UNIT 22 FORCE AND MOTION

WHAT ARE FORCES

A Force is any influence that causes an object to undergo a change in speed, a change in direction or a change in shape. A force is a push or pull upon an object resulting from the interaction of an object, with another object. Forces exist only as a result of an interaction. When there is an interaction between 2 objects, there is a force upon each of the objects. When the interaction stops, the 2 objects no longer experience the force.

Force causes motion: Force is a vector quantity that tends to produce movement of a body in the direction of its application. There is only one cause for change in motion and that is called force.
Forces can be of 2 broad categories

1. **Contact forces** – These are forces when 2 interacting objects are physically contacting each other e.g. friction, air resistance.
2. **Action at a distance forces** – These are forces that result when 2 interacting objects are not in physical contact with each other, yet are able to exert a push or pull despite their physical separation e.g. gravity, magnetic force, tides.

PUSH VERSUS PULL FORCES

A force that acts on a object can be push or pull. A pull force, is a child pulling a wagon or a magnetic force pulling something to it. A push force is a person pushing a box on the floor, or the wind pushing a sail boat forward.

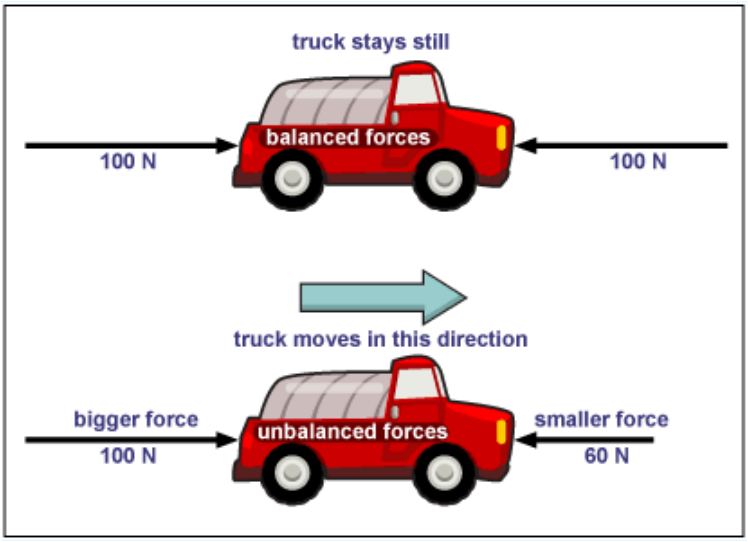
UNIT OF FORCE: Newton

BALANCED VERSUS UNBALANCED FORCES

A force is a push or pull. Forces occur in pairs and can be either balanced or unbalanced.

Balanced forces do not cause a change in motion. They are equal in size and opposite in direction. For example if you are wrestle with a friend who is about as strong as you are, there will be a time when both are pushing hard but your arms stay in the same place. This is an example of a balanced force. The force exerted by each person is equal but they are pushing in opposite directions. Because the force that each person is exerting is equal, the two forces cancel each other out and the resulting force is zero. Therefore, there is no change in motion.
Another good example of balanced forces is tug of war. If both teams have equal strength, the rope will stay pretty much in the same place. Again the resulting force is zero and there is no change in motion.

Imbalanced Forces – An unbalanced force is any force that is not opposed by some other force. They are not equal & opposite and they almost always cause a change in motion. For example in the case of arm wrestling, if you are wrestling against someone stronger, the force of their arm will push yours down. This is an unbalanced force.
Another example of an unbalanced force would be if your car breaks down and you push it forward to move it. This causes the car to move and is an unbalanced force.
Thus unbalanced forces are when the NET or TOTAL force acting on an object is non zero and this extra force causes the object to move if it was at rest, speed up or accelerate, or slow down and / or change direction.



Net Force: It is the combination of all forces acting on an object.

GRAVITY

Why things fall? If something is dropped, it falls to the ground. This is because of gravity. There is force acting between any 2 objects in the universe and this causes them to move to each other. This is called gravity.

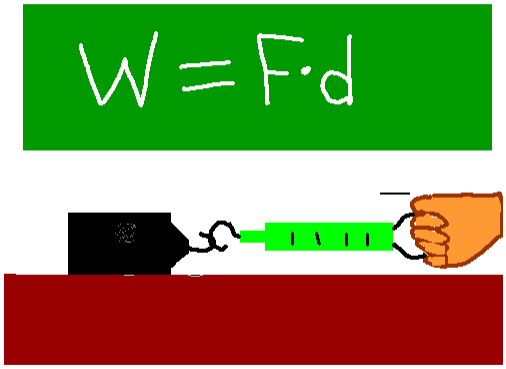
Gravity is a force of attraction that exists between any 2 masses, any two bodies, and any 2 particles. It is an attraction that exists between all objects e.g. the Sun's gravity keeps the Earth in orbit, the Moon's gravity causes tides, the Earth's gravity causes an apple falling from a tree to come to the ground. The more massive something is, the more gravitational pull it exerts. As we walk on the surface of the Earth which is so much more massive than we are, the pull from us is not strong enough to move the Earth while the pull from the Earth can make us fall. In addition to mass, gravity also depends on how far you are from something. This is why we are on Earth, instead of being pulled off to the Sun, which has more gravity than Earth.

WORK

It is a physical or mental effort (or activity) that is directed towards the production or accomplishment of something. Work is the application of a force over a distance. It can also be defined as transfer of energy. If one object transfers energy to a 2nd object, then the first object does work on the 2nd object. In science, Work is the transfer of energy from one object to another, especially in order to make the second objection move in a certain direction.

Work = Force X Distance.

Work refers to an activity involving a force and movement in the direction of the force. A force of 20 newtons pushing an object 5 meters in the direction of the force does 100 joules of work. If you are pulling a friend in a wagon, but he puts his feet on the ground and won't let you move, you are applying a force but not doing any work. The unit of work is **joule.**



ENERGY

Energy is the capacity for doing work. You must have energy to accomplish work. To do 100 joules of work, you must expend 100 joules of energy. If power is like the strength of a weightlifter, energy is like his endurance.

Energy is a measure of how long we can sustain the output of power, or how much work we can do. Energy and work are closely inter related. Energy is the ability to do work. Work done on an object gives the object potential or kinetic energy.

POWER

Power is the rate of doing work. If you do 100 joules of work in one second, the power is 100 watts. Power is work per time. If you do the same amount of work in a shorter time, it takes more power. Two cars might weigh the same and they can climb the same hill, so they do the same amount of work. But if one of the cars is old and clunky and the other is a powerful sports car, the sports car can climb the hill much faster because it has a more powerful engine.

SIMPLE MACHINES

A Simple Machine is a device that helps make work easier, a device that makes it easier to move something. These machines have few moving parts, use energy to work. Almost all complex machines are a combination of 6 types of simple machines.

There are 6 types of simple machines

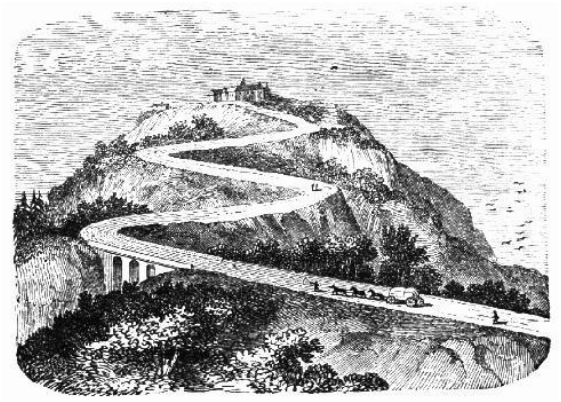
1) Inclined Plane
2) Wedge
3) Screw
4) Pulley
5) Lever
6) Wheel and Axle.

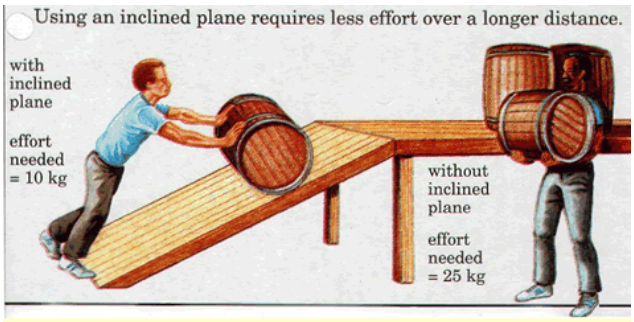
INCLINED PLANE

It is a simple machine with no moving parts. It is simply a straight slanted surface. An inclined plane is a slanting surface connecting a lower level to a higher level. The inclined plane helps to overcome a large resistance by applying a relatively small force, through a longer distance than the load is to be raised. Examples are a playground slide, roadway up a mountain, steps, a wheelchair ramp. Consider the steps you climb at school or in your home. They help to move from a lower level to a higher level with less work.

Effect of steepness: A steeper inclined plane requires more effort force for a given job. This is because it has a shorter distance and since work = force x distance, more force has to be applied and more work has to be done.

How is mechanical advantage calculated for an inclined plane: By dividing the length of the inclined plane by its height. A longer ramp has greater MA. This is because moving the effort through a longer distance allows the effort to be smaller for a given amount of work.





Inclined plane
Image src: http://www.sirinet.net/~jgjohnso/inclineplanecolored.jpg

WEDGE

It is an object with at least one slanting side ending in a sharp edge which cuts material apart. A wedge is a combination of 2 inclined planes joined together. Examples are a nail, ax, knife, fork, hatch, carpenters plane, chisel, door stop.

SCREW

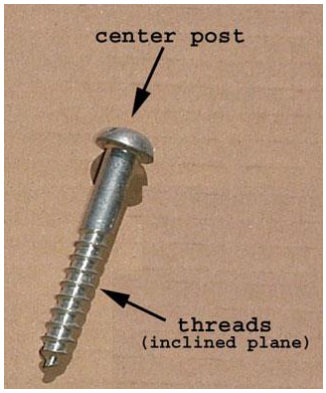
It is an inclined plane that has been wrapped around some central axis or a central bar. The spiral ridges are called the threads. The distance from thread to thread is called the pitch. The closer together the threads of a screw, the more the force is multiplied. Screws are designed to change the direction of effort. As the screw threads turn, objects move up or down. When you turn the screw into a piece of wood with a screw driver, the screw goes down. Also in a screw, circular motion is turned into forward motion. This is how a fan creates a current of air.

A screw is an inclined plane that winds around itself.

Screws that have larger pitch (threads that are farther apart) tend to have lower mechanical advantage. The threads tend to be farther apart when the inclined planes of the screw is steeper. We know that steeper inclined planes have a lower MA.

Examples are the lid of a jam jar, the jack with which you lift the car to change a tire, airplane propeller, blades of the fan.

Question for thought: One screw is made with a steep inclined plane. Another is made with a shallow inclined plane. Which screw has threads closer together? Which screw will have greater MA?

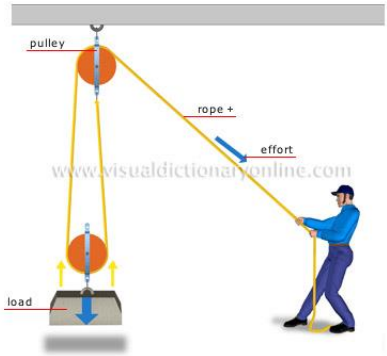


GEAR

It is a machine that has 2 footed wheels that fit together either directly or through a chain or belt so that one wheel will turn the other. A gear is a special form of a lever. It is really just a wheel with notched teeth.

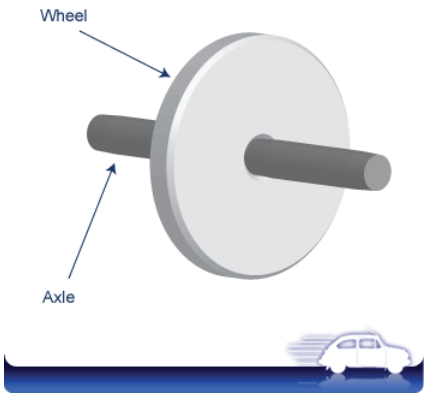
PULLEY

A pulley is a wheel with a grooved rim in which a rope can run, to change the direction of the pull and so lift a load. Examples are a flag pole, pulling water from a well, a sailing mast. There are two types of pulleys: fixed and movable.



WHEEL AND AXLE

It is a simple machine that is made up of 2 circular objects of different size. The axle (a small wheel) is attached to the center of a larger wheel. All Wheels need an axle. The wheel and axle must move together. When effort is applied to the wheel, it spreads the force over a greater distance. Examples are door knobs, roller skates, handle of taps/faucets, bicycle, Ferris wheel, a hand turned large pencil sharpener



LEVER

A lever is a rigid bar that rests on a fulcrum (fixed point). Force must be put on a lever to make it work.

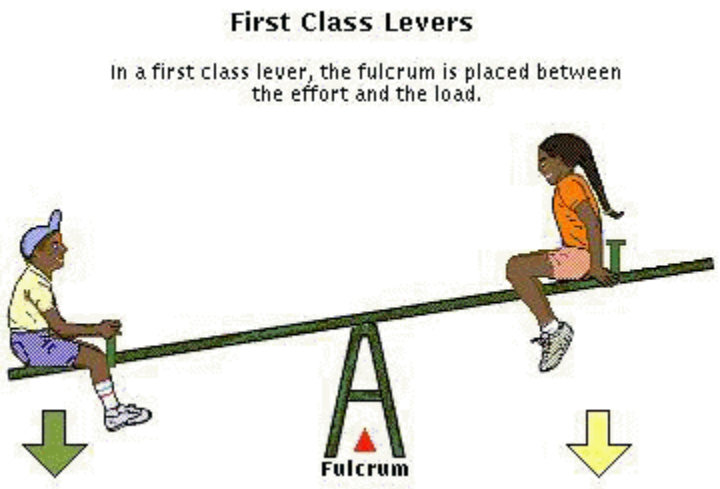
Terms to understand:

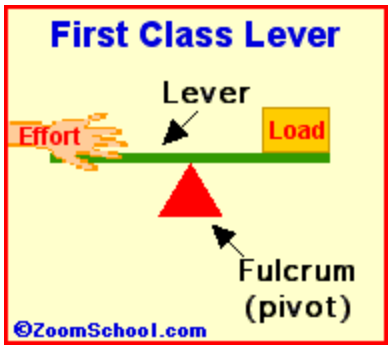
Load: It is the object, force, weight that is being moved.
Effort: It is the force or work that is done to move the load.
Fulcrum: It is the support or point, around which a lever pivots. Without it, a lever is ineffective.

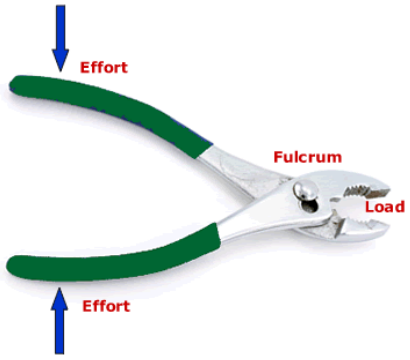
There are 3 classes of levers
http://www.enchantedlearning.com/physics/machines/Levers.shtml

CLASS 1 LEVER

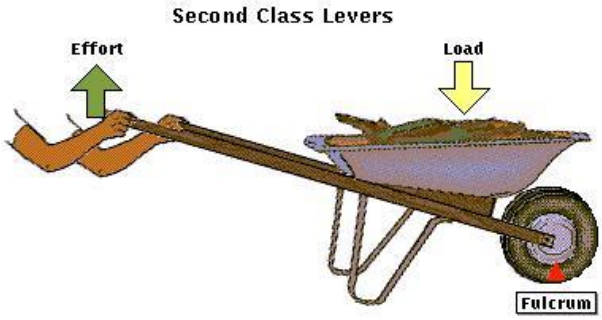
Here the fixed point is between the effort & load for example seesaw, scissors, pliers, a hammer being used to pull a nail. The effort arm of a 1st class lever must be longer than the resistance arm for the lever to increase the strength of the effort force.

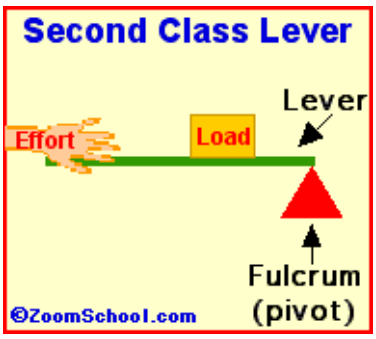




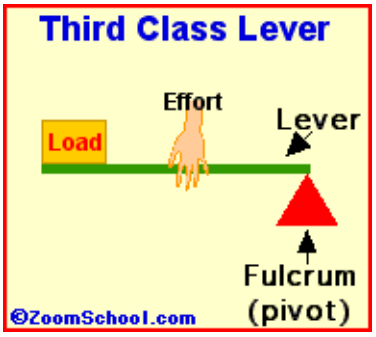


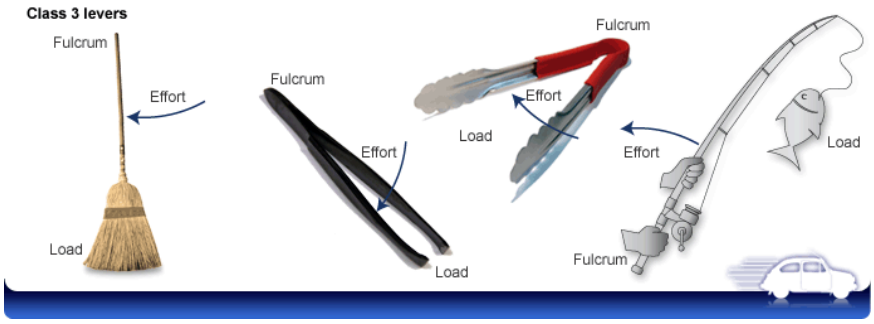
CLASS 2 LEVER: Here the fulcrum (fixed point) is at one end, the effort is at the other end, and the load is in the middle. For example: a wheel barrow, stapler, can opener, shovel, nail cutter, nut cracker, bottle opener, paper cutter





CLASS 3 LEVER – Here the fulcrum is at one end, the load at the other end and the effort is between the fulcrum and load. For example: baseball bats, hockey sticks, golf clubs, and tennis rackets, fishing rod, tweezers, tongs, broom, human forearm





SIMPLE MACHINE EXAMPLES

INCLINED PLANE: roller coasters, parking ramp, hill with a cable car, bathtub, stairs, car ramps, ladder, dump truck, ramps for wheel chairs, playground slide, slanted roadway up a hill, escalator

SCREW: drill, screw jar lid, swivel piano stool, cork screw, machine screws, door lock, base of a light bulb, jack to lift a car, spiral staircase, airplane propellers, helicopter blades, and blades that screw through the air, clamp, drill bits used to make holes.

WEDGE: ax, knife, fork, scissors blade, chisel, nail, pin, plough,

PULLEY: flag pole, window blinds, oil rigs, sail boats, cranes,

WHEEL AND AXLE: car steering wheel, door knob, gear wheels of a bicycle, screwdrivers, hand turned pencil sharpener, roller skates,

CLASS 1 LEVER: seesaw, scissors (it is considered a double class 1 levers), pliers, a hammer claws, oars on a boat

CLASS 2 LEVER: wheelbarrow, nail cutter, stapler, bottle opener, nut cracker,

CLASS 3 LEVER: tweezers, tongs, fishing rod, hockey stick, broom,

COMPOUND MACHINES

A compound machine is a combination of two or more simple machines. There are 6 types of simple machines – lever, pulley, inclined plane, wheel & axle, wedge, screw. Most machines are compound machines. Compound machines can do more difficult jobs than simple machines alone. Their mechanical advantage is far greater. Some examples of compound machines and the simple machines they are made up of are

1. Axe/shovel – wedge and a lever
2. Pencil sharpener – wheel & axle, wedge
3. Bicycle – wheel & axle, lever, screw (seat)

MECHANICAL ADVANTAGE

The mechanical advantage of a machine is the number of times a machine increases a force exerted on it. The ratio of the output force to input force gives the mechanical advantage.

Mechanical Advantage = Output force / Input force

For example if you exert an input force of 10 newtons on a can opener, and the can opener exerts an output force of 30 newtons on the can, then the mechanical advantage of the can opener is 30/ 10 = 3. This means that the can opener triples your input force. Without the mechanical advantage of the can opener, opening the can would be very difficult.

Suppose that with a pulley system, you need to exert a force of 1400 Newtons to lift a heavy object. But without the pulley system, you need to exert 4200 Newton to lift the object. What is the mechanical advantage of the pulley system?

EFFICIENCY

It would seem by studying mechanical advantage that the work you put into a machine is exactly equal to the work done by the machine. However, in real situations the output work by the machine is always less than the input work.

If you have tried to cut something with scissors that barely open and close, you know that a large part of your work is wasted overcoming the tightness, or friction, between the parts of the scissors. In every machine, some work is wasted overcoming the force of friction. The less friction there is, the closer the output work is to the input work.

The efficiency of a machine compares the output work to the input work and determines how efficient the machine is. Efficiency is expressed as percent. The higher the percent value, the more efficient is the machine. In the above example, if the scissors have an efficiency of 50%, then only half of the work you do, is going into cutting the paper. The rest is wasted in overcoming the friction in the scissors.

If it was possible to find a machine with 100% efficiency, it would be an ideal machine. Unfortunately such a machine does not exist. All the machines used such as cars, screwdrivers, pulleys, lost some work due to friction and have less than 100% efficiency.

To calculate the efficiency of a machine, divide the output work by the input work and multiply the result by 100%.

Efficiency = Output work/ Input work x 100

Example 1: You do 20 joules of work while using a hammer. The hammer does 18 joules of work on a nail. What is the efficiency of the hammer?
Answer: 18/20 x 100 = 90 %

Example 2: Suppose you left your lawn mower outdoors all winter. Now its rusty. Of your 250,000 joules work, only 100,000 joules goes to cutting the lawn. What is the efficiency of the lawn mower?
Answer: 100,000/250,000 x 100 = 40%

SURFACE TENSION

It is a property of the surface of a liquid. It is what causes the surface portion of a liquid to be attracted to another surface (like another portion of liquid like connecting bits of water.

WATER STRIDER

It is also known as a pond skater. It is a true bug that can run across the surface of water. It rarely goes under water. The underside of its body is covered with water repellent hair, it lives on ponds and slow running streams. It is an insect, so it has a 3 part body (head, thorax, abdomen), 6 jointed legs, 2 antennae. Water striders eat small insects that fall on the water's surface and also lava.

FRICTION

It is the resistive force acting between bodies that tends to oppose or damp out motion. It is a force on objects in contact with each other that resists motion of the objects relative to each other.

Friction is the force resisting the relative motion between 2 surfaces – (solid surfaces, fluid layers or material elements sliding against each other). Friction is the “evil” of all motion. No matter which direction something moves in, friction pulls it the other way. It appears as if nature has given us friction to stop us from moving anything.

Though the surface of 2 objects might look smooth, microscopically they are rough & jagged. As the slide against each other, their contact is not smooth; they grind and drag against each other. This is where friction comes from. Friction is a force which causes the motion between 2 surfaces to be reduced. It happens because surfaces are not perfectly smooth. The rougher the surface, the more the friction. But friction is not all bad. Without it, we wouldn’t be able to walk, sit anything. We would keep slipping & falling all over the place.

There are 2 types of friction:

Static friction: It is the frictional force that opposes placing a body at rest into motion

Kinetic friction: It is the frictional force that tends to slow down a body in motion.

ENERGY

Energy can be defined as the capacity for doing work. Energy is working all around us. It is the capacity or power to do work. Energy powers cars and gives us light. It keeps urns warm and overate sound.

There are 2 types of energy in many forms

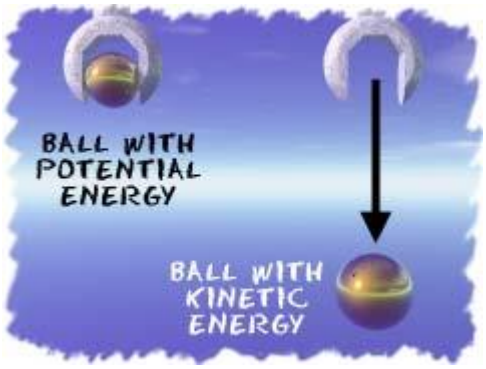
1. **Kinetic energy** – energy of motion
2. **Potential energy** – stored energy

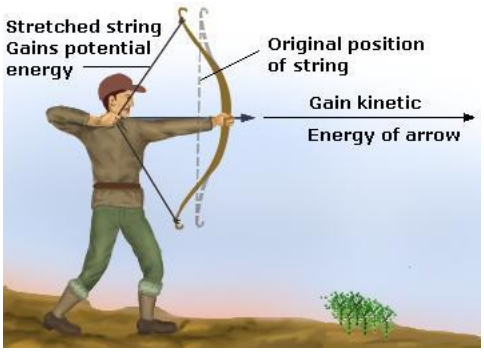
KINETIC ENERGY

This is energy that is moving. For example: the wind of waves in the ocean. An displane too or even a moving atom. Kinetic energy appears in many forms (Radiant Tigers Eat Some Mangoes)

1. Radiant energy - show up as light, x rays, radio waves.
2. Thermal energy - It is beat caused by movement or vibration.
3. Electrical energy - due to movement of electrical charges lighting, electricity to the home
4. Sound Energy - caused by vibration of the ear drum
5. Motion energy - comes from movement like water flowing of wind.

When an object falls from a high position, its potential energy begins changing to kinetic energy. At the bottom, it reaches its highest speed because all the potential energy has become kinetic energy. A roller coaster is very slow at the top. As it starts down the incline it sppeds up and when it reaches the bottom, it reaches its highest speed.





POTENTIAL ENERGY

It is stored energy that will possibly become energy in motion. It can be in several forms. (Good Chickadees Sleep Nightly)

1. Gravitational energy - It comes from the potential power that gravity can have on an objection. It is the energy of position or place. For example, before a sky diver jumps from a plane, he has stored potential energy. Hydro power, such as water in a reservoir behind a dam, is an example of gravitational potential energy. So is a rock resting on the top of a hill.

2. Chemical energy - It is stored inside the bonds of atoms or molecules.
3. Stored energy - Like a stretched rubber band or a coiled compressed spring.
4. Nuclear energy - Stored in the nucleus of an atom.

Whenever an object is raised above the ground, it gains potential energy. The greater the objects height and weight, the more it gains potential energy. The amount of gravitational potential energy can be calculated by multiplying its weight by its height. If the weight is in newtons and the height is in meters, then the potential energy is in joules.

THERMAL ENERGY

Thermal energy comes from heat. The atoms and molecules that make up a substance are in constant motion. This movement is what gives a material its temperature; the more the molecules are moving about, the higher the temperature. Thermal energy is simply the energy possessed by a substance due to the movement of its atoms or molecules. It is important not to confuse this with heat, which is energy that is transferred from one place to another. Thermal energy is used for cooking, heating, and power generation.

ELECTRICAL ENERGY

Electrical energy is the energy that is carried by moving electrons in a conductor. It is the flow of electric charge. It cannot be seen but it is one of the most useful forms of energy.

There are two types of charges- positive and negative. If two electrically charged objects are brought together, they will experience a force. If the charges are the same, the force will act to repel. If the charge is different, the force will act to attract the objects to each other. This attraction or repulsion is known as electromagnetic force, and it can be harnessed to create a flow of electrical energy.

Electrical energy is useful to industrial processes, generation of light, and to use many devices like computers, TV’s, to turn motors, and more. Most electrical energy is generated by devices that convert rotational movement into electrical energy.

CHEMICAL ENERGY

Chemical energy is stored in the bonds of atoms and molecules and can be released during a chemical reaction. Batteries, food, coal, natural gas all release chemical energy.

Food is a good example of stored chemical energy. During digestion, the food molecules are broken down and chemical reactions occur. This releases energy. The

energy produced keeps us warm, maintains and repairs our body, and helps us move about.

MAGNETIC ENERGY

Magnetic energy and electrical energy are closely related to one another. When electrons move through a wire, a magnetic field is created around the wire. The magnetic energy generated by electromagnets can be used in devices like cars, door bells, compasses and more.

LAW OF CONSERVATION OF ENERGY

Energy is neither gained nor lost, it just changes form. In the example of the bowling ball, the kinetic energy of the ball when it is dropped => some of energy is converted to heat and a little is converted to sound. The sound slowing down of the kinetic energy of the pendulum is due to resistance by the air.

Important Note – While energy is always conserved, in practice it is impossible to convert all energy of one type completely 100%, into energy of another form. There will always be some loss due to friction and some conversion to heat. However it is possible to convert any form of energy entirely to heat. The conversion to thermal energy can be 100% efficient.

ENERGY TRANSFORMATION

Energy transformation is the process of changing energy from one form to another. This process is happening all the time. For example, when people consume food, the body converts the chemical energy in the food to mechanical energy for work, and thermal energy for heat. The engine of a car converts the chemical energy of gas into the mechanical energy of engine movement. Windmills harness energy of wind and convert it to mechanical energy (turbines) and then electrical energy.

INTERCONVERSION OF FORMS OF ENERGY

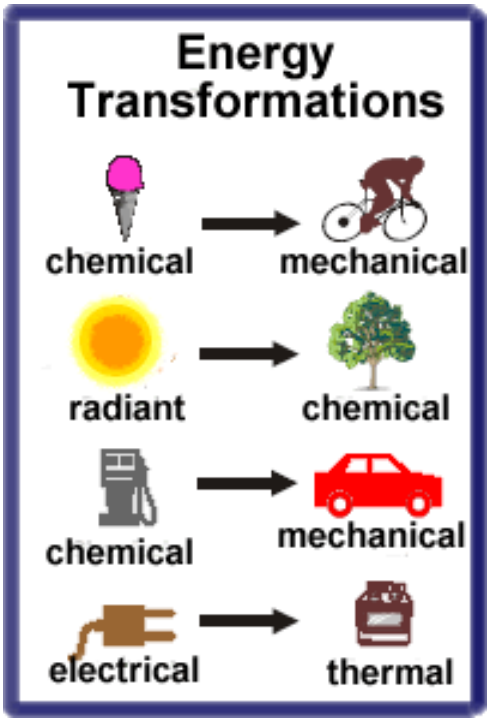
Energy can be changed from one form to another. For example, when a bowling ball is rolled, its potential energy changes into kinetic energy. Another example is the slamming of a screen door, the potential energy of the open door with the stretched spring, turns into the kinetic energy of the moving door as the door slams. Another example is a pendulum at rest and its energy is completely potential energy. This changes to kinetic energy as the pendulum swings.

Inter conversion of mechanical and electrical energy – Mechanical energy can be converted to electrical energy by generators and the reverse, electrical energy can be converted to mechanical energy by motors.

Inter conversion of chemical energy and electrical energy – A battery converts chemical energy to electrical energy. Fuel cells also do the same.

Inter conversion of light energy and chemical energy – The fire fly converts its food or chemical energy to light. All plants convert light energy (sunlight) to chemical energy (sugars & starches for food).

Inter conversion of electrical energy & light energy – The light bulb and even a toaster oven converts electrical energy to light (and heat). A solar cell or solar cooker turns light and heat energy from the sun and converts it into electrical energy.


Energy Transformations
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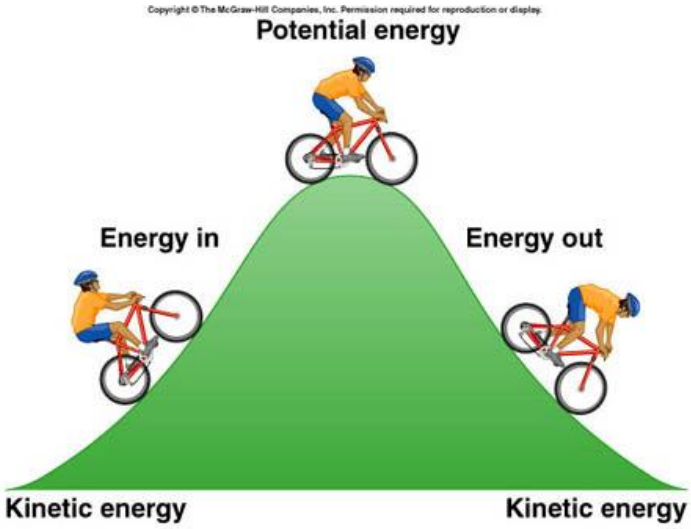
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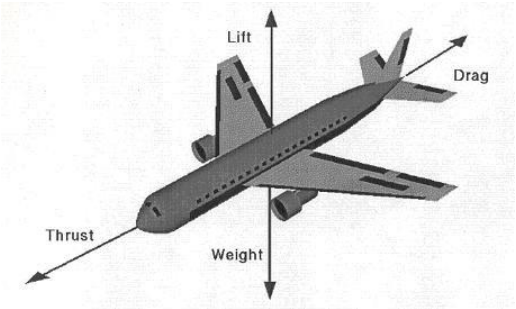
Potential energy
Energy in
Energy out
Kinetic energy
Kinetic energy

THRUST

Thrust is one of the 4 forces acting on an aircraft. It is the force necessary to move the aircraft forward. The other 3 forces are **lift, drag, weight** of the airport (the downward acting force produced by gravity).

Thrust means to push, or drive quickly and forcibly, in a specified direction. Thrust is the force which moves an aircraft through the air. Thrust is a mechanical force which is generated by the engines to move the aircraft through the air. The engine doses work on gas, and as the gas accelerated to the rear, the engine is accelerated in the opposite direction and produces a forward force on the plane



DRAG

Drag is the aerodynamic force that opposes an aircrafts' motion through the air. Drag is a force that is generated by the interaction and contact of a solid body with a fluid liquid or gas. Drag is generated by the difference in velocity between the solid object and fluid. Drag acts in a direction that is opposite to the motion of the aircraft.

AIR RESISTANCE

Air resistance, also called drag, is the force that is in opposition to the relative motion of an object through the air. Air resistance is a force which acts in the opposite direction you are travelling. It is cause by molecules of air colliding with an object, causing it to slow down and eventually stop. Drag is overcome by thrust.

LIFT

Lift is the force that directly opposes the weight of an airplane and holds the airplane in the air. Lift is generated mainly by the wings. Lift acts through the center of pressure of the object and is directed perpendicular to the flow direction.

COMBUSTION

Combustion is the burning of a fuel and oxidant to produce heat and /or work. Combustion is very important for aircraft and rocket propulsion.

MOTION: Motion is the change in position during a time period. There are 3 types of motion- speed, velocity, acceleration.

SPEED

Speed is how fast something going. Another way to think of this is as how far you can go in a certain amount of time. Speed is the rate of motion or the rate of change of position. It is expressed as distance moved per unit of time. Speed is measured in the same physical units of measurement as velocity, but does not contain an element of direction.
Speed is a measure of the rate of motion. It is the ratio of the distance traveled by an object, to the time required to travel that distance.

- Definition: Speed is the rate at which an object moves
- Formula: Speed = Distance / Time
- Units : km/sec or miles/sec
- Constant speed: speed that does not change
- Average speed: add all the speeds and divide by total number
- Graphs. In a speed graph time is on X axis and distance is on Y axis.

SPEED CALCULATIONS

Example 1: If 2 runners ran the same distance (10 kms) but one completed it in 3000 seconds and the other in 2800 seconds, what were each of their average speeds.

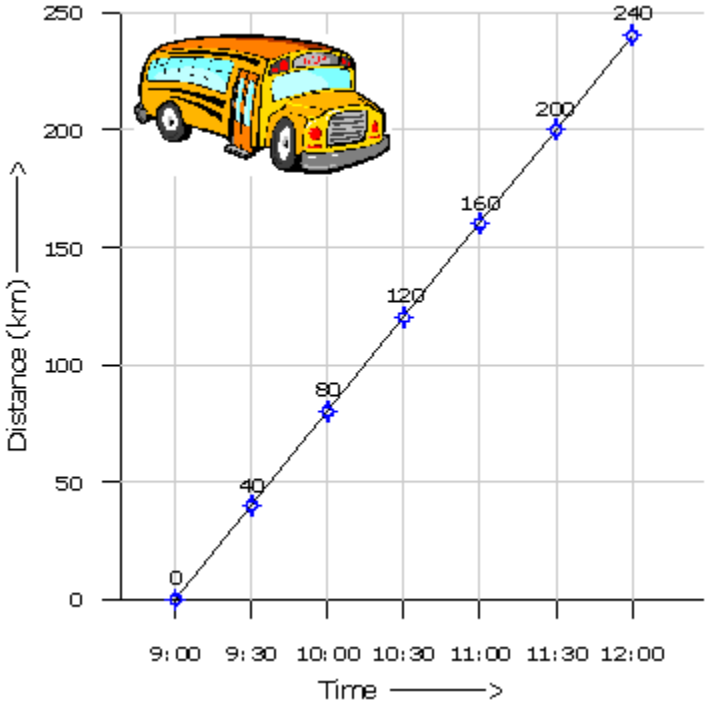
Speed = distance / time

Runner 1: distance/time is 10km / 3600 sec. Speed is .00278 kms/sec

Runner 2: distance/time is 10km/2800 sec. Speed is .00357 kms/sec

Runner 2 has the greater average speed.

SPEED GRAPH


250
200
150
100
50
0
Distance (km) ——>
0
40
80
120
160
200
240
9:00
9:30
10:00
10:30
11:00
11:30
12:00
Time ——>

VELOCITY

Velocity is the rate at which a position changes. Velocity is measurement of the rate at which an object is changing its position. In order to measure it, one must define both the speed at which an object is moving and also the direction of movement.

Imagine a person moving rapidly, one step forward and one step back, always returning to the original starting position. While this might result in a lot of motion, it would result in zero velocity. If a person in motion wishes to maximize their velocity, then he must make effort to maximize the amount they move from their original position.

This means that velocity is direction aware. When evaluating the velocity of an object, one must keep track of direction. It would not be enough to say that an object has a velocity of 55 miles/hr, one must include direction information. You must describe an objects velocity as being 55 miles/hr, east.

This is one of the essential differences between speed & velocity. Speed does not keep track of direction, it is just how fast an object is moving. Velocity is direction aware.

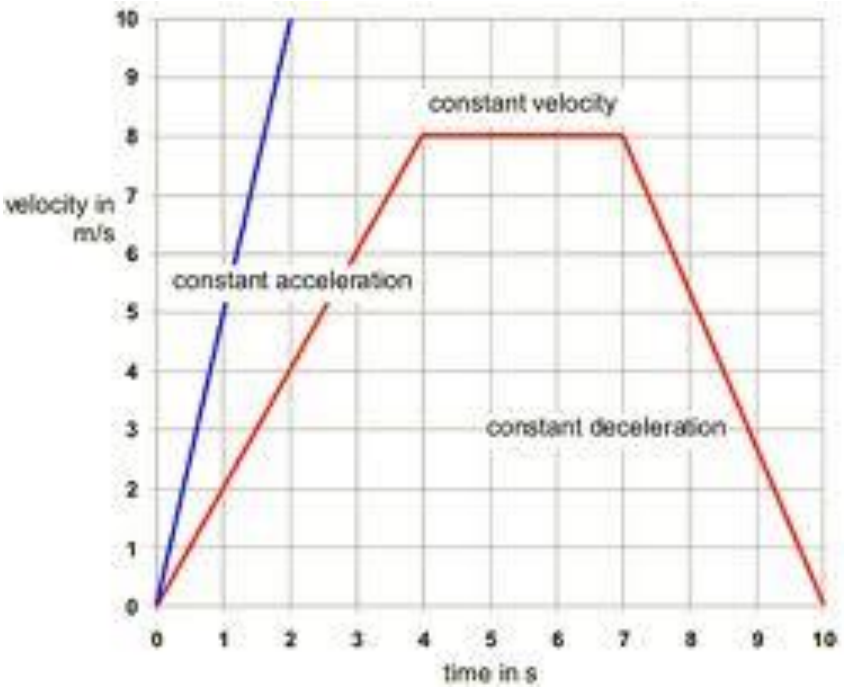
- Definition: Velocity is speed plus direction (north, south, east, west)
- Formula: Velocity = Distance / Time, plus direction
- Units: mile/sec or km/sec, north, south, east or west.
- Velocities can be combined- add velocities in the same direction. Subtract velocities in the opposite direction.
- Graphs: Time is plotted on the X axis and distance is on the Y axis. It is the same as speed graphs, but also had direction.

VELOCITY CALCULATIONS

Example 1: If a runner is running east at 10 miles per second, what is her velocity.
Answer: 10m/s east

Example 2: If you are rowing a boat downstream at 16 km/hr, and the current is moving at 10 km/hr, how fast does the boat "look" like it's going to someone on shore
Answer: 16 + 10= 26 km/hr downstream
Example 3 : If you are rowing a boat upstream at 15 km/hr, against a current moving at 8 km/hr, what is your actual velocity to an observer on the shore
Answer: 15-8 = 7 km/hr upstream.

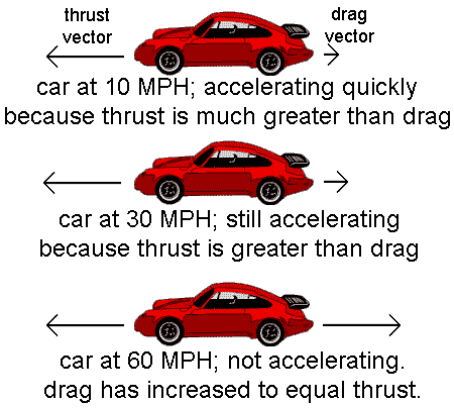
VELOCITY GRAPH



ACCELERATION

It is the rate of change of velocity. It can have positive or negative value. If positive, the object is speeding up, if negative the object is slowing down. To accelerate an object, it requires the application of a force. Acceleration is the increase in the rate or speed of something. Acceleration is change of velocity/ time taken

- Definition: It is the rate of change in velocity- speeding up, slowing down, changing direction
- Formula: Acceleration = Final velocity- original velocity / time
- Units: mile/sec/sec or km/sec/sec
- Increasing velocity gives positive acceleration. Decreasing velocity gives negative acceleration or deceleration.
- Graph: X axis has time. Y axis has distance. The object must be changing velocity. The line is smooth and curving, (not straight). It is a changing line.
- An object traveling in a circle is accelerating even if it moves at a steady speed because its direction of travel is constantly changing.



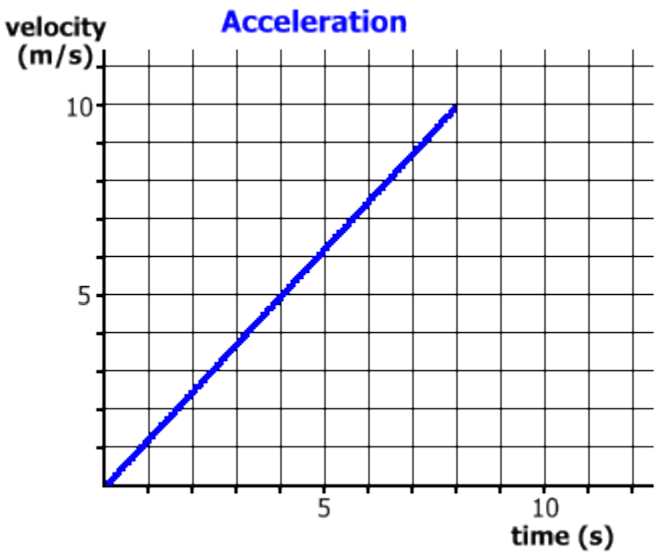
ACCELERATION CALCULATIONS

Example 1: A roller coasters velocity at the top of a hill is 10 m/s. Two seconds later it reaches the bottom of the hill with a velocity of 26 m/s. What is the acceleration of the roller coaster.

Answer Acceleration = Final velocity (Vf) – Original velocity (V0) / time
26-10/2 = 8 m/s/s

Example 2: A car's velocity at the bottom of a hill is 25 m/s. Three seconds later it reaches the top of the next hill, moving at 10 m/s. What is the deceleration of the roller coaster?
Answer: A = Vf – V0 / T A = 10-25 / 3 = - 5 m/s/s

ACCELERATION GRAPH



WHAT IS A G

The acceleration of an object falling freely near the Earth's surface due to gravity is called a G. Anytime pilots are accelerated at the same rate as a freely falling object, they feel one G. Several seconds of 5 G's can cause their eyesight to dim and even lose consciousness. Accelerations of 9 G's or more can be deadly after a few seconds. Air carfts have instruments called accelerometers that allow pilots to see how much they are accelerating. Air bags in a car are also activated from accelerometers.

MOMENTUM

Momentum refers to moving things. It can be defined as “mass in motion”. All objects have mass, so if an object is moving, then it has momentum. An object that is at rest or is not moving has no momentum. Momentum is a product of the mass of an object and its velocity.

- Definition: It depends on the mass and velocity of an object.
- Formula: Momentum = Mass x Velocity
- Units: kg.m/s

MOMENTUM CALCULATIONS

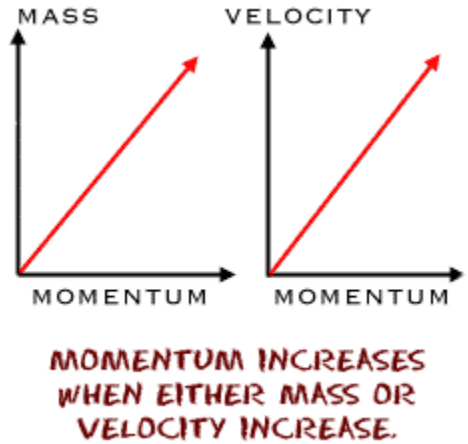
Example 1: If 2 football players are running at the same velocity towards an opponent and Player 1 weighs 170 lbs while Player 2 weighs 250 lbs, who is going to move the opponent further and why?

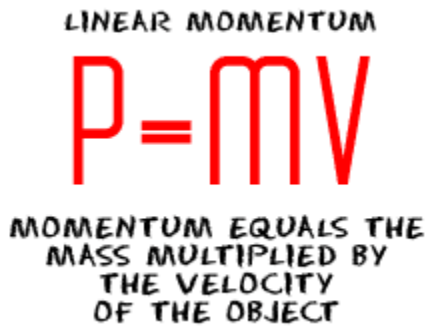
Answer: Momentum = Mass x Velocity. Since both players are moving at the same velocity, the larger player will have more momentum and will move the opponent further.

Example 2: Why will it be harder to stop a car traveling at 65 miles/hr than it is to stop one traveling at 35 miles/hr?

Answer: Since Momentum = m x v, the cars have the same mass, so the faster car will have more momentum and will be harder to stop.

Example 3: What is the momentum of a 0.3 kg bird running into a window while flying at 17 m/s.
Answer: momentum= mass x velocity.
Momentum = 0.3 x 17 = 5.1 kg m/s





LAW OF CONSERVATION OF MOMENTUM

If you have ever played pool or marbles, you have probably noticed that when a moving ball strikes a resting ball, the moving ball stops or slows down and the resting ball is set into motion. This is due to the law of conservation of momentum.

This law states that in a closed system, the amount of momentum within a system will stay steady or constant. In a collision between 2 objects in an isolated system, the total momentum of the two objects before the collision is equal to the total momentum of the two objects after the collision. That is, the momentum lost by the 1st object is equal to the momentum gained by the 2nd object.

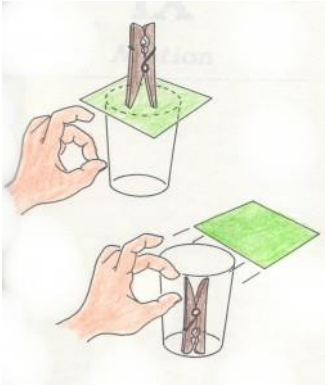
Conservation of momentum is a fundamental law of physics which states that the momentum of a system is constant if there are no external forces acting on the system. It is embodied in Newton's first law of motion. (the law of inertia)

INERTIA

It is the resistance of any object to a change in its state of motion or rest. It is proportional to an object's mass. This means that the heavier an object, the more it's resistance to change, the more it's inertia. Inertia is part of Newton's first law of motion

1. An object at rest tends to stay at rest
2. An object in motion tends to stay in motion

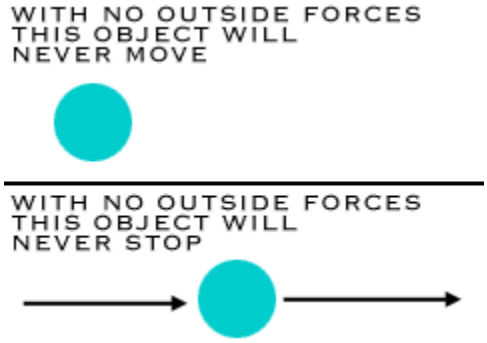
Inertia is the quality in matter, that lets it stay still, if it is at rest, or keeps it moving if it is moving. If you want to overcome inertia, you have to apply a force. A force will make something which is at rest, start to move, like flicking a piece of paper with a pencil will make it move. Also, force will slow or stop something that is already moving. For example, a piece of paper will be slowed down by resistance from the air it is passing.

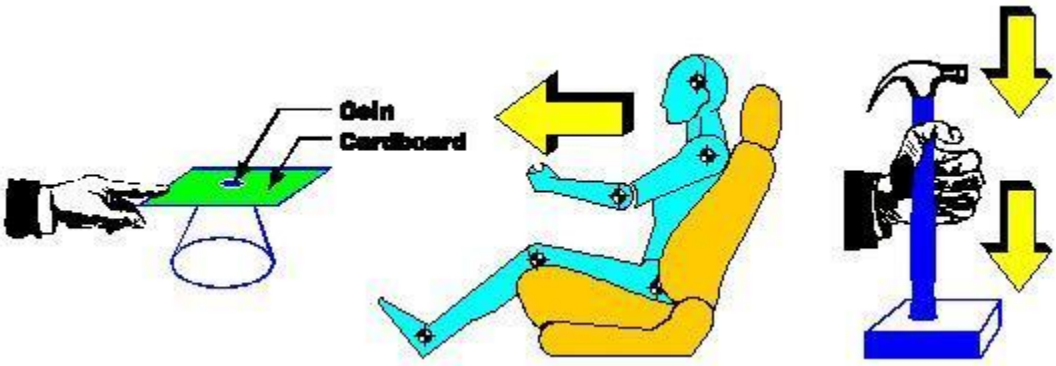


NEWTON'S 3 LAWS OF MOTION

FIRST LAW OF MOTION

An object at rest will remain at rest unless acted on by a force. An object at motion continues in motion with the same speed and in the same direction unless acted upon by a force. This means that there is a natural tendency of objects to keep on doing what they are doing. In the absence of a force, an object will stay in rest or motion. This law is the reason why you should always wear a seat belt. This law is often called the "law of inertia"





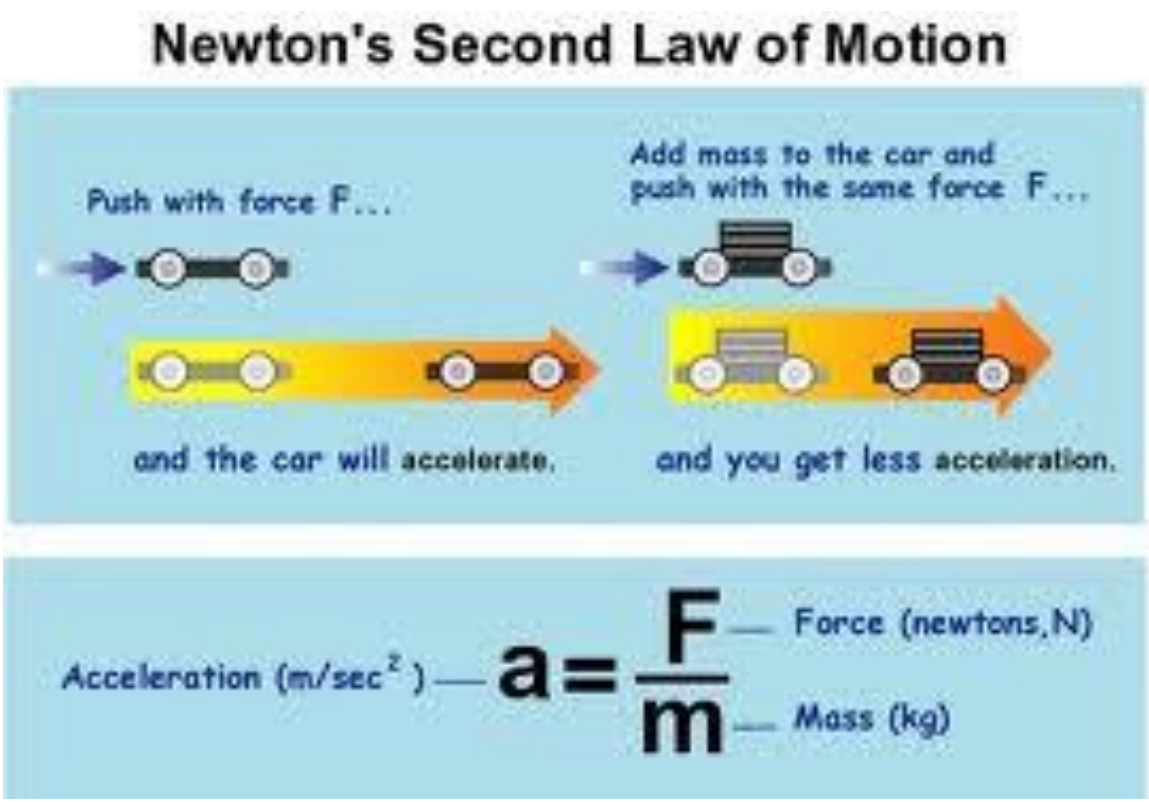
SECOND LAW OF MOTION

When a force acts on a mass or object, then it moves it. The greater the mass of the object, the greater the amount of force needed to accelerate or move the object. Heavier objects require more force to move the same distance, than lighter objects do. The 2nd law gives an exact relationship between force, mass and acceleration. This law is called the "law of acceleration"

In Newton's 2nd law, it states

1. A force acting on an object causes it to accelerate or move.
2. Acceleration is directly related to the size of the force and is in the same direction as the force. In other words large force, large acceleration
3. Acceleration is inversely related to the mass of the object. In other words large mass, small acceleration or small movement.
4. Combining the effects of force, mass & acceleration as an equation

Acceleration = force / mass **OR rewritten** force = mass x acceleration (**F= M X A**)



All of the following except one will cause the acceleration of an object to double. Which one is it ?

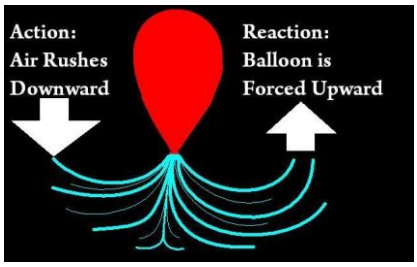
1. All forces on the object double.
2. The net force acting on the object doubles
3. Both the net force acting on the object and the mass of the object double
4. The mass of the object is reduced by a factor or two

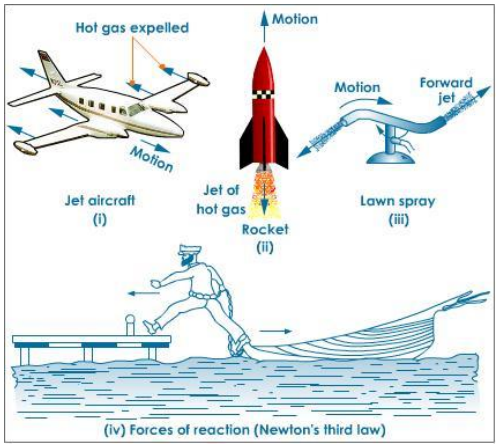
NEWTON'S THIRD LAW OF MOTION

For every action, there is an equal and opposite reaction. This means that for every force, there is a reaction force that is equal in size, but opposite in direction. This means that whenever an object pushes another object, it gets pushed back in the opposite direction equally hard.

Imagine you are in a football game and an opponent crashes into you. You feel a force. But your opponent also feels a force. In other words, while he applied a force on you, you also applied a force on him. In other words, there isn't just one force acting; there is a pair of forces. Newton was the first to realize that all forces occur in pairs and there is no such thing as an isolated force existing all by itself. The third law of motion deals with this fundamental characteristic of forces.

For example, a rocket action is to push down on the ground with the force of it's powerful engines. The reaction is that the ground pushes the rocket upwards with an equal force. So the rocket flies up.



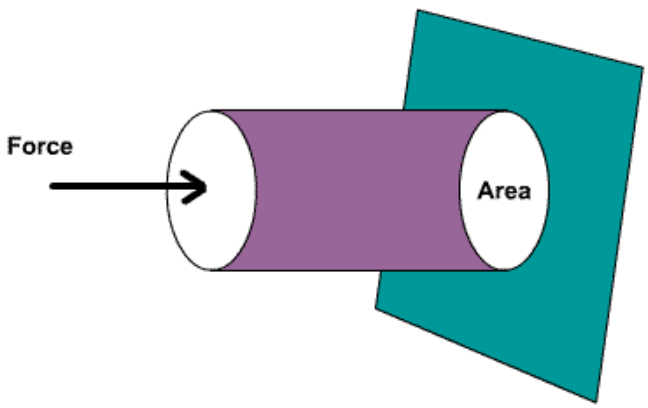


PRESSURE

Pressure is the exertion of a force upon a surface. In science, pressure is the force per unit area applied to a direction perpendicular to the surface of an object.

Pressure = Force / Area

In many cases the force is the weight of an object. A pressure gauge helps us to inflate the tires of a car. A diver will feel more pressure as he goes deeper into water. Blood pressure is the pressure exerted by blood on the walls of a blood vessel. The SI unit of pressure is **Pascal.**



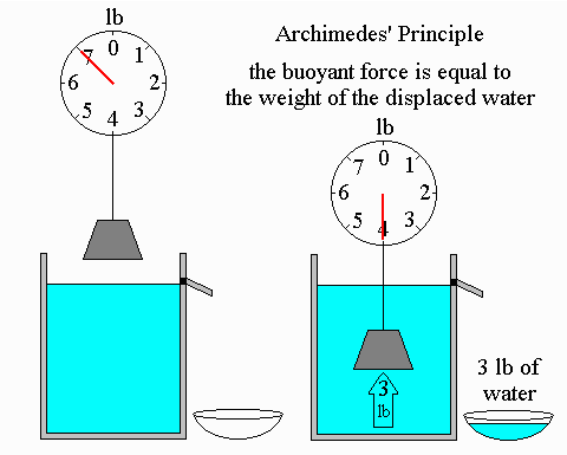
BUOYANCY

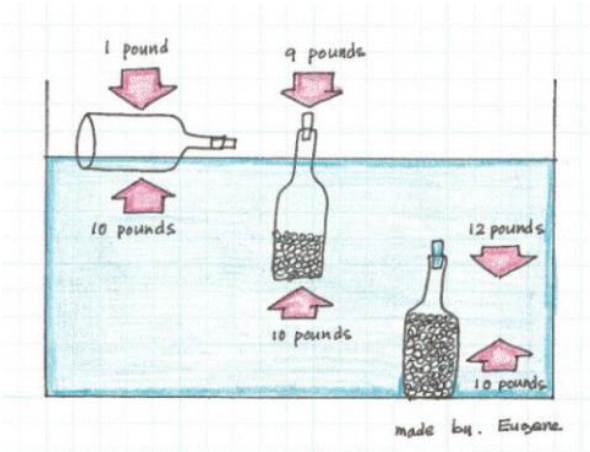
Buoyancy is an upward force exerted by a fluid that opposes the weight of an immersed object. When an object is submerged in a fluid, the fluid pushes on it. This push is greater at the bottom than the top. An object seems to lose weight when placed underwater. This is because the water pushes the object upward. The push is called buoyant force.

ARCHIMEDES PRINCIPLE

This is a law stating that the upward buoyant force exerted on a body immersed in a fluid, is equal to the weight of the fluid that the body displaces. This law explains why some objects sink in fluids while others float. An object that is immersed in a fluid is pushed up by a force equal to the weight of the fluid displaced by the object.

http://www.youtube.com/watch?v=QvZR7eUvLZA





HOW DOES ARCHIMEDES PRINCIPLE EXPLAIN THE FLOATING OR SINKING OF AN OBJECT

Archimedes principle states that the strength of the buoyant force acting upward on a submerged object is equal to the weight of the liquid displaced by that object.

Floating and sinking can be explained in terms of buoyant force. If you place a block of material in water and release it. If the upward buoyant force on the block is greater than the downward weight of the block, the block will rise to the surface and float. On the other hand, if the weight of the block is greater than the buoyant force, then the block will sink.

Example of a submarine: To make a submarine sink, the crew pumps seawater into its tanks. Its weight is now more than the buoyant force so it sinks. To make the submarine rise, the crew pumps air into the tanks, forcing the water out. The submarine now has less weight and the buoyant force pushes it up.

HOW DOES DENSITY OF AN OBJECT DETERMINE WHETHER IT SINKS OR FLOATS

Density is the amount of matter in an object; it is the mass per unit volume.

Density = mass x volume.

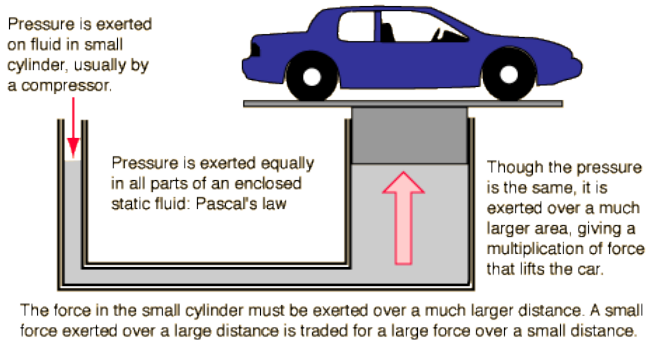
By comparing densities, you can predict whether an object will float or sink in a fluid. For example, the density of water is 1 g/cc3. The density of oil is 0.5 g/cc3. Since oil has less density than water, it will float on water. The density of copper is 8.8 g/cm3. It will sink in water because it has more density.

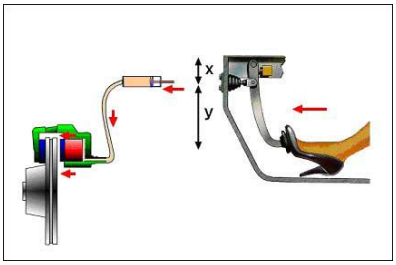
PASCAL'S LAW

It is a statement that in a fluid that is at rest in a closed container, if there is a pressure change in one part, it will be transmitted without any loss to every other part of the fluid and to the walls of the container.

Pressure = Force / Area

http://www.youtube.com/watch?v=A9mGr9mHrlg





BERNOULLI'S PRINCIPLE

It is the principle that allows wings to produce lift, and planes to fly. This principle works on the idea that as a wing passes through the air, its shape makes the air travel more over the top of the wing than beneath it. This creates a higher pressure beneath the wing than above it. The pressure difference causes the wing to push upwards and lift is created.

http://www.youtube.com/watch?v=O8qCA2mZvVI

Bernoulli's principal states that an increase in the speed of fluid, is accompanied by a decrease in the fluid's pressure. Examples are

1. An airplane wing: its shape allows it to lift
2. If you blow air over a roll of toilet paper on a rod with a blower, the toilet paper will fly off
3. A ping pong ball can be kept in the air with a blow dryer
4. If you blow between two cans, the cans will move together.
5. If you fold a piece of paper and tape the edges to a ruler, then blow the paper, it will lift up.