Domain: Physical Science
Theme: Quest

Before beginning this set of experiments, students learned about Newton's quest to understand the laws of motion. They explored forces and inertia using a flat sheet of Plexiglas, a wooden block, and a marble. Using balls and ramps, students then experimented with the principles of velocity, momentum, and gravity (Experiments 1-3). After many trials, we determined that solid spheres of a similar material roll down a ramp at the same speed, even if they are of different size or mass. We teased apart the technical difficulties of the experiment and worked to minimize factors (like friction) that would affect our results. We discussed at length the variables that could affect our results.

Students then examined the axis of rotation and the distribution of mass (moment of inertia) for several rounded objects (solid and hollow spheres, disks, cylinders, and hoops) and tested the effect on acceleration (Experiment 4). Using the ten possible pair-wise combinations, students compared the speed of two objects at a time. Classes combined and analyzed the data (almost 1000 trials for 34 students!) and ordered the objects from fastest to slowest.

This set of experiments was conducted over a period of three laboratory blocks (four classes per block).




Name:_____

Experiment 1: Balls and Ramps

Question: Does the height of the ramp have an effect on the speed of the ball?

Hypothesis: (don't forget the "because" word!)

_____

_____

_____

_____

Roll the ball down the ramp at 3 different heights. Record your results each time.

Height from base to highest point	Low Height cm	Med. Height cm	High Height cm
Trial 1 speed			
Trial 2 speed			
Trial 3 speed			

How close in time were your three trials? Explain what could have caused any differences. _____

_____

_____

_____

Did height have an effect on the speed of the ball? Why or why not? _____

_____

_____

_____

_____

_____

Name:_____

Experiment 2: Mass and Circumference

Question: Which rolls faster? Comparing two balls with the same circumference, but different mass.

Hypothesis: (don't forget the "because" word!)

_____
_____
_____
_____

Steel ball weight:_____

Glass ball weight:_____

Which is the first down the ramp? Conduct 20 trials.

	First down the ramp
Steel	
Glass	
Tie	

Results:

_____
_____
_____
_____

Name:_____

Experiment 3: Mass and Circumference Part II

Question: Which rolls faster: a small ball or a larger ball, with the same mass, but different circumference?

Hypothesis: _____

Ball	Weight	Circumference
Small		
Large		

Which is the first down the ramp? Conduct 20 trials.

	First down the ramp
Small	
Large	
Tie	

Results:

Summary of experiments 1-3

(Here I have students reflect on the data they have collected so far.)

Same size, different mass

What happened: _____

I think this happened because: _____

Same mass, different size

What happened: _____

I think this happened because: _____

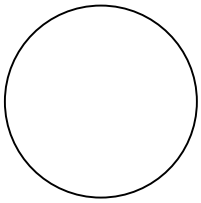
Name:_____

Experiment 4: Distribution of Mass

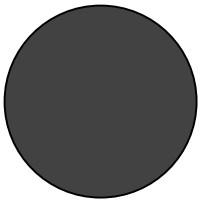
Question: Which rolls faster? Comparing different rounded objects and how the distribution of mass affects speed.

(Note: Before starting this experiment we took a trip down to the playground. Students experimented on spinning equipment. They asked how fast do we spin with our arms in versus our arms out? Equipped with these observations, we examined the rounded objects diagramed below. Students hypothesized about velocity and the distribution of mass.)

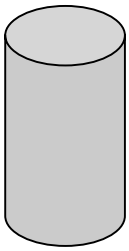
Indicate where the mass is distributed.



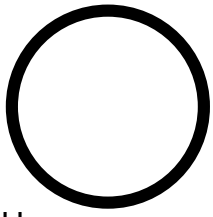
Hollow ball



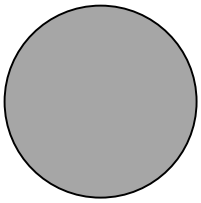
Solid ball



Cylinder



Hoop



Disk

Hypothesis: Which will roll the fastest? Slowest? Explain your thinking!

_____

_____

_____

_____

_____

_____

Name:_____

Experiment 4: Hollow and solid spheres, hoops, disks, and cylinders

	Type	Measurements (mass and circumference)
Object 1		
Object 2		
Object 3		
Object 4		
Object 5		

Data: Set 1. Conduct at least 20 times.

	first down the ramp
Object 1	
Object 2	
Tie	

Results from set 1. What happened? _____

2. Now add a new object with a different distribution of mass. Measure and then complete the trials.

	first down the ramp
Object	
Object	
Tie	

Results from experiment 2. What happened? _____

_____

_____

_____

3. Select another object to add to your trials.

	first down the ramp
Object	
Object	
Tie	

Results. What happened? _____

_____

_____

Conclusion

List each of your trials and circle the winner in each.

What can you conclude? How does the distribution of mass affect the rotation speed?

What experiment would you do next? Why?

Name:_____

Rolling Objects Class Data

Times overall winner	Times overall winner
Disk	Solid sphere
Disk	Hoop
Cylinder	Hoop
Cylinder	Disk
Hollow sphere	Hoop
Hollow sphere	Solid sphere
Disk	Hollow sphere
Hoop	Solid sphere
Cylinder	Solid sphere
Cylinder	Hollow sphere

Which was the fastest (had the most momentum)? Slowest? Explain why (don't forget the because word!)

_____

_____

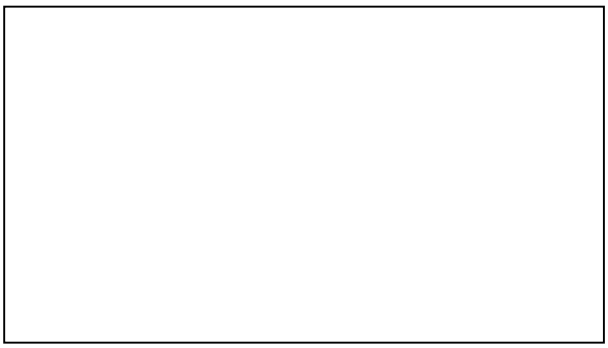
_____

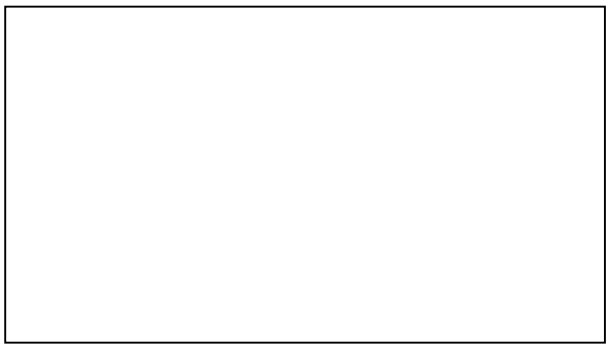
_____

_____

_____

How could this information be useful in an engineering or design project? Be creative!





Glossary

acceleration - the rate of change of velocity with respect to time

angular momentum - a vector quantity that is a measure of the rotational momentum of a rotating body or system, that is equal in classical physics to the product of the angular velocity of the body or system and its moment of inertia with respect to the rotation axis, and that is directed along the rotation axis

friction - the force that resists relative motion between two bodies in contact

inertia - a property of matter by which it remains at rest or in uniform motion in the same straight line unless acted upon by some external force

mass - the property of a body that is a measure of its inertia and that is commonly taken as a measure of the amount of material it contains and causes it to have weight in a gravitational field

moment of inertia - a measure of the resistance of a body to angular acceleration about a given axis that is equal to the sum of the products of each element of mass in the body and the square of the element's distance from the axis

momentum - a property of a moving body that the body has by virtue of its mass and motion and that is equal to the product of the body's mass and velocity; broadly : a property of a moving body that determines the length of time required to bring it to rest when under the action of a constant force or moment

velocity - the rate of change of position along a straight line with respect to time: the derivative of position with respect to time

Materials

Ramps
Smooth (finished) wooden planks (ours measured 11”x44”)
Large wooden blocks to vary the height
Carpet square to prevent the ramp from slipping
Plastic bin at ramp bottom to capture balls

Spheres
Bouncy balls of various sizes
Ping Pong balls
Size assortment of steel balls
Assortment of plastic, Styrofoam, and foam balls (borrowed from PE teacher)
Glass, cork, and steel ball set (Nasco product SB28570M)

Hoops
Tape rolls of various size

Cylinders
Batteries of various size

Disk
Antacid tablets or jar lids

Other
Timers
Rulers
Materials to record data

References

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Kwitter, K. and Souza, S. (1999) *Force and Motion: Hands-On Science Series*, Portland, ME: Walch Publishing.

Shamos, M.H. (ed.) (1987) *Great Experiments in Physics: Firsthand Accounts form Galileo to Einstein*, New York, NY: Dover Publications, Inc.

Tolman, M. N. (1995) *Hands-On Physical Science Activities for Grades K-8*, West Nyack, NY: Parker Publishing Co.

VanCleave, J. (1991) *Physics for Every Kid: 101 Easy Experiments in Motion, Heat, Light, Machines, and Sound*, New York, NY: John Wiley & Sons, Inc.

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