GHSGT Science Review
Domain 5: Forces, Waves, and Electricity

FORCE

- A force is a push or pull that starts, stops, or changes the direction of an object. Force transfers energy to an object. To determine the amount of force being used, you need the mass of the object and its acceleration. Force is measured in Newtons, N.
- The equation is: **Force = mass x acceleration**
- Forces that are in opposite directions and equal in size are called balanced forces
- Friction is a force that opposes motion. It slows down an object. Motion of an object is going to occur when the forces acting upon it are unbalanced. There are three types of friction: fluid friction, rolling friction, and sliding friction. Fluid friction has the least amount of force and sliding has the most.

NEWTON'S FIRST LAW (Law of Inertia)

- Newton's first law states that an object in motion will remain in motion and an object at rest will remain at rest unless acted upon by an unbalanced force. Objects tend to keep on doing what they're doing. This tendency to resist changes in their state of motion is described as inertia. Inertia is the resistance an object has to a change in its state of motion. The more mass an object has, the more inertia an object has. An object with a lot in inertia is difficult to get moving and also harder to stop once it is moving.
- A ball thrown on earth will not keep going forever. The ball thrown on earth is acted on by gravity and friction. So it slows down and falls to earth. Gravity and friction are the unbalanced forces.

GRAVITY

- The universal Law of Gravitation states that every object in the universe is attracted to every other object in the universe. This force of attraction depends on the mass of the two objects as well as the distance that separates them. The more mass it has, the greater its gravitational force. The closer the two objects are, the greater the gravitational force. On earth, when you let go of an object, it falls to the ground at $9.8 m/s^2$. This is acceleration due to gravity. Objects accelerate as they fall due to gravity.
- Gravity is measured by weight and the unit is the Newton, N. If you change the force of gravity, you will change the weight. Weightlessness occurs when the force acting upon an object is equal and opposite to the force of gravity.

WORK

- Work is force applied over a distance.
- The equation is : **Work = Force x distance**
- The unit for work is joules (Newton-meter).

MACHINES

- Simple machines are devices that make work easier
- If you change the amount of force or distance, the amount of work will change.
- EFFORT FORCE is the force applied to the machine by you.
- RESISTANCE FORCE is the force opposing the effort force – often the weight of the object
- Mechanical advantage is the number of times a machines multiplies the force.
  - It is the ratio of the force that comes out of the machine to the force that is put into the machine.
- **Actual mechanical advantage = resistance force ÷ effort force**.
- The formula for ideal mechanical advantage is calculated by:
  - **Ideal mechanical advantage = effort length ÷ resistance length**
- 6 Types of simple machines:
  - Lever family includes: lever, pulley, and wheel and axle
  - Inclined plane family includes: inclined plane, wedge, and screw
- Compound machines are two or more simple machines

MOTION

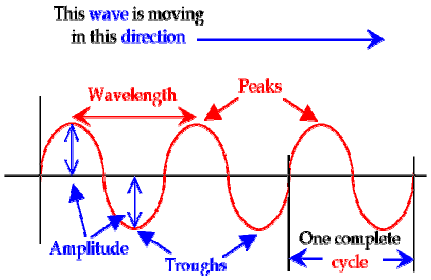
- For motion to occur there must be unbalanced forces.
- To measure motion, calculate speed. **Speed = $\frac{\text{distance}}{\text{Time}}$**
- Constant speed means the object is not changing its motion
- Average speed is the total distance traveled divided by the total time.
- **Velocity** is speed in a particular direction
- **Acceleration** is the change in an object's velocity, speeding up or slowing down.

- **The formula for acceleration** is **Acceleration = <u>final velocity – initial velocity</u>**
  Time
- Projectile motion is the motion of a thrown object. The arched path that the object takes is due to gravity pulling down and friction slowing it down.

WAVES

- A wave is a disturbance that transfers energy through matter or through space.
- Some waves, like sound waves, must travel through matter while others, like light, can travel through space and do not need a material to move through.
- Waves can be compressions of energy (compression/longitudinal wave) or made up of up and down movements (transverse waves)
- Examples: sound – compressional wave; earthquakes and light – transverse waves

<u>Parts of a Wave:</u>



A. Amplitude - the height of a wave above or below the midline
B. Crest - the peak or top of the wave
C. Midline - original position of the medium before the waves move through it.
D. Trough - the lowest point of the wave
E. Wavelength (cycle) - the distance between two peaks.

<u>Relating Frequency and Wavelength</u>

- Frequency is how fast a wave is moving. It is the number of crests that pass a point in a second.
- Wavelength is the distance between 2 consecutive crests
- A long wave has a low frequency and low energy. A short wave has high frequency and high energy
- The speed of a wave depends on the wavelength and frequency. The formula is: **speed = wavelength x frequency**

THE ELECTROMAGNETIC SPECTRUM

The electromagnetic spectrum is an order of electromagnetic waves in order of wavelength and frequency - a long wavelength has a low frequency, a short wavelength has a high frequency. Electromagnetic waves can travel through space. They do not need to travel through a medium like air or water, though they can.

<u>The Spectrum in Order</u>

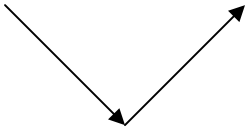
Least Energy ↓ Most Energy

Radio Waves	lowest frequency and longest wavelength, used for communication (radio and TV)
Microwaves	used in cooking and for RADAR
Infrared Waves	cannot be seen, felt as heat, "below" red, used for cooking, medicine, and night sight
Visible Light	portion of the spectrum that your eye is sensitive to, consists of seven colors (ROYGBIV), red has the lowest frequency/energy and violet has the highest frequency/energy
Ultraviolet Waves	present in sunlight, "beyond" violet, energy is enough to kill living cells, used for sterilization
X-Rays	energy is enough for photons to pass through the skin, for medicine
Gamma Rays	highest frequency, shortest wavelength, certain radioactive materials emit them, have tremendous ability to penetrate matter, used in the treatment of cancer

INTERACTIONS

When a wave hits a piece of matter, the wave can be absorbed or it can be reflected.

- **<u>Reflection</u>**
- the bouncing back after a wave strikes an object that does NOT absorb the wave's energy.

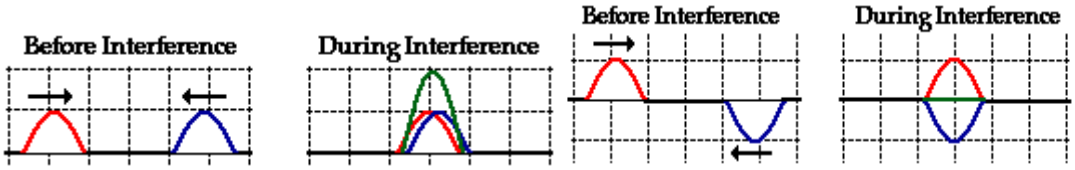


- The Law of Reflection states that the angle of the incidence is equal to the angle of reflection
- There are three types of mirrors that reflect light. PLANE - flat surface, reflected image is the same size. CONCAVE - curves inward, like the bowl of a spoon, reflected image is either enlarged (original image was close to the mirror) or the reflected image is smaller and upside-down (original image was far away). CONVEX - curves outward, like the back side of a spoon, reflected image is always smaller and right side up, provide a wide angle of view so a large area can be seen.
- The reflection of sound is called an ECHO.

- **Refraction**
- The bending of waves due to a change in speed. This time the wave is absorbed and not reflected.
- Waves move at different speeds in different types of matter. Temperature can also affect the speed of a wave.
- Examples include prisms (bends white light into its component colors), lenses like glasses and contacts, and a mirage.

- **Diffraction**
- The bending of waves around a barrier. When a wave encounters a barrier, it can go around it.
- Electromagnetic waves, sound waves, and water waves can all be diffracted. Diffraction is important in the transfer of radio waves. Longer AM wavelengths are easier to diffract than shorter FM wavelengths. That is why AM reception is often better than FM reception around tall buildings and hills.
- Examples include rainbow glasses, diffraction gratings.

- **Interference**
- The phenomenon which occurs when two waves meet while traveling along the same medium. The interference of waves causes the medium to take on a shape which results from the net effect of the two individual waves.
- When two waves' crests or troughs combine, there is an additive effect – this is called constructive interference. When one wave's crest and another's trough combine, there is a subtractive effect – this is called destructive interference.



Constructive interference **Destructive interference**

DOPPLER EFFECT
- It is a change in the pitch whenever there is motion between the source of a sound (or light) and its receiver. It depends on the frequency
- Example: an approaching ambulance. As the ambulance approaches, the waves become pushed together creating shorter wavelength and higher frequencies. So, the pitch goes up. As the ambulance moves away, the wavelengths become longer, the frequencies are lower, and the pitch goes down.

ELECTRICITY AND MAGNETISM

METHODS OF GENERATING ELECTRICITY
- Electricity is a form of energy called electrical energy. It is basically moving electrons.
- Electricity can be produced by:
  - **Static electricity**
    a. is the build up of electrical charge when electrons are exchanged from one object to another
    b. Static electricity is a result of friction
    c. Ways to generate static electricity are to rub silk and glass or plastic and wool.
  - **Electric Current**
    a. This is a streams of electrons that flow through a conductor, like a wire
    b. An electric current can be produced chemically, by moving water (hydroelectric), by solar cells (using sunlight), by wind, and by nuclear radiation (fission reaction).

INSULATORS AND CONDUCTORS

- Conductors are materials that are good at carrying an electric charge
- Good conductors of electricity include metals, water, electrolytes (solutions containing ions), and the human body
- Insulators keep an electric charge from flowing
- Good insulators include nonmetals, rubber, plastic, and wood.

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ELECTRICAL UNITS

There are three ways to measure electricity. They are current, voltage, and resistance.

- **Current:** This is the rate at which electric current flows through a wire. It is the number of electrons that pass by a specific point in a circuit in one second. The symbol is "I" and is measured in amps (A).
- **Voltage:** Electrons need energy to force the electrons through the wire. Voltage is the amount of energy available to move the electrons. The higher the voltage, the more work the electrons can do. The symbol for voltage is "V" and it is measured in volts (V).
- **Resistance:** This is the measure of how difficult it is to move electrons through a circuit. It is the force opposing the flow of electrons. Good conductors have a low resistance and poor conductors have a high resistance. Resistance depends on the material's length, thickness, and temperature. The symbol for resistance is "R" and it is measured in ohms (Ω).

Ohm's Law relates current, resistance, and voltage: Current = voltage ÷ resistance

MAGNETISM

- Magnetism is a universal force like gravity
- A magnet always has two poles - north and south. . Like poles repel each other and opposite poles attract.
- There is a magnetic field around a magnet and the invisible lines of force run from one pole to the other.
- A magnetic field can be produced using a current through a wire and a piece of metal that can be magnetized.

ELECTROMAGNETISM

- An electromagnet is a temporary magnet
- A simple electromagnet consists of a battery, copper wire, and an iron nail. The strength of the electromagnet depends on the number of turns in the wire coil and the size of the iron core. The greater the number of turns, the stronger the magnetic field that is produced.
- Magnets are used in electric motors. An electric motor is a device that produces a direct current. It contains an electromagnet, a permanent magnet, and a commutator. The electromagnet is placed between the poles of the permanent magnet. The poles repel and attract each other and the electromagnet spins. Electric energy is converted into mechanical energy. This is the opposite of a generator.
- A transformer is a device that uses electromagnetic induction to change the voltage of a current. Transformers are basically iron cores with wires wrapped around them. There are transformers at the power plant, at power substations, and on the utility pole near your house. . A transformer works by stepping up or stepping down the voltage of electricity. More current in a wire means that more energy is wasted due to resistance in the wire.