EVERYDAY SCIENCE

Real-Life Activities

John M. Scott
illustrated by
David Morin

J. WESTON
WALCH
PUBLISHER
PORTLAND, MAINE

CONTENTS

Chapter Topics

Chapter 1

NATURE'S TRAFFIC LAWS

They're Enough to Kill You

On the night of April 8th, a red Corvette roared down Highway 18. Its speed was later estimated to be in excess of 100 miles per hour. The police took up the chase. By the time the police car turned the corner and reached the junction of Highway 18, not even the taillights of the speeding car could be seen. They thought that the driver had escaped, and thus succeeded in breaking a traffic regulation.

Nature, however, was "on the job" and insisted on "playing it straight." Just south of town, behind Campion High School, Highway 18 makes a slight curve. The speed of the Corvette, however, was so great that Newton's First Law of Motion took over.

Instead of making it around the curve, the Corvette zoomed straight into a field. An eyewitness said the car shot through the air 450 feet and rolled over 4 times. The shattered body of the driver was found 120 feet from the car. The car was stripped clean of most of its fiberglass body.

The "Highway Killer" that lurks on our expressways is known as Newton's First Law of Motion: "**EVERY BODY PERSISTS IN A STATE OF REST, OR IN UNIFORM MOTION IN A STRAIGHT LINE, UNLESS ACTED UPON BY AN EXTERNAL FORCE.**"

Newton's First Law of Motion has killed more Americans in auto accidents than the total number of Americans killed in World War I, World War II, the Korean War, Vietnam, and all other wars involving the United States.

Your first lesson in safe driving begins long before you sit behind the wheel of the family car. The most essential laws governing safe driving are not the ones enforced by the police. They are the fundamental laws of Nature.

The truth is that you can sometimes violate a traffic regulation and escape the consequences. But—and here is the most important fact—you cannot break nature's traffic laws.

Last year approximately 48,000 Americans tried to break nature's traffic laws. They paid the penalty—with their lives. Nature's laws are unrelenting, always in force, always demanding obedience. You do what nature says or pay the penalty—which is swift, sudden, and sure. No questions asked, no trial by jury, no delay.

700 PEOPLE STRETCHED OUT ON ROAD

In order to remind people of the deaths on their highways, 700 citizens of Portland, Oregon, did something very dramatic. They stretched out on a Portland highway to remind everyone that in the previous year 700 people died in car accidents in Oregon. Mobil Oil used a picture of this in a $4 million advertising campaign to promote auto safety. *Life* magazine gave a full page to this overwhelming picture of 700 bodies.

WATCH THAT CURVE!

Do you realize that the only "external force" that enables a car to turn is friction between the tires and road? When the road is covered with ice, there is less friction. The chance of making the turn is decreased and the conclusion is simple: "Cars that wreck themselves going around curves do so because they obey Newton's First Law of Motion!"

A CHILD IS TOP-HEAVY!

During the fall of 1980 a special warning was sounded for parents of young children. An infant is proportioned differently than an adult. This means that small children are top-heavy, usually until the age of five. If these children are not restrained in a car crash, or even a sudden stop, they tend to pitch forward headfirst. Even a minor collision can throw a small child against the car's interior and cause serious injuries.

Holding a child in a parent's arms is not a substitute for a Child Restraint System. Some people think that holding a child in a car protects the child but safety experts disagree. In an accident, a child in a parent's arms can be crushed between the car's interior and the unrestrained parent. Even if the parent is wearing a selt belt, in a 30-mile-per-hour collision a 10-pound child exerts a 300-pound force against the parent's grip. Chances are that even a strong adult won't be able to hold on to a child in such a situation.

SNOWMOBILE BRINGS DEATH

On Monday, December 19, 1983, the Des Moines, Iowa, *Register* carried a news item about two men who were killed riding a snowmobile. The men were traveling at such a high rate of speed that they missed a sharp curve. The snowmobile became airborne, flew about 80 feet in the air, and landed in a deep ravine.

NAVY PILOT SHOOTS HIMSELF DOWN

A Navy pilot who forgot Newton's First Law of Motion shot himself down. This fantastic accident, the first of its type in aviation history, occurred when test pilot Tom Attridge put his Grumman F11F-1 into an 888-mile-per-hour dive and fired two quick bursts over the Atlantic Ocean near Long Island.

The Navy gave the following explanation of the accident: "When a stream of cannon shells spewed from the four guns at the rate of 1000 rounds per minute, or better than 64 rounds for each four-second burst, they were traveling more than 1500 feet faster than the airplane. The shells were traveling forward and also were falling towards the earth. They were following a curved course toward the ocean. The jet meanwhile went into a steeper dive and increased its speed.

"About 2 to 3 miles from the point where the firing began, the plane and shells collided. One shell shattered the bulletproof glass in the jet's windshield. A second shell pierced the engine, which died, causing the jet to crash land in a wood. The 33-year-old pilot was hospitalized with a fractured leg and three broken vertebrae."

DANGER ON YOUR LAWN

Newspapers recently carried this warning: "The boy David of Biblical times is no longer with us, but on many lawns across America are modern mechanized 'Davids' which make use of Newton's First Law of Motion to injure more than 80,000 people every year.

"The 23-inch blade of a common rotary lawn mower can pick up a rock or chunk of metal and hurl it at speeds up to 240 miles per hour. A piece of wire traveling at this speed can penetrate a shoe, and be driven almost completely through the foot, damaging both bone and flesh. Physicians consider rotary mowers one of the most dangerous pieces of machinery their patients use."

CANNONBALL

Hugo Zacchini, billed as the Human Cannonball, is a gentleman who has put

Newton's First Law of Motion to work for many years. Ever since he was 20 years old, Hugo has been sliding into a cannon and getting hurtled out again by a force of compressed air equal to 250 pounds per square inch. Black powder is exploded at the same time, but only for dramatic effect.

As soon as Zacchini slips into the mouth of the cannon, the barrel begins to rise until it stands at an angle of 45°. There is a deafening blast, and Zacchini bursts from the cannon muzzle amid a cloud of theatrical smoke. Traveling at nearly 90 miles per hour, he sails upward with his arms extended like Superman. He narrowly avoids the yellow vinyl banners.

Now he begins his descent over the potted dwarf trees. He lands finally in the middle of a broad nylon net. The net sags like an old bed, nearly swallowing up Zacchini. Then the net shoots him upward like a watermelon seed. He bounces twice before he stops. He has traveled 170 feet.

DEADLY STATISTICS

A government report states that auto accidents are the leading cause of death of America's young people ages 1 to 24.

A study of the circumstances surrounding the death of the 20,279 young people who died in one year on our highways, reveals the following:

Most were male.
Most were drunk or on drugs.
Most were driving too fast.
Most were not using seat belts.
Most were not paying attention.
Most were driving on a Saturday.

DEER, DEER!

The Iowa Department of Transportation informs us that November is Iowa's most dangerous month of the year for traffic accidents involving deer. In 1983 there were 1,700 traffic accidents involving deer. Two persons were killed and 194 injured. The most dangerous time of the day for traffic accidents involving deer is from 6 P.M. until midnight.

PUNCH DRUNK

One of the most tragic and devastating examples of Newton's First Law of Motion is found in boxing. The human brain sits inside the skull like a mound of

Jell-O in a bowl. If a blow is delivered to the head, the bony ridges on the inner surface of the skull may slam into the outer membrane surrounding the brain. This membrane, which carries much of the brain's blood supply, may be torn. Blood then leaks into the space between the skull and the brain, building up brain-damaging pressure. More violent blows can damage the brain tissue itself when the skull smashes against the brain.

Even blows landed by inexperienced, relatively lightweight boxers can be very powerful. Tests at the University of Wisconsin show that a 145-pound amateur boxer produced an average of 600 pounds of pressure with each punch. The results of a punch of this force delivered to the head can be devastating. They include bruising, bleeding, and swelling within the brain, tearing of blood vessels leading to the brain, and damage to brain centers controlling speech, walking, and facial expressions.

Because punches to the head are so quickly effective in disabling an opponent, they are among the most potent and most frequently used weapons in the boxer's arsenal. So it may not be surprising that in a 25-year period more than 400 boxing matches have ended in the death of one of the contestants.

Recently, the Royal College of Physicians in London completed a 7-year study of 224 former professional boxers. The researchers came to the conclusion that the longer a man boxes, the greater the chances of permanent injury to his brain.

WHY IS THE PITCHER'S MOUND HIGHER?

Before he was felled by a stroke in July 1980, Houston Astros pitcher J.R. Richard was considered the best righthander in baseball. This 6-foot 8-inch giant could hurl a baseball at a speed of 98 miles per hour.

But not even J.R. Richard could throw a baseball in a straight line!

Why not? Does not Newton's First Law of Motion state that "a body in motion continues in motion in a straight line"?

It does, but it likewise adds, "unless compelled by an external force to change."

What is the "external force" that makes it impossible for a baseball, a bullet, or an arrow to continue in a straight line?

The answer is gravity. The pull of gravity makes the path of a baseball a parabola, a curve that goes down in a graceful arc.

As the baseball travels the 60½ feet from the pitcher's mound to home plate, it drops 3 to 4 feet. In order to allow for this loss in height, the pitcher's mound is made three to four feet higher than the bottom of the strike zone at home plate.

INERTIA

The tendency of a body at rest to remain at rest—and a body in motion to remain in motion in a straight line—unless acted upon by an external force, is called inertia.

If you are riding in the front seat of a car and the driver suddenly slams on the brakes, your body will continue to move forward unless stopped by an external force—hopefully by the seat belt and shoulder strap—or, unfortunately, by the windshield.

The word "inertia" comes from the Latin word "iners," meaning idle or unskilled. When we say that matter is inert, we mean that it does not have the power to move itself, or, if it is put into motion, it cannot stop itself.

"THE FASTEST MAN ON EARTH"

"The Fastest Man on Earth" is the title held by Lt. Col. J.P. Stapp. He was strapped into the rocket sled Sonic Wind. In just 5 seconds he was accelerated to a speed of 632 miles per hour. The rocket sled was then stopped in 1.4 seconds. Col. Stapp's arms and legs were securely tied to the sled. His eyes, however, tried to obey Newton's First Law of Motion. To see what happened, turn to page 259 of the *National Geographic* magazine for August 1955. You will find the most frightening pair of "shiners" you have ever seen. Col. Stapp suffered a temporary loss of vision. The experiments with the Sonic Wind were stopped. The risk to vision was considered to be too great to permit further testing.

HEADLONG DASH TO INJURY

A lead article in *Medical World News* on skiing was introduced with the caption "HEADLONG DASH TO INJURY." The subtitle read, "For 12,000 skiers the trail this season will end in the doctor's office."

One dramatic photo of a falling skier had this caption: "Boot-top fractures of the leg bones occur when the ski jams against an obstruction. As the body continues its forward motion, force is exerted against stopped ankle, snapping bones."

POLE VAULTING

Pole vaulting is a magnificent demostration of Newton's First Law of Motion. A young man holding a pole runs forward at maximum speed. As soon as he thrusts the pole into the ground, the pole becomes an "external force" that changes the horizontal, straight-line motion of the runner into a vertical motion that may carry him to a height of 18 feet.

"COASTING" ON A BOEING 747

If you've ever made an air trip between distant cities, such as Chicago and San Francisco, you may have noticed something strange. While your Boeing 747 jet is still many miles from your destination, the pilot cuts down on the power of the engines. You become aware of a decrease in the noise of the jets. In the near-silence you feel as though you are "coasting" through the sky. And so, indeed, you may. The inertia of the jet keeps the Boeing 747 moving forward.

BROAD JUMP

When track season rolls around in the spring, perhaps you try to win the broad jump. You run as fast as possible, then leap. Once you leap, you depend on Newton's First Law of Motion to carry you to victory.

WHIPLASH

Newton's First Law of Motion can cause great pain in a whiplash injury. The car of the whiplash victim, whether at rest or in motion, is struck from the rear by a second vehicle, usually moving at an appreciably greater speed.

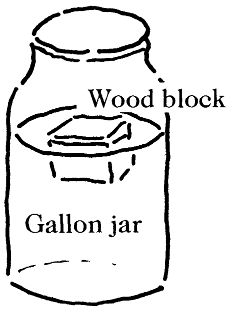
The impact of the collision acts instantaneously upon the seat of the car, since it is part of the chassis. The seat, in turn, pushes rapidly forward against the torso, or upper part of the body.

The weighty head, however, tends to stay in its previous position. The result is that the torso is forced by the impact to pass *under* the head. The effect is that the heavy head pushes down on the neck and spine, compressing them.

"A BODY AT REST TENDS TO REMAIN AT REST"

Perhaps you have demonstrated the first part of Newton's First Law of Motion on a school morning in mid-January when your mother called you to get out of bed. You proved only too thoroughly the fact that "a body at rest tends to remain at rest."

ACTIVITIES

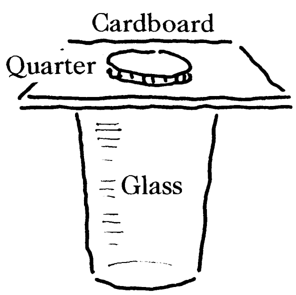


Activity 1

1. BLOCK IN JAR — *Home*

Fill a wide-mouth gallon jar about ¾ full of water. The school cafeteria or a restaurant may be able to supply you with a gallon jar. Place a small wood block in the water.

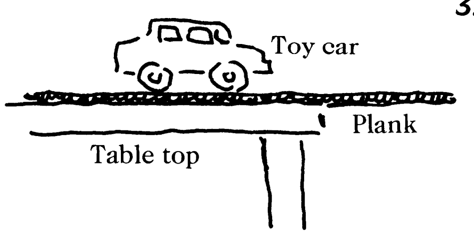
Now take hold of the gallon jar with both hands. Lift the jar off the table. Turn the jar through half a turn. What happens? Why?



Activity 2

2. QUARTER AND GLASS — *Home*

Place a small square of stiff cardboard over the open end of a drinking glass. Place a quarter in the center of the cardboard. Now give the card a sudden snap on the edge with your finger. The card will scoot away, and the quarter will drop into the glass. The quarter tends to stay at rest. It does not suddenly move forward with the cardboard.



Activity 3

3. CAR ON PLANK — *Supervised Classroom*

Place a small plank or heavy piece of cardboard on one side of a table, with about one foot of the plank extending out over the end of the table.

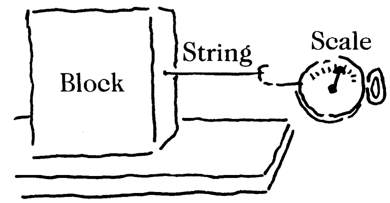
On top of the plank place a heavy toy car. Now grasp the free end of the plank and pull rapidly. Newton's First Law will keep the car on the table. It wants to remain at rest.

4. EXPERIMENT WITH THIS BOOK — *Home*

Instead of using a plank and a car, as in the previous experiment, try placing a piece of strong wrapping paper on top of the table. Leave about four inches of the paper sticking out over the edge of the table. On top of the paper place this book. Now take hold of the paper with both hands. Give a rapid pull on the paper. The paper will come with you, but the book will be left sitting where it was. This simple demonstration illustrates the fact that "a body at rest tends to remain at rest."

5. *HOW TO GET GOING* — ***Supervised Classroom***

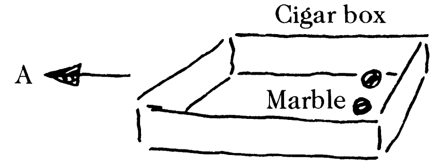
Hook a spring scale to a heavy block of wood or a toy automobile. Pull rapidly on the scale. Notice the indicator the moment you jerk the block into motion. What happens when you continue to pull? Why?



Activity 5

6. *ROLLING MARBLES* — ***Home***

Place a couple of marbles in the "back" end of an open cigar box. Push the box rapidly to the left, as indicated by the arrow pointing to the letter A. Stop the box suddenly. Note that the marbles will continue to move forward in the direction of A.

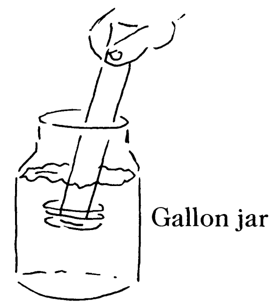


Activity 6

7. *WHIRLING WATER* — ***Home***

In this experiment we again use the wide-mouth gallon jar we used in our first experiment. After you fill the jar about ¾ full of water, do the following.

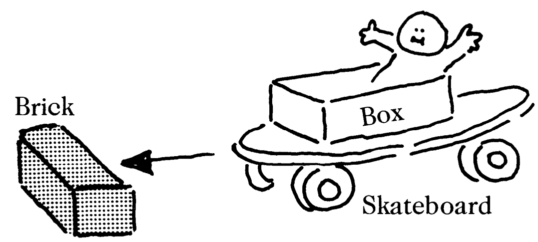
Insert a wooden ruler vertically into the jar and stir the water. When the water is racing around the walls of the jar at top speed, remove the ruler. Drop a small wooden block into the jar. What happens? Why?



Activity 7

8. *CABBAGE PATCH DOLL* — ***Home***

Tie an empty shoe box (or any other similar box) to a skateboard. Seat a Cabbage Patch doll, or any similar object, in the back of the box. Give the skateboard a swift push so it rolls swiftly across the sidewalk to collide with a brick or rock. Explain what happens.



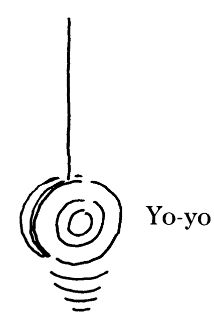
Activity 8

9. *YO-YO* — ***Home***

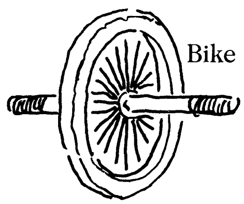
Put a yo-yo in motion and explain how it demonstrates Newton's First Law of Motion.

10. *GYROSCOPE* — ***Supervised Classroom***

One of the most interesting demonstrations I do for my students is this. I mount a big bike wheel (along with its heavy balloon tire) on an axle. On the ends of this axle I mount handles.



Activity 9



Activity 10

I pick up the bike wheel with my left hand and hold it in a vertical position. I grasp the tire with my right hand and give the wheel the fastest spin I can. I now place one handle of the rapidly spinning wheel into the right hand of a student. I ask the student to turn the spinning wheel from a vertical to a horizontal plane.

Students find this most difficult to do. The spinning wheel tends to stay in motion in one plane—in this case, a vertical plane. It resists any attempt to make it change.

11. SPINNING STOOL — Supervised Classroom

The next demonstration is even more interesting. I ask a student to sit on a swivel lab stool that is about 2½ feet high. I ask the student to sit far enough back on the swivel stool so his feet do not touch the floor. I ask him to extend both hands and grasp the handles of the bike wheel mentioned in the previous experiment. I ask him to keep the wheel in a vertical position.

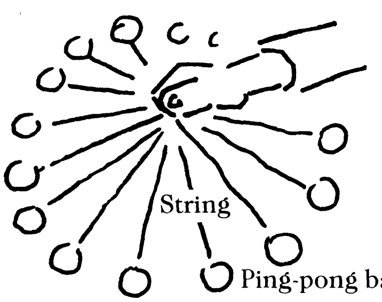
Now I grasp the tire with both hands. With all the strength at my command, I give the wheel a spinning force. I instruct the student to turn the spinning bike wheel from a vertical to a horizontal position. As soon as he does so, the student finds that he is spinning around on the swivel stool.

Now I ask the student to turn the wheel 180° so the bike wheel is spinning in the opposite direction. As soon as he does, the swivel stool also changes the direction of its spin.

Students delight in conducting this experiment for themselves long after the class period is over.

12. PING-PONG BALL — Home

Is it true that an object moving in a circle is trying to travel in a straight line?



Activity 12

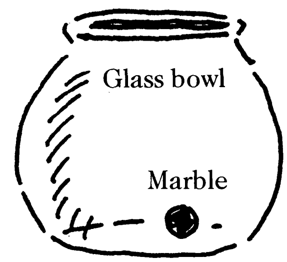
You can find out by whirling a safe "slingshot" that won't cause damage. Get a strong thread or string about 2 feet long. Use a darning needle to run the string through a ping-pong ball. After you've pulled the string through and tied a knot to hold it in place, pick it up and whirl it.

You soon become aware that the ping-pong ball is pulling on the string. This is because the whirling ping-pong ball keeps moving outward from the center of rotation. This outward pull is known as centrifugal force. ("Centrifugal" comes from a Latin term that means "to flee from the center.")

Now let the string go. The ping-pong ball becomes a body in motion in a straight line.

13. MARBLE IN GLASS BOWL — Home

Put a marble in a big glass bowl. Pick up the bowl with both hands. Give it a rotary motion. What happens? Why?

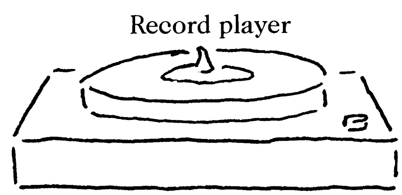


Activity 13

14. RECORD PLAYER — Home

An old 78 rpm record player with adjustable speed control is an excellent piece of equipment to demonstrate how centrifugal force depends on weight, radius, and speed of the objects placed on the turntable.

a. Place various small weights on the rim of the spinning turntable. What happens?
b. Place a weight at various distances from the center of the spinning turntable. What do you notice?
c. Vary the speed of the turntable. What happens to the weights placed on it?

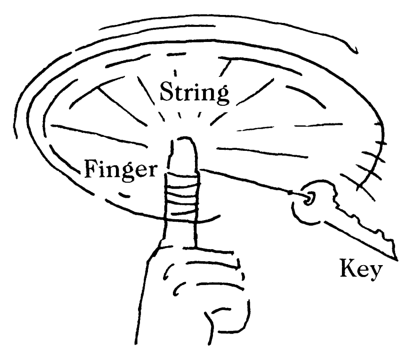


Activity 14

15. REDUCE THE RADIUS — Home

What happens when you reduce the length of the radius of the circle in which a body is turning?

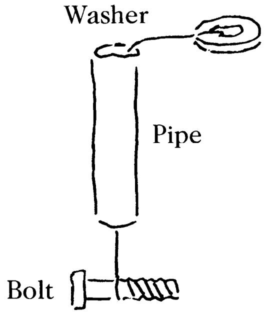
To find out, get a piece of strong thread, or string, about 10 inches long. Tie one end of the string around the index finger of your right hand. Tie the other end of the string to a paper clip or small key. Whirl the paper clip in a circle. Stop moving your hand suddenly. Note the change in the circling time as the string winds around your finger. Note that the smaller the radius, the faster the paper clip picks up speed.



Activity 15

16. INCREASE YOUR SPIN — Home

Here is an interesting experiment for you to do if you have a revolving piano stool. Sit on the stool with your arms extended as far out as possible. In each hand hold a heavy book. Let a friend start spinning you slowly. Now pull the books in toward your chest. Note what happens.



Activity 17

17. *PIPE AND BOLT* — *Supervised Classroom*

Run a string through a small pipe about 6 inches long. Tie a washer or big cork to the top end of the string. Tie a small bolt or nail to the other end.

Hold the pipe in an upright, vertical position. When there is no motion, the heavier bolt will draw the washer to the top rim of the pipe. Now give the pipe a stirring motion. What happens when you increase the speed of rotation?

18. *PAINT WITH CENTRIFUGAL FORCE* — *Supervised Classroom*

For a science fair, some of my students conducted this delightful and artistic demonstration of centrifugal force. They secured:

—an old 78 rpm record player with speed control
—three empty plastic squeeze bottles (they once held honey)
—three small cans of paint (red, blue, and green)

Each can of paint was poured into one of the plastic squeeze bottles.

The students collected a number of smooth, white pieces of cardboard of the type that are inserted in shirts when they are returned from the laundry. These cardboards were cut into circles big enough to cover the turntable of the record player.

Now the experiment was ready.

The students placed the turntable inside a cardboard box about 5 inches deep. This was to protect bystanders from unwanted results of centrifugal force. A piece of cardboard was pushed down over the spindle and positioned snugly against the turntable. The turntable was set in motion. Now a student picked up the plastic bottle with the red paint. Pointing the nozzle at the center of the card, he squeezed a few drops of red paint on the spinning cardboard. He then did the same with the blue and green paints.

The results are so fantastic, there is no way to describe them. You will have to do this demonstration yourself to enjoy the artistic results. Repeat the experiment several times, and change the speed of the turntable each time.

19. *WATCH YOUR DOG* — *Home*

The next time your dog comes out of a lake or pond, watch how he puts Newton's First Law of Motion to work to dry himself.

HIGHLIGHTS OF THIS CHAPTER

- The "Highway Killer" lurking on our expressways is Newton's First Law of Motion. It kills more than 48,000 Americans each year.

- Newton's First Law of Motion informs us that "Every body persists in a state of rest, or in uniform motion in a straight line, unless acted upon by an external force."

- The tendency of a body at rest to remain at rest, and a body in motion to remain in motion in a straight line, is called inertia. When we say that matter is inert, we mean that it does not have the power to move itself or, if it is put into motion, to stop itself.

Multiple-Choice Questions

1. When you receive a whiplash it is because:
   a. your head is moving rapidly in a forward direction.
   b. your head makes you top-heavy.
   c. your head tends to stay in its previous position.
   d. your body is not inert.

2. Judged by the number of Americans it has killed, the most dangerous weapon in the United States today is:
   a. the atom bomb.
   b. the hydrogen bomb.
   c. a handgun called the "Saturday Night Special."
   d. the automobile.

3. As a baseball travels the 60½ feet from the pitcher's mound to home plate, it drops:
   a. one to two feet.
   b. two to three feet.
   c. three to four feet.
   d. less than one foot.

4. If you don't leap out of bed when your alarm clock goes off at 6:30 A.M., this is most likely due to:
   a. lack of will power.
   b. lazy muscles.
   c. inertia.
   d. the fact that your mind is not yet in focus.

5. If a driver turn sharply to the left and the right door is not securely closed, it may swing open. This is because:
   a. it wants to keep going in a straight line.
   b. an object traveling around a curve tends to keep moving in a circle.
   c. the counterclockwise motion of the car imparts a clockwise motion to the door.
   d. there is not enough centrifugal force.

True or False Questions

1. Whiplash results from an unplanned demonstration of Newton's First Law of Motion.

2. A pitcher's mound is made three to four feet higher than the bottom of the strike zone at home plate because the speeding baseball is compelled by an external force to change its straight-line motion.

3. When a spinning ice skater draws her limbs in toward the center of her body, she will spin more slowly.

4. If you spin a lasso, centrifugal force throws the rope outward.

5. A basketball is said to be inert because it does not have the power to move itself or, if it is put into motion, to stop itself.