the distance between cars
   (1) increases
   (2) decreases
   (3) remains the same

9. If the car behind you hits you, you
   (1) are thrown forward
   (2) are thrown backward
   (3) move with the car

10. When you rapidly step on the accelerator, you
   (1) lunge forward
   (2) are thrown backward
   (3) move with the car

SEABREEZE PHYSICAL SCIENCE IN-PARK EXERCISE

CAROUSEL

1. If the carousel were to suddenly stop, would you
   (1) be thrown forward
   (2) be thrown backward
   (3) be thrown toward the center

2. Have one person make a sound with a constant pitch stand on the ground. As the person on the carousel is moving towards the sound, it appears to the person moving that the
   (1) sound has a higher pitch
   (2) sound has a lower pitch
   (3) sound has the same pitch

3. The time it takes for a person near the outside rim to go around compared with the time it takes for some near the inside to go around is
   (1) the same time (2) longer (3) shorter

4. Two adjacent horses that ride up and down
   (1) have the same frequency
   (2) do not have the same frequency

5. Compared to a person standing at the center of the carousel, a person standing at the rim has
   (1) a greater velocity
   (2) a smaller velocity
   (3) the same velocity

6. Have one person make a sound with a constant pitch sit on the carousel. As the sound approaches, according to a person on the ground the sound
   (1) appears as a higher pitch
   (2) appears as a lower pitch
   (3) appears to have the same pitch

7. The power to turn the carousel comes from
   (1) an electric motor
   (2) a gasoline engine
   (3) horse power

8. Have one person make a sound with a constant pitch sit on the carousel. As the sound is moving away, according to a person on the ground the sound
   (1) appears as a higher pitch (2) appears as a lower pitch (3) sound has the same pitch

9. The horses that ride up and down
   (1) return to the same height after one complete revolution
   (2) do not return to the same height after one complete revolution
   (3) move with the car

10. Have one person make a sound with a constant pitch stand on the ground. As the person on the carousel is moving away from the sound, it appears to the person moving that the sound has
    (1) a higher pitch (2) a lower pitch (3) the same pitch

SEABREEZE PHYSICAL SCIENCE IN-PARK EXERCISE

JACK RABBIT

1. If the second hill is taller than the first hill
   (1) the car will make it up and over the next incline
   (2) the car will not make it up and over the next incline
   (3) the car may not make it up & over the next incline if there is too much friction present

2. At the bottom of the hill as the car is moving, the energy is
   (1) kinetic energy
   (2) all nuclear energy
   (3) all potential energy

3. If the car makes a right turn you are
   (1) thrown to the left
   (2) thrown to the right
   (3) thrown forward

4. The conversion of energy that makes the roller coaster work is similar to
   (1) a battery lighting a light bulb
   (2) a bowling ball rolling down a hill
   (3) an electric stove that boils water

5. Your velocity at the bottom of the highest hill is
   (1) practically zero
   (2) the greatest during the entire ride
   (3) somewhere in between

6. When the chain first pulls you up the roller coaster track, you
   (1) lunge forward
   (2) are thrown backward
   (3) do not move

7. If the car makes a left turn, you are
   (1) thrown to the left
   (2) thrown to the right
   (3) thrown forward

8. Your energy at the top of the first hill is
   (1) all kinetic energy
   (2) all nuclear energy
   (3) all potential energy

9. At the top of the first incline you velocity is
   (1) practically zero
   (2) the greatest during the entire ride
   (3) somewhere in between

10. If you were in a lighter car the time it would take to get to the bottom of the first hill
   (1) would be the same
   (2) take less time
   (3) take more time

SEABREEZE PHYSICAL SCIENCE IN-PARK EXERCISE

LOG FLUME

1. The boat is sitting lower in the water when
   (1) there is no one in the boat
   (2) when one person is in the boat
   (3) when everyone is in the boat

2. Your energy at the top of the hill is
   (1) all kinetic energy
   (2) all nuclear energy
   (3) all potential energy

3. At the top of the first hill your velocity is
   (1) practically zero
   (2) the greatest during the entire ride
   (3) somewhere in between

4. When the belt first pulls you up the hill, you
   (1) lunge forward
   (2) are thrown backward
   (3) do not move

5. To a person in the log boat, when they hit the water, the water
   (1) goes forward
   (2) flies backward

6. The log boat slows down when it hits the water because
   (1) the log boat collides with the massive water
   (2) the brakes
   (3) friction with the bottom

7. If there was no water on the slide, you would go down the slide
   (1) faster
   (2) at the same speed
   (3) slower

8. To a person standing on the ground, when the log boat hits the water, the water
   (1) goes forward
   (2) flies backward

9. When you first step in the log boat, the boat
   (1) raises slightly
   (2) there is no change
   (3) sinks slightly

10. When the log boat hits the water, you
    (1) lunge forward
    (2) are thrown backward
    (3) do not move

SEABREEZE PHYSICAL SCIENCE IN-PARK EXERCISE

SEA DRAGON

1. The force on you is greatest when you are
   (1) at the bottom
   (2) at the top
   (3) somewhere between

2. At the highest point the potential energy is
   (1) a maximum
   (2) a minimum
   (3) not involved with this ride

3. Between the highest point and the lowest point
   (1) the kinetic energy is changing to potential energy
   (2) the potential energy is changing to kinetic energy

4. The energy to lift the Sea Dragon in the air comes from
   (1) a nuclear power generator
   (2) a gasoline engine
   (3) an electric motor

5. You have the greatest acceleration when you are
   (1) at the bottom
   (2) at the top
   (3) somewhere between

6. You weigh the greatest when you are
   (1) at the bottom
   (2) at the top
   (3) somewhere between

7. The Sea Dragon is similar to
   (1) a yo-yo
   (2) a pendulum
   (3) a carousel

8. The force on you is similar to the force introduced from the
   (1) Wildwater Log Flume
   (2) Carousel
   (3) Bumper Cars

9. It is easier to see people on the ground when you are
   (1) at the bottom
   (2) at the top
   (3) somewhere between

10. You are moving the fastest
   (1) at the bottom
   (2) at the top
   (3) somewhere between

SEABREEZE PHYSICAL SCIENCE IN-PARK EXERCISE

TWIRLIN' TEA CUPS

1. You have the greatest acceleration when
   (1) the ride is stationary
   (2) the ride is at full speed
   (3) the ride first starts

2. The faster the Tea Cup turns,
   (1) the less the force that holds you to the side
   (2) the greater the force that holds you to the side
   (3) there is no difference in the force holding you to the side

3. If there was no friction between you and the seat
   (1) you would still be able to make the Tea Cup rotate
   (2) you would not be able to make the Tea Cup rotate
   (3) friction does not play a part in you ability to make the Tea Cup rotate

4. By shifting your mass towards the direction of rotation, you
   (1) make the Tea Cup rotate faster
   (2) make the Tea Cup rotate slower
   (3) will not affect the rotational speed of the Tea Cup

5. The type of force exerted on you is similar to the force found riding the
   (1) Log Flume (2) Jack Rabbit (3) Tilt-A-Whirl

6. The force is greater on you when you are
   (1) nearest the outside of the ride's path
   (2) nearest the inside of the ride's path
   (3) somewhere in between the two

7. What is the centripetal force that keeps you moving in a circle as you spin in the Tea Cup
   (1) gravity
   (2) friction

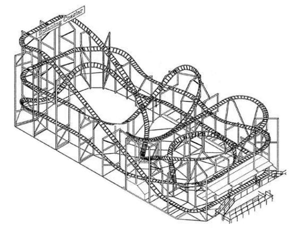
8. You are moving the fastest when you are
   (1) nearest the inside of the ride's path
   (2) nearest the outside of the ride's path
   (3) somewhere in between the two

9. If the center wheel turns counterclockwise, the Tea Cup
   (1) rotates counterclockwise
   (2) rotates clockwise
   (3) sometimes clockwise and sometimes counterclockwise

10. You have the greatest change in velocity when
   (1) the ride is stationary
   (2) the ride is at full speed
   (3) the ride first starts

SEABREEZE PHYSICAL SCIENCE IN-PARK EXERCISE

WHIRLWIND



1. As the car reaches the top of the first hill the energy the cars possess is primarily
   (1) potential energy
   (2) kinetic energy
   (3) chemical energy
   (4) electrical energy

2. As the car moves down the first hill what happens to its potential energy?
   (1) increases
   (2) decreases
   (3) stays the same

3. As the car moves down the first hill what happens to its kinetic energy?
   (1) increases
   (2) decreases
   (3) stays the same

4. As the car moves down the first hill what happens to its total energy?
   (1) increases
   (2) decreases
   (3) stays the same

5. As the car rotates you feel
   (1) as if you're being pulled in toward the center
   (2) as if you're being pushed toward the outside of the car
   (3) no difference from before the car started rotating

6. The sensation you experience while you rotate can best be described by
   (1) Newton's 3rd Law of Motion
   (2) Newton's 1st Law of Motion
   (3) Kepler's 3rd Law of Planetary Motion
   (4) Ohm's Law

7. The motion of a rotating car moving around a circular track most closely resembles
   (1) a car moving down a straight road
   (2) a planet moving in orbit around the Sun
   (3) a runner sprinting around a track.

8. Your apparent weight is greatest when
   (1) you're going over the top of the 2nd hill.
   (2) while you're being brought to a stop at the end of the ride.
   (3) you're moving through the bottom of the tallest hill.

9. The energy conversions taking place during this ride most closely resembles
   (1) Mechanical → Electrical → Chemical → Heat
   (2) Electrical → Mechanical → Sound → Heat
   (3) Nuclear → Chemical → Heat → Electromagnetic

10. Any energy lost during the ride is lost due to the conversion of mechanical energy into
    (1) electromagnetic energy and heat
    (2) chemical energy and nuclear energy
    (3) sound and heat

SEABREEZE PHYSICAL SCIENCE TEST ANSWERS

BUMPER CARS	CAROUSEL	JACK RABBIT	LOG FLUME	SEA DRAGON	TWIRLIN' TEA CUPS	WAVE SWINGER	WHIRLWIND
1. #2	1. #1	1. #3	1. #3	1. #2	1. #3	1. #2	1. #1
2. #3	2. #1	2. #1	2. #3	2. #1	2. #2	2. #2	2. #2
3. #3	3. #1	3. #1	3. #1	3. #2	3. #2	3. #3	3. #1
4. #3	4. #1	4. #2	4. #2	4. #2	4. #1	4. #2	4. #3
5. #1	5. #1	5. #2	5. #2	5. #1	5. #3	5. #1	5. #2
6. #1	6. #1	6. #2	6. #3	6. #1	6. #1	6. #2	6. #2
7. #2	7. #3	7. #2	7. #3	7. #2	7. #3	7. #2	7. #2
8. #1	8. #2	8. #3	8. #1	8. #1	8. #1	8. #2	8. #3
9. #2	9. #1	9. #1	9. #3	9. #2	9. #1	9. #1	9. #2
10. #2	10. #2	10. #1	10. #1	10. #1	10. #2	10. #2	10. #3

SEABREEZE PHYSICAL SCIENCE IN-PARK EXERCISE

WAVE SWINGER

1. The force keeping you moving in the circle is similar to
   (1) a satellite moving in a circular path around the earth
   (2) a stone attached to a string swung in a circular path
   (3) a fast car banking on a turn and the passenger side door keeps you from flying outside across the seat

2. If the wheel were rotating in the other direction, you would
   (1) fly in towards the center
   (2) fly away from the center
   (3) hang directly below the chain

3. As you are turning
   (1) the distance between you and the chair ahead of you is increasing
   (2) the distance between you and the chair ahead of you is decreasing
   (3) the distance between you and the chair ahead of you is constant

4. If the ride is turning faster, you
   (1) fly in towards the center more
   (2) fly away from the center more
   (3) hang directly below the chain

5. As you are turning, you
   (1) can see the person ahead of you clearly
   (2) cannot see the person ahead of you clearly

6. As you are turning, you
   (1) can see the center post clearly
   (2) cannot see the center post clearly

7. As you are turning, you
   (1) can see the people on the ground clearly
   (2) cannot see the people on the ground clearly

8. As you are turning, you
   (1) can return the chair so that it hangs beneath the chains
   (2) cannot return the chair so that it hangs beneath the chains

9. If gravity were not present, as you turn you
   (1) would fly all the way out so that you were horizontal
   (2) would hang directly below the chain
   (3) would fly in towards the center post

10. As you are turning, you
   (1) fly in towards the center
   (2) fly away from the center
   (3) hang directly below the chain

Rides and Concepts

Concepts	Carousel	Jack Rabbit	Twirlin' Tea Cups	Whirlwind	Wave Swinger (Rotating Swing)	Bumper Cars	Log Flume (Free fall)	Sea Dragon (Pendulum Ride)
Doppler	X				X			
Centrifugal	X	X	X	X	X			
Centripetal	X				X			
Potential		X		X	X		X	X
Kinetic	X	X	X	X	X	X	X	X
Friction	X	X	X	X	X	X	X	X
Inertia						X		
Positive Acceleration Negative	X	X	X	X	X	X	X	X

Circular Motion (Centrifugal, Centripetal)

Kinematics (Potential, Kinetic)

Newton's (Inertia, Positive Acceleration Negative)

X = Most Obvious

NEWTON'S 3 LAWS OF MOTION

Law #1: Law of Inertia

- An object moving at a constant speed will remain moving at a constant speed unless acted upon by an outside force.

- An object at rest will remain at rest unless acted upon by an outside force.

- *This law explains why you fly forward in a car when it comes to a sudden stop, or why you lean to the right when your car makes a left turn.*

Law #2:

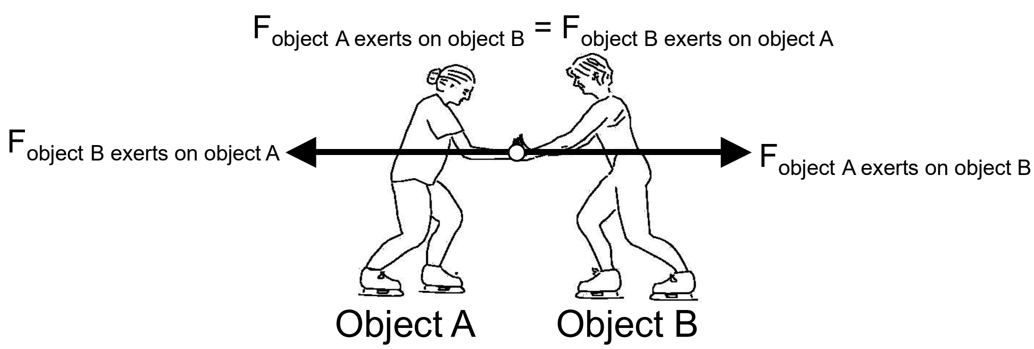
- The acceleration of an object is directly proportional to the force applied to the object and inversely proportional to the object's mass.

    - Basically this law says two things:
        - If the force applied to an object increases, the acceleration of that object will increase.
        - If the mass of an object increases and the force on it stays the same, the acceleration will decrease.

Law #3: Law of Action/Reaction

- For every action there is an equal and opposite reaction.

- If object A exerts a force on object B, then object B will exert an equal force on A but in the opposite direction.



In-class Exercise

Objective: To observe the effect of man on inertia.

Introduction: Newton's First Law: Inertia

If you tie a baseball on a string hanging from the ceiling it will stay where you place it. If you hit it with another baseball, both balls will rebound in different directions.

How far the balls move depends upon the force you use to throw the ball and the mass of each ball. For example, if you replace the hanging ball with a soccer ball and hit it with the baseball, the baseball will move faster and farther than will the soccer ball.

Newton's first law states that objects at rest tend to stay at rest unless acted upon by an unbalanced force. The soccer ball will hang towards the floor unless acted upon by the force of the thrown baseball. Newton's law also states that objects in motion tend to stay in motion in a straight line unless acted upon by an unbalanced force.

In this exercise you will apply an unbalanced force on two coins. Each coin will move in a straight line at a constant speed and direction. When they collide, both coins will change their speed and direction until the force of the friction stops their motion. How far and fast each coin moves depends upon their individual masses and the beginning force. It is important to keep the beginning force the same for each coin.

Newton's First Law: Inertia

Materials:

quarter	penny	piece of paper
dime	ruler(metric)	
nickel	pencil	

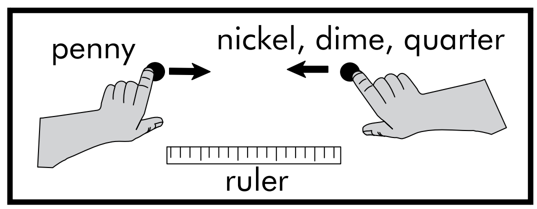


DIAGRAM # 1

Procedure:

1. Take your ruler and place it on the edge of a table so that the centimeter side is right-side up.
2. Take the penny and the dime and hold them 30cm apart.
3. Slide the penny and the dime togther so they can rebound off each other.
4. Use a pencil to mark where the penny and the dime hit. Mark where the dime hit. Mark where the penny stopped.
5. Measure how far the penny traveled from the point that it hit the dime. Record the information on a chart with these headings: coins, distance penny-cm; distance: dime-nickel-quarter- penny-cm.
6. Measure how far the dime traveled from the point that it hit the penny. Record the information.
7. Take the penny and nickel and hold them 30cm apart.
8. Slide the penny and nickel together so they rebound off each other.
9. Use a pencil to mark where the penny and nickel hit each other.
10. Measure how far the penny traveled from the point that it hit the nickel. Record the information.
11. Measure how far the nickel traveled from the point that it hit the penny. Record the information.

(Cont.)

In-class Exercise

Procedure (cont.):

12. Take the penny and the quarter and hold them together like in diagram #1.
13. Slide the penny and the quarter together so they rebound off each other.
14. Use pencil to mark where the penny and the quarter hit each other.
15. Measure how far the penny traveled from the point it hit the quarter.
16. Measure how far the quarter traveled from the point that it hit the penny. Record the information.
17. Predict the hitting of a penny to a penny,
18. Test your prediction.

Interpretation Questions:

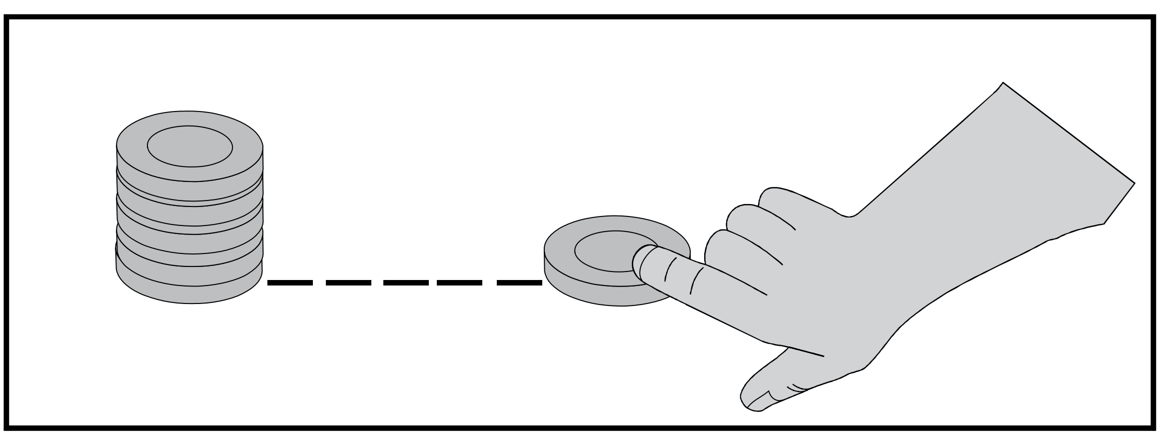
1. State Isaac Newton's First Law of Inertia.
2. Explain how this lab could explain what would happen when:

    A) a half back hits a lineman
    B) a truck hits a car
    C) a bumper car hits another bumper car
    D) a bowling ball hits the pins

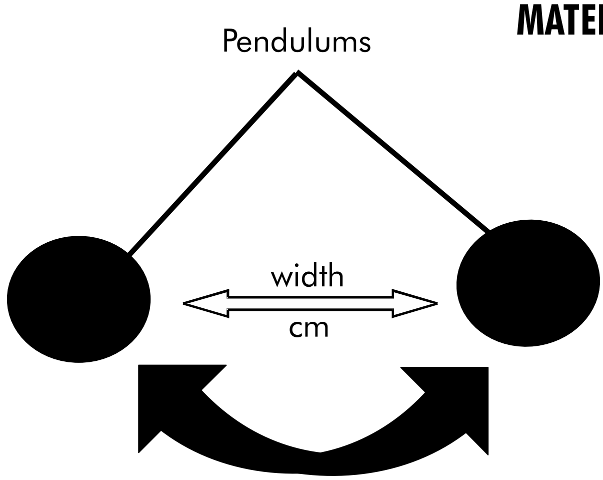
Demonstration

Use a bar magnet to show the motion of an object to and away from the magnet.
Use different balls to show the effects of their weights and sizes on the distances they bounce.
For example use: golf ball and ping pong ball/tennis ball and baseball.

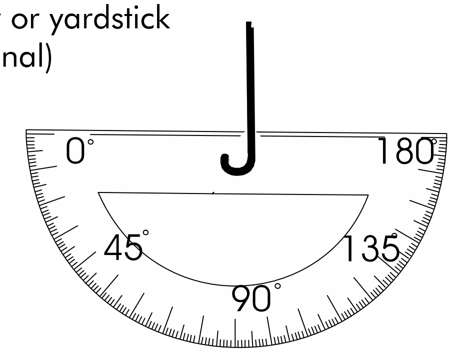
Stack a group of checkers in a column. Hit another checker in the stack. Look at the resulting location of (1) the checkers from the bottom of the stack; (2) the checker you hit.



In-class Exercise



MATERIALS: string
steel washers or nuts(different weights)
stop watch or watch w/second hand
ruler, meter or yardstick
scale (optional)



OBJECTIVE: To study the effect of the length and weight of a pendulum.

INTRODUCTION: A pendulum is a suspended weight free to swing between two extreme points. Galileo was the first scientist to study the movement of a pendulum. His interest began while watching a chandelier swing from the ceiling of a cathedral. The experiments Galileo conducted were similar to what you will now do.

EXPERIMENT:

1. Cut the string into 3 different lengths: 2 meter, 1.5 meter and a 1 meter.
2. Securely fasten or tie one end to a hook, plant hanger or shelf that is higher than the length of string.
3. Tie one of the washers or nuts to the other end.
4. Make sure your pendulum can swing freely without hitting any objects.
5. Make a chart to record your findings:

LENGTH (m)	NUMBER OF WEIGHTS	WIDTH OF SWING(cm)	TOTAL TIME 1 SWING	TIME OF 10 SWINGS

6. Record the length of string used and the number of weights used.
7. Move the weight to one side and let it go.
8. Time and record how long it takes for the pendulum to make 10 complete swings.(One complete swing is from the starting point to the other side and back again.)
9. Carefully measure and record the distance between the two extreme points.
10. To get an average for the swings: Divide the total time by 10 and record the average time for one swing.
11. Using the same length of string, change weights and repeat #7 - #10.
12. Secure your second length of string and repeat #6 - #10.
13. Secure your third length of string and repeat steps #6 - #10.

INTERPRETATION: According to your findings:

a) Does the length of string change the time for one complete swing?
b) Does the weight affect the time for one complete swing?

In-class Exercise

Introduction: Centrifugal and Centripetal Force

As an object goes in a circle around a point there are two forces which act on that object. One force holds the object toward the center and the other force is one which would carry the object into space

The name of the force which holds the object towards the center is called centripetal; the force which goes off at an angle is called centrifugal.

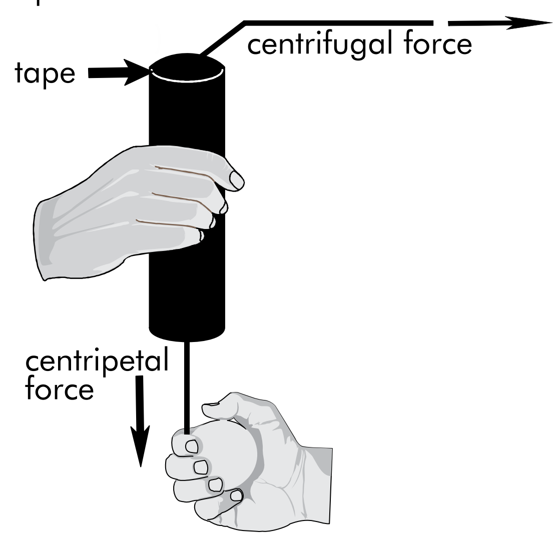
When a space craft is hurled into an orbit by a force sufficient to overcome the gravitational pull, it enters into an orbit around the earth. The force which holds it towards earth, centripetal, is called gravity. To keep the space craft in its orbit additional energy must be added to it.

In this exercise, we will observe the forces acting on an object as it goes in a circle. These are similar to forces which are in effect on many amusement park rides.

Materials:

string (1.5 meters)
*spring scale (newtons)
tube (paper towel or toilet paper)
weight (nut or washer)
safety glasses
tape

* not necessary for procedure A



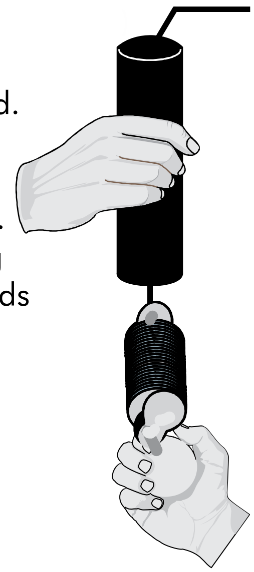
Procedure A

1. Tie the 1.5 meter string around a weight.
2. Place tape around one end of the paper towel or toilet paper tube.
3. Thread the string through the tube with the weighted end at the taped end.
4. Firmly hold the end of the string.
5. Swing the tube so the weighted end does not line up with another person.
6. Feel the tug against your hand. This tug or pull is called centripetal force. It is the force pulling an object towards the center of its curved path.
7. Vary the length of the string from the top of the tube to the weight.
8. Feel the change of the centripetal force as you vary the size of the circle.
9. When swinging the weight in the circle, let out about 30 cm. CAUTION: DO NOT LET GO OF THE STRING.
10. Observe the path that the weight takes immediately when you release your hold.

(Cont'd.)

In-class Exercise

Procedure B:



1. Tie the 1.5 meter string around a weight.
2. Place tape around one end of the paper towel or toilet paper roll.
3. Use the spring scale to measure its weight in newtons.
4. Record its weight.
5. Thread the string through the tube with the weighted end at the taped end.
6. Attach the spring scale to the end of the string at the bottom of the tube.
7. Firmly hold the end of the spring scale.
8. Swing the tube so the weighted end does not line up with another person.
9. Feel the tug that the weighted end is exerting against your hand. This tug or pull is called centripetal force which is the force pulling an object towards the center of its curved path.
10. Observe the force on the spring scale.
11. Record the centripetal force.
12. Vary the length of string from the top of the tube to the weight.
13. Each time you vary the length of the string, record the centripetal force.
14. When swinging the weight in the circle, let out about 30 cm.
    CAUTION: DO NOT LET GO OF THE STRING.
15. Observe the path that the weight takes immediately when you release your hold.

Interpretations:

1. Draw and label the parts and forces of the apparatus.
2. Based on your past amusement park experiences list rides in which some of the thrill is in centripetal and centrifugal forces.
3. Many toys are based on these forces. Name them.

Demonstration:

1. Place sand into a bucket. Use water if you are adventurous.
2. Swing the bucket in a circle
3. Discuss the force which keeps the bucket from flying out into space and the force which holds the sand/water in the bucket.

There are several variations of the above demonstration.

* Make a platform of wood and string. Tie a length of string to where those strings intersect. On the platform place a clear plastic cup with water in it. Swing the platform in a circle.
* Place a board on a clothes hanger. Attach a string to the hook of the hanger. Swing the hanger in a circle.