

**BHARTIYA SKILL DEVELOPMENT UNIVERSITY****School of Electrical Skills****Session: 2019-20 (Summer Semester)****B. Voc. Program, 5<sup>th</sup> Semester,****End – Sem. Examination****Course Code: ELE 1501****Time: 2 Hours****Course Name: Fundamental of Power Electronics****Max. Marks: 50**

**Instruction:** Answer all questions from section A, each question carries one mark. Answer all questions from section B, each question carries four marks. Answer all questions from section C, each question carries six marks. Scientific calculator is allowed.

**Section – A**

10X01 = 10 Marks

1. When the diode is reverse biased, it is equivalent to:  
(a) Zero resistance      (b) An On switch      (c) A high resistance      (d) None of these
2. The p-region has a greater concentration of \_\_\_\_\_ as compared to the n-region in a P-N junction:  
(a) holes      (b) electrons      (c) phonons      (d) None of these
3. Which of the below mentioned statements is false regarding a p-n junction diode?  
(a) Diode are uncontrolled devices      (b) Diodes are rectifying devices  
(c) Diodes are unidirectional devices      (d) Diodes have three terminals
4. A silicon controlled rectifier (SCR) is a:  
(a) Unijunction device      (b) Device with three junction  
(c) Device with four junction      (d) None of these
5. Which of the following is true in case of an unbiased p-n junction diode?  
(a) Diffusion does not take place  
(b) Diffusion of electrons & holes goes on infinitely  
(c) There is zero electrical potential across the junctions  
(d) Charges establish an electric field across the junctions
6. Which of the following devices does not belong to the transistor family?  
(a) IGBT      (b) MOSFET      (c) GTO      (d) BJT
7. Which of the following terminals does not belongs to the MOSFET?  
(a) Drain      (b) Gate      (c) Base      (d) Source
8. Choose the correct statement:  
(a) MOSFET is a uncontrolled device  
(b) MOSFET is a voltage controlled device  
(c) MOSFET is a current controlled device  
(d) MOSFET is a temperature controlled device
9. The three terminals of the IGBT are:  
(a) base, emitter & collector      (b) gate, source & drain  
(c) gate, emitter & collector      (d) base, source & drain
10. Which terminal does not belongs to the SCR?  
(a) Anode      (b) Gate      (c) Base      (d) Cathode

**BHARTIYA SKILL DEVELOPMENT UNIVERSITY****Section – B**

04X04 = 16 Marks

1. Define the term power electronics. In the modern technology what is the place of power electronics?
2. What is inverter? What are the applications of Inverter?
3. State the terms:  
(i) Latching Current                      (ii) Holding Current
4. A diode carries forward current of 50-mA when forward voltage applied is 0.2V. Find its D.C. forward resistance. It carries reverse current of 25  $\mu$ -A when reverse voltage is 60V, find its D.C. reverse resistance.

**Section – C**

04X06 = 24 Marks

1. What is a power diode? How power diode is differ from a signal diode?
2. With neat diagram, explain the working principle of pn-junction diode.
3. Define rectifier. With neat diagram, and wave form explain the working principle of full wave rectifier.
4. A full wave rectifier uses a center-tap transformer whose turns ratio to half secondary is 10:1 and is supplied with 230V at 50HZ. If the load resistance is 50 ohm, then calculate the value of maximum voltage and current.

## Set - A

Course Name: - Fundamental of Power Electronics

Course code: - ELE1501

## Section - A

1. Ans: - (c)
2. Ans: - (a)
3. Ans: - (d)
4. Ans: - (b)
5. Ans: - (d)
6. Ans: - (c)
7. Ans: - (c)
8. Ans: - (b)
9. Ans: - (c)
10. Ans: - (c)

## Section - B

1. Ans:

Power electronics is the technology associated with efficient conversion, control and conditioning of electrical power from its available input into the desired electrical output form.

Power electronics has found an important place in modern technology being a core of power and energy control.

2. Ans: -

DC to AC converters is called inverters. The function of inverter is to change the DC input voltage into AC output voltage of desired magnitude and frequency.

Inverters are widely used in industrial applications like uninterruptible power supplies, variable AC motor drives etc.

3. Ans!

(a) Latching current: -

It is minimum current required to turn on the SCR from forward blocking state to forward conduction state.

(b) Holding current: -

It is minimum current required to hold the SCR in forward conduction state.

our Ans!

It is given

$$I_f = 50 \text{ mA}$$

$$V_f = 0.2 \text{ V}$$

$$I_R = 25 \text{ mA}$$

$$V_R = 60 \text{ V}$$

$$R_{foc} = ?$$

\*  $R_{foc} = ?$

Since  $V = IR$

$$R_{foc} = \frac{V_f}{I_f} = \frac{50 \times 10^{-3}}{0.2} = 250 \times 10^{-3}$$

$$\boxed{R_{foc} = 250 \times 10^{-3} \Omega}$$

$$R_{foc} = \frac{0.2}{50 \times 10^{-3}}$$

or

$$R_{foc} = \frac{V_R}{I_R} = \frac{60}{25 \times 10^{-3}}$$

$$= 4 \times 10^{-3} \times 10^3$$

$$\boxed{R_{foc} = 4 \Omega}$$

Heavily

$$R_{ROC} = \frac{V_R}{I_R} = \frac{60}{25 \times 10^{-6}} = 2.4 \times 10^6 \Omega$$

$$R_{ROC} = 2.4 \times 10^6 \Omega$$

### Section - C

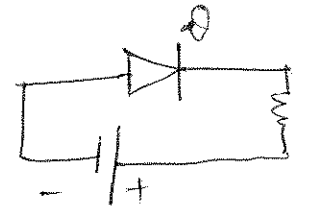
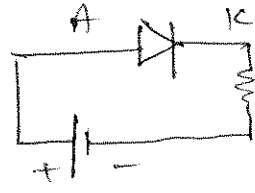
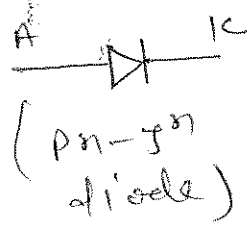
Ans:

Power diode consists of heavily doped  $n^+$ -substrate, on it a lightly doped  $n^-$  layer is grown. basically for high current application we use power diode.

The current rating of power diode vary from 1A to several 1000 amp. The voltage rating of power diode varies from 50V to about 5kV.

Power diode is differ from a signal diode, as  $n^-$  layer is basically structural feature not found in signal diode.

2. Ans: —



The process of applying the voltage across the pn-junction diode is called biasing of diode.

In forward biasing mode +ve terminal of battery is connected to p-type and negative terminal of battery is connected to n-type.

In Reverse bias +ve terminal of battery is connected to n-type and -ve terminal of battery is connected to p-type.

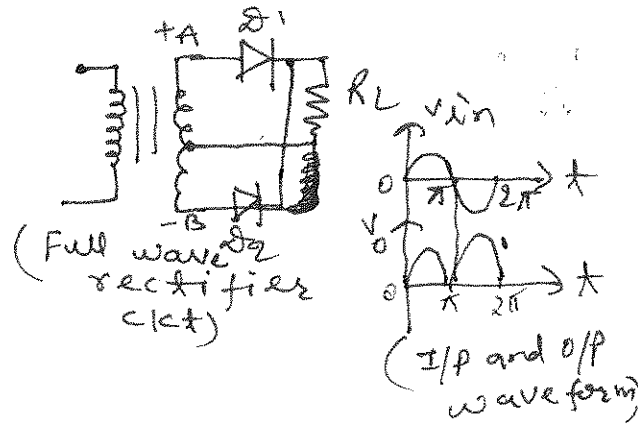
Applied vol. above the barrier Pot. val. diode starts conducting in forward biasing.

3. Ans: —

A rectifier is a device that converts AC signal into pulsating DC signal.

Full wave rectifier is a type of rectifier which converts both half cycles of AC signal into

pulsating dc signal.



4. Ans: —

It is given that

$$\frac{E_{p\text{rms}}}{E_{s\text{rms}}} = \frac{10}{1}$$

$$\text{or, } E_{s\text{rms}} = \frac{E_{p\text{rms}}}{10} = \frac{230}{10} = 23\text{V}$$

Since,

$$E_{s\text{rms}} = \frac{E_m}{\sqrt{2}}$$

$$E_m = \sqrt{2} \times 23 = 32.52\text{V}$$

$$I_m = \frac{E_m}{R_L} = \frac{32.52}{50} = 0.65\text{A}$$

So, max<sup>m</sup>. val.  $E_m = 32.52\text{V}$   
max<sup>m</sup>. current  $I_m = 0.65\text{A}$

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School of Electrical Skills

Session: 2019-20 (Summer Semester)

B. Voc. Program, 5<sup>th</sup> Semester,

End – Sem. Examination

Course Code: ELE-1502

Time: 2 Hours

Course Name: Substation Practices and Supervision

Max. Marks: 50

**Instruction:** Answer all questions from section A, each question carries one mark. Answer all questions from section B, each question carries four marks. Answer all questions from section C, each question carries six marks. Scientific calculator is allowed.

**Section – A**

10X01 = 10 Marks

- Which of the following generation station has minimum running cost?  
(a) Thermal power station (b) Hydro-electric power station  
(c) Nuclear power station (d) None of these
- Out of the following which one is not an unconventional source of energy.  
(a) Tidal power (b) Geothermal energy  
(c) Nuclear energy (d) Wind power.
- The area under the load curve represents:  
(a) The average load on power system (b) maximum demand  
(c) number of units generated (d) load factor
- Which of the following is equal to the maximum demand?  
(a) The ratio of area under curve to the total area of rectangle  
(b) The ratio of area under curve and number of hours  
(c) The peak of the load curve  
(d) The area under the curve
- Load duration curve indicates:  
(a) the variation of load during different hours of the day  
(b) total number of units generated for the given demand  
(c) total energy consumed by the load  
(d) the number of hours for which the particular load lasts during a day
- During which time the demand of electrical energy is maximum.  
(a) 2 A.M. to 5 A.M. (b) 5 A.M. to 12 P.M.  
(c) 12 P.M. to 7 P.M. (d) 7 P.M. to 9 P.M.
- Size and cost of installation depends upon:  
(a) average load (b) maximum demand  
(c) square mean load (d) square of peak load
- What is Demand factor?  
(a) Ratio of connected load to maximum demand  
(b) Ratio of average load to connected load  
(c) Ratio of maximum demand to the connected load  
(d) Ratio of kilowatt hour consumed to 24 hours
- Which of the following represents the annual average load?  
(a) (KWh supplied in a day)/24 (b) {(KWh supplied in a day)/ 24 } × 365  
(c) {(KWh supplied in a month)/(30 × 24)} (d) (KWh supplied in a year) / (24 × 365)

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10. The load factor is:

- (a) always less than unity  
(b) less than or greater than 1  
(c) always greater than 1  
(d) less than zero

**Section – B**

04X04 = 16 Marks

1. In what way an isolator is different from an air-break switch?
2. What is substation? And list out the equipment used in a substation.
3. What is capacity factor?
4. Differentiate between fixed and operating (variable) costs of power plants.

**Section – C**

04X06 = 24 Marks

1. What is the objective of Indian Electricity Grid Code (IEGC) or Grid Code?
2. A new residential cum shopping complex is to be electrified from an existing distribution system. It will have 600 apartments each having a connected load of 5 kW. The shopping complex will have 20 general purpose shops each having a connected load of 2 kW with demand factor of 0.8 and will have the following services in addition:

Service	Connected load	Demand Factor
1 Flour Mill	10 kW	0.7
1 Saw Mill	5 kW	0.8
1 Laundry	20 kW.	0.65
1 Cinema	80 kW	0.5

The street lighting for the complex will consist of 200 tube lights of 40 Watt each.

The residential load demand factor, group diversity factor and peak diversity factor may be assumed as 0.5, 3.0, and 1.25 respectively. The group and peak diversity factors for the commercial load may be taken as 2.0 and 1.6. the street lighting demand, group and peak diversity factors, may be taken as unity. Find the increase in peak demand of the system resulting from this complex.

3. A steam station has two 110 MW units. The cost data is as under

Unit 1	Unit 2
UC <sub>1</sub> = Rs. 18000 per kW	UC <sub>2</sub> = Rs. 30000 per kW
FCR <sub>1</sub> = 10 percent	FCR <sub>2</sub> = 10 percent
CF <sub>1</sub> = 0.55	CF <sub>2</sub> = 0.60
Fuel consumption = 0.7 kg/kWh	Fuel consumption = 0.65 kg/kWh
Fuel cost = Rs. 1500 per 1000 kg	Fuel cost = Rs. 1500 per 1000 kg
OM <sub>1</sub> = 20 percent of annual fuel cost	OM <sub>1</sub> = 15 percent of annual fuel cost
Utilization Factor = 1	Utilization Factor = 1

Calculate (a) annual plant cost and generation cost of unit 1 (b) annual plant cost and generation cost of unit 2 (c) overall generation cost of the station.

4. What is depreciation reserve? Why is it necessary to maintain it? Discuss the methods to calculate the depreciation charges.



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Course Code: ELE-1502

Course Name: Substation Practices and Supervision

Time: 2 Hours

Max. Marks: 50

Section – A

10X01 = 10 Marks

10 objective type questions, each question carries 01 mark.

1. Which of the following generation station has minimum running cost?
  - a) Thermal power station
  - b) Hydro-electric power station**
  - c) Nuclear power station
  - d) None of these
2. Out of the following which one is not a unconventional source of energy?
  - (A) Tidal power
  - (B) Geothermal energy
  - (C) Nuclear energy**
  - (D) Wind power.
3. The area under the load curve represents \_\_\_\_\_
  - a) The average load on power system
  - b) maximum demand
  - c) number of units generated**
  - d) load factor
4. Which of the following is equal to the maximum demand?
  - a) The ratio of area under curve to the total area of rectangle
  - b) The ratio of area under curve and number of hours
  - c) The peak of the load curve**
  - d) The area under the curve
5. Load duration curve indicates \_\_\_\_\_
  - a) the variation of load during different hours of the day
  - b) total number of units generated for the given demand
  - c) total energy consumed by the load
  - d) the number of hours for which the particular load lasts during a day**
6. During which time the demand of electrical energy is maximum?
  - a) 2 A.M. to 5 A.M.
  - b) 5 A.M. to 12 P.M.
  - c) 12 P.M. to 7 P.M.
  - d) 7 P.M. to 9 P.M**
7. Size and cost of installation depends upon \_\_\_\_\_
  - a) average load
  - b) maximum demand**



- c) square mean load  
d) square of peak load
8. What is Demand factor?
- a) Ratio of connected load to maximum demand  
b) Ratio of average load to connected load  
**c) Ratio of maximum demand to the connected load**  
d) Ratio of kilowatt hour consumed to 24 hours
9. Which of the following represents the annual average load?
- a) (KWh supplied in a day)/24  
b) {(KWh supplied in a day)/ 24 } × 365  
c) {(KWh supplied in a month)/(30 × 24)  
**d) (KWh supplied in a year) / (24 × 365)**
10. The load factor is \_\_\_\_\_
- a) **always less than unity**  
b) less than or greater than 1  
c) always greater than 1  
d) less than zero

### Section – B

04X04 = 16 Marks

04 short answer type questions, each question carries 04 marks.

Q1 In what way is an isolator different from an air-break switch? And also explain the the functions of a substation?

**Ans: Isolators are used to connect or disconnect the line only under no-load condition while air-break switches are used for making and breaking of the circuit under loaded condition. Air-break switches are provided with arc control devices.**

: The functions of an electric substations are:

- ✓ It receives electric energy from an incoming line at a voltage and supplies the same to outgoing lines at a reduced voltage level employing power transformers.
- ✓ It acts as a connection point for local networks.
- ✓ It regulates voltage to compensate for system voltage drop by injecting reactive power to the transmission or distribution circuits.
- ✓ It acts as a monitoring point for control centre using current and potential transformers.
- ✓ It acts as a switchyard for switching electric transmission and distribution circuits into and out of the system using bus bars, circuit-breakers and isolators.
- ✓ It protects the electric system insulation against abnormal over voltages caused due to lightning and switching, employing protective devices like surge diverters.
- ✓ It protects the system equipments against abnormal short-circuit currents employing relays and circuit-breakers.

Q2 What is substation? And list out the equipment used in a substation.

**Ans: Substation:** A power substation is a subsidiary station of an electricity generation, transmission and distribution system where voltage is transformed from high or medium to low or the reverse using transformers. Electric power flows through several substations



between generating plant and consumer changing the voltage level in several stages. At first substations were connected to only one power station where the generator was housed and were subsidiaries of that power station.

Equipment used in a substation are Transformer (s); Bus-Bars; Circuit breakers; CTs; PTs; Insulators; Isolators; Switchgears (Fuses, air-break switches etc.); Protective Relays; Surge arresters; Cables; Fire-fighting equipment; Batteries; Earthing arrangement; Wave traps; Reactors etc.

Q3 What is capacity factor?

Ans: The plant capacity factor (also known as plant factor) is the ratio of the average annual load to the power plant capacity.

Capacity Factor = Average Annual Load / Rated Plant Capacity

It can also be defined as the ratio of the energy produced by the plant in a year to the maximum energy that the plant could have produced. If the plant is always run at its rated capacity, the capacity factor is 100%.

The capacity factor depicts the extent of the use of the generating station. It is different from load factor because of the reason that the rated capacity of each plant is always greater than the expected maximum load. The power plants have always some reserve capacity to take into account the future expansion, increase in load and maintenance.

Capacity Factor = (Maximum Load/Plant Capacity)\*Load Factor

It is evident that if the rated plant capacity equals the maximum load, the capacity factor and load factor become identical.

Q4 Differentiate between fixed and operating (variable) costs of power plants.

Ans:

Fixed costs	Variable costs
The annual fixed cost of a plant includes interest, taxes, insurances, maintenance, depreciation, managerial, salary and rate of return	The Variable fixed cost of a plant means expenses which vary with the operation or the amount of energy produced
The fixed cost of the steam plant consists of cost of land, installation, equipment, design power house building, testing, commissioning etc.	The variable fixed cost of a steam plant includes the cost of coal, oil, repair, water, salaries of operating staff
The fixed cost of a hydro plant consists of the cost of survey, bridges, dam, earthwork, railhead, highways, other civil engineering works, powerhouse structure, design, specifications, equipment testings, commissioning etc.	The variable cost of a hydro plant includes salaries and wages of operating staff, maintenance staff and suppliers. The operating cost of hydro plant is very small
The fixed cost of a nuclear plant includes the cost of plant site, equipment testing and commissioning	The variable cost of a nuclear plant includes the cost of fuel, water, material, required for repair and maintenance, salaries of operating and maintenance staff. The operating cost is very high

**Section – C**

04X06 = 24 Marks

04 long type questions, each question carries 06 marks.

Q1 What is the objective of Indian Electricity Grid Code (IEGC) or Grid Code?



Ans: The IEGC brings together a single set of technical and commercial rules, encompassing all the Utilities connected to/or using the inter-State transmission system (ISTS) and provides the following:

1. Documentation of the principles and procedures which define the relationship between the various Users of the inter-State transmission system (ISTS), National Load Despatch Centre, as well as the Regional and State Load Despatch Centres
2. Facilitation of the optimal operation of the grid, facilitation of coordinated and optimal maintenance planning of the grid and facilitation of development and planning of economic and reliable National / Regional Grid
3. Facilitation for development of power markets by defining a common basis of operation of the ISTS, applicable to all the Users of the ISTS.
4. Facilitation of the development of renewable energy sources by specifying the technical and commercial aspects for integration of these resources into the grid.

Q2 A new residential cum shopping complex is to be electrified from an existing distribution system. It will have 600 apartments each having a connected load of 5 kW. The shopping complex will have 20 general purpose shops each having a connected load of 2 kW with demand factor of 0.8 and will have the following services in addition:

Service	Connected load	Demand Factor
1 Flour Mill	10 kW	0.7
1 Saw Mill	5 kW	0.8
1 Laundry	20 kW	0.65
1 Cinema	80 kW	0.5

The street lighting for the complex will consist of 200 tube lights of 40 Watt each.

The residential load demand factor, group diversity factor and peak diversity factor may be assumed as 0.5, 3.0, and 1.25 respectively. The group and peak diversity factors for the commercial load may be taken as 2.0 and 1.6. the street lighting demand, group and peak diversity factors, may be taken as unity. Find the increase in peak demand of the system resulting from this complex.

Ans:

**SOLUTION.**  
Maximum demand of each apartment =  $5 \times 0.5 = 2.5$  kW

Maximum demand of 600 apartments =  $\frac{600 \times 2.5}{3} = 500$  kW

Demand of 600 apartments at the time of the system peak =  $\frac{500}{1.25} = 400$  kW

Maximum demand of total commercial complex  
$$= \frac{20 \times 2 \times 0.8 + 10 \times 0.7 + 5 \times 0.8 + 20 \times 0.65 + 80 \times 0.5}{2}$$
$$= \frac{32 + 7 + 4 + 13 + 40}{2}$$
$$= 48 \text{ kW}$$

Demand of the commercial load at the time of the system peak =  $\frac{48}{1.6} = 30$  kW

Demand of street lighting at the time of the system peak =  $\frac{200 \times 40}{1000} = 8$  kW

Increase in system peak demand =  $400 + 30 + 8 = 438$  kW

#### 5. TYPES OF LOAD



Q3 A steam station has two 110 MW units. The cost data is as under

UNIT 1	Unit 2
$UC_1 = \text{Rs. } 18000 \text{ per kW}$	$UC_2 = \text{Rs. } 30000 \text{ per kW}$
$FCR_1 = 10 \text{ percent}$	$FCR_2 = 10 \text{ percent}$
$CF_1 = 0.55$	$CF_2 = 0.60$
Fuel consumption = 0.7 kg/kWh	Fuel consumption = 0.65 kg/kWh
Fuel cost = Rs. 1500 per 1000 kg	Fuel cost = Rs. 1500 per 1000 kg
$OM_1 = 20 \text{ percent of annual fuel cost}$	$OM_1 = 15 \text{ percent of annual fuel cost}$
Utilization Factor = 1	Utilization Factor = 1

Calculate (a) annual plant cost and generation cost of unit 1

(b) annual plant cost and generation cost of unit 2

(c) overall generation cost of the station.

Ans:

$$(a) AFC_1 = \text{Rs.} \left( \frac{10}{100} \right) (18000)(110 \times 10^3) = \text{Rs.} 198 \times 10^6$$

$$E_1 = 8760(.55)(110 \times 10^3) = 52998 \times 10^4 \text{ kWh}$$

Annual fuel consumption of unit 1 =  $52998 \times 10^4 \times .7 = 37098.6 \times 10^4 \text{ kg}$

$$FC_1 = (37098.6 \times 10^4) (1500/1000) = \text{Rs. } 556479 \times 10^3$$

$$OM_1 = 0.2 (556479 \times 10^3) = \text{Rs. } 111295.8 \times 10^3$$

$$AOC_1 = \text{Rs. } (556479 \times 10^3 + 111295.8 \times 10^3) = \text{Rs. } 667774.8 \times 10^3$$

$$APC_1 = \text{Rs. } (198 \times 10^6 + 667774.8 \times 10^3) = \text{Rs. } 865774.8 \times 10^3$$

$$GC_1 = \frac{865774.8 \times 10^3}{52998 \times 10^4} = \text{Rs. } 1.6336/\text{kWh}$$

$$(b) AFC_2 = \text{Rs.} \left( \frac{10}{100} \right) (30000) (110 \times 10^3) = \text{Rs. } 330 \times 10^6$$

$$E_2 = 8760 (.60) (110 \times 10^3) = 57816 \times 10^4 \text{ kWh}$$

Annual fuel consumption of unit 2 =  $0.65 (57816 \times 10^4) = 375804 \times 10^3 \text{ kg}$

$$FC_2 = \text{Rs. } (375804 \times 10^3)(1500/1000) = \text{Rs. } 563706000$$

$$OM_2 = \text{Rs. } (0.15) (563706000) = \text{Rs. } 84555900$$

$$AOC_2 = \text{Rs. } (563706000 + 84555900) = \text{Rs. } 648261900$$

$$APC_2 = \text{Rs. } (330 \times 10^6 + 648261900) = \text{Rs. } 978261900$$

$$GC_2 = \frac{978261900}{57816 \times 10^4} = \text{Rs. } 1.692/\text{kWh}$$

$$(c) OGC = \frac{(865774800 + 978261900)}{52998 \times 10^4 + 57816 \times 10^4} = \text{Rs. } 1.664/\text{kWh}$$

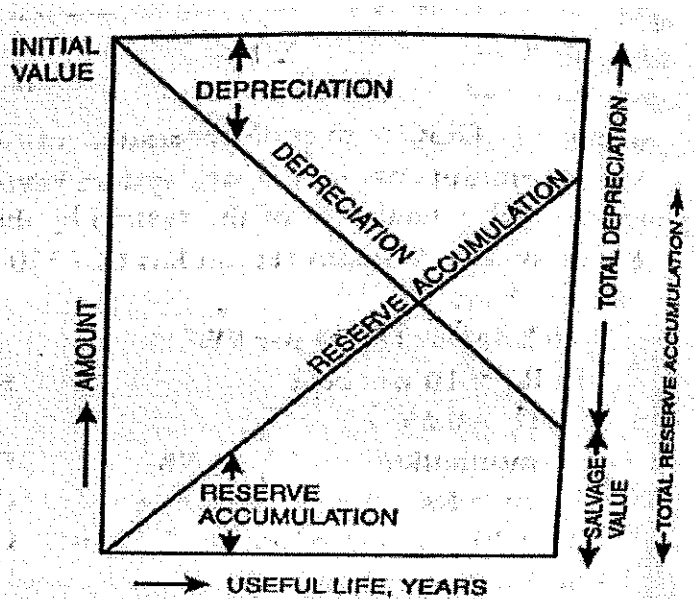
Q4 What is depreciation reserve? Why is it necessary to maintain it? Discuss the methods to calculate the depreciation charges.

Ans: The value of the power plant decreases from its initial value to the salvage value at the end of its useful life. This depreciation is due to ageing, wear and tear of machinery, corrosion, weathering, inadequacy and obsolescence of equipment etc. at the end of the useful life of the plant, funds must be available to replace the equipment. The depreciation charge represents the amount which is set aside from income every year and placed in depreciation reserve. For calculating this charge, it is necessary to estimate the useful life of plant. The life of heavy electrical equipment and steam turbines is generally taken as 20-25 years, hydraulic turbines 30 years and civil engineering works 50 years. The depreciation charge may be based on straight line method or sinking fund method or fixed percentage method.

**3.7.1. Straight line method.** This method assumes that depreciation occurs according to a straight line law.

$$\text{Straight line annual depreciation reserve} = \frac{\text{Initial cost} - \text{Salvage value}}{\text{Number of years of useful life}} \quad \dots (3.8)$$

This method neglects the interest that the depreciation reserve would earn. It is very popular because of its simplicity. Fig. 3.1 illustrates this method.



**Fig. 3.1.** Straight line depreciation.

**3.7.2. Sinking fund method.** This method is based on the fact that the annual depreciation reserve, when invested at compound interest, will accumulate to the difference between the initial cost and the salvage value at the end of the useful life of the equipment.

Annual sinking fund depreciation reserve

$$= [\text{Initial cost} - \text{Salvage value}] \times \left[ \frac{r}{(1+r)^n - 1} \right]$$

... (3.9)

where  $r$  is the interest rate and  $n$  is the number of years. The sinking fund method is illustrated in Fig. 3.2.

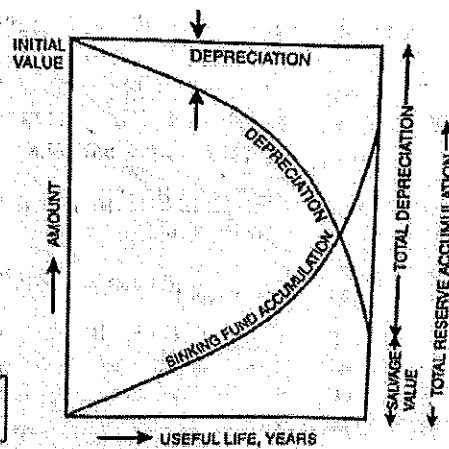


Fig. 3.2. Sinking fund depreciation.

= Rs.  $232 \times 10^6$  per year.

**3.7.3. Fixed percentage method.** In this method the depreciation reserve during any year is a fixed percentage (say  $x$ ) of the remaining balance of initial investment minus total accumulated depreciation at the beginning of the year. This method is also known as declining balance method.

Let  $C$  be the initial investment and  $n$  years be the life of the equipment. Then

$$\text{Annual depreciation during first year} = \frac{Cx}{100}$$

$$\text{Remaining balance at the beginning of second year} = C - \frac{Cx}{100} = C \left( 1 - \frac{x}{100} \right)$$

$$\text{Annual depreciation during second year} = C \left( 1 - \frac{x}{100} \right) \frac{x}{100}$$

Remaining balance at the beginning of third year

$$= C \left( 1 - \frac{x}{100} \right) - C \left( 1 - \frac{x}{100} \right) \frac{x}{100} = C \left( 1 - \frac{x}{100} \right)^2$$

$$\text{Annual depreciation during third year} = C \left( 1 - \frac{x}{100} \right)^2 \frac{x}{100}$$

Remaining balance at the beginning of fourth year (i.e. end of third year)

$$= C \left( 1 - \frac{x}{100} \right)^2 - C \left( 1 - \frac{x}{100} \right)^2 \frac{x}{100} = C \left( 1 - \frac{x}{100} \right)^3$$

$$\text{Remaining balance at the end of } n \text{ years (i.e. life of equipment)} = C \left( 1 - \frac{x}{100} \right)^n$$

The remaining balance at the end of  $n$  years should be equal to salvage value  $S$ . Thus

$$C \left( 1 - \frac{x}{100} \right)^n = S \quad \dots (3.10)$$

In Eq. (3.10),  $C$ ,  $S$  and  $n$  are known and hence  $x$  can be found.



**BHARTIYA SKILL DEVELOPMENT UNIVERSITY**

School of Electrical Skills

Session: 2019-20 (Summer Semester)

B. Voc. Program, 5<sup>th</sup> Semester,

End – Sem. Examination

Course Code: ELE 1503

Course Name: Electrical Machines

Time: 2 Hours

Max. Marks: 50

**Instruction:** Answer all questions from section A, each question carries one mark. Answer all questions from section B, each question carries four marks. Answer all questions from section C, each question carries six marks. Scientific calculator is allowed.

**Section – A**

10X01 = 10 Marks

1. The speed at which a magnetic field rotates is defined as:
  - (a) Synchronous speed of an induction motor
  - (b) The rotor speed of an induction motor
  - (c) The speed of an induction motor at no load
  - (d) None of these
2. If the stator frequency of an induction motor is  $F_s$ , then the rotor frequency  $F_r$  is given by:
  - (a)  $F_r = S * F_s$
  - (b)  $F_r = S / F_s$
  - (c)  $F_r = 1 / S * F_s$
  - (d) None of these
3. In a shaded pole single-phase motor, the revolving field is produced by the use of:
  - (a) Inductor
  - (b) Capacitor
  - (c) Resistor
  - (d) Shading coils
4. For an induction motor, given  $f = 60$  Hz,  $N_s = 1800$  rpm the number of poles in the machine is:
  - (a) 1
  - (b) 2
  - (c) 3
  - (d) 4
5. The emf induced in the rotor of an induction motor is proportional to:
  - (a) Voltage applied to stator
  - (b) Relative velocity between flux and rotor conductors
  - (c) Both (a) and (b)
  - (d) Slip
6. Which of the following machines can use a universal motor?
  - (a) Portable tools
  - (b) Lathe machines
  - (c) Oil expeller
  - (d) Floor polishing machine
7. The purpose of stator winding in the compensated repulsion motor is to:
  - (a) Provide mechanical balance
  - (b) Improve power factor and provide better speed regulation
  - (c) Prevent hunting in the motor
  - (d) Eliminate armature reaction
8. In an induction motor, no-load slip is generally:
  - (a) less than 1%
  - (b) 1.5%
  - (c) 2%
  - (d) 4%



9. If the air gap of an induction motor is increased, then:
- (a) The magnetising current of the rotor will decrease
  - (b) The power factor will decrease
  - (c) speed of motor will increase
  - (d) None of these
10. The number of slip rings in a squirrel cage induction motor is usually:
- (a) zero
  - (b) One
  - (c) Two
  - (d) Four

**Section – B**

04X04 = 16 Marks

1. Why an induction motor cannot run on synchronous speed?
2. Explain the working principle of repulsion motor.
3. A 4-pole, 3-phase, 50 Hz, star connected induction motor has a slip of 3%. Calculate full load speed of motor.
4. Draw and explain the equivalent circuit of an induction motor

**Section – C**

04X06 = 24 Marks

1. Draw and explain the equivalent circuit of a transformer.
2. Explain the torque slip characteristics of three phase induction motor and clearly specify the stable and unstable zone.
3. A 3 phase induction motor draws 80kW from the 3 phase source. Given that Synchronous Speed  $N_s = 1200$  RPM, Rotor speed  $N_r = 1152$  RPM, Total stator loss = 5Kw. Find the Rotor output power produced by the machine.
4. Explain the working of universal motor and write its applications.

**BHARTIYA SKILL DEVELOPMENT UNIVERSITY****School of Electrical Skills****5<sup>st</sup> Semester, End-Sem. Examination****B. Voc. Program, Summer Semester (2019-20)****Course Code: ELE 1503****Time: 2 Hours****Course Name: Electrical Machines****Max. Marks: 50****Section – A**

10X01 = 05 Marks

1. (a) Synchronous speed of an induction motor
2. (a)  $f_r = S \cdot f_s$
3. (d) Shading coils
4. (d) 4
5. (c) Both (a) and (b)
6. (a) Portable tools
7. (b)
8. (a) less than 1%
9. (b) The power factor will decrease
10. (a) zero

**Section – B**

04X04 = 16 Marks

1. On what speed an induction motor can run, why?  
Less than Synchronous Speed. If rotor runs at the synchronous speed, which is the same speed of the rotating magnetic field, then the rotor will appear stationary to the rotating magnetic field and the rotating magnetic field will not cut the rotor. So, no induced current will flow in the rotor and no rotor magnetic flux will be produced so no torque is generated and the rotor speed will fall below the synchronous speed. When the speed falls, the rotating magnetic field will cut the rotor windings and a torque is produced
2. Explain the working principle of repulsion motor

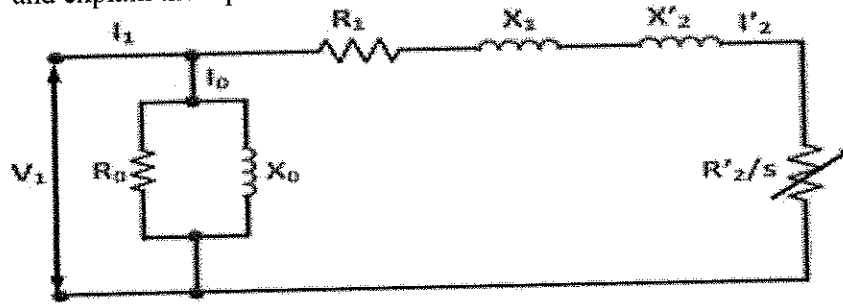
The basic principle behind the working of repulsion motor is that “similar poles repel each other.” This means two North poles will repel each other. Similarly, two South poles will repel each other.

When the stator winding of repulsion motor is supplied with single phase AC, it produces a magnetic flux along the direct axis as shown in figure above by arrow mark. This magnetic flux when link with the rotor winding, creates an emf. Due to this emf, a rotor current is produced. This rotor current in turn produces a magnetic flux which is directed along the brush axis due to commutator assembly. Due to the interaction of stator and rotor produced fluxes, an electromagnetic torque is produced

3. An 4-pole, 3-phase, 50 Hz, star connected induction motor has a slip of 3%. Calculate full load speed of motor?  
: In Induction Motor,  
Speed  $N_s = (120 \cdot \text{frequency}) / (\text{No. of poles})$   
Speed  $N_s = (120 \cdot 50) / 4 = 1500 \text{ rpm.}$   
So the slip  $S = (N_s - N) / N_s$   
 $0.03 = (1500 - N) / 1500$   
 $N = 1455 \text{ rpm}$

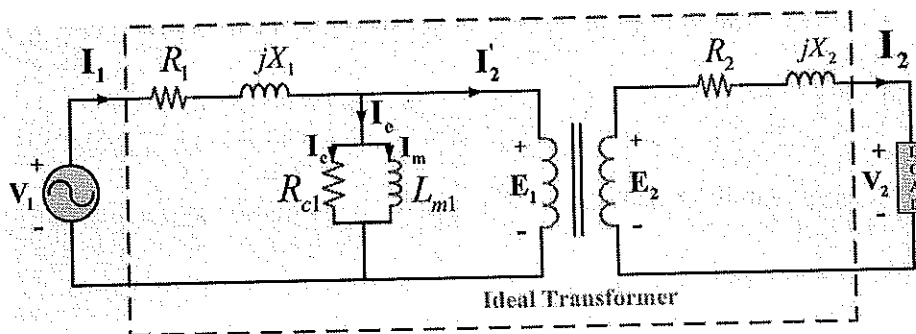
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4. Draw and explain the equivalent circuit of an induction motor

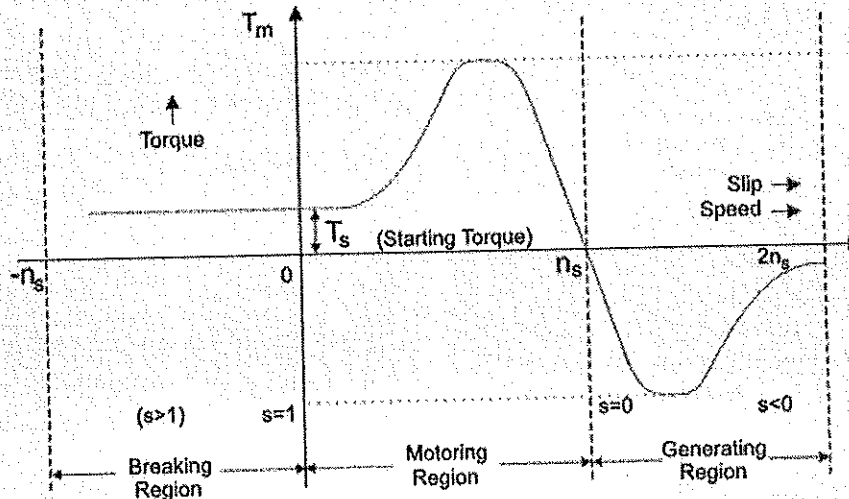


**Section - C**

1. Draw and explain the equivalent circuit of transformer



2. Explain the torque slip characteristics of three phase induction motor and clearly specify the stable and unstable zone?



**Torque Slip Curve for Three Phase Induction Motor**

The torque slip curve for an induction motor gives us the information about the variation of torque with the slip. The slip is defined as the ratio of difference of synchronous speed and actual rotor speed to the synchronous speed of the machine. The variation of slip can be obtained with the variation of speed that is when speed varies the slip will also vary and the torque corresponding to that speed will also vary.

**Motoring Mode**

In this mode of operation, supply is given to the stator sides and the motor always rotates below the synchronous speed. The induction motor torque varies from zero to full load torque as the slip varies. The slip varies from zero to one. It is zero at no load

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and one at standstill. From the curve it is seen that the torque is directly proportional to the slip.

That is, more is the slip, more will be the torque produced and vice-versa. The linear relationship simplifies the calculation of motor parameter to great extent.

**Generating Mode**

In this mode of operation induction motor runs above the synchronous speed and it should be driven by a prime mover. The stator winding is connected to a three phase supply in which it supplies electrical energy. Actually, in this case, the torque and slip both are negative so the motor receives mechanical energy and delivers electrical energy. Induction motor is not much used as generator because it requires reactive power for its operation.

That is, reactive power should be supplied from outside and if it runs below the synchronous speed by any means, it consumes electrical energy rather than giving it at the output. So, as far as possible, induction generators are generally avoided.

**Braking Mode**

In the Braking mode, the two leads or the polarity of the supply voltage is changed so that the motor starts to rotate in the reverse direction and as a result the motor stops. This method of braking is known as plugging. This method is used when it is required to stop the motor within a very short period of time. The kinetic energy stored in the revolving load is dissipated as heat. Also, motor is still receiving power from the stator which is also dissipated as heat. So as a result of which motor develops enormous heat energy. For this stator is disconnected from the supply before motor enters the braking mode.

3. For a 3 phase induction motor draws 80kW from the 3 phase source. Given that Synchronous speed  $N_s = 1200$  RPM, Rotor speed  $N_r = 1152$  RPM, Total stator loss = 5kW. Find the Rotor output power produced by the machine.

$$P_i = 80 \text{ kW}$$

$$\text{So, } P_g = 80 - 5 = 75 \text{ kW}$$

$$P_m = P_g - P_{\text{rloss}}$$

$$P_{\text{rloss}} = P_g - P_m$$

$$P_{\text{rloss}} = T \omega_s - T \omega_r$$

$$= T(\omega_s - \omega_r)$$

$$= T \omega_s (1 - \omega_r / \omega_s)$$

$$= P_g (\omega_s - \omega_r / \omega_s)$$

$$P = P_g * s$$

$$S = (N_s - N_r) / N_s$$

$$S = (1200 - 1152) / 1200$$

$$S = 0.04$$

$$\text{So, } P_{\text{rloss}} = 0.04 * 75$$

$$= 3 \text{ kW}$$

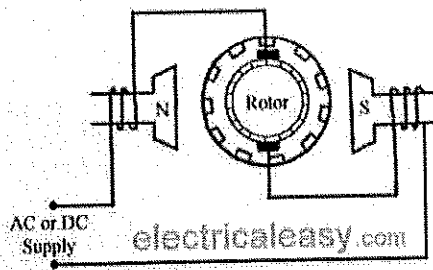
$$\text{Then } P_m = P_g - P_{\text{rloss}}$$

$$= 75 - 3$$

$$72 \text{ kW}$$

4. Explain the working and application of universal motor  
Working of Universal Motor

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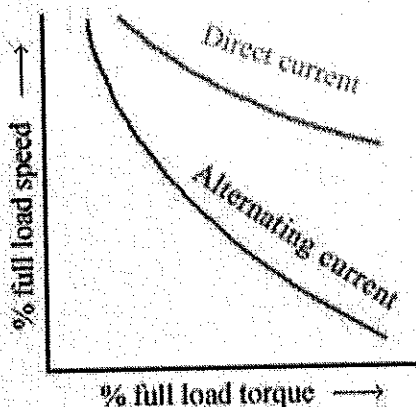
A universal motor works on either DC or single phase AC supply. When the universal motor is fed with a DC supply, it works as a DC series motor. When current flows in the field winding, it produces an electromagnetic field. The same current also flows from the armature conductors. When a current carrying conductor is placed in an electromagnetic field, it experiences a mechanical force. Due to this mechanical force, or torque, the rotor starts to rotate. The direction of this force is given by Fleming's left hand rule.

When fed with AC supply, it still produces unidirectional torque. Because, armature winding and field winding are connected in series, they are in same phase. Hence, as polarity of AC changes periodically, the direction of current in armature and field winding reverses at the same time.

Thus, direction of magnetic field and the direction of armature current reverses in such a way that the direction of force experienced by armature conductors remains same. Thus, regardless of AC or DC supply, universal motor works on the same principle that DC series motor works.

**Speed/Load Characteristics**

Speed/load characteristics of a universal motor is similar to that of DC series motor. The speed of a universal motor is low at full load and very high at no load. Usually, gears trains are used to get the required speed on required load. The speed/load characteristics are (for both AC as well as DC supply) are shown in the figure.



**Applications of Universal Motor**

- Universal motors find their use in various home appliances like vacuum cleaners, drink and food mixers, domestic sewing machine etc.
- The higher rating universal motors are used in portable drills, blenders etc.

**BHARTIYA SKILL DEVELOPMENT UNIVERSITY**

School of Electrical Skills

Session: 2019-20 (Summer Semester)

B. Voc. Program, 5<sup>th</sup> Semester,

End-Sem. Examination

Course Code: ELE 1504

Time: 2 Hours

Course Name: Solar PV Technology

Max. Marks: 50

**Instruction:** Answer all questions from section A, each question carries one mark. Answer all questions from section B, each question carries four marks. Answer all questions from section C, each question carries six marks. Scientific calculator is allowed.

**Section – A**

10X01 = 10 Marks

1. How much time sunlight takes to reach at the earth?  
(a) 8 seconds                      (b) 8 minutes                      (c) 20 seconds                      (d) 100 seconds
2. A module is a:  
(a) Series-arrangement of solar cells                      (b) Parallel arrangement of solar cells  
(c) Random arrangement of solar cells                      (d) None of the above
3. Solar radiation which reaches the surface without scattering or absorbed is called:  
(a) Beam Radiation                      (b) Infrared radiation  
(c) Ultraviolet radiation                      (d) Diffuse radiation
4. If a PV cell produces 0.7 V, then four PV cells connected in series will produce:  
(a) 2.8 V                      (b) 0.5 V                      (c) 2.5 V                      (d) 1.0 V
5. Solar energy travels through space by the process of:  
(a) Conduction                      (b) Convection                      (c) Radiation                      (d) Transportation
6. What does MNRE stand for?  
(a) Ministry of New and Right energy  
(b) Mandate for Non-renewable Energy  
(c) Ministry of New and Renewable Energy  
(d) Ministry of Natural and Renewable Energy
7. The position of sun when it is located directly overhead is called:  
(a) Sun at beneath                      (b) Sun at inclination  
(c) Sun at zenith                      (d) Sun at top
8. Solar cells are made of:  
(a) Aluminum                      (b) Germanium                      (c) Silicon                      (d) Cadmium



9. What is the total output power, if three PV cells of 0.6V connected in series and a single PV cell produces 1A current?
- (a) 1.8 W                      (b) 0.5 W                      (c) 2.5 W                      (d) 1.0 W
10. A grid tied inverter converts power from:
- (a) AC to DC                      (b) DC to AC                      (c) DC to DC                      (d) None of these

**Section – B**

04X04 = 16 Marks

1. Distinguish between renewable and non-renewable energy sources.
2. What are the factor over which electricity generated by solar cell depends?
3. Define the following terms:  
(i) STC                      (ii) Air mass
4. The current density of solar cell having an area of 200 cm<sup>2</sup> at STC is given as 35 mA/ cm<sup>2</sup>. Find out the output current of solar cell.

**Section – C**

04X06 = 24 Marks

1. With neat diagram, explain the working principle of solar cell.
2. What is solar PV system? What are the types of solar PV system?
3. Draw I-V curve of solar cell and describe its parameters.
4. Calculate the output power for solar cells of efficiencies 20%. When the input power is say, 500, 800, and 1000 W/m<sup>2</sup> and area of solar cell is 0.1 m<sup>2</sup>.

Set-A

Course Name: Solar PV Technology

Course code: ELE1504

Set-A

1. Ans: - (b)

2. Ans: - (a)

3. Ans: - (a)

4. Ans: - (a)

5. Ans: - (c)

6. Ans: - (c)

7. Ans: - (c)

8. Ans: - (c)

9. Ans: - (a)

10. Ans: - (b)

## Section-B

1 Ans: A source of energy that can be exhaustible is called non-renewable energy.

ex:- coal, petrol etc.

A source of energy that can be in-exhaustible is called renewable energy.

ex:- solar, wind, etc.

2. Ans: —

There are five common factors that affect the power generated by solar cells, they are as follows: —

- (i) Conversion efficiency ( $\eta$ )
- (ii) The amount of light ( $P_{in}$ )
- (iii) The solar cell area ( $A$ )
- (iv) The angle at which light falls ( $\theta$ ).
- (v) The operating temperature ( $T$ )

3. Ans:

(a) STC: - At STC all solar modules are characterized. At STC: -  
 incident radiation =  $1000 \text{ W/m}^2$   
 temp. =  $25^\circ \text{C}$   
 Air mass = A.M 1.5

(b) Air mass: - The thickness of earth's atmosphere is referred to as air mass (AM).

ex: -

AM0  $\rightarrow$  Air mass travelled is zero  
 AM1  $\rightarrow$  when sun is exactly at overhead position.

4. Ans:

It is given

$$A = 200 \text{ cm}^2 \text{ at STC}$$

$$J = 35 \text{ mA/cm}^2$$

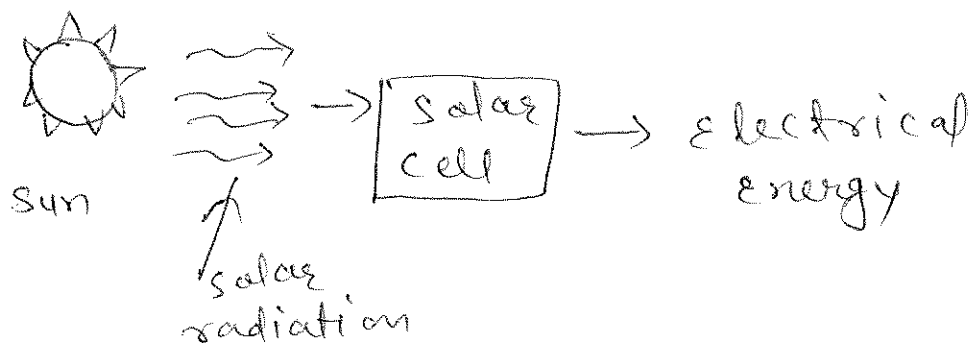
Since,  $J = \frac{I}{A}$

$$\text{or, } I_{\text{out}} = J \cdot A = 35 \text{ mA/cm}^2 \times 200 \text{ cm}^2 = 7000 \text{ mA}$$

$$\text{or, } \boxed{I_{\text{out}} = 7.0 \text{ A}}$$

## Section - C

1 Ans:



(fig: Energy from solar PV conversion)

- (i) when sunlight incident on solar cell, an electron hole pair is generated.
- (ii) separation and transportation of charge carriers towards electrodes occurs due to inbuilt electric field in depletion region.
- (iii) collection of charge carrier by electrodes and electricity transferred to load.

2. Ans:

In a solar PV system, there is a source which generates electricity and load that consumes electricity. For reliable operation of solar PV - systems, the power to the load should be made available whenever it is required by the user.

There are mainly two types of solar PV-system:-

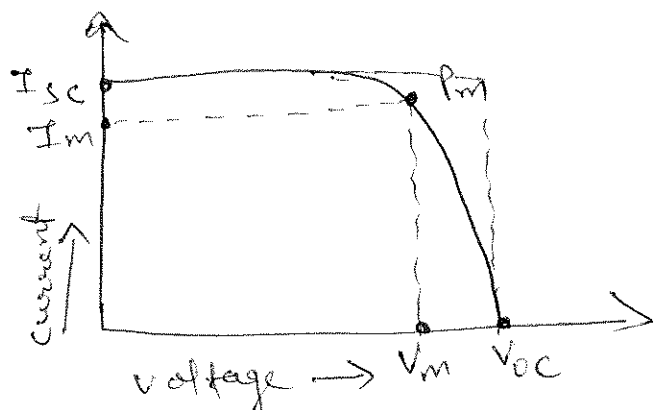
(i) OFF-grid.

(ii) ON-grid.

(i) OFF-grid:  $\rightarrow$  off-grid solar PV-system are one which is not connected to grid. It stores energy in battery for night time, when there is no sunlight.

(ii) ON-grid  $\rightarrow$  ON-grid solar PV-system are one which is connected to grid. This type of system can take power from grid or can feed power to grid.

3. Ans:



(I-v curve of solar cell)

The list of solar cell parameters is following.

- (i)  $I_{sc}$  (short circuit current): — It is the  $\text{max}^m$ . current that a solar cell produce.
- (ii)  $V_{oc}$  (open circuit voltage) — It is the  $\text{max}^m$ . voltage that a solar cell can produce.
- (iii)  $P_m$  (~~max~~  $\text{max}^m$ . power point) — It is the  $\text{max}^m$ . power that a solar cell produce under STC.
- (iv)  $I_m$  (current at  $P_m$ ) → This is the current which solar cell produces when operating at  $P_m$ .
- (v)  $V_m$  (voltage at  $P_m$ ) → This is the voltage which solar cell will produce when operating at  $P_m$ .

∴ Ans: —

It is given,  $\eta = 20\%$

$P_{in} = 500 \text{ W/m}^2, 800 \text{ W/m}^2$  and  $1000 \text{ W/m}^2$

$$A = 0.1 \text{ m}^2$$

$$P_{out} = \eta \cdot P_{in} \times A$$

at  $P_{in} = 500 \text{ W/m}^2$

$$P_{out} = \frac{20}{100} \times 500 \text{ W/m}^2 \times 0.1 \text{ m}^2 = 100 \text{ W}$$

$$P_{out} = 100 \text{ W}$$

$$\text{At } P_{in} = 800 \text{ W/m}^2$$

$$P_{out} = \frac{20}{100} \times 800 \text{ W/m}^2 \times 0.1 \text{ m}^2 = 16.0 \text{ W}$$

$$P_{out} = 16.0 \text{ W}$$

$$\text{At } P_{in} = 1000 \text{ W/m}^2$$

$$P_{out} = \frac{20}{100} \times 1000 \text{ W/m}^2 \times 0.1 = 20 \text{ W}$$

$$P_{out} = 20 \text{ W}$$

