Bowler's Ed

STEM

International Bowling Campus
Youth Development

15_648 08/15

SCIENCE TECHNOLOGY ENGINEERING AND MATH (STEM) BOWLING

TEACHING OBJECTIVES AND STUDENT KNOWLEDGE

Why are bowling lanes oiled with more oil placed at the start of the lane and less at the end? What is the advantage of throwing a “hook” ball? And why do those pins remain standing though the ball hit them? Using an elementary-based physics approach, the student and teacher will benefit through a practical application and learning when participating in the In-School Bowling/Bowler’s Ed experience.

The United States Bowling Congress (USBC) and Bowling Proprietors’ Association of America (BPAA) understand science, technology, engineering and mathematics (STEM) are not just for professional scientists anymore and regularly are taught in elementary education. Through the unique characteristics of the sport of bowling, we are able to provide a fun and academically sound addition to the Bowler’s Ed curriculum, further increasing cross-curricular opportunities and academic enrichment.

Bowling is enjoyable for players of all skill levels because it is easy to get started and see real results (like bowling a strike), yet most people can play for years without coming close to the elusive perfect game. The dynamics of the bowling ball, the oil, the gutters, etc. exhibit interesting concepts from math and physics that are accessible to anyone with a background in differential equations.

The addition to the Bowler’s Ed Teachers Curriculum was designed to meet the growing needs of STEM instruction in elementary education. In a simple game of bowling, we can witness all types of situations that deal with motion, speed, velocity, acceleration, forces and more! The following teaching tool will cover bowling history, vocabulary and additional activities that can be taught in the classroom/ bowling center or to an advanced audience.

Through the instruction of the Bowler’s Ed program and continued participation, it allows the educator to use science terminology and literacy devices covered in language arts classes. Students will be met with more cross-curricular learning opportunities compatible with history, geometry and many more activities blending athletics and academics. Finally, advanced teaching tools can be found at the end of this section to assist with higher-level learning.

Teaching Objectives:

- Inertia effects on objects of varying masses
- Friction is a force that can effect inertia
- Energy of moving objects
- Transference of energy
- Motion of objects during a collision
- Applied force affects collisions

Student Knowledge and Understanding:

- Newton’s Law of Motion
- Force and Acceleration
- Rotational and Circular Motion
- Inertia vs. objects of varying masses
- Friction is a force and its effect on inertia
- Transfer of energy between moving objects
- Motion of objects during a collision
- How applied force effects collisions

INTRODUCTION

Bowling looks easy! Especially when USBC Team USA or bowling professionals are seen competing in the bowling center or on television. However, there is a lot more to bowling than simply throwing a ball down a stretch of wood to knock over some pins. Bowling is a precision sport, and to fully appreciate it one must fully understand the bowling environment.

Nothing helps develop understanding and interest in science, technology, engineering and mathematics principles more than application examples a student can relate to. Bowling provides a fun platform to illustrate different principles and explain how changes in technology have made large impacts on a familiar sport.

Before we talk about the science in bowling, we need to understand the vocabulary relating to bowling through a scientific lens. **Motion** is the act of an object moving from one place to another. A **Force** is any pull or push that causes an object to move, stop or change direction. **Friction** is a force that opposes motion when two surfaces rub against each other. **Magnetism** is the force of pushing or pulling between poles of magnets. **Gravitation** is a force that pulls all objects toward one another. **Inertia** is the property of matter that keeps an object moving in a straight line or keeps it at rest.

Objects that have a lot of **mass** also have a lot of **inertia**. Inertia means that objects want to keep on doing what's they're already doing. For instance, it is difficult for us to push a 16-pound bowling ball to get it moving since it is so massive. The 16-pound ball has a lot of inertia. A marble, on the other hand, is not as massive as a bowling ball. If we chose to move a marble, it would not be as hard as the bowling ball. A marble has less inertia since it has less mass. In either case, objects at rest will stay at rest, and objects in motion will stay in motion unless acted upon by an outside force.

Activity #1- Mass & Distance

Question: which of these marbles has more inertia?

A **B** **C**

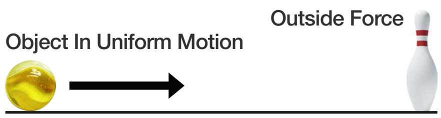
Activity on Page 13

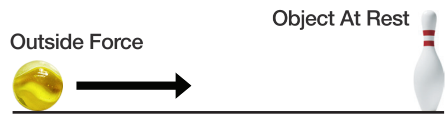
Did you know....

In 1930, British anthropologist Sir Flinders Petrie, along with a team of archaeologists, discovered various primitive bowling balls, bowling pins and other materials in the grave of a protodynastic Egyptian boy dating to 3200 B.C., very shortly before the reign of Narmer, one of the very first Egyptian pharaohs?

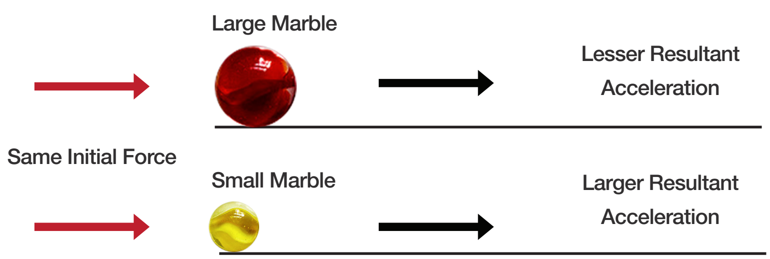
NEWTON'S LAWS OF MOTION

Sir Isaac Newton formulated three laws of motion. **Newton's first law** being, an object at rest will remain at rest and an object in motion will continue to move at the same speed and in a straight line unless acted upon by an external force. The most basic example of this is the bowling pins will remain standing and at rest until they are acted upon by the external force of the **unbalanced force** bowling ball knocking them over. Another example is that when the ball is released, it will continue to roll in the same direction until acted upon by a force. Either the ball will hit the pins, or it will roll off the carpet lane (in the case of Bowler's Ed) or into the gutter (in the case of in-center bowling).

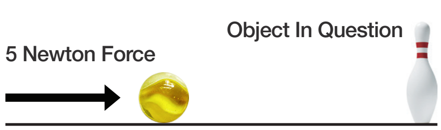


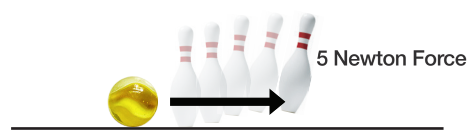


Newton's Second Law of Motion states that if the same force is exerted on two objects of different masses there will be a difference in the change of motion of the two objects. The change in motion is called **acceleration**. When a bowler lines up for their four-step approach, the first thing that happens to the ball is that it accelerates away from the bowler. Then the ball stops and accelerates on the back swing. Just like a pendulum, the ball accelerates forward as the bowler releases the ball down the lane toward the pins. Remember, the pins are at rest. When the accelerating ball hits the resting pins, it causes them to become unbalanced forces and they accelerate into each other.



Newton's Third Law of Motion states that for every action force there is an equal and opposite reaction force. When you sit in a chair at the bowling center, the force of you sitting in the chair is equal to the force of the chair supporting you. In a practical on-lane application, when the ball is rolled down the lane, the ball is the action force to the pins. The falling pins become the reaction force.





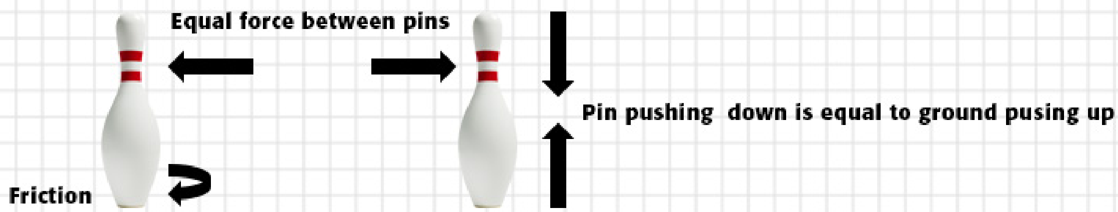
Did you know....

The first nationally televised 300 game by a woman was thrown by Michelle Feldman?

FORCES, FRICTION AND MOMENTUM

Forces acting on an object can sometimes balance each other. Forces that are equal in size and opposite in direction are **balanced forces**. An example of a balanced force is two pins standing next to each other. When the forces are equal, the object will remain stopped or continue to move at the same speed and direction. When we see the pins set up at the end of the lane, it seems as if there is no force acting on the pins, but there is. The force of the ground is holding up the pins. The force of gravity is pulling the pins toward the center of the earth. The force of **friction** is helping to keep the pins from sliding off the lanes.

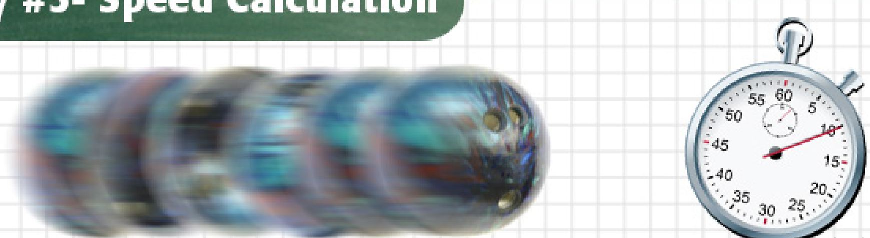
Activity #2- Effects of Friction



Activity on Page 14

When one force is greater than its opposite force, they are **unbalanced forces.** We rely on the unbalanced forces of the rolling ball to knock down the pins. The force of the rolling ball is greater than the forces of the pins, thus knocking them down. Once the pins start to fall, they become unbalanced and can knock each other down. The ball itself cannot hit every pin; therefore, we must rely on unbalanced forces of the falling pins to get a strike.

Activity #3- Speed Calculation



Activity on Page 15

Does it matter how hard we roll the ball? The answer is…YES! If we do not apply enough force on the ball, it won't have the **energy** to knock down the bowling pins. The ball might not even make it to the end of the lane! Remember: energy from our arms is transferred to the ball; this makes the ball move. The ball now has **momentum** moving down the lane. This energy is then transferred to the pins during collision. The energy from the ball causes the pins to fall down. But both the pins and the ball have **inertia**. They will not move unless we apply **force** to them.

Any **mass** that is in motion has momentum. In fact, momentum depends upon mass and speed. Mass is the amount of “stuff” that is moving. Speed is how fast the “stuff” is moving. A 16-pound bowling ball has a lot of momentum, much more than a marble moving at a high speed which has less momentum. What happens when a marble collides with another marble that is at rest? Energy in the moving marble is transferred to the marble at rest and will cause it to move, similar to if you struck it with your finger.

Momentum is a measure of how hard it is for an object to slow down or stop. The conservation of momentum can be illustrated in the basic collision of the ball and pin. When a bowling ball collides with a pin, the momentum lost by the ball is equal to the momentum gained by the pins. An example of this principle is the coefficient of restitution test that USBC conducts on all bowling balls. The coefficient of restitution (COR) of two colliding objects is typically a positive real number between 0.0 and 1.0 representing the ratio of speeds after and before an impact, taken along the line of the impact. The CoR test we run on bowling balls and bowling pins is done on a custom-built device. For our CoR testing, we use a test pin designated only for CoR testing and roll the approval sample ball down a ramp into the pin from a set distance. We use sensors to detect the speed of the ball and the pin (in feet per second) before and after impact.

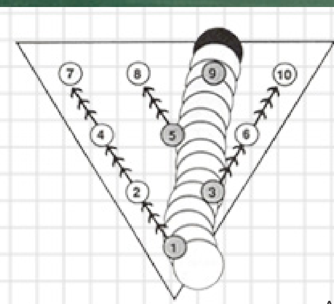
Momentum is a quantity formed by the mass of an object and its velocity, described in mathematical terms:

p (momentum) = mass (m) times velocity (v)

If we throw the ball as hard as we can, it doesn’t mean that all of the pins will fall down. The energy in the ball must be transferred to the pins to get them to move. The bowling pins have inertia. This means they don’t want to fall down on their own. They want to keep standing. To get them to fall, we must apply a force. That force comes from the momentum of our bowling ball. To increase our momentum, we have to increase our force. We also have to increase the balls’ torque so its spins long and far. With all these things to think about, are we ready to knock them all down every time?

No, not yet! Where we throw the ball is just as important as how hard we throw it. Remember, the bowling pins have inertia. They want to remain standing. If no force is applied, none will fall. Our force must be evenly distributed. This means it has to be spread to every pin. To get a perfect “strike” every time, you have to hit the front pin just the right way. This is what makes bowling so challenging! The figure below shows one way the ball can travel through the pins as the other pins collide into each other. For most strikes, the ball will only contact the 1-pin, 3-pin, 5-pin and 9-pin. The rest of the pins fall because they are contacted by another pin.

Activity #4- Targeting and Angles



Activity on Page 16

TECHNOLOGY, EQUIPMENT AND SPECIFICATION

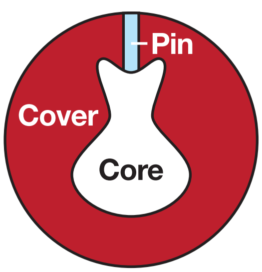
Technology touches areas of everyday life. Bowling is no different and for years also has been changed by technology.

Ball - Early in bowling, the ball was made of a solid piece of very hard wood. After that, hard rubber was the cover of the ball in the early 1900s. Plastic (polyester) coverstocks became popular in the 1960s. The smooth texture and hard surface of this coverstock allowed the ball to skid on the lane. Because of the durability and lower cost of these balls, they are what is primarily used as the “house balls” in most bowling centers. Urethane coverstocks came into bowling in the 1980s. These covers were softer and more porous than the previous plastic covers, allowing the ball to hook more on the lane. In the early 1990s, bowling ball coverstocks changed yet again to what is being primarily used today – Reactive resin. By adding an additional component to the urethane coverstocks, even more texture was created in the cover allowing for even more hook on the lane.

Pin - Bowling pins have also changed slightly over time. The starting point for bowling pins has stayed fairly similar throughout the years. They are then shaped into a bowling pin using a lathe – a wood cutting tool. In the past, the pins were only painted. Pins have a tough life being hit by bowling balls over and over, so instead of just applying a coat of paint, pins today are coated in a layer of plastic.

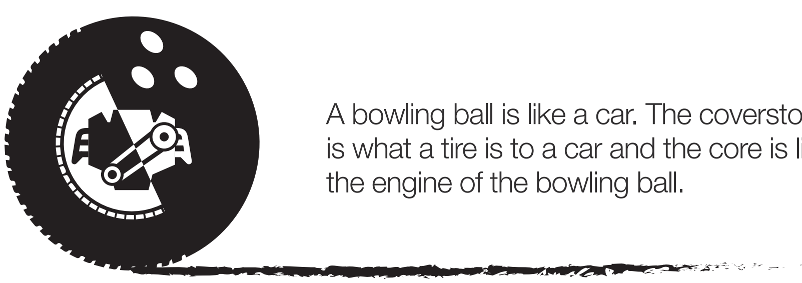
Lane - If a lane is heavily oiled, a softer ball must be used in order for that all-important curve to take effect. If the lane is lightly oiled, a harder ball must be used to prevent the ball from over-curving. Most significantly, however, it requires a knowledge of the playing conditions, a familiarity with ball-lane interactions, and, above all, a healthy respect for SCIENCE!

BOWLING BALLS



Bowling balls are made up of 2 main components:

1. Coverstock (the exterior material of the ball)
2. Core (the interior of the ball)
   * Both have evolved over time.



A bowling ball is like a car. The coverstock is what a tire is to a car and the core is like the engine of the bowling ball.

All bowling balls are NOT created equal. Aside from the obvious weight differences, each ball must be custom fitted to your hand in order to provide maximum control and comfort. In addition, the finish of the ball is very important. A very hard ball will not grip the lane as well as a soft ball. This is very important in controlling how much one's ball curves as it makes its way toward the pins. Finally, the core of the bowling ball is not necessarily uniform. Some balls are heavier on one side, further promoting spin and curve. The ball grips the lane, and, if thrown with a spin, will curve much more easily than a hard thrown ball. If a straight throw down the middle is more your style, a hard ball is more in order. It allows for less finesse, but more power. The engine of the bowling ball, or core, is very important because the shape of the core changes the way the ball rolls down the lane.

Did you know....

Each year approximately 310 brand new bowling balls approved by USBC?

Each bowling ball that is approved for use during USBC competition must meet a set of measurement specifications. Specifications are set limits on certain properties of a bowling ball to ensure that everyone is using a ball that fits within a specified range so someone does not get an unfair advantage.

Every bowling ball is measured for the following:

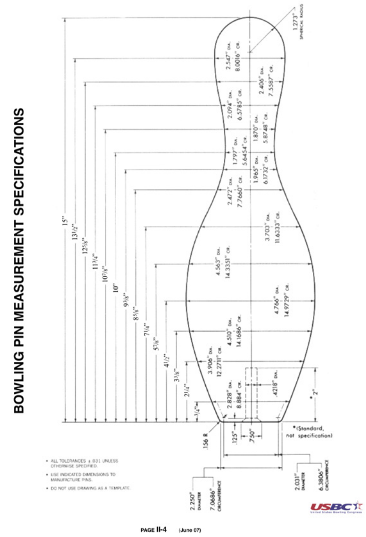
- Weight
- Hardness of the coverstock
- Circumference (or size of the ball – ten-pin bowling balls are all the same size)
- Roundness (the ball must be round like a sphere instead of oval like an egg)
- Radius of gyration (how hard or easy it is for the ball to rotate about an axis)
- Differential radius of gyration (difference between the highest and lowest radius of gyration)
- Coefficient of restitution (ratio of the speed of the ball and the pin before impact to after impact)
- Coefficient of friction (measure of force between ball and lane surface as ball moves on the lane)
- Surface roughness (measurement of the texture of the ball's coverstock)

Did you know....

USBC takes 38 measurements on each bowling ball submitted for USBC approval?

BOWLING PINS

Step 1 Step 2 Step 3



Did you know....

It takes between 7 and 17 pieces of wood to make a wood bowling pin? USBC takes 91 individual measurements on each bowling pin submitted for USBC approval.

A sample number of bowling pins for annual approval are measured for the following:

- Plastic coating thickness
- Radius of gyration
- Center of gravity
- Hardness consistency of the coating (rebound and impact)
- Diameter of the base
- Weight
- Height
- Size of the hole in the base
- Radius of the base
- Diameter at 13 specified distances
- Coefficient of Restitution

BOWLING LANE

Lanes are oiled from the foul line until about two-thirds of the way down the lane. This means the path of the ball is relatively unaffected by its spin until it reaches the lesser oiled third of the lane. Then, depending on its hardness, the spin of the ball imparts a curve upon it. This is why some bowlers throw the ball far from the center, and then it suddenly appears to veer into the pocket, as if by magic.

Did you know....

Over 1,100 miles of bowling lane surface are certified by USBC each bowling season.

ADVANCED LEARNING

Professional Bowlers vs. Recreational Bowlers

Top-level bowlers are able to adjust the speed at which they throw the ball, as well as the rate of revolution that is applied to the ball. Characterizing these bowlers by one set of parameters is very difficult since they adjust so well to throw the ball in a manner that makes them the most successful based on the competition they face.

In general, many league bowlers throw the ball at an average speed of 18 miles per hour and an average rate of 275 revolutions per minute.

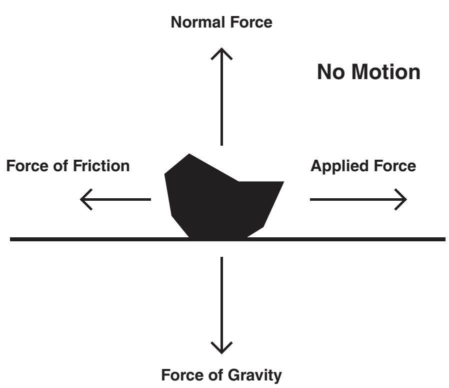
E.A.R.L., the bowling robot at USBC headquarters used for conducting research projects, can throw the ball as slow as 10 miles per hour at his release point and as quick as 24 miles per hour. Additionally, E.A.R.L. can impart from 0 revolutions per minute at release on the ball up to 900 revolutions per minute. E.A.R.L. has some super-human capabilities. He can throw the ball at any combination within those ranges.

Did you know....

Bowling pins weigh very close to the same, but bowling balls have a maximum weight of 16 pounds with no minimum weight? If a bowling ball that is 16 pounds impacts pins with the same speed as a 12-pound bowling ball, there will be different accelerations of the pins based on which ball is thrown.

Friction

A ball thrown down the lane will slow down over its course. The main cause of this is **Friction**. The magnitude of the friction between the bowling ball and bowling lane depends on what the surfaces are made of and the amount of oil on the lane, if there is any at all, and the mass of the ball. Some lanes will have no conditioning on it at all, while others will have oil placed to a certain degree on different areas of the lane. As the bowling ball travels down the lane, the friction between the ball and the boards will slow it down. The composition of the oil, and where it is denser on the lane, will have a different effect of the ball as it travels along the lane. The more oil that is laid down, the less friction there is between the ball and the lane surface. The less friction, the harder it is for the bowler to send the ball in a curved path imparted by the spin that the bowler puts on the ball at the instant of release.



Center of Gravity

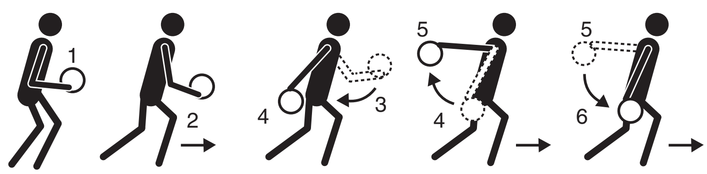
The **Center of Gravity** (CoG) is the point at which gravity can be considered to act. In most cases (with uniform gravity) it is equal to the center of mass. The CoG in bowling is both for the bowling pins and bowling ball. Bowling pins have a low center of gravity due to their shape, which make them more stable. The center of gravity of a bowling ball is not always in the absolute middle of the ball. The vector the center of gravity falls on within the ball is usually indicated by the position of the logo or punch mark on the surface of the ball.

Elastic or inelastic Collisions

A perfectly **elastic collision** is defined as one in which there is no loss of kinetic energy in the collision. An inelastic collision is one in which part of the kinetic energy is changed to some other form of energy in the collision. After collisions between bowling balls and the pins, you see the pins scatter and bounce when struck by the ball, transferring some of the kinetic energy from the bowling ball to the pins. Therefore, the collision is somewhat elastic. However, both the pins and ball get damaged over time, and come to rest after the collision, so the answer is that the collision is somewhat inelastic.

Energy

There are two basic kinds of energy: 1.energy of position 2.energy of motion



1 = Potential 2 = Kinetic 3 = Potential 4 = Kinetic 5 = Potential 6 = Kinetic

Kinetic energy is energy in use or in motion. Anything in motion has kinetic energy. Potential energy is energy that is at rest. All objects have potential energy. When the bowler holds the ball, the ball has potential energy. When the ball is pushed away from the body, the ball has kinetic energy and when the ball stops before the back swing, it has potential energy again. As the bowler begins the backswing, the ball returns to kinetic energy. For a brief second, the ball stops at the end of the backswing, and has potential energy until the bowler swings and rolls it forward down the lane. When the ball hits the pins, it causes the pins, which started out with potential energy, to have kinetic energy.

VOCABULARY

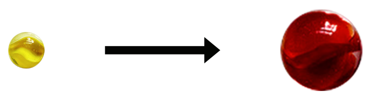
Speed	The ability to move your body or parts of your body swiftly
Static Balance	State of equilibrium, without movement. Stationary
Torque	A turning, or rotary force
Velocity	Rate of motion in a particular direction in relation to time. Quickness of motion.
Force	That which alters or tends to alter a body's state of rest or uniform motion in a straight line. The push or pull effect that one body produces on another body.
Inertia	The property of matter that resists an object's change in motion
Momentum	Measure of how hard it is to slow down or stop an object
Absorption	Interception of force or energy.
Acceleration	The rate at which velocity changes with respect to time.
Inertia	The tendency of all objects to resist any change in motion.
Moment of Inertia	Resistance to change in rotation
External Forces	Forces outside of the system that change or alter movement. Examples are air resistance, gravity, and contact with the ground or some other body.
F.I.T.T.	Frequency, Intensity, Time and Type, which are four key ways that activity can be manipulated to create a desired outcome.
Flexibility	The elasticity of muscles and connective tissues, which determines the range of motion of the joints.
Manipulative Skills	A skillful movement done to or with objects such as throwing a bean bag, striking a soccer ball, catching a Frisbee or juggling.
Radius of Gyration (RG)	Measured in inches, distance from the axis of rotation at which the total mass of a body might be concentrated without changing its moment of inertia.
Range of Motion (ROM)	Varying degrees of motion around a joint.
Radius of Rotation	Linear distance from an axis to a point on a rotating body.
Balance	The ability to control or stabilize your equilibrium while moving or staying still.
Balanced Forces	Forces that are equal in size and opposite in direction.
Dynamic Balance	State of the body moving with constant speed and direction with zero acceleration.
Center of Gravity	The imaginary point inside a body of matter where the total weight of the body is thought be concentrated
Core	The interior of the bowling ball; the core may consist of the inner core (weight block) and/or the outer core (lighter filler material).
Coverstock	The exterior or outer shell of the bowling ball.
Pin (in bowling ball)	This is used to indicate where the top of the weight block is located in the ball. It is also the axis of the ball with the lowest radius of gyration.

ACTIVITES

Activity #1 – Mass & Distance

Materials Needed:
Varying size marbles
string or tape
ruler

Procedure 1: Mass and Distance
a. Record the masses of each of the four marbles.
b. On paper, measure a distance of 12 inches using your ruler, and draw a line
c. Place a small marble on one end of your line, a larger marble at the other.
d. Roll the small marble so that it collides with the larger marble
e.



f. Measure with your ruler the distance that the larger marble traveled, after the collision.
g. Record your measurement. Do this three times: trail 1, trail 2 and trail 3.
h. Repeat experiment with the larger marble striking the smaller. Push larger marble into smaller one
i. Record your measurement. Repeat this three times.

Questions:

1. After the collision, which marble traveled farthest?
The collision involving the large marble striking the small marble will produce the largest distance. This is because the larger marble has more inertia, and strikes the smaller marble with the most force. The larger the force applied to an object, the more energy will be transferred, therefore producing the most distance. The small marble will not move the larger marble as far due to the fact it has less inertia.

2. Why do you think this happened?
Students should relate each of the interactions to inertia, force, and energy. They should understand that if an object has a large mass, it has more inertia, and therefore requires more force to get it to move. Because more force is applied, the object also will have more energy, which can cause motion. Larger things are harder to stop (require more force) than smaller things.

3. Does mass have anything to do with how far the marbles traveled?
a. Yes. The largest mass striking the smallest will result in the most distance. The largest mass has the most energy, and provides the greatest force for the smallest marble.

4. Did the hardness of your throw have a possible effect?
"Hardness of throw" is another way of saying "supply of force". A hard throw has a lot of force; a gentle lob does not supply much force. The greater the force, the more energy stored within the marble.

5. Complete the sentence:
The smaller marble travels farthest when struck with the most massive marble because the most **massive** marble has the greatest **inertia.**

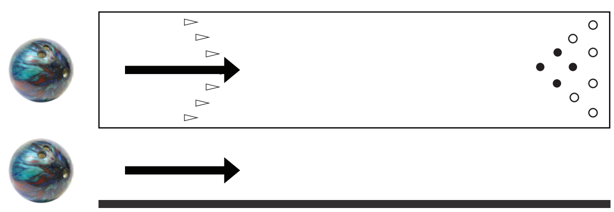
Activity #2 - Effects Of Friction

What makes the bowling ball roll best?

* This is best done as a controlled teacher demonstration

a. Place the Bowler's Ed carpeted lane down and tape off a similar lane distance alongside.
b. Make a prediction of how far you think your bowling ball will travel on the gym floor versus the carpeted lane. **Do you think the ball will roll easier on the carpet or on the gym surface?**
c. Place a ball on the carpeted lane and push it gently down the laneway from a seated position.
d. Record the distance traveled.
e. Place a ball on the gym floor. Push it gently across the marked area of the floor.
   * Have a student at the other end to stop the ball if it continues rolling.
f. Record the distance traveled.
g. Repeat this procedure 3 times for each.

(c)
(e)



	Distance 1	Distance 2	Distance 3
Carpet			
Gym Floor (not carpet)			

1. On which surface did the ball seem to roll the farthest?
a. Gym floor, since it provides the least amount of friction.

2. What difference did you notice between the floor and the carpet?
a. The carpet prevents the ball from rolling very far when gently pushed. The carpet is rough, and provides more friction. The gym floor is smooth, and does not have as much frictional force as the carpet.

3. Which of the two, carpet or gym floor, provides the least friction?
a. The gym floor, being the smoothest, provides the least amount of friction.

4. Why are bowling lanes made of wood and not carpet?
a. The wood allows the ball to roll quickly and farther than a carpeted surface. It would take too much force to roll a ball down a laneway made of carpet, because the ball will eventually stop rolling on a carpeted lane and never even make it to the pins.

5. How do you think it would differ if the bowling alley were made of sand? Grass? Ice?
a. Sand and grass would be difficult to roll the balls, in that they have a lot of friction: they are not smooth surfaces. Ice, being smooth and slippery, would be another alternative to the wood: both are smooth and provide little friction. This is why we slip on ice if we try to walk on it - it provides us with little friction.

Activity #3 - Force & Speed

Calculate the speed in which the ball traveled and the amount of force applied.

* Calculations of this nature are for students that have knowledge of how to divide numbers

Trial 1:
From a seated position, use both hands to push the bowling ball gently.
When the ball is released from your hands, start the timer.
When the ball reaches the end of the lane, stop the timer.
Record the time it took for the ball to travel down the laneway.

Trial 2:
Increase your force and push the ball it slightly harder.
Record the time it took for the ball to travel down the laneway.

Trail 3:
You may stand up. Using one hand, you may roll the ball quickly.
Record the time it took for the ball to travel down the laneway.

Switch with your partner and repeat the experiment.
Calculate the average speed for both you and your partner.

Calculate speed by dividing the distance in meters by the time in seconds.

Speed = Distance (m) ÷ Time (s)

	Lane Distance	Time Ball Rolled	Partner's Ball Speed (m/s)	Partner #2 Ball Speed (m/s)
Trial 1				
Trial 2				
Trial 3				
Average				

- Determine the length of the laneway with a metric tape measure.
- Have a partner ready with a stopwatch by the side of the lane.

1. On which throw did the ball travel the fastest?
a. Students should respond that the ball thrown quickly traveled the fasted. When they try to roll it fast, it means they are supplying more force. A greater amount of force means they will be providing the ball with more energy. More energy overcomes inertia.

2. On which throw did you apply the most force?
a. The last of the trials, where they threw the ball quickly, supplied the most force.

3. What can you conclude about how hard you throw the ball, and how fast it travels?
a. Students will be able to explain that the harder the ball is rolled, the faster it will travel. This is because they are providing the most force when they try to make it go farthest. The force applied to the ball provides the ball with energy.

<u>Activity #4 - Angles and Collisions</u>

<u>Materials Needed:</u>
Bowler's Ed In-School Bowling Equipment
Gymnastic mats or similar mats for 'bumpers' alongside lane

a. Roll the ball as straight as you can down the laneway.
b. Record how many pins you knock down.
   Repeat this 2 more times.
c. Roll the ball slightly to the left of the front pin. Record how many fall.
   Repeat this 2 more times.
d. Roll the ball slightly to the right of the front pin.
e. Record how many fall.
   Repeat this 2 more times.
f. Roll the ball down the alley so that it bounces off the sides. Observe ball speed after it bounces.
   Record how many pins are knocked down.
g. Repeat this 2 more times.
h. Find the average number of pins knocked down using each method.
   Construct a bar graph of your data.

	Lane Distance	Time Ball Rolled	Partner's Ball Speed (m/s)	Partner #2 Ball Speed (m/s)
Trial 1				
Trial 2				
Trial 3				
Average				

1. Which method knocked down the most pins?
a. Students' responses will all vary, due to how hard they roll the ball. In general, the straight forceful throw will knock down the most pins.

2. Which method knocked down the least?
a. The throw where they have to bounce the ball off the side-rails will knock down the least amount of pins, due to the fact that the ball loses energy to friction and due to the collisions (energy leaves the ball and it transferred to the rail each time it strikes). In these instances, the ball may not be able to roll the total distance to reach the pins since it loses so much energy, or it simply does not have enough force to knock down the pins when it reaches them.

3. What happened to the ball's speed after it bounced each time?
a. The ball's speed will decrease.

4. What happened to the ball's energy after it bounced off of the sides?
a. As energy decreases, speed decreases. Some of the ball's energy is transferred to the side-rails each time it strikes them, causing the ball to loose energy, and therefore loose speed.

REFERENCES AND CONTINUED LEARNING RESOURCES

References:

Walker, N., Dann, S., (2003) Bowling in Action. Crabtree Publishing Company

Oliver, K., Bowling the In-School Way with Lessons for Math and Science. Retrieved from http://www.okaloosaschools.com/shalimar/sites/okaloosaschools.com.shalimar/files/users/gilll/Bowling%20Book.pdf

Harcourt School Publishers. Harcourt Science, Life, Earth and Physical Science. N.p.: Harcourt School, 2000. Print.

Showers, N., (1969) Bowling. Pacific Palisades, Calif., Goodyear Pub. Co. 85 p. illus. 22 cm.

Day, N., and Raymner, M., (1962) How to Improve Your Bowling Athletic Institute. Chicago: Athletic Institute

Boomer Parks Elementary Fieldtrip Curriculum. Elementary Bowling Lesson Activities. Retrieved from http://www.boomersparks.com/site/Dania/educational/ELEMENTARYv2.pdf

Continued Learning:

Sports Science – PBA's Sean Rash
http://www.youtube.com/watch?v=gY-8BUnSgf4
In this video demonstration from ESPN Sport Science you will learn about velocity, acceleration and the force on a bowling ball and body upon release.

Science Chanel How It's Made – Bowling Ball
http://www.youtube.com/watch?v=cW4H31DS0QY
In this video you will learn about the combination of liquids that made up a bowling ball core, bowling ball and manipulation of bowling balls through construction and design.

Science Chanel How It's Made – Bowling Pin
http://www.youtube.com/watch?v=Y7ekdqyO-yM
Learn about the creation of a regulation bowling pin throughout the entire process. Additionally, you will learn about the weight, height, bowling pin dimensions and creation time.

Time Warp – PBA's Michael Fagan Swing Analyzed
http://www.youtube.com/watch?v=of92oOD6SqQ
In this video, PBA star Michael Fagan has his swing, bowling ball rotation speed and how he creates the speed/velocity analyzed on the lane.

15_648 08/15