Note Booklet #4:
Energy

Work

In physics work means that force is applied to an object and that object moves.

Work =

The unit for work is

Work is always done from one thing to another thing.

Example: A person pushes a block 25m across a floor with an applied force of 45N.

Example: A person pushes a block 15m across a floor with an applied force of 62N.

Example: A person pushes a block 15m across a floor with an applied force of 46N while friction pushes against the motion with a force of 25N.

Example: A person pushes a block 45m across a floor at a constant velocity with an applied force of 56N.

Example: A person pushes on a wall with a force of 26 N for 2.5 seconds but the wall does not move.

Example: A puck slides 26m over a frictionless surface at a constant velocity of 2.9 m/s.

Example: A 26 kg block is lifted by a person at a constant velocity to a height of 3.0m.

Example: A 6.2 kg block is lifted by a person at a constant velocity to a height of 91.2m.

What Work Does

Consider a block which is pushed 10.0 m by a force of 25N.

Situation 1: The block was pushed over a frictionless surface.

Situation 2: The block was pushed up a frictionless ramp at a constant velocity.

Situation 3: The block was pushed over a surface where friction equals the applied force.

Potential Energy

Potential energy is energy that is ________________________

For example:

The type of potential energy we will most focus on is ___________________________________

This is the energy which is stored due to ____ above a reference point.

Gravitational potential energy =

Example: A 2.0 kg object sitting on a table 1.0 m above the floor is lifted 0.5 m. How much gravitational potential energy does it have

a) With respect to the table

b) With respect to the floor

Example: What is ΔE_p when a 50 kg object is dropped from a height of 20m to 10m?

Practice:

1. How much gravitational potential energy does a 1500 kg car have if a hoist lifts it up to a height of 2.0 m above the floor?

2. A book of mass 1.2 kg drops from a height of 2.6 m to a height of 0.4 m. What is the value of ΔE_p?

3. It takes 90J of work to lift an object to a height of 1.2m. What is the mass of the object?

Kinetic Energy

Kinetic Energy is the energy of ___________________________. The faster an object is moving the more energy it has.

Kinetic energy =

Note that energy is not a vector, it does not matter what direction the object is moving.

Example: A 2.0 kg object is moving at 25 m/s. How much kinetic energy does it have?

Example: What is the mass of an object if it has 250 J of kinetic energy and is moving at 5.0m/s?

Example: What is the velocity of an object if it has 5600 J of kinetic energy and has a mass of 29kg?

Practice:

1. A 14 object is moving at 276 m/s. How much kinetic energy does it have?

2. What is the velocity of an object if it has 840 J of kinetic energy and has a mass of 29kg?

3. What is the mass of an object if it has 195 J of kinetic energy and is moving at 2.5m/s?

Conservation of Energy

A fundamental low of the universe is the law of conservation of energy:

Give an example of a technology which transforms energy from:

Electrical energy into kinetic energy:

Electrical energy into light energy:

Chemical energy into kinetic energy:

Chemical energy into electrical energy:

Example: A 20.0 kg rock is dropped from a height of 5.0m. It hits the ground at 8.5 m/s. How much heat energy was generated?

Thermal Energy

Thermal energy is the ____________________________________ of the molecules and atoms in a substance.

As a substance "heats up" the molecules and atoms that make up the substance move and vibrate more, thus increasing their kinetic energy.

Temperature is the _______________________ kinetic energy of a substance.

Thermal energy, like all energy is measured in ___________________

Temperature is measured in degrees Fahrenheit or Celsius or in Kelvin.

Kelvin is based on absolute zero which is the lowest possible temperature, at 0K there is _____________________________________.

0 K = _________ $°C$

Specific Heat Capacity

The amount of energy needed to raise the temperature of a substance depends on the chemical structure of that substance. For instance, if you applied 5000 J of heat energy to 1kg of water, copper iron or concrete.

The ability to absorb heat energy is a property of matter called ________________________________

The symbol for it is _______.

The table to the right shows specific heat capacities for several substances. For copper c = $430\frac{J}{kg{\cdot}°C}$. This means

Material	Specific Heat Capacity (J/(kg·C))
Water	4200
Ice	2040
Alcohol	2380
Concrete	880
Aluminum	900
Copper	430
Iron	450
Steel	480
Lead	130

The formula for solving problems with specific heat capacity is

ΔE_h =

where ΔE_h =

m =

c =

ΔT =

EXAMPLE: How much energy is needed to heat 2.5 kg of copper from 19° C to its melting point of 1085$°C$?

EXAMPLE: How much would the temperature of a 2.0 kg block of aluminum change if 3500 J of energy is applied to it.

EXAMPLE: What is the heat capacity of zinc if a 1.41 kg sample required 3.82$\times$ 10^3J of energy to raise its temperature from 20.0°C to $26.0°C$

Power

Power is

If two machines do the same amount of work but one machine finishes the job faster, then the faster machine is more powerful. Mathematically speaking,

Another useful formula:

Units

An alternative unit of power is "horsepower" (hp). The conversion factor between watts and horsepower is

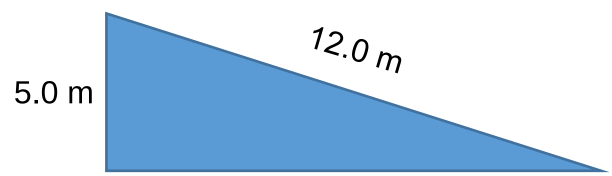
EXAMPLE: A car's engine outputs 1 200 000 J of energy in 5.0 seconds. What is the power of the engine in watts and in horsepower?

EXAMPLE: A 1600 W hairdryer is used for 35 seconds. How much energy does it use in that time?

EXAMPLE: How long does it take a 6 hp engine to use 1 000 000 J of energy?

EXAMPLE: A student runs up the ramp shown.

Their power output is 2300 W. How long will it take them to run up the ramp?



EXAMPLE: A motor has a maximum power output of 4.9 watts. What is the maximum mass it can lift at 3.0 m/s? What about at 0.5 m/s?

EXAMPLE: A 70.0 kg runner increases their speed from rest to 10.0 m/s in 4.0 seconds. What is their power output?

Efficiency

A machine converts one type of _______________ into _______________________________.

For example:

No machine is 100% efficient, that is ____________________ < ______________________

The "lost" energy is generally converted into ____________________.

Efficiency is a measure of what percentage of the input energy is transformed into the output or what percentage of the input power is transformed into output power.

EXAMPLE: A 2600 W motor outputs 2300 W of power. What is the efficiency of the motor?

EXAMPLE: A lever is used to lift a 50.0 kg object 10.0 cm. To do this we must apply a force of 75 N to the end of the lever which displaces 1.00 m. Find the efficiency of the lever.

EXAMPLE: How much work can a 22 kW electric car engine do in 60 seconds if it is 75 % efficient?

EXAMPLE: A 12 kW machine pulls a 680 kg block across a surface with $\mu = 0.44$ at 2.5m/s. What is the efficiency of the machine?