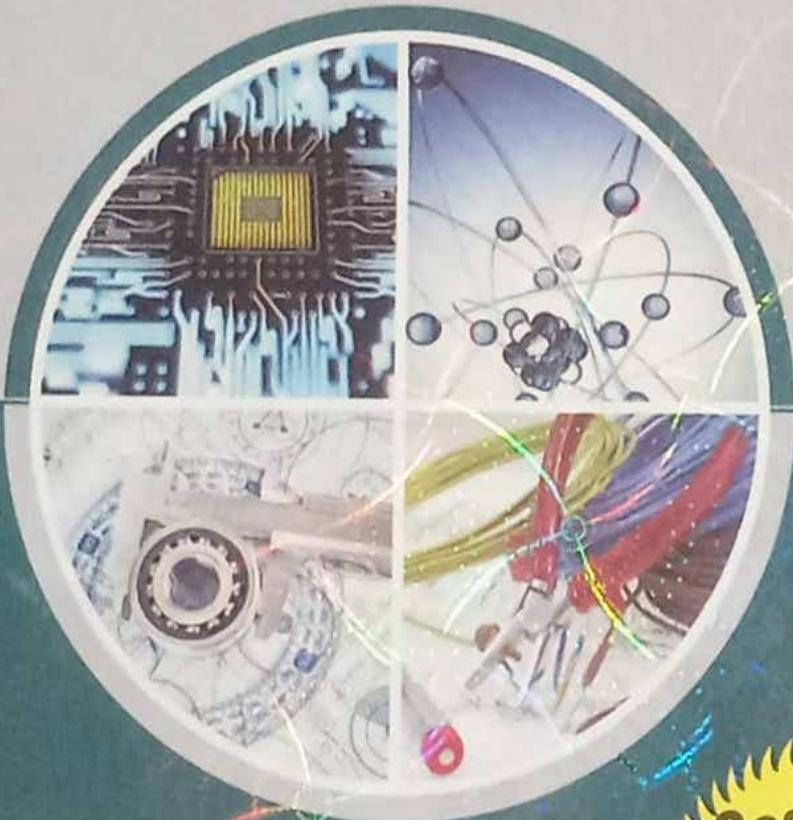




# QUANTUM Series

Semester - 3 & 4 ME/CE/AG/EE/CSE & Allied Branches

## Energy Science & Engineering



- Topic-wise coverage of entire syllabus in Question-Answer form.
- Short Questions (2 Marks)

Session  
**2019-20**

Odd & Even  
Semester

Includes solution of following AKTU Question Papers

• 2018-19

# CONTENTS

**KOE 033 / KOE 043 : Energy Science & Engineering**

**UNIT-1 : ENERGY & ITS USAGE**

(1-1 G to 1-31 G)

Units and scales of energy use, Mechanical energy and transport, Heat energy: Conversion between heat and mechanical energy, Electromagnetic energy: Storage, conversion, transmission and radiation, Introduction to the quantum, energy quantization, Energy in chemical systems and processes, flow of CO<sub>2</sub>, Entropy and temperature, carnot and Stirling heat engines, Phase change energy conversion, refrigeration and heat pumps, Internal combustion engines, Steam and gas power cycles, the physics of power plants. Solid-state phenomena including photo, thermal and electrical aspects.

**UNIT-2 : NUCLEAR ENERGY**

(2-1 G to 2-20 G)

Fundamental forces in the universe, Quantum mechanics relevant for nuclear physics, Nuclear forces, energy scales and structure, Nuclear binding energy systematics, reactions and decays, Nuclear fusion, Nuclear fission and fission reactor physics, Nuclear fission reactor design, safety, operation and fuel cycles.

**UNIT-3 : SOLAR ENERGY**

(3-1 G to 3-24 G)

Introduction to solar energy, fundamentals of solar radiation & its measurement aspects, Basic physics of semiconductors, Carrier transport, generation & recombination in semiconductors, Semiconductor junctions: metal-semiconductor junction & p-n junction, Essential characteristics of solar photovoltaic devices, 1<sup>st</sup> Generation Solar Cells, 2<sup>nd</sup> Generation Solar Cells, 3<sup>rd</sup> Generation Solar Cells.

**UNIT-4 : CONVENTIONAL & NON-CONVENTIONAL ENERGY SOURCE**

(4-1 G to 4-29 G)

Biological energy sources and fossil fuels, Fluid dynamics and power in the wind, available resources, fluids, viscosity, types of fluid flow, lift, Wind turbine dynamics and design, wind farms, Geothermal power and ocean thermal energy conversion, Tidal/wave/hydro power.

**UNIT-5 : SYSTEMS AND SYNTHESIS**

(5-1 G to 5-21 G)

Overview of World Energy Scenario, Nuclear radiation, fuel cycles, waste and proliferation, Climate change, Energy storage, Energy conservation. Engineering for Energy conservation: Concept of Green Building and Green Architecture; Green building concepts, LEED ratings; Identification of energy related enterprises that represent the breath of the industry and prioritizing these as candidates; Embodied energy analysis and use as a tool for measuring sustainability. Energy Audit of Facilities and optimization of energy consumption.

**SHORT QUESTIONS**

(SQ-1 G to SQ-13 G)

**SOLVED PAPERS (2018-19)**

(SP-1 G to SP-3 G)



## Energy and its Usage

### CONTENTS

- Part-1 :** Units and Scales of Energy Use ..... **1-2G to 1-3G**
- Part-2 :** Mechanical Energy and Transport ..... **1-3G to 1-5G**
- Part-3 :** Heat Energy : Conversion between ..... **1-5G to 1-6G**  
Heat and Mechanical Energy
- Part-4 :** Electromagnetic Energy : ..... **1-6G to 1-9G**  
Storage, Conversion,  
Transmission and Radiation
- Part-5 :** Introduction to the Quantum, ..... **1-9G to 1-11G**  
Energy Quantization
- Part-6 :** Energy in Chemical Systems ..... **1-12G to 1-15G**  
and Processes, Flow of CO<sub>2</sub>
- Part-7 :** Entropy and Temperature ..... **1-15G to 1-16G**
- Part-8 :** Carnot and Stirling ..... **1-16G to 1-18G**  
Heat Engines
- Part-9 :** Phase Change Energy ..... **1-18G to 1-21G**  
Conversion, Refrigeration  
and Heat Pump
- Part-10 :** Internal Combustion Engines ..... **1-21G to 1-26G**
- Part-11 :** Steam and Gas Power Cycles ..... **1-26G to 1-30G**
- Part-12 :** Physics of Power Plant, ..... **1-30G to 1-31G**  
Solid-State Phenomena  
including Photo, Thermal  
and Electric Aspects

**PART-1***Units and Scales of Energy Use.***CONCEPT OUTLINE**

**Energy :** It is defined as the capacity to exert a force through a distance. It exists in various forms like heat energy, chemical energy, nuclear energy, mechanical energy, etc.

**Units of Energy :** Energy can be measured in :

1. Joule,
2. Calorie, and
3. kWh.

**Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 1.1.** What are the various scales of energy ? Where are they used ?

**Answer**

Various scales of energy that exists are as follows :

1. **Femto ( $10^{-15}$ ) :** Femto refers to something that is in the  $10^{-15}$  range.

**Uses :** Certain specialized medical facilities, have a certain lasers referred to as Femtosecond lasers. So, Femtosecond lasers are laser which are 'on' for of a second and then they go 'off'.

2. **Pico ( $10^{-12}$ ) :** Pico refers to something that is in the  $10^{-12}$  range.

**Uses :** High precision power supply used in laboratories to make very precise measurements of current, voltage and resistance of specific samples.

3. **Nano ( $10^{-9}$ ) :** Nano refers to something that is in the  $10^{-9}$  range.

**Uses :** Electron micrograph is an example of instrument using  $10^{-9}$  range.

4. **Micro ( $10^{-6}$ ) :** Micro refers to something that is in the  $10^{-6}$  range.

**Uses :** In measuring instrument in the fields of science and engineering.

5. **Milli ( $10^{-3}$ ) :** Milli refers to something that is in the  $10^{-3}$  range.

**Uses :** A typical scientific calculator uses power in the scale of 0.1 milli Watt.

6. **Kilo ( $10^3$ ) :** Kilo refers to something that is in the  $10^3$  range.

- Uses :** In solar panels and batteries in Hubble space telescope.
7. **Mega ( $10^6$ ) :** Mega refers to something that is in the  $10^6$  range.  
**Uses :** Used in large vehicles like submarines.
8. **Giga ( $10^9$ ) :** Giga refers to something that is in the  $10^9$  range.  
**Uses :** Modern day mobile phones have built in storage, which are the order of 16 GB, 64 GB which mean mobile phone store data several gigabyte.
9. **Tera ( $10^{12}$ ) :** Tera refers to something that is in the  $10^{12}$  range.  
**Uses :** Cameras and computers today uses hard disks in the terabyte scale.
10. **Peta ( $10^{15}$ ) :** Peta refers to something that is in the  $10^{15}$  range.  
**Uses :** Today's supercomputers operate in hundreds of petaflops.
11. **Exa ( $10^{18}$ ) :** Exa refers to something that is in the  $10^{18}$  range.  
**Uses :**  $10^{18}$  is a kind of a quantity that is indicated with prefix exa, the world today uses energy in the range of 500 exa joules.
12. **Zetta ( $10^{21}$ ) :** Zetta refers to something that is in the  $10^{21}$  range.  
**Uses :** In 2010 humanity is said to have crossed the 1 zetta byte mark in terms of data created and stored overall. And we might be crossing 7 zetta byte mark by 2020.
13. **Yotta ( $10^{24}$ ) :** Yotta refers to something that is in  $10^{24}$  range.  
**Uses :** We can understand this scale when we compare against something in the scale of the galaxies and universe.

**PART-2***Mechanical Energy and Transport.***CONCEPT OUTLINE**

**Mechanical Energy :** It is the sum of potential energy and kinetic energy. It is the energy associated with the motion and position of an object, e.g. a moving car possesses mechanical energy due to its motion.

**Questions-Answers**

Long Answer Type and Medium Answer Type Questions

Que 1.2.

Define kinetic energy and also derive an expression for it.

**Answer**

- A. Kinetic Energy :** The energy that a body possesses by virtue of its motion is known as kinetic energy.

Mathematically,  $KE = \frac{1}{2}mv^2$

- B. Mathematical Expression for Kinetic Energy :**

1. Consider a body of mass  $m$  starting from rest. Let it be subjected to an accelerating force  $F$  and after covering a distance  $s$ , its velocity becomes  $v$ .
  1. Initial velocity,  $u = 0$
  2. Now, work done  $= Fs$  ... (1.2.1)
  3. We know that,  $F = ma$
  4. Substituting the value of  $F$  in eq. (1.2.1), we have

$$\text{Work done} = m \times (as) \quad \dots(1.2.2)$$

5. From equation of motion, we have

$$v^2 - u^2 = 2as \quad \text{or} \quad v^2 - 0^2 = 2as \quad (\because u = 0)$$

$$as = \frac{v^2}{2}$$

6. Substituting the value of  $as$  in eq. (1.2.2), we get

$$\text{Work done} = m \frac{v^2}{2}$$

7. But work done on the body is equal to KE possessed by the body.

$$KE = \frac{1}{2}mv^2$$

**Que 1.3.** Define potential energy and also give principle of conservation of mechanical energy.

**Answer**

- A. Potential Energy :** It is defined as the capacity to do work by virtue of its position.

Mathematically,  $PE = mgh$

- B. Principle of Conservation of Mechanical Energy :**

1. If a body is subjected to a conservative system of forces then its mechanical energy remains constant for any position in the force field.
2. Consider a body either sliding down a smooth incline or freely falling. Since it is initially at rest, all of its energy is potential energy.
3. As it accelerates downwards, some of its potential energy is converted into kinetic energy.

4. At the bottom of the incline or at the ground level, the energy will be purely kinetic, assuming the bottom of the slope or the ground level as the datum for potential energy.
5. By the principle of conservation of energy, we see that the loss in potential energy is equal to the gain in kinetic energy.

Mathematically,

$$(PE)_i - (PE)_f = (KE)_f - (KE)_i$$

6. On rearranging, we have

$$(PE)_i + (KE)_i = (PE)_f + (KE)_f$$

$$(PE) + (KE) = \text{Constant}$$

7. Thus, we see that the total mechanical energy, i.e., sum of potential and kinetic energies remain constant. This is known as principle of conservation of mechanical energy.

### PART-3

*Heat Energy : Conversion between Heat and Mechanical Energy.*

#### CONCEPT OUTLINE

**Heat Energy :** It is the result of the movement of fine particles called atoms, molecules or ions in solids, liquids and gases. It can be transferred from one object to another.

#### Questions-Answers

#### Long Answer Type and Medium Answer Type Questions

**Que 1.4.** What is a heat reservoir or thermal energy reservoir ?  
Also define heat source and heat sink.

#### Answer

- A. **Heat Reservoir :** It is defined as the source of infinite heat energy and a finite amount of heat absorbed or heat rejected from the heat reservoir will not have any effect on its temperature i.e., heat reservoir is maintained at a constant temperature.
- B. **Heat Source :**
  1. Thermal reservoir which supplies heat to a system is known as source.
  2. This is at high temperature, e.g., boiler furnace, combustion chamber, nuclear reactor etc.

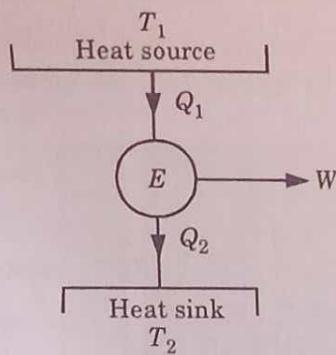
**C. Heat Sink :**

1. Thermal reservoir which absorbs heat from a system is known as sink.
2. This is at low temperature, e.g., ocean, river, atmospheric air.

**Que 1.5.** Discuss in short about the heat engine.

**Answer**

1. Heat engine is defined as a thermodynamic device which is used for continuous production of work from heat when operating in a thermodynamic cyclic process.
2. Both heat and work interactions occur across the boundary of this device, e.g., internal combustion engines, external combustion engines, gas turbines etc.
3. Consider a heat engine which receives  $Q_1$ , from heat source at  $T_1$  temperature and produces mechanical work  $W$ .
4. The remainder of energy is rejected to heat sink at  $T_2$  temperature.

**Fig. 1.5.1.**

5. From the principle of conservation of energy,

$$Q_1 = W + Q_2$$

or

$$W = Q_1 - Q_2$$

6. Thermal efficiency,  $\eta = \frac{\text{Net work output}}{\text{Heat input (supplied)}} = \frac{W}{Q}$

$$\eta = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$$

7. Thermal efficiency is the measure of performance of a heat engine.

**PART-4**

*Electromagnetic Energy : Storage, Conversion,  
Transmission and Radiation.*

**CONCEPT OUTLINE**

**Electromagnetic Energy :** It is a form of energy that is reflected or emitted from objects in the form of electrical and magnetic waves that can travel through space.

**Electromagnetic Storage Devices :**

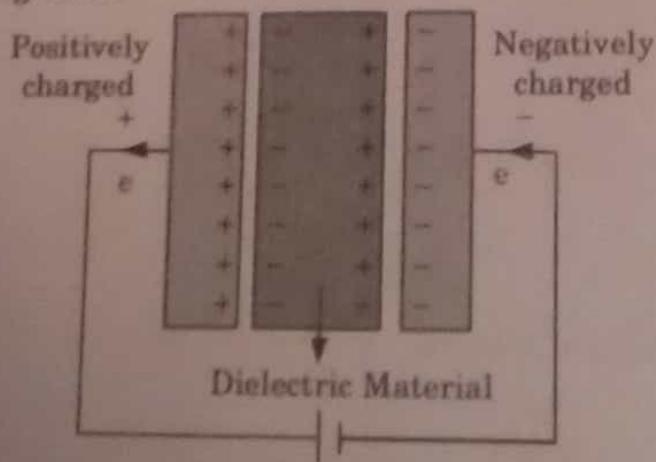
1. Capacitor, and
2. Superconducting magnetic energy storage (SMES).

**Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 1.6.** Write a short note on capacitor.

**Answer**

1. A capacitor has two parallel plates or electrodes to which we connect an external battery. And in the middle we have a dielectric material as shown in Fig. 1.6.1.



**Fig. 1.6.1.**

2. Electrons start entering one plate and exiting other. So, one plate becomes positively charged and other negatively charged. Then correspondingly the side of the dielectric material that faces the negative electrode becomes positively charged, and the side of the dielectric material that is facing the positive electrode becomes negatively charged.
3. There is overall charge neutrality because of just the same amount of positive and negative charge.
4. Charge is given as,  $Q = CV$

Where,

$V$  = Voltage

$C$  = Capacitance in Farad.

5. The energy being stored is in the form of electrical energy and there is no chemical change.
6. Regions in capacitor are flat. So, this is the way in which the capacitor is functioning and in this process energy is stored.

**Que 1.7.** Discuss in brief about superconducting magnetic energy storage (SMES).

**Answer**

1. Superconducting magnetic energy storage (SMES) systems store energy in a magnetic field created by the flow of direct current through a superconducting coil.
2. A SMES system comprises a superconducting coil in a cryogenic enclosure, an electronic converter to match the DC power in the coil to the AC on the grid, and an electronic switch to control the flow of current into and out of the coil.
3. The superconducting coil is charged by applying a DC voltage which causes the current through the coil to increase.
4. When the current reaches its working value an electronic switch isolates the DC supply and short-circuits the coil. Because the coil has zero resistance, the current continues to circulate without losses and with no heat generation.
5. To release the stored energy, the switch is opened and the coil discharges through the converter, yielding AC power which can be fed to the grid.
6. Their primary advantage compared to other types of energy storage is their very short reaction time and ability to provide high power for short periods.
7. Because they can be switched on with virtually no time delay, SMES systems can counteract abrupt changes in demand for applications where even the shortest interruptions are unacceptable.

**Que 1.8.** Briefly describe about the transformer with suitable sketch.

**Answer**

1. Transformer is a static device which transfers energy from one circuit to another which are electrically isolated but magnetically coupled without change in frequency.
2. Transformer provides link between generator and transmission line and between transmission line and distribution system. And finally transformers are used to deliver energy to load.
3. The transformer isolates the expensive generator from the exposed overhead power grid.

4. The transient over voltages caused by atmospheric disturbance will propagate along the lines as waves, having high crests and steep voltage fronts and velocities slightly less than that of light.

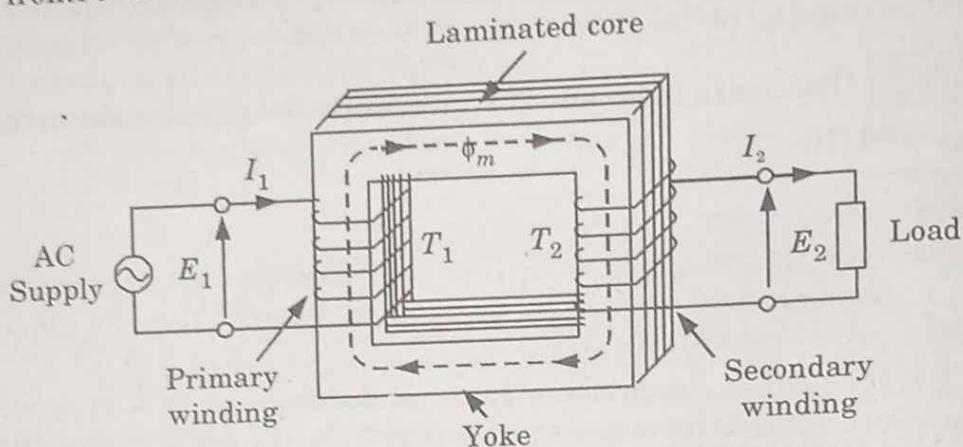


Fig. 1.8.1. Arrangement of a simple transformer.

5. As these waves are being reflected at the transformer terminals, high voltage amplitude will be built up which will stress the insulation of the transformer than in a generator windings.
6. Transformers come in sizes ranging from distribution transformers rated a few kVA to huge three phase rating in excess of 1000 MVA.

**Que 1.9.** Write a short note on electromagnetic radiation.

**Answer**

1. Electromagnetic radiation is an electric and magnetic disturbance traveling through space at the speed of light.
2. It contains neither mass nor charge but travels in packets of radiant energy called photons, or quanta.
3. Examples of EM radiation include radio waves and microwaves, as well as infrared, ultraviolet, gamma, and X-rays.
4. Some sources of EM radiation include sources in the cosmos e.g., the sun and stars, radioactive elements, and manufactured devices. EM exhibits a dual wave and particle nature.
5. The energy of electromagnetic radiation is quantified by an electron volt (eV), where 1 eV describes the energy gained by an electron as it is accelerated through a potential difference of 1 volt.

**PART-5**

*Introduction to the Quantum, Energy Quantization.*

### CONCEPT OUTLINE

**Wave Particle Duality :** According to Einstein, the energy of light is concentrated in small bundles called photon. Hence, light behaves as a wave on one hand and as a particle on the other hand. This nature of light is known as dual nature, while this property of light is known as wave particle duality.

**Wave Function and its Significance :** The wave function  $\psi$  is described as mathematical function whose variation builds up matter waves.  $|\psi|^2$  defines the probability density of finding the particle within the given confined limits.

**Schrodinger's Wave Equation :** This wave equation is a fundamental equation in quantum mechanics and describes the variation of wave function  $\psi$  in space and time.

**Quantization :** The process of restricting the possible values of a physical quantity to a set of discrete values is called quantization.

### Questions-Answers

#### Long Answer Type and Medium Answer Type Questions

**Que 1.10.** What are de Broglie's waves or matter waves ?

**Answer**

- When a material particle moves in a medium, a group of waves is associated with it due to which it shows the wave particle duality. These waves are known as matter waves or de Broglie waves.
- According to de Broglie's concept, each material particle in motion behaves as waves, having wavelength  $\lambda$  associated with moving particle of momentum  $p$ .

$$\lambda = \frac{h}{p} \Rightarrow \lambda \propto \frac{1}{p}$$

$$\text{Wave nature} \propto \frac{1}{\text{Particle nature}}$$

**Que 1.11.** Derive time independent Schrodinger wave equation.

**Answer**

- Consider a system of stationary wave to be associated with particle and the position coordinate of the particle ( $x, y, z$ ) and  $\psi$  is the periodic displacement of any instant time ' $t$ '.

2. The general wave equation in 3D in differential form is,

$$\nabla^2 \psi = \frac{1}{v^2} \frac{\partial^2 \psi}{\partial t^2} \quad \dots(1.11.1)$$

Where,

$v$  = Velocity of wave, and

$$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} = \text{Laplacian operator.}$$

3. The wave function may be written as,

$$\psi = \psi_o e^{-i\omega t} \quad \dots(1.11.2)$$

4. Differentiate eq. (1.11.2) wrt time, we get

$$\frac{\partial \psi}{\partial t} = -i\omega \psi_o e^{-i\omega t} \quad \dots(1.11.3)$$

5. Again differentiating eq. (1.11.3),

$$\frac{\partial^2 \psi}{\partial t^2} = +i^2 \omega^2 \psi_o e^{-i\omega t}$$

$$\frac{\partial^2 \psi}{\partial t^2} = -\omega^2 \psi \quad \dots(1.11.4)$$

6. Putting these value in eq. (1.11.1),

$$\nabla^2 \psi = \frac{-\omega^2}{v^2} \psi \quad \dots(1.11.5)$$

7. But  $\omega = 2\pi v = \frac{2\pi v}{\lambda} \Rightarrow \frac{\omega}{v} = \frac{2\pi}{\lambda}$

8. Eq. (1.11.5) becomes,

$$\nabla^2 \psi = -\frac{4\pi^2}{\lambda^2} \psi \quad \dots(1.11.6)$$

9. From de-Broglie's wavelength,  $\lambda = \frac{h}{mv}$

Then  $\nabla^2 \psi = \frac{-4\pi^2 m^2 v^2}{h^2} \psi \quad \dots(1.11.7)$

10. If  $E$  and  $V$  are the total and potential energies of a particle and  $E_k$  kinetic energy, then

$$E_k = E - V \text{ or } \frac{1}{2} mv^2 = E - V \text{ or } m^2 v^2 = 2m(E - V)$$

11. Now eq. (1.11.7) becomes,

$$\nabla^2 \psi = \frac{-4\pi^2 2m [E - V] \psi}{h^2} \quad \left[ \text{Since } \hbar = \right]$$

$$\therefore \nabla^2 \psi + \frac{2m [E - V] \psi}{\hbar^2} = 0 \quad \dots(1.11.8)$$

This is required time-independent Schrodinger wave equation.

**PART-6***Energy in Chemical Systems and Processes, Flow of CO<sub>2</sub>.***CONCEPT OUTLINE**

**Fuel Cell :** A fuel cell is an electrochemical cell that converts the chemical energy of a fuel into electricity.

**Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 1.12.** Discuss the application and economic aspect of fuel cells.

**AKTU 2019-20, Marks 10****Answer**

- A. Applications of Fuel Cell :** Various applications of fuel cells are as follows :
- Portable Applications :** These include :
    - Portable power generators,
    - Consumer electronics,
    - Portable military equipments, etc.
  - Transportation Applications :** These include :
    - Auxiliary power units,
    - Light traction vehicles,
    - Marine propulsion, etc.
  - Stationary Applications :** These include :
    - Distributed power generation,
    - Combined heat and power,
    - Back up power supply, etc.
- B. Economic Aspects of Fuel Cells :**
- As a new energy technology, fuel cells have not yet significantly penetrated the energy market. Cost, durability, and reliability are the main challenges in the commercialization of fuel cells.
  - The manufacturing life cycle and value chain represent the production procedure and cost of fuel cycle.

3. The manufacturing cost includes the design, materials, component fabrication and assembly, labour, and equipment capital, which is required in the overall assembly of custom fabricated and commercially produced fuel cells.
4. The stack, air management, fuel management, and thermal management were the most expensive parts of the system. The stack system assembly and balance made up 14 % of the total cost.
5. It is clear that most studies on existing fuel cell costs are based only on stack manufacturing costs, without consideration of repair and maintenance costs. However, the cost of repair and maintenance is necessary for stack service and end-user acceptance.

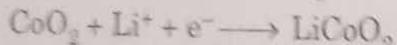
**Que 1.13.** Write short note on following :

- a. Lithium-ion battery.
- b. Nickel metal hydride.

**Answer**

- a. **Lithium-ion Battery :**

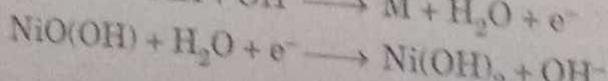
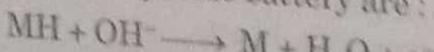
1. It is the most popular battery at this point of time. It is lighter than the nickel metal hydride battery because lithium is the lightest metal.
2. Therefore, it has much better energy density. It is rechargeable. Its ion part makes it rechargeable and it can also discharge over period of time if not used.
3. Reactions of Lithium-ion battery are :



4. It uses lithium in carbon as the anode, so when it discharges lithium leaves the anode and releases the electron which goes into the external circuit.
5. Then the lithium ion which comes through the electrolyte and the electrons which come through the external circuit react with cobalt oxide ( $\text{CoO}_2$ ) and form lithium cobalt oxide ( $\text{LiCoO}_2$ ). This reaction is reversible. So, it is the rechargeable battery.

- b. **Nickel Metal Hydride (NiMH) Battery :**

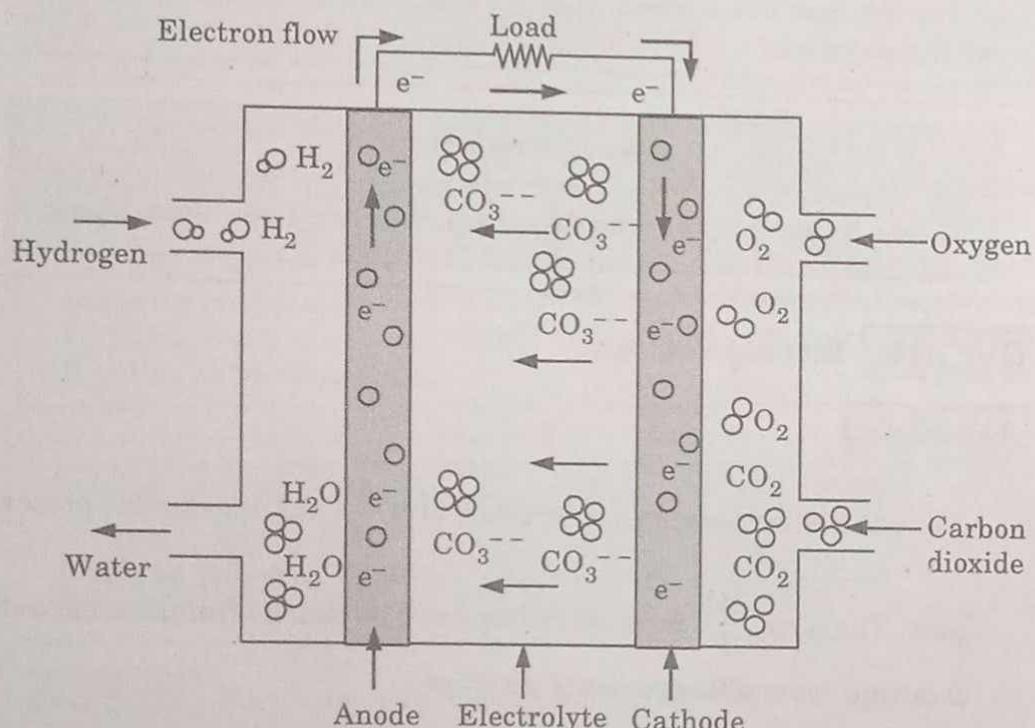
1. It is rechargeable battery. This is non toxic so it can replace alkaline as well as nickel cadmium batteries. This does not have the memory effect.
2. It has high capacity and high energy density and its energy density approaches that of lithium ion.
3. It can self-discharge means it will slowly discharge if we do not use it.
4. Reactions of nickel metal hydride battery are :



**Que 1.14.** Explain the working of molten carbonate fuel cells using appropriate diagram and write the various chemical reactions involved in this type of fuel cell.

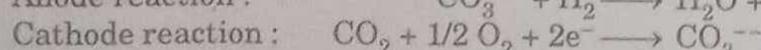
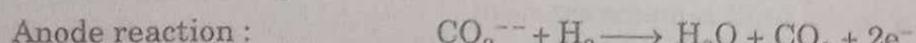
**Answer**

1. It uses an electrolyte, which is a molten mixture of carbonate salts.
2. Two mixtures commonly used are :
  - a. Lithium carbonate and potassium carbonate, and
  - b. Lithium carbonate and sodium carbonate.



**Fig. 1.14.1.** Molten carbonate fuel cell.

3. Since, these salts can act as electrolytes only in liquid phase, the operating temperature should be as high as 650 °C.
4. Due to high temperature, these salts melt and become conductive to carbonate ions (CO<sub>3</sub><sup>2-</sup>).
5. These ions flow from the cathode to the anode where they combine with hydrogen to give water, carbon dioxide and electrons.
6. The electrons flow through external circuit and reaches to cathode, generating electricity and byproduct heat.
7. The reactions are given below :



- Total reaction:  $H_2 + 1/2 O_2 + CO_2 \longrightarrow H_2O + CO_2$
8. The emf produced by each cell is theoretically 1 V and actual emf of 0.8 V at 700 °C and the expected efficiency is about 60 %.

**PART-7***Entropy and Temperature.***CONCEPT OUTLINE**

**Entropy:** Entropy is defined as the quantitative measure of disorder or randomness in a system. It deals with the transfer of heat energy within a system.

**Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 1.15.** Discuss entropy.

**Answer**

1. From Clausius theorem, cyclic integral of  $\frac{\delta Q}{T}$  for a reversible process is zero. The term  $\frac{\delta Q}{T}$  is called entropy and its change from state 1 to state 2 during reversible process is given as,

$$\int_1^2 \left( \frac{\delta Q}{T} \right)_{rev} = \int_1^2 ds = s_2 - s_1$$

2. Entropy is a measure of degree of randomness of molecules comprising a system. Higher the disorderness, greater is the increase in entropy.  
 3. In other words, entropy is the function of quantity of heat which shows the possibility of conversion of that heat into work. On heat addition entropy of system increases and on heat rejection, it decreases.

**Que 1.16.** Explain entropy principle.

**Answer**

1. According to this principle, entropy of an isolated system either increases or in the limit remains constant.

2. An isolated system does not undergo any energy interaction (i.e., work or heat energy) with its surroundings, and the total energy of all the possible states remains constant. Therefore for an isolated system,

$$\delta Q = 0$$

$$\therefore (ds)_{\text{Isolated}} \geq 0$$

3. If the process is reversible,  $(ds)_{\text{Isolated}} = 0$  and if the process is irreversible,  $(ds)_{\text{Isolated}} > 0$ .
4. From above we see that the entropy of an isolated system can never decrease. It always increases with every irreversible process and remains constant during a reversible process. This is called principle of entropy increase.

## PART-8

### Carnot and Stirling Heat Engines.

#### CONCEPT OUTLINE

**Carnot Engine :** It is a theoretical engine which works on the Carnot cycle.

**Stirling Engine :** It is a heat engine which is operated by a cyclic compression and expansion of air or other gas at different temperatures such that there is a net conversion of heat energy to mechanical work. It works on Stirling cycle.

#### Questions-Answers

#### Long Answer Type and Medium Answer Type Questions

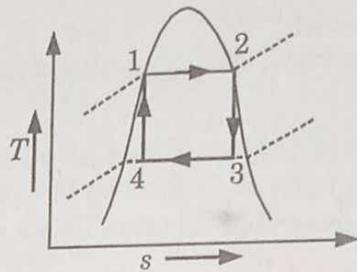
**Que 1.17.** Explain the Carnot vapour power cycle with T-s diagram. Also find out the efficiency of Carnot cycle.

#### Answer

##### A. Carnot Cycle :

1. It is an ideal cycle having highest thermodynamic efficiency. Carnot cycle is shown in Fig. 1.17.1.
2. Various processes of Carnot cycle are as follows :
  - a. **Process 1-2 :** It is reversible isothermal heat addition process in the boiler.
  - b. **Process 2-3 :** It is reversible adiabatic expansion process in steam turbine.
  - c. **Process 3-4 :** It is reversible isothermal heat rejection process in the condenser.

- d. **Process 4-1 :** It is reversible adiabatic compression process or pumping process in feed water pump.



**Fig. 1.17.1. Carnot vapour power cycle.**

### B. Efficiency:

- Net work = Turbine work – Pump work

For unit mass flow,

$$W = (h_2 - h_3) - (h_1 - h_4)$$

- Heat added in process 1-2,

$$Q_{1-2} = h_2 - h_1$$

- Thermal efficiency =  $\frac{\text{Net work}}{\text{Heat added}}$

$$\begin{aligned}\eta_{\text{Carnot}} &= \frac{(h_2 - h_3) - (h_1 - h_4)}{(h_2 - h_1)} \\ &= 1 - \frac{h_3 - h_4}{h_2 - h_1}\end{aligned}$$

- Heat rejected in process 3-4,

$$Q_{3-4} = h_3 - h_4$$

So,  $\eta_{\text{Carnot}} = 1 - \frac{Q_{3-4}}{Q_{1-2}}$

- Heat added or rejected can also be expressed in terms of temperature and entropy, so

$$Q_{3-4} = T_3(s_3 - s_4)$$

and

$$Q_{1-2} = T_1(s_2 - s_1)$$

$$\eta_{\text{Carnot}} = 1 - \frac{T_3(s_3 - s_4)}{T_1(s_2 - s_1)}$$

- As we know,  $s_1 = s_4$  and  $s_2 = s_3$

So,

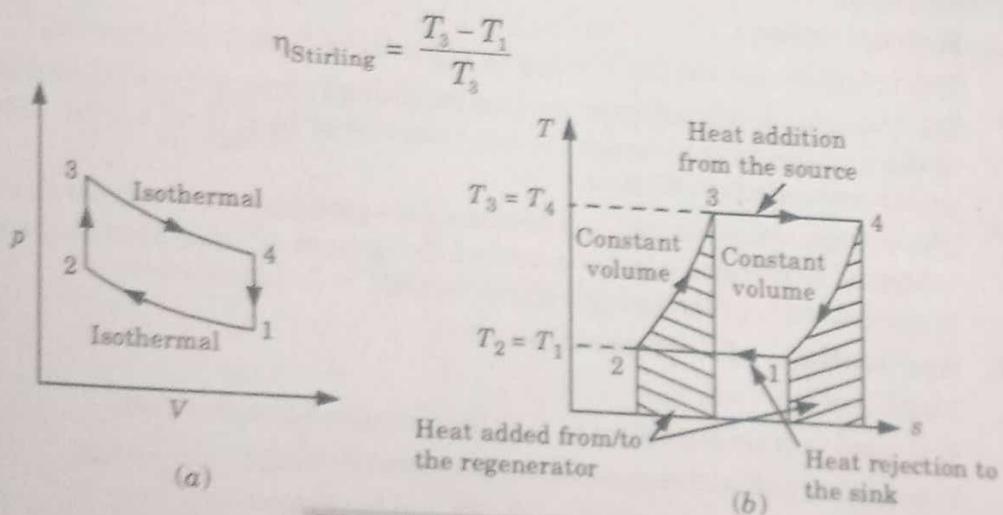
$$s_3 - s_4 = s_2 - s_1$$

$$\eta_{\text{Carnot}} = 1 - \frac{T_3}{T_1}$$

**Que 1.18.** Describe the Stirling cycle.

**Answer**

1. Stirling cycle consists of two isothermal and two constant volume processes. It is externally reversible cycle.
2. Heat rejection and heat addition takes place at constant volume.
3. This cycle has mean effective pressure greater than Carnot cycle. But efficiency in ideal case is equal to the Carnot cycle.
4. From Fig. 1.18.1(b), it is clear that amount of heat addition and rejection during constant volume process is same. So efficiency of cycle is given as,



**Fig. 1.18.1. Stirling cycle.**

5. In practical use, Stirling cycle incorporated with a heat exchanger, which absorb the heat rejected during constant volume process and supplies back to the cycle in heat addition during constant volume.
6. So amount of heat transfer through heat exchanger (absorb heat and heat supplied back to cycle) is same. But efficiency of heat exchanger is not 100 %. So efficiency of Stirling cycle will be less than the Carnot cycle.

**PART-9**

*Phase Change Energy Conversion, Refrigeration and Heat Pump.*

**CONCEPT OUTLINE**

**Phase Change :** Phase change process is the change of material physical state from one state to another like solid to liquid and vice-versa. Material utilizes its latent heat during phase change processes.

**Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 1.19.** Define refrigeration. State the application of refrigeration.

**AKTU 2019-20, Marks 10**

**Answer****A. Refrigeration :**

1. Refrigeration means the cooling or removal of heat from a system.
2. It is the science of producing and maintaining temperatures below that of the surrounding atmosphere *i.e.*, removal of heat from a substance under controlled conditions.
3. The equipment employed to maintain the system at a low temperature is termed as refrigerating system and the system which is kept at lower temperature is called refrigerated system.

**B. Applications of Refrigeration :**

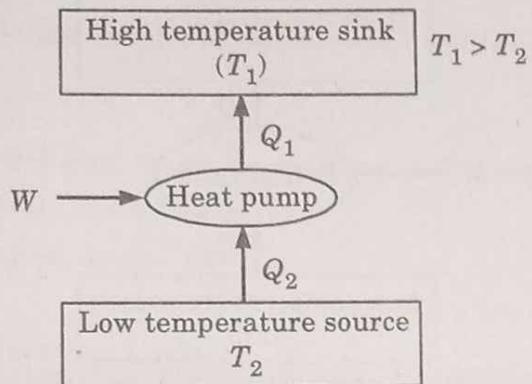
1. Making of ice.
2. It is used in transportation of food at a required temperature.
3. It is used in industrial and comfort air conditioning.
4. It is used in processing food products and beverages.
5. It is used in manufacturing and treatment of metals.

**Que 1.20.** Write short note on the following :

- a. Heat pump.
- b. Refrigerator.

**Answer****a. Heat Pump :**

1. A heat pump is a reversed heat engine. It receives heat from a low temperature reservoir (source) and rejects it to a high temperature reservoir (sink).
2. This transfer of heat from a low temperature body to a high temperature one is essentially a non-spontaneous process. And that calls for the help of an external work which is supplied to the heat pump (Fig. 1.20.1).
3. A heat pump extracts  $Q_2$  amount of heat from the low temperature ( $T_2$ ) source and delivers  $Q_1$  amount of heat to the high temperature ( $T_1$ ) sink by consuming  $W$  amount of external work.



**Fig. 1.20.1.** A schematic diagram of a heat pump.

4. Coefficient of performance,

$$\text{COP} = \frac{\text{Desired effect}}{\text{Work input}} \quad \dots(1.20.1)$$

5. Now, the desired effect for a heat pump is to supply heat  $Q_1$  to the hot body. Therefore,

$$\text{COP}_{\text{HP}} = \frac{Q_1}{W} \quad \dots(1.20.2)$$

6. From the first law of thermodynamics,

$$\sum_{\text{cycle}} Q = \sum_{\text{cycle}} W$$

$$\therefore Q_1 - Q_2 = W$$

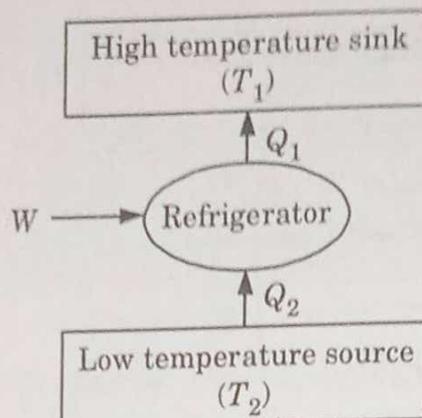
Hence, eq. (1.20.2) becomes

$$\text{COP}_{\text{HP}} = \frac{Q_1}{Q_1 - Q_2}$$

#### b. Refrigerator :

1. A refrigerator is similar to a heat pump. It operates as a reversed heat engine.
2. Its duty is to extract heat as much as possible from the cold body/space and deliver the same to high temperature body/surroundings.
3. The desired effect of a refrigerator, under a steady state, is to pump out the heat in the same rate as is infiltrating into the system ( $Q_2$ ). And in order to do so, the refrigerator takes up  $W$  amount of external work (Fig. 1.20.2).
4. The desired effect of a refrigerator is to remove  $Q_2$  heat infiltrating into the cold space.
5. By using the external work, it rejects  $Q_1$  heat to the high temperature reservoir (surroundings). Therefore,

$$\text{COP}_{\text{ref}} = \frac{\text{Desired effect}}{\text{Work input}} = \frac{Q_2}{W} \quad \dots(1.20.3)$$



**Fig. 1.20.2.** A schematic diagram of a refrigerator.

6. From the first law of thermodynamics,

$$\sum_{\text{cycle}} Q = \sum_{\text{cycle}} W$$

$$\therefore Q_1 - Q_2 = W$$

7. Hence, eq. (1.20.3) becomes

$$\text{COP}_{\text{ref}} = \frac{Q_2}{Q_1 - Q_2} \quad \dots(1.20.4)$$

Where,  $Q_2$  is the heat infiltrating into the cold space of the refrigerator.

## PART-10

### *Internal Combustion Engines.*

#### **CONCEPT OUTLINE**

**IC Engines :** The engines in which the combustion takes place inside the engine or within the cylinder are known as internal combustion engines.

##### **Types of IC Engine Based on Ignition :**

1. Spark Ignition (SI) engine.
2. Compression Ignition (CI) engine.

**Four Stroke Engines :** The engines in which cycle of operation completed in four stroke of piston or two revolution of crankshaft are known as four stroke engines.

**Two Stroke Engines :** The engines in which cycle of operation completes in two stroke of piston or one revolution of crankshaft are known as two stroke engines.

#### **Questions-Answers**

**Long Answer Type and Medium Answer Type Questions**

**Que 1.21.** Classify the internal combustion engine.

**Answer**

Internal combustion engine can be classified as follows :

i. **According to Basic Engine Design :**

1. Reciprocating engine, and
2. Rotary engine.

ii. **According to Working Cycle :**

1. Otto cycle, and
2. Diesel cycle.

iii. **According to Number of Stroke :**

1. Four stroke engine, and
2. Two stroke engine.

iv. **According to Fuel Employed :**

1. Gasoline or petrol engine,
2. Diesel engine,
3. LPG engine, and
4. CNG engine.

v. **According to Fuel Supply and Mixture Preparation :**

1. Carbureted type, and
2. Injection type.

vi. **According to Method of Ignition :**

1. Battery ignition, and
2. Magneto ignition.

vii. **According to Method of Cooling :**

1. Water cooled engine, and
2. Air cooled engine.

viii. **According to Cylinder Arrangement :**

1. Inline engine,
2. V-engine, and
3. Radial engine.

**Que 1.22.** Describe the basic terminology used in internal combustion engine.

**Answer**

Terms used in internal combustion engine are as follows :

- i. **Cylinder Bore** : It is the nominal inner diameter of the working cylinder. It is represented by  $D$ .
- ii. **Piston Area** : It is the area of a circle of diameter equal to the cylinder bore.
- iii. **Stroke** : The distance travelled by piston from top dead centre to bottom dead centre is known as stroke.
- iv. **Bottom Dead Centre (BDC)** : It is the dead centre when the piston is nearest to the crankshaft or lowest position of the piston towards the crank end side of cylinder.
- v. **Top Dead Centre (TDC)** : It is the dead centre when the piston is farthest from the crankshaft or top most position of the piston towards cover end side of cylinder.
- vi. **Displacement Volume (or Piston Swept Volume) :**
  1. This is the volume swept by the piston moving from one dead centre to other.
  2. It is calculated as the product of piston area and stroke.

$$v_s = \text{Piston area} (A) \times \text{Stroke} (L)$$

$$= \frac{\pi}{4} D^2 L$$

- vii. **Clearance Volume** : The volume contained in the cylinder above the top of the piston when the piston is at top dead centre is called clearance volume.

**viii. Cylinder Volume :**

1. The sum of swept volume and clearance volume is known as cylinder volume.

**ix. Compression Ratio :**

1. This is defined as the ratio of the volume at the beginning of compression to the volume at the end of compression.

$$r = \frac{v_c + v_s}{v_c} = 1 + \frac{v_s}{v_c}$$

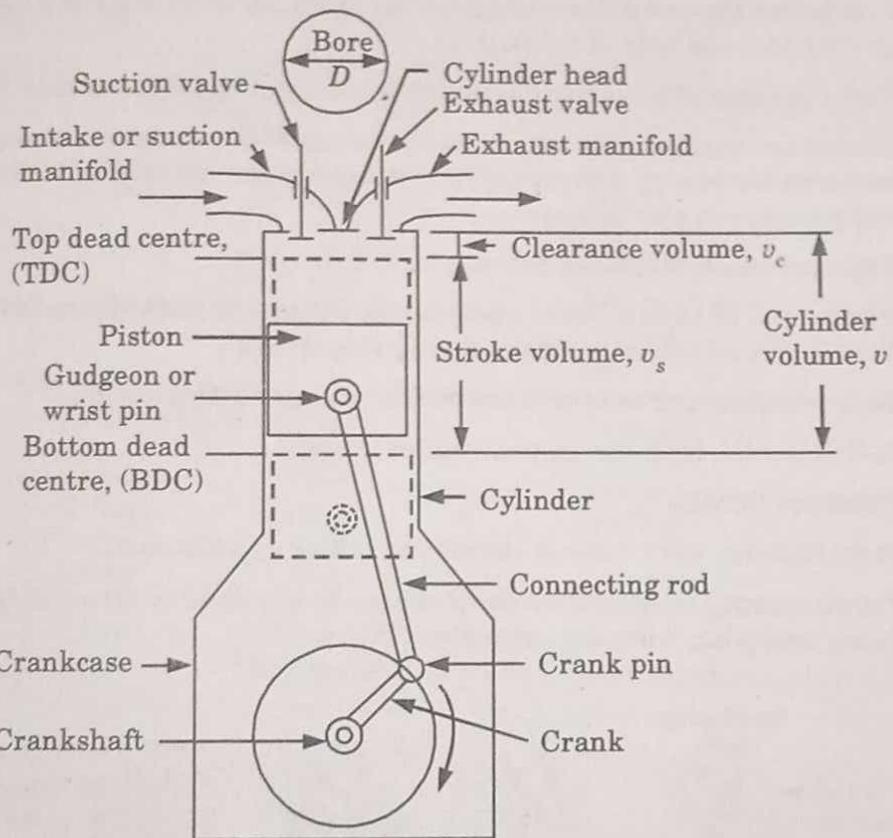


Fig. 1.22.1. Important positions and volumes in reciprocating engine.

**Que 1.23. How internal combustion engines work ?**

AKTU 2019-20, Marks 10

**Answer**

Working of internal combustion four stroke spark ignition engine is as follows :

**a. Suction Stroke :**

1. Suction stroke (Fig. 1.23.1) starts when the piston is at top dead centre position and about to move toward bottom dead centre.
2. During this stroke, inlet valve is open and outlet valve is closed.
3. Due to the suction created by downward motion of the piston, charge consists of mixture of air and fuel drawn into the cylinder.
4. At the end of suction stroke, both the inlet and outlet valves are closed.

**b. Compression Stroke :**

1. The fresh charge taken into the cylinder during the suction stroke is compressed during the return stroke of the piston.

2. In this stroke, both the inlet and outlet valves remain closed.
  3. Just before the end of the compression stroke, mixture of air and fuel is ignited with the help of spark plug.
  4. Burning takes place when the piston is almost at top dead centre.
  5. During the burning process, chemical energy of the charge is converted into sensible energy and producing a temperature rise of about  $2000^{\circ}\text{C}$  and pressure is also increased.
- c. **Expansion or Working Stroke :**
1. Due to high pressure, burnt gases forces the piston towards the bottom dead centre so power is obtain during this stroke.
  2. Both pressure and temperature decreases during this stroke.
  3. In this stroke, both the valves remain closed.
- d. **Exhaust Stroke :**
1. In this stroke, inlet valve is closed and outlet valve is open.
  2. Piston moving from bottom dead centre to top dead centre and burnt gases sweep out from the cylinder.

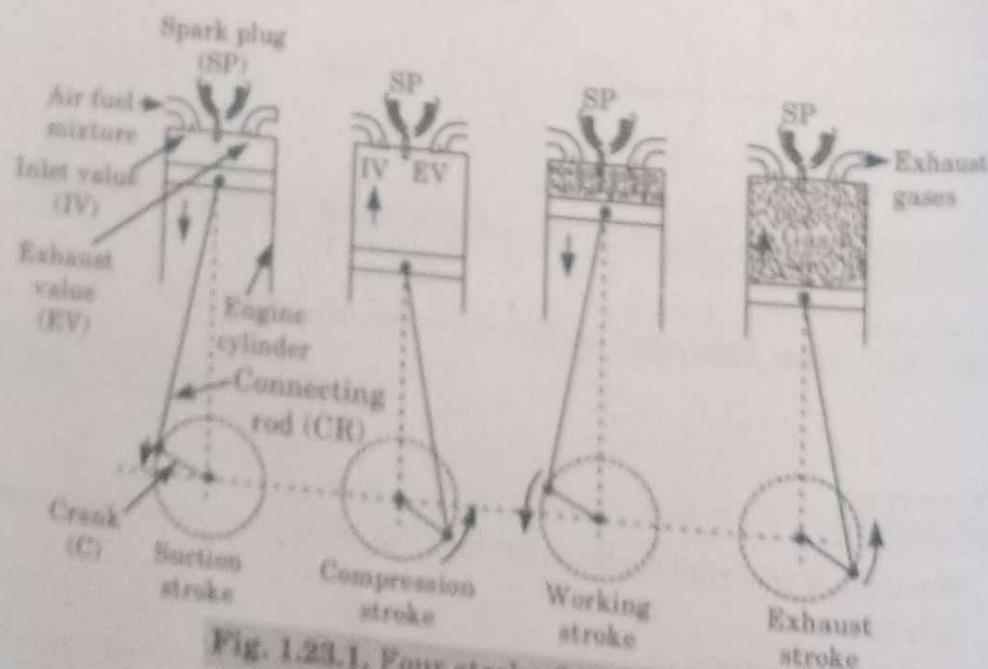


Fig. 1.23.1. Four stroke Otto cycle engine.

**Ques 1.24.** Compare the SI and CI engine.

**Answer**

S. No.	Description	SI Engine	CI Engine
1.	Basic cycle	Otto cycle	Diesel cycle
2.	Fuel used	Gasoline (petrol)	Diesel
3.	Ignition	Spark plug is used.	Self ignition due to high pressure and temperature caused by compression of air.
4.	Compression ratio	6 to 10	14 to 22
5.	Weight	Lighter	Heavier
6.	Speed	High speed	Low speed
7.	Efficiency	Lower efficiency due to low compression ratio.	Higher efficiency due to high compression ratio.

**PART- 11***Steam and Gas Power Cycles.***CONCEPT OUTLINE**

**Steam Power cycles :** These are the cycles which uses steam as their working fluid. Rankine cycle is the example of steam power cycle.

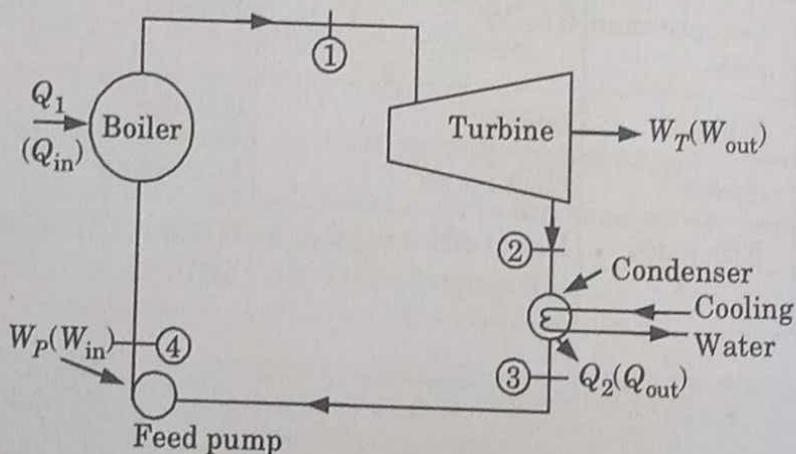
**Gas Power Cycles :** These are the cycles which use air or gas as their working fluid. Otto cycle, Diesel cycle, Bryton cycle are the examples of gas power cycles.

**Questions-Answers****Long Answer Type and Medium Answer Type Questions**

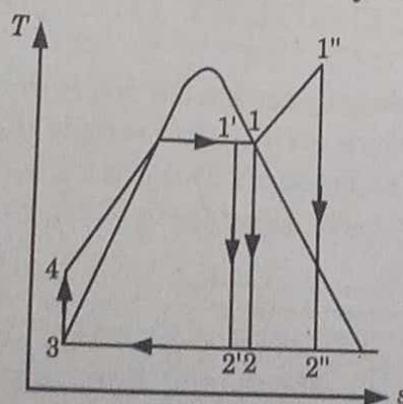
**Que 1.25.** Describe the different operations of Rankine cycle. Also derive the expression for its efficiency.

**Answer****A. Rankine Cycle :**

1. Rankine cycle is the theoretical steam cycle on which the steam turbine (or engine) works.
2. The Rankine cycle is shown in Fig. 1.25.1. It consists of following processes :
  - a. **Process 1-2** : Adiabatic expansion (in turbine).
  - b. **Process 2-3** : Isobaric heat release (in condenser).
  - c. **Process 3-4** : Adiabatic pumping (in pump).
  - d. **Process 4-1** : Isobaric heat addition (in boiler).

**Fig. 1.25.1.** Rankine cycle.

3. Fig. 1.25.2 shows *T-s* diagram of Rankine cycle.

**Fig. 1.25.2.****B. Efficiency of Rankine Cycle :**

1. Consider 1 kg of fluid applying steady flow energy equation.  
i. For boiler :

$$h_{f4} + Q_1 = h_1 \quad Q_1 = h_1 - h_{f4} \quad \dots(1.25.1)$$

- ii. For turbine :

$$h_1 = W_T + h_2 \quad W_T = h_1 - h_2 \quad \dots(1.25.2)$$

iii. For condenser :

$$\begin{aligned} h_2 &= Q_2 + h_{f3} \\ Q_2 &= h_2 - h_{f3} \end{aligned} \quad \dots(1.25.3)$$

iv. For feed pump :

$$\begin{aligned} h_{f3} + W_P &= h_{f4} \\ W_P &= h_{f4} - h_{f3} \end{aligned} \quad \dots(1.25.4)$$

2. Efficiency of Rankine cycle is given by,

$$\begin{aligned} \eta_{\text{Rankine}} &= \frac{W_{\text{net}}}{\text{Heat supplied}} = \frac{W_T - W_P}{Q_1} \\ &= \frac{(h_1 - h_2) - (h_{f4} - h_{f3})}{(h_1 - h_{f4})} \end{aligned} \quad \dots(1.25.5)$$

3. Using general property relation for adiabatic compression,

$$Tds = dh - vdp \quad (\because ds = 0)$$

$$dh = vdp$$

or  $\Delta h = v\Delta p$  (Since change in volume is negligible.)

$$\text{or } h_{f4} - h_{f3} = v_3(p_1 - p_2)$$

4. The feed pump term  $(h_{f4} - h_{f3})$  being a small quantity in comparison with turbine work,  $W_P$ , is usually neglected, especially, when the boiler pressures are low.

$$\text{Then, } \eta_{\text{Rankine}} = \frac{h_1 - h_2}{h_1 - h_{f4}}$$

**Que 1.26.** Explain Brayton cycle and obtain expression for efficiency in terms of pressure and temperature ratio.

### Answer

A. Brayton Cycle :

- It is a theoretical cycle for gas turbines and also known as constant pressure cycle for a perfect gas.
- The basic components of a Brayton cycle are shown in Fig. 1.26.1.

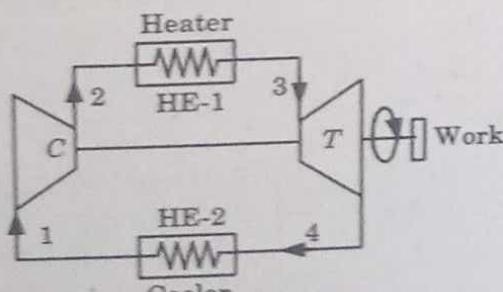


Fig. 1.26.1.

3. There occur two isentropic processes and two constant pressure processes. Compression and expansion of working fluid is done by isentropic process while addition and rejection of heat is done at constant pressure.
4. Brayton cycle on  $p-v$  and  $T-s$  diagram is shown in Fig. 1.26.2(a) and 1.26.2(b) respectively.

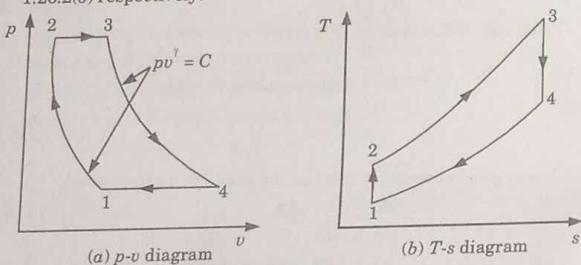


Fig. 1.26.2.

5. Brayton cycle shows following processes :
- 1-2 : Adiabatic compression.
  - 2-3 : Constant pressure heat addition.
  - 3-4 : Adiabatic expansion.
  - 4-1 : Constant pressure heat rejection.
6. Now, Work done / cycle = Heat added/cycle - Heat rejected/cycle  
 Heat added in process 2-3 =  $mC_p(T_3 - T_2)$   
 Heat rejected in process 4-1 =  $mC_p(T_4 - T_1)$   
 Work done / cycle =  $mC_p(T_3 - T_2) - mC_p(T_4 - T_1)$

**B. Efficiency of Brayton Cycle :**

$$\begin{aligned} \text{Efficiency, } \eta_{\text{air-standard}} &= \frac{\text{Work done / cycle}}{\text{Heat addition / cycle}} \\ &= \frac{mC_p(T_3 - T_2) - mC_p(T_4 - T_1)}{mC_p(T_3 - T_2)} \\ \eta_{\text{air-standard}} &= 1 - \frac{T_4 - T_1}{T_3 - T_2} \quad \dots(1.26.1) \end{aligned}$$

2. From process 1-2,

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma-1}} \quad \left(\because \frac{P_2}{P_1} = r_p = \text{Pressure ratio}\right)$$

$$T_2 = T_1 (r_p)^{\frac{1}{\gamma-1}}$$

3. Similarly, from process 3-4,

3.  $T_3 = T_4 (r_p)^{\frac{1}{\gamma-1}}$   
 4. Putting the values of  $T_2$  and  $T_3$  in eq. (1.26.1), we get

$$\eta_{\text{air-standard}} = 1 - \frac{\frac{T_4 - T_1}{T_4(r_p)^{\frac{1}{\gamma-1}} - T_1(r_p)^{\frac{1}{\gamma-1}}}}{1 - \frac{1}{(r_p)^{\frac{1}{\gamma-1}}}}$$

**PART-12**

*Physics of Power Plant, Solid State Phenomena including Photo, Thermal and Electric Aspects.*

**CONCEPT OUTLINE**

**Solid State Phenomena :** It finds out the fundamentals of the structure and their influence on the properties of solid.

**Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 1.27.** List the factors which should be considered while designing a power plant.

**Answer**

Following factors should be considered while designing a power plant :

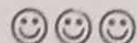
1. Availability of cooling water (if cooling towers are used the possibility of adequate make up water).
2. Availability of fuel (water, rail or pipe connection to the fuel source, and the cost of fuel transport).
3. Distance from the centre of gravity of load demand.
4. Cost of land including space for extension, maintenance, workshop and storage yard.
5. Character of soil.
6. Main wind direction and water current in cooling water source (sea, lake or river) in order to minimize air and water pollution, and other ecological considerations.
7. With coal fired stations, disposal of ash.
8. If the plant is erected far from a town, accommodation for staff.

9. Rail and road connections.
10. Security considerations.

**Que 1.28. How can a power plant be designed economically ?**

**Answer**

1. While planning a power plant, first the power output to be installed is determined from the estimated maximum demand, anticipated growth of demand and reserve capacity needed.
2. After determining the installed capacity, the size and number of generating units are decided according to the load curve or load duration curve.
3. The variable load problem affects power plant design and operation as well as the cost of generation.
4. Due to variable load on the plant, the equipment cannot operate at the designed load points.
5. In order to follow the variable load curve very closely, the total plant capacity has to be usually subdivided into several power units of different sizes.
6. If more units of smaller size are selected than a few units of bigger size, then the total plant capacity would more nearly coincide with the variable load curve.
7. The size and number of generating units should be so chosen that each unit operates on about full load or the load at which it gives the maximum efficiency.
8. The load duration curve helps to decide the size of units to supply the base, intermediate and peak loads.
9. The peak load unit / plant should be of smaller capacity to reduce the cost of generation. Some units must be of unequal capacities to fit the load curve closely. However, identical units result in saving in the fixed cost.
10. In a power plant with many generating units, there must be some spinning reserve in order to maintain the continuity of service.
11. Spinning reserve is that reserve generating capacity which is connected to the bus and is ready to take the load.



# 2

UNIT

## Nuclear Energy

### CONTENTS

<b>Part-1 :</b>	Fundamental Forces .....	<b>2-2G to 2-3G</b>
	in the Universe, Quantum Mechanics Relevant for Nuclear Physics	
<b>Part-2 :</b>	Nuclear Forces, Energy .....	<b>2-3G to 2-4G</b>
	Scales and Structure	
<b>Part-3 :</b>	Nuclear Binding .....	<b>2-5G to 2-11G</b>
	Energy Systematics, Reactions and Decays	
<b>Part-4 :</b>	Nuclear Fusion,.....	<b>2-11G to 2-15G</b>
	Nuclear Fission and Fission Reactor Physics	
<b>Part-5 :</b>	Nuclear Fission .....	<b>2-15G to 2-19G</b>
	Reactor Design	
<b>Part-6 :</b>	Safety, Operation.....	<b>2-19G to 2-20G</b>
	and Fuel Cycles	



## Nuclear Energy

### CONTENTS

- |                 |   |                       |
|-----------------|---|-----------------------|
| <b>Part-1 :</b> | Fundamental Forces .....  | <b>2-2G to 2-3G</b>   |
|                 | in the Universe, Quantum<br>Mechanics Relevant for<br>Nuclear Physics |                       |
| <b>Part-2 :</b> | Nuclear Forces, Energy .....  | <b>2-3G to 2-4G</b>   |
|                 | Scales and Structure  |                       |
| <b>Part-3 :</b> | Nuclear Binding .....   | <b>2-5G to 2-11G</b>  |
|                 | Energy Systematics,<br>Reactions and Decays                           |                       |
| <b>Part-4 :</b> | Nuclear Fusion,.....  | <b>2-11G to 2-15G</b> |
|                 | Nuclear Fission and<br>Fission Reactor Physics                        |                       |
| <b>Part-5 :</b> | Nuclear Fission .....   | <b>2-15G to 2-19G</b> |
|                 | Reactor Design  |                       |
| <b>Part-6 :</b> | Safety, Operation .....   | <b>2-19G to 2-20G</b> |
|                 | and Fuel Cycles   |                       |

**PART- 1**

*Fundamental Forces in the Universe, Quantum Mechanics  
Relevant for Nuclear Physics.*

**Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 2.1.** What are the various fundamental forces present in nature ?

**Answer**

Various fundamental forces present in nature are as follows :

- i. **Gravitational Force** : It is the force of mutual attraction between any two objects by virtue of their masses. It is a universal force as every object experiences this force due to every other object in the universe.
- ii. **Electromagnetic Force** : It is the force between charged particles. Charges at rest have electric attraction (between unlike charges) and repulsion (between like charges). Charges in motion produce magnetic force. Together they are called electromagnetic force.
- iii. **Strong Nuclear Force** : It is the attractive force between protons and neutrons in a nucleus. It is charge-independent and acts equally between a proton and a proton, a neutron and a neutron, and a proton and a neutron.
- iv. **Weak Nuclear Force** : This force appears only in certain nuclear processes such as the  $\beta$ -decay of a nucleus. In  $\beta$ -decay, the nucleus emits an electron and an uncharged particle called neutrino.

**Que 2.2.** What do you understand by quantum mechanics relevant for nuclear physics ?

**Answer**

1. Nuclear physics is about the physical nucleus of an atom.
2. So when we are doing quantum mechanics on nuclear physics, it means that we are dealing with mechanisms which affects the nucleus of an atom, such as protons, neutrons, the strong force that keeps the nucleus together, and the other forces that cause nuclear radiation.

**Que 2.3.** What do you understand by thermal neutron ? Also explain the properties of neutrons.

**Answer**

- A. Thermal Neutron :** Thermal neutron is a free neutron that has an average energy of motion corresponding to the average energy of the particles of the ambient materials.
- B. Properties of Neutrons :**
1. Neutrons are fundamental constituents of a nucleus. Inside a nucleus, neutrons stay forever but as a projected particle outside it, it exists for a short time only.
  2. In nuclei of heavier elements, the number of neutrons is greater than the number of protons. It is this abundance of neutrons which makes the elements stable.
  3. Since neutrons are uncharged particles, therefore these are neither affected by external magnetic or electric fields nor by the presence of protons when they enter or penetrate the nucleus.
  4. Depending upon their speed, neutrons are put in two categories :
    - i. Fast neutrons, and
    - ii. Slow neutrons.
  5. Both are fully capable of penetrating a nucleus and causing artificial disintegration in the nucleus.

**PART-2***Nuclear Forces, Energy Scales and Structure.***CONCEPT OUTLINE**

**Nuclear Force :** These are the forces which act between two or more nucleons. They bind protons and neutrons into atomic nuclei.

**Questions-Answers****Long Answer Type and Medium Answer Type Questions****Que 2.4.****Explain the properties of nuclear forces.****Answer**

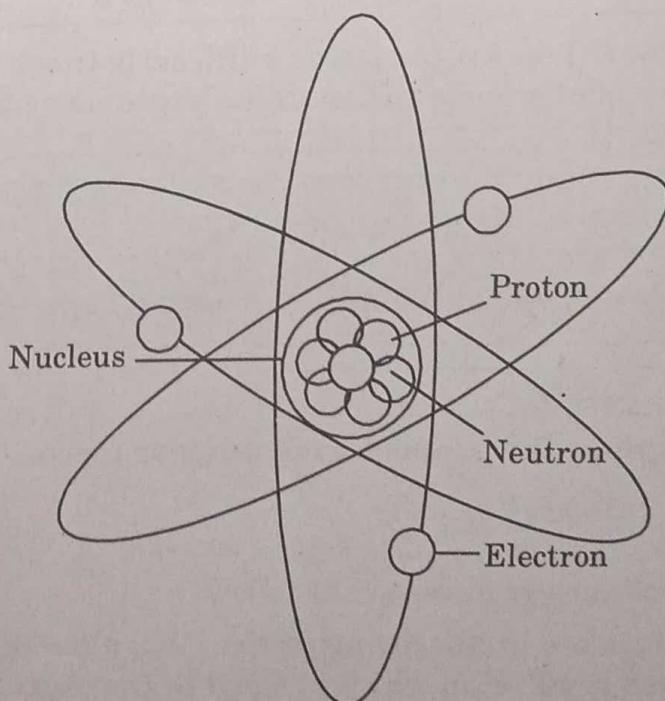
- Properties of nuclear forces are as follows :
1. Nuclear forces are ordinarily attractive. When the distance between two nucleons is  $10^{-14}$  m which is equal to the size of a nucleus, the nuclear force comes into play as an attractive force.

2. Nuclear forces are charge independent. The nuclear force between two neutrons is the same as that between two protons or between a proton and a neutron.
3. Nuclear forces are short range forces.
4. Nuclear forces are spin dependent. The force between two nucleons having parallel spins is stronger than the force existing between two nucleons having anti parallel spins.
5. Nuclear forces show saturation properties. A nucleon can interact only with those nucleons which are its nearest neighbours.

**Que 2.5.** Discuss in brief about structure of nucleus.

**Answer**

1. The atomic nucleus is present in the center of the atom. It consists of protons and neutrons collectively known as nucleus.
2. The number of protons and neutrons in the atom define what type of atom or element it is.
3. The structure of the atomic nucleus gives us lots of information about the element it represents. The number of protons inside the nucleus gives us the atomic number. The protons have a positive charge.
4. In order for the atom to have a neutral charge, the electrons need to balance it out with their negative charge. Therefore, in a neutral atom there are just as many protons as electrons.
5. So, if we know the atomic number and know the charge of the atom then the number of electrons is easy to find.



**Fig. 2.5.1.** Structure of nucleus.

**PART-3***Nuclear Binding Energy Systematics, Reactions and Decays.***Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 2.6.** What do you mean by binding energy ? What are the total binding energy and binding energy per nucleon for the  ${}^6C^{12}$  nucleus ?

**Answer****A. Binding Energy :**

1. Binding energy is defined as the energy required to overcome the binding forces of nucleus.
2. When the nucleus of an atom is formed then the nucleons come closer to each other and this distance between the two nucleons is of the order of nearly  $10^{-15}$  mm.
3. At the moment of combination there is a release of energy which is known as binding energy.

**B. Numerical :**

1. The atomic weight of  ${}^6C^{12}$  = 12.000 amu
2. The predicted mass of  ${}^6C^{12}$  is given as :

$$\text{Mass of 6 protons} = 1.00759 \times 6 = 6.04554 \text{ amu}$$

$$\text{Mass of 6 neutrons} = 1.00898 \times 6 = 6.05388 \text{ amu}$$

$$\text{Mass of 6 electrons} = 0.00055 \times 6 = 0.00330 \text{ amu}$$

$$\text{Total} = 12.10272 \text{ amu}$$

$$\text{Isotopic mass} = 12.00000 \text{ amu}$$

3. Therefore, Mass defect =  $12.10272 - 12.00000$   
 $= 0.10272 \text{ amu}$

4. Energy equivalent of 1 amu

$$= 933.75 \text{ MeV}$$

5. Therefore, total binding energy

$$= 933.75 \times 0.10272 = 95.91 \text{ MeV}$$

6. Binding energy per nucleon,

$$= \frac{95.91}{12}$$

$$= 7.99 \text{ MeV}$$

**Que 2.7.** Draw the binding energy curve showing variation of binding energy per nucleon with mass number. With the help of this, explain the phenomenon of nuclear fusion and fission.

AKTU 2019-20, Marks 10

**Answer**

**A. Binding Energy Curve :**

1. The graphical relationship between binding energy per nucleon and mass number is called binding energy curve.
2. Fig. 2.7.1 shows binding energy curve. The average binding energy per nucleon is plotted against mass number for naturally occurring nuclei.
3. Following are the special features of binding energy curve.
  - i. The binding energy per nucleon of very light nuclides such as  ${}^2H$  is very small.
  - ii. Initially, there is a steep rise in curve. This indicates a rapid rise in the value of binding energy per nucleon.
  - iii. Between mass number 4 and 20, the curve shows cyclic recurrence of peaks corresponding to  ${}^4He$ ,  ${}^8Be$ ,  ${}^{12}C$ ,  ${}^{16}O$  and  ${}^{20}Ne$ . This shows that the binding energy per nucleon of these nuclides is greater than those of their immediate neighbours.

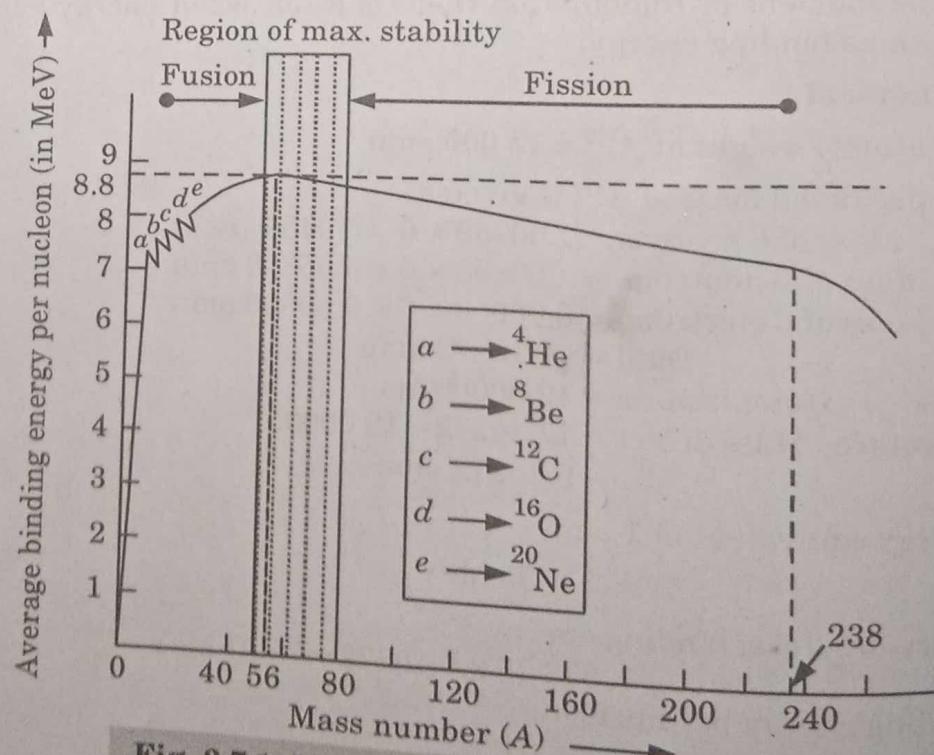


Fig. 2.7.1. Plot of binding energy per nucleon as a function of mass number.

- iv. After mass number 20, there is a gradual increase in binding energy per nucleon. The maximum value is reached at  $A = 56$ . This value is 8.8 MeV. Clearly, the iron nucleus ( $^{56}_{26}\text{Fe}$ ) is the most stable.
- v. The binding energy per nucleon of nuclides having mass numbers ranging from 40 to 120 is close to the maximum value. So, these elements are highly stable and non-radioactive.
- vi. Beyond  $A = 120$ , the value decreases and falls to 7.6 MeV for uranium. This decrease is primarily due to repulsion among protons whose number increases in heavy nuclides.
- vii. Beyond  $A = 238$ , the binding energy per nucleon shows a rapid decrease with increase in mass number.
- viii. The fact that the binding energy curve droops at both high and low mass numbers has very important practical consequences.

**B. Phenomenon of Nuclear Fusion and Fission :**

1. The drooping of the binding energy curve at high mass numbers tells us that nucleons are more tightly bound when they are assembled into two middle mass nuclei rather than into a single high mass nucleus. This is known as nuclear fission.
2. The drooping of the binding energy curve at low mass numbers, on the other hand, tells us that energy will be released if two nuclei of small mass numbers combine to form a single middle mass nucleus. This process, the reverse of fission is called nuclear fusion.

**Que 2.8.** Write a short note on chain reaction.

**Answer**

1. A chain reaction is that process in which the number of neutrons keeps on multiplying rapidly during fission till whole of the fissionable material is disintegrated.
2. If at least one fission neutron becomes available for causing fission of another nucleus then the chain reaction will become self-sustaining or self-propagating.
3. This condition can be conveniently expressed in the term of multiplication factor or reproduction factor of the system which may be defined as :

$$K = \frac{\text{Number of neutrons in any particular generation}}{\text{Number of neutrons in the preceding generation}}$$

4. If  $K > 1$ , chain reaction will continue and if  $K < 1$ , chain reaction cannot be maintained.

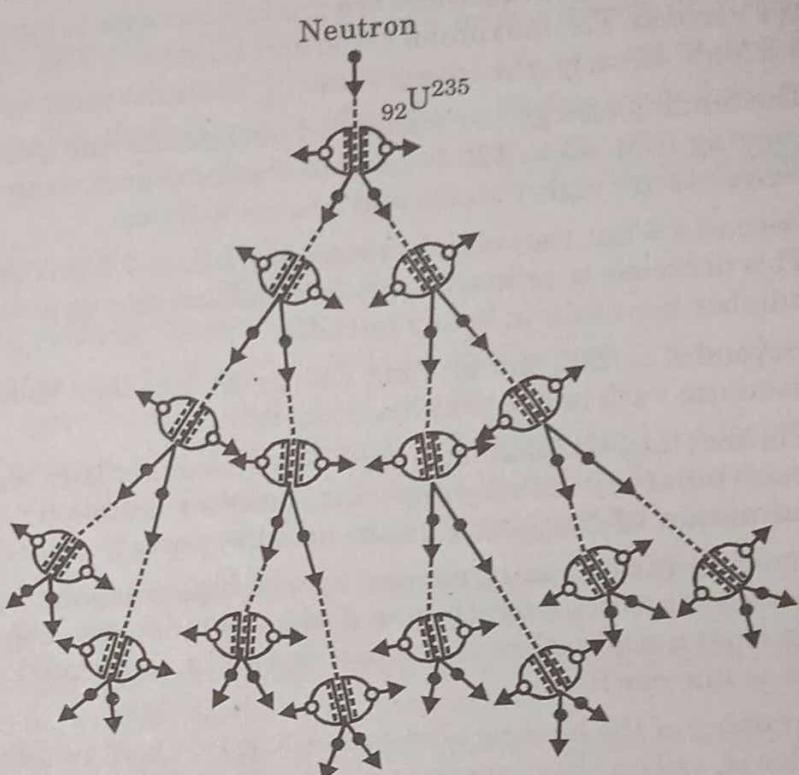


Fig. 2.8.1. Chain reaction.

**Que 2.9.** Write a short note on radioactivity.

**Answer**

1. Most of the naturally occurring isotopes are stable. But those isotopes which are not stable are known as radioactive isotopes.
2. A continuously undergoing spontaneous (i.e., without outside help) disintegration of radioactive isotopes is called radioactivity.
3. This is accompanied by the emission of one or more smaller particles from the parent nucleus.
4. The resulting nucleus is known as daughter nucleus.
5. The parent nucleus is said to decay into the daughter nucleus.
6. The daughter nucleus may or may not be stable, and several successive decays may occur until a stable isotope is formed.
7. Radioactivity may be natural or artificial.

**Que 2.10.** Show that radioactive decay follows exponential law.

**Answer**

1. We know that the small amount of disintegration of the isotope in a small period is directly proportional to the total number of radioactive nuclei and proportionality constant.

2. Let,  $N$  = Number of radioactive nuclei present at any time  $t$ ,  
 $N_0$  = Initial number of such nuclei, and  
 $\lambda$  = Proportionality constant.

3. This can be stated in the form of equation as follows :

$$\Delta N = -\lambda N \Delta t \quad \dots(2.10.1)$$

$$\frac{dN}{dt} = -\lambda N \quad \dots(2.10.2)$$

The negative sign represents that during disintegration the number of the nuclei is decreasing.

4. Integrating the eq. (2.10.2) within the proper limits, we get

$$\int_{N_0}^N \frac{dN}{N} = -\lambda \int_0^t dt \quad \dots(2.10.3)$$

$$\text{or } \log_e N - \log_e N_0 = -\lambda t \quad \text{or} \quad \log_e \frac{N}{N_0} = -\lambda t$$

$$\text{or } \frac{N}{N_0} = e^{-\lambda t} \quad \text{or} \quad N = N_0 e^{-\lambda t}$$

$$\frac{dN}{dt} = -\lambda N = -\lambda N_0 e^{-\lambda t} \quad \dots(2.10.4)$$

The eqn. (2.10.4) represents that the decay scheme follows the exponential law.

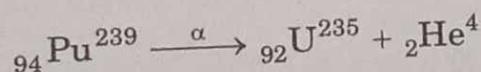
### Que 2.11. What are the various types of radioactive decay ?

#### Answer

Various types of radioactive decay are as follows :

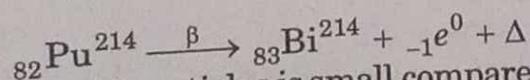
##### a. Alpha ( $\alpha$ ) Decay :

- $\alpha$  particles are helium nuclei, each consisting of two protons and two neutrons and are commonly emitted by the heavier radioactive nuclei.
- The decay of  $\text{Pu}^{239}$  into fissionable  $\text{U}^{235}$  and  $\alpha$  ( $\text{He}^4$ ) particles is an example of  $\alpha$ -decay.



##### b. Beta ( $\beta$ ) Decay :

- It is commonly accompanied by the emission of neutrino ( $\Delta$ ) and  $\gamma$  radiation.
- An example of  $\beta$  decay,



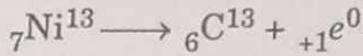
- The penetrating power of  $\beta$  particles is small compared to  $\gamma$  rays, however, it is larger than that of  $\alpha$  particles.

**c. Gamma ( $\gamma$ ) Decay :**

- $\gamma$  particles are electromagnetic radiation of extremely short wavelength and very high frequency resulting in high energy.
- $\gamma$  rays originate from the nucleus while X-rays from the atom.  $\gamma$  wavelength are on an average, about one tenth those of X-rays, though energy ranges overlap somewhat.
- There is no alternation of atomic or mass number due to  $\gamma$  decay.

**d. Positron Decay :**

- Positron decay is caused when the radioactive nucleus contains an excess of protons.
- An example of this is the decay of  ${}_{7}\text{Ni}^{23}$  into  ${}_{6}\text{C}^{13}$  which is shown below,



**Que 2.12.** Explain briefly the following terms related to radioactive decay :

- Activity,
- Half life, and
- Average (mean) life.

**Answer****a. Activity :**

- Activity is defined as the intensity of emitted radiation.
- This is directly dependent on the rate of disintegration of the element.
- Let,  $A$  = Activity at time  $t$ ,

$$A_1 = \text{Initial activity, and}$$

$$k = \text{Detection coefficient.}$$

$$\begin{aligned} \therefore A &= k \left( -\frac{dN}{dt} \right) = k\lambda N \\ &= k\lambda N_0 e^{-\lambda t} \\ A &= A_1 e^{-\lambda t} \end{aligned}$$

**b. Half Life :**

- Half life represents the rate of decay of the radioactive isotopes.
- The half life is the time required for half of the parent nuclei to decay or to disintegrate.
- We know that,  $N = N_0 e^{-\lambda t}$  ... (2.12.1)

- Putting  $N = \frac{N_0}{2}$  and  $t = t_{1/2}$  in eq. (2.12.1), we get

$$\frac{N_0}{2} = N_0 e^{-\lambda t_{1/2}}$$

- Therefore,  $e^{-\lambda t_{1/2}} = 1/2$

$$\lambda t_{1/2} = \log_e 2 = 0.693$$

$$t_{1/2} = \frac{0.693}{\lambda} \quad \dots(2.12.2)$$

c. **Average (Mean) Life :**

1. Average (mean) life indicates the average of total time for which the radioactive nuclei has disintegrated for several half lives. Hence this is greater than half life.
2. This is obtained by taking the sum of the decay time of the radioactive nuclei and then it is divided by the initial number of nuclei.
3. If  $T$  is the time of average life, then

$$T = \frac{-\int_0^\infty t dN}{N_0} = \frac{\lambda N_0 \int_0^\infty t e^{-\lambda t} dt}{N_0}$$

4. On solving,

$$T = \left[ -te^{-\lambda t} - \frac{e^{-\lambda t}}{\lambda} \right]_0^\infty$$

$$T = \frac{1}{\lambda} \quad \dots(2.12.3)$$

5. On dividing eq. (2.12.3) by eq. (2.12.2), we get  $\frac{T}{t_{1/2}} = 1.445$
6. So, it is clear that mean life is 1.445 times greater than half life.

#### PART-4

*Nuclear Fusion, Nuclear Fission and Fission Reactor Physics.*

#### CONCEPT OUTLINE

**Fusion :** In fusion, two or more light nuclei fuse to form heavier nuclei.

**Fission :** In fission, a heavy nucleus is split into two or more lighter nuclei.

#### Questions-Answers

#### Long Answer Type and Medium Answer Type Questions

Que 2.13. What is nuclear fusion ? How does it differ from nuclear fission ?

AKTU 2019-20, Marks 10

**Answer**

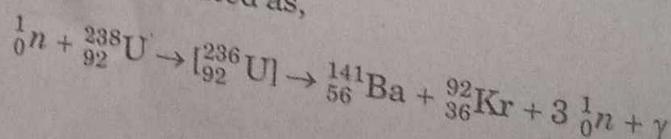
- A. Nuclear Fusion :** It is a reaction in which two or more atomic nuclei are combined to form one or more different atomic nuclei and subatomic particles (neutrons or protons).
- B. Comparison of Nuclear Fission and Nuclear Fusion Processes:**

S.No.	Nuclear Fission	Nuclear Fusion
1.	A heavy nucleus breaks up to form two lighter nuclei.	Two nuclei combine to form a heavy nucleus.
2.	It involves a chain reaction.	Chain reaction is not involved.
3.	Nuclear reaction residual problem is high.	Residual problem is much less.
4.	Amount of radioactive material in a fission reactor is high.	Amount of radioactive material is less.
5.	Because of higher radioactive material, health hazard is high in case of accidents.	Because of lesser radioactive material, health hazard is much less.
6.	We have proper mechanisms to control fission reaction for generating electricity.	Proper mechanisms to control fusion reaction are yet to be developed.
7.	Raw material is not easily available and is costly.	Raw material is comparatively cheap and easily available.
8.	Disposal of nuclear waste is a great environment problem.	Disposal of nuclear waste is not involved.

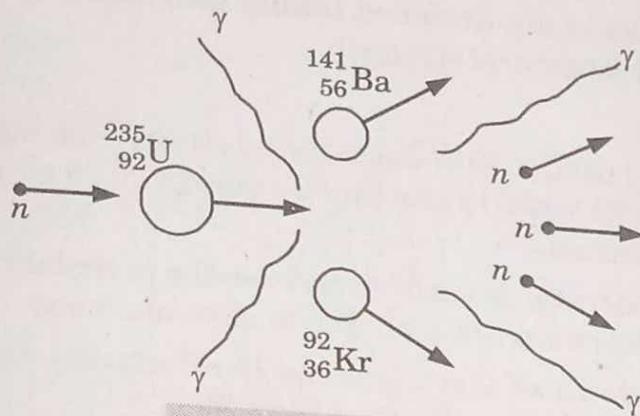
**Que 2.14.** Write short note on nuclear fission.

**Answer**

1. Nuclear fission is defined as a type of nuclear disintegration in which heavy nucleus splits up into two nuclei of nearly comparable masses with liberation of energy.
2. The fission is accompanied by the release of three neutrons and radiation energy in the form of  $\gamma$ -rays.
3. The reaction is represented as,



4. The diagrammatic sketch is given in Fig. 2.14.1. A neutron strikes the  $^{235}_{92}\text{U}$  nucleus and in the process two nuclides  $^{141}_{56}\text{Ba}$  and  $^{92}_{36}\text{Kr}$  are formed with the release of 3 neutrons.



**Fig. 2.14.1. Nuclear fission.**

5. The wavy lines indicate the energy released in the form of  $\gamma$  radiations. A slow neutron is used to cause fission.
6. Further whereas one neutron is lost in the process to produce fission, three neutrons are produced as a product of the fission. This fact has tremendous significance in the construction of nuclear bomb.

**Que 2.15.** What do you mean by nuclear reactor ? Explain its different parts.

**Answer**

**A. Nuclear Reactor :**

1. The nuclear reactor may be regarded as a substitute for the boiler fire box of steam power plant or combustion chamber of gas turbine plant.
2. The heat produced in the nuclear reactor is by fission process whereas in steam and gas power plants, the heat is produced by combustion of fuel.
3. The other cycle of operation and components required is the same either as steam plant or a gas turbine plant.
4. The steam or gas may be the working fluid in nuclear power plant.

**B. Different Parts of Nuclear Reactor :**

i. **Fuel Element :**

1. The nuclear fuels which are generally used in reactors are  $^{92}_{92}\text{U}^{235}$ ,  $^{94}_{92}\text{Pu}^{239}$  and  $^{92}_{92}\text{U}^{233}$ .
2. Out of the three, the  $^{92}_{92}\text{U}^{235}$  is only naturally available upto 0.7 % in the uranium are 239 and the remaining is  $^{92}_{92}\text{U}^{238}$ .
3. The other two fuels  $^{94}_{92}\text{Pu}^{239}$  and  $^{92}_{92}\text{U}^{233}$  are the byproduct and formed in the nuclear reactor during fissioning process from  $^{92}_{92}\text{U}^{238}$  and  $^{90}_{90}\text{Th}^{232}$  due to absorption of neutron without fission.

4. The selection of the shape of the fuels and their locations in the reactor are made keeping in view of uniform heat production within the reactor.
5. The fuel elements are designed taking into account the heat transfer, corrosion and structural strength.

**ii. Moderator :**

1. It is a material used to slow down the neutrons from high kinetic energy (1 MeV or 13200 km/s) to low kinetic energy (0.25 eV or 2200 m/s) in a fraction of a second.
2. Further, a moderator is used to increase the probability of reaction and to maintain the chain reaction due to slow neutrons.
3. The slowing down of the neutrons is effectively done by the light elements such as  $H_2$ ,  $D_2$ ,  $N_2$ ,  $O_2$ , C and Be.

**iii. Reflector :**

1. In order to keep the critical size of the reactor and hence the amount of fissionable material as small as possible, it is important to conserve neutrons.
2. This is possible by surrounding the reactor core with a material which reflects escaping neutrons back into the core. This material is called reflector.
3. The required properties of a good reflector are low absorption and high reflection for neutrons, high resistance to oxidation and irradiation as well as high radiation stability.
4. Many times the materials used as moderator is also used as reflector.
5. The  $H_2O$ ,  $D_2O$  and carbon are also used as reflector.

**iv. Coolant :**

1. The main purpose of the coolant in the reactor is to transfer the heat produced in the reactor and to keep the fuel assembly at a safe temperature to avoid their melting and destruction.
2. The same heat carried by the coolant is used in the heat exchanger for further utilization in the power generation either generating steam or using hot gas.
3. The water, heavy water, gas ( $He$ ,  $CO_2$ ), a metal in liquid form ( $Na$ ) and organic liquids are used as coolant.

**v. Control Rods :**

1. The control system controls the rate of energy generated. It starts increase, decrease and stops the reaction.
2. These rods may be shaped like the fuel rods themselves and are interspread throughout the core.
3. Instead of containing fuel, they contain neutron absorber such as boron, cadmium or indium.

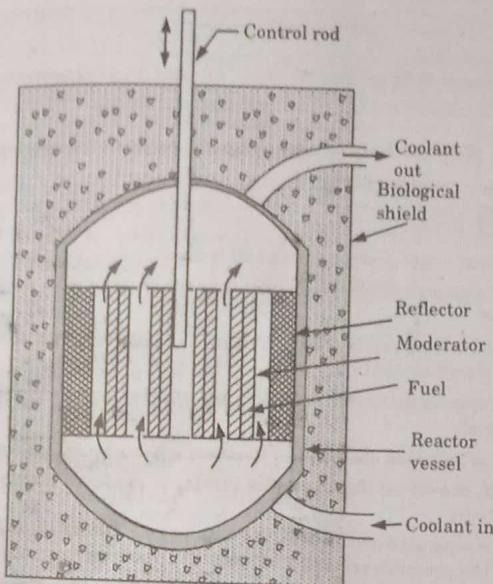


Fig. 2.15.1. Principal parts of a nuclear reactor.

**vi. Biological Shield :**

1. The intensity of radiations and radioactive fragments from the reactor core is too high for the human body to tolerate.
2. Therefore, it is necessary to surround the reactor with shielding material to prevent damage of human body due to radiation.

**vii. Reactor Vessel :**

1. The reactor vessel encloses the reactor core, reflector and shield. It also provides coolant inlet and outlet passages.
2. The reactor vessel has to withstand the pressure at 200 bar or above.
3. The reactor core (fuel and moderator assembly) is generally placed at the bottom of the vessel.

**PART-5****Nuclear Fission Reactor Design.**

**Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 2.16.** With the help of neat diagram, explain the working of a boiling water reactor (BWR).

**Answer**

1. In a boiling water reactor enriched fuel is used.
2. The arrangement of BWR is simpler than the pressurized water reactor (PWR).
3. The plant can be safely operated using natural convection within the core or forced circulation.
4. The pressure in the forced circulation is maintained constant irrespective of the load.
5. In case of part load operation of the turbine some steam is bypassed.
6. In BWR, the steam flowing to the turbine is produced directly in the reactor core.
7. Steam is separated and dried by mechanical devices located in the upper part of the pressure vessel assembly.
8. The dried steam is sent directly to the high pressure turbine thus eliminating the need for steam generators.
9. The coolant thus serves the triple function of coolant, moderator and working fluid.

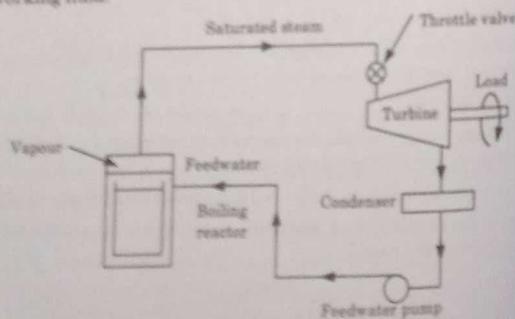


Fig. 2.16.1. Schematic of a direct cycle BWR plant.

10. Since the coolant boils in the reactor itself, its pressure is much less than that in a PWR and it is maintained at about 70 bar with steam temperature around 285 °C.

11. An increase in the boiling rate displaces water (moderator) to thermalize neutrons and hence, reduces the reactor power level.
12. The saturated liquid that separates from the vapour at the top of the reactor in a steam separator flows downward either internally within the reactor or externally outside the reactor and mixes with the return condensate.

**Que 2.17.** With a neat sketch, explain pressurized water reactor (PWR) highlighting its merits and demerits.

AKTU 2019-20, Marks 10

**Answer****A. Pressurized Water Reactor (PWR) :**

1. A pressurized water reactor is a light water cooled and moderated thermal reactor having an unusual core design, using both natural and highly enriched fuel.
2. The principal parts of PWR are :
  - a. Pressure vessel,
  - b. Reactor thermal shield,
  - c. Fuel elements,
  - d. Control rods,
  - e. Reactor containment, and
  - f. Reactor pressurizer.
3. In PWR, the primary circuit passes through the fuel core and is radioactive.
4. This primary circuit then produces steam in a secondary circuit which consists of heat exchanger or the boiler and the turbine.

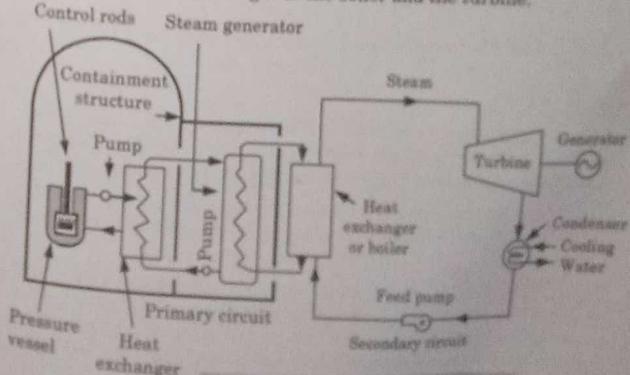


Fig. 2.17.1. Pressurized water reactor.

5. As the steam in the turbine is not radioactive and need not be shielded.
6. The pressure in the primary circuit should be high so that the boiling of water takes place at high pressure.
7. A pressurizing tank keeps the water at about  $100 \text{ kgf/cm}^2$  so that it will not boil.
8. Electric heating coil in the pressurizer boil some of the water to form steam that collects in the dome.
9. The pressure of the dome goes on increasing as more steam is forced into it.
10. By providing the cooling coils or spraying water on the steam the pressure may be reduced.
11. Water acts both as coolant as well as moderator.
12. A pressurized water reactor can produce only saturated steam. By providing a separate furnace the steam formed from the reactor could be superheated.

**B. Merits of PWR :**

1. Water used in reactor is cheap and easily available.
2. The reactor is compact and power density is high.
3. Fission products remain contained in the reactor and are not circulated.
4. A small number of control rods are required.

**C. Demerits of PWR :**

1. Capital cost is as high primary circuit requires strong pressure vessel.
2. In the secondary circuit the thermodynamic efficiency of this plant is quite low.
3. Fuel suffers radiation damage and, therefore its reprocessing is difficult.
4. Severe corrosion problems.

**Que 2.18. Describe pressurized heavy water reactor (PHWR).**

**Answer**

1. A pressurized heavy water reactor (PHWR) is a nuclear power reactor, commonly using unenriched natural uranium as its fuel that uses heavy water (deuterium oxide  $D_2O$ ) as its coolant and moderator.
2. The heavy water coolant is kept under pressure, allowing it to be heated to higher temperatures without boiling much as in a typical pressurized water reactor.
3. While heavy water is significantly more expensive than ordinary light water, it yields greatly enhanced neutron economy, allowing the reactor to operate without fuel enrichment facilities and generally enhancing the ability of the reactor to efficiently make use of alternate fuel cycles.

4. The CANDU reactor is the first and most widely used heavy water reactor.

**PART-6***Safety, Operation and Fuel Cycles.***Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 2.19.** Explain nuclear fuel cycle with block diagram.

**Answer**

1. ✓ The nuclear fuel cycle is the series of industrial processes which involves the production of electricity from uranium in nuclear power reactors.
2. Fuel removed from a reactor, after it has reached the end of its useful life, can be reprocessed so that most is recycled for new fuel.

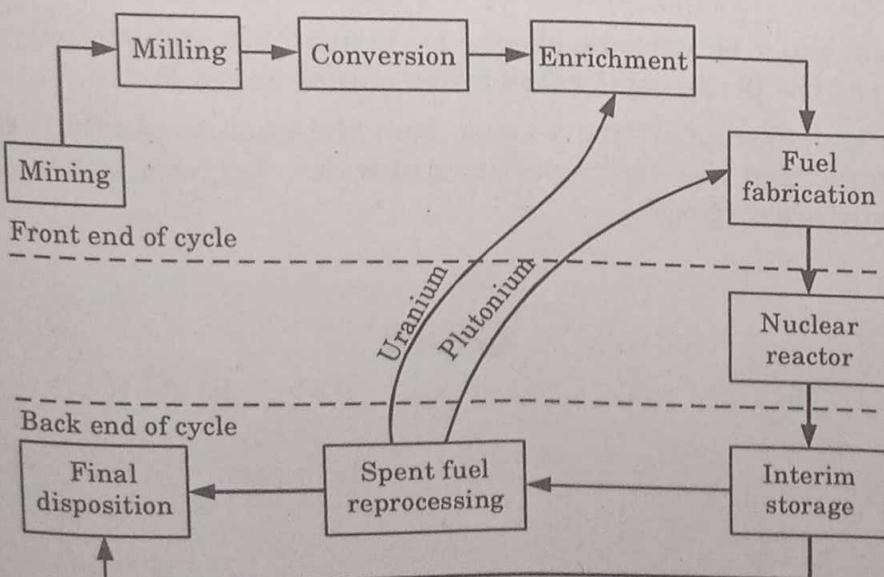


Fig. 2.19.1.

3. The various activities associated with the production of electricity from nuclear reactions are referred to collectively as the nuclear fuel cycle.
4. The nuclear fuel cycle starts with the mining of uranium and ends with the disposal of nuclear waste. With the reprocessing of used fuel as an option for nuclear energy, the stages form a true cycle.

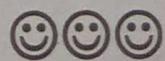
5. To prepare uranium for use in a nuclear reactor, it undergoes the steps of mining and milling, conversion, enrichment and fuel fabrication. These steps make up the front end of the nuclear fuel cycle.
6. After uranium has spent about three years in a reactor to produce electricity, the used fuel may undergo a further series of steps including temporary storage, reprocessing, and recycling before wastes are disposed. Collectively these steps are known as the back end of the fuel cycle.

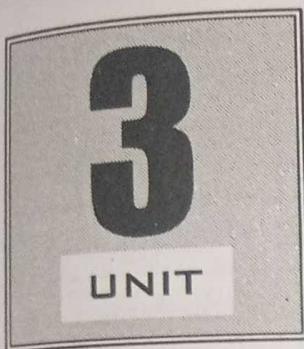
**Que 2.20** Discuss some safety measures for nuclear power plants

**Answer**

Safety measures for nuclear power plants are as follows :

1. A nuclear power plant should be constructed away from human habitation. An exclusion zone of 106 km radius around the plant should be provided where no public habitation is permitted.
2. The materials to be used for the construction of a nuclear power plant should be of required standards.
3. Waste water from nuclear power plant should be purified.
4. The nuclear power plant must be provided with such a safety system which should safely shut down the plant as and when necessity arises.
5. There must be periodic checks to ensure that radioactivity does not exceed the permissible value in the environment.
6. While disposing off the wastes from the nuclear plants it should be ensured that there is no pollution of water of river or sea where these wastes are disposed.





## Solar Energy

### CONTENTS

- Part-1 : Introduction to Solar Energy ..... 3-2G to 3-3G
- Part-2 : Fundamentals of Solar ..... 3-3G to 3-10G  
Radiation and its  
Measurement Aspects
- Part-3 : Basic Physics of ..... 3-10G to 3-15G  
Semiconductors, Carrier  
Transport, Generation  
and Recombination  
in Semiconductors
- Part-4 : Semiconductor Junctions : ..... 3-15G to 3-18G  
*Saturday*  
Metal-Semiconductor  
Junction and *p-n* Junction
- Part-5 : Essential Characteristics of ..... 3-18G to 3-21G  
Solar Photovoltaic Devices
- Part-6 : First Generation Solar Cells, ..... 3-21G to 3-24G  
Second Generation Solar cells,  
Third Generation Solar Cells

**PART- 1***Introduction to Solar Energy.***CONCEPT OUTLINE**

**Solar Cell :** Solar cells are energy conversion device which are used to convert sunlight to electricity by the use of the photovoltaic effect.

**Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 3.1.** **Describe solar energy along with its merits and demerits.**

**Answer****A. Solar Energy :**

1. Solar energy is a clean, cheap and abundantly available renewable energy and it is also the most important of the non-conventional sources of energy because it is non-polluting and therefore helps in decreasing the green house effect.
2. Solar energy can be used :
  - i. By direct conversion to a fuel by photosynthesis.
  - ii. By direct conversion to electricity by photovoltaic.
  - iii. By conversion to electricity via thermo-electric power system.
3. The sun releases the enormous amount of energy due to continuous fusion reaction taking place inside the sun.
4. The sun sends out the energy in the form of radiations at the rate of  $3.7 \times 10^{20}$  MW.
5. However, the energy intercepted by the earth is about  $1.85 \times 10^{11}$  MW.
6. This energy available is several times more than all the energy produced and consumed in the world.

**B. Merits of Solar Energy :**

1. Noiseless operation.
2. Occupies less space on floor as there is no need of storage vessels.
3. Cheaper initial cost and no need of containers to store the fuel.

**C. Demerits of Solar Energy :**

1. Solar equipments fail to work in nights, cloudy days or rainy season.

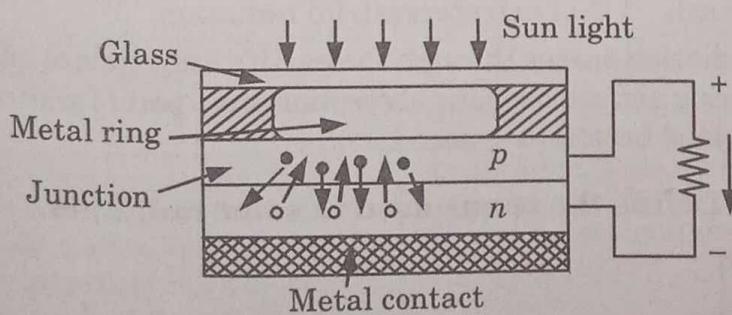
2. Large space is required for the collection of solar energy at a useful rate.
3. High initial cost for solar panels.

**Que 3.2.** Explain with a neat sketch, working of a solar cell.

**AKTU 2019-20, Marks 10**

**Answer**

1. When light reaches the  $p-n$  junction, the light photons can easily enter in the junction, through very thin  $p$ -type layer.
2. The light energy, in the form of photons, supplies sufficient energy to the junction to create a number of electron-hole pairs.
3. The incident light breaks the thermal equilibrium condition of the junction.
4. The free electrons in the depletion region can quickly come to the  $n$ -type side of the junction. Similarly, the holes in the depletion can quickly come to the  $p$ -type side of the junction.
5. Once, the newly created free electrons come to the  $n$ -type side cannot further cross the junction because of barrier potential of the junction. Similarly, the newly created holes once come to the  $p$ -type side cannot further cross the junction because of same barrier potential of the junction.
6. As the concentration of electrons becomes higher in one side, i.e.,  $n$ -type side of the junction and concentration of holes becomes more in another side, i.e., the  $p$ -type side of the junction, the  $p-n$  junction will behave like a small battery cell.
7. A voltage is set up which is known as photo voltage. If we connect a small load across the junction, there will be a tiny current flowing through it.



**Fig. 3.2.1.**

**PART-2**

*Fundamental of Solar Radiation and its Measurement Aspects.*

### CONCEPT OUTLINE

**Solar Constant :** The rate at which solar radiation strikes at the top of the atmosphere is called the solar constant.

#### Questions-Answers

#### Long Answer Type and Medium Answer Type Questions

**Que 3.3.** Write a short note on solar radiation.

**Answer**

1. Solar radiation is the electromagnetic radiation emitted by the sun. This radiation can be converted into useful forms of energy, such as heat and electricity by the different types of technologies.
2. The solar radiations received by the earth's surface vary with the location.
3. However radiation received outside the earth's atmosphere is different than what we receive on the earth surface because of absorption, reflection, scattering and attenuation by particulates and clouds present in the atmosphere.
4. The solar radiation is grouped in the following two categories :
  - a. **Extraterrestrial Solar Radiation :**
    1. Extraterrestrial radiation is the measure of solar radiation that would be received in the absence of atmosphere.
  - b. **Terrestrial Solar Radiation :**
    1. The radiation we receive on the earth surface is called terrestrial radiation and is nearly 70 % of extraterrestrial radiation.
    2. Solar radiation passes through the earth's atmosphere and is subjected to scattering and atmospheric absorption and a part of scattered radiations are reflected back into space.

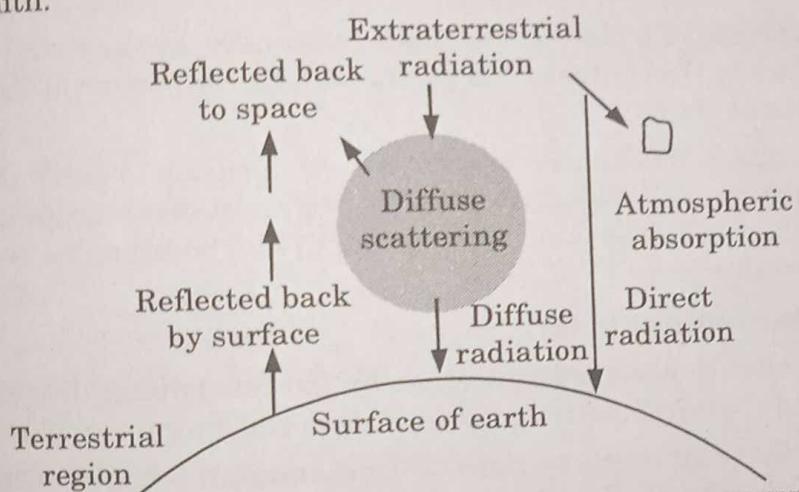
**Que 3.4.** Define the terms used in solar radiation.

**Answer**

Terms used in solar radiations are as follows :

- i. **Beam Radiation ( $I_b$ ) :** Solar radiation received on the earth's surface without change in direction is known as beam or direct radiation.
- ii. **Diffuse Radiation ( $I_d$ ) :** The radiation received on a terrestrial surface (scattered by aerosols and dust) from all parts of the sky dome is known as diffuse radiation.

- iii. **Total Radiation ( $I_T$ )**: The sum of beam and diffuse radiation intercepted at the earth's surface per unit area of location is known as total radiation and it is also known as insolation. The radiations received by a collector surface are always global radiations.
- iv. **Air Mass ( $m_a$ )**: It is the ratio of the path length of beam radiation through the atmosphere, to the length of path when sun is at over head or zenith.



**Fig. 3.4.1. Direct diffuse and total solar radiation.**

**Que 3.5.** Explain the difference between direct radiation and diffuse radiation. AKTU 2019-20, Marks 10

**Answer**

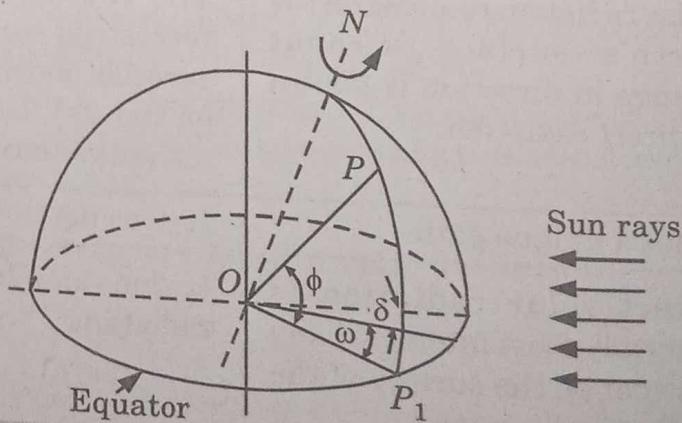
S.No.	Direct Radiation	Diffuse Radiation
1.	Solar radiation received on the earth's surface without change in direction is known as direct radiation.	The radiation received on a terrestrial surface (scattered by aerosols and dust) from all parts of the sky dome is known as diffuse radiation.
2.	It has a unique path.	It does not have a unique path.
3.	Direct solar radiation is generally most intense at any one spot on the surface of the earth at solar noon.	It does not happen in diffuse radiation.
4.	It has the least amount of the atmosphere to travel through.	It has the more amount of the atmosphere to travel through.

**Que 3.6.** Explain solar radiation geometry.

**Answer**

Various angles related to solar radiation geometry are as follows :

- a. **Incident Angle ( $\theta$ ) :** It is defined as the angle between the incident beam radiation and the normal to a plane surface.
- b. **Latitude Angle ( $\phi$ ) :**
  1. The latitude of a place is the angle subtended by the radial line joining the place to the centre of the earth, with the projection of the line on the equatorial plane.
  2. The latitude is taken as positive for any location towards the northern hemisphere and negative towards the southern hemisphere i.e., the latitude at equator is  $0^\circ$  while at north and south poles are  $+90^\circ$  and  $-90^\circ$  respectively.
- c. **Declination Angle ( $\delta$ ) :**
  1. The declination is the angle made by the line joining the centres of the sun and the earth with its projection on the equatorial plane.
  2. The declination angle varies from a maximum value of  $+23.5^\circ$  on June 21 to a minimum of  $-23.5^\circ$  on December 21.
- d. **Hour Angle ( $\omega$ ) :**
  1. It is the angle through which the earth must be rotated to bring the meridian of a point directly in line with the sun's ray.
  2. In other words, it is the angular displacement of the sun, east or west of the local meridian, due to the rotation of the earth on its axis at an angle of  $15^\circ$  per hour.
- e. **Altitude Angle ( $\alpha$ ) :** It is a vertical angle between the projection of the sun's rays on the horizontal plane and the direction of the sun's rays.



**Fig. 3.6.1. Latitude  $\phi$ , hour angle  $\omega$  and sun's declination  $\delta$ .**

- f. **Zenith Angle ( $\theta_z$ ) :** It is the vertical angle between the sun's rays and line perpendicular to the horizontal plane through the point.
- g. **Surface Azimuth Angle ( $\gamma$ ) :** It is the angle in the horizontal plane between the line due south and the horizontal projection of the normal to the inclined plane surface.

**b. Slope ( $\beta$ ) :**

1. It is the angle between the plane surface, under consideration, and with the horizontal.
2. It is taken to be positive for surface sloping towards south and negative for surfaces sloping towards north.

**i. Solar Azimuth Angle ( $\gamma_s$ ) :**

1. It is the angle in a horizontal plane, between the line due south and the projection of beam radiation on the horizontal plane.
2. Thus it gives the direction of the shadow cast in the horizontal plane by a vertical rod.

**Que 3.7.** What are the devices used for measuring the solar radiations ? Explain each with their construction and working.

**Answer**

Various devices used for measuring the solar radiations are as follows :

- A. **Pyranometer** : It is a device used for measuring global or diffuse radiations.
- a. **Construction** : It consists of following components :
  - i. **Black Surface** : This receives the beam as well as diffuse radiations which rises heat.
  - ii. **Glass Dome** : It prevents the loss of radiation received by the black surface.
  - iii. **Thermopile** : It is a temperature sensor and consists of a number of thermocouples connected in series to increase the sensitivity.
  - iv. **Supporting Stand** : It keeps the black surface in a proper position.

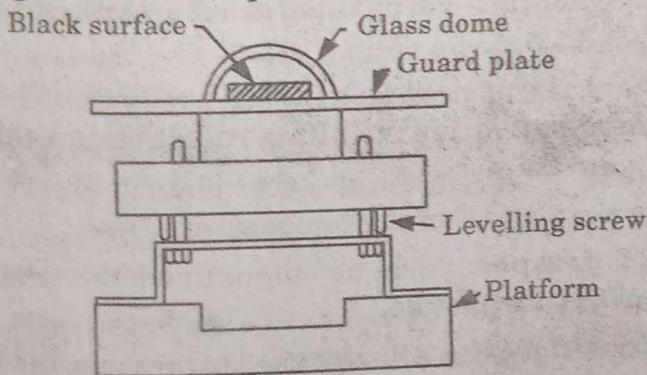


Fig. 3.7.1. Pyranometer.

**b. Working :**

1. The pyranometer is kept exposed to the sun and it starts receiving the radiations.
2. Due to the absorption of the radiation, the surface temperature starts rising and the increase in temperature of the absorbing surface is detected by the thermopile.

3. The thermopile generates a thermo-emf which is proportional to the radiations absorbed and this thermo-emf is calibrated in terms of the received radiations. This measures the global radiations.
- B. Pyrheliometer :** It is a device used for measuring the beam or direct radiations.
- a. **Construction :** It consists of following components :
- i. **Receiver :** It is in the shape of a hollow tube with reflecting surface inside.
  - ii. **Absorber Plate :** It consists of a blackened surface and it is placed at the bottom of the tube.
  - iii. **Thermopile :** It is a sensing element of temperature consisting of a group of thermopiles.

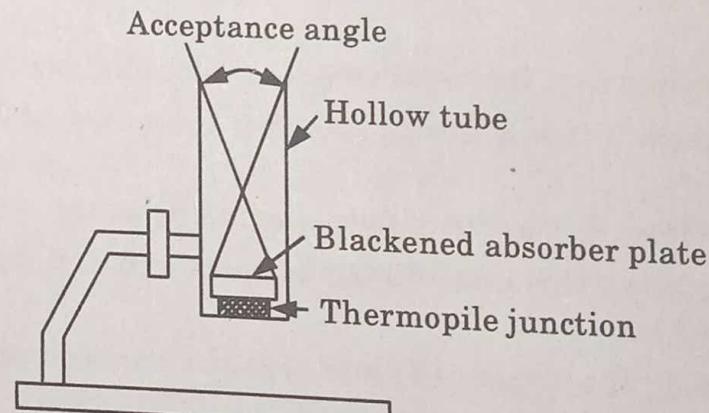
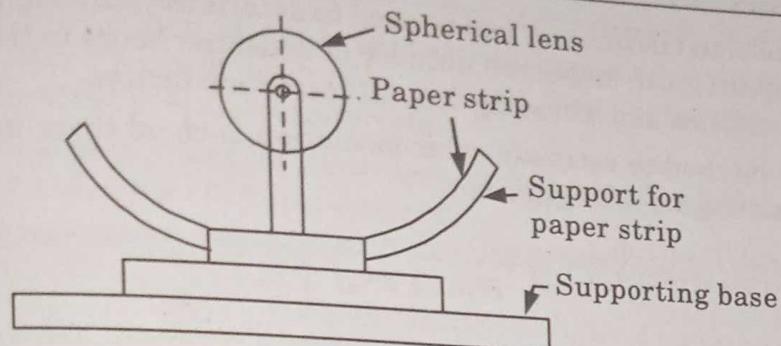


Fig. 3.7.2. Pyrheliometer.

- b. **Working :**
    1. The hollow receiver tube can be tilted about an axis perpendicular to its length.
    2. Thus, the tube can be made to face the sun's radiation, thereby receiving only the beam radiation and no diffuse radiation can enter the tube.
    3. When the radiation falls on the absorber plate, it absorbs the radiation and it gets heat up, and thereby temperature rises.
    4. The rise in temperature is measured by measuring the thermo-emf of the thermopile.
- C. Sunshine Recorder :** It is a device used to measure the hours of bright sunshine in a day.
- a. **Construction :** It consists of a glass sphere installed in a section of spherical metal bowl, having grooves for holding a recorder card strip and the glass sphere for adjusting the focus of sun rays to a point on the card strip.

**Fig. 3.7.3. Sunshine recorder.****b. Working :**

1. Sun's beam is focused to a point by a spherical glass, which acts as a convex lens and graduated paper strip is placed at the focal point.
2. Due to the heating effect of the focused beam, a burn mark is produced on the paper and the graduation on the paper is done as per the hours of the day.

**Que 3.8. Write short note on :**

- a. Solar radiance, and
- b. Solar insolation.

**Answer****a. Solar Radiance :**

1. The solar radiance is an instantaneous power density in units of  $\text{kW/m}^2$ .
2. The solar radiance is strongly dependant on location and local weather.
3. Solar radiance measurements consist of global and/or direct radiation measurements taken periodically throughout the day.
4. The measurements are taken using either a pyranometer or a pyrheliometer.

**b. Solar Insolation :**

1. The solar insolation is the total amount of solar energy received at a particular location during a specified time period, often in units of  $\text{kWh}/(\text{m}^2 \text{ day})$ .
2. Solar insolation data is commonly used for simple photovoltaic (PV) system design while solar radiance is used in more complicated PV system.
3. By knowing the insolation levels of a particular region we can determine the size of solar collector that is required and how much energy it can produce.
4. Solar insolation can be measured using sunshine recorders. These sunshine recorders measure the number of hours in the day during which the sunshine is above a certain level.

5. Data collected in this way can be used to determine the solar insolation by comparing the measured number of sunshine hours to those based on calculations and including several correction factors.
6. A final method to estimate solar insolation is cloud cover data taken from existing satellite images.

### PART-3

*Basic Physics of Semiconductors, Carrier Transport, Generation and Recombination in Semiconductors.*

#### CONCEPT OUTLINE

**Semiconductors :** The elements whose conductivity lies between metals and insulators. Most frequently used semiconductors in construction of electronic devices are Ge, Si, and GaAs.

#### Questions-Answers

#### Long Answer Type and Medium Answer Type Questions

**Que 3.9.** Give the classification of semiconductors.

#### Answer

The semiconductors can be divided into following two types :

- a. **Intrinsic Semiconductors :**
  1. An intrinsic semiconductor, also called an undoped semiconductor or I-type semiconductor, is a pure semiconductor without any significant dopant species.
  2. The number of charge carriers is therefore determined by the properties of the material itself instead of the amount of impurities.
  3. The conductivity of intrinsic semiconductors can be due to crystal defects or due to thermal excitation.
  4. In an intrinsic semiconductor, the number of electrons in the conduction band is equal to the number of holes in the valence band.
- b. **Extrinsic Semiconductors :**
  1. An extrinsic semiconductor is a semiconductor that has been doped, i.e., into which a doping agent has been introduced, giving it different electrical properties than the intrinsic (pure) semiconductor.

2. Doping involves adding dopant atoms to an intrinsic semiconductor which changes the electron and hole carrier concentrations of the semiconductor at thermal equilibrium.
3. The electrical properties of extrinsic semiconductors make them essential components of many electronic devices.
4. Dominant carrier concentrations in an extrinsic semiconductor classify it as either :
  - i.  $n$ -type semiconductor, and
  - ii.  $p$ -type semiconductor.

**Que 3.10.** What is the difference between intrinsic and extrinsic semiconductor ?

**AKTU 2019-20, Marks 10**

**Answer**

S.No.	Intrinsic Semiconductor	Extrinsic Semiconductor
1.	It is a pure semiconductor with no impurity.	It is an impure semiconductor i.e., a controlled pentavalent or trivalent impurity is added.
2.	The number of free electrons in the conduction band is equal to the number of holes in the valence band.	In an $n$ -type semiconductor, free electrons far exceed the holes. In $p$ -type semiconductor, it is the reverse.
3.	Its electrical conductivity is low.	Its electrical conductivity is high.
4.	Its electrical conductivity depends on the temperature alone.	Its conductivity depends on the temperature and amount of doping.
5.	It is of no practical use.	It is used in electronic devices.

**Que 3.11.** Classify semiconductors on the basis of energy band gap with the help of suitable diagram.

**Answer**

A. Direct Band Gap Semiconductors :

1. In direct band gap semiconductors, an electron in conduction band fall directly to valence band, giving off the energy difference  $E_g$  as a photon of light.
2. It cannot undergo change in energy and momentum.

Example : GaAs, GaN etc.

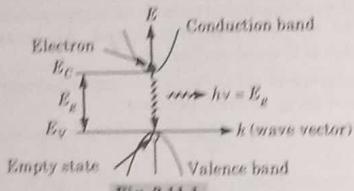


Fig. 3.11.1.

**B. Indirect Band Gap Semiconductors :**

1. In indirect band gap semiconductors, an electron in conduction band fall indirectly to valence band giving a part of energy to the lattice in the form of heat.
2. It undergoes a change in momentum as well as energy.

Example : Si, Ge etc.

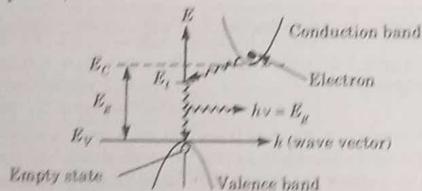


Fig. 3.11.2.

**Que 3.12.** Explain n-type and p-type semiconductors.**Answer****A. n-type Semiconductors :**

1. When a small amount of pentavalent impurity is added to pure semiconductor crystal during the crystal growth, the resulting crystal is called n-type extrinsic semiconductor.
2. Fig. 3.12.1 shows the arsenic (As) atom fits in germanium (Ge) crystal in such a way that its four valence electrons form covalent bond with four germanium atom.
3. The fifth electron of arsenic is not bonded and acts as free electron.
4. This electron is available as a carrier of current.
5. This free electron acts as donor whenever required with any other semiconductor.
6. The electrons are the majority carriers while holes are the minority carriers in such cases.

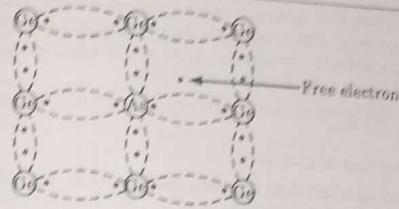


Fig. 3.12.1. Arsenic electron as free electron (donor).

**B. p-type Semiconductors :**

1. When a small amount of trivalent impurity is added to pure crystal during the crystal growth, the resulting crystal is called p-type extrinsic semiconductor.
2. Fig. 3.12.2 shows each atom of boron i.e., trivalent impurity is added to pure germanium crystal.

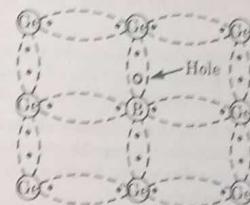


Fig. 3.12.2. Boron hole (acceptor).

3. The three valence electrons form covalent bond while the fourth covalent bond is formed due to germanium atom contribution and deficiency of one electron is left in form of hole.
4. The remaining fourth electron also tries to form a bond and treated as acceptor.
5. In p-type semiconductor, the majority carriers are holes while minority carriers are the electrons.

**Que 3.13.** Briefly describe :

- i. Generation of carriers, and
- ii. Recombination of carriers.

**Answer****A. Generation of Carriers :**

- i. The process by which free electrons and holes are generated in pair is called generation of carriers.

2. When electrons in a valence band get enough energy, then they will absorb this energy and jumps into the conduction band. The electron which is jumped into a conduction band is called free electron and the place from where electron left is called hole.
3. Likewise, two types of charge carriers (free electrons and holes) get generated.

**B. Recombination of Carriers :**

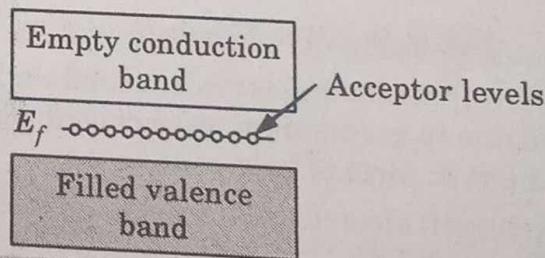
1. The process by which free electrons and the holes get eliminated is called recombination of carriers.
2. When free electron in the conduction band falls in to a hole in the valence band, then the free electron and hole gets eliminate.

**Que 3.14.** Describe charge carrier concentration for *p*-type and *n*-type extrinsic semiconductor.

**Answer**

**A. Charge Carrier Concentration for *p*-type Extrinsic Semiconductor :**

1. We create a *p*-type extrinsic semiconductor by taking a group 4A element (like silicon) and doping small quantities of group 3A elements (like boron, aluminum, gallium, indium, thallium) into it.
2. These group 3A elements have one valence electron less, than that of silicon and so, they are potentially incapable of grabbing onto an electron or in other words releasing that vacant location. This releasing of vacant location is referred to as a hole.



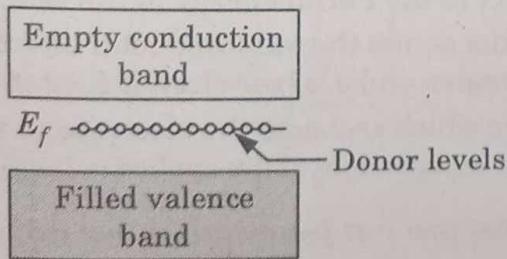
**Fig. 3.14.1. *p*-type extrinsic semiconductor.**

3. Now we have acceptor levels that can accept the electrons very easily, and acceptor levels are just above the valence band. Whereas, in a intrinsic semiconductor the Fermi energy level is right in the middle between the valence band and the conduction band. In the case of a *p*-type extrinsic semiconductor, it essentially lines up at the acceptor levels.
4. This changes the behaviour of the semiconductor quite dramatically. Now the charge carrier concentration is not solely dependent on temperature. For a significant fraction of temperature range, we find that the charge carrier concentration depends only on the dopant concentration.

5. So, if we increase the dopant concentration, then for that entire temperature range we will have a higher charge carrier concentration.
6. If we decrease the dopant concentration for the entire temperature range we will have lower charge carrier concentration. Again conductivity depends on the dopant concentration, because it depends on the charge carrier concentration.

### B. Charge Carrier Concentration for *n*-type Extrinsic Semiconductor :

1. *n*-type extrinsic semiconductor has conceptually many similarities to the *p*-type except fundamentally the charge carrier is different here.
2. We create a *n*-type extrinsic semiconductor by taking a group 4A element (like silicon) and doping small quantities of group 5A elements (like nitrogen, phosphorus, arsenic, antimony, bismuth) into it.
3. These elements have essentially one additional valence electron available to them, and that valence electron is available for more free movement within the system and therefore, at very marginal availability of energy this electron begins to run around the system.
4. That is captured in the band diagram by this donor level (Fig. 3.14.2) which stays very close to the empty conduction band. So, at very small amount of energy we can get these donor electrons to get into the conduction band and then carry out the conduction processes.



**Fig. 3.14.2. *n*-type extrinsic semiconductor.**

### PART-4

*Semiconductor Junctions : Metal-Semiconductor Junction and p-n Junction.*

#### Questions-Answers

Long Answer Type and Medium Answer Type Questions

**Que 3.15.** Define metal-semiconductor junction. Discuss it in forward bias and reverse bias condition.

**Answer****A. Metal-Semiconductor Junction :**

1. Metal-semiconductor (M-S) junction is a type of electrical junction in which a metal comes in close contact with a semiconductor material.
2. Metal-semiconductor (M-S) junctions can behave as either Schottky barriers or as Ohmic contacts depending on the interface properties.
3. The principle of forming different types of the metal-semiconductor contact is the mismatch of the Fermi energy between metal and semiconductor material which is due to the difference in work functions.

**B. M-S Junction in Forward Bias :**

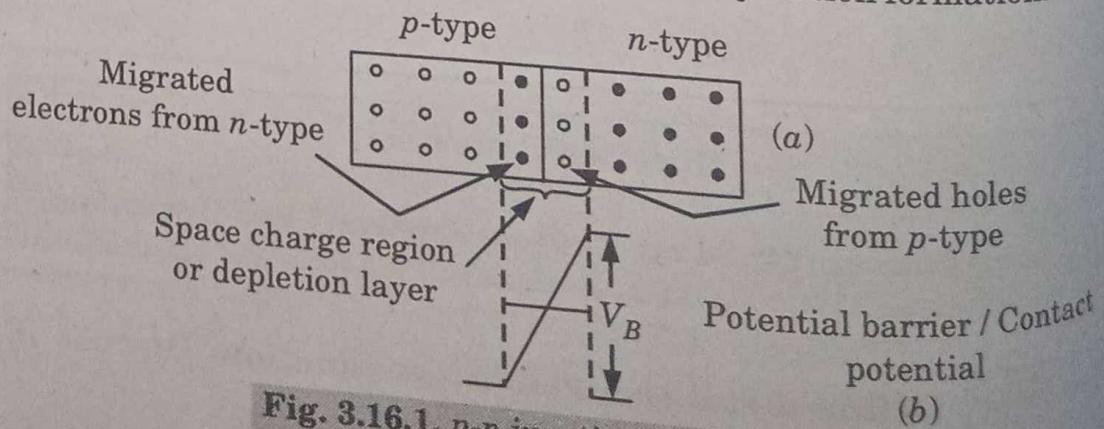
1. As a positive bias is applied to the metal, the Fermi energy of the metal is lowered with respect to the Fermi energy in the semiconductor. This results in a smaller potential drop across the semiconductor.
2. The balance between diffusion and drift is disturbed and more electrons will diffuse towards the metal than the number of electrons drifting into the semiconductor.
3. This leads to a positive current through the junction at a voltage comparable to the built-in potential.

**C. M-S Junctions in Reverse Bias :**

1. As a negative voltage is applied, the Fermi energy of the metal is raised with respect to the Fermi energy in the semiconductor.
2. The potential across the semiconductor now increases, yielding a larger depletion region and a larger electric field at the interface.
3. The barrier which restricts the electrons to the metal is unchanged so that barrier independent of the applied voltage limits the flow of electrons.

**Que 3.16. Discuss p-n junction under no bias condition.****Answer**

1. This is a two terminal device consisting of a p-n junction.
2. When p-type material is intimately joined (diffused) to n-type, a p-n junction is formed. Fig. 3.16.1 shows the p-n junction formation.

**Fig. 3.16.1. p-n junction semiconductor.**

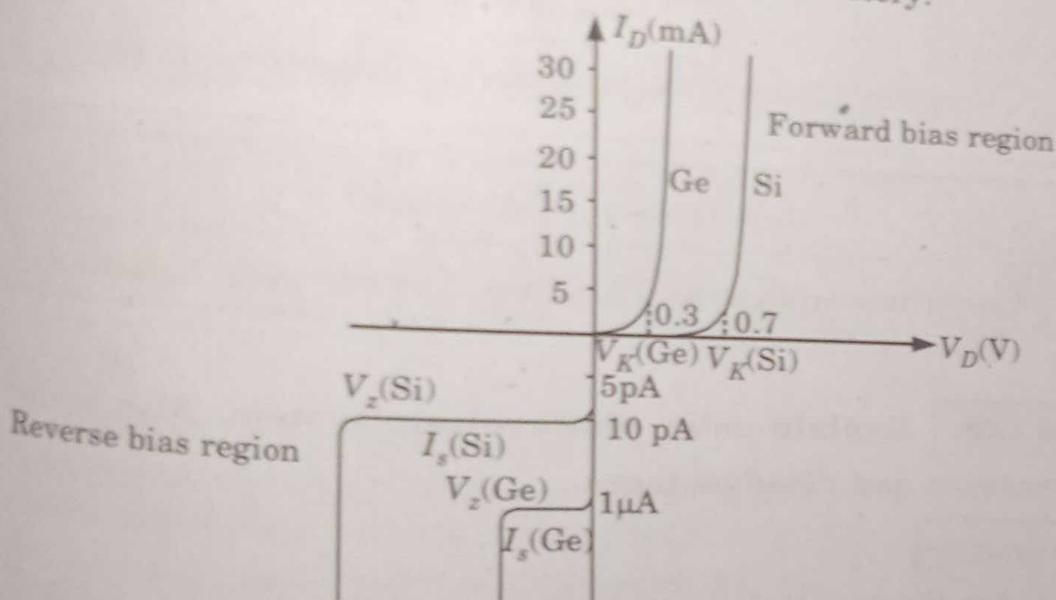
3. As *p*-type has high concentration of holes and *n*-type has high concentration of free electrons, hence there is a tendency of holes to diffuse to *n*-side and electrons to *p*-side. The process is known as diffusion.
4. Thus, a region is formed which is known as depletion layer or charge free region or space charge region.
5. The diffusion of electrons and holes continues till a potential barrier is developed which prevents further diffusion and such condition is no bias condition for *p-n* junction.

**Que 3.13.** Discuss *p-n* junction in forward bias and reversed bias condition.

**Answer**

**A. *p-n* Junction in Forward Bias :**

1. For the forward bias of a *p-n* junction, *p*-type is connected to the positive terminal while the *n*-type to negative terminal of battery.



**Fig. 3.17.1.** Volt-ampere characteristics of *p-n* junction.

2. The potential can be varied with potential divider. At some forward voltage (0.3 V for Ge and 0.7 V for Si) the potential barrier is altogether eliminated and current starts flowing. This voltage is known as threshold or knee voltage ( $V_K$ ).
  3. As the forward applied voltage increases beyond threshold voltage, the forward current rises exponentially as shown in Fig. 3.17.1.
  4. Beyond a certain safe value, it produces an extremely large current which may destroy the junction due to overheating.
- B. *p-n* Junction in Reverse Bias :**
1. The *p*-type is connected to the negative terminal while *n*-type is connected to the positive terminal of a battery.

2. In this case the junction resistance becomes very high and practically no current flows through the circuit.
3. In practical, a small current of the order of  $\mu\text{A}$  flows in the circuit due to minority carriers. This is known as reverse current. The reverse current is shown in Fig. 3.17.1.
4. As the reverse bias is increased from zero, the reverse current quickly rises to its maximum or saturation value. The slight increase is due to impurities on the surface which behaves as a resistor and hence obeys Ohm's law. This gives rise to a current called surface leakage current.
5. If the reverse voltage is further increased, the kinetic energy of electrons becomes so high that they knock out from the semiconductor atoms. At this stage breakdown of junction occurs and there is a sudden rise of reverse current. Now the junction is destroyed completely.
6. Thus,  $p-n$  junction is one way device which offers a low resistance when forward biased and behaves like an insulator when reverse biased.

## PART-5

*Essential Characteristics of Solar Photovoltaic Devices.*

### Questions-Answers

### Long Answer Type and Medium Answer Type Questions

**Que 3.18.** Explain solar photovoltaic system. Also write its advantages and disadvantages.

#### Answer

##### A. Solar Photovoltaic System :

1. It refers to a wide variety of solar electricity systems.
2. This system use solar array made of silicon to convert sunlight into electricity.
3. Components other than PV array are collectively known as balance of system (BOS) which includes storage batteries, an electronic charge controller and an inverter.
4. Storage batteries with charge regulators are provided for back-up power supply during periods of cloudy day and during nights.
5. Batteries are charged during the day and supply power to loads.
6. The capacity of a battery is expressed in ampere-hours and each cell of the lead-acid battery is of 2 volts.

1. Batteries are installed with a microprocessor based charge regulator to monitor the voltage and temperature.
2. It also regulates the input and the output current to eliminate overcharging and excessive discharge respectively.
3. An inverter is provided for converting DC power from battery or PV array to AC power.
4. It needs to have an automatic switch-off in case the output voltage from the array is too low or too high.

**B. Advantages of Solar Photovoltaic Systems :**

1. No operational cost.
2. Low maintenance.
3. These systems are durable.
4. More flexibility is available in solar photovoltaic systems.
5. These systems are eco-friendly.

**C. Disadvantages of Solar Photovoltaic Systems :**

1. Low efficiency.
2. Weather dependent.
3. Installation cost is more.

**Que 3.19. Write short note on :**

- i. Principle of solar photovoltaic, and
- ii. Photovoltaic effect.

**Answer**

**i. Principle of Solar Photovoltaic :**

1. It is a field of solar energy utilization by which solar radiation is converted into electrical energy using a device called photovoltaic cell or solar cell.
2. A solar cell is made up of a semiconductor material like silicon (Si) or gallium arsenide (GaAs).
3. In semiconductors, atoms carry four electrons in the outer valence orbit, some of which can be dislodged to move freely in the materials, if extra energy is supplied.
4. Then, a semiconductor attains the property to conduct the current. This is the basic principle on which the solar cell works and generates power.

**ii. Photovoltaic Effect :**

1. Photoelectric effect is the emission of electrons or other free carriers when light hits a material.
2. When a solar cell is illuminated, electron-hole pairs are generated and the electric current  $I$  is obtained.
3.  $I$  is the difference between the solar light generated current  $I_L$  and the diode dark current  $I_d$ .

4. Mathematically,  $I = I_L - I_j$

$$= I_L - I_o \left[ \exp\left(\frac{eV}{kT}\right) - 1 \right]$$

Where,

$I_o$  = Saturation current,

$e$  = Electronic charge,

$T$  = Absolute temperature, and

$k$  = Boltzmann's constant.

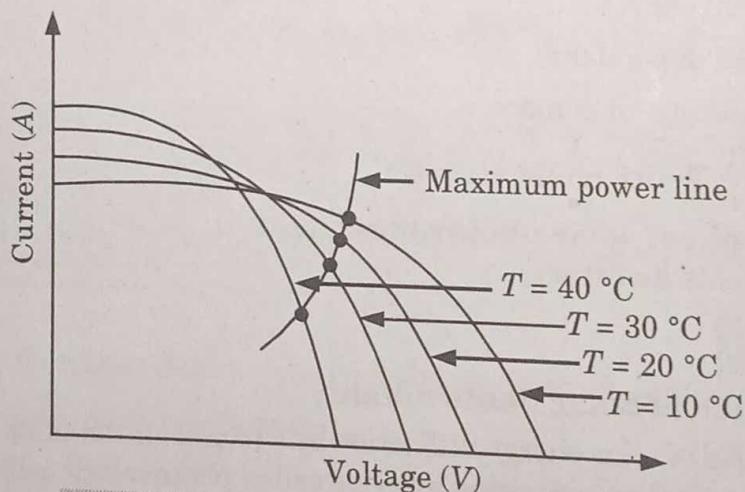
$$= 1.38 \times 10^{-23} \text{ J/K.}$$

**Que 3.20.** Describe V-I and P-V characteristics of photovoltaic device.

**Answer**

**A. V-I Characteristic of Photovoltaic (PV) Device :**

1. The V-I characteristic of a PV device is a non-linear graph between current and voltage generated by PV module as shown in Fig. 3.20.1.



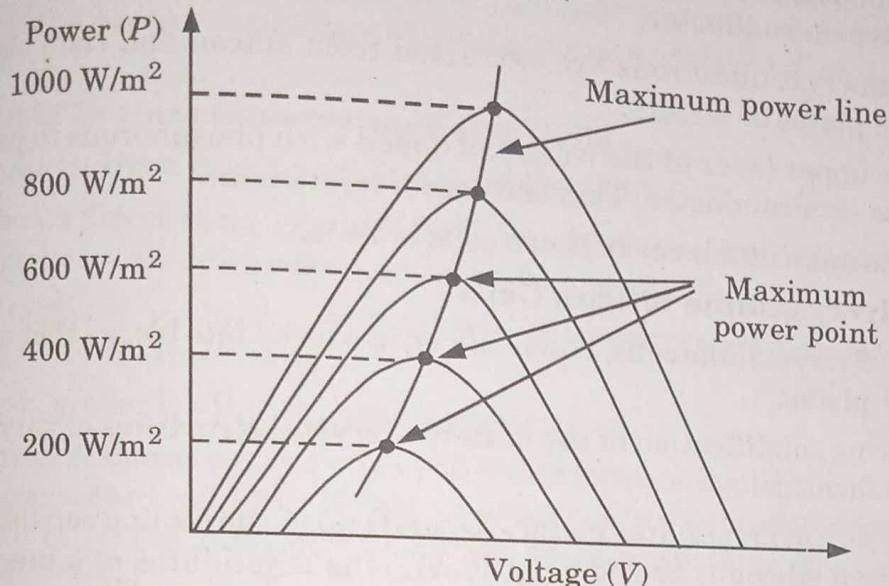
**Fig. 3.20.1.** V-I characteristics of a PV device.

2. For different temperature levels, different graphs have been plotted.
3. Maximum power points have also been shown to represent the point at which maximum power can be drawn from a PV device.
4. These maximum power point constitute the maximum power line (MPL).
5. MPL represents the track or path tracked by maximum power point tracker (MPPT).

**B. P-V Characteristic of Photovoltaic Device :**

1. P-V characteristic curve of a PV device is also a non-linear curve plotted between power and voltage of a PV device.
2. For different power densities in  $\text{W/m}^2$ , different graphs have been plotted between power and voltage of a PV module.

3. On the paper of these graphs, maximum power points are shown in Fig. 3.20.2.
4. The maximum power point (MPP) constitute, the maximum power line (MPL). MPL is also non-linear in nature.



**Fig. 3.20.2. P-V characteristic of a PV module.**

### PART-6

*First Generation Solar Cells, Second Generation  
Solar cells, Third Generation Solar Cells.*

#### Questions-Answers

**Long Answer Type and Medium Answer Type Questions**

**Que 3.21.** What do you understand by first generation solar cells ? Explain their various types.

#### Answer

A. **First Generation Solar Cells :**

- These cell consists of a large area, single crystal, single layer  $p-n$  junction diode, capable of generating usable electrical energy from light sources with the wavelengths of sunlight.
- These cells are typically made using a diffusion process with silicon wafers.
- These silicon wafer based solar cells are the dominant technology in the commercial production of solar cells, accounting for more than 86 % of the terrestrial solar cell market.

**B. Various types of First Generation Solar Cells :****a. Monocrystalline Silicon Cells :**

1. In monocrystalline silicon cells, silicon is doped with boron to produce  $p$ -type semiconductor.
2. Monocrystalline rods are extracted from silicon and then sawed into thin plates or wafers.
3. The upper layer of the wafers is doped with phosphorous to produce  $n$ -type semiconductor. This becomes  $p-n$  junction.
4. Maximum efficiency of these cells is 24 %.

**b. Polycrystalline Silicon Cells :**

1. In polycrystalline cells, liquid silicon is poured into blocks that are sawed into plates.
2. During solidification of the material, crystal structures of varying sizes are formed.
3. The size of crystallites mainly depends upon the cooling condition. If the molten silicon is cooled very slowly, the crystallites of larger size are obtained.
4. The silicon solar cells made from polycrystalline silicon are low cost but low efficiency.
5. Maximum efficiency of these cells is 17.8 %.

**c. Amorphous Silicon Cells :**

1. If a silicon film is deposited on glass or another substrate material, this is so called amorphous or thin layer cell.
2. The layer thickness is less than  $1 \mu\text{m}$ , so production costs are lower due to the low material costs.
3. However, the efficiency of amorphous cells is much lower than that of the other cells. Because of this, they are primarily used in low power equipment such as watches, pocket calculators etc.
4. Maximum efficiency of these cells is 13 %.

**Que 3.22.** Define second generation solar cells. Explain their types.

**Answer****A. Second Generation Solar Cells :**

1. These cells are based on the use of thin epitaxial deposits of semiconductors on lattice matched wafers.
2. There are two classes of epitaxial photovoltaic - space and terrestrial.
3. Space cells typically have higher efficiencies (28-30 %) in production, but also have a higher cost per watt.

4. There are currently a number of technologies / semiconductor materials under investigation or in mass production. Examples include amorphous silicon, polycrystalline silicon, micro-crystalline silicon, cadmium telluride, copper indium selenide / sulfide etc.
5. Second generation solar cells now comprise a small segment of the terrestrial photovoltaic market, and approximately 90 % of the space market.

### B. Types of Second Generation Solar Cells :

#### a. Copper Indium (Gallium) Diselenide (CIS) Cell :

1. CIS has a direct band gap of 1.0 eV. Incorporation of Ga into the CIS mixture increases the band gap beyond 1.1 eV.
2. A heterogeneous junction with *n*-type Cd-S and *p*-type CIS is fabricated using thin-film technology.
3. Its main attraction is inexpensive preparation.
4. It is more stable as compared to a Si cell in outdoor applications and has efficiency of around 10 %. However, exposure to elevated temperatures results in loss of efficiency but light soaking restores it to original efficiency level.

#### b. Cadmium Telluride Cell :

1. Cd-Te has a favorable direct band gap of 1.44 eV.
2. Thin film heterogeneous junction with *n*-type Cd-S and *p*-type Cd-Te is fabricated as shown in Fig. 3.22.1.
3. Here, a transparent conducting oxide layer is used instead of metallic contact at the top on the *n* side.
4. EVA (ethylene vinyl acetate) is used for encapsulation.
5. Its efficiency is about 10 % and open circuit cell voltage is around 0.8 V.

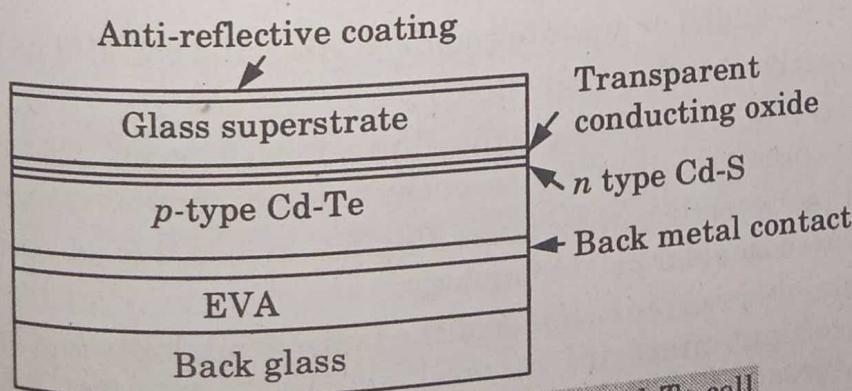


Fig. 3.22.1. Basic structure of Cd-Te cell.

Que 3.23.  
types.

Define third generation solar cells. Explain their various

**Answer****A. Third Generation Solar Cells :**

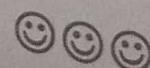
1. They are proposed to be very different from the previous semiconductor devices as they do not rely on a traditional *p-n* junction to separate photogenerated charge carriers.
2. For space applications quantum well devices (quantum dots, quantum ropes, etc.) and devices incorporating carbon nanotubes are being studied with a potential for up to 45 % production efficiency.
3. For terrestrial applications, these new devices include photoelectrochemical cells, polymer solar cells, nanocrystal solar cells, dye sensitized solar cells and are still in the research phase.

**B. Types of Third Generation Solar Cells :****a. Organic PV Cell :**

1. The solar cells based on organic semiconductor can provide a low cost alternative for solar PV.
2. The thickness of the active layer of organic solar cells is only 100 nm thin, which is about 1000 times thinner than the crystalline silicon solar cells, and it is about 10 times thinner than the current inorganic thin film solar cells.
3. In the low material consumption per solar cell and the relatively simpler cell processing of organic semiconductors, there is a large potential for low cost large area solar cells.
4. Due to this reason, there is a considerable interest in organic photovoltaic devices.
5. Their principal advantage is that they are flexible and can bend without breaking, unlike Si, which is brittle.
6. They are also very light and cheap.
7. They may be folded or cut into required sizes and can still be used.

**b. Dye Sensitized Solar Cell (DSC) :**

1. The DSC can be considered as a thin film solar cell device. This technology is not yet commercialized but is on the verge of commercialization.
2. The DSC solar cells can be made flexible. It has a good potential for being a low cost solar cell technology.
3. This is mainly possible because of the large availability and low cost of the ingredient material as well as due to the low processing temperatures.
4. The DSC is a photo-electro-chemical device. In its operation it involves a photon, an electron and a chemical reaction.
5. The operation of DSC is considered similar to that of a photosynthesis process.



# 4

UNIT

## Conventional and Non-Conventional Energy Sources

### CONTENTS

Part-1 :	Biological Energy Sources .....	4-2G to 4-5G
	and Fossil Fuels	
Part-2 :	Fluid Dynamics and Power in .....	4-5G to 4-12G
	the Wind, Available Resources,	
	Fluids, Viscosity, Types of	
	Fluid Flow, Lift	
Part-3 :	Wind Turbine Dynamics .....	4-13G to 4-16G
	and Design	
Part-4 :	Wind Farms .....	4-16G to 4-17G
Part-5 :	Geothermal Power and Ocean .....	4-17G to 4-22G
	Thermal Energy Conversion	
Part-6 :	Tidal Power .....	4-22G to 4-25G
Part-7 :	Wave Power .....	4-25G to 4-26G
Part-8 :	Hydropower .....	4-27G to 4-29G

**PART - 1***Biological Energy Sources and Fossil Fuels.***Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 4.1.** Discuss various biological energy sources along with their merits and demerits.

**Answer**

Various biological energy sources are as follows :

**a. Solar Energy :**

1. Solar energy is a clean, cheap and abundantly available renewable energy and it is also the most important of the non-conventional sources of energy because it is non-polluting and therefore helps in decreasing the green house effect.
2. Solar energy can be used :
  - i. By direct conversion to a fuel by photosynthesis.
  - ii. By direct conversion to electricity by photovoltaic.
  - iii. By conversion to electricity via thermo-electric power system.
3. The sun releases the enormous amount of energy due to continuous fusion reaction taking place inside the sun.
4. The sun sends out the energy in the form of radiations at the rate of  $3.7 \times 10^{20}$  MW.
5. However, the energy intercepted by the earth is about  $1.85 \times 10^{11}$  MW.
6. This energy available is several times more than all the energy produced and consumed in the world.

**i. Merits :**

1. Noiseless operation.
2. Occupies less space on floor as there is no need of storage vessels.

**ii. Demerits :**

1. Solar equipments fail to work in nights, cloudy days or rainy season.
2. Large space is required for the collection of solar energy at a useful rate.

**b. Hydro Energy :**

1. It is a renewable energy source which is used to generate electricity.
2. Hydropower is obtained from water flow or falling water from a height.

3. Water stored behind dam and at a height has a lot of potential energy which is converted into mechanical and electrical energy.
4. The water is released gradually and is allowed to fall under the gravitational force and drive which rotate hydraulic turbines.
5. The generators attached with turbine produce the electricity.

i. **Merits :**

1. Hydropower does not pollute the water or the air during operation and no waste products are formed.

ii. **Demerits :**

1. It results in ecological disturbance like flooding situation and adverse effects on flora and fauna.

c. **Wind Energy :**

1. Wind energy is a renewable source of non-polluting energy and it has tremendous potential which if harnessed, can easily satisfy the energy demands of a country.
2. Estimates reveal that 2 % of the total solar energy falling on earth is converted to kinetic energy in the atmosphere.
3. 30 % of this kinetic energy occurs in the lowest 1000 m of elevation i.e., wind in the lowest kilometer has maximum kinetic energy which can be converted into mechanical energy which in turn can be utilized to generate electricity or to perform some other useful work.
4. Since, the energy possessed by wind is by virtue of its motion, so the device used to extract its energy should be capable of slowing down the wind.

i. **Merits :**

1. Abundance availability for no price.
2. Useful at remote places for electricity generation.

ii. **Demerits :**

1. Less favourable in city locations as the wind is available at higher locations.
2. It is unreliable and intermittent. It is not available regularly.

d. **Wave Energy :**

1. The motion of the sea surface in the form of wind waves forms a source of energy.
2. Floating propellers are placed in shallow waters, near the shores and due to motion of the waves, the propellers also get the motion and this kinetic energy can be used to drive turbines.

i. **Merits :**

1. This is cheap, clean and inexhaustible source of energy.

2. Collector size of wave machines is comparatively smaller than solar devices.

**ii. Demerits :**

1. Corrosion of materials used in plant.

**e. Geothermal Energy :**

1. The energy harnessed from the hot rocks present inside the earth is called geothermal energy.

2. There is an increase in the temperature of the earth with increasing depth below the surface.

3. The fission of radioactive material naturally occurring in the rocks increases the temperature of the earth as we move down from the earth's surface.

4. Hot molten rocks called magma is present in the core of the earth. This causes sometimes volcanic action.

5. This hot steam is used to operate turbines to generate electricity.

6. Artificially it can also be harnessed with the help of pipes by drilling the hot rocks, which make the hot water to gush out through pipes which turns the turbine of the generator to produce electricity.

**i. Merits :**

1. It is cheap and clean source of energy.

2. Geothermal plants require little land area.

**ii. Demerits :**

1. Air pollution results in case of release of gases like  $H_2S$ ,  $NH_3$  present in the steam waste.

2. Noise pollution results from the drilling operations.

**Que 4.2. Write short note on following :**

- i. Coal energy, and
- ii. Natural gas

**Answer**

**i. Coal Energy :**

1. Coal is a conventional energy source.

2. It is formed due to degradation of trees and plants buried under layers of silt.

3. It is composed of mainly carbon and hydrocarbons.

4. Uses of coal :

i. Coal is used to generate electricity. Power plants use coal for heating the water to generate steam which runs the turbines to generate electricity.

- ii. Coal is heated in furnace to make coke which is used to melt iron for making steel.

#### Environmental problems :

- i. Due to combustion of coal, carbon dioxide is produced which is responsible for causing global warming.
- ii. Coal also produces sulphur dioxide which is a cause for acid rain.

#### Natural Gas :

- 1. Natural gas is formed by decomposition of dead animals and plants buried under the earth.
- 2. It is mainly composed of methane ( $\text{CH}_4$ ) with small amount of propane and ethane.
- 3. Natural gas is the cleanest fossil fuel.

#### Uses of natural gas :

- i. It is used as a domestic and industrial fuel.
- ii. It is also used in thermal power plants for generating electricity.

#### Advantages of natural gas :

- i. Natural gas has a high calorific value and it burns without any smoke.
- ii. It can be easily transported through pipelines.

**Que 4.3. What are conventional and non-conventional energy sources ? Write short notes on classification of energy sources.**

**AKTU 2019-20, Marks 10**

#### Answer

A. **Conventional (Non-Renewable) Energy Sources :** These are the sources of energy which are exhaustible i.e., cannot be replaced if once they are used.

**Example :** Coal, petroleum products, natural gas, etc.

B. **Non-Conventional (Renewable) Energy Sources :** These are the sources of energy which are inexhaustible i.e., can be used to produce energy again and again.

**Example :** Sun, water, animal dung, agro-waste, wind, etc.

C. **Classification of Energy Sources :** Refer Q. 4.1, Page 4-2G, Unit-4.

#### PART-2

Fluid Dynamics, Power in the Wind, Available Resources, Fluids, Viscosity, Types of Fluid Flow, Lift.

## CONCEPT OUTLINE

**Fluid :** A fluid is a substance which deforms continuously when subjected to external shearing force.

**Newton's Law of Viscosity :** This law states that the shear stress ( $\tau$ ) on a fluid element layer is directly proportional to the rate of shear strain.

Mathematically,

$$\tau = \mu \frac{du}{dy}$$

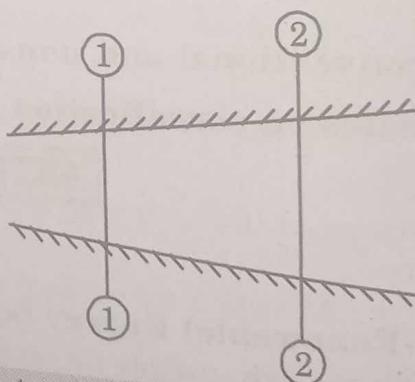
### Questions-Answers

#### Long Answer Type and Medium Answer Type Questions

**Que 4.4.** Derive the continuity equation for 1-D fluid flow.

**Answer**

1. Consider two cross-section of a pipe as shown in Fig. 4.4.1.



**Fig. 4.4.1.** Fluid flow through a pipe.

2. Let,  $a_1$  = Area of the pipe at section 1–1,  
 $v_1$  = Velocity of the fluid at section 1–1,  
 $\rho_1$  = Density of the fluid at section 1–1, and  
 $A_2, v_2, \rho_2$  = Corresponding values at section 2–2.
3. The total quantity of fluid passing through section 1–1 =  $\rho_1 a_1 v_1$   
 The total quantity of fluid passing through section 2–2 =  $\rho_2 a_2 v_2$   
 From the law of conservation of matter (theorem of continuity), we have  

$$\rho_1 a_1 v_1 = \rho_2 a_2 v_2$$
  
 Eq. (4.4.1) is applicable to the compressible as well as incompressible fluids and is called continuity equation.
4.  $\rho_1 a_1 v_1 = \rho_2 a_2 v_2$   
 Eq. (4.4.1) is applicable to the compressible as well as incompressible fluids and is called continuity equation.

In case of incompressible fluids,  $\rho_1 = \rho_2$  and the continuity eq. (4.4.1) reduces to

$$a_1 v_1 = a_2 v_2$$

Que 4.5.

### State Bernoulli's theorem for fluid flow

Answer

- Bernoulli's theorem states that in a steady, ideal flow of an incompressible fluid, the total energy at any point of the fluid is constant.
- It can be mathematically stated as given below,  
Pressure energy + Kinetic energy + Potential energy = Constant

$$\frac{p}{\rho g} + \frac{v^2}{2g} + z = \text{Constant}$$

- Bernoulli's equation for real fluids is,

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2 + h_L$$

Where,  $h_L$  = Loss of energy.

Que 4.6.

### Derive expression for wind power.

Answer

- The moving wind possesses kinetic energy in it, and can be harnessed for other applications by suitable conversion system.
- Let  $m$  be the mass flow rate of air moving with velocity  $v$  through opening provided at any time. The kinetic energy associated with this moving air is

$$E = \frac{1}{2} m v^2 \quad \dots(4.6.1)$$

This is maximum power associated within the wind.

- Fig. 4.6.1 shows the motion of wind through the opening of area ( $a$ ) flowing with velocity ( $v$ ). The discharge rate ( $Q$ ) of air through the opening at point 1 and 2 is given as,

$$Q = av$$

- Mass flow rate (kg/s) of air through the opening,  $\dots(4.6.2)$

$$m = \rho a v$$

- From eq. (4.6.1) and (4.6.2), we get  $\dots(4.6.3)$

$$E = \frac{1}{2} \rho a v v^2$$

- Power developed by wind depends upon the swept area ( $a$ ) and wind velocity ( $v$ ). If  $D$  the diameter of opening eq. (4.6.3) reduces to,

$$E = \frac{1}{2} \rho \frac{\pi}{4} D^2 v^3$$

7. This is the maximum energy available within that opening, hence

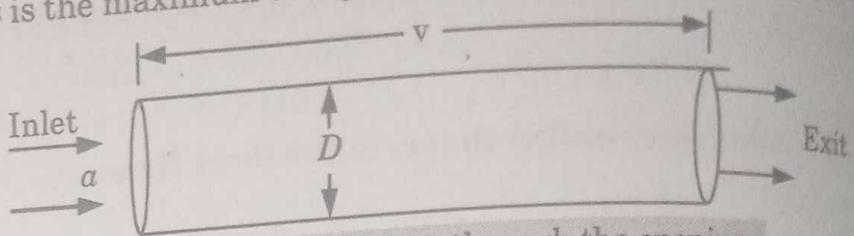


Fig. 4.6.1. Wind flow through the opening.

$$E_{\max, \text{wind}} = \frac{\pi}{8} \rho D^2 v^3$$

**Que 4.7.** Write down the principle of power generation in wind mills. Derive an expression for maximum efficiency.

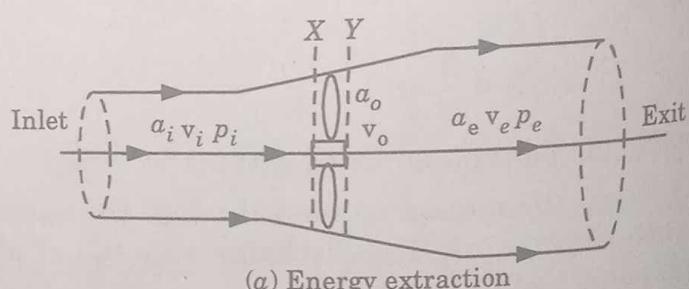
**Answer**

**A. Principle of Power Generation in Wind Mills :**

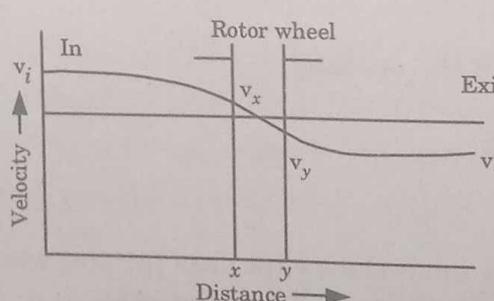
1. The basic principle of wind energy is to convert the kinetic energy of wind into rotational motion to operate an electric generator.

**B. Expression for Maximum Efficiency :**

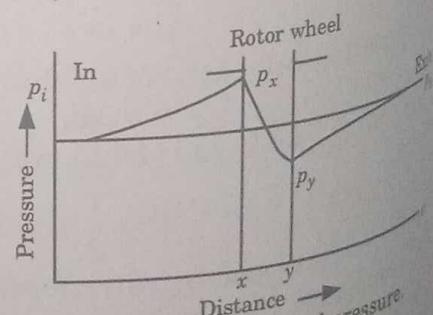
1. The power in the wind can be extracted by allowing it to pass through moving wings that exert torque on a rotor.
2. The amount of power transferred is directly proportional to the density of the air, the area swept out by the rotor, and the cube of the wind speed.
3. Fig. 4.7.1 shows the air flow diagram on rotor, with variation of velocity and pressure at different sections.



(a) Energy extraction



(b) Variation in wind velocity.



(c) Variation in wind pressure.

Fig. 4.7.1. Air flow through the rotor.

As the air passes through the rotor disk, there is a drop in static pressure such that pressure is below the atmospheric pressure while it leaves the blade.

The speed of the wind also gets reduced in the section (wake) and after this section the atmospheric pressure and speed of air again increases.

Let  $a_i$  and  $a_e$  = Inlet and outlet area of air enclosure,

$a_o$  = Rotor swept volume,

$v_i$  and  $v_e$  = Velocity of wind at inlet and outlet of enclosure,

$v_o$  = Velocity of rotor,

$\rho$  = 1.25, air density, and

$\dot{m}$  = Mass flow rate of air over rotor.

i. The thrust on the turbine by moving air as it passes over the rotor,

$$F = \dot{m} (v_i - v_e) \quad \dots(4.7.1)$$

ii. The power extracted by turbine,

$$P_T = \dot{m} (v_i - v_e) v_o \quad \dots(4.7.2)$$

iii. Instantaneous loss in kinetic energy of wind as it passes through rotor,

$$P_W = \frac{1}{2} \dot{m} (v_i^2 - v_e^2) \quad \dots(4.7.3)$$

iv. From eq. (4.7.2) and eq. (4.7.3), we have

$$\dot{m} (v_i - v_e) v_o = \frac{1}{2} \dot{m} (v_i^2 - v_e^2)$$

or  $v_o = \frac{v_i + v_e}{2}$   $\dots(4.7.4)$

v. From eq. (4.7.2) and eq. (4.7.4), we have

$$P_T = \dot{m} (v_i - v_e) \frac{(v_i + v_e)}{2} \quad \dots(4.7.5)$$

vi. The mass flow rate through turbine rotor,

$$\dot{m} = \rho a_o v_o = \rho a_o \left( \frac{v_i + v_e}{2} \right) \quad \dots(4.7.6)$$

vii. From eq. (4.7.5) and eq. (4.7.6), we have

$$P_T = \rho a_o \left( \frac{v_i + v_e}{2} \right) (v_i - v_e) \left( \frac{v_i + v_e}{2} \right) \quad \dots(4.7.7)$$

$$P_T = \frac{1}{4} \rho a_o (v_i + v_e) (v_i^2 - v_e^2)$$

viii. For maximum power,

$$\frac{\partial P_T}{\partial v_e} = 0$$

$$3v_e^2 + 2v_i v_e - v_i^2 = 0$$

15. On solving, we get

$$v_e = \frac{1}{3} v_i$$

16. On putting this value in eq. (4.7.7), we get

$$P_{T,\max} = \frac{8}{27} \rho a_o v_i^3$$

17. The maximum efficiency of turbine is,

$$\eta_{\max} = \frac{P_{T,\max}}{E_i} = \frac{8}{27} \times 2 \quad \left( \because E_i = \frac{1}{2} \rho a_o v_i^3 \right)$$

$$= 0.59$$

#### Que 4.8.

**Discuss some physical properties of fluids in brief.**

#### Answer

Some physical properties of fluids are as follows :

- a. **Density or Mass Density** : It may be defined as the mass per unit volume at a standard temperature and pressure. It is also known as specific mass. It is denoted by  $\rho$  and its unit is  $\text{kg/m}^3$ .

Mathematically,  $\rho = \frac{m}{v}$

Where,

$m$  = Mass ( $\text{kg}$ ), and

$v$  = Volume ( $\text{m}^3$ ).

- b. **Weight Density** : It can be defined as the weight per unit volume at the standard temperature and pressure. It is also known as specific weight. It is denoted by  $W$  and its unit is  $\text{N/m}^3$ .

Mathematically,  $W = \frac{\text{Weight}}{\text{Volume}} = \frac{mg}{v} = \rho g$   $\left( \because \frac{m}{v} = \rho \right)$

- c. **Specific Volume** : It is defined as the volume per unit mass of fluid.

Mathematically,  $V = \frac{v}{m} = \frac{1}{\rho}$

- d. **Specific Gravity** : It is the ratio of the specific weight of the given fluid to the specific weight of a standard fluid.

$$S = \frac{\text{Specific weight of given fluid}}{\text{Specific weight of standard fluid}}$$

- e. **Viscosity** : It is defined as the property of a fluid which determines the resistance to shearing stresses. Its SI unit is  $\text{Pa}\cdot\text{s}$  and CGS unit is  $\text{poise}$ . An ideal fluid has no viscosity. It is a measure of the internal friction which causes resistance to flow.

**Que 4.9.** Explain the following :

- i. Steady and unsteady flows,
- ii. Laminar and turbulent flows,
- iii. Rotational and irrotational flows,
- iv. Compressible and incompressible flows, and
- v. Uniform and non-uniform flows.

**Answer****i. Steady and Unsteady Flows :**

1. Steady flow is that type of flow in which the fluid characteristics like velocity, pressure, density, etc., at a point do not change with time.
2. Unsteady flow is that type of flow in which the velocity, pressure, density, etc, at a point changes with respect to time.

**ii. Laminar and Turbulent Flows :**

1. Laminar flow is one in which the fluid particles move along well defined paths or stream line and all the stream lines are straight and parallel.
2. Turbulent flow is that type of flow in which the particles move in a zig-zag way.

**iii. Rotational and Irrotational Flows :**

1. Rotational flow is that type of flow in which the fluid particles while flowing along stream lines also rotate about their own axis.
2. If the fluid particles while flowing along stream lines, do not rotate about their own axis that type of flow is called irrotational flow.

**iv. Compressible and Incompressible Flows :**

1. Compressible flow is that type of flow in which the density of the fluid changes from point to point.
2. Incompressible flow is that type of flow in which the density is constant for the fluid flow.

**v. Uniform and Non-uniform Flows :**

1. Uniform flow is defined as that type of flow in which the velocity at any given time does not change with respect to space.
2. Non-uniform flow is that type of flow in which the velocity at any given time changes with respect to space.

**Que 4.10.** Write short note on following :

- i. Subsonic, sonic and supersonic flows,
- ii. Subcritical, critical and supercritical flows, and
- iii. One, two and three dimensional flows.

**Answer**

- i. **Subsonic, Sonic and Supersonic Flows :**
  1. When Mach number is less than 1 ( $M < 1$ ), flow is subsonic flow.
  2. When Mach number is equal to 1 ( $M = 1$ ), flow is sonic flow.
  3. When Mach number is greater than 1 ( $M > 1$ ), flow is supersonic flow.
- ii. **Subcritical, Critical and Supercritical Flows :**
  1. When Froude number is less than one ( $Fe < 1$ ), the flow is subcritical flow.
  2. When Froude number is equal to one ( $Fe = 1$ ), the flow is critical flow.
  3. When Froude number is greater than one ( $Fe > 1$ ), the flow is supercritical flow.
- iii. **One, Two and Three Dimensional Flows :**
  1. One dimensional flow is that type of flow in which the flow parameter such as velocity is a function of time and one space co-ordinate only.
  2. Two dimensional flow is that type of flow in which the velocity is a function of time and two rectangular space co-ordinates.
  3. Three dimensional flow is that type of flow in which the velocity is a function of time and three mutually perpendicular directions.

**Que 4.11.** Explain the force exerted by a flowing fluid on a stationary body.

**Answer**

1. The total force ( $F_R$ ) exerted by the fluid on the body is perpendicular to the surface of the body. Thus the total force is inclined to the direction of motion.
2. The component of total force ( $F_R$ ) in the direction of flow is called drag and is given as,

$$F_D = C_D \frac{a\rho v^2}{2}$$

Where,

$C_D$  = Coefficient of drag.

3. The component of total force ( $F_R$ ) in the direction perpendicular to the direction of flow is known as lift and is given as,

$$F_L = C_L \frac{a\rho v^2}{2}$$

Where,

$C_L$  = Coefficient of lift.

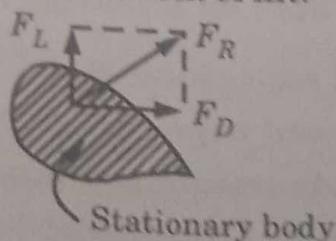


Fig. 4.11.1.

**PART-3***Wind Turbine Dynamics and Design.***Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 4.12.** Discuss the following parameters :

- i. Pitch angle
- ii. Pitch control
- iii. Tip speed ratio
- iv. Solidity
- v. Angle of inclination
- vi. Angle of incidence
- vii. Nacelle
- viii. Yaw control.

**Answer**

- i. **Pitch Angle ( $\beta$ )** : Angle between the direction of wind and direction perpendicular to the plane of blades is known as pitch angle.
- ii. **Pitch Control** : It is the control of pitch by turning the blades or blade tips.
- iii. **Tip Speed Ratio** : The ratio of the speed of the rotor blade tips to the speed of the wind is known as tip speed ratio.
- iv. **Solidity** : It is defined as the percentage of the circumference of the rotor which is filled by the rotor blades.

$$\text{Solidity (s)} = \frac{Nb}{\pi d}$$

Where,

$N$  = Number of blades,

$b$  = Average breadth of blade, and

$d$  = Diameter of the circle described by a blade.

- v. **Angle of Inclination ( $I$ )** : It is the angle between the relative velocity vector and the plane of rotation.
- vi. **Angle of Incidence ( $i$ )** : It is the angle between the relative velocity vector and the chord line of aero file.
- vii. **Nacelle** : It is the assembly consists of wind turbine, gears, bearings, generator etc., mounted in a housing.
- viii. **Yaw Control** : Control of orienting the axis of wind turbine in the direction of wind is known as yaw control.

**Que 4.13.**

Discuss the aerodynamic consideration in wind mill design.

**Answer**

1. Aerodynamics is the branch of science which deals with air and gases in motion and their mechanical effects.
2. Nomenclature of aerodynamics is as given below :

$v$  = Impinging wind velocity,

$v_T$  = Wind velocity in plane of rotation due to blade turning,

$v_R$  = Resultant wind velocity,

$F_L$  = Lift force perpendicular to  $v_R$ ,

$F_D$  = Drag force perpendicular to  $v_R$ ,

$F_R$  = Resultant force on blade,

$F_T$  = Component of  $F_R$  producing torque,

$F_{th}$  = Thrust force component,

$\alpha$  = Angle of attack, and

$\beta$  = Pitch angle.

Undisturbed wind

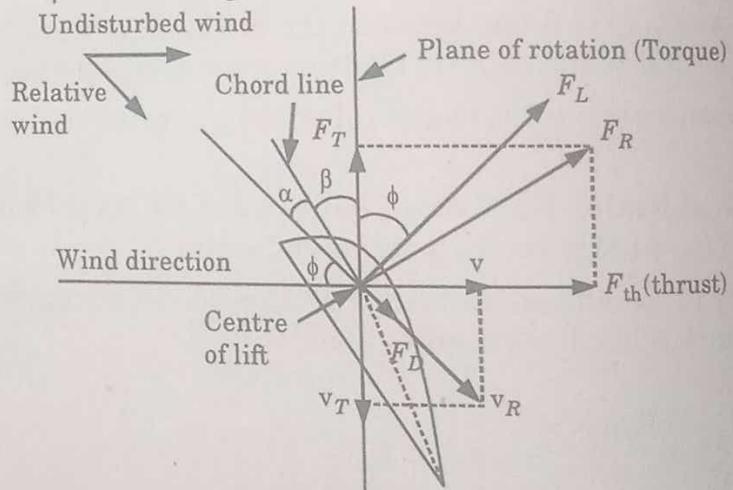


Fig. 4.13.1.

3. Blade is moving in the plane of rotation and it sees a tangential wind velocity  $v_T$  in the plane of rotation.
4.  $v_R$  is the resulting wind velocity, which is the vector sum of tangential velocity  $v_T$  and impinging wind velocity  $v$ .
5. The lift force  $F_L$  acts perpendicular to the resultant velocity  $v_R$  and drag force  $F_D$  is parallel to  $v_R$ .
6. The vector sum of lift force  $F_L$  and drag force  $F_D$  is  $F_R$ .
7. Now resolve  $F_R$  into two forces i.e.,  $F_T$  which is torque producing component and  $F_{th}$  thrust producing component.
8. The tower and structural members of the wind turbine must be designed to withstand  $F_{th}$ .
9. The vector diagram is centred on the centre of lift of the aerodynamic blade.

10. The angle of attack ( $\alpha$ ) is very important parameter and it determines lift and drag forces.

**Que 4.14.** Describe various parameters of designing of wind turbine rotor.

**Answer**

Various parameter of designing of wind turbine rotor are as follows :

a. **Diameter of the Rotor :**

1. The diameter of the rotor is determined from the operating wind speed and the rated power output.
2. The generated power is given by,

$$\begin{aligned} P &= P_0 \eta_e \eta_m C_p \\ &= \frac{1}{2} \rho A v_\infty^3 \eta_e \eta_m C_p \\ &= \frac{1}{8} \pi \rho D^2 v_\infty^3 \eta_e \eta_m C_p \end{aligned}$$

Where,

$\eta_m$  = Efficiency of mechanical transmission and

$\eta_e$  = Efficiency of electrical generation.

b. **Choice of the Number of Blades :**

1. It is obvious that the efficiency of power extraction from wind depend on the proper choice of the number of blades.
2. There will be little power extraction if the blades are so close to each other or rotate so fast that every blade moves into the turbulent air created by the preceding blade.
3. It will also be less than optimum if the blades are so far apart or move so slowly that much of the air stream passes through the wind turbine without interacting with a blade.
4. Thus, the choice of the number of blades should depend on the TSR (tip speed ratio).

c. **Choice of the Blade Profile and Material :**

1. For low TSR water pumping wind mills, the blade is generally a flat metallic plate.
2. In some cases it is a simple, circularly curved metallic sheet, which leads to certain aerofoil-like characteristics, but with uniform thickness throughout the blade. Because of their low rigidity, these blades have to be fixed to a circular metallic frame for structural support.

d. **Choice of the Pitch Angle :**

1. The pitch angle is given by  $\beta = I - i$ .
2. As  $I$  vary along the length of the blade,  $\beta$  should also vary to ensure an optimal angle of incidence at all points of the blade. Thus the desirable twist along the blade can be calculated easily.

- e. **The Tower :**
1. In a horizontal axis wind turbine, the tower supports the whole machinery, including the blades, the gear box, the generator, and the control equipment.
  2. It therefore requires high strength which is achieved with a steel or concrete structure based on tubular or lattice construction.
  3. It is necessary to avoid amplification of vibration through careful design of the resonant frequencies of the tower, blades, rotor, etc.

f. **Transmission System and Gear Box :**

1. In general, the optimal speed of rotation of an electrical generator is much higher than the optimal speed of a wind turbine.
2. In order to ensure that a low speed of the turbine produces a high rotational speed at the generator, a gear box is inserted in the transmission system.
3. If the great system has fixed gear ratio, the transmission system is relatively simple and inexpensive.

#### PART-4

Wind Farms.

#### Questions-Answers

#### Long Answer Type and Medium Answer Type Questions

**Que 4.15.** Write a short note on wind farms.

#### Answer

1. Wind farms or wind parks often have many turbines generator units.
2. The wind farms are open spaces away from forest, cities and mountains so that average annual wind speed should not be less than 7 m/s and not away from the distribution centre.
3. Since each turbine extracts some of the energy of the wind, it is important to provide adequate spacing between turbines to avoid excess energy loss.
4. A wind farm has 10-50 turbines unit depending on its size.
5. Where land area is sufficient, turbines are spaced three to five rotor diameters apart perpendicular to the prevailing wind, and five to ten rotor diameters apart in the direction of the prevailing wind, to minimize the loss inefficiency.

**Que 4.16.** What parameters are to be considered while selecting a site for wind farms ?

#### Answer

Parameters to be considered while selecting a site for wind farms are as follows :

1. Flat open area should be selected, as the wind velocities are high in flat open area.
2. The proposed altitude is to be selected by taking average wind speed data.
3. Minimum wind speed should be available throughout the year.
4. Ground surface should be stable and high soil strength.
5. To minimize the transmission losses, the wind power should be near the consumers.
6. It should be at least 5 km away from the cities to reduce the effect of noise pollution.
7. Low land cost.
8. Approach roads upto site.

#### PART-5

Geothermal Power and Ocean Thermal Energy Conversion.

#### CONCEPT OUTLINE

**Geothermal Energy :** The enormous amount of energy available inside the earth in the form of heat is known as geothermal energy. Geothermal energy is a form of renewable energy and independent of sun, having the source of natural heat inside the earth.

#### Questions-Answers

#### Long Answer Type and Medium Answer Type Questions

**Que 4.17.** Discuss different systems used for generating the power using geothermal energy.

#### Answer

Different systems used for generating the power using geothermal energy are given below :

a. **Vapour Dominated Power Plant :**

1. In a vapour dominated power plant, steam is extracted from geothermal wells, passed through a separator to remove particulate contents and flows directly to a steam turbine.
2. Steam then operates the turbine coupled with the generator at a temperature of about  $245^{\circ}\text{C}$  and pressure 7 bar which are less than those in conventional steam cycle plants.
3. Thus, the efficiency of geothermal plants is low, i.e., about 20 %.
4. Exhaust steam from the turbine passes through a condenser and the water so formed circulates through the cooling tower.
5. It improves the efficiency of the turbine and controls environmental pollution associated with the direct release of steam into the atmosphere.
6. Waste water from the cooling tower sump is re-injected into the geothermal well to ensure continuous supply.

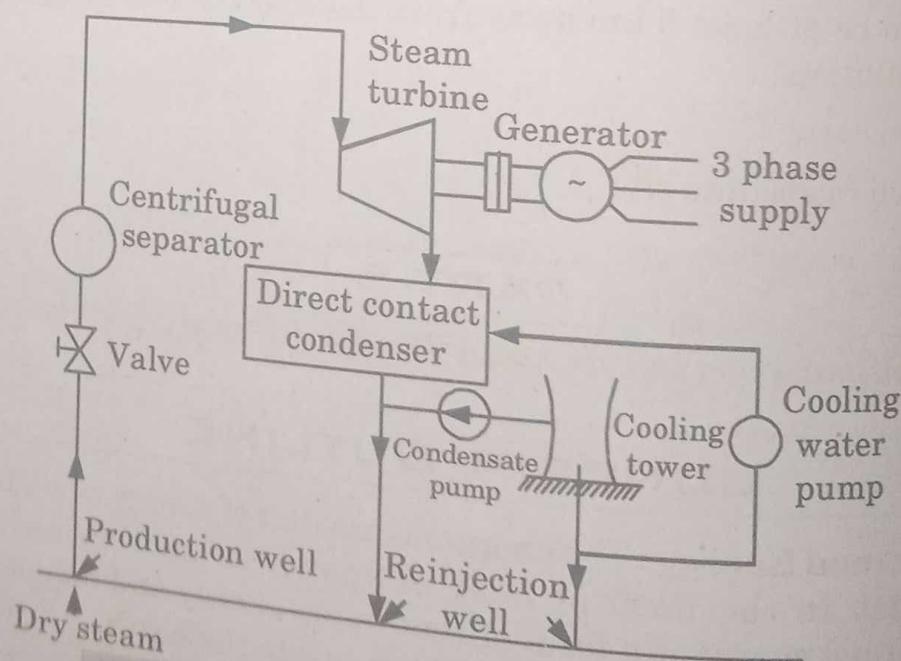


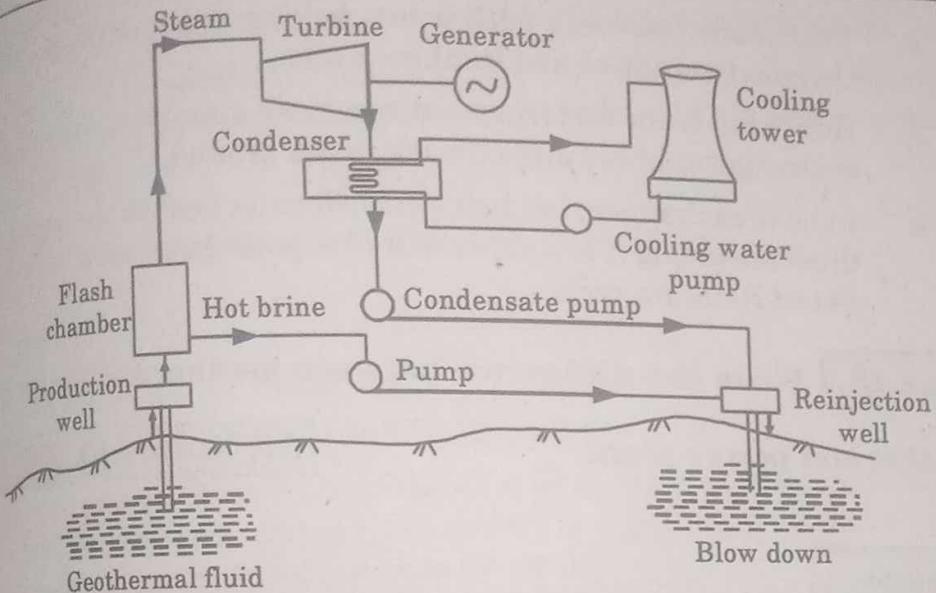
Fig. 4.17.1. Vapour dominated power plant.

b. **Liquid Dominated Power Plants :**

1. These plants are also called wet steam plants because they give wet steam i.e., a mixture of hot water and steam under high pressure.
2. There are two types of liquid dominated power plants :

i. **Flashed Steam System :**

1. Flashed system is preferred for high temperature mixture of geothermal brine and steam with low dissolved impurities.

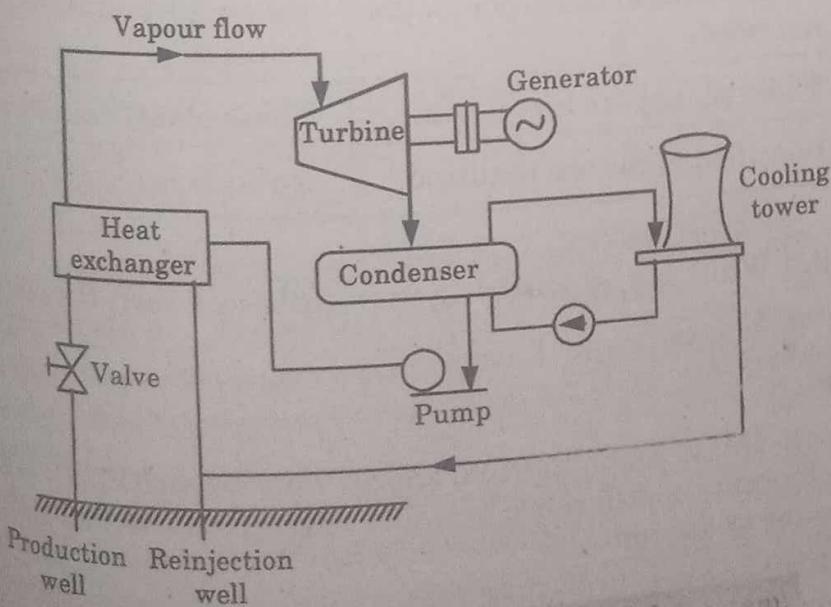


**Fig. 4.17.2. Flashed steam geothermal power plant.**

2. Geothermal fluid (mixture of brine and steam) passes through a flash chamber where a large part of the fluid is converted to steam.
3. Dry saturated steam passes through the turbine coupled with the generator to produce electric power.
4. Hot brine from the flash chamber and the turbine discharges from the condenser are re-injected into the ground and reinjection of the spent brine ensures a continuous supply of geothermal fluid from the well.

i. **Binary Cycle System :**

1. A binary cycle is used where geothermal fluid is hot water with temperature less than 100 °C.



**Fig. 4.17.3. Schematic view of binary cycle system.**

2. This plant operates with a low boiling point working fluid in a thermodynamic closed Rankine cycle.
3. Hot brine from underground reservoir circulates through a heat exchanger and is pumped back to the ground.
4. In heat exchanger, hot brine transfers its heat to the organic fluid thus converting it to a superheated vapour that is used in a standard closed Rankine cycle.

**Que 4.18.** Write the difference between geothermal power plant and thermal power plant.

AKTU 2019-20, Marks 10

**Answer**

S. No.	Geothermal Power Plant	Thermal Power Plant
1.	It uses inexhaustible source of energy.	It uses exhaustible source of energy.
2.	It is more environment friendly	It is less environment friendly.
3.	These power plants in some dangerous cases can cause earthquakes.	There is no such problem.
4.	It is mainly used for power generations process.	It can be used for various industrial processes.
5.	Set up cost is high.	Set up cost is low.
6.	By-products of these plants are not used.	By-products of these plants can be used.
7.	These plants are less flexible.	These plants are more flexible.
8.	Specified areas are required.	No such restriction.

**Que 4.19.** What is the working principle of ocean thermal energy conversion ?

**Answer**

1. The principle of ocean thermal energy conversion (OTEC) is that there is a temperature difference between water at the bottom of the sea and the water at the top.
2. This temperature difference can be used to operate a heat engine and most of the radiation is being absorbed at the surface layer of water.

The mixing between hot and cold water is prevented because no thermal convection occurs between hot and cold water layer. This means that the surface layer will act as a source and cold layers act as a sink. Therefore, it is essential to connect the reversible heat engine between source and cold sink to produce work that can be converted into required applications.

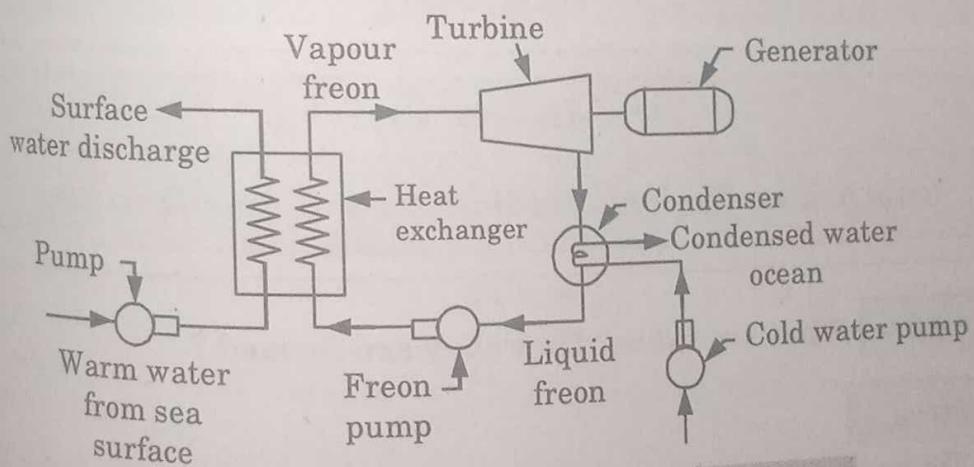
**Que 4.20. What are the types of OTEC system ?**

**Answer**

Following are the two basic types of OTEC system :

**Closed or Anderson Cycle OTEC System :**

1. In this system, the working fluids for heat engines use the fluids like ammonia, freon 12, butane gas having low boiling point because the working temperature of sea water is small.
2. Warm water from ocean surface is circulated through a pump to a heat exchanger which acts as boiler to generate freon vapour at high pressure.
3. This vapour expands in the turbine to develop mechanical power and it is used to drive an electric generator which produces electric energy.
4. Freon vapour from turbine at low pressure is condensed in the condenser with the help of cold water drawn from the depth of ocean through a pump. The overall efficiency of such plant is very low in the range of 2 to 3 % only.

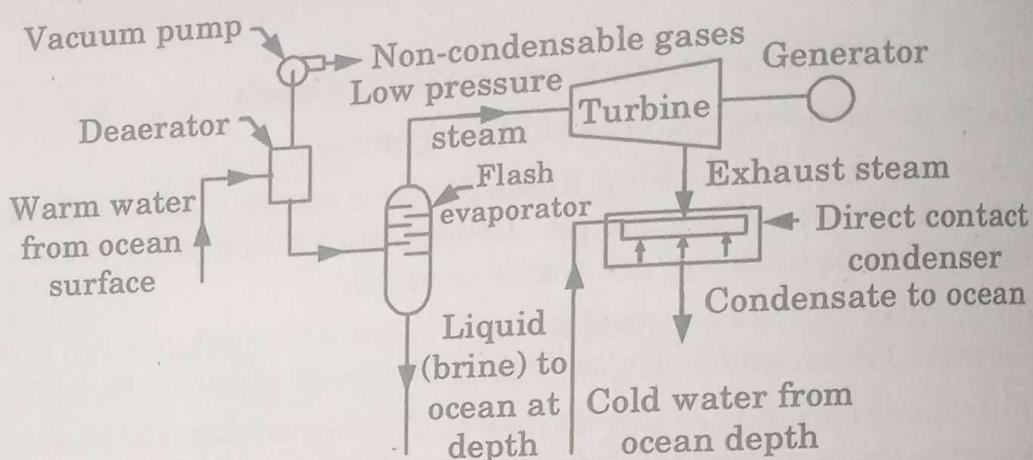


**Fig. 4.20.1. Closed or Anderson cycle OTEC plant.**

**b. Open Cycle or Claude Cycle OTEC System :**

1. In this system, the warm water from ocean surface is admitted through the deaerator to the flash evaporator which is maintained under high vacuum.
2. As a result, a low pressure steam is generated due to throttling effect and the remainder liquid is discharged back to the ocean at high depth.
3. The deaerator also removes the dissolved non-condensable gases from water before supplying to the evaporator.

4. This low pressure steam having very high specific volume is supplied to turbine where it expands and the mechanical power so developed is converted into electrical power by the generator.
5. The exhaust steam from turbine is discharged into a direct contact type heat exchanger and mixes with the cold water drawn from ocean at a depth of about 1 to 2 km.
6. The mixture of condensed steam and ocean cold water are discharged into the ocean.



**Fig. 4.20.2. Open or Claude cycle OTEC system.**

## PART-6

### Tidal Power.

#### Questions-Answers

#### Long Answer Type and Medium Answer Type Questions

**Que 4.21.** What are tides ? How they are formed ?

#### Answer

1. Tides are generated by the action of gravitational forces of the sun and the moon in the ocean, by the spinning of the earth about its axis and the relative positions of the earth, moon and the sun.
2. The highest level of tidal water is known as high tide and the lowest level of tidal water is known as low tide.
3. The level of difference between high and low tides is called tidal range.
4. The tides are the periodic vertical rise and fall of ocean water.
5. The tidal rise and fall of water accompanied by periodic horizontal to and fro motion of water is called tidal currents.

The tidal currents flow in horizontal direction and have kinetic energy. This energy is called tidal current energy.

The rise and fall of the water level follows a sinusoidal curve.

Point A indicates the high tide point and B indicates low tide point.

The tidal range ( $R$ ) is the difference between consecutive high tide and low tide water levels.

$$R = (\text{High tide level}) - (\text{Low tide level})$$

Lunar day 24.83 hour

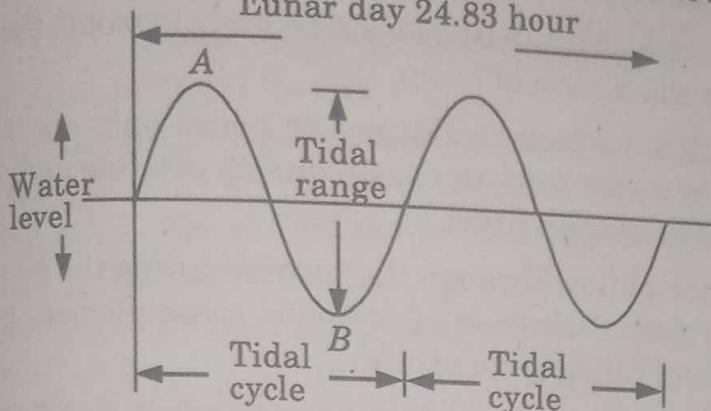


Fig. 4.21.1.

**Ques 4.22.** Explain with sketches the various methods of tidal power generation. Write the advantages and limitations of tidal power.

OR

How tidal power plants are classified and what are the limitations of tidal power plant ?

AKTU 2019-20, Marks 10

**Answer**

Principle : To utilize tidal energy, water must be trapped at high tide behind a dam or barrage and then made to drive turbine as it returns to sea during low tides. The available energy is proportional to the square of the amplitude.

Components of Tidal Power Plant : Main components of a tidal power plant are :

Barrage : It is a dam of low head and requires the following features :

Less sloopy towards the ocean and basin side.

It should be able to withstand the shock load of tides and wave.

Low height and shorter in length to minimize the cost of construction.

Steel foundation frame and channels are embedded in the ducts within the barrage for turbine and gates steel foundation.

Sluice Gates : These gates are opened by water pressure and no mechanical means is required.

Turbine : The Kaplan or bulb type turbine is used to operate with low head and the entire turbine generator unit is submerged in the water.

4-24 G (ESC-Sem-3 & 4) Conventional & Non-Conventional Energy Sources

- d. **Basin :** The basin can be single, pair or multiple types and have different designs.
- C. **Working of Tidal Power Plant :**
  1. The working of tidal power plant is described according to the type of basins.
  2. Following two types of basin system are as follows :
  - a. **Single Basin System :**
    1. In a tidal power plant (based on single basin system), the power house is situated at the mouth of basin.
    2. The hydraulic turbine in the power house only operates during the discharge of water from the basin during ebb tide and during the high tide the basin is again filled.
    3. The direction of flow through the turbine during the ebb and flood tides alternates and generation of power is accomplished, both during the emptying and filling cycle of basin.
    4. Though the double cycle system has only short duration interruptions in turbine generator operation, but the continuous power generation is still not possible.
    5. Further, the power generation coincides occasionally with the peak power demands. This problem is overcome in double basin system.

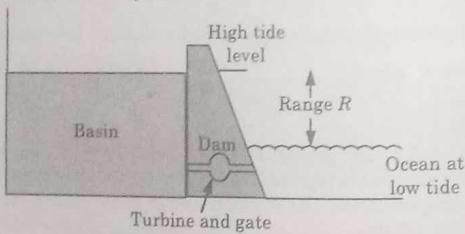


Fig. 4.22.1. Single basin system.

b. **Double Basin System :**

1. This system has two basins at different levels and a dam is provided in between these basins.
2. Inlet and outlet sluice gates are provided in the dam and the water level in upper basin is maintained above the level of water in the lower basin.
3. When the water level in upper basin is maximum during high tide, the inlet sluice is closed and the level of water in lower basin keeps on rising due to discharge of water by the turbine.
4. When the level of water in lower basin equals during the ebb tide, the outlet sluice is opened and it is closed when the water level reaches to its minimum level which is equal to the level of water in upper basin.
5. Again the inlet sluice is opened and the cycle is repeated.

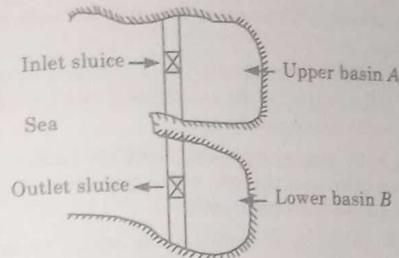


Fig. 4.22.2. Double basin system.

D. **Advantages of Tidal Power :**

1. Protection of coastline against damage from high storm tides by providing a barrage.
2. The main advantage of tidal power plant is that it is inexhaustible.
3. It produces electricity reliably.
4. It is unaffected by the changing mood of the nature such as failure of monsoon.
5. It is pollution free.

E. **Limitations of Tidal Power :**

1. Initial capital cost of plant is very high and needs long constructional period.
2. Output power is variable due to uneven operation.
3. Sedimentation of basin is a serious problem.
4. Due to variable tidal range, the efficiency of plant is affected.
5. Marine life is affected.

**PART-7**

Wave Power.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.23. Discuss the working principle of wave energy conversion system.

**Answer**

1. Ocean waves are created by wind interaction with the ocean surface and are an indirect form of utilizing the solar energy, because the wind

- is created by pressure differences in the earth atmosphere due to unequal solar heating.
2. The energy transferred to water by wind is kinetic as well as potential energy and it depends upon the wind speed, blowing time of wind, and distance of wind travel over the sea.
  3. The blowing wind creates a pressure over the surface of ocean water and air pushes down each particle, which again comes up. So, it actually moves up and down in circular path.
  4. Every particle passes on its motion to the next. This movement of the water particles produces a pattern, which we see as wave.
  5. These waves travel a long distance as they propagate and are continuously strengthened by the new wind as they pass and retain their energy even winds die down.
  6. The ocean wave energy is created because of periodic to and fro, up and down motion of water particles in the form of progressive waves.
  7. It is important to note that water does not travel with wave while the disturbance or wave travels in wind direction.
  8. The height of the wave depends on the speed of the wind.
  9. These waves develop for few seconds and get superimposed on ocean water.
  10. The power potential of these waves can be converted to electricity by mechanical means and harnessing this oceanic energy of waves has been developed over past 30 years using wave machines.

**Que 4.24. | What are the advantages and disadvantages of wave power ?**

**Answer**

**A. Advantages of Wave Power :**

1. It is a concentrated form of energy and can naturally accumulate over time.
2. It is an ecofriendly renewable source of energy.
3. No space coverage on land as required by wind and solar devices.
4. Large concentrated power carried in wave's motion.
5. The running cost is negligible as this energy is available free of cost.

**B. Disadvantages of Wave Power :**

1. The device operates in ocean and needs consideration for construction, maintenance, and reliability.
2. Capital cost of system is high.
3. Problem in maintenance occurs.

**PART-8***Hydropower.***CONCEPT OUTLINE**

**Hydropower :** It is the power derived from the energy of falling or fast running water which may be harnessed for useful purpose.

**Application of Hydropower :**

1. Controlling the floods in the rivers.
2. Storage of irrigation water.
3. Storage of the drinking water supply besides generation of power.

**Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 4.25.** What do you mean by hydroelectric power plant ?

**Answer**

Hydroelectric power plant converts the hydraulic energy of water into electrical energy.

The level of any place is higher than sea level, thus rain water falling over the earth's surface possesses potential energy relative to sea or ocean and flows towards sea.

This datum (potential) energy (head) of rain water available at appreciable vertical height is converted into mechanical energy by allowing the water to flow through the hydraulic turbine runner.

The mechanical energy is then utilized to run an electric generator coupled to the turbine shaft.

Hydroelectric projects have long useful life extending over 50 years and help in opening of avenues for the development of remote and backward areas.

Nearly 20 percent of the total power requirement of the world is met by hydroelectric power plants.

**Que 4.26.** Give general layout and function of essential element of hydroelectric power plant.

**Answer**

- A. General Layout :** Fig. 4.26.1 shows a general layout of a hydroelectric power plant in which an artificial storage reservoir formed by constructing dam has been shown.

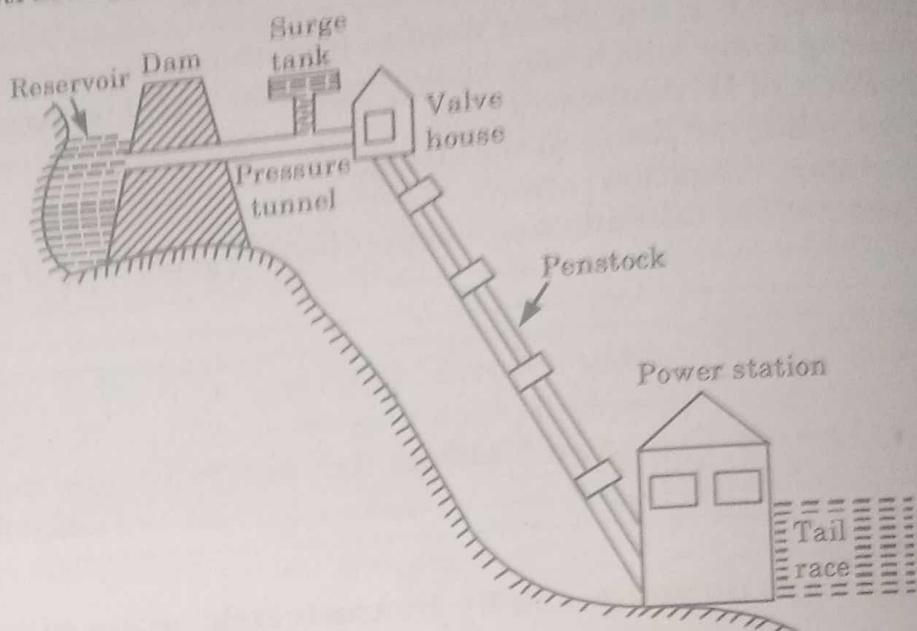


Fig. 4.26.1. General layout of a hydroelectric power plant.

- B. Functions of Essential Element of Hydroelectric Power Plant:**
- Reservoir :** Its purpose is to store water which may be utilised to run the prime mover to produce electrical power.
  - Dam :** The function of dam is to provide a head of water to be utilised in the water turbine.
  - Trash Rack :** The purpose of providing a trash rack is to prevent entr debris which might damage the wicket gates and turbines runners or mean choking of nozzles of the impulse turbines.
  - Forebay :** The forebay serves as a regulating reservoir storing water temporarily when load on the plant is reduced and providing water for initial increase on account of increasing load during which time water in the canal is being accelerated.
  - Surge Tank :** This may be considered as an additional storage space near the turbine, usually provided in high head, medium head plants when there is a considerable distance between the water source and the turbine which necessitates a long penstock.
  - Penstock :** It is a conduit system for taking water from the intake works and forebay to the turbines.

- vii. **Spillway :** This may be considered a sort of safety valve for a dam. A spillway serves to discharge excess in the reservoir beyond the full permissible level.
- viii. **Power House :** It is generally located at the foot of the dam and near the storage reservoir.
- ix. **Prime mover :** The purpose of prime mover is to convert kinetic energy of water into mechanical energy.



# 5

UNIT

## Implications of Holistic Understanding of Harmony on Professional Ethics

### CONTENTS

- |          |  |                |
|----------|--|----------------|
| Part-1 : | Natural Acceptance of Human Values .....   | 5-2Y to 5-3Y   |
| Part-2 : | Definitiveness of Ethical Human Conduct and Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order ..... | 5-4Y to 5-6Y   |
| Part-3 : | Competence in Professional Ethics .....  | 5-6Y to 5-12Y  |
| Part-4 : | Case Studies of Typical Holistic Technologies, Management Models and Production Systems .....  | 5-12Y to 5-16Y |
| Part-5 : | Strategy for Transition from the Present State to Universal Human Order .....  | 5-16Y to 5-20Y |

5-1 Y (CC-Sem-3 & 4)

5-2 Y (CC-Sem-3 & 4)

Implications of Holistic Understanding

PART - 1

Natural Acceptance of Human Values  
Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.1. What are the values in interaction of human beings with the material things? Give one example of each.

AKTU 2018-19(IV), Marks 07

What is utility value and artistic value? How are both important in human life? Explain with example.

OR

'When there is no utility, there is no scope for art too'. Explain.

OR

- Answer**
1. Competence of living in accordance with universal human values or the participation of a unit in the larger order- its natural characteristics or svabhava.
  2. Values are a part of our ethical conduct. They are the natural outcome of realization and right understanding, which are always definite.
  3. Values need not to be imposed through fear, greed or blind belief.
  4. The vastu mulya (values of Human Being in the Interaction with the Rest of the Nature) is the participation of the human being with the rest of the nature. It is further categorized as:
    - i. Utility Value (Upyogita Mulya) : The participation of human being in ensuring the role of physical facility in nurture, protection and providing means for the body.
    - ii. Artistic value (kala mulya) : The participation of a human being in ensuring the role of physical facility to help and preserve its utility.
  5. For example, the utility value of a pen is that it aids in writing. This provides a means to the body.  
Providing a cap to the pen so that the ink does not spill, a proper design for holding of the pen while writing, etc., preserve the utility of the pen.
  6. A shirt has the utility that it protects the body. This is its utility value. Designing the shirt so that it can be easily put on is the artistic value.

**Que 5.2.** List some suggestions to make value education more effective in the present scenario. **AKTU 2017-18(III), Marks 07**

**Answer****Ways for Promoting Value Education :**

1. The value orientation should become the main focus of our educational system. In providing education for values whole of the society should be involved. The emphasis should be on moral development of the students.
2. Value education cannot be provided through proper text book but with inspiration and initiative of the teachers, the can be taught in a proper way. There are some ways for providing value education for the students. These are as follows.
3. Social and ethical values, examples from day-to-day situations, extracts from sayings of great even, incidents and problems which develop values judgments among the pupils, poems, religious stories etc., can be taught to the students.
4. In school yoga and other religious activities like - pray to god, social service etc. can be taught to the students in the classrooms. Group activities like cleaning the school camps, visiting slums, service campus, visits to hospitals, visits to place of worship of different faiths should form part of content in value education.
5. 'Personality Development Retreats' could be held to enable the students to develop self-control, punctuality, sharing and caring respect for other faiths, cooperation etc.
6. There should be an integrated approach in the value oriented educational programme. There should be foundation courses both at the secondary schools and universities among at giving the children basic knowledge about India its people and cultural tradition.
7. Special schools designed for value oriented education should be established. Every state should have at least one institution which may impart value-oriented education from nursery to the post graduate level.
8. Special teacher orientation programmes should be taken up at the state level to train teachers in the effective methods of development of value among students and teachers.
9. Television which is a craze for the young of today should also be used to present value based programmes through skits, cartoon scripts and such other means. There need not be any special classroom lectures on moral value based education. These values need to be taught through mutual interaction and inter communication.
10. It is never needed to identify any particular religion or faith - god is one and we are all children of the same God - that is the basic lesson that needs to be given.

**PART-2**

*Definitiveness of Ethical Human Conduct and Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order.*

**Questions-Answers****Long Answer Type and Medium Answer Type Questions**

**Que 5.3.** What is ethical human conduct ? Explain in terms of values, policies and character with appropriate examples.

**AKTU 2018-19(IV), Marks 07**

**What do you mean by ethical human conduct ? Explain its relevance.**

**AKTU 2014-15(III), Marks 04**

**OR**  
Explain any five values which are necessary for ethical human conduct.

**AKTU 2016-17(III), Marks 05**

**OR**  
What do you mean by definitiveness of ethical human conduct?  
How can it be ensured ?

**AKTU 2018-19(III), Marks 07**

**OR**  
How does realization and understanding lead to definiteness of human conduct ?

**AKTU 2015-16(III), Marks 10**

**Answer**

**Ethical Human Conduct :** Ethical human conduct can be defined as the combined representation of values, policy and character which is acquired through right understanding and self-exploration. It is universal in nature and is in combination with universal human values. It is also called definite human conduct. When we acquire right understanding we are able to bridge the gaps between our present conduct and ethical human conduct. We can say a person is conducting himself/herself ethically. Also when they :

1. Respect humanity, not be in conflict with societal norms, not steal, kill, fraud and should be honest.

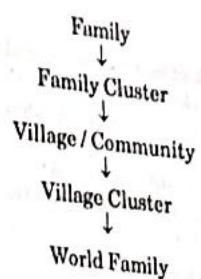
### 5-5 Y (CC-Sem-3 & 4)

- Universal Human Values & Professional Ethics**
2. Do not have conflict with the self "I" at an individual level.
  3. When they have established right understanding and are in harmony with the rest of the orders of the universe such as essential equality of all men and women, human or natural rights, obedience to the law of land concern, safety etc.
  4. Work towards enrichment of the rest of the nature.  
But unless we have the right understanding, we are not able to identify the definitiveness of ethical human conduct. It can be understood in terms of the following:
    - i. **Values (Mulya)** : Competence of living in accordance with universal human values or the participation of a unit in the larger order- its natural characteristics or svabhava is known as values. Values are a part of our ethical conduct.
    - ii. **Policy (Niti)** : policy is the decision (plan, program, implementation, results, evaluation) about the enrichment, protection and right utilization of the resources (self, body and wealth - mana, tana and dhana).
    - iii. **Character (Charitra)** : The definiteness of my desire, thought and selection gives definiteness to my living. Definiteness of character is the outcome of the definiteness of my behaviour and work.
  5. Five values which are necessary for ethical human conduct are :
    - i. **Love** : Unconditional and unselfish care.
    - ii. **Peace** : Control the mind.
    - iii. **Truth** : Indispensable ethical discipline.
    - iv. **Non-violence** : It means respect for life and recognition of rights of others.
    - v. **Right conduct** : Truth in action is right conduct.

### 5-6 Y (CC-Sem-3 & 4)

#### Implications of Holistic Understanding

- is necessary. A correct appraisal of our surrounding will lead to help us to find a viable alternative of prevailing pattern of human living.
3. Human beings need to move from family to world family to achieve this harmony.



### Que 5.5. Discuss Humanistic education and Humanistic Constitution.

#### Answer

##### Humanistic Education :

1. The basis for humanistic education is the transformation from animal consciousness to human consciousness.
2. Now a days man has exploited the natural resources, so much that there is danger of human survival and national resources are over exploited.
3. By human consciousness we can think that our actions should be checked and we should take action in such a way that nature is source and earth should be a good place to live.

##### Humanistic Constitution :

1. It is the set of policies for humans to follow for the welfare of mankind. It makes possible the co-ordination and fulfillment of the human order. With the other three orders viz., material order, pranic order and animal order. Human constitution is the human framework living harmonious life with himself and with entire existence.
2. Thus these are the basics for humanistic education and humanistic constitution.

### PART-3

#### Competence in Professional Ethics.

#### Questions-Answers

#### Long Answer Type and Medium Answer Type Questions

**Que 5.6.** How will you define work ethics? Discuss the guidelines for work ethics.

AKTU 2014-15(IV), Marks 04

**Answer**

**Work ethics :** Work ethics can be defined as the moral benefit we can derive from hard work and diligence. Work ethic not only includes ones feeling or opinion about their occupation and the workplace, it also involves their attitude towards their professional responsibilities, communication skills, interactive skills and their devotion to their profession. Work ethic demonstrates the inherent qualities of the professional's character.

**Guidelines for work ethics :**

1. Maintain a friendly relationship with clients, consultants, contractors and other people associated with the company.
2. Should abide by the legal norms applicable to their business ventures.
3. Should not take bribe or offer bribe in forms of meals, gifts or entertainments.
4. Should guard all confidential and propriety information.
5. Should not have conflict of interest with the employer, and must remain faithful.
6. Should cautiously use the employer's assets.

**Que 5.7.** What do you understand by professional ethics ?

Explain.

**Answer**

**Professional Ethics :**

1. Professional ethics refers to the code of conduct, moral ideals and policies, any professional should follow.
2. It is the ethical obligation that people in a profession have to follow, due to their professional status.
3. It is the activity and discipline aimed at understanding the moral values associated with any particular profession.
4. Every occupation has its own set of ethical obligation.
5. For the engineering profession it can also be termed as engineering ethics. It is not a fixed text to be learnt once. One has to review it constantly against changing standards.

AKTU 2018-19(IV), Marks 07

**Que 5.8.** What are the reasons of unethical practices in profession OR Critically examine the issues in professional ethics in the current scenario. List any five unethical practices in profession today and the methods being tried to curb them.

Elaborate on any two practices that are unethical but still quite prevalent in profession today. Suggest few measures to solve the problems in a sustainable way.

OR  
Mention some of the unethical practices in society today. How do the prevailing world views lead to such unethical practices?

**Answer**

1. The driving ethos in the present times has the thrust upon wealth accumulation and profit maximization. It is a widespread tendency to consider these as the parameters of happiness and prosperity.
2. Now a days people consider happiness in terms of maximization of sensory enjoyment therefore the motivation is that of wealth accumulation. This is resulting in hazardous consequences.
3. The present trend is to have narrow world view and care for interests of personal gain and forgetting the benefit and interests of world family and nature.
4. Some of the major unethical practices prevailing in today's world are :
  - i. Corruption in various forms also hawala and benami transactions.
  - ii. Misappropriation of funds and tax evasion.
  - iii. Cut throat competition and exploitation at various levels.
  - iv. Misleading propaganda by way of unethical advertisement.
  - v. Activities contributing to global warming and other natural disasters, like oil leakage in sea, Bhopal gas tragedy, etc.
  - vi. Hunger, poverty, illiteracy.
  - vii. Endangering health and public safety.
5. We can feel the malaise of these actions all around us. We can take some measures to control the situation which is running out of hands. For example :
  - i. We need to emphasize on the importance of professional ethics and create more awareness.
  - ii. Prescribe stricter code of conducts for specific profession and teach people that profession should be looked upon essentially as a service.

- iii. Organizations should set up more monitoring activities.
- iv. Promoting transparency in the systems.
- v. Filing public interest litigations.
- vi. We can only curb the ill effects by the above mentioned methods. But the root cause behind all these malaises can be treated only by change in the world view. We have to create awareness so that people do not follow the wrongly perceived notions of happiness and prosperity. This can only be achieved through right understanding.

**Que 5.9.** What are the characteristics of people-friendly & Eco-friendly production system which is sustainable ?

AKTU 2017-18(IV), Marks 07

**Answer**

A. Characteristics of People-Friendly Production System :

1. Resilience : The art of pushing through even when things get a bit dark.
2. Empathy : The ability to connect compassionately and identify with the unique experiences of others.
3. Patience : Keeping cool when things don't automatically go your way.
4. Sacrifice : Forgoing your own satisfaction for someone else's.
5. Politeness : Learning manners and being considerate of others.
6. Humour : Seeing the funny side of situations and being able to laugh at oneself.
7. Self-awareness : Being accountable for your actions by being connected to who you are.
8. Forgiveness : Cutting others slack and excusing errors when possible.
9. Hope : The belief in all the great things that are yet to come, and knowing that there is something better on the horizon.
10. Confidence : Having the ability to believe in yourself and taking risks.

B. Characteristics of Eco-Friendly Production System :

1. Reduction in CO<sub>2</sub> Emissions : Rengo is actively introducing energy-efficient facilities and adopting less harmful, clean energy sources, as part of its efforts to reduce CO<sub>2</sub> emissions, which have a significant impact on the global environment.
2. Waste Reduction : Trimming waste, the most common type of waste generated by corrugated plants, is recycled back into containerboard at Rengo's paper mills.
3. Prevention of Air and Water Pollution : Water is a vital resource used in the production of paperboard. We have long been looking into ways to utilize water effectively at our paper mills, where water is currently used for ten cycles on average.

**Que 5.10.** What do you mean by competence in professional ethics?

Elaborate with examples.

AKTU 2016-17(IV), Marks 15

What do you mean by competence in professional ethics? Give two examples of its implication in industry.

AKTU 2018-19(III), Marks 07

**Answer**

Competence in Professional Ethics :

1. Professional ethics means to develop professional competence with ethical human conduct.
2. Developing ethical competence to the individual (profession) is the only effective way to ensure professional ethics. The development of ethical competence is a long term process to be achieved through appropriate value education. As profession is only a subset of the life of one's right understanding.
3. The salient features characterizing this competence can be summarized as follows :
  - i. Clarity about comprehensive human goal : Samadhan - Samadhi - Abhay - Sahastitva and its fulfillment through universal human order.
  - ii. Confidence in oneself : Based on the right understanding of oneself and the rest of existence.
  - iii. Mutually fulfilling behaviour : Clarity and confidence in ethical human conduct and its correlation with sustained personal as well as collective happiness and prosperity.
  - iv. Mutually enriching interaction with nature : Self-sufficiency in fulfillment of physical needs; ability to assess the needs for physical facilities for the family and their fulfillment through production systems ensuring harmony in the nature. In the light of the above, one acquires the ability to identify and develop appropriate (people-friendly and eco-friendly) technologies, production systems etc.

**Que 5.11.** What is ethical competence or value competence of an individual ?

**Answer**

Ethical Competence or Value Competence : Ethical competence or value competence is a manifestation of one's right understanding. It is a long-term process which can be achieved through appropriate value education. Ethical competence can be achieved through :

1. Clarity about comprehensive human goal.
2. Confidence in one self and believe in harmony and co-existence. Faith in the concept of family to world family.
3. Confidence and clarity in ethical human conduct and competence in mutually fulfilling behaviour.
4. Competence of mutually enriching interaction with nature.
5. Competence of one's understanding in real life.

**Que 5.12.** How do human values affect the life of professionals?

AKTU 2015-16(IV), Marks 05

Illustrate.

**Answer**

- i. Quality of life is largely affected by the work by which we earn our livelihood. Our work shapes our attitudes and personality. We often have conflicts between individual value and value in work life. These conflicts can be categorized under the following:
  - i. Attitudes to work
  - ii. Work ethics and quality of work life
  - iii. Organizational values
  - iv. Pursuit of excellence.
- ii. **Attitudes To Work :** Why do we work? We work to earn our living and support our family. Work is a necessity, rather it is a compulsion. At the second level work means gaining social prestige, esteem and authority. Farmers, artisans, labourers have a lower social status than managers, business owners, bureaucrats and politicians who enjoy a higher status in the society. At the third level through work we use our talent, sharpen our skills and develop our creativity and get opportunity to learn, grow and improve our knowledge, skills and human relationship. It is said, Work is Worship meaning, our work in reality, is an offering (PUJA) to Good.
- iii. **Work Ethics And Quality of Work Life :** A worker is paid his salary/wages and in return he is expected to contribute his best to the organization. Without such an ethical consideration the employer/employee relationship becomes exploitative with little trust and cooperation between them. The second dimension of work ethics is a sense of loyalty to the organization. A loyal employee does not promote his personal interest at the cost of the organization. The third dimension is that the organization must have a written, as well as, an unwritten rules/norms and ways of working. Team working and team spirit are the essential strengths of a successful organization. Personal honesty and integrity are most important. The following attitudes must be avoided:
  - a. Misrepresentation of facts

- b. Going back on words and promises
- c. Promoting selfish or hidden agenda
- d. Corruption and bribery
- e. Scams, frauds, kick-backs, accepting gifts, favors, even donation for charities etc.
- iii. **Organizational Values :** Organizations are Social and Human units, purpose of a business is not just making profit; the fundamental value lies in the special worth of its products/services and its impact on quality of life. Man must eat to live but man does not live only to eat. A good organization should be good to the corporate citizen. It should obey laws, pay taxes, preserve the environment, help solve community problems, have due regard to national problems and priorities and share its earning culture. We must discourage vices like jealousy, back biting, destructive competitiveness etc.
- iv. **Pursuit of Excellence :** Excellence means achievement of exceptional accomplishments or success and getting excellent result from life as a whole. Chances of failure are always there. Hence, desire for success is always associated with anxiety. In reality at times achieving a goal becomes so important that any means fair or foul are adopted. Foul means include Bending rules/regulation, Cutting corners, Exploiting other, Offering bribes etc.

**PART-4**

Case Studies of Typical Holistic Technologies, Management Models and Production Systems

Questions-Answers

Long Answer Type and Medium Answer Type Questions

**Que 5.13.** Analyze the importance of holistic technology in the current scenario with different examples.

AKTU 2016-17(III), Marks 05

**Answer**

**Importance of Holistic Technology :**

1. A holistic model is inherently conducive to the comprehensive human goal.

2. The three broad criteria to guide the development of such technologies and systems are :
  - i. In accordance to appropriate needs and life styles.
  - ii. People-friendly
  - iii. Eco-friendly
3. **Evaluation Criteria for Technologies :** The technology adopted must fulfill the following criteria :
  - i. It should satisfy the real human needs.
  - ii. Compatible with nature.
  - iii. It must promote the use of renewable resources of energy.
  - iv. Low cost and energy efficient.
  - v. Safe and people friendly.
  - vi. It must not harm health.
  - vii. The products must be recyclable.
  - ix. Effective utilization of human body, plants, animals and material.
4. Some of the technologies and production systems which are based on Holistic systems are as follows :
  - i. Solar energy devices.
  - ii. Green building materials and techniques.
  - iii. Water shed management.
  - iv. Bio-mass based energy technologies.
  - v. Eco-friendly agriculture.
  - vi. Eco-sanitation technologies.

**Que 5.14.** How does the career interest of a professional be reconciled with organizational values ?

AKTU 2015-16(IV), Marks 05

**Answer**

1. The policies, character and general conduct of our day to day life is reflected in our professional life as well. An individual should adhere to the rules and regulations set by the organization they are employed in. Professional ethics are learnt by reviewing a person's behaviour against constantly changing surroundings and standards. A good professional should :
  - i. Maintain a friendly relationship with clients, consultants, contractors and other people associated with the company.
  - ii. Should abide by the legal norms applicable to their business ventures.

5.14 Y (CC Sem 3 & 4)

Implementation of Holistic Understanding

- ii. Should not take bribe or offer bribe in forms of meals, gifts or entertainments.
- iv. Should guard all confidential and proprietary information.
- vi. Should not have conflict of interest with the employer, and must remain faithful.
- viii. Should cautiously use the employer's assets.
2. A professional should not feel hurt if he or she acknowledges that he or she needs help. A professional carries additional more of responsibilities towards their employer. As professionals are trusted people they have to take decisions and make informed choices when situations demand. They are people vested with authority and power. They are representatives of the organization they are working with. A good professional always realizes that he is working with the client's trust. Therefore he/she always works upto their full potential. Therefore he/she is sensitive, responsive, energetic, tireless and dynamic in profession, passionate to commitment and loyal to his/her team and associates.

**Que 5.15.** Which professional you will choose for his/her services, a person with understanding of value education and living accordingly or without it ? What about you when you will offer a service to other ?

AKTU 2017-18(IV), Marks 07

**Answer**

1. The real way to ensure ethical conduct of profession is to have a correct understanding of profession, a correct understanding of happiness and prosperity and then to develop the competence to fulfill this notion.
2. The whole purpose of value education is to enable the development of this understanding and competence which is essential to ensure professional ethics.
3. Hence we will choose a professional with understanding of value education and living accordingly for his/her services.
4. When I will offer my services to other I will also offer it with understanding of value education.

**Que 5.16.** Discuss the features of an ideal management model.

**Answer**

**Features of an Ideal Management Model :** The management should always keep in mind that they not only need to keep the user satisfied but also fulfill the needs of people involved in the production process. An idealistic or humanistic management model should therefore have :

1. A whole-unit of workers working together with a feeling of brotherhood.
2. The management should be cooperative to the needs of the workers and should motivate them to work better.
3. Regular and fair appraisal of hard work.
4. Consumer satisfaction should be the key goal and not profit maximization.
5. Continuous value addition to the working system.
6. Effective integration of individual competencies.

By improved management models we can attain rewards for all those who were involved in the process.

**Que 5.17.** Imagine that you have joined at middle management level in an organization where you find unethical practices prevalent. How will you proceed to promote ethics among your colleagues? Mention a few steps you may take to improve the situation without creating an atmosphere of opposition.

AKTU 2017-18(III), Marks 07

**Answer**

1. Promoting ethics in the workplace creates a positive culture for managers and employees, as well as a successful business. Businesses with strong workplace ethics add value to the organization and support an environment where employees feel safe and valued.
2. Following are the list of practices for management to help create a more ethical workplace culture :
  - i. **Be a Role Model and Be Visible :** Employees look at top managers to understand what behaviour is acceptable. Senior management sets the tone for ethics in the workplace.
  - ii. **Communicate Ethical Expectations :** An organizational code of ethics can reduce ethical ambiguities. The code of ethics should state the organization's primary values and the ethical rules that employees are expected to follow. Managers should remember that a code of ethics is worthless if leaders fail to model ethical behaviours.
  - iii. **Offer Ethics Training :** Managers should set up seminars, workshops and similar programs to promote ethics in the workplace. Training sessions reinforce the organization's standards of conduct, to clarify what practices are and are not permissible, and to address possible ethical dilemmas.
  - iv. **Visibly Reward Ethical Acts and Punish Unethical Ones :** Performance appraisals of managers should include evaluations of how actions measure up against the organization's code of ethics. Appraisals need to include how managers achieve these goals, as well as the goals themselves.

Implications of Holistic Understanding

- v. **Provide Protective Mechanisms :** The organization needs to provide formal mechanisms that allow employees to discuss ethical dilemmas and report unethical behaviour without fear of reprimand. This could include developing roles for ethical counselors, ombudsmen or ethical officers.
- vi. **Enhancing the Workplace :** A better workplace requires leaders to model behaviour in every aspect of their role. In your career, the ability to demonstrate leadership with a sound ethical basis is essential to your success for any role.

**PART-5**

Strategy for Transition from the Present State to Universal Human Order.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

**Que 5.18.** What are strategies for transition from the present state to universal human order?

AKTU 2017-18(IV), Marks 07

**Answer**

1. Transition is a gradual change for the betterment. In the present situation we need to strive for a better situation which may prove beneficial for us. The main step towards transition is adequate realization of the need for the self exploration.
2. We have learnt that we need to change the dominant world view which is based on material comforts and sensory privileges. The consumerist and profit making attitude will have to be left behind to make way for comprehensive human goal to be implemented at all levels. This transition can be achieved by the following steps :
  - i. **Promoting Mass Awareness and moving towards Humanistic Education :** Awareness has to be created so that people accept that we need to work towards eco-friendly measures. Individual professionals like engineers, doctors, business managers should take the responsibility on them to put emphasis upon the importance of human value and professional ethics. Journalists can also help in creating awareness through their writings.
  - ii. **Developing Holistic Model of Living :** To bring about this transition we need to develop holistic technologies, production systems and

management models. For this engineers will have a huge responsibility on their shoulders. They can work towards simple, cheap, efficient, pollution free and renewable resources as source of energy. The production systems can be environment friendly. The production processes can be made safe for the workers, consumer and also for the nature. Care should be taken to manage industrial waste.

**iii. Implementing Strict Policies and Social System :** With right understanding the economic, social and political systems should be based on the comprehensive human goal. Government officials and legislators can pass strict laws for defaulters.

The problem we are facing is of urgent global concern. Delaying in finding a solution can prove to be a threat to our own survival. If we make a dedicated effort to bring about a change in the human consciousness focus on humanistic education and right understanding we should be able to make this world a better place to live.

**Que 5.19.** Critically examine the role of 'madness for profit' in human being for the destruction of other three orders of nature.

**AKTU 2014-15(III), Marks 04**

**Answer**

1. The innate harmony and orderliness in the universe exists already, it cannot be created by human beings.
2. When human beings tamper with certain natural phenomena they disturb it and as a result this harmony is also disturbed. Earth's natural environment has been under threat due to deforestation, pollution and oil spills.
3. Many birds and animals are getting extinct due to such activities. In absence of the innate harmony and orderliness there will be no happiness and prosperity.

**Que 5.20.** What do you mean by sustainable development ?

Discuss.

**AKTU 2014-15(IV), Marks 04**

**AKTU 2017-18(III), Marks 10**

**Answer**

**Sustainable Development :**

1. Sustainable development is often defined as 'wise use of resource such that it meets the present need without disturbing future generation'.
2. Sustainable development adopts a number of guidelines that were governed by local ecological condition and the environment as whole.

3. For instance, sustainable agriculture involved a choice of the crop that most suited a particular season, soil and water regime.
4. It also makes use of organic manure and organic pesticides.
5. It has shown the way to a system of producing food that is least determined to the environment.
6. Hence, sustainable development works on the principle of ecological cycle. It realizes the dynamic nature of ecosystems.
7. Hence, sustainable development works on the principle of ecological cycle.
8. It realizes the dynamic nature of ecosystems.
9. Sustainable development is the organizing principle for meeting human development goals while at the same time sustaining the ability of natural systems to provide the natural resources and ecosystem services upon which the economy and society depend.
10. The desired result is a state of society where living conditions and integrity and stability of the natural system.
11. Sustainable development can be classified as development that meets the needs of the present without compromising the ability of future generations..

**Que 5.21.** Compare any three inputs that you got through this course with your earlier pre-conditionings and explain how this will help you play a meaningful role in the society at large after you graduate.

**AKTU 2014-15(III), Marks 04**

**Answer**

1. The solution to this problem is to start verifying our desires, thoughts and expectations on the basis of our natural acceptance. Since the natural acceptance of each of us is constant and unchanging, this is what we should be verifying our desires against. Once we access our natural acceptance, we have the right understanding of the harmony at all levels of our living. This results in us being able to see our 'true nature' and understand what we truly want. So our desires start getting set on the basis of our right understanding. Since our right understanding is based on harmony at all levels of being, which is definite, our thoughts, desires and selection become aligned with this right understanding. This puts an end to all conflicts, contradictions and unhappiness. Thus, there is harmony within us, within our family, within society and nature in general.
2. Realization and understanding are two very important aspects of this state of harmony. Realization means the ability to 'see' the reality as it is.

- Understanding means to be able to see the way all levels of our being are linked together in a harmonious manner. So, working on the basis of our natural acceptance in other words means working on the basis of our realization and understanding. The process then is this: with realization and understanding, our desires or imagination gets set according to right understanding. Consequently, our analyzing takes place according to the desires/imagination, which in turn leads to thoughts/analysis becoming the basis for expectations or selection/taste. This process leads to svatantrata or self-organization. This state of being self-organized leads to continuous happiness as we are able to understand the harmony at all levels of our living and all desires, thoughts and expectations become definite. Most importantly, both realization and understanding help us to have certainty in our behaviour, which helps to reduce contradictions and the resulting unhappiness.
3. Thus, living with definiteness is the direct result of realization and understanding. But the problem is that both these activities are not yet activated in most of us. Once we 'activate' these two activities, the process of self-exploration begins, which leads us to understand our natural acceptance.

**Que 5.22.** Explain Maslow's Hierarchy of needs.

AKTU 2018-19(III), Marks 07

**Answer**

**Maslow's Hierarchy of Needs :**

1. Maslow's hierarchy of needs is a motivational theory in psychology comprising a five-tier model of human needs, often depicted as hierarchical levels within a pyramid.
  2. Needs lower down in the hierarchy must be satisfied before individuals can attend to needs higher up. From the bottom of the hierarchy upwards, the needs are: physiological, safety, love and belonging, esteem and self-actualization.
  3. Maslow stated that people are motivated to achieve certain needs and that some needs take precedence over others. Our most basic need is for physical survival, and this will be the first thing that motivates our behavior. Once that level is fulfilled the next level up is what motivates us, and so on.
- i. **Physiological needs :** These are biological requirements for human survival, e.g. air, food, drink, shelter, clothing, warmth, sex, sleep. If these needs are not satisfied the human body cannot function optimally. Maslow considered physiological needs the most important as all the other needs become secondary until these needs are met.
- ii. **Safety needs :** Protection from elements, security, order, law, stability, freedom from fear.

- iii. **Love and belongingness needs :** After physiological and safety needs have been fulfilled, the third level of human needs is social and involves feelings of belongingness. The need for interpersonal relationships motivates behavior. Examples include friendship, intimacy, trust, and acceptance, receiving and giving affection and love. Affiliating, being part of a group (family, friends, work).
- iv. **Esteem needs :** Which Maslow classified into two categories: (i) esteem for oneself (dignity, achievement, mastery, independence ) and (ii) the desire for reputation or respect from others (e.g., status, prestige). Maslow indicated that the need for respect or reputation is most important for children and adolescents and precedes real self-esteem or dignity.
- v. **Self-actualization needs :** Realizing personal potential, self-fulfillment, seeking personal growth and peak experiences. A desire "to become everything one is capable of becoming".

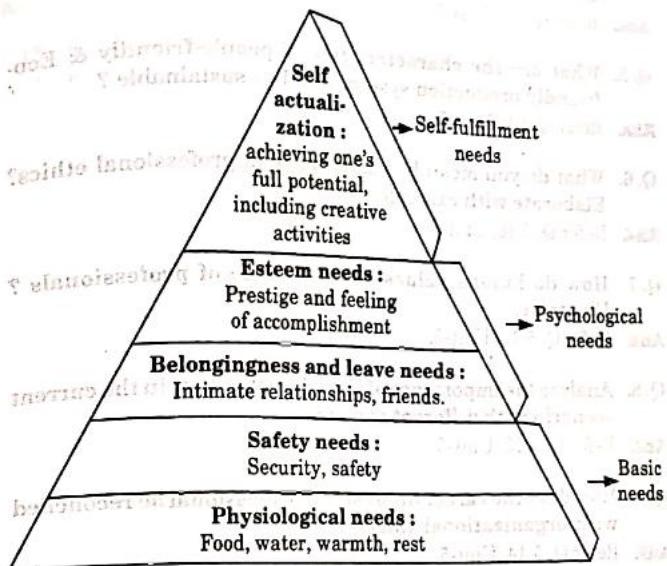


Fig. 5.22.1

**VERY IMPORTANT QUESTIONS**

**Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.**

**Universal Human Values & Professional Ethics**

**5-21 Y (CC-Sem-3 & 4)**

- Q. 1. What are the values in interaction of human beings with the material things? Give one example of each.  
Ans. Refer Q. 5.1, Unit-5.
- Q. 2. What is ethical human conduct? Explain in terms of values, policies and character with appropriate examples.  
Ans. Refer Q. 5.3, Unit-5.
- Q. 3. How will you define work ethics? Discuss the guidelines for work ethics.  
Ans. Refer Q. 5.6, Unit-5.
- Q. 4. What are the reasons of unethical practices in profession today? What is the real solution to the above problems? Give your opinion.  
Ans. Refer Q. 5.8, Unit-5.
- Q. 5. What are the characteristics of people-friendly & Eco-friendly production system which is sustainable?  
Ans. Refer Q. 5.9, Unit-5.
- Q. 6. What do you mean by competence in professional ethics? Elaborate with examples.  
Ans. Refer Q. 5.10, Unit-5.
- Q. 7. How do human values affect the life of professionals? Illustrate.  
Ans. Refer Q. 5.12, Unit-5.
- Q. 8. Analyze the importance of holistic technology in the current scenario with different examples.  
Ans. Refer Q. 5.13, Unit-5.
- Q. 9. How does the career interest of a professional be reconciled with organizational values?  
Ans. Refer Q. 5.14, Unit-5.
- Q. 10. Imagine that you have joined at middle management level in an organization where you find unethical practices prevalent. How will you proceed to promote ethics among your colleagues? Mention a few steps you may take to improve the situation without creating an atmosphere of opposition.  
Ans. Refer Q. 5.17, Unit-5.

**5-22 Y (CC-Sem-3 & 4)**

**Implications of Holistic Understanding**

- Q. 11. What are strategies for transition from the present state to universal human order?  
Ans. Refer Q. 5.18, Unit-5.
- Q. 12. Critically examine the role of 'madness for profit' in human being for the destruction of other three orders of nature.  
Ans. Refer Q. 5.19, Unit-5.
- Q. 13. What do you mean by sustainable development? Discuss.  
Ans. Refer Q. 5.20, Unit-5.
- Q. 14. Compare any three inputs that you got through this course with your earlier pre-conditionings and explain how this will help you play a meaningful role in the society at large after you graduate.  
Ans. Refer Q. 5.21, Unit-5.
- Q. 15. Explain Maslow's Hierarchy of needs.  
Ans. Refer Q. 5.22, Unit-5.





## Introduction (2 Marks Questions)

1.1. What do you mean by values or human values ?

AKTU 2016-17, 2018-19(IV), Marks 02

**ANS:** Values are the main guiding forces in an individual's life. Whatever becomes a means of achieving happiness becomes valuable to us. All our thoughts, behaviour and actions are based on the values that an individual has.

1.2. What is Natural Acceptance ?

AKTU 2015-16(III), Marks 02

OR

What do you mean by your natural acceptance and experiential validation ?

AKTU 2018-19(IV), Marks 02

**ANS:** Natural Acceptance : Natural Acceptance is something that is within us. It is not something that we can find anywhere else. Whatever seems naturally acceptable to us is right and whatever causes confusion or conflict within us is wrong.

Experiential Validation : Experiential validation is a process that infuses direct experience with the learning environment and content.

1.3. What is fundamental value of life ? Elucidate.

AKTU 2015-16(IV), Marks 02

**ANS:** Human values are the positive, desirable qualities of character such as honesty, integrity, tolerance, responsibility, compassion, justice and respect inherent in all human beings. Human values are fundamental to human existence and span across cultures, nationalities and classes. Human values emerge from the following factors :

1. From society
2. Due to one's own awareness, choice and judgment etc.

1.4. What are the five core human values ?

SQ-3 Y (CC-Sem-3 & 4)

Introduction

**ANS:** Five core human values are as follows :

1. Love
2. Truth
3. Peace
4. Right understanding
5. Non-violence

1.5. Describe the basic nature of man. How is it helpful in obtaining Natural acceptance ?

AKTU 2015-16(IV), Marks 02

The needs of human nature can be expressed as tendencies to self-preservation, to preservation of the species and to the acquisition of the material conditions necessary to achieve these needs. Natural acceptance is something that is within us. Whatever seems naturally acceptable to us is right and whatever causes confusion in us is wrong. Basic nature helps human being to decide what is right and what is wrong.

1.6. What is the difference between prosperity and wealth ?

AKTU 2016-17(IV), Marks 02

OR Discuss prosperity.

OR

Define wealth.

**ANS:** Prosperity : Prosperity is the feeling of having or making available more than required physical facilities. To ascertain prosperity, two things are essential :

1. Correct assessment of need for physical facilities.
2. The competence of making available more than required physical facilities.

Wealth : Wealth is a physical thing. It means having money, or having a lot of physical facilities, or both.

1.7. Define SVDD & SSDD ?

AKTU 2016-17(IV), Marks 02

**ANS:** SVDD : SVDD stand for 'SadhanaViheenDukhiDaridra'. He/She does not possess material facilities and happiness and feels materially deficient, unhappy and deprived.

SSDD : SSDD stand for 'SadhanaSampannDukhiDaridra'. He/She does possess material possessions but is still unhappy and feels deprived.

1.8. What do you understand by LOVE ?

AKTU 2016-17(IV), Marks 02

- Ques:**
1. Love : The feeling of being related to all is love (or prema).
  2. The feeling of love leads to an Undivided Society, it starts from a family and slowly expands to the world family. Every human being has natural acceptance for relatedness upto the world family in the form of love.
  3. We start with trust, which becomes foundation for being related to one (Affection), and we reach the state of being related to everyone-Love.
- 1.3. What is the method to fulfill basic aspiration of human-being? Is it same for everyone.

AKTU 2017-18(IV), Marks 02

- Ans:**
1. Right Understanding : Right understanding helps us to decide how we work for physical facilities and maintain feelings of different relationship with others.
  2. Relationship : In nature to create harmony there is a basic need for affectionate relations with other individuals.
  3. Physical Facilities : Physical facilities like food, clothes, shelter and protection are the basic need of all human beings.

#### 1.10. What is Sukh and Daridrata?

AKTU 2015-16(III), Marks 02

- Ans:**
- Sukh :** Sukh results from a variety of feelings that are effortless and comes naturally to us. Trust, honesty, respect, confidence etc., are feelings that we welcome with open arms at all times. They lead us to a state of harmony within us and with others around us.
- Daridrata :** Daridrata is basically deprived of physical facilities in order to satisfy the self and body. Daridrata makes human being unhappy. Human being is coexistence of self and body. The needs of the body can be fulfilled by materials or physical facilities. Lacking of these materials and physical facilities leads to daridrata.

#### 1.11. Which will be true testimony of ethical human conduct for an individual?

- I. Person holding certificate of value education.
- II. Person believes in value education.
- III. Person reflecting his or her behaviour accordingly.

AKTU 2017-18(IV), Marks 02

- Ans:** Person reflecting his or her behaviour accordingly.

#### 1.12. Verify proposal, "Value education augment to utilize your professional competence".

AKTU 2017-18(IV), Marks 02

- Ans:**
1. Professional ethics means to develop professional competence with ethical human conduct.
  2. The development of ethical competence is achieved through value education.
  3. Developing ethical competence in the individual is the only effective way to ensure professional ethics. Hence value education augments to utilize your professional competence.

#### 1.13. What is the need for value education in technical and other professional Institutions ?

AKTU 2017-18(III), Marks 02

- Ans:** The subject that enables us to understand 'what is valuable' for human happiness is called value education. The present education system has become largely skill-based. The prime emphasis is on science and technology. However, science and technology can only help to provide the means to achieve what is considered valuable. It is not within the scope of science and technology to provide the competence of deciding what really is valuable.

#### 1.14. What are the two basic aspirations of any human being ?

AKTU 2018-19(III), Marks 02

- Ans:** **Basic Aspirations :** Following are the basic aspirations of a human being :
1. Every Human Being aspires to be happy. All his efforts are toward this end. The outcome from his efforts depends on the focus of the effort, specifically on his notions about happiness.
  2. When these notions are right, the outcome is mutual happiness. When the notions are wrong, the outcome is unhappiness.

#### 1.15. What are the abbreviations given as SVDD, SSDD AND SSSS signify ?

AKTU 2018-19(IV), Marks 02

- Ans:**
1. Those that do not have physical facilities/ wealth and feel unhappy and deprived. i.e., SVDD : Sadhan Viheen Dukhi Daridra - Materially Deficient, Unhappy and Deprived.
  2. Those that have physical facilities/ wealth and feel unhappy and deprived. i.e., SSDD : Sadhan Sampunn Dukhi Daridra - Materially Affluent, Unhappy and Deprived.
  3. Those that have physical facilities and feeling happy and prosperous i.e., SSSS : Sadhan Sampunn Sukhi Samriddha - Materially Adequate, Happy and Prosperous.

#### 1.16. What is meant by continuity of happiness ?

**Ques.** Continuity of happiness means that human being doesn't have happiness in spurts, in intervals, but want it continuously.  
**Ans.** Give the importance of value education.

- It helps us to explore our inner happiness.
- It helps us to visualize our goals clearly.
- It widens our perception towards analyzing things.
- It helps us to build up strong relation.

**Ques.** Briefly explain happiness.

**Ans.** Happiness results from a variety of feelings that are experienced naturally to us. Trust, honesty, respect, confidence, etc., are the feelings that we welcome with open arms at all times. They lead us to a state of harmony within us and with others around us.

**Ques.** What is self-exploration ?

**Ans.** It is the process of observing what is within us and focusing attention on yourself, your present beliefs and aspirations. It is a process of dialogue between 'what we are' and 'what we really want to be'.

**Ques.** What is unhappiness ?

**Ans.** Unhappiness is the result of any kind of contradiction, struggle, conflict within us or with any other person. Mistrust, dishonesty, lack of respect and lack of confidence are some feelings that lead to unhappiness.

**Ques.** Discuss briefly mutual fulfillment and mental prosperity.

**Ans.** Mutual fulfillment = Right understanding + Relationship facilities.  
Mutual prosperity = Right understanding + Physical facilities.

**Ques.** Write the need for Value Education.

**Ans.** The need for Value Education is :

- Correct identification of our aspirations.
- Understanding universal human values to fulfill our aspirations continuity.
- Complementarily of values and skills.
- Evaluation of our beliefs.
- Technology and human values.

**Ques.** Explain the difference between animal consciousness and human consciousness.

**AKTU 2018-19(III, Marks 12)**

**Ans.** 1. Giving all priorities to physical facilities only, or to live solely on basis of physical facilities, maybe termed as 'Animal Consciousness'

2 Living with all three : Right understanding, relationship and physical facilities is called "human consciousness".

**Ques.** What is the difference between belief and understanding?

**Ans.** Distinction between belief and understanding can be determined by evaluating following points:

S.No.	Belief	Understanding
1	Beliefs are the ad-hoc values.	Correct understanding is the universal human values.
2	They usually not the same for everybody.	They are same for everyone.
3	Beliefs are assumed values.	Understanding is evaluated values.
4	Belief usually change with time.	Understanding does not change with time.

999

## 2 UNIT

# Understanding Harmony in the Human Being (2 Marks Questions)

2.1. Define Materialism.

AKTU 2015-16(III), Marks 02

**ANS:** An entity that does not have the activity of knowing, assuming, recognizing and fulfilling is a Material Entity. Since, the Body is only able to recognize and fulfill, we can conclude that the Body is a Material Entity.

2.2. How can self control ensure healthy life ?

AKTU 2015-16(III), Marks 02

**ANS:** Sanyama (or self control or self regulation) refers to a feeling of responsibility for nurturing, protecting and rightly utilizing the body. When the body is fit to act according to the needs of the Self ('T) and, there is harmony among the parts of the Body, it is referred to as health or Svasthya. Sanyama (or self-regulation) is the basic of Svasthya.

2.3. What is Sanyam ?

AKTU 2016-17(IV), Marks 02

**ANS:** Sanyama or self-regulation is basically the feeling of response in the Self to nurture, protect and rightly utilize the body. Since the Body is an instrument of the Self, there is a need to take care of the Body so that it is capable of carrying out the instructions of the Self.

2.4. What do you mean by Sukh and Suvidha ?

AKTU 2016-17, 2018-19(IV); Marks 02

**ANS:** Sukh and Suvidha :

1. Sukh is a complete and all surrounding state of the mind that creates inner harmony. Sukh is also called as happiness.
2. Suvidha implies that it is looking for physical comforts and all the sources of attaining such comforts.
3. When our body gets used to a certain level of comfort then we will only feel comfortable at that level e.g. comfort in cooler or air conditioner.

Explain briefly how Self is Conscious Entity?  
OR Explain how the Body is the Material Entity?

- ANS:**
1. The Self or I has the ability to think, imagine, talk, walk, work etc., and thus it is the jeevan. It possesses the characteristic of being aware or conscious. So, T is a conscious unit.
  2. An entity that does not have the activity of knowing, assuming, recognizing and fulfilling is a Material Entity. Since, the Body is only able to recognize and fulfill, we can conclude that the Body is a Material unit.

2.6. Define Sanyam and Svasthya. How are the two related ?

AKTU 2017-18(III), Marks 02

- ANS:**
1. Sanyama or self-regulation is basically the feeling of responsibility in the Self to nurture, protect and rightly utilize the Body.
  2. Svasthya can be explained as having two elements : when the Body acts according to the needs of the I and when there is harmony among all the parts of the Body.
  3. When the Body is in harmony with the Self, the state of svasthya occurs, making the Body fit for use by the Self. Svasthya also means being anchored to the Self and being in close harmony with the Self.

2.7. Can Σ D, T, E, activities of self be definite ? Give name to both definite, indefinite state of activities in self.

AKTU 2017-18(IV), Marks 02

- ANS:** Yes Σ D, T, E, activities of self is definite.  
Definite state of activity = Swatantrata.  
Indefinite state of activity = Partantrata.

2.8. Differentiate between the activities of the Self and the Body on any two grounds.

AKTU 2018-19(III), Marks 02

Fabulous and the most common example of differentiation between the two grounds is that the activities of the Self are conscious and voluntary, whereas the activities of the Body are unconscious and involuntary.

**Ques:** Difference between Activities of the Self and the Body :

	I (self)	Body
Activities are	Desire, thinking, etc. Knowing, assuming, recognizing, fulfilling	Breathing, heart-beat etc. Recognizing, fulfilling

**2.9. What is preconditioning ? What is their source ?**

AKTU 2018-19(IV), Marks 02

**ANS:** Preconditioning : Preconditioning means we have assumed something about our desires on the basis of prevailing notion about it.**Sources :** They comes from what we read, see, hear, what our parents tell us, our friends talk about what the social media talk of, what we see on the TV etc.**2.10. What are the four levels of living ?****ANS:** The four levels of our living are :

1. Living in myself.
2. Living in family.
3. Living in society.
4. Living in nature/existence.

**2.11. How is our body a self-organized unit ?****ANS:** The various functions that a body is involved with at all times, including when we are asleep, makes it a self-organized unit. The human body is a highly sophisticated mechanism and involves numerous organs and glands and their ongoing function. Thus each all in the body is self-organized and participates in the self-organization of the body as a whole.**2.12. What are the various problems faced by us due to preconditioning ?****ANS:** It includes :

1. Wavering aspirations.
2. State of resignation.
3. Lack of confidence.
4. Lack of qualitative improvement.

**2.13. What happens when our desires are being set by outside ?****ANS:** When our desires are being set by outside, there is a chance that we may be in conflict. If our desires are being set by a preconditioning, it is called manyata and if by some sensation from the body, we are enslaved, it is called partantra.**Ques:** What are the three requirements related to the Body ?

1. Nutrition
2. Protection
3. Right utilization

**2.15. Why Sukh and Suvidha both are important ?****ANS:** We need both Sukh and Suvidha for a happy and content human being and so one cannot replace the other. For instance, if we only have the trust of people around us but no house to live in, we will not be happy and if we have a big house to live in with all the comforts but no one whom we can trust and love, we will still be unhappy. So, both are needs to be completely satisfied.**2.16. Explain briefly Seer.****ANS:** The Seer is the one who understands and is also known as the drasta. The Seer sees when the individual is happy or sad, angry or upset. Sometimes the Self sees and understands through the body and sometimes without the help of the Body.**2.17. Who is Enjoyer ?****ANS:** The Enjoyer is the one who enjoys and is also known as the bhokta. When an action is carried out, the Self is the one who enjoys it.

# 3

UNIT

## Understanding Harmony in the Family & Society (2 Marks Questions)

Q1. State the comprehensive human goals in society.

AKTU 2018-19(III), Marks 02

OR

Comment on Profession in the light of comprehensive  
human goal realization.

AKTU 2015-16(III), Marks 02

**Ans:** The programs (Such as Right living, Self Regulation, Preservation, work or Storage) are needed to achieve the comprehensive human goal are right understanding among the human being and to facilitate the fulfilment of the basic aspirations of all human beings in the society.

Q2. Explain the relationship between Truth and Respect.

AKTU 2018-19(III), Marks 02

**Ans:** Respect is a state of harmony between two human beings. When I respect the other and the other respects me, I like to be in that situation. It gives me happiness. To maintain this relationship you have to be truthful to yourself and the other person. So, truth and respect goes hand in hand with each other.

Q3. What do you understand by trust ?

AKTU 2016-17, 2018-19(IV); Marks 02

OR

Define trust. Illustrate the feeling of trust with one example.

AKTU 2017-18(III), Marks 02

**Ans:** Trust or vishwas is the fundamental value in all relationship. "To be assured that each human being inherently wants one self and the other to be happy and prosperous" is known as trust.

Q4. What is the meaning of education and sanskara ? How does sanskara follow education ?

AKTU 2017-18(III), Marks 02

**Ans:** Education : Education means to understand the harmony at all the four levels viz. individual, family, society and nature.  
Sanskara : Sanskar refers to live in harmony at all four levels of living.

Q5. How can we move towards the universal human order ?

AKTU 2015-16(III), Marks 02

- Ans:**
- Living in harmony of an individual right from the individual level to the level of the entire order or existence is known as universal human order.
  - Universal human order can be achieved only by right understanding.

Q6. How does affection lead to harmony in the family ?

AKTU 2015-16(III), Marks 02

- Ans:** These are :
- We must understand the relationships that exist between one self and another self.
  - The self has feelings in the relationship between the two people.
  - These feelings in the self are definite and can be identified with definiteness.
  - It is by recognizing and fulfilling these feelings that happiness in a relationship can be guaranteed.

Q7. Define trust. Explain the methods of its verification in brief.

AKTU 2015-16(IV), Marks 02

OR

What are the needs to develop trust ?

- Ans:** To develop trust, we need to :
- Be consistent in our actions.
  - Faith in competencies.
  - Do not keep secrets.
  - Do not pretend.

Q8. Point out as to what is invariant and universal among all human beings ?

AKTU 2015-16(IV), Marks 02

**Ans:** Whatever we study as value education has to be universally applicable to all human being and be true at all times and all places. In addition, it need not restrict itself to a certain sex, race, gender, nationality etc.

Q9. Describe the correct priorities of life. Explain the role of right understanding in brief.

**ANS:**

1. Correct priority of life :
- i. Right understanding
- ii. Love
- iii. Truth
- iv. Peace

In order to be prosperous and to enrich nature, we need to have right understanding'. The right understanding will enable us to work out our requirement for physical facilities.

**3.10. Out of intention and competence, point out the right criterion for human judgment.**

**ANS:**

1. Intention is what we aspire to achieve, therefore, it can be defined as performing an action according to a specific purpose till the end or goal that is aimed in mind.
2. Competence is ability to perform a specific task, action or function successfully.
3. Generally we judge ourselves on the basis of our intention while others on the basis of their competence.

**3.11. Define Justice in relationships.**

**ANS:** Justice is recognizing that feelings are definite in relationships, fulfilling the relationships and the right evaluation of the fulfillment which results in mutual happiness.

**3.12. Write the elements of Justice.**

**ANS:** Justice is composed of four elements :

1. Recognition of values or the definite nature of feelings.
2. Fulfillment.
3. Evaluation.
4. Ensuring mutual happiness.

**3.13. What are the problems with relationships today ?**

**ANS:** The problems with relationships today are recognizing them based on body and exchange of physical goods.

**3.14. Define intention.**

**ANS:** Intention is what we aspire to achieve, therefore it can be defined as performing an action according to a specific purpose, the end or goal that is aimed in mind. It is the purpose behind our actions or conduct.

**3.15. What is competence ?**

**ANS:** Competence is the ability to perform a specific task, action or function successfully. The quality of being competent demands possession of required skill, knowledge, qualification, or ability to perform a task.

**3.16. Briefly explain undivided society.**

**ANS:** The feeling of being related to every human being in society leads to our participation in an undivided society. When we have achieved harmony at the level of individual and explored the harmony at the family level, we walk towards achieving harmony at the level of society and this gives us a feeling of world family.

**3.17. You are having feeling of affection. What are two natural feeling as outcome of affection define them in brief.**

**ANS:** The feeling of affection comes only if trust and respect are already ensured. Without trust and respect, we feel the other is trying to make us unhappy, does not wish well for us and hence we can never feel affection for him/her. We always see the other as being in opposition.



trust and respect

without trust and respect

affection

without affection

mutual happiness

without mutual happiness

harmony

without harmony

family

without family

society

without society

## Understanding Harmony in the Nature & Existence (2 Marks Questions)

**4**  
**UNIT**

4.1. Define existence.

**AKTU 2015-16(III), Marks 02**

Ans: Understanding the self is the knowledge of self or I, this is known as Jivan Gyan. Understanding the knowledge of existence is the knowledge of Astitva. The knowledge of human conduct is known as Manavyata Purna Acharan Gyan. These three knowledge put together forms the right understanding of existence.

4.2. Elaborate on the meaning of swatwa (innateness).

**AKTU 2015-16(III), Marks 02**

Ans: Each unit in existence exhibits innateness, quality that cannot be separated from it. We refer to this principle as 'Innateness' also, called 'Dhárana' of that unit. This is intrinsic to the unit.

4.3. Define harmony in nature. **AKTU 2016-17(IV), Marks 02**

Ans: When all the living organisms on earth live together peacefully and overlook the mutual differences, it is called harmony.

4.4. What do you mean by co-existence?

**AKTU 2016-17(IV), Marks 02**

Ans: It is a state in which two or more groups live together keeping in mind their differences. The parties involved establish a relationship where they can live non-violently.

4.5. Define the terms Gathansheel, Gathanpuran, Kriyapurnata and Acharanpurnata. **AKTU 2018-19(IV), Marks 02**

Ans: Gathansheel : The material units are transformable, and their composition keeps on changing, hence these are gathansheel.  
Gathanpurna : The other category of units the sentient T, do not transform and are complete in composition, hence gathanpurna.

**SQ-16 Y (CC-Hem-3 & 4) Understanding Harmony in the Nature & Existence**

Kriyapurnata : Completion of right understanding in human being is called kriyapurnata.  
Acharanpurnata : Ability to live with complete understanding is called acharanpurnata.

4.6. Give the four orders of nature.

- Ans: There are :
1. Material order
  2. Plant/Bin order
  3. Animal order
  4. Human order

4.7. Give brief details about space.

Ans: Space can be defined as an unlimited entity. It maintains certain regularity and obey certain laws. It is reflecting. This means that it can be explained in terms of its relation with other objects.

4.8. What is a holistic technology?

Ans: By holistic approach, we mean the processes and the technology adopted by us must be compatible with nature. A holistic model is inherently conducive to the comprehensive human goal.

4.9. Define sentient material and insentient material.

Ans: Sentient Material : Any material which has consciousness is called sentient material.  
Example : The pranic/plant order.  
Insentient Material : Any material which does not have consciousness is called insentient material.  
Example : Cosmic objects.

4.10. Give the types of co-existence.

Ans: There are two types of co-existence :

1. Active co-existence
2. Passive co-existence

4.11. What is active co-existence?

Ans: The relationship based on mutual respect for the diversity is called active co-existence. The parties in this relationship enhances each other differences, have got equal access to resources and opportunities. The environment is free of peace, social cohesion, justice and equality.

4.12. Define passive co-existence.

Ans: This is a kind of co-existence where one of the groups is less powerful than the other. In this environment, there's lot of violence but it has an unequal relationship.

4.13. Discuss material order.

**ANSWER:** This order comprises of non-living things. Also, various forms of energy like sound, light, heat etc are also part of this order. The fundamental characteristic of this order is composition/decomposition.

4.14. Explain briefly plant/bio order.

**ANSWER:** They comprise from single cell organism like fungi, algae to water plants, herbs, shrubs and trees. They can reproduce, accept nutrition from outside, digest, assimilate and grow. They also provide nutrition to the animal and to the human order.

4.15. Define animal order.

**ANSWER:** The members of this order are living things. They share many of the features of the plant order. They have greater degree of locomotion than plants. The natural characteristic of this order is that they realize or they are aware of the fact that there exists the quality of self(I), therefore they have an intellectual faculty.

@@@



## Implications of Holistic Understanding of Harmony on Professional Ethics (2 Marks Questions)

5.1. What do you mean by Ethics?

AKTU 2018-19(III), Marks 02

**ANSWER:** Professional ethics refer to the code of conduct, moral ideals and policies any professional should follow. It is the ethical obligation that people in a profession have to follow due to their professional status.

5.2. Discuss universal human values.

**ANSWER:** These are the values which are needed to be exercised by human beings to live. They are a combination of likes, dislikes, judgments, point of views of a human being. They are manifestation of truth of existence.

5.3. What do you mean by 'profession'? Why is it required to acquire ethical competence in profession?

AKTU 2017-18(III), Marks 02

**ANSWER:**

1. Profession is only a subset of the life activities.
2. The profession is not only a means of earning one's livelihood but a means of one's evaluation by appropriate participation in the larger order.
3. Developing ethical competence to the individual (profession) is the only effective way to ensure professional ethics.

5.4. Explain Intrinsic and Extrinsic values.

AKTU 2018-19(III), Marks 02

**ANSWER:** Intrinsic Values :

Intrinsic value is valuable in itself. Truth, beauty and goodness are universally accepted as they intrinsic values of human life.

**Extrinsic Values :** Extrinsic (Relative) value means that the worth of something has for the sake of something else.

Extrinsic value is not desirable or worthy in itself.

5.7. Briefly explain utility value.

**ANS:** Utility value is the participation of body in ensuring the role of physical facility of nurture, protection and providing means for the body.

5.8. What is artistic value?

**ANS:** Artistic value is the participation of a body in ensuring the role of physical facility to help preserve its utility. Artistic value of an object arises from its utility value.

5.9. What is ethical competence?

**ANS:** Ethical competence or value competence is a manifestation of one's right understanding. It is a long-term process which can be achieved through appropriate value education.

5.10. Give some features of ideal management model.

**ANS:** An ideal management model should have :

1. A whole-unit of workers working together with a feeling of brotherhood.
2. Regular and fair appraisal of hard work.
3. Continuous value addition to the working system.
4. Effective integration of individual competencies.

5.11. Give some criteria's which should be a part of holistic technologies.

**ANS:** They are :

1. Aim towards catering day to day human needs.
2. It should be durable.
3. It should have a low maintenance cost.
4. It should not have any health hazards.

5.12. What do you understand by Svarajya?

**ANS:** Our surroundings include air, water, space, plants and animals. The total existence has a togetherness and co-existence. This togetherness in an organized manner where every individual serves a function and is ready to help and support others is known as Svarajya.

5.13. Explain energized and energy in equilibrium.

**AKTU 2015-16(III), Marks 02**

**ANS:** What we normally call or consider as energy today, is the 'transfer of energy'. All units are energized in space. This energy is available to all units. In other words, space is equilibrium energy, all units are in space; all units are energized and active being in space.

5.14. What are the five values

life in harmony?

**ANS:** These are :

1. Love
2. Care
3. Truth
4. Responsibility
5. Justice

5.15. Give some essential qualities desired in a good professional.

**ANS:** A good professional should :

1. Maintain a friendly relationship with clients, consultants, contractors and other people associated with the company.
2. Should not take bribe or offer bribe in forms of meals, gifts or entertainments.
3. Should cautiously use the employer's assets.

5.16. How ethical competence can be achieved?

**ANS:** It can be achieved through :

1. Competence of one's understanding in real life.
2. Competence of mutually enriching interaction with nature.
3. Clarity about comprehensive human goal.

5.17. List some unethical practices which are prevalent in today's world.

**ANS:** These are :

1. Corruption.
2. Misappropriation of funds and tax evasion.
3. Hunger, poverty, illiteracy.
4. Endangering health and public safety.

