Solar Energy

The rate at which solar energy arrives at the top of the atmos-phere is called the **solar constant** Is This is the amount of energy received in unit time on a unit area perpendicular to the sun's direction at the mean distance of the earth from the sun. Because of the sun"s distance and activity vary throughout the year, the rate of arrival of solar radiation varies accordingly. The so called solar constant is thus an average from which the actual values .
The National Aeronautics and Space Administration's (NASA) standard value for the solar constant,**1.353 kilowatts per square metre** or 1353 watt per square meter.

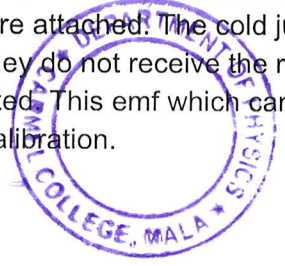
Beam and Diffuse Solar Radiation. The solar radiation that penetrates the earth's atmosphere and reaches the surface differs in both amount and character from the radiation at the top of the atmos-phere. In the first place, part of the radiation is reflected back into the space, especially by clouds. Further more, the radiation entering the atmosphere is partly absorbed by molecules in the air.. In addition, part of the solar radiation is scattered (i.e., its direction has been changed) by droplets in clouds by atmos- pheric molecules, and by dust particles.

Diffuse radiation is that solar radiation received from the sun after its direction has been changed by reflection and scattering by the atmosphere.

Solar radiation that has not been absorbed or scattered and reaches the ground directly from the sun is called **"direct radiation"or Beam radiation.**
The insolation is defined as the total solar radiation energy received on a horizontal surface of unit area (e.g., 1 sq. m) on the ground in unit time .

Two basic types of instruments are employed for solar radiation

A pyrheliometer is an instrument which measures beam radiation. In contrast to a pyranometer, the sensor disc is attached at the base of the tube. Thus diffuse radiation is essentially blocked from the sensor surface. Most pyrheliometers used for routine measurements operate on the thermopile effect. In practice, direct solar radiation is measured by attaching the instrument to an electrically driven equatorial mount tor tracking the sun. The diffuse component is avoided by installing a collimator tube over the sensor with a circular cone angle °.
B) Pyranometers. A pyranometer measures total or global radiation over a hemispherical field of view. In most pyranometers, the sun's radiation allowed to fall on a black surface to which the hot junctions of thermopile are attached. The cold junctions of the thermopile are located in such a way that they do not receive the radiation. As a result an e.m.f. proportional to the solar radiation is generated. This emf which can be read, recorded or integrated over a period of time with regular calibration.



Battery

A battery is defined up a combination of individual cell. In a charged cell electrical energy is stored as chemical energy which can be recovered as electrical energy then the cell is discharged.

Types of battery

1. primary battery which is not rechargeable eg. dry cell. Chemical reaction are non reversible
2. secondary battery - Rechargeable battery. eg. lead acid battery

Cell consists of electrodes anode and cathode immersed in a suitable electrolyte. When load is connected to the electrodes, charge separation occurs at electrode electrolyte interface freeing charge carriers. Electrons flow through external load and ions through electrolyte constituting current.

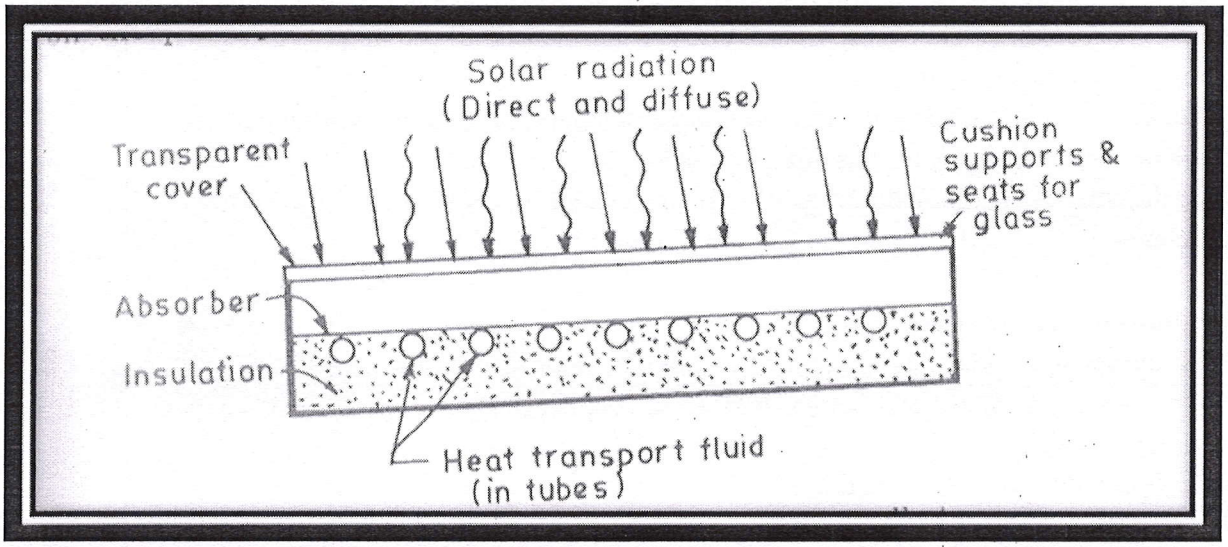
Magnitude of the terminal voltage and polarity is a function of electrode material electrolyte cell temperature and other practice

Advantages of batteries for bulk energy storage

1.mitigation of oil shortage and import problems
2. Lower cost of electrical energy, Battery
3. Saving in power transmission
4. shorter time for construction
5. reliability in power emergency and regulation

Flat-plate solar collectors

Flat-plate solar collectors may be divided into two main classification based on the type of heat transfer fluid used.
Liquid heating collectors are used for heating water and non-freezing aqueous solutions and occasionally for non-aqueous heat trans-fer fluids.
Air or gas heating collectors are employed as solar air heaters.
The principal difference between the two types is the design of the passages for the heat for the transfer fluid.
The majority of the flat-plate collector have five main components as follows:
(i) A transparent cover which may be one or more sheets of glass or radiation transmitting plastic film or sheet.
(ii) Tubes, fins, passages or channels are integral with the collector absorber plate or connected to it, which carry the water, air or other fluid.
(iii) The absorber plate, normally metallic or with a black,surface, although a wide variety of other materials can be used with air heaters.
(iv) Insulation, which should be provided at the back and sides to minimise the heat losses. Standard insulating materials such as fiberglass or styro-foam are used for this purpose.
(v) The casing or container which enclose the other components and protects them from the weather.
(A) A Typical Liquid Collector



It suffers from cèrtain drawbacks, one is the possibility of freezing in the collector tubes in cold climates during cold nights.Ethylene glycol is added to prevent freezing, but this generally adds to the complexity of the heating system.
Furthermore, the antifreeze solution is less effective than water for heat removed from the absorber.
Another problem arises from corrosion of the metal tubes by the water.The oxygen in air increases the rate of corrosion of most metals. Corrosion can be minimized by using copper tubing. Aluminium is a less expensive alternative, although periodic chemical treatment of water is desirable.
Finally, leaks in a water (or anti freeze) circulation system require immediate attention.

Physical Principles of the Conversion of Solar Radiation into Heat

The fundamental process now in general use for heat conversion is the **green house effect.** Most of the energy we receive from the sun comes in the form of light, a shortwave radiation, not all of which is visible to the human eye. When this radiation strikes a solid or liquid, it is absorbed and transformed into heat energy; the material becomes warm and stores the heat, conducts it to surrounding materials (air water, other solids or liquids) or reradiates it to other materials of lower temperature T .The reradiation is a long wave radiation. Hence the green house effect brings about an accumulation of energy of the ground.

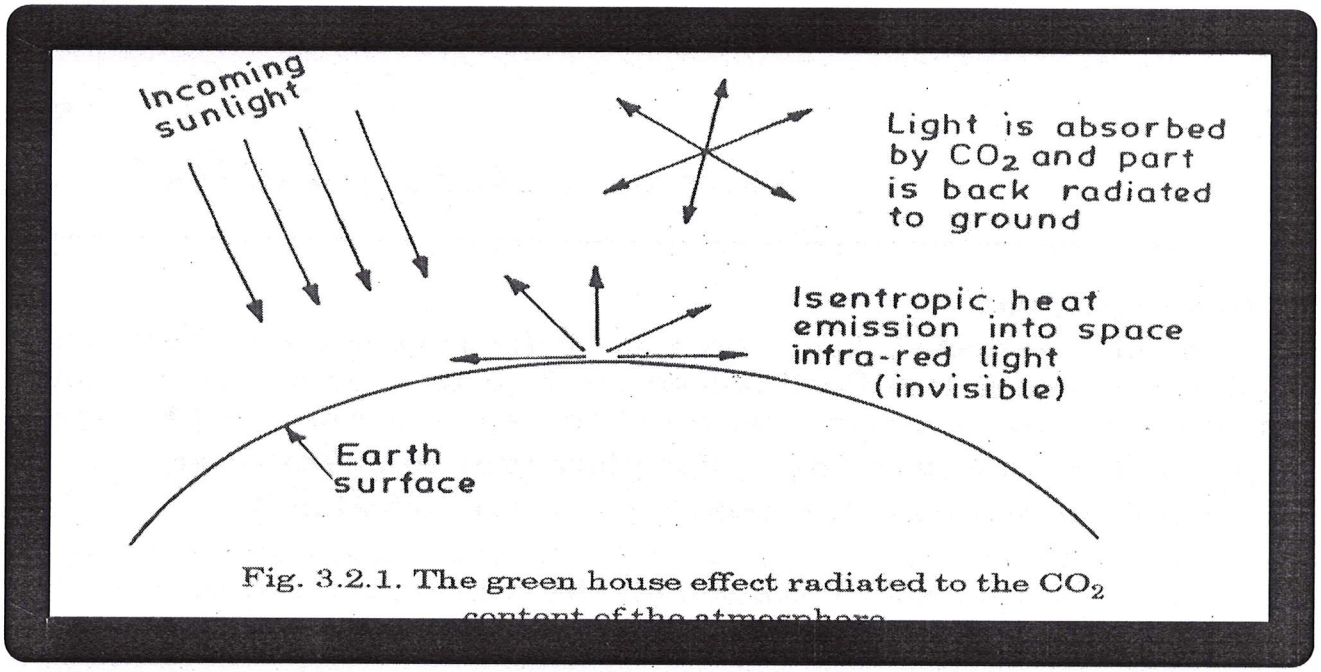


Fig. 3.2.1. The green house effect radiated to the CO_2 content of the atmosphere

Glass easily transmits short-wave radiation,, but it is a very opaque transmitter of long-wave radiation. Once the sun's energy has passed through the glass windows and has been absorbed by some material inside, the heat will not be reradiated back outside. Glass therefore act as a heat trap. a black-painted plate absorbs the incoming sunlight. When the temperature of the black plate increases, it emits an increment of thermal heat in the form of infra-red light.
Since glass is opaque to IR radiation, it is reflected back to the black surface. As a result temperature inside cavity increases

Methods for obtaining energy from Biomass

Solar energy stored in plants is called Biomass. The biomass energy can be converted into various energy forms. Biomass transportation of high cost because of its low density and low energy content per unit weight but Biomass produced would be converted on-site into electricity, synthetic natural gas energy and more economical to transport.

The processes by which the products of energy farms can be converted into various energy forms are

Combustion

direct combustion of biomass with a moisture content around 15% or less as it requires drying period to combustion for most of the crops. The combustion produces steam both for process use and for electricity. electricity can also be produced by installing power plants near the industry.

Anaerobic digestion

Anaerobic digestion of organic waste may constitute an effective device for pollution control in addition to energy generation. The main advantage is that it utilizes Biomass with water content as high as 99%. Another advantage is that smaller units can be kept at individual farms and also the residue has fertilizer value. The main limitation of this process is that a large quantity of wastewater is to be disposed after digestion.

Pyrolysis

It is a reversible chemical change caused by the action of she It is an Irreversible chemical change caused by the action of heat in absence of oxygen. It made yield either solid liquid or gaseous fuel. Heating in absence of oxygen splits the chemical bonds and leaves the energy stored in Biomass. Pyrolysis of cow manure wood saw dust liberates hydrogen, nitrogen, carbon monoxide, carbon dioxide etc. Hydrogen and carbon monoxide can be converted into methanol, gasoline, diesel Ammonia can be used for fertilizers drugs, building or bonding material and synthetic textiles. The main advantages of pyrolysis include compactness ,simple equipment, low pressure operation, negligible waste product and high conversion efficiency of the order of 83%.

hydrolysis and ethanol fermentation

hydrolysis is the technology which converts cellular to alcohol to fermentation. ethyl alcohol can be produced from a variety of sugar by fermentation with yeast. molasses is diluted with water sugar content of about 20%, acidified and mixed with yeast culture. Ammonia is used to reduce acidity. Alcohol fermentation of large variety of substrate has been obtained .

Gasifiers

Gasification is a very promising conversion Technology. This technology can be used for Generation of gas and electric production from Biomass waste materials.

Tides

The periodic rise and fall of the water level of the sea which are carried by the action of sun and moon on the water of earth is called tides. Tides are produced mainly by the gravitational attraction of the moon and the sun on the water of solid Earth and ocean. about 70% of the Tides producing force is due to the moon and 30% is due to the sun.

The surface water is pulled away from the Earth on the side face in the moon and at the same time the solid Earth is pulled away from the water on the opposite side. Thus high tide occurs in these two areas with low Tides at intermediate points.

Two tidal cycles occurs during a lunar day of 24 hours and 50minutes the time between high tide and low tide at any given location is a little over 6 hours. A high tide will be experienced at a point which is directly under the moon at the same time a diametrically opposite point on earth surface also experience as a high tide due to dynamic balancing.

the difference between high and low water level is called the range of the tide

At the time near full or new Moon and Earth approximately in a line, the gravitational forces of sun and moon enhance each other; the tidal range is then exceptionally large. The high Tides are higher and low Tides are lower than the average. These high Tides are called spring tides.

On the other hand near the first and third quarters of the moon, and the sun and moon are at right angles with respect to earth Neap tide occurs the tidal range is then exceptionally small. The high Tides are lower and low Tides are higher than the average and the range is not a constant.

The Tides are a periodical phenomenon but no two tide in any cycle are alike

The mean tidal range varies from place to place.

components of tidal power plants

There are three main components of a tidal power plant

1. power house
2. The dam or barrage to form pool or basin
3. Sluice ways from the basin into the sea and Vice versa

the turbine, electric generators and other optional equipment are the main equipment's of a power house

The dam is a barrier between the sea and the bean

Sluice ways are used either to fill the basin during the high tide or empty the basin during the low tide as per operational requirements. These are gate controlled devices.

Advantages of tidal power generation

1.The biggest advantage of tidal power plant is it is independent of rain and its uncertainty
2. it is free from pollution
3. it does not demand large land area
4. peak power demand can be effectively met when it works in combination with thermal a hydroelectric system

Limitations

1. the fundamental drawback of tidal power is its output variability
2. since the tidal range is highly variable the turbines have to work on a wide range of head variation, this affects the efficiency of the plant.
3. there is a chance of corrosion since seawater is salty
4. Construction in sea is found to be difficult
5. it requires high installation cost
6. it may cause difficulties in fishing and navigation

Advantages of wave energy

- **Renewable**: The best thing about wave energy is that it will never run out. Unlike fossil fuels, which are running out.The waves flow back from the shore, but they always return.
- **Environment Friendly**: Also unlike fossil fuels, creating power from waves creates no harmful byproducts such as gas, waste and pollution
- The energy is free - no fuel needed, no waste produced.
- Not expensive to operate and maintain.
- Can produce a great deal of energy.
- It is a reliable source
- Easily predictable

Disadvantages of wave energy

1. All equipment must be operated in marine environment, hence problems of maintenance, high cost, low life time.

2. Energy must be transported a greater distance to shore

3. Energy converters must be capable of with standing storms etc

Wave energy conversion devices

the mechanical energy in waves is the energy of Forward motion of the wave

wave energy conversion by floats

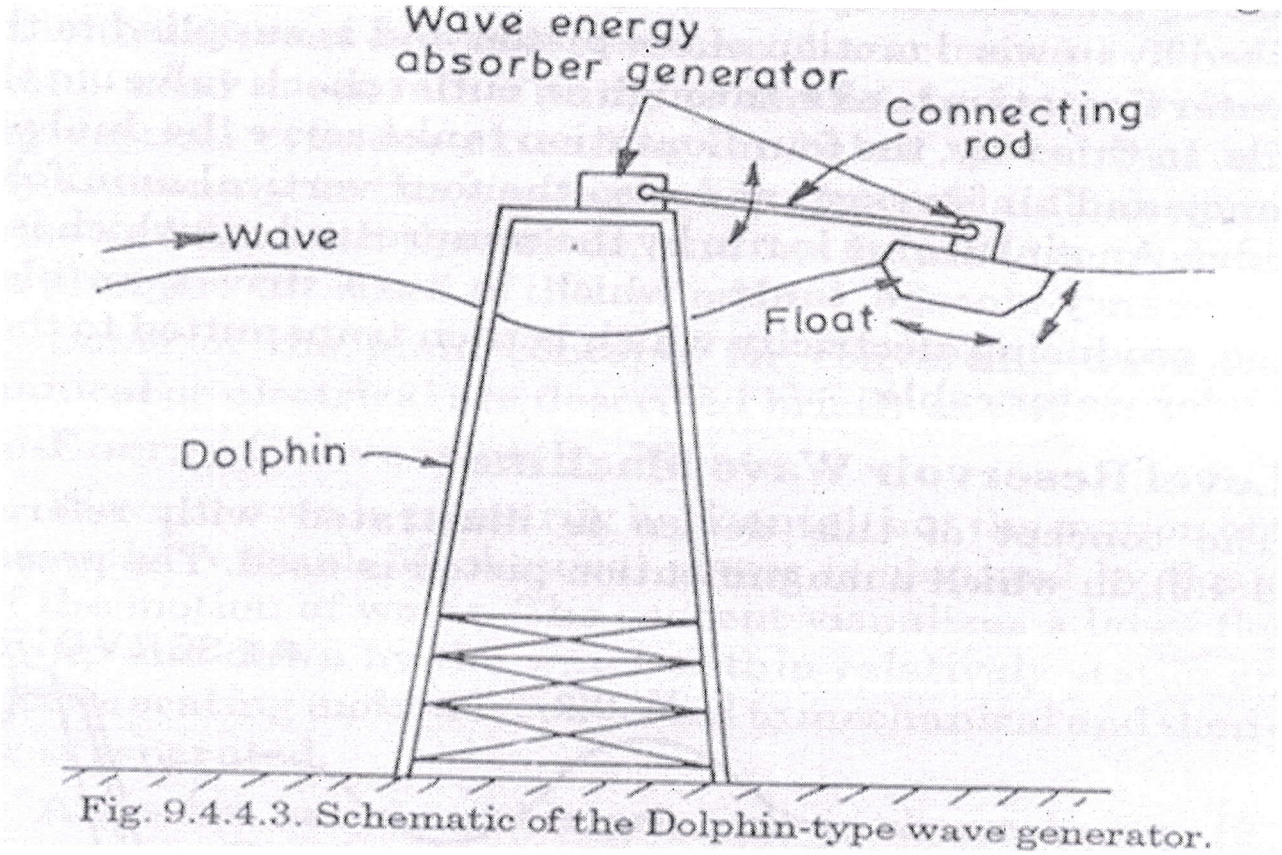


Fig. 9.4.4.3. Schematic of the Dolphin-type wave generator.

The system consist of a dolphin, a float ,a connecting rod and 2 electrical generators

This device uses the float which has two motion the first motion about its own fulcrum with the connecting rod. Revolving moments are caused between the float and the connecting rod. The other is a nearly vertical motion about the connecting rod fulcrum .In both cases the movements are amplified and converted by gears into continuous rotary motions that drives the electrical generators and produce electricity.

Two dimensional projectile motion

$$v_{x(i+1)} = v_{xi} + h a_{xi}$$

$$x_{i+1} = x_i + h v_{xi}$$

$$v_{y(i+1)} = v_{yi} + h a_{yi}$$

$$y_{i+1} = y_i + h v_{yi}$$

A body is projected with a horizontal velocity of 1 m/s and moving under gravity. Tabulate the position and velocity for the first 1 second with an interval of 0.25 second.

X	Y
Initial velocity $v_{x0} = 1$ m/s	Initial velocity $v_{y0} = 0$
Initial position $x_0 = 0$	Initial position $y_0 = 0$
$a_x = 0$	$a_y = 9.8 \text{ m/s}^2$
$h = 0.25$s	$h = 0.25$s
~~$v_{x1} = v_x$~~	
$t = 0.25$s	$t = 0.25$s
$v_{x0.25} = v_{x0} + h \cdot a_x$	$v_{y0.25} = v_{y0} + h a_y$
$= 1 + 0.25 \times 0 = 1$	$= 0 + 0.25 \times 9.8$
$x_{0.25} = x_0 + h \cdot 0.25$	$= 2.45$
$= 0 + 0.25 \times 1 = 0.25$	$y_{0.25} = y_0 + h v_{y0.25}$
	$= 0 + 0.25 \times 2.45$
	$= 0.613$

$V_{x0.5} = V_{x0.25} + h a_x$

$= 1 + 0.25 \times 0 = 1$

$x_{0.5} = x_{0.25} + h V_{x0.5}$

$= 0.25 + 0.25 \times 1$

$= 0.5$

$t = 0.75$s

$V_{x0.75} = V_{x0.5} + h a_x$

$= 1 + 0.25 \times 0$

$= 1$

$x_{0.75} = x_{0.5} + h V_{x0.75}$

$= 0.5 + 0.25 \times 1$

$= 0.75$

$t = 1$s

$V_1 = V_{x0.75} + h a_x$

$= 1 + 0.25 \times 0$

$= 1$

$x_1 = x_{0.75} + h V_{x1}$

$= 0.75 + 0.25 \times 1$

$= 1$

$V_{y0.5} = V_{y0.25} + h a_y$

$= 2.45 + 0.25 \times 9.8$

$= 4.9$

$y_{0.5} = y_{0.25} + h V_{y0.5}$

$= 0.613 + 0.25 \times 4.9$

$= 1.838$

$t = 0.75$s

$V_{y0.75} = V_{y0.5} + h a_y$

$= 4.9 + 0.25 \times 9.8$

$= 7.35$

$y_{0.75} = y_{0.5} + h V_{y0.75}$

$= 1.838 + 0.25 \times 7.35$

$= 3.676$

$t = 1$s

$V_{y1} = V_{y0.75} + h a_y$

$= 7.35 + 0.25 \times 9.8$

$= 9.8$

$y_1 = y_{0.75} + h V_{y1}$

$= 3.676 + 0.25 \times 9.8$

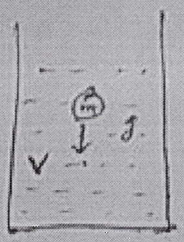
$= 5.636$

Time	V_x	V_y	x	y
0	1	0	0	0
0.25	1.0	2.45	0.25	0.613
0.5	1	4.9	0.5	1.838
0.75	1	7.350	0.75	3.676
1	1	9.8	1	6.36

Freely falling body in viscous

$F = mg$ Viscous force $F = 6\pi\eta r v$

Total force acting on the ball due to viscous medium



$$F = mg - 6\pi\eta r v$$

$$ma = mg - 6\pi\eta r v$$

$$a = g - \frac{6\pi\eta r}{m} v$$

Let $\frac{6\pi\eta r}{m} = c$

$$a = g - cv$$

A gently placed metallic ball of radius 0.05 m is moving and mass of 1 kg is moving down in castor oil of coefficient of viscosity 0.7 Pa s. Estimate the position and velocity after 0.75 seconds under the influence of viscous force. Use a step size of 0.25s.

Initial position $x_0 = 0$

Initial velocity $v_0 = 0$

Time $= 0.75$ s.

Coefficient of viscosity $\eta = 0.7$

Radius of the ball $r = 0.05$

Mass of the body $m = 1$ kg.

step size, $h = 0.25$

$$c = \frac{6\pi\eta\lambda V}{m} = \frac{6 \times 3.14 \times 0.7 \times 0.5}{1}$$

$$c = 0.6594$$

$$a = g - cv_i = 9.8 - 0.6594 v_i$$

$$v_{i+1} = v_i + h a_i$$

$$x_{i+1} = x_i + h v_i$$

~~$t = 0.25$~~ $t = 0.5$

$$a = 9.8 - c v_0 = 9.8$$

$$v_0 = 0.$$

$$x_0 = 0.$$

$t = 0.25$ s

$$a_{0.25} = 9.8 - c v_0 = 9.8 - 0 = 9.8$$

$$v_{0.25} = v_0 + h a_{0.25}$$

$$= 0 + 0.25 \times 9.8 = 2.45$$

$$x_{0.25} = x_0 + h v_0$$

$$= 0 + 0.25 \times 0 = 0$$

$t = 0.5$ s

$$a_{0.5} = 9.8 - c v_{0.25} = 9.8 - (0.6594 \times 2.45)$$

$$a_{0.5} = 8.184$$

$$v_{0.5} = v_{0.25} + h a_{0.5}$$

$$= 2.45 + 0.25 \times 8.184$$

$$= 4.496$$

$$x_{0.5} = x_{0.25} + h.v_{0.25}$$

$$= 0 + 0.25 \times 2.45 = 0.613$$

$t = 0.75s$

~~$v_{0.75} = v_{0.5}$~~

$$a_{0.75} = g - cv_{0.5} = 9.8 - 0.6594 \times 4.496$$

$$a_{0.75} = 6.835$$

$$v_{0.75} = v_{0.5} + h a_{0.75}$$

$$= 4.496 + 0.25 \times 6.835$$

$$= 6.205$$

$$x_{0.75} = x_{0.5} + h v_{0.5}$$

$$= 0.613 + 0.25 \times 4.496$$

$$= 1.737$$

Time	Acceleration	Velocity	Position
0.000	9.800	0.000	0.000
0.250	9.800	2.450	0.000
0.500	8.184	4.496	0.613
0.750	6.835	6.205	1.737

Position and velocity of a freely falling body

$a = 9.8\ m/s^2$

$V_{i+1} = V_i + hg_i$

$x_{i+1} = x_i + hv_i$

A body is freely falling from a height under gravity. Find the velocity and position at the end of 1 second. Tabulate the values at an interval of 0.25 seconds.

Ans: Initial position $x_0 = 0$.

Initial velocity $V_0 = 0$.

$a = 9.8\ m/s^2$ $\quad h = 0.25$

At 0.25s

$V_{0.25} = V_0 + ah$

$V_{0.25} = 0 + 0.25 \times 9.8 = 2.45$

$x_{0.25} = x_0 + V_0 h$

$= 0 + 0 \times 0.25 = 0$

At 0.5s

$V_{0.5} = V_{0.25} + ha$

$= 2.45 + 0.25 \times 9.8 = 4.9$

$x_{0.5} = x_{0.25} + V_{0.25} h$

$= 0 + 2.45 \times 0.25 = 0.613.$

At 0.75s

$V_{0.75} = V_{0.5} + ha.$

$= 4.9 + 0.25 \times 9.8 = 7.350$

$$x_{0.75} = x_{0.5} + h v_{0.5}$$

$$= 0.613 + 0.25 \times 4.9 = 1.838.$$

At 1s.

$$v_1 = v_{0.75} + ha$$

$$= 7.350 + 0.25 \times 9.8 = 9.8$$

$$x_1 = x_{0.75} + h v_{0.75}$$

$$= 1.838 + 0.25 \times 7.350 = 3.676.$$

Time	Velocity	Position
0.000	0.000	0.000
0.250	2.450	0.000
0.500	4.900	0.613
0.750	7.350	1.838
1.000	9.800	3.676

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At 0.25s

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$x_{0.25} = x_0 + v_0 h$

$= 0 + 0 \times 0.25 = 0$

At 0.5s

$v_{0.5} = v_{0.25} + ha$

$= 2.45 + 0.25 \times 9.8 = 4.9$

$x_{0.5} = x_{0.25} + v_{0.25} h$

$0 + 2.45 \times 0.25 = 0.613.$

At 0.75s

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