S.V.L.N.S. GOVERNMENT DEGREE COLLEGE, BHEEMUNIPATNAM
Teaching Synopsis (2017-18)

Name of the Department/Subject	**PHYSICS**
Name of the Lecturer	**M.RAJESWARA RAO**
Course/Group	**I St B.Sc. (M.P.C)**
Paper	**Physics I (Mechanics and Properties of Matter)**
Name of the Topic	**Central forces**
Hours required	**12**
Learning Objectives	**Understanding the Kepler's laws of planetary motion.**
Previous Knowledge to be reminded / revised	**Polar coordinates, Properties of ellipse, Vectors.**

TEACHING PLAN (SYNOPSIS)

Topic Synopsis

CENTRAL FORCES

Central force is a force that acts from a fixed point or away from the fixed point and its magnitude depends only on the distance from the fixed point. We can easily solve the motion of a particle under the central forces by using the polar coordinates.

If a particle P moving along the curved path under the influence of central force as shown in figure then the position vector of the particle in Cartesian coordinates is

$$\overrightarrow{OP} = \vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$$

In polar coordinates $\overrightarrow{OP} = \vec{r} = r\hat{r}$ where $\hat{r}$ is the unit radial vector along the direction of $\overrightarrow{OP}$. In this system, central forces are can be denoted as $\overline{F} = f(r)\hat{r}$.

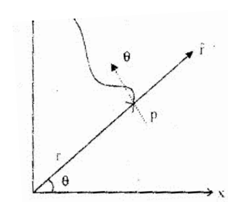
Examples: Gravitational force, electrostatic force, Elastic force.

i) Characteristics of the Central forces

Central force is a conservative force

If the work done by the force moving a particle from one point to another point depends only on the position of the points and independent of the path followed by the particle then the force is called as conservative force.

According to the laws of vectors a force is said to be conservative only if it is irrational .ie .curl of that force becomes zero.



Central force $\overline{F} = f(r)\hat{r}$

Curl of the central force $\overline{\nabla} \times \overline{F} = \overline{\nabla} \times f(r)\hat{r}$

$$= \overline{\nabla} f(r) \times \hat{r} + f(r)\left(\overline{\nabla} \times \hat{r}\right)$$

$$= f'(r)\hat{r} \times \hat{r} + f(r)\left(\overline{\nabla} \times \hat{r}\right)\left(\because \overline{\nabla} f(r) = f'(r)\hat{r}\right)$$

$$= 0 + 0 = 0\left(\because \hat{r} \times \hat{r} = 0 \text{ and } \overline{\nabla} \times \hat{r} = 0\right)$$

$$\therefore \overline{\nabla} \times \overline{F} = 0$$

So that central force is irrational and hence central force is conservative.

ii) Angular momentum of central forces is conserved.

The torque acting on a particle rotating about a certain axis under the central forces is

$$\tau = \overline{r} \times \overline{F}$$

$= \bar{r} \times f(r)\hat{r} \left(\because \text{ Central force } \bar{F} = f(r)\hat{r}\right)$

$= r\hat{r} \times f(r)\hat{r} \left(\because \hat{r} = \frac{\bar{r}}{r}\right)$

$= rf(r)\left(\hat{r} \times \hat{r}\right) = 0 \left(\because \hat{r} \times \hat{r} = 0\right)$

$\therefore \tau = 0$

But torque is the rate of change of angular momentum $\frac{d\bar{J}}{dt}$

$\therefore \tau = \frac{d\bar{J}}{dt} = 0$

$\Rightarrow d\bar{J} = 0$

$\Rightarrow \bar{J} = \text{constant}$

The angular momentum of a particle under central forces rotating about a certain axis is constant. Angular momentum of central forces is conserved

iii) Central forces as negative gradient of potential energy.

Work done on the object aginst the central forces increases the potential energy.

If $U(x, y, z)$ is the potential energy function of central forces

Then change in potential energy $dU = \frac{\partial U}{\partial x}dx + \frac{\partial U}{\partial y}dy + \frac{\partial U}{\partial z}dz$

$= \frac{\partial U}{\partial x}\bar{i}.\bar{i}dx + \frac{\partial U}{\partial y}\bar{j}.\bar{j}dy + \frac{\partial U}{\partial z}\bar{k}.\bar{k}dz \left(\because \bar{i}.\bar{i} = \bar{j}.\bar{j} = \bar{k}.\bar{k} = 1\right)$

$= \left(\bar{i}\frac{\partial U}{\partial x} + \bar{j}\frac{\partial U}{\partial y} + \bar{k}\frac{\partial U}{\partial z}\right).\left(\bar{i}dx + \bar{j}dy + \bar{k}dz\right)$

$\therefore dU = \left(\bar{i}\frac{\partial U}{\partial x} + \bar{j}\frac{\partial U}{\partial y} + \bar{k}\frac{\partial U}{\partial z}\right).\overline{dr}$ **--------- (1)**

The work done against the central forces $\bar{F}$ **is equal to the change in the potential energy**

$\therefore dU = -\bar{F}.\overline{dr}$**------------(2)**

Comparing Equations 1 and 2 we have

$\bar{F} = -\left(\bar{i}\frac{\partial U}{\partial x} + \bar{j}\frac{\partial U}{\partial y} + \bar{k}\frac{\partial U}{\partial z}\right) = \left(\bar{i}\frac{\partial}{\partial x} + \bar{j}\frac{\partial}{\partial y} + \bar{k}\frac{\partial}{\partial z}\right)U$

$\therefore \bar{F} = -\bar{\nabla}U$

Accelation of a paricle in polar coordiantes under the central forces

Radial accelaration along the radius vector $\bar{a}_r = \ddot{\bar{r}} - \bar{r}\dot{\theta}^2 = \left(\ddot{r} - r\dot{\theta}^2\right)\hat{r}$

Transverse accelaration $\bar{a}_\theta = \bar{r}\ddot{\theta} + 2\dot{\bar{r}}\dot{\theta}$

The areal velocity of a particle moving under the influence of central forces is constant.

Areal Velocity $\frac{dA}{dt} = \frac{1}{2}r^2\dot{\theta} = \frac{h}{2} =$**Constant**

Equation of motion of a particle in central forces

If central force $\bar{F} = F(r)\hat{r}$ is acting **on a particle of mass m then the transverse acceleration of the particle becomes zero and it has only radial acceleration.**

According to Newtons Second Law

$$ma_r = \bar{F}$$

$\Rightarrow m\left(\ddot{r} - r\dot{\theta}^2\right)\hat{r}) = F(r)\hat{r}\left(\because \text{radial accelaration } \bar{a}_r = \ddot{\bar{r}} - r\dot{\theta}^2\right)$

$\Rightarrow m\left[\frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2\right] = F(r)$

$\Rightarrow \frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2 = \frac{F(r)}{m} = f(r)$**------------------(1)**

Let $u = \frac{1}{r} \Rightarrow r = \frac{1}{u}$

$\Rightarrow \frac{dr}{dt} = \frac{d}{dt}\left(\frac{1}{u}\right)$

$\Rightarrow \frac{dr}{dt} = -\frac{1}{u^2}\frac{du}{dt}. = -\frac{1}{u^2}\frac{du}{d\theta}.\frac{d\theta}{dt} = -r^2\dot{\theta}\frac{du}{d\theta}\left(\because \frac{d\theta}{dt} = \dot{\theta}\right)$

But areal velocity $\frac{1}{2}r^2\dot{\theta} = \frac{h}{2} = \text{constant} \Rightarrow r^2\dot{\theta} = h \Rightarrow \dot{\theta} = hu^2$**--------(2)**

$\therefore \frac{dr}{dt} = -h\frac{du}{d\theta}$

$\frac{d^2r}{dt^2} = \frac{d}{dt}\left(\frac{dr}{dt}\right)$

$= \frac{d}{dt}\left(-h\frac{du}{d\theta}\right)$

$= -h\frac{d}{d\theta}\left(\frac{du}{d\theta}\right)\left(\frac{d\theta}{dt}\right)$

$= -h\dot{\theta}\frac{d^2u}{d\theta^2}$ = $-h\left(hu^2\right)\frac{d^2u}{d\theta^2}\left(\because\ \dot{\theta} = hu^2\right)$

$\therefore \frac{d^2r}{dt^2} = -h^2u^2\frac{d^2u}{d\theta^2}$**--------------------(3)**

Substituting Eqn (3)in Eqn(**1**) we get

$-h^2u^2\frac{d^2u}{d\theta^2} - \frac{1}{u}\left(hu^2\right)^2$ **=**$f(r)$

$\Rightarrow -h^2u^2\frac{d^2u}{d\theta^2} - h^2u^3$ **=**$f(r)$

Dividing both sides with $-h^2u^2$

$\frac{d^2u}{d\theta^2} + u$ **=**$-\frac{f(r)}{h^2u^2}$

This is the equation of a particle under cental force

Gravitational potential

The gravitational potential at V at a point distant r from a body of mass M is equal to the work done in moving a unit mass from infinity to that point.

$V(r) = -\frac{GM}{r}$

Potential energy of a body of mass m

$u(r) = mV(r) = -\frac{GMm}{r}$

Kepler Laws

1. The path of a planet is an elliptical orbit around the sun with sun at one of its foci.- law of elliptical orbits

2. The radius vector drawn from the sun to a planet sweeps out equal areas in equal intervals of time.-law of areas

3.The square of the time period of a planet is proportional to the cube of the semi-major axis. Harmonic law

Derivation of kepler first Law

The equation of a particle under cental forceis

$\frac{d^2u}{d\theta^2} + u$ **=**$-\frac{f(r)}{h^2u^2}$**--------(1)**

where $f(r)$ **is the force per unit mass** $\frac{F(r)}{m}$ **and** $r = \frac{1}{u}$

If the distance between planet of mass m and sun of mass M is r then according to the Newton's gravitational formula

Gravitational force $F = -\frac{GMm}{r^2}$

Force acting on unit mass$f(r)$**=** $\frac{F}{m} = -\frac{GM}{r^2} = -GMu^2\left(\because\ r = \frac{1}{u}\right)$

Substituting$f(r)$ **value in Equation** (**1**) **we have**

$\frac{d^2u}{d\theta^2} + u$ **=**$-\frac{-GMu^2}{h^2u^2} = \frac{GM}{h^2}$

Let $GM = \mu$

$\therefore \frac{d^2u}{d\theta^2} + u$ **=**$\frac{\mu}{h^2}$

లేదా $\frac{d^2}{d\theta^2}\left(u - \frac{\mu}{h^2}\right) + \left(u - \frac{\mu}{h^2}\right) = 0$**-------(1)**

This is second order differential Equation. Its solution is

$u - \frac{\mu}{h^2} = A\cos(\theta - \theta_0)$

$\Rightarrow u = \frac{\mu}{h^2} + A\cos(\theta - \theta_0)$

$\Rightarrow \frac{1}{r} = \frac{\mu}{h^2}\left(1 + \left(\frac{Ah^2}{\mu}\right)\cos(\theta - \theta_0)\right)\left(\because\ u = \frac{1}{r}\right)$

$\Rightarrow \frac{1}{r} = \frac{1+\left(\frac{Ah^2}{\mu}\right)\cos(\theta-\theta_0)}{\left(\frac{h^2}{\mu}\right)}$ **---------- (2}**

This is the solution of the equation of conic section in polar coordinates

$\frac{1}{r} = \frac{1+e\cos\theta}{l}$**--------------(3)**

Comparing equations 2 and we have

Length of semi Latus Rectum $l = \frac{h^2}{\mu}$

eccentricity $e = \frac{Ah^2}{\mu}$

eccentricity of conic section

If $e < 1$ then path is elliptical

If $e = 1$ path is parabola

If $e < 1$path is hyperbola

Energy of a planet in polar coordinates

$$E = \frac{1}{2}m\dot{r}^2 + \frac{1}{2}mr^2\dot{\theta}^2 + U(r)\left(\because\ velocty\ of\ aprticle\ \textbf{in polar coordinates}\ \overline{v} = \dot{r}\hat{r} + r\dot{\theta}\hat{\theta}\right)$$

where $U(r) = \textbf{potential Energy} = -\frac{GMm}{r}$

In the equation conic related to path of a planet at the point of minimum $\dot{r} = 0$

$\therefore$Total energy of planet $E = \frac{1}{2}mr^2\dot{\theta}^2 - \frac{GMm}{r}$

Angular moment of planet $J = mr^2\dot{\theta} \Rightarrow J^2 = m^2r^4\dot{\theta}^2 \Rightarrow mr^2\dot{\theta}^2 = \frac{J^2}{mr^2}$

$$E = \frac{J^2}{2mr^2} - \frac{GMm}{r}$$

$$\Rightarrow \frac{J^2}{2mr^2} - \frac{GMm}{r} - E = 0$$

$$\Rightarrow \left(\frac{J^2}{2m}\right)\frac{1}{r^2} - (GMm)\frac{1}{r} - E = 0$$

This is the quadratic equation in $\frac{1}{r}$

Its roots are $\frac{1}{r} = \frac{-[-(GMm)] \pm \sqrt{[-(GMm)]^2 - 4\left(\frac{J^2}{2m}\right)(-E)}}{2\left(\frac{J^2}{2m}\right)}$

$$\Rightarrow \frac{1}{r} = \frac{GMm \pm \sqrt{G^2M^2m^2 + 4\left(\frac{J^2}{2m}\right)E}}{2\left(\frac{J^2}{2m}\right)}$$

$$\Rightarrow \frac{1}{r} = \frac{m}{J^2}\left[GMm \pm \sqrt{G^2M^2m^2\left(1 + \frac{2J^2\,E}{G^2M^2m^3}\right)}\right]$$

$$\Rightarrow \frac{1}{r} = \left[\frac{GMm^2}{J^2} \pm \frac{GMm^2}{J^2}\sqrt{\left(1 + \frac{2J^2\,E}{G^2M^2m^3}\right)}\right]$$

$$\Rightarrow \frac{1}{r} = \frac{GMm^2}{J^2}\left[1 \pm \sqrt{\left(1 + \frac{2J^2\,E}{G^2M^2m^3}\right)}\right]$$

in the above equation r is minimum for +ve sign

$$\Rightarrow \frac{1}{r_{min}} = \frac{GMm^2}{J^2}\left[1 + \sqrt{\left(1 + \frac{2J^2\,E}{G^2M^2m^3}\right)}\right] \text{----------------(4)}$$

In conic equation **(2) If** $\theta - \theta_0 = 0$ **or** $\cos(\theta - \theta_0) = 1$ r will be minimum.

$$\therefore \frac{1}{r_{min}} = \frac{1 + \left(\frac{Ah^2}{\mu}\right)}{\left(\frac{h^2}{\mu}\right)} \qquad \text{------------------(5)}$$

Equating eqation (4) and (5) we have

$$\frac{1 + \left(\frac{Ah^2}{\mu}\right)}{\left(\frac{h^2}{\mu}\right)} = \frac{GMm^2}{J^2}\left[1 + \sqrt{\left(1 + \frac{2J^2\,E}{G^2M^2m^3}\right)}\right]$$

$$\Rightarrow 1 + \left(\frac{Ah^2}{\mu}\right) = \frac{h^2}{\mu}\frac{GMm^2}{J^2}\left[1 + \sqrt{\left(1 + \frac{2J^2\,E}{G^2M^2m^3}\right)}\right]$$

$$\Rightarrow \frac{Ah^2}{\mu} = \frac{h^2}{GM}\frac{GMm^2}{J^2}\left[1 + \sqrt{\left(1 + \frac{2J^2\,E}{G^2M^2m^3}\right)}\right] - 1(\because GM = \mu)$$

$\Rightarrow \frac{Ah^2}{\mu} = \frac{h^2m^2}{h^2m^2}\left[1 + \sqrt{\left(1 + \frac{2J^2 E}{G^2M^2m^3}\right)}\right] - 1 (\because r^2\dot{\theta} = h, J = mr^2\dot{\theta} \Rightarrow J = hm \Rightarrow J^2 = h^2m^2)$

$\Rightarrow \frac{Ah^2}{\mu} = \left[1 + \sqrt{\left(1 + \frac{2J^2 E}{G^2M^2m^3}\right)}\right] - 1 = \sqrt{\left(1 + \frac{2J^2 E}{G^2M^2m^3}\right)}$

But eccentricity $\frac{Ah^2}{\mu} = e$

$\therefore$ eccentricity $e = \sqrt{\left(1 + \frac{2J^2 E}{G^2M^2m^3}\right)}$

The planet is always attracted by the Sun.so that the total energy E is always negative. (E<1) **.Hence $e < 1$ and path of the planet is elliptical.This is keplers Ist Law**

Keplers 2nd Law

Let a planet is revolving around the Sun S in elliptical orbit as shown figure.In during Δt time period planet P moves from the point P to the point Q .During this period angle made by the planet at S is $\Delta\theta$.

The radius vector joing Sun and planet $\overline{SP} = \bar{r}$, $Area\ sweeps\ out\ in\ \Delta t$ time period is

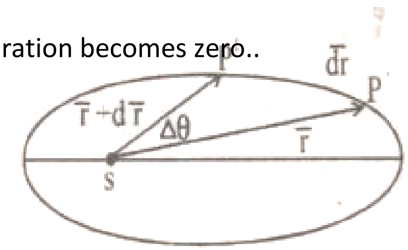
$$\Delta A = \frac{1}{2}r(r\Delta\theta) = \frac{1}{2}r^2\Delta\theta$$

Areal velocity $\lim_{\Delta t\to 0}\frac{\Delta A}{\Delta t} = \lim_{\Delta t\to 0}\frac{1}{2}r^2\left(\frac{\Delta\theta}{\Delta t}\right)$

Areal velocity $\frac{dA}{dt} = \frac{1}{2}r^2\frac{d\theta}{dt} = \frac{1}{2}r^2\dot{\theta}$ ----(1)

The force between sun and the planet is a central force hence transverse accelaration becomes zero..

Transverse accelaration $a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta} = 0$



$\Rightarrow \frac{d}{dt}\left(\frac{1}{2}r^2\dot{\theta}\right) = 0$

$$\Rightarrow \frac{1}{2}r^2\dot{\theta} = \text{constant}\text{-------(2)}$$

From eqn (1) and (2) $\frac{dA}{dt} = \frac{1}{2}r^2$ **=cost**

This is Keplers 2nd Law .

Keplers **3rd law**

Let the lengths of the semi major axis and semi minor axis of an ellipse of a planet revolving round the sun in ellipse are a and b respectively. The area occupied by the planet for one complete resolution is equal to area of the ellipse.

Area of ellipse $A = \pi ab$

If Areal Velocity $\frac{dA}{dt} = \frac{1}{2}r^2\dot{\theta} = \frac{h}{2}$

Time taken by the planet to complete one resolution around the sun is colled time periodT .

$$T = \frac{\text{Area occupied by the planet revolving round the sun}}{\text{Areal Velocity}}$$

$$T = \frac{\pi ab}{\frac{h}{2}} = \frac{2\pi ab}{h}\text{-------(1)}$$

length of latus rectum $l = \frac{b^2}{a}$

But length of latus rectum $l = \frac{h^2}{\mu}$

$$\therefore \frac{b^2}{a} = \frac{h^2}{\mu}$$

$\Rightarrow b^2 = \frac{h^2a}{\mu}$**--------(2)**

Squaring the equation(1) on both sides we get

$$T^2 = \frac{4\pi^2a^2b^2}{h^2} \text{ ------ (3)}$$

Using equations (2),(3) we get $T^2 = \frac{4\pi^2a^2h^2a}{h^2\mu} = \frac{4\pi^2}{GM}a^3 (\because GM = \mu)$

The square of the time period of a planet is proportional to the cube of the semi-major axis. This is Kepler's IIIrd Law

Motion of Satellite:

Satellites are revolving round the earth in circular orbits under the influence of earth's gravitational field. We can measure the time period of the satellite using the Keplers. III law of planetary motion.

Let us consider a satellite is revolving round the earth of mass M and radius R at a distance h from the surface of earth. Then the radius of the orbit of satellite becomes $a = R + h$
From the keeper's III law

$$T^2 = \frac{4\pi^2}{GM}a^3 \quad \Rightarrow \quad T^2 = \frac{4\pi^2}{GM}(R+h)^3 \text{-------(1)}$$

Where T = Time period, G = Universal Gravitational Constant, $R + h$ = Radius of orbit, M = Mass of Earth
If m is the mass of the satellite then the gravitational force acting on the satellite is

$$F = -\frac{GMm}{(R+h)^2}$$

This force should be equal to the weight –mg of the satellite

$$\therefore -\frac{GMm}{(R+h)^2} = -mg$$

$$GM = g(R+h)^2$$

Substituting GM value in (1) we have

$$T^2 = \frac{4\pi^2}{g(R+h)^2}(R+h)^3 = \frac{4\pi^2(R+h)}{g}$$

$$\Rightarrow T = \sqrt{\frac{4\pi^2(R+h)}{g}} = 2\pi\sqrt{\frac{(R+h)}{g}}$$

This is the gives the time period of satellite revolving round the earth at a distance h from its surface..

Orbital Velocity:
The minimum velocity required for a satellite to revolving round the earth in circular orbit in uniform speed is known as orbital velocity.
Let us consider a satellite is revolving round the earth of mass M and radius R at a distance h from the surface of earth. Then the radius of the orbit of satellite becomes $a = R + h$.*Let orbital velocity is* V_o .

Time period of satellite $T = \frac{\text{circumfence of orbit of the satellite}}{\text{orbital velocity of the satellite}} = \frac{2\pi(R+h)}{V_o}$ **-------(1)**

But Time period of satellite $T = 2\pi\sqrt{\frac{(R+h)}{g}}$ **-----(2)**

From eaquations 1 and 2 we have $2\pi\sqrt{\frac{(R+h)}{g}} = \frac{2\pi(R+h)}{V_o}$

$$\Rightarrow V_o = 2\pi\sqrt{\frac{(R+h)}{g}} = (R+h)\sqrt{\frac{g}{(R+h)}} = \sqrt{g(R+h)}$$

$$\therefore V_o = \sqrt{g(R+h)}$$

The velocity of the satellite revolving round the nearer to the earth in circular orbit is known as launching velocity.
As $h \to 0$ then launching velocity $V_l = \sqrt{gR}$

Escape Velocity:
The minimum velocity required for a satellite to escape from the earth's gravitational field is known as escape velocityV_e. The minimum kinetic energy required for the satellite should be equal to its potential energy on the earth's surface.

$$\therefore \frac{1}{2}mV_e^2 = \frac{GMm}{R}$$

$$\Rightarrow V_e^2 = \frac{2GM}{R}$$

$$\Rightarrow V_e = \sqrt{\frac{2GM}{R}}$$

But $GM = gR^2$ **Substituting this value on the above the equation we have**

$\therefore$ **Eascape velocity** $V_e = \sqrt{\frac{2gR^2}{R}} = \sqrt{2gR}$ **The escape velocity on the earth is approximately 11.2km/sec.The orbital velocity and eascape velocities of satelites depends only on the earths mass and radius but not on the satellite's mass.**

Examples/ Illustrations:	**Problem solving**
Additional inputs:	**AUCET questions**
Teaching aids used:	**PPT, Animations**
Reference cited:	**Mechanics by D.S.Mathur, Unified Physics Vol 1, Telugu academy 1, JPN Physics Vol I (CBCS)**
Student activity planned after the teaching:	**Test**
Activity planned outside class room if any:	**Assignment**
Any other activity:	**Asked students to locate their residence using GPS in mobile phone.**
Signature of the Lecturer	

S.V.L.N.S. GOVERNMENT DEGREE COLLEGE, BHEEMUNIPATNAM
Teaching Synopsis (2021-22)

Name of the Department/Subject	**PHYSICS**
Name of the Lecturer	**M.RAJESWARA RAO**
Course/Group	**II B.Sc. (M.P.C)**
Paper	**Physics VII C (Renewable energy)**
Name of the Topic	**Unit I Energy introduction and Environmental Effects**
Hours required	**12**
Learning Objectives	**Understanding the energy concepts and effects on environment**
Previous Knowledge to be reminded / revised	**Work, Power, Energy concepts, Themodynamics**

TEACHING PLAN (SYNOPSIS)

Topic Synopsis

WORK,ENERGY AND POWER
Work done:
Work done by force is measured by the product of magnitude of force and the displacement of its point of application in the direction of force.
Work done W= $F.S$
The S.I unit of work done is Joule.
One joule is amount of work done by a force of one newton in displacing a body through one metre in the direction of force.

$$1J = 1N \times 1m$$

Energy
Energy is the capacity of a physical system to perform to work. It is ability to do the work. Energy exists in different forms like heat, kinetic, potential, light, electrical energy, etc..
S.I unit of energy is joule.
Electrical energy is measured in Kilowatt-hours (kWh).
1kWh is 3.6×10^6 joule.
Power
Power is defined as rate of work done.
Power $P = \frac{work\ done}{time} = \frac{W}{t}$
S.I unit of power is Watt
When one joule of work is done in one second, the power is one watt
Power is also measured in Horse Power
1HP = 746 W
Common units of energy
Mtoe : million tone of oil equivalent $= 4.1868 \times 10^{16} J$
MBtu: million British thermal units= $1055.056J$
kWh: kilo watt hours= $3600000J$
MWh: mega watt hours= $1000kwh$
GWh: giga watt hours= $1000000kwh$
TWh: tera watt hours= $1000000000kWh$
Forms of energy
Energy exists in various forms in nature.
Thermal Energy: The energy, a substance or system has related its temperature. Thermal energy is the main form energy by which electrical energy is generated.
When is coal is burnt, to produce steam (thermal energy) and then steam is used to produce mechanical energy (to rotate turbine) and finally mechanical energy is used to produce electrical energy by using a generator

Conservation of Energy

The energy conservation is achieved when growth of energy consumption is reduced. Energy conservation can be the result as several processes or developments, such as productivity increase or technological process.

Energy efficiency is achieved when energy intensity is a specific product, process or area of production or consumption is reduced wiyhout affecting output, consumption or comfort levels.

Production of energy efficiency will contribute to energy conservation and hence it is an integral part of energy conservation policies.

Immediate Strategy

1. Rationalizing the tariff structure of various energy products.
2. Optimum utilization of existing asserts.
3. Efficiency in production systems and reduction in distribution losses, including those in traditional energy sources.
4. Promoting R&D, transfer and use of technologies and practices for environmentally sound energy systems, including new and renewable energy sources.

Mid term Strategy

1. Demand management through greater conservation of energy, optimum fuel mix, structural changes in the economy

Appropriate model: Greater dependence on rail than on the road for the movement of goods and passengers and a shift away from private modes to public modes for passenger transport.

2. There is need to shift to less intensive modes of transport .

Ex: Better roads, better design of vehicles, use of CNG, better urban planning

3. There is need to move away frm non renewable to renewable energy sources

Ex: Solar, Wind, Biomass energy, etc.

Medium Term Strategy.

Demand management through greater conservation of energy, optimum fuel mix, structural changes in the economy. An appropriate model mix in the transport sector, i.e., greater independence on rail than on road for the movement of goods and passengers and shift away from private modes to public modes for passenger transport.

Changes in design of different products to reduce the material intensity of those products, recycling, etc.

2. There is need to shift to less energy- intensitive modes of transport . This would include measures to improve the transport infrastructure viz. roads, better design of vehicles , use of compressed natural gas (CNG) and synthetic fuel etc.

SECOND LAW OF THERMODYNAMICS

Kelvin's Statement Of Second Law

We know that a heat engine takes heat from the source ,converts a part into mechanical work and the balance is rejected to the sink. As the engine absorbs more and more heat from the source , the temperature of source continuously falls and after sometime becomes as that of surroundings. Now no heat flow will be possible. In this case, the engine stops working, i.e., no work can be obtained from the engine. This consideration led kelvin to state the second law as:

"It is impossible to derive a continuous supply of work by cooling a body to temperature lower than that of coldest of its surroundings".

This statement is equal to the fact that heat engine works only when a source and sink are in higher and lower temperatures respectively.

ENERGY FLOW DIAGRAM TO EARTH

Solar energy is received on earth in the form of radiations. Solar radiation is the total frequency spectrum of electromagnetic radiations produced by the sun. this spectrum covers visible light and near-visible radiation such as X-ray, ultraviolet radiation, infrared radiation and radio waves.

Solar radiation pass through the atmosphere and are absorbed by the earth. Some of this absorbed radiation is reflected back. Fortunately this radiated heat is "trapped" by a number of "greenhouse" gases present in the atmosphere.

Absorption is the process by which "Incident radiant energy is retained by a substance". In energy flow to earth, the substance is the atmosphere. When the atmosphere absorbs energy, the result is an irreversible transformation of radiation into another form of energy. This energy is transformed according to the nature of the medium doing absorbing.

ORIGIN AND TIME SCALE OF FOSSIL FUELS

Fuels are substances that are burned to generate heat or power. Fossils are remains or traces of animals or plants from past ages. Thus, fossil fuels are substances that are derived from the remains of organisms that lived millions of years ago. They have been preserved as deposits in reasonable proximity to the earth's surface (typically less than 10km deep). We can thus extract them and use them as a source of energy.

ORIGIN AND TIME SCALE OF FOSSIL FUELS

The fossil fuels used as energy sources today are coal, petroleum and natural gas. Enormous resources of fossil fuels exist. However, they are not yet in large scale commercial use. Examples of fossil fuels not used currently, but potentially useful in future, are oil shale and tar sands. The common feature of all fossil fuels is that they contain a lot of carbon. Coal is especially rich, with up to 95%. The others are mainly hydrocarbons (compounds of carbon with hydrogen), sometimes with other elements present. However, even in these the proportional of carbon is high, around 82-87% by weight.

ORIGIN AND TIME SCALE OF FOSSIL FUELS

Plants absorb CO_2 by virtue of a process known as "photosynthesis". The carbon from CO_2 thus becomes part of the living plants. It also finds its way into the cells of animals that eat the plants. Eventually, this food chain in living organisms comes to a halt. The remains of dead plants or dead animals decompose and produce gaseous CO_2 which is returned to the atmosphere. This normal 'aerobic' decay process, which occurs in the presence of abundant oxygen from the air, completes the carbon cycle by returning gaseous CO_2 to the atmosphere. This can be illustrated by the following representative chemical reaction:

$$C_6H_{12}O_6 + 6O_2 = 6\,CO_2 + 6H_2O$$

glucose oxygen carbon dioxide water

ORIGIN AND TIME SCALE OF FOSSIL FUELS

Fossil fuels arise when this normal decay process is interrupted.. The existence of an environment that favors abundant growth of living organisms, while preventing their rapid decay to CO_2 *and* H_2O, makes possible this 'detour' in the carbon cycle. Three conditions must exist for the development of such an environment;

Abundant light (required to promote photosynthesis)

Warmth (since not many organisms flourish in the arctic or Antarctic regions), and

Moisture (since not many organisms flourish in deserts).

ORIGIN AND TIME SCALE OF FOSSIL FUELS

The kinds of environments that provide these conditions are subtropical swamps river deltas, lakes, lagoons or shallow seas. Precisely such conditions prevailed in many regions of the word in the late Paleozoic and the Mesozoic period of Earth's history. The main deposits of fossil fuels are from the 'carboniferous period' which was a part of the Paleozoic era. "carboniferous" gets its name from carbon, the basic element in coal and other fossil fuel.

ORIGIN AND TIME SCALE OF FOSSIL FUELS

The carboniferous period occurred from about360 to 286 million years ago.

At that time the land was covered with swamps filled with huge trees, ferns and other large leafy plants.

The water and seas were filled with algae- the green stuff that forms on a stagnant pool of water.

Algae are actually millions of very small plants.

ORIGIN AND TIME SCALE OF FOSSIL FUELS

As the trees and plants died, they sank to the bottom of the swamps of oceans.

They formed layers of a spongy material called peat.

Over many hundreds of years, the peat was covered by sand and clay and other minerals, which turned into a type of sedimentary rock.

More and more rock piled on the top of rock and it weighted more and more. It begun to press down on the peat.

The peat was squeezed and squeezed until the water came out of it over millions of years at last it turned into coal, oil, petroleum and natural gas.

Origin of coal

Coal is a hard, black colored rock like substance, it is made up of carbon, hydrogen, oxygen, nitrogen, and varying amounts of sulfur.

Coal is formed by the prolonged action of geological forces on the plant and vegetal matter accumulated below the earth crust.

The process is called coalification. It is both force and time dependent. Coalification brings following changes to the accumulated plant.

Wood -------Peat-----Lignite-----Bituminous-------Anthracite---- Graphite

Increase in time and magnitude of force

ROLE OF ENERGY IN ECONOMIC DEVELOPMENT AND SOCIAL TRANSFORMATION.

The word 'energy' is derived from the Greek word 'en-ergon', which means 'in work' or 'work content'. Energy is essential for every activity of life. Any physical activity in this world, whether carried out by human beings or by nature, is caused due to flow of energy in one form or the other. The work output depends on the energy input.

ENERGY CONSUMPTION AND STANDARD OF LIVING (SOCIAL TRANSFORMATION)

Energy access to modern energy services is essential for socio-economic development. This includes removal of poverty also. In the world, including India, crores of people lack access to affordable basic energy services such as effective lightning and clean cooking. This has now been termed as "energy poverty". Today there is a growing focus on energy poverty which implies lack of access to modern energy services. These services are defined as household access to electricity and clean cooking solutions such as fuels and cooking stoves that are not harmful to health and environment.

ENVIRONMENTAL DEGRADATION DUE TO ENERGY PRODUCTION AND UTILIZATION.

"Environmental degradation" is the deterioration of the environment through depletion of resources such as air, water and soil. This may lead to the destruction of ecosystems and the extinction of wildlife. It is defined as "any change or disturbance to the environment perceived to be undesirable". When natural habitats are destroyed or natural resources are depleted, environment is degraded.

The degradation of environment causes illness and premature deaths of living organisms. If improvements are made in human health, millions of people will be living longer. In the poorest regions of the world, an estimated 11million children (1.10 crore), or about 1 in 5, will not live to see their fifth birthday. This is primarily because of environment-related diseases like malaria, acute respiratory infections or diarrhea—illness that are largely preventable.

The various causes of environmental degradation are:

(1)unsustainable resource use of energy production.

(2)non-inclusion of environmental cost in market price of energy produced

ENVIRONMENTAL DEGRADATION DUE TO ENERGY PRODUCTION AND UTILIZATION.

(3) Environmental management with inadequate knowledge

(4)rapid population leading to increase in utilization of energy.

(5)poverty due to which people destroy forests (for firewood), water supplies, wild life, soil and grasslands to meet their daily requirements.

Here, we will concentrate only on issues related to energy production and utilization.

ENERGY ISSUES.

There are many environmental issues relating to energy with the largest being climate change due to the burning of fossil fuels and the direct impact of green house gases on the earth's environment. In recent years there has been a trend towards the use of various renewable energy sources. Global warming and climate change due to human activity is generally accepted as being caused by gas emissions. The majority of these emissions are due to burning of fossil fuels. Another major cause of global warming and climate change is due to deforestation.

(1)FOSSIL FUEL USE: The three main fossil fuels are coal, petroleum and natural gas. It was estimated by energy information administration that in 2006 primary sources of energy consisted of—petroleum 36.8%, coal 26.6%, natural gas 22.9%, amounting to an 86% share of fossil fuels in primary energy production in the world.

the burning of fossil fuels produces around 21.3 billion tonne of carbon dioxide per year. It is estimated that natural processes can only absorb about half of this amount.

ENERGY ISSUES

So there is a net increase of 10.65 billion tonne of atmospheric carbon dioxide per year (one tonne of atmospheric carbon is equivalent to 3.7 tonne of carbon).carbon dioxide is one of the green house gases that enhances radiative forcing and contributes to global warming. This causes the average surface temperature of the earth to rise in response, which causes major adverse effects. On the other hand, natural gas is the cleanest fossil fuel. It produces fewer pollutants than other fossil fuels. But natural gas itself is a greenhouse gas for more potent than carbon dioxide when released into the atmosphere. However, it is generally released in smaller amounts.

(2) FIREWOOD: direct burning of fire wood as an energy resource is known as firewood. This is probably the most ancient energy suppliant. Unsustainable firewood harvesting can lead to loss of forest cover. The graveness of the situation can be understood by the example of Africa, the largest forest area. Earlier Africa boasted 7million square kilometer of forest but now a third of that has been lost, most of it as firewood.

ENERGY ISSUES

The solution to energy problem lies in searching and developing alternative energy sources, for example, BIOFUEL. Biofuel is defined as "solid liquid or gaseous fuel obtained from relativity lifeless or living biological material".

It is different from fossil fuels which are derived from long dead biological material. Also, various plants and plant-derived materials are used for biofuel manufacturing. Biofuels are renewable energy. They are sustainable (carbon neutral) in terms of green house gas emissions because they are in the carbon cycle for a short term.

AIR POLLUTION

Our earth is surrounded by air on all sides. It is invisible and the area covered by air is called *"atmosphere*". When the air gets dirty and is unhealthy to breathe it is called as "air pollution". Air pollution is a term used to describe the presence of contaminants in the atmosphere which are injurious to human health and other natural environmental processes

The occurrence of wastes in the atmosphere of one or additional contaminants in excess and for long period is harmful to human health, animals and plant life. Air pollution can cause health problems and it can also smash up the atmosphere and material goods.

NATURE OF AIR POLLUTANTS:

There are two types of air pollutants:

(1) Particulate matter

(2)gaseous

AIR POLLUTION

Particulates are small solid or liquid substances in the air resulting mostly from fuel combustion and industrial processes. The gaseous air pollutants result from combustion processes in industries.

Few examples of air pollution are sulphur dioxide (SO2), nitrous oxide (NOx) and carbon monoxide (CO) which are emissions from boilers and furnaces, chlorofloro carbons (CFC) emissions from refrigeras use, etc. in chemical and fertilizers industries, toxic gases are released. Cement plants and power plants spell out particulate matter.

Exponential increase in world’s Energy Consumption
Energy consumption of world rose from 81970 TWh to 98022 TWh in 2008.
If we observe the general trend of world’s energy consumption, we find the following
From 1950 to 1975: Increase of 5% per year
From 1975 to 1985: Increase of 3% per year
From 1985 to 2015: Increase of 2% per year
From 2015 to 2020: increase of 1.5% per year.
Exponential increase in world’s Energy Consumption
From 1950 to 2010 there has been exponential increase in world’s energy consumption.
Then after 2010 it was steady at around 1% per year.
The study and analysis of historical data is important
The result of analysis of this exponential rise are already evident from the fact that world’s energy consumption increased by 0.5% in 2015 and was 1% in 2016.
China is the world’s largest energy consumer since 2009.
Its energy consumption slowed over past three years in comparison to trend observed over the period 2000-2015.
Exponential increase in world’s Energy Consumption
Energy consumption USA was flat during last few years because of deep fall in coal use, offset by slight increase in iol and gas consumption.
India continued to support world energy consumption representing a quarter of the global rise.
Strong raising trends are observed in Turkey and in Asian countries such as Indonesia, Malaysia, South Korea.
Energy consumption has been declined in Brazil, Colombia, Mexico.
In European union it is steady.
FACTS THAT LED TO EXPONENTIAL RISE IN WORLD ENERGY CONSUMPTION
1. Population and labour force growth:
World Economic growth (Gross World Product 3.3%pa) during the period 1970 to 2015.
High population growth from 3.7billion people in 1970 to 7.4 billion in 2015 took place
Rapid growth of labour force at 1.7%pa was complemented with a high rate of growth of productivity.
FACTS THAT LED TO EXPONENTIAL RISE IN WORLD ENERGY CONSUMPTION
New technologies and productivity:
Economic growth always leads to a high level of productivity 1.7%.
In some countries such as China this has averaged greater than 40% of GDP in the past three decades.
Industrial technologies
New information, computational and communication tools.
Rapid rise in internet
Rise in use of smartphones
World energy consumption
Slowdown in energy consumption growth in 2019 (+0.6%), much below its historical trend
Global energy consumption growth slowed down in 2019 (+0.6%) compared to an average 2%/year over the 2000-2018 period, in a context of slower economic growth.
Energy consumption increased at a slower pace than in previous years in China (+3.2%), the world’s largest consumer since 2009, in Russia (+1.8%) and in India (+0.8% only). It declined in almost all OECD countries, including the USA (-1%), the EU (-1.9%), Japan (-1.6%), Canada and South Korea. Australia was the only exception, posting a 6.3% growth (caused by soaring gas consumption from LNG plants) well above the historical average. Consumption remained dynamic in Indonesia and Algeria, continued to increase in Saudi Arabia, Nigeria and South Africa but declined in Latin America (stable in Brazil and slight decrease in Mexico). US sanctions contributed to reduce Venezuela’s and Iran’s consumption.
POLLUTION DUE TO THERMAL POWER STATIONS
Thermal power stations use fossil fuels for generation of electricity.
Fossil fuels include coal, oil, natural gas.
Including India the largest capacities in the world is that of coal fired power stations with a high pressure boiler.
In thermal power stations air pollution occurs due to burning of coal.
Water pollution occurs due to large quantities required for cooling and feed water to the boiler for raising steam.
In addition water pollution also caused by coal mining, oil production from off shore wells, oil spills during transportation, acid rains, etc,.
VARIOUS AIR POLLUTANTS EMITTED FROM COAL FIRED POWER PLANTS
Acid gases:
Combustion of coal to generate electricity is the predominant source of hydrochloric acid emissions to the atmosphere.
Coal burning stations are the largest source of Hydrogen chloride and hydrogen fluoride emissions to the air. These emissions are strongly corrosive acids.

hydrogen fluoride is emitted as a gas or particle. HF particle remain suspended in atmosphere, they can travel 500Km or more. They deposit on land and water.
When HCl combined with water produces strong acids.
Chloride from HCl is associated with cloud acidity.

POLLUTION DUE TO NUCLEAR POWER STATION

Any undesirable effect caused to the environment due to radioactive substances or radiations is called nuclear pollution.
Nuclear pollution happens when radioactive element come into contact with other elements in environment.
They emit alpha and gamma rays which is a serious threat in living organisms.
Nuclear fission is the process in which a large nucleus splits into two smaller nuclei with the release of energy.
Fission is the process in which a nucleus divided into two or more fragments with the release of neutrons and energy.

EFFECTS OF HYDROELECTRIC POWER STATIONS ON ECLOGY AND ENVIRONMENT

A hydroelectric power station is a very clean project.
It causes no pollution to the river while generating electricity.
The major concern is the dam and reservoir which is constructed for storing water enough for at least one year.
They have significant effects on physical, biological and human environment in and near the site area.
Physical effects:
The river and ecosystem of the surrounding land area will be altered as soon as construction begins.

GLOBAL ENERGY SCENARIO

World energy consumption is the total energy produced and used by humans. Typically measured per year, it involves all energy harnessed from every energy source applied towards activity across all industrial and technological sectors, in every country. It does not include energy from food. World energy consumption has implications for the socio-economic-political sphere.
Institutions such as the International Energy Agency (IEA), the U.S. Energy Information Administration (EIA), and the European Environment Agency (EEA) record and publish energy data periodically. Improved data and understanding of world energy consumption may reveal systemic trends and patterns, which could help frame current energy issues and encourage movement towards collectively useful solutions.

URBAN AND RURAL ENERGY CONSUMPTION

The major commercial energy consuming sectors in India are classified as:
(1) Industrial
(2) transport
(3) residential (lightning and cooling)
(4) agriculture
(5) others which include municipal water and sewage pumping, commercial buildings like hotel, hospitals, shopping malls, public offices, public parks and street lightning.

RURAL ENERGY CONSUMPTION PATTERN

In rural household sector, 40% of the total energy requirements are met by non-commercial energy sources. These include fuel wood, crop residue and animal waste. Human and animal power is also used to large extent. Fuel wood is viewed as a non-commercial source because it is gathered at zero private cost and is not purchased from the market as a commodity.
A significant amount of rural energy used is derived from biomass. This puts heavy pressure on the already declining vegetation in villages. Use of inefficient chulhas often increases the misery of women and children who are involved in collection of fuel wood. More over, the smoke generated during indoor cooking from these chulhas affects the respiratory health of women and children to a great extent.

URBAN ENERGY CONSUMPTION PATTERN

In urban areas energy is consumed for:
(1) domestic or residential consumption which includes cooking, lighting, heating, cooling and entertainment.
(2) Industries
(3) Transport
(4) municipal water and sewage pumping, street lighting and commercial buildings like hotels, hospitals, shopping malls, public offices, public parks etc.
Urban lifestyle consumes more energy. The growth of the middle-class, rising incomes and more electricity enabled appliances and machines contribute to more electricity demand in urban areas.
Another interesting fact is that household energy consumption increases in spite of declining family size.

COMPARSION BETWEEN RURAL AND URBAN ENERGY CONSUMPTION

A comparison is now made between the rural and urban energy consumption. The data used is from the census of India, 2011:
(1) COOKING:

In rural India, 86.5% of households depend on solid biomass including firewood, crop residue, cow dung, coal, lignite, and charcoal as primary fuel for cooking. About 12.1% of the rural households depend on modern fuels including kerosene, LPG, petroleum natural gas PNG as primary fuel for cooking and the rest depend on other fuel sources including biogas for the purpose of cooking. Under the "*Ujjwala Yojna"* of government LPG is now extensively provided in the rural areas. This is bound to change the above data in the coming years.

ENERGY SOURCES AVAILABLE IN INDIA

India has all the possible sources of energy. These include all forms of non-renewable and renewable energy sources. However, the energy sources are not uniformly distributed. The regions where large fossil and renewable energy sources are available have lower per capita energy consumption. This leads to additional cost in transportation of sources of energy or transmission losses in case electricity is distributed through grid system.

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ENERGY SOURCES AVAILABLE IN INDIA

[1] Coal

India has the third-largest hard coal reserves in the world (roughly 12% of the world total). It also has significant deposits of lignite. Yet, the deposits are generally of low quality, high ash content (25-50%), low heat value (3000-4000cal/kg) and low sulfur content (1%). India faces major problems in the development of its coal resources in a way that keeps pace with growing domestic needs

OIL AND OIL PRODUCTS

India has relatively modest oil resources . Most of the proven reserves (around 5.7 billion barrels) are located in the western part of the country, notably in Rajasthan and in off-shore areas near Gujarat and Maharashtra. The Assam-Arakan basin in the northeast is also an oil-producing basin and contains nearly quarter of total reserves.

Oil accounts for about 36% of India's total energy consumption. In terms of sector wise petroleum product consumption, transport sector accounts for 42%, followed by domestic (24%) and industrial sector (24%).

Natural gas

India has natural gas reserves of 7.9 trillion cubic meter (m3). Around half of this is conventional(almost all offshore) gas and half is unconventional (in the form of shale gas and coal bed methane). The main onshore producing fields are in the states of Assam in the northeast, Gujarat in the west and Andhra Pradesh and Tamilnadu in the south. Some of the most promising areas are offshore, including the Krishna Godavari basin off the east coast.

→Natural gas accounts for about 6% of energy consumption in the country. It is source of half of the LPG produced in the country. However, like oil, we are dependent on imports of natural gas also.

→oil and natural gas corporation (ONGC) And oil India limited (OIL) are the main producers of natral gas. Gas authority of India limited (GAIL) is the major transporter and distributer of gas.

NUCLEAR ENERGY

According to the modern theories of atomic structure, atom is the basic particle of matter. Nuclear energy takes advantage of the power locked in the structure of atoms. The nucleus of an atom contains all of its positively-charged *protons* and non-charged *neutrons*. Negatively-charged *electrons* orbit the nucleus. Atoms are electrically neutral as they contain equal numbers of protons and electrons.

Atoms can have different number of neutrons in their nuclei. Nuclei from the same element with different number of neutrons are called *isotopes.* Most isotopes are stable but some can spontaneously break apart, emitting energy and particles. Nuclear energy can be obtained by nuclear *fusion* and *fission* chain reactions as follows:

NUCLEAR POWER PLANTS

Nuclear power plants operate by precisely controlling the rate at which the nuclear reaction occurs. Uranium ore is enriched and formed into fuel pellets. The fuel pellets are stacked in long, cylindrical fuel rods. To maintain a sustained controlled nuclear reaction, for every 2 or 3 neutrons released, only one must be allowed to strike another uranium nucleus. If this ratio is less than one then the reaction will die out; if it is greater than one it will grow uncontrolled (an atomic explosion).

RENEWABLE ENERGY SOURCES IN INDIA

In the strict thermodynamic sense energy cannot be destroyed or produced. It can be only converted from one form to another. These conversions are associated with an increase of the total entropy, which means a loss in the "*quality"* of the energy i.e., a loss of exergy. Apparently, renewable energy is contradiction from a strict thermodynamics point of view. However, the term is used frequently. Renewable energy is then understood as energy that is supplied directly or indirectly from the sun or the moon and thermal energy stored or generated below the crust of our planet, the earth.

NEED FOR USE OF RENEWABLE ENERGY SOURCES

There has been a rapid depletion of commercial energy sources. Over the years, the concern for environment has increased due to pollution caused by utilization of commercial or conventional energy sources. Therefore, a need for alternative energy sources has been felt. The need for use of new and renewable energy sources has been felt due to the following reasons:

The demand of energy is increasing day by day due to rapid industrialization and population growth. The conventional sources of energy will not be sufficient to meet the growing demand.

Examples/ Illustrations:	**You tube videos**
Additional inputs:	**AUCET questions**
Teaching aids used:	**PPT, Animations**
Reference cited:	**Renewable energy, Unified Physics, Non conventional energy sources by G D Roy**
Student activity planned after the teaching:	**Test, Quoz**
Activity planned outside class room if any:	**Assignment**
Any other activity:	**Proposed conduct survey on energy utilized by students (Carbon foot print)**
Signature of the Lecturer	