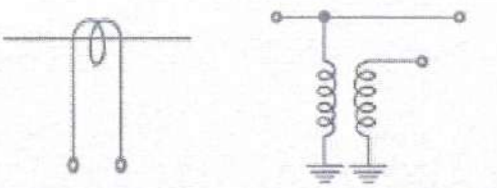
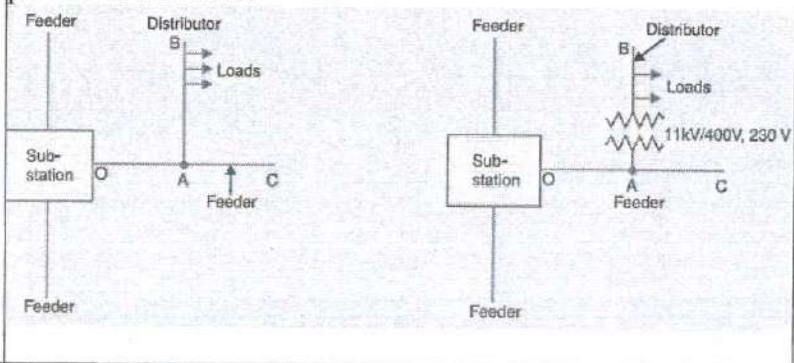
SET I

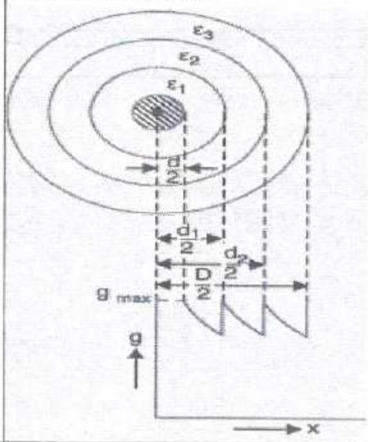
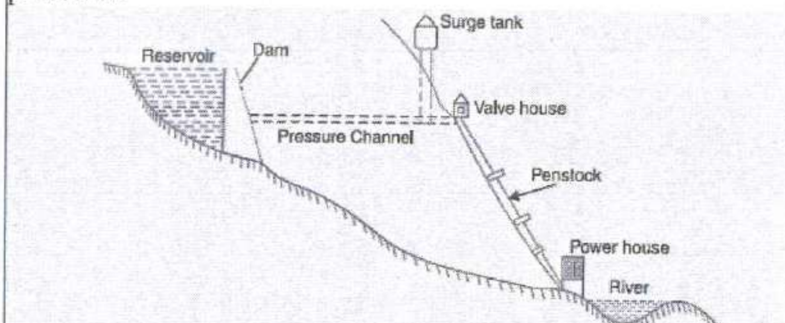
SCORING INDICATORS

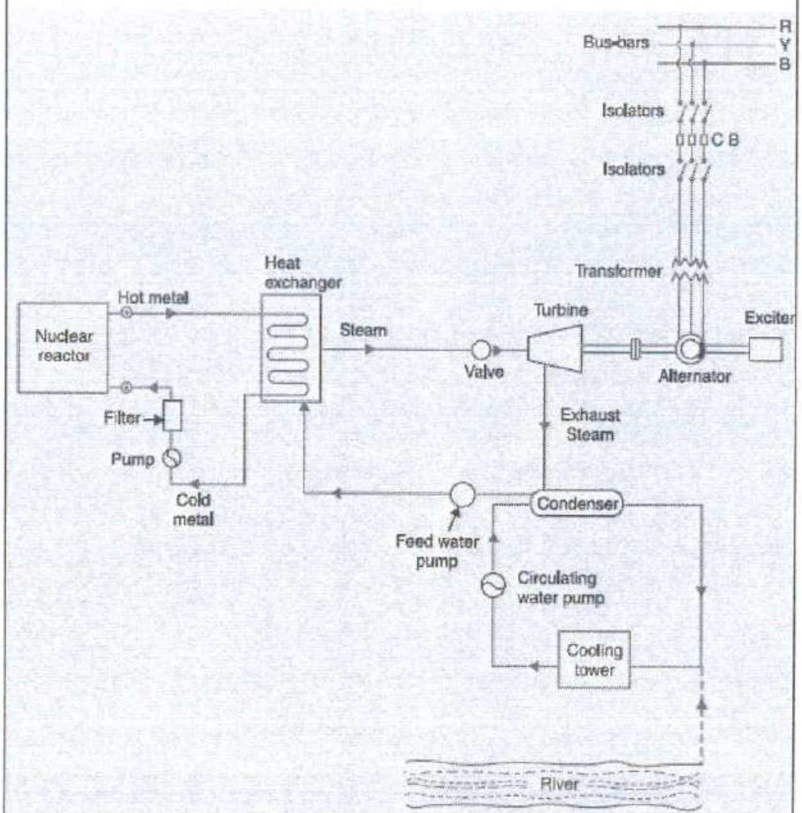
COURSE NAME : ELECTRICAL GENERATION, TRANSMISSION AND DISTRIBUTION

COURSE CODE : 5032 **QID :** 2109230053

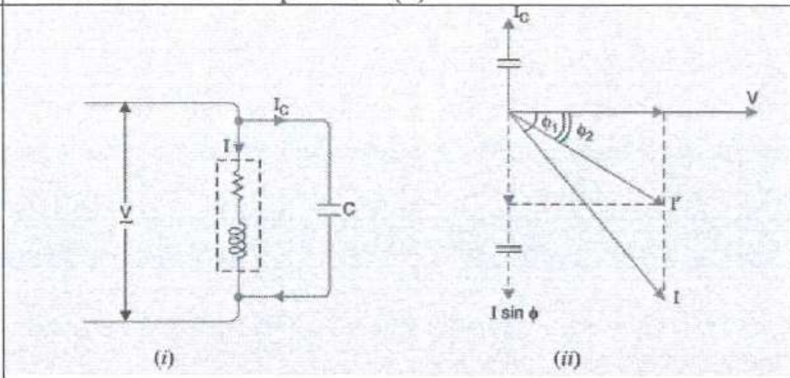
Q No	Scoring Indicators	Split score	Sub Total	Total score
	PART A			**9**
I. 1	Conventional and Non-conventional sources	½ each	1	
I. 2	Economizer		1	
I. 3	to slow down the neutrons and control nuclear fusion		1	
I. 4	Sum of individual maximum demands/Maximum demand on the power station		1	
I. 5	Static Capacitors, Synchronous Condenser, Phase Advancer	½ each (any two)	1	
I. 6	400 kV, 220 kV, 110 kV and 66 kV AC lines.	½ each (any two)	1	
I. 7	Sag		1	
I. 8		½ each	1	
I. 9	String efficiency = $\frac{\text{Voltage across the string}}{n \times \text{Voltage across disc nearest to conductor}}$ n = number of discs in the string.		1	
	PART B			**24**
II. 1	Weight of water available is W = Volume of water × density = $(5 \times 10^6) \times (1000)$ (mass of 1 m^3 of water is 1000 kg) = 5×10^9 kg = $5 \times 10^9 \times 9{\cdot}81$ N - (1) Electrical energy available = W × H × η overall = $(5 \times 10^9 \times 9{\cdot}81) \times (200) \times (0{\cdot}75)$ watt sec = 2.044×10^6 kWh (2)	1 + 2	3	
II. 2	Exchange of peak loads Use of older plants Ensures economical operation Increases diversity factor	Any three	3	
II. 3	(i)Supply of Fuel (ii)Availability of water. (iii) Transportation facilities (iv) Cost and type of land. (v) Nearness to load centres.	Any three	3	

II. 4	Units generated/annum = Average load (in kW) × Hours in a year = Max. demand (in kW) × L.F. × 8760 = $100 \times 10^3 \times 0.4 \times 8760 = 3504 \times 10^5$ KWh	3	3	
II. 5	(i) Large kVA rating of equipment (ii) Greater conductor size. (iii) Large copper losses. (iv) Poor voltage regulation. (v) Reduced handling capacity of system	Any three 1 + 1 + 1	3	
II. 6	The Ferranti effect is a phenomenon in which the voltage at the receiving end (load side) is greater than the voltage at the sending end (source or generating side) of a long transmission line or cable during light load or no load conditions. The rise in voltage is due to more reactive power being generated by the line capacitance in the power lines than the power being consumed. Ferranti Effect mainly occurs due to the presence of a huge charging current due to the capacitance of the transmission line. Although different factors affect the current in the transmission line. However, Ferranti Effect occurs due to the following three reasons.	3	3	
II. 7	***i)Short transmission lines***. When the length of an overhead transmission line is up to about 50 km and the line voltage is comparatively low (< 20 kV), it is usually considered as a short transmission line. ***(ii) Medium transmission lines.*** When the length of an overhead transmission line is about 50- 150 km and the line voltage is moderately high (>20 kV < 100 kV), it is considered as a medium transmission line. ***(iii) Long transmission lines.*** When the length of an overhead transmission line is more than 150 km and line voltage is very high (> 100 kV), it is considered as a long transmission line.	1+1+1	3	
II. 8	Radial System. In this system, separate feeders radiate from a single substation and feed the distributors at one end only. Fig. shows a single line diagram of a radial system for d.c. distribution where a feeder OC supplies a distributor AB at point A. Obviously, the distributor is fed at one end only i.e., point A is this case. 		3	
II.9	By using longer cross arms By grading the insulators	3 points	3	

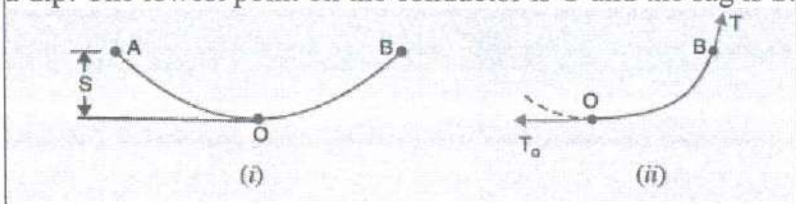
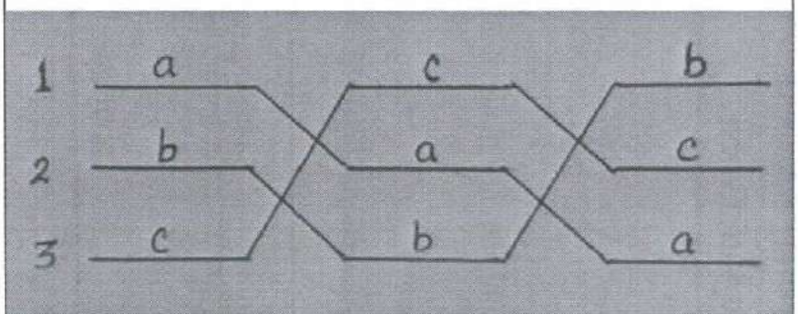
	By using a guard ring	1 each		
II.10	*The process of achieving uniformity in the dielectric stress by using layers of different dielectrics is known as* **capacitance grading.** In capacitance grading, the homogeneous dielectric is replaced by a composite dielectric. The composite dielectric consists of various layers of different dielectrics in such a manner that relative permittivity εr of any layer is inversely proportional to its distance from the centre. 		3	
	PART C			
III	The dam is constructed across a river or lake and water from the catchment area collects at the back of the dam to form a reservoir. A pressure tunnel is taken off from the reservoir and water brought to the valve house at the start of the penstock.  Schematic arrangement of a Hydro-electric plant The valve house contains main sluice valves and automatic isolating valves. The former controls the water flow to the power house and the latter cuts off supply of water when the penstock bursts. From the valve house, water is taken to water	Figure 4 Explanation 3	7	

<table>
<tr><td></td><td>turbine through a huge steel pipe known as penstock. The water turbine converts hydraulic energy into mechanical energy. The turbine drives the alternator which converts mechanical energy into electrical energy.
A surge tank (open from top) is built just before the valve house and protects the penstock from bursting in case the turbine gates suddenly close* due to electrical load being thrown off.</td><td></td><td></td><td></td></tr>
<tr><td>IV</td><td>The whole arrangement can be divided into the following main stages :
(i) Nuclear reactor (ii) Heat exchanger (iii) Steam turbine (iv) Alternator.
Nuclear reactor. It is an apparatus in which nuclear fuel (U235) is subjected to nuclear fission. It controls the chain reaction* that starts once the fission is done. If the chain reaction is not controlled, the result will be an explosion due to the fast increase in the energy released.
(ii) Heat exchanger. The coolant gives up heat to the heat exchanger which is utilized in raising the steam
(iii) The steam produced in the heat exchanger is led to the steam turbine through a valve. After doing a useful work in the turbine, the steam is exhausted to condenser. The condenser condenses the steam which is fed to the heat exchanger through feed water pump.


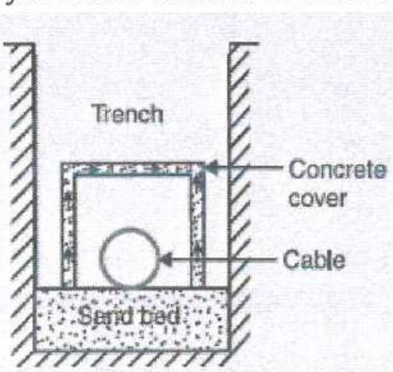
(iv) Alternator. The steam turbine drives the alternator which converts mechanical energy into electrical energy. The</td><td>Fig – 4
Explanation - 3</td><td>7</td><td></td></tr>
</table>

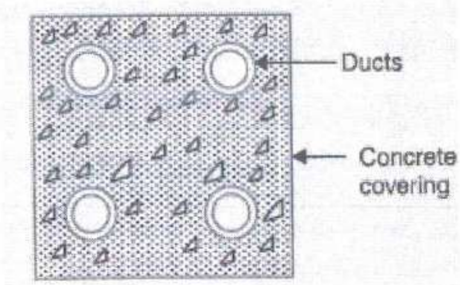
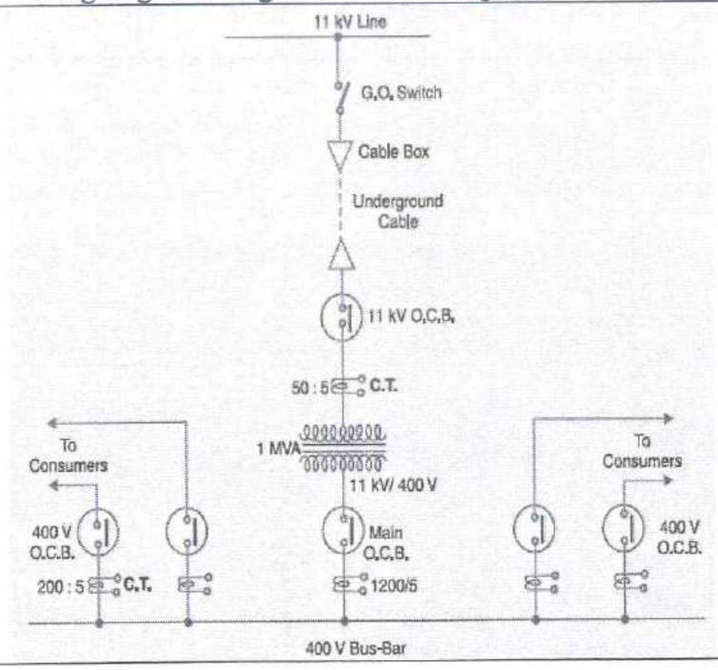
	output from the alternator is delivered to the bus-bars through transformer, circuit breakers and isolators fed to the reactor.			
V	(*i*) Diversity factor = (1500 + 800 + 100 + 500)/2500 = **1·16** **(3)** (*ii*) Average demand = $\frac{\text{kWh generated / annum}}{\textit{Hours in a year}}$ = 45 × 10^5/8760 = 513·7 kW ∴ Load factor = $\frac{\textit{Average load}}{\textit{Maximum demand}}$ = 513.7/2500= 0·205 = **20·5%** **(4)**	3 4	7	
VI	Assume the load factor and power factor to be unity. ∴ Maximum demand = (220 x 25 x 1)/1000 = 5.5 kW (i) Units consumed in 500 hrs = 5·5 × 500 = 2750 kWh Charges for 2750 kWh = Rs 0·2 × 2750 = Rs. 550 Remaining units = 9750 − 2750 = 7000 kWh (3) Charges for 7000 kWh = Rs 0·1 × 7000= Rs.700 ∴ Total annual bill = Rs (550 + 700) = Rs. 1250 (ii) Equivalent flat rate = Rs 1250/8760 = Rs. 1426 =14.26 paise (4)	3 + 4	7	
VII	 Consider an inductive load taking a lagging current I at a power factor cos φ1. In order to improve the power factor of this circuit, the remedy is to connect such an equipment in parallel with the load which takes a leading reactive component and partly cancels the lagging reactive component of the load. Fig shows a capacitor connected across the load. The capacitor takes a current Ic which leads the supply voltage V by 90'. The current Ic partly cancels the lagging reactive component of the load current as shown in the phasor diagram. The resultant circuit current becomes I′ and its angle of lag is φ2. It is clear that φ2 is less than φ1so that new p.f. cos φ2 is more than the previous p.f. cos φ1.	Fig 4 Exp 3	7	

VIII	The total cost of electrical energy generated can be divided into three parts, namely ; (i) Fixed cost ; (ii) Semi-fixed cost ; (iii) Running or operating cost. **(i) Fixed cost**. It is the cost which is independent of maximum demand and units generated. The fixed cost is due to the annual cost of central organisation, interest on capital cost of land and salaries of high officials. The annual expenditure on the central organisation and salaries of high officials is fixed since it has to be met whether the plant has high or low maximum demand or it generates less or more units. Further, the capital investment on the land is fixed and hence the amount of interest is also fixed. **(ii) Semi-fixed cost**. It is the cost which depends upon maximum demand but is independent of units generated. The semi-fixed cost is directly proportional to the maximum demand on power station and is on account of annual interest and depreciation on capital investment of building and equipment, taxes, salaries of management and clerical staff. The maximum demand on the power station determines its size and cost of installation. The greater the maximum demand on a power station, the greater is its size and cost of installation. Further, the taxes and clerical staff depend upon the size of the plant and hence upon maximum demand. **(iii) Running cost**. It is the cost which depends only upon the number of units generated. The running cost is on account of annual cost of fuel, lubricating oil, maintenance, repairs and salaries of operating staff. Since these charges depend upon the energy output, the running cost is directly proportional to the number of units generated by the station. In other words, if the power station generates more units, it will have higher running cost and vice-versa	7	7	
IX	While erecting an overhead line, it is very important that conductors are under safe tension. If the conductors are too much stretched between supports in a bid to save conductor material, the stress in the conductor may reach unsafe value and in certain cases the conductor may break due to excessive tension. In order to permit safe tension in the conductors, they are not fully stretched but are allowed to have a dip or sag. The difference in level between points of supports and the lowest point on the conductor is called sag.Fig. shows a conductor suspended between two equilevel supports A and B. The conductor is not fully stretched but is allowed to have		7	

	a dip. The lowest point on the conductor is O and the sag is S.  (i) When the conductor is suspended between two supports at the same level, it takes the shape of catenary. However, if the sag is very small compared with the span, then sag-span curve is like a parabola. (ii) The tension at any point on the conductor acts tangentially. Thus tension To at the lowest point O acts horizontally. (iii) The horizontal component of tension is constant throughout the length of the wire. (iv) The tension at supports is approximately equal to the horizontal tension acting at any point on the wire. Thus if T is the tension at the support B, then T = To. Sag, $S = \frac{w(l/2)^2}{2T} = \frac{w\,l^2}{8\,T}$			
X	In order that voltage drops are equal in all conductors, we generally interchange the positions of the conductors at regular intervals along the line so that each conductor occupies the original position of every other conductor over an equal distance. Such an exchange of positions is known as transposition. The phase conductors are designated as A, B and C and the positions occupied are numbered 1, 2 and 3. The effect of transposition is that each conductor has the same average inductance.  	Fig – 3 Exp - 4	7	

XI	(i) Conductors which carry electric power from the sending end station to the receiving end station. The conductor is one of the important items as most of the capital outlay is invested for it. Therefore, proper choice of material and size of the conductor is of considerable importance. Commonly used conductor materials. The most commonly used conductor materials for overhead lines are copper, aluminium, steel-cored aluminium, galvanised steel and cadmium copper. (ii) Supports which may be poles or towers and keep the conductors at a suitable level above the ground. The supporting structures for overhead line conductors are various types of poles and towers called line supports. The line supports used for transmission and distribution of electric power are of various types including wooden poles, steel poles, R.C.C. poles and lattice steel towers. The choice of supporting structure for a particular case depends upon the line span, X-sectional area, line voltage, cost and local conditions. (iii) Insulators which are attached to supports and insulate the conductors from the ground. The overhead line conductors should be supported on the poles or towers in such a way that currents from conductors do not flow to earth through supports i.e., line conductors must be properly insulated from supports. This is achieved by securing line conductors to supports with the help of insulators. The insulators provide necessary insulation between line conductors and supports and thus prevent any leakage current from conductors to earth. (iv) Cross arms which provide support to the insulators. (v) Miscellaneous items such as phase plates, danger plates, lightning arrestors, anti-climbing wires etc.		7	
XII	**D.C. transmission.** **Advantages.** The high voltage d.c. transmission has the following advantages over high voltage a.c. transmission : (i) It requires only two conductors as compared to three for a.c. transmission. (ii) There is no inductance, capacitance, phase displacement and surge problems in d.c. transmission. (iii) Due to the absence of inductance, the voltage drop in a d.c. transmission line is less than the a.c. line for the same load and sending end voltage. For this reason, a d.c. transmission line has better voltage regulation. (iv) There is no skin effect in a d.c. system. Therefore, entire cross-section of the line conductor is utilised. (v) For the same working voltage, the potential stress on the insulation is less in case of d.c. system than that in a.c. system. Therefore, a d.c. line requires less insulation. (vi) A d.c. line has less corona loss and reduced interference	7 points		

	with communication circuits. (vii) The high voltage d.c. transmission is free from the dielectric losses, particularly in the case of cables. (viii) In d.c. transmission, there are no stability problems and synchronising difficulties. **DC transmission** **Disadvantages** i) Electric power cannot be generated at high d.c. voltage due to commutation problems. (ii) The d.c. voltage cannot be stepped up for transmission of power at high voltages. (iii)The d.c. switches and circuit breakers have their own limitations. **AC Transmission-Advantages** i) The power can be generated at high voltages. (ii) The maintenance of a.c. sub-stations is easy and cheaper. (iii) The a.c. voltage can be stepped up or stepped down by transformers with ease and efficiency. This permits to transmit power at high voltages and distribute it at safe potentials. **Disadvantages** An a.c. line requires more copper than a d.c. line. (ii) The construction of a.c. transmission line is more complicated than a d.c. transmission line. (iii) Due to skin effect in the a.c. system, the effective resistance of the line is increased. (iv) An a.c. line has capacitance. Therefore, there is a continuous loss of power due to charging current			
XIII	1. **Direct laying**. This method of laying underground cables is simple and cheap and is much favoured in modern practice. In this method, a trench of about 1·5 metres deep and 45 cm wide is dug. The trench is covered with a layer of fine sand (of about 10 cm thickness) and the cable is laid over this sand bed. The sand prevents the entry of moisture from the ground and thus protects the cable from decay. After the cable has been laid in the trench,it is covered with another layer of sand of about 10 cm thickness.  2. Draw-in system. In this method, conduit or duct of	Fig 3 Exp 4	7	

	glazed stone or cast iron or concrete are laid in the ground with manholes at suitable positions along the cable route. The cables are then pulled into position from manholes. Fig. shows section through four-way underground duct line. Three of the ducts carry transmission cables and the fourth duct carries relay protection connection, pilot wires  3. Solid system. In this method of laying, the cable is laid in open pipes or troughs dug out in earth along the cable route. The troughing is of cast iron, stoneware, asphalt or treated wood. After the cable is laid in position, the troughing is filled with a bituminous or asphaltic compound and covered over. Cables laid in this manner are usually plain lead covered because troughing affords good mechanical protection.				
XIV	 	Fig 3 Exp 4	7		