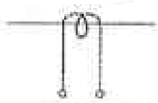
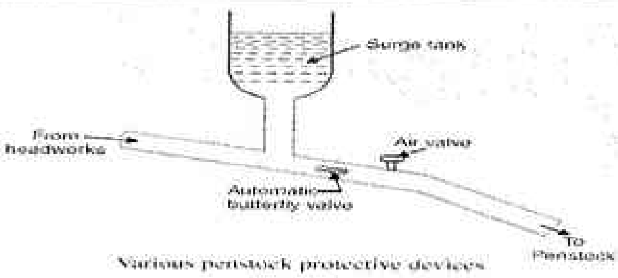
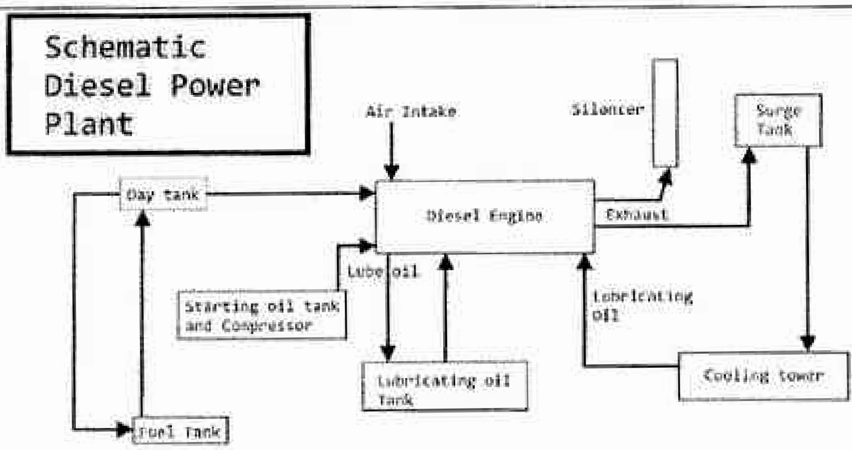
ANSWER KEY SET 2 QID :2109230056

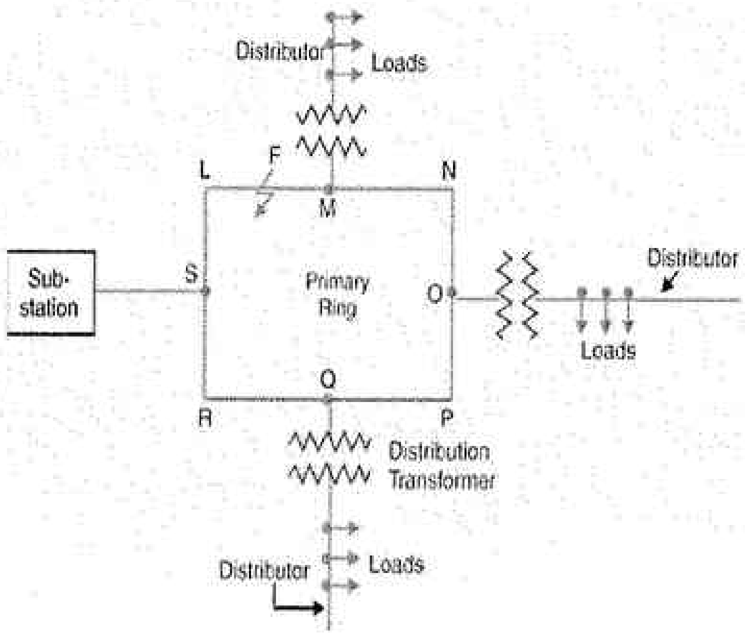
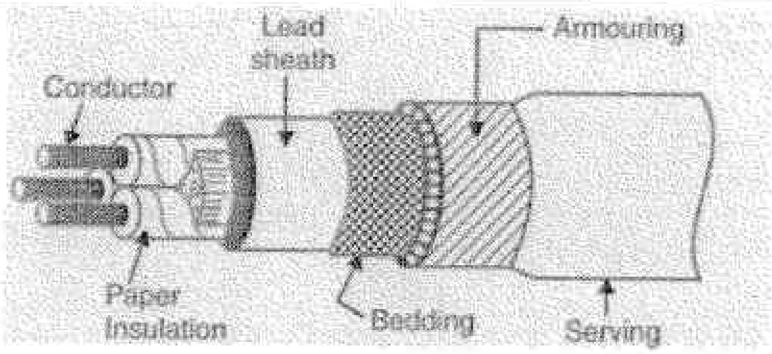
ELECTRICAL GENERATION TRANSMISSION AND DISTRIBUTION 5032

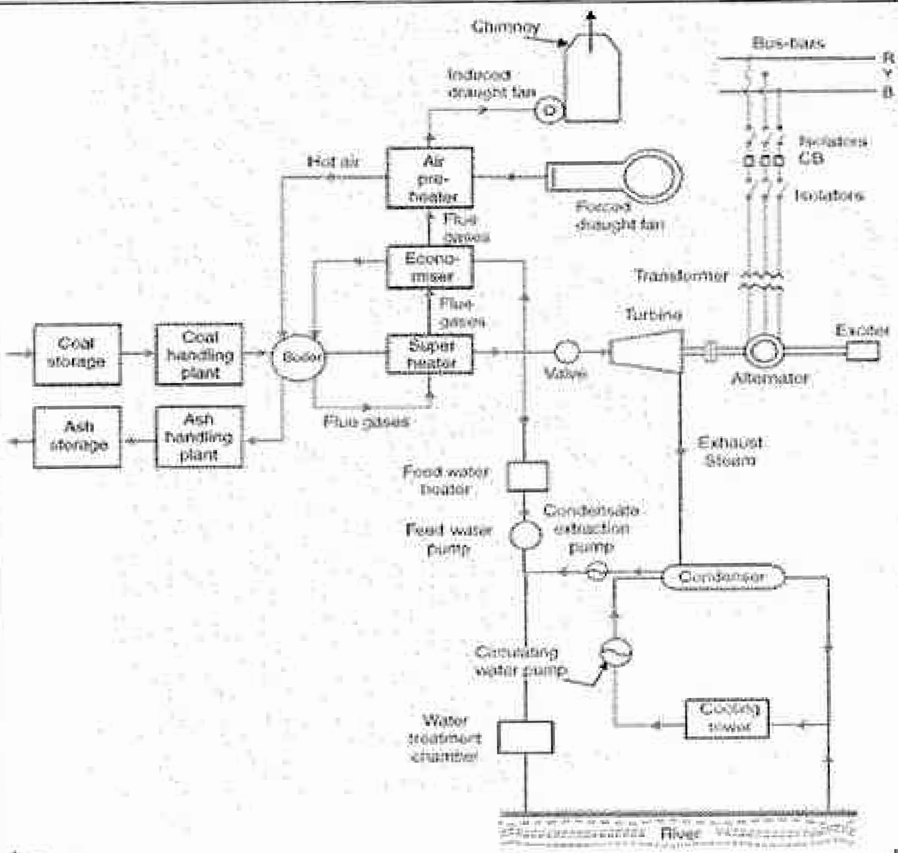
I	PART A	Split up	Sub total	total
1	Economiser	1	1	7
2	They are strong neutron absorber and thus regulates the supply of neutrons for fission and thus control the chain reaction	1	1	
3	The ratio of the sum of individual maximum demands to the maximum demand on power stationis known as **diversity factor** i.e., Diversity factor = $\frac{\text{Sum of individual max. demands}}{\text{Max. demand on power station}}$	1	1	
4	Time of day (TOD) is a tariff structure in which different rates are applicable for use of electricity at different times of the day.	1	1	
5	Sag, $S = \frac{w(l/2)^2}{2T} = \frac{w l^2}{8T}$	1	1	
6	The effect in which the voltage at the receiving end of the transmission line is more than the sending voltage due to light load	1	1	
7	%age String efficiency $= \frac{V}{3 \times V_3} \times 100$ Voltage across third unit from top, V_3 Voltage across string V	1	1	
8	Armouring consists of one or two layer of galavanised steel purpose is to protect cable from mechanical injury and also for earth connectivity	1	1	
9	Current transformer 	1	1	

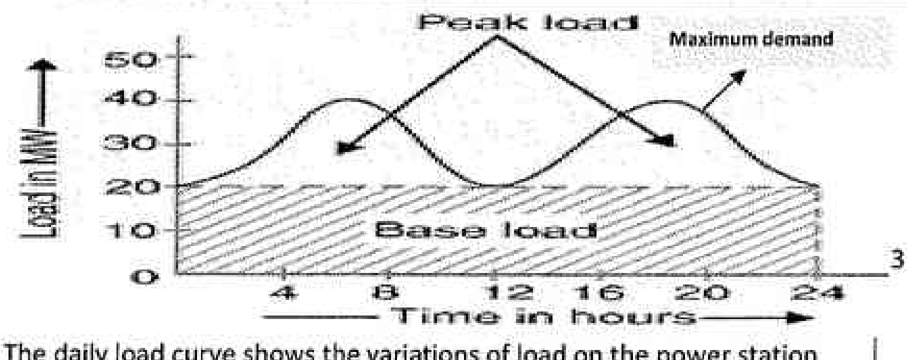
II	PART B	Split up	Sub total	total
1	 Various penstock protective devices Fig. 2.3	2		

	A surge tank is a small reservoir or tank located near the beginning of the conduit.in which water level rises or falls to reduce the pressure swings in the conduit. Thus prevent conduit pipe from bursting.	1	3	
2	1 ***Availability of water.*** As sufficient water is required for cooling purposes, therefore, the plant site should be located where ample quantity of water is available 2 ***Disposal of waste.*** The waste produced by fission in a nuclear power station is generally radioactive which must be disposed off properly to avoid health hazards. Therefore, the site selected for such a plant should have adequate arrangement for the disposal of radioactive waste. 3 ***Distance from populated areas.*** The site selected for a nuclear power station should be quite away from the populated areas as there is a danger of presence of radioactivity in theatmosphere near the plant.. 4 ***Transportation facilities.*** The site selected for a nuclear power station should have adequatefacilities in order to transport the heavy equipment during erection and to facilitate the movement of the workers employed in the plant. *Any 3	3 x 1	3	
3		3	3	
4	Water head, $H = 150$ m ; $Q = 1$ m^3/sec ; $\eta_{overall} = 0{\cdot}8 \times 0{\cdot}9 = 0{\cdot}72$ Wt. of water available/sec, $W = Q \times 1000 \times 9{\cdot}81 = 9810\ N$ Power produced $= W \times H \times \eta_{overall} = 9810 \times 150 \times 0{\cdot}72$ watts $= 1060 \times 10^3$ watts $= 1060$ kW $\therefore$ Energy generated/hour $= 1060 \times 1 =$ **1060 kWh**	1 1 1	3	

5	*The rate at which electrical energy is supplied to a consumer is known as* **tariff** **objectives** 1. Recovery of cost of producing electrical energy at the power station. 2. Recovery of cost on the capital investment in transmission and distribution systems. 3. Recovery of cost of operation and maintenance of supply of electrical energy e.g., metering equipment, billing etc. 4. A suitable profit on the capital investment.	1 2	3	
6	Units consumed/year = Max. demand × L.F. × Hours in a year $= (250) \times (0{\cdot}5) \times 8760 = 1095000\ \text{kWh}$ Annual charges = Annual M.D. charges + Annual energy charges $= \text{Rs}\,(100 \times 250 + 0.3 \times 1095000$ $= \text{Rs}\,353500$	1 2	3	x
7	The tendency of alternating current to concentrate near the surface of a conductor is known as skin effect. Due to skin effect, the effective area of cross-section of the conductor through which current flows is reduced. <u>Ways to reduce skin effect</u> 1. By using stranded conductors in place of solid conductors 2. Decreasing the operating frequency 3. Decrease the diameter of conductor 4. Select material having less skin effect property • Any 2	1 2	3	

8		3	3	
9	**i) By using longer cross-arms** string efficiency can be reduce by reducing the shunt capacitance, by increasing the distance of conductor from tower using longer cross arms. **(ii) By grading the insulators.** In this method, insulators of different dimensions are so chosen that each has a different capacitance. The insulators are capacitance graded i.e. they are assembled in the string in such a way that the top unit has the minimum capacitance, in- creasing progressively as the bottom unit (i.e., nearest to conductor) is reached **(iii) By using a guard ring** The potential across each unit in a string can be equalised by using a guard ring which is a metal ring electrically connected to the conductor and surrounding the bottom insulator	3	3	
10		3	3	

	PART C	Split up	Sub total	total
III	 In the steam power plant the pulverised coal is fed into the boiler and it is burnt in the furnace. The water present in the boiler drum changes to high pressure steam. From the boiler the high pressure steam passed to the super heater where it is again heated up to its dryness. This super heated steam strikes the turbine blades with a high speed and the turbine starts rotating at high speed. A generator is attached to the rotor of the turbine and as the turbine rotates it also rotates with the speed of the turbine. The generator converts the mechanical energy of the turbine into electrical energy. After striking on the turbine the steam leaves the turbine and enters into the condenser. The steam gets condensed with the help of cold water from the cooling tower. The condensed water with the feed water enters into the economiser. In the economiser the feed water gets heated up before entering into the boiler. This heating of water increases the efficiency of the boiler. The exhaust gases from the furnace pass through the super heater, economiser and air pre-heater. The heat of this exhaust gases is utilised in the heating of steam in the super heater, feed water in the economiser and air in the air pre-heater. After burning of the coal into the furnace, it is transported to ash handling plant and finally to the ash storage.	4 3	7	

IV	The connection of several generating stations in parallel connecting the consumer load through a network of distribution,transmission lines is known as interconnected grid system advantages of interconnected system are listed below : (i) **Exchange of peak loads :** An important advantage of interconnected system is that the peak load of the power station can be exchanged. If the load curve of a power station shows a peak demand that is greater than the rated capacity of the plant, then the excess load can be shared by other stations interconnected with it. (ii) **Use of older plants :** The interconnected system makes it possible to use the older and less efficient plants to carry peak loads of short durations. Although such plants may be inadequate when used alone, yet they have sufficient capacity to carry short peaks of loads when interconnected with other modern plants. Therefore, interconnected system gives a direct key to the use of obsolete plants. (iii) **Ensures economical operation :** The interconnected system makes the operation of con cerned power stations quite economical. It is because sharing of load among the stations is arranged in such a way that more efficient stations work continuously throughouts the year at a high load factor and the less efficient plants work for peak load hours only. **(iv) Increases diversity factor :** The load curves of different interconnected stations are gener ally different. The result is that the maximum demand on the system is much reduced as compared to the sum of individual maximum demands on different stations. In other words, the diversity factor of the system is improved, thereby increasing the effective capacity of the system. **(v) Reduces plant reserve capacity :** when several power stations are connected in parallel, the reserve capacity of the system is much reduced. This increases the efficiency of the system. **(vi) Increases reliability of supply :** The interconnected system increases the reliability of sup- ply. If a major breakdown occurs in one station, continuity of supply can be maintained by other healthy stations. Any 5 points.	2 5 X 1	7	
V	 i) The daily load curve shows the variations of load on the power station	3		

	during different hours of the day. (ii) The area under the daily load curve gives the number of units generated in the day. Units generated/day = Area (in kWh) under daily loadcurve. (iii) The highest point on the daily load curve represents the maximum demand on the station on that day. (iv) The area under the daily load curve divided by the total number of hours gives the average load on the station in the day. Average load = Area (in kWh) under daily loadcurve/24hrs (v) The ratio of the area under the load curve to the total area of rectangle in which it is contained gives the load factor. Load factor = Average load/Max. demand (vi) The load curve helps in selecting the size and number of generating units. (vii) The load curve helps in preparing the operation schedule of the station. *ANY 4 points	4 X 1	7	
VI	**1.Fixed Cost** It is independent of the maximum demand, the plant capacity and the energy generated. Fixed cost includes: • Annual charges of the central organization management • Salary of the employees (usually higher officials) • Interest on the land costs **2.Semi Fixed Charges of Power Generation** These charges mainly depend on the installed capacity of the plant and are independent of the electrical energy output of the plant. These charges include the following : 1. Interest and depreciation on the capital cost of the generating plant, transmission and distribution network, buildings and other civil engineering works etc. Capital cost of the plant also includes the interest paid during the construction of the plant, salaries of engineers and other employees, development and construction of the power station. It also includes cost incurred on account of transportation, labor etc. to bring the equipment on site and installing the same, all of which are involved for the overall economics of power generation. It is particularly note worthy, that in nuclear stations the capital cost of the station also includes the cost of initial charges of the nuclear fuel minus the salvage value paid at the end of its useful life. 2. It also includes all types of taxes, insurance premiums pain on policies to cover the risk of accidental breakdown. 3. Rent paid for the land being actually used for the construction purpose. 4. The cost due to starting and shutting down of plants are also included in this category, when the power plant operates on one or two shift basis **3.Running Or Operating Cost** :unning charges will depend mainly upon the energy (in units or Wh) generated by the plant. 1. Cost of fuel: 2.Cost of maintenance and repairs: 3.Salaries of the operating staff: 4.Other Costs:	2 3 2	7	

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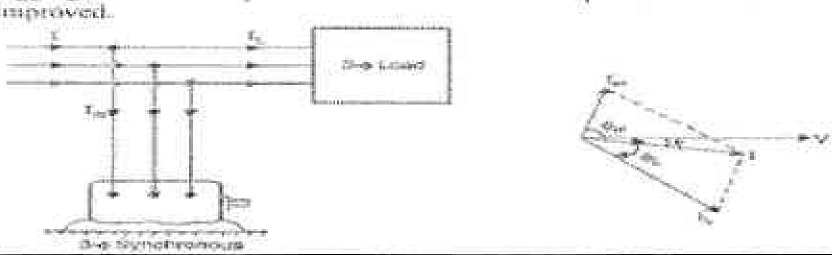
1. Static capacitor: The power factor can be improved by connecting capacitors in parallel with the equipment operating at lagging power factor. The capacitor draws a leading current and partly or completely neutralises the lagging reactive component of load current. This raises the power factor of the load. For three-phase loads, the capacitors can be connected in delta or star as shown in Fig.

(i) (ii)

2. Synchronous condenser: A synchronous motor takes a leading current when over-excited and, therefore, behaves as a capacitor. An over-excited synchronous motor running on no load is known as synchronous condenser. When such a machine is connected in parallel with the supply, it takes a leading current which partly neutralises the lagging reactive component of the load. Thus the power factor is improved.



The 3φ load takes current I_L at low lagging power factor cos φ_L. The synchronous condenser takes a current I_m which leads the voltage by an angle φ_m. The resultant current I is the phasor sum of I_m and I_L and lags behind the voltage by an angle φ. It is clear that φ is less than φ_L so that cos φ is greater than cos φ_L. Thus the power factor is increased from cos φ_L to cos φ.

3. Phase advancers: Phase advancers are used to improve the power factor of induction motors. The low power factor of an induction motor is due to the fact that its stator winding draws exciting current which lags behind the supply voltage by 90°. If the exciting ampere turns can be provided from some other a.c. source, then the stator winding will be relieved of exciting current and the power factor of the motor can be improved. This job is accomplished by the phase advancer which is simply an a.c. exciter. The phase advancer is mounted on the same shaft as the main motor and is connected in the rotor circuit of the motor.

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<td>VIII</td>
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The different tariff are

- Simple/uniform tariff
- Flat rate tariff
- Block rate tariff
- Two part tariff
- Three part tariff
- Power factor tariff
- Maximum demand tariff
- TOD tariff

I **Two-part tariff.** When the rate of electrical energy is charged on the basis of maximum demand of the consumer and the units consumed,
In two-part tariff, the total charge to be made from the consumer is split into two components *viz.*,fixed charges and running charges. The fixed charges

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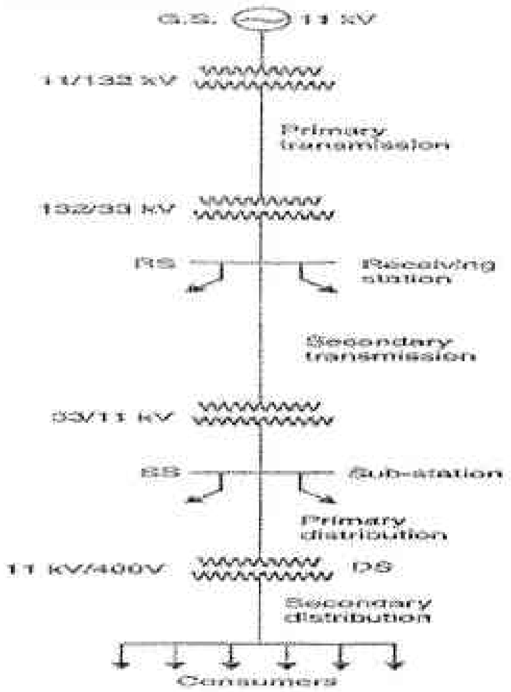
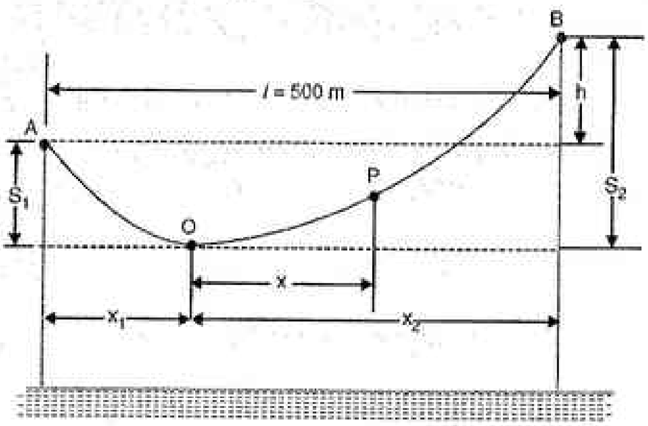
	depend upon the maximum demand of the consumer while the running charges depend upon the number of units consumed by the consumer **Advantages** *It is easily understood by the consumers. *It recovers the fixed charges which depend upon the maximum demand of the consumer butare independent of the units consumed. **Disadvantages** *The consumer has to pay the fixed charges irrespective of the fact whether he has consumedor not consumed the electrical energy. *There is always error in assessing the maximum demand of the consumer **Ii Flat rate tariff.** When different types of consumers are charged at different uniform per unit rates, In this type of tariff, the consumers are grouped into different classes and each class of consumers is charged at a different uniform rate. **advantage** * *it is more fair to different types of consumers * is quite simple in calculations **Iii Block rate tariff.** When a given block of energy is charged at a specified rate and the succeeding blocks of energy are charged at progressively reduced rates,. In block rate tariff, the energy consumption is divided into blocks and the price per unit is fixed ineach block. The price per unit in the first block is the highest and it is progressively reduced for the succeeding blocks of energy **advantage** *the consumer gets an incentive to consume more electricalenergy	2 2 2	7	
IX	 **Generating station** : G.S. represents the generating station where electric power is produced by 3-phase alternators operating in parallel. The usual	3	7	

	generation voltage is 11 kV. For economy in the transmission of electric power, is stepped upto 132 kV at the generating station with the help of 3-phase trans- formers. The transmission of electric power at high voltages has several advantages including the saving of conductor material and high transmission efficiency. **Primary transmission.** The electric power at 132 kV is transmitted by 3-phase, 3-wire overhead system to the out- skirts of the city **Secondary transmission**. The primary transmission line terminates at the receiving station (RS) which usually lies at the outskirts of the city. At the receiving station, the voltage is reduced to 33kV by step-down transformers. From this station, electric power is transmitted at 33kV by 3-phase, 3-wire over- head system to various sub-stations (SS) located at the strategic points in the city. This forms the secondary transmission. **Primary distribution.** The secondary transmission line terminates at the sub-station (SS) where voltage is reduced from 33 kV to 11kV, 3-phase, 3-wire. The 11 kV lines run along the important road sides of the city. **Secondary distribution.** The electric power from primary distribution line (11 kV) is deliv ered to distribution sub-stations (DS). These sub-stations are located near the consumers' localities and step down the voltage to 400 V, 3-phase, 4-wire for secondary distribution. The voltage between any two phases is 400 V and between any phase and neutral is 230 V.	4		
X	**D.C. transmission.** **Advantages.** 1 It requires only two conductors as compared to three for a.c. transmission. 2 There is no inductance, capacitance, phase displacement and surge problems in d.c. trans- mission. 3 There is no skin effect in a d.c. system. Therefore, entire cross-section of the line conductor is utilised. 4 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. 5 A d.c. line has less corona loss and reduced interference with communication circuits. The high voltage d.c. transmission is free from the dielectric losses, particularly in the case of cables. **Disadvantages** 1 Electric power cannot be generated at high d.c. voltage due to commutation problems. 2 The d.c. voltage cannot be stepped up for transmission of power at high voltages. 3 The d.c. switches and circuit breakers have their own limitations. **A.C. transmission.** **Advantages** 1 The power can be generated at high voltages. 2 The maintenance of a.c. sub-stations is easy and cheaper.	7	7	

	3 The a.c. voltage can be stepped up or stepped down by transformers with ease and effi- ciency. This permits to transmit power at high voltages and distribute it at safe potentials. **Disadvantages** 1 An a.c. line requires more copper than a d.c. line. 2 The construction of a.c. transmission line is more complicated than a d.c. transmission line. 3 Due to skin effect in the a.c. system, the effective resistance of the line is increased. 4 An a.c. line has capacitance. Therefore, there is a continuous loss of power due to charging current even when the line is open.			
XI	Span length, l = 200 m; Working tension, T = 2500 kg Wind force/m length of conductor, $w_w = 1{\cdot}5$ kg Wt. of conductor/m length, w = Sp. Gravity × Volume of 1 m conductor = 10 × 2 × 100 = 2000gm = 2 kg Total weight of 1 m length of conductor isW = $\sqrt{w^2 + w_w^2}$ =2.5KG Sag, S = $\frac{w_t l^2}{8T}$=K sag=5 M			
XII	the conductor suspended between two supports A and B at differentlevels with O as the lowest point on the conductor. Here, l = 500 m ; w = 1·5 kg ; T = 1600 kg. Difference in levels between supports, h = 90 – 30 = 60 m. Let the lowest  point O of the conductor be at a distance x_1 from the support at lower level (*i.e.*, support A) and at a distance x_2 fromthe support at higher level Obviously, $x_1 + x_2$ = 500 m	2	7	

Now Sag $S_1 = \frac{w x_1^2}{2T}$ and Sag $S_2 = \frac{w x_2^2}{2T}$

$\therefore$ $h = S_2 - S_1 = \frac{w x_2^2}{2T} - \frac{w x_1^2}{2T}$

or $60 = \frac{w}{2T}(x_2 + x_1)(x_2 - x_1)$ 5

$\therefore$ $x_2 - x_1 = \frac{60 \times 2 \times 1600}{1 \cdot 5 \times 500} = 256$ m

Solving exps. (*i*) and (*ii*), we get, $x_1 = 122$ m; $x_2 = 378$ m

Now, $S_1 = \frac{w x_1^2}{2T} = \frac{1 \cdot 5 \times (122)^2}{2 \times 1600} = 7$ m

Clearance at lowest point =30-7 = 23m

XIII d.c. distributors are classified as:

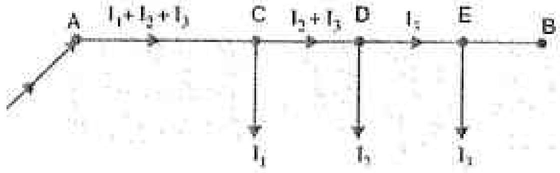
(i) Distributor fed at one end

(ii) Distributor fed at both ends

(iii) Distributor fed at the centre

(iv) Ring distributor.

Distributor fed at one end. In thistype of feeding, the distributor is connected to the supply at one end andloads are taken at different points along the length of the distributor. Fig. shows the single line diagram of a d.c. distributor *AB* fed atthe end *A* (also known as *singly fed distributor*) and loads I_1, I_2 and I_3 tapped off at points *C, D* and *E* respectively. 2



The current in the various sections of the distributor away from feeding point goes on decreasing. Thus current in section *AC* is more than the current in section *CD* and current in section*CD* is more than the current in section *DE*.

Distributor fed at both ends. In this type of feeding, the distributor is connected to the supply mains at both ends and loads are tapped off at different points along the length of the distributor. The voltage at the feeding points may or may not be equal. Fig. shows a distributor *AB* fed at the ends *A* and *B* and loads of I_1, I_2 and I_3 tapped off at points *C, D* and *E* respectively. Here, the load voltage goes on decreasing as we move away from one feeding point *say A*, reaches minimum value and then again starts rising and reaches maximum value when we reach the other feeding point*B*. 2

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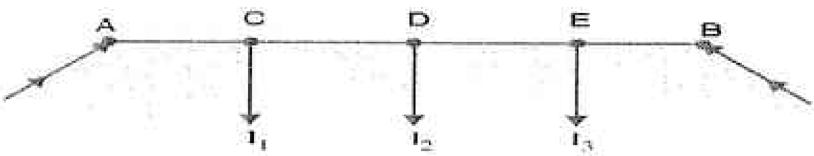

Distributor fed at the centre. In this type of feeding, the centre of the distributor is connected to the supply mains as shown in. It is equivalent to two singly fed distributors, each distributor having a common feeding point and length equal to half of the total length.

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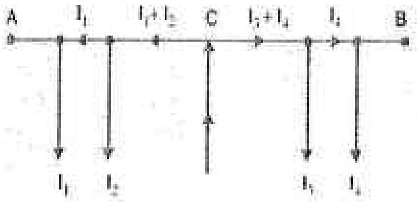
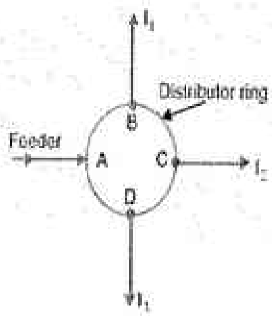


Distributor fed at the centre



Ring mains

Ring mains. In this type, the distributor is in the form of a closed ring as shown .It is equivalent to a straight distributor fed at both ends with equal voltages, the two ends being brought together to form a closed ring. The distributor ring may be fed at one or morethan one point.

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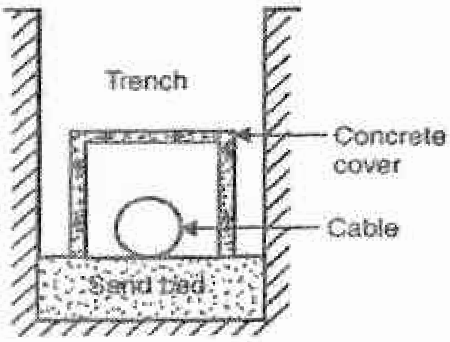
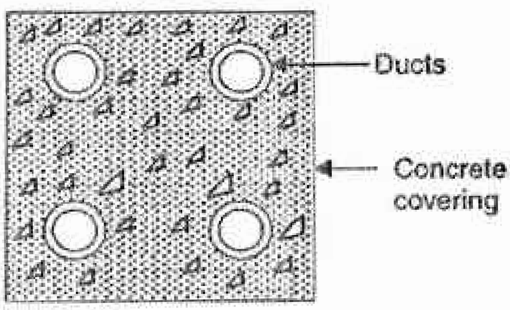
XIV	There are three main methods of laying underground cables viz., direct laying, draw-in system and the solid system. **1. Direct laying:** In this method, a trench of about 1·5 metres deep and 45 cm wide is dug. The trench is covered with a layer of fine sand (of about 10 cm thickness) and the cable 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. The trench is then covered with bricks and other materials in order to protect the cable from mechanical injury. When more than one cable is to be laid in the same trench, a horizontal or vertical interaxial spacing of atleast 30 cm is provided in order to reduce the effect of mutual heating and also to ensure that a fault occurring on one cable does not damage the adjacent cable.  	3		
	2.Draw-in system: In this method, conduit or duct of 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. The distance between the manholes should not be too long so as to simplify the pulling in of the cables. The cables to be laid in this way need not be armoured but must be provided with serving of hessian and jute in order to protect them when being pulled into the ducts.  	3	7	
	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 provides good mechanical protection.	1		