Unit 5
Energy

PHYSICAL SCIENCE
MRS. VALENTINE

5.1 Thermal Energy and Heat Transfer

- Objective:
  - I will be able to recognize the six forms of energy. I will be able to distinguish between heat and temperature. I will understand the types of heat transfer.

- Vocabulary:

Energy	Work	Conduction	Radiation	Absolute Zero
Convection	Nuclear Energy	Thermal Energy	Heat	Temperature
Chemical Energy	Electrical Energy	Electromagnetic Energy	Thermal Conductor	Thermal Insulator

5.1 Thermal Energy and Heat Transfer

- Energy
  - The ability to do work.
  - Work is a transfer of energy.
  - SI Unit: Joules (J)
    - $1J = 1Nm = 1\ kgm^2/s^2$

5.1 Thermal Energy and Heat Transfer

- There are six major forms of energy
  - Mechanical Energy - associated with the motion and position of everyday objects.
  - Chemical Energy – the energy stored in chemical bonds.
  - Electrical Energy – the energy associated with electric charges.
  - Electromagnetic Energy – a form of energy that travels through space in the form of waves.
  - Nuclear Energy – the energy stored in atomic nuclei
  - Thermal Energy – the total kinetic and potential energy of all the microscopic particles in an object

5.1 Thermal Energy and Heat Transfer

- Thermal Energy and Matter
  - Thermal energy depends on the mass, temperature, and phase (solid, liquid, or gas) of an object.
  - Difference between Heat and Temperature
    - Heat
      - The transfer of thermal energy from one object because of a temperature difference.
      - Heat flows spontaneously from hot objects to cold objects.

5.1 Thermal Energy and Heat Transfer

- Temperature
  - A measure of how hot or cold an object is compared to a reference point.
  - Absolute zero is one such reference point, equaling 0 Kelvin (-273°C)
  - Related to the average kinetic energy of the particles in an object due to their random motions through space.
  - As an object heats up, the particles move faster, on average.
  - Particle collisions from the increased movement transfer thermal energy from hot to cold objects.

5.1 Thermal Energy and Heat Transfer

- Thermal Expansion
  - The increase in volume of a material due to a temperature increase.
  - Occurs because particles of matter tend to move farther apart as temperature increases.
  - Used in glass thermometers.

5.1 Thermal Energy and Heat Transfer

- Heat Transfer
  - Heat is transferred from one substance to another via one of three methods.
    - Conduction
      - The transfer of thermal energy with no overall transfer of matter.
      - Occurs when materials are touching.
      - Conduction in gases is slower than in liquids and solids because the particles in a gas collide less often.

5.1 Thermal Energy and Heat Transfer

- Conductors and insulators
  - Thermal Conductors
    - A material that conducts thermal energy well.
    - Ex: Metal, Tile
  - Thermal Insulators
    - A material that conducts thermal energy poorly
    - Ex: Air, Rubber

5.1 Thermal Energy and Heat Transfer

- Convection
  - The transfer of thermal energy when particles of a fluid move from one place to another.
  - A convection current occurs when a fluid circulates in a loop as it alternately heats up and cools down.
  - Ex: air circulating in an oven
  - Convection currents are important in many natural cycles, such as ocean currents, weather systems, and movements of hot rock in Earth's interior.

5.1 Thermal Energy and Heat Transfer

- Radiation
  - The transfer of energy by waves moving through space.
  - Ex: heat lamps
  - All objects radiate energy. As an object's temperature increases, the rate at which it radiates energy increases.

5.2 Law of Conservation of Energy

- Objective:
  - I will be able to identify and calculate kinetic and potential energies. I will understand how energy is conserved and converted in various situations.
- Vocabulary:

Kinetic Energy	Potential Energy	Elastic Potential Energy	Energy Conversion	
Law of Conservation of Energy		Gravitational Potential Energy		

5.2 Law of Conservation of Energy

- Kinetic and Potential Energy
  - Kinetic Energy
    - The energy of motion.
    - The kinetic energy of any moving object depends upon its mass and speed.
    - Equation & SI Units
      - Equation: ^{2}
      - SI Unit: Joules

5.2 Law of Conservation of Energy

- Practice
  - A 70.0-kilogram man is walking at a speed of 2.0m/s. what is his kinetic energy?
  - A 1400-kilogram car is moving at a speed of 25m/s. How much kinetic energy does the car have?
  - A 50.0-kilogram cheetah has a kinetic energy of 18 000 J. How fast is the cheetah running?

5.2 Law of Conservation of Energy

- Potential Energy
  - Energy that is stored as a result of position or shape.
  - Types
    - Gravitational Potential
      - Potential energy that depends upon an object's height.
      - Increases with height.
      - An object's gravitational potential energy depends on its mass, its height, and the acceleration due to gravity.
      - Another way to say this is to multiply the object's weight by its height.
      - Equation : mgh
      - Ex: a man sitting on a cliff edge

5.2 Law of Conservation of Energy

- Elastic Potential
  - Potential energy of an object's that is stretched or compressed.
  - Something is said to be elastic if it springs back to its original shape after it is stretched or compressed.
  - Ex: a stretched hairband or a compressed spring

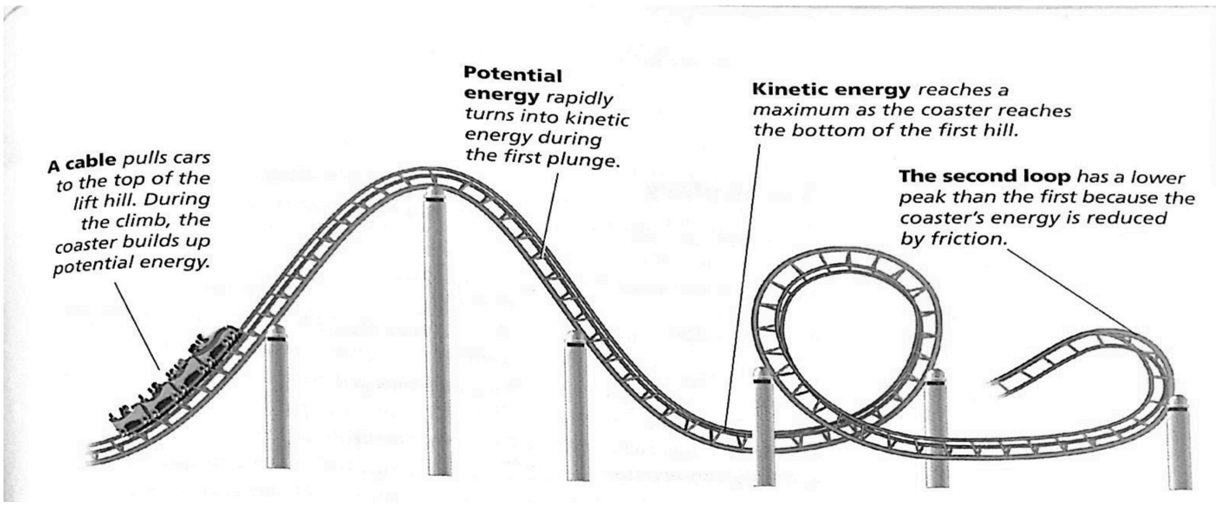
5.2 Law of Conservation of Energy

- Law of Conservation of Energy
  - Energy can be converted from one form to another.
  - The process of changing energy from one form to another is energy conversion
  - The law of conservation of energy states that energy cannot be created or destroyed.
  - In a closed system (nothing can enter or leave), the amount of energy at the start o a process is the same amount of energy at the end.

5.2 Law of Conservation of Energy

- Energy Conversions
  - The gravitational potential energy of an object is converted to the kinetic energy of motion as the object falls.
  - Examples
    - Roller Coaster
      - A roller coaster goes through a series of exchanges between potential and kinetic energy.

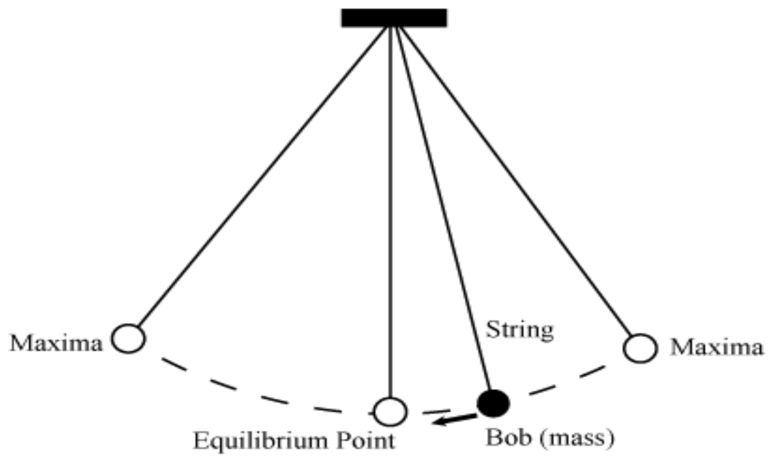
5.2 Law of Conservation of Energy



5.2 Law of Conservation of Energy

- Pendulums
  - A pendulum consists of a weight swinging back and forth from a rope or string.
  - Kinetic energy and potential energy undergo constant conversions in a pendulum as it swings.
  - At the highest point, the pendulum momentarily is motionless, and has zero kinetic energy and maximum potential energy.
  - As the pendulum swings downward, potential energy is converted back to kinetic energy.
  - At the bottom of the swing, the pendulum has zero potential energy and maximum kinetic energy.
  - Unless additional force is added to the pendulum continuously, the pendulum will eventually stop because of friction forces.

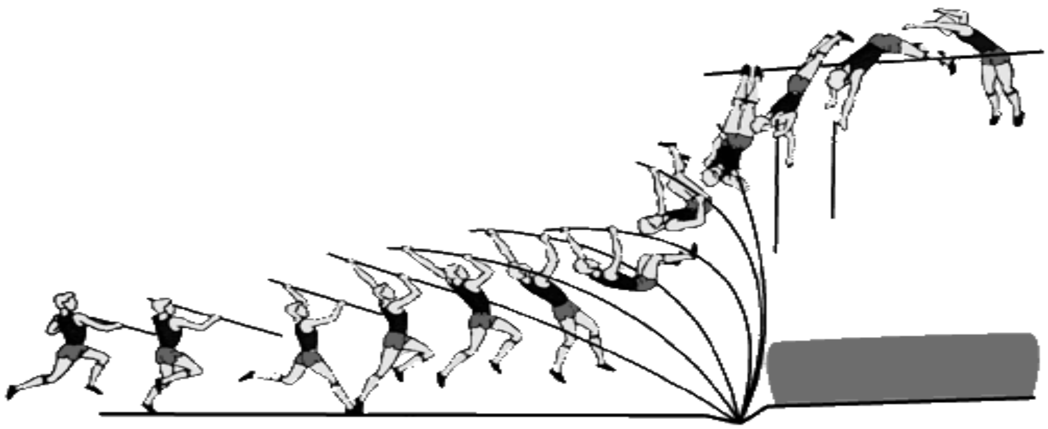
5.2 Law of Conservation of Energy



5.2 Law of Conservation of Energy

- Pole Vault
  - When the pole-vaulter springs down the run way, he gains as much kinetic energy as he can. Upon planting his pole, some of that kinetic energy is converted to elastic potential energy as the pole bends.
  - The pole springs back into shape, propelling the pole-vaulter upward, converting his kinetic energy into gravitational potential energy.
  - Once the highest point has been reached, his gravitational potential energy begins to convert back to kinetic energy. The pole-vaulter picks up speed as he falls.

5.2 Law of Conservation of Energy



5.2 Law of Conservation of Energy

- Equation: $(KE+PE)_{beginning} = (KE+PE)_{end}$
- Practice
  - A 10-kg rock is dropped and hits the ground below at a speed of 60m/s. Calculate the gravitational potential energy of the rock before it was dropped. You can ignore the effects of friction.
  - A diver with a mass of 70.0kg stands motionless at the top of a 3.0-m-high diving platform. Calculate the potential energy relative to the water surface while standing on the platform, and his speed when he enters the pool.
  - A pendulum with a 1.0kg weight is set in motion from a position 0.04m above the lowest point on the path of its weight. What is the kinetic energy of the pendulum at the lowest point? Assume there is no friction.

5.3 Work and Power

- Objective:
  - I will be able to calculate work and power.

- Vocabulary:

Work	Power	Horsepower	Watt	Joule

5.3 Work and Power

- Work
  - In science, work is the product of force and distance.
  - Work is done when a force acts on an object in the direction the object moves.
  - Ex: applying force upward to lift a box off the ground.
  - For a force to do work on an object, some of the force must act in the same direction as the object moves. If there is no movement, no work is done.
  - A force does not have to act entirely in the direction of movement to do work, so long as a portion of the force is in the direction of the movement.

5.3 Work and Power

- Any part of a force that does not act in the direction of motion does no work on an object.
- Equation: *work = F * d*
- SI Unit: Joules (J)

5.3 Work and Power

- Practice
  - How much work is done to lift a 1600N barbell 2.0m?
  - A mover pushes a 150N box up a 6m incline. How much work did the mover do on the box?
  - A teacher leans on a wall with a force of 50N. How much work did the teacher do? Explain.

5.3 Work and Power

- Power
  - Power is the rate of doing work.
  - Doing work at a faster rate requires more power. To increase power, you can increase the amount of work done in a given time, or you can do a given amount of work in less time.
  - Moving snow to clear a driveway requires work. Which one has more power, shoveling by hand or using a snow blower? Why?

5.3 Work and Power

- Equation:
- SI Unit: Watt (W)
  - 1W = 1J/s
  - Approximately equal to lifting your textbook a height of one meter in half a second.
  - Horsepower (hp) is another unit used for power. 1hp = 746 watts.

5.3 Work and Power

- Practice
  - Your family is moving to a new apartment. While lifting a box 1.5m straight up to put it on a truck, you exert an upward force of 200 N for 1.0s. How much power is required to do this.
  - You lift a book from the floor to a bookshelf 1.0m above the ground. How much power is used if the upward force is 15.0N and you do the work in 2.0s?
  - You apply a horizontal force of 10.0N to pull a wheeled suitcase at a constant speed of 0.5m/s across flat ground. How much power is used?

5.4 Work and Machines

- Objective:
  - I will understand how to relate work and machines. I will be able to determine how a machine makes work easier and its efficiency.
- Vocabulary:

Machine	Input Distance	Output Force	Input Force	Work Input
Output Distance	Work Output	Mechanical Advantage		Efficiency
Ideal Mechanical Advantage		Actual Mechanical Advantage		

5.4 Work and Machines

- Machines Do Work
  - A machine is a device that changes a force.
  - Machines make work easier to do. They change the size of a force needed, the direction of a force, or the distance over which a force acts.
    - Increasing Force
      - When using a machine, a small force exerted over a larger distance becomes a larger force exerted over a smaller distance.
      - Ex: Turning a steering wheel with a smaller force applies a larger force to the smaller steering column.

5.4 Work and Machines

- Increasing Distance
  - A machine that decreases the distance through which you exert a force increases the amount of force required.
  - Ex: When you swing a baseball bat, your hands do not travel as far as the other end of the bat. You apply a larger force to the bat over a smaller distance while the bat applies a smaller force to the ball over a larger distance.

5.4 Work and Machines

- Changing Direction
  - Changing the direction of a force can make work easier without changing distance or magnitude of the force.
  - Ex: Hoisting a sail, you pull down on a rope to pull the sail up.

5.4 Work and Machines

- Input and Output Work
  - Because of friction, the work done by a machine is always less than the work done on the machine.
  - Work Input to a Machine
    - The force you exert on a machine is called the input force.
    - The distance the input force acts through is known as the input distance.
    - The work done by the input force acting through the input distance is called the work input.
    - $work_{input}$ F_{input} d_{input}

5.4 Work and Machines

- Work Output of a Machine
  - The force that is exerted by a machine is called the output force.
  - The distance the output force is exerted through is the output distance.
  - The output work of a machine is the output force multiplied by the output distance.
  - $work_{output} = F_{output} * d_{output}$
  - Without a change to the input work, the output work will remain the same.

5.4 Work and Machines

- Mechanical Advantage
  - The mechanical advantage of a machine is the number of times than the machine increases an input force.
  - For example, if a nutcracker exerts a force seven times greater than the input, then its mechanical advantage is 7.
  - Mechanical advantage does not have a unit.
  - Actual Mechanical Advantage (AMA)
    - AMA equals the ratio of the output force to the input force.
    - Equation: $AMA = \frac{F_{output}}{F_{input}}$

5.4 Work and Machines

- Ideal Mechanical Advantage (IMA)
  - IMA is the maximum mechanical advantage possible if the machine were frictionless.
  - Because friction is always present, the actual mechanical advantage of a machine is always less than the idea mechanical advantage.
  - Equation: $IMA = \frac{d_{input}}{d_{output}}$

5.4 Work and Machines

- Practice
  - A student working in a grocery store after school pushes several grocery carts together along a ramp. The ramp is 3 meters long and rises 0.5 meters. What is the ideal mechanical advantage of the ramp?
  - A construction worker moves a crowbar through a distance of 0.50m to lift a load 0.05m off of the ground. What is the IMA of the crowbar?
  - The IMA of a simple machine is 2.5. If the output distance of the machine is 1.0m, what is the input distance?

5.4 Work and Machines

- Efficiency
  - The percentage of the work input that becomes work output is the efficiency of a machine.
  - Because there is always some friction, the efficiency of any machine is always less than 100%.
  - Equation: $efficiency = \frac{work_{output}}{work_{input}} * 100\%$

5.4 Work and Machines

- Practice
  - You have just designed a machine that uses 1000J of work from a motor for every 800J of useful work the machine supplies. What is the efficiency of your machine?
  - If a machine has an efficiency of 40%, and you do 1000J of work on the machine, what will be the work output of the machine?

5.5 Simple Machines

- Objective:
  - I will be able to identify and calculate the mechanical advantage for each of the six types of simple machines. I will understand what a compound machine is.
- Vocabulary:

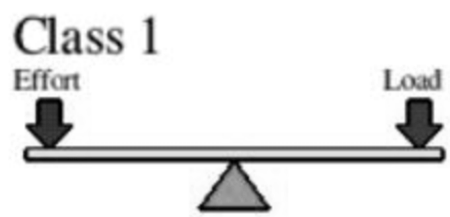
Lever	Fulcrum	Input Arm	Output Arm	Wheel and Axle
Inclined Plane	Wedge	Screw	Pulley	Compound Machine

5.5 Simple Machines

- The six types of simple machines are the level, the wheel and axle, the inclined plane, the wedge, the screw, and the pulley.
- Six Types
  - Levers
    - A lever is a rigid bar that is free to move around a fixed point.
    - The fixed point the bar rotates around is called the fulcrum.
    - The input arm of a lever is the distance between the input force and the fulcrum.
    - The output arm is the distance between the output force and the fulcrum.
    - Equation: $IMA = \frac{d_{input\ arm}}{d_{output\ arm}}$

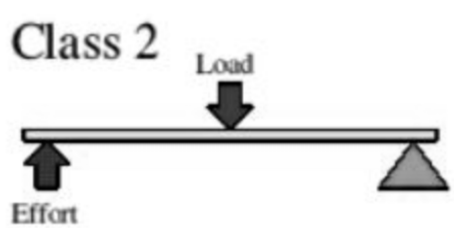
5.5 Simple Machines

- Three Classes
  - 1st Class
    - The fulcrum is in between the input and output forces.
    - Changes the direction of the force applied.
    - IMA can be 1, >1, or <1 (depending on location of fulcrum)
    - Examples: seesaw, scissors, tongs



5.5 Simple Machines

- 2nd Class
  - The input and output forces are on the same side of the fulcrum; the output force is closer to the fulcrum.
  - Output force > input force; output arm > input arm
  - IMA > 1
  - Examples: wheelbarrow, bottle opener

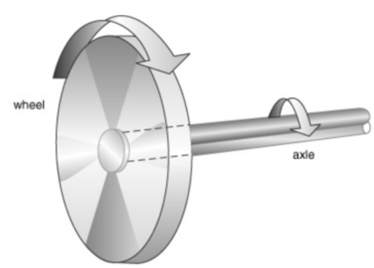


5.5 Simple Machines

- 3^{rd} Class
  - The input and output forces are on the same side of the fulcrum; the input force is closer to the fulcrum.
  - Output force < input force; output arm < input arm
  - IMA < 1
  - Examples: baseball bat, rake, broom, hockey stick

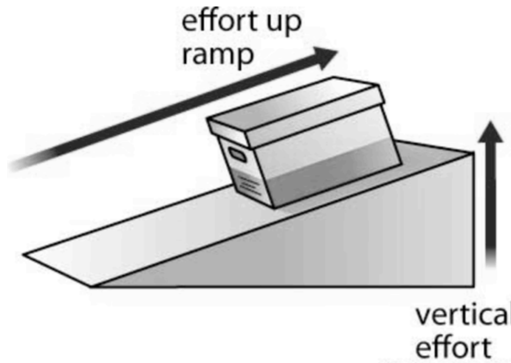
5.5 Simple Machines

- Wheel & Axle
  - A wheel and axle is a simple machine that consists of two disks or cylinders, each one with a different radius.
  - Depending on the purpose of the machine, the input force can be exerted on the wheel (IMA >1) or the axle (IMA < 1).
  - Examples: screwdriver, steering wheel
  - Equation: $IMA = \frac{r_{input}}{r_{output}}$



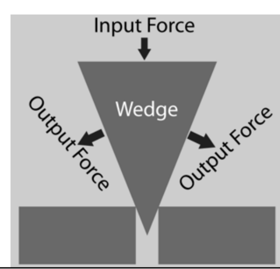
5.5 Simple Machines

- Inclined Planes
  - An inclined plane is a slanted surface along which a force moves an object to a different elevation.
  - Examples: Wheelchair ramp, boarding ramp onto a ship
  - Equation: $IMA = \frac{d_{plane}}{d_{height}}$



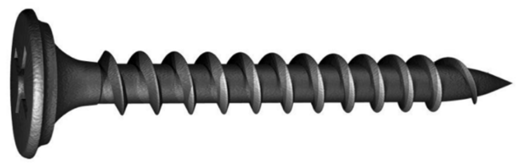
5.5 Simple Machines

- Wedge
  - A wedge is a V-shaped object whose sides are two inclined planes sloped toward each other.
  - IMA > 1
  - A thin wedge of a given length has a greater ideal mechanical advantage than a thick wedge of the same length.
  - Examples: zipper teeth, knife, axe head



5.5 Simple Machines

- Screw
  - A screw is an inclined plane wrapped around a cylinder.
  - Screws with threads that are closer together have a greater ideal mechanical advantage.
  - The thread on a screw is usually measured in threads per inch or threads per centimeter.
  - Examples: wood screws, jar lids, nuts

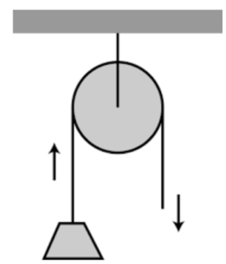


5.5 Simple Machines

- Pulleys
  - A pulley is a simple machine that consists of a rope that fits into a groove in a wheel.
  - Can change magnitude, distance, or direction of input force.
  - Three Types

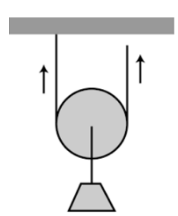
5.5 Simple Machines

- Fixed Pulley
  - A wheel attached in a fix location.
  - Often able to rotate in place.
  - Changes the direction of the applied force, but not the magnitude or distance.
  - IMA = 1
  - Examples: flag pole, pulley used to pull up blinds



5.5 Simple Machines

- Movable Pulley
  - A wheel attached to the object being moved (the rope is attached to a fix location).
  - If you are pulling up, IMA = 2
  - Examples: pulleys used to hoist sails, skyscraper window washers stand on platforms suspended by movable pulleys.



5.5 Simple Machines

- Pulley System
  - Combinations of fixed and movable pulleys
  - Can achieve high IMA

- Equation: IMA = # rope sections supporting the load being lifted

5.5 Simple Machines

- Compound Machines
  - Combination of two or more simple machines that operate together.
  - Examples: system of gears, a car, washing machine