Classification of Energy

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Energy

Physics: the study of energy and its interaction with matter. Energy is the ability to do work or cause change.

Matter

Chemistry: the study of matter and its properties and composition. Matter occupies space and has mass.

Living Matter

Biology: the study of the interaction of matter and energy in living organisms and systems.

Forms of Energy

Work is the transfer of energy from one object to another - the ability of one object to exert a force (push or pull) across a distance on another. Thus, energy can be transformed from one form to another.

Forms of Potential Energy

Energy Due to Position

Potential energy results from interaction between objects.

All objects possess potential energy due to their relative position and interaction with other objects (Ex. planets; atomic particles).

Strong and Weak Nuclear Interactions:

- **Nuclear**: PE associated with the binding of nucleons in atoms.

Electromagnetic Interactions:

- **Electric:** PE associated with an object's electric charge. $PE_{electric} = kQq/r$, where k is Coulomb's constant, Q and q are the two charged objects, and r is the distance between objects.
- **Magnetic**: PE associated with an object's magnetic field.
- **Chemical:** PE associated with chemical bonds in matter.
- **Elastic**: PE associated with internal stresses of matter due to a deformed elastic object. For a linear spring, $PE_{elastic} = ½kx^2$, where k is the spring constant and x is the displacement.

Gravitational Interactions:

- **Gravitational**: PE associated with an object due to the gravitational force of another object. $PE_{gravitational} = -GMm/r$, where G is the gravitational constant, M and m are the masses of the objects, and r is the distance between the objects. For objects near the Earth's surface (experiencing a constant gravitational field), $PE_{gravitational} = mgh$, where m is mass in kilograms, g is the constant acceleration of object, and h is height of object in meters.

Forms of Kinetic Energy

Energy Due to Motion

Kinetic energy results from motion of an object.

All objects in motion have kinetic energy (Ex. the Earth revolving around the sun; the movement of atomic particles).

- **Radiant**: KE produced by the interaction of electric and magnetic fields. All objects absorb and emit electromagnetic radiation (waves) - does not require a medium to propagate. Heat energy is transferred to an object via infrared radiation.

- **Thermal**: KE produced by the random motion of particles within an object. Heat is transferred between objects via convection and conduction - requires medium to propagate. Thermal energy is produced by internal (nuclear, chemical, electrical) and external (mechanical, radiant, conduction) means. KE of an atom/molecule, $KE_{average} = ½mv^2$, where m is mass in kilograms, and v is velocity is meters / second.

- **Electrical**: KE produced by motion of charged particles (electrons, protons, ions). $KE_{electrical} = ½mv^2$.

- **Mechanical**: KE produced by the motion of an object. Examples: sound and moving objects. $KE_{mechanical} = ½mv^2$.

W = mad, where W is work in Joules, m is the mass of the object in kilograms, a is the acceleration of the object in m/s^2, and d is the distance the object moves in meters.

Conservation of Energy: total energy of an isolated (closed) system is constant over time – energy and momentum are conserved. Total energy is the sum of its potential and kinetic energies. Example: chemical energy in gasoline in a car is transformed to thermal and mechanical kinetic energy.

Energy-Mass Equivalence: a given mass has an equivalent amount of energy and vice versa. Per $E = mc^2$, mass is a form of concentrated energy. Converting one gram of mass completely into energy will produce about $9 * 10^{13}$ Joules of energy – this is enough energy to power a 100-watt lightbulb for 30,000 years. All forms of energy are measured in Joules - one Joule is equal to 1 kg m^2 / s^2.