Important suggestions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and communication skills)
4) While assessing figures, examiner may give credit for principle components indicated in a figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q.1	**Attempt any TEN of the following:** **20**
i)	**State the necessity of transmission of electricity.**
Ans:	**Because of following points there is necessity of transmission of power:-** **(Any Two Points are Expected)** 1. Electrical load on power system is not concentrated at one place but it is widely spread. 2. Load points are located away from generating station. 3. Due to limitation of site selection criteria of major generating Station (HPP, TPP & NPP) are located far away from load centers and hence the electricity need to transmit from generating stations to the point of actual utilization of it (consumers) for this purpose transmission electricity is necessary
b)	**State voltage's at different levels from generation to distribution: (i) Generation voltage (ii) Primary transmission voltage (iii) Secondary transmission voltage (iv) Primary distribution voltage**
Ans:	**Voltage's at different levels from generation to distribution:** **(Each Level: 1 /2 Mark)** **i) Generation Voltage :** 3.3KV, 6.6KV,11KV and 17.5 KV etc. **ii) Primary Transmission voltage :-** 220 KV, 400KV, 765 KV (750 KV) **iii) Secondary Transmission voltage :-** 220 KV, 132 KV, 110 KV, 66 KV **iv) Primary Distribution voltage :-** 33 KV, 22KV, 11 KV and for long distance line it may be 66 KV

c)	**State any four components of transmission line.**
Ans:	**Following are the some components of transmission Line:-** **(Any four components are expected: 1/2 Mark each, Total 2 Marks)** 1. Supporting structure (pole) 2. Line insulator 3. Overhead conductor 4. 'V' Cross arm 5. Top pin support 6. Two Pin Cross arm 7. Four pin cross arm 8. Stay set (Stay wire of 7/8 or 7/10 SWG) 9. Lighting arrestors 10. Guarding wires 11. Continuous earth wire 12. Cables 13. Fuses and Isolating switches 14. Different types of Clamp (A-type, B-Type) 15. Bird guards 16. Vibration damper 17. Jumpers
d)	**State the long form of (i) AAC (ii) AAAC**
Ans:	**The long form of** **(Each long form: 1 Mark, Total 2 Marks)** 1. AAC : All Aluminum Conductor 2. AAAC : All Aluminum Alloy Conductor
e)	**State the effect of line parameters on performance of transmission line.**
Ans:	**Following are the effect on performance of transmission line:** **(Each effect: 1/2 Mark, Total 2 Marks)** 1. Due to resistance (R), voltage drop in transmission line & copper losses in transmission line produces.

	2. Due to inductance (L) voltage drop in transmission line produces. 3. Capacitor (C) draws charging current through transmission line. This charging current produces additional copper losses & voltage drop in transmission line. 4. Due to above reasons, transmission line efficiency, voltage regulation & also power factor of transmission line gets affected.
f)	**State desirable properties of cable (any four points).**
Ans:	Following are the main desirable properties of cables: **(Any Four Points are Expected)** **(Any Four properties expected: 1/2Mark each, Total 2 Marks)** **1. Stranded Conductor:** The conductor used for cable should be stranded specially for large size of cable. **2. Annealed Conductor:** Annealed conductor should be used to become conductor soft. **3.Tinned conductor:-** Tinned conductor should be used so that conductor will not stick with insulation. **3.Cross Section Of Conductor:** Cross Section Of Conductor should be proportional to magnitude of current. **4. Insulation Thickness:** The insulation thickness provided to cable should be proportional to magnitude of voltage. To give high degree of safety and reliability. **5. Mechanical Protection:** Especially underground cable should be provided with mechanical protection (armouring). So that it will withstand against rough handling and mechanical injury. **6. Life:** The material used for cable should have long life.

g) State any two HVDC transmission line in India.

Ans: **Following are HVDC transmission line in India.** **(1 Mark for each , Total 2 Marks)**

(Any Two Lines are Expected)

S.N.	From	To
1	Rihand (U.P) (from 1990)	Dadri
2	Talcher- is the biggest HVDC transmission passes through Orissa (A.P) Tamilnadu & Karnataka	Kolar
3	Chandrapur- Padghe (Maharashtra) in Western Region	Padghe (Maharashtra)
4	Bersoor (M.P.)	Lower Sileru (Arunachal Pradesh)
5	Connecting Northern region (Sasaram- Pusawali)	Eastern Region
6	Connecting Northern region (Vindhyachal)	Western Region

h) State maximum HVDC transmission voltage in India.

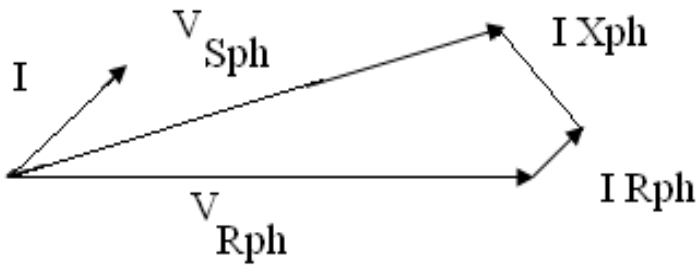
Ans: **Maximum HVDC transmission voltage in India:** **(2 Marks)**

Maximum HVDC Transmission Voltage **in India** is ± 500 KV.

i) Draw vector diagram at leading P.F. in transmission line? State its effect on regulation.

Ans: **vector diagram at leading P.F. in transmission line:**

(1 Mark for Vector diagram, 1 Mark for effect , Total 2 Marks)



or equivalent figure

Effect on regulation:

At Leading power factor receiving voltage is more than Sending end **hence regulation is negative.**

j)	**State four requirements of a distribution system.**
Ans:	**(Any Four requirements expected: 1/2Mark each, Total 2 Marks)**

Distribution system should posses following properties or requirements:-

1) Proper Study of the area carefully & estimate the load densities, present and future
2) As far as shortest route should be selected
3) As close as possible to the road for easy approach during construction & for easy maintenance.
4) Route in direction of possible future load.
5) Angle points should be less.
6) Select the transformer size & conductor size from the result of load study.
7) Determine the load centers
8) **Design of Layout:** layout should be simple in design.
9) **Distribution system:** It should follow standards in electricity rules for-
   - Installation
   - Protection
   - Safety
   - Quality supply to consumers
   - Operation & maintenance of lines & sub-station
10) Maximum Flexibility and Expendability in future
11) Make the system with minimum distribution losses.
12) Proper clearances should be maintained from safety point.
13) **Time required for completion:** Time required for completion of work should be less.

	14) **Initial Cost:** It should be less.(To make the system economical) 15) **Maintenance:** It should be low, easy, less costly & less time consuming. 16) **Reliability:** It should have high reliability. 17) **Voltage fluctuation:** It should have less voltage fluctuation. 18) **Voltage Regulation :-** Within permissible limit 19) **Availability of power: -**Power should be available whenever needed(Power must be available to all consumers on demand that they may require from time to time.). 20) A steady, uniform, non-fluctuating flow of power is necessary to feed loads of all categories of consumers 21) **Stability:** Fault on nearest distribution system should not affect stability of existing distribution system.
k)	**Why radial distribution system used for short distance.**
Ans:	**Radial distribution system is used for short distance:** **(2Mark)** Since there is only one feeder to distribution transformer center (DTC)feed at one point so, 1) There is no reliability to maintain supply at the time of fault on incoming feeder. 2) There is no reliability to maintain supply at the time of maintenance of incoming feeder. If the system is used for long distance then it takes more time for fault finding & repairing. Hence radial distribution system is not used for long distance even its initial cost is low Therefore it is used for short distance only.
l)	**State the classification of substation according to method of construction.**
Ans:	**(Any Four Types are expected: 1/2 Mark each, Total 2 Marks)** **According to Method of Construction:-** 1. **Indoor Substation:** In this substation all equipments including transformer are installed under closed construction building is called 'indoor substation. 2. **Outdoor Substation:** In this substation all equipments including transformer are installed in air (Open to sky) only control room is constructed is called outdoor substation

	3. **Gas insulated Substation:** Space required for GIS is very less even then indoor substation. 4. **Underground Substation:** In underground substation all equipments including transformer are installed under closed construction in underground. Underground substation is preferred in thickly populated area, Space available for building & equipments is limited (In congested place) and where cost of land is very high. 5. **Pole mounted substation:** Generally distribution transformer substation are pole mounted. 6. **Plinth Substation:** Generally large capacity transformers are plinth mounted because its weight is high. Transformer 315 KVA & above are generally plinth mounted. 7. **Compact/prefabricated substation:** Now day's compact or prefabricated distribution substations are more popular. Its appearance is better than pole mounted and plinth mounted distribution substation.
Q.2	**Attempt any FOUR of the following : 16 Marks**
a)	**State any four applications where HVDC transmission is used through cable only and not by overhead line.**
Ans:	**Applications where HVDC transmission is used through cable only and not by overhead line** **(Any Four** applications **are expected: 1 Mark each, Total 4 Marks)** 1. HVDC is preferred for underground cable when power transmission through underground cable is greater than 40-50 KM than only HVDC uniqueally suited. 2. HVDC is preferred for underground cable transmission as incoming line in megacities. 3. HVDC is preferred for underground cable transmission for crossing long lake, ocean etc. 4. HVDC is preferred for underground cable transmission where atmospheric conditions are too bad for overhead transmission line, e.g. High wind pressure, rainfall, icefall etc. 5. HVDC is preferred for underground cable for underwater power links. 6. HVDC is preferred for underground cable for powering island from onshore. 7. HVDC is preferred for underground cable for taking power from offshore wind farm. 8. HVDC is preferred for underground cable for powering oil and gas offshore floating platform.

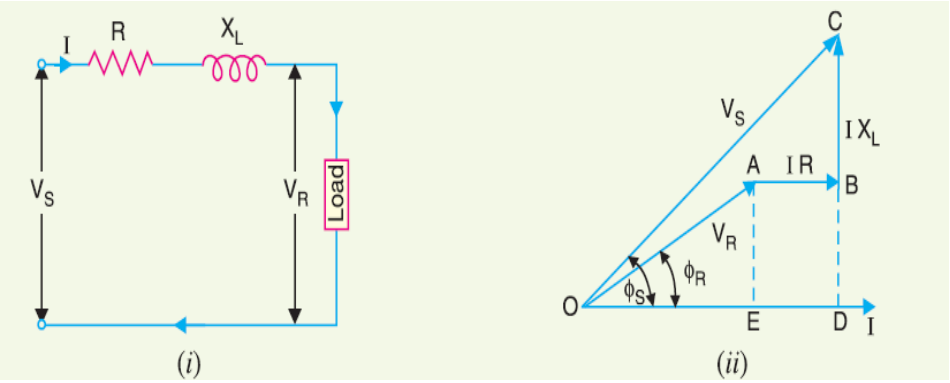
b)	**State two chemical and two thermal properties of insulating materials. List any four insulating materials used for manufacturing of transmission and distribution insulators.**
Ans:	**(2 Mark For properties and 2 Mark For names of insulating materials, Total 4 Marks)** **1) Chemical Properties of insulating material:- (1 Mark) (Any two Properties are expected)** 1. It should not be hygroscopic (which absorbs moisture). 2. It should have high resistance to acid & alkaline. 3. It should have high resistance to oil. **2) Thermal Properties of insulating material:- (1 Mark) (Any two Properties are expected)** 1. It should have high thermal conductivity. 2. It should be non -inflammable. 3. It should withstand at high temperature. 4. Ii should have thermal Stability. 5. Co-efficient of thermal expansion should be low. **List of insulating materials used for manufacturing T & D insulators: (2 Mark)** **(Any two names are expected)** 1. Porcelain 2. Glass 3. Steatite 4. Polymer Insulator (Composite conductor)
c)	**State any four factors on which skin effect depends. What is the effect on transmission efficiency and voltage regulation due to skin effect.**
Ans:	**(2 Mark For factors skin Effect depends and 2 Marks for effect on transmission efficiency and voltage regulation, Total 4 Marks)** **On following factors skin Effect depends**: **(Each point : 1/2 Mark Total 2 Marks)** 1. Supply frequency: As frequency increases skin effect increases. 2. Cross section of conductor: Skin effect increases with increase in diameter of conductor.

	3. Solid conductors have more skin effect than stranded conductors. 4. Permeability of conductor material. **Following effect on transmission efficiency and voltage regulation due to skin effect.** **(2 Mark)** 1. Transmission efficiency reduces. 2. Voltage regulation becomes poor (increases)
d)	**State any four factors on which proximity effect depends. State two points how proximity effect can be reduced?**
Ans:	**(2 Mark For factors proximity effect depends and 2 Marks for how proximity effect can be reduced , Total 4 Marks)** **Proximity effect depends on following factors:-** **(Any Four point expected : 1/2 Mark each Total 2 Marks)** 1. Magnitude of frequency. 2. Distance between two conductors 3. Size of conductor. 4. Resistivity conductor material. 5. Permeability of conductor material. **Due to following points Proximity effect can be reduced:-** **(Any Two point expected : 1Mark each Total 2 Marks)** 1. By increasing the distance between two conductors i.e. by using longer cross arm 2. By using overhead transmission system instead of underground. Because in cable distance between two conductor is less. So proximity effect is more 3. Effects are negligible for small size, small current carrying conductor 4. Use DC transmission system instead of AC transmission system to avoid proximity effect, Since frequency of DC supply is Zero

e) Derive formula for voltage regulation in case of short transmission line.

Ans:

Short transmission line representation: (Vector diagram 2 Marks and Derivation 2 Marks)



Let, I = Load current,

R_T = Total resistance / Loop resistance/i.e. resistance of both conductor

X_T = Total reactance/ Loop reactance

V_R = Receiving end voltage

Cos $Ø_R$ = Receiving end power factor (lagging)

V_S = Sending end voltage

Cos $Ø_S$ = Sending end power factor

The vector diagram of the line for lagging load power factor is shown in figure. From the right angled triangle ODC, we get,

From vector diagram:

$$(OC)^2 = (OD)^2 + (DC)^2$$

$$V_S^2 = (OE+ED)^2 + (DB+BC)^2$$

$$V_S^2 = (V_R Cos\phi_R + I R_T)^2 + ((V_R Sin\phi_R + I X_T)^2$$

$$V_S = \sqrt{(V_R Cos\phi_R + I R_T)^2 + ((V_R Sin\phi_R + I X_T)^2}$$

After solving above equation and neglecting the higher order terms, we obtain

$$\mathbf{Vs} \cong V_R + I\left(R_T \cos\phi_R \pm X_T \sin\phi_R\right)$$

$$\% \text{ age Voltage Regulation} = \frac{V_S - V_R}{V_R} \times 100$$

f)	**State the equation A, B, C and D constants for short transmission line.**
Ans:	**Equation A, B, C and D constants for short transmission line:** **(Each equation 1 Mark , Total 4 Marks)** $A = \frac{V_{S\,ph}}{V_{R\,ph}}$ ---------- Voltage Ratio $B = \frac{V_{S\,ph}}{I_R}$ ---------- Impedance in ohm $C = \frac{I_S}{V_{R\,ph}}$ ---------- Conductance in mho $D = \frac{I_S}{I_R}$ ---------- Current Ratio
Q.3	**Attempt any Four of the following : 16 Marks**
a)	**Under which conditions Ferranti effect occurs state any four conditions? What is Ferranti effect?**
Ans:	**(Conditions Ferranti effect occurs 2 Marks and Meaning of Ferranti effect 2 Marks, Total 4 Marks)** **Due to following Conditions Ferranti effect occurs in transmission line**: **(Any four conditions are expected)** 1. When there is no load on transmission line ($I_L = 0$) Or 2. When There is no load at receiving sub-station or Lightly loaded Or 3. When there is sudden load thrown OFF. Or 4. When there is sudden load shading. Or 5. When Transmission line is open circuited due to load failure. **Ferranti effect:-** Under any one of the above mention conditions, it is found that receiving end voltage (V_R) is found to be greater than sending end voltage (V_S). **This phenomenon is known as Ferranti effect.**

b)	**State any four factors which affects corona? State two points how corona effect can be reduced.**
Ans:	**(Factors which affects corona 2 Marks and how corona effect can be reduced 2 Marks, Total 4 Marks)** **The Following Factors affecting corona:- (Any Four point expected : 1/2 Mark each)** 1. **Magnitude of Voltage :** If voltage across two conductors is greater than 30 KV/cm, i.e. breakdown voltage of air than corona formation starts. Corona will not start if voltage is below 30 KV/cm 2. **Distance between two conductor:** If spacing between two conductors is very large as compare to their diameter than there is no possibility of corona formation. Because value of voltage at which corona occurs increases. 3. **Size of conductor:** If size (Cross section) of conductor is more, than magnitude of voltage required to occur the corona increases. 4. **Condition of conductor & Hardware:** Rough and irregular surface of conductor and hardware will give more corona than solid, smooth body conductor & hardware. 5. **Atmospheric Condition:** As corona takes place due to ionization of air so it depends on condition of air so for dry air formation of corona occurs late than in wet air (damp atmosphere condition/ rainy season/thunderstorms/fog air becomes more conductivity) 6. Effect of supply Frequency: Corona loss varies directly as the supply frequency 7. Effect of density of air: Corona loss increases with the decrease in the density of air (The corona loss of transmission line passing through hilly area is higher than that of a similar line in plain due to reduced value of air density at high level /altitude) **Due to following points how corona effect can be reduced:** **(Any two point expected: 1 Mark each)** 1. By increasing distance between two conductor i.e. by using longer cross arm. 2. By using larger size(diameter) of conductor e.g./ using ACSR, bundled conductor 3. By using smooth body conductor and hardware.

c) Compare EHVAC and HVDC transmission line on given points: (i) Number of conductors for double circuit (ii) Capital cost of sub-station (iii) Skin effect (iv) Proximity effect (v) Ferranti effect (vi) Corona loss (vii) Copper loss (viii) String efficiency.

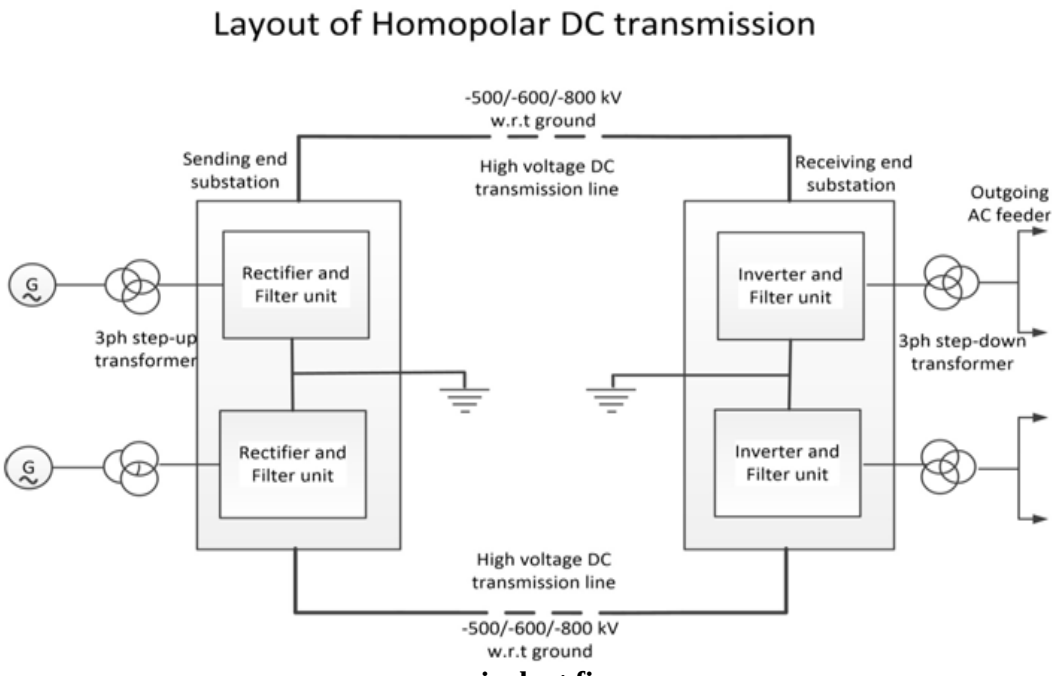
Ans:

(Each Point : 1/2 Mark, Total 4 Marks)

Sr.No	Points	EHV A.C	HVDC
1	Number of conductor required for single circuit	Three conductors (R.Y.B)	One conductor.& Ground is used as a return path
2	Capital cost of S/S	Less	More
3	Skin effect	Present	Absent
4	Proximity effect	Present	Absent
5	Ferranti effect	Present	Absent
6	Corona losses	More	Less
7	Copper loss	More	Less
8	String efficiency	Less than 100 %	100 %

d) Draw layout of Homopolar HVDC transmission line mention polarity of overhead conductor. **(4 Marks)**

Ans:



or equivalent figure

e)	**Write sequence of operation of isolator and circuit breaker while opening and closing.**
Ans:	**(Sequence of operation while opening 2 Marks and Sequence of operation while closing 2 Marks, Total 4 Marks)** Sequence of operation of Isolator, C.B. while opening & closing is as below: ➢ While Opening: 1. Open circuit breaker 2. Open Isolator 3. Close earthing switch ➢ While Closing: 1. Open earthing switch 2. Close isolator 3. Close circuit breaker
f)	**State the function of equipments used in substation: (i) Earth switch (ii) Relay (iii) Lighting Arrester (iv) Auxiliary transformer**
Ans:	**Function of equipments used in substation: (1 Mark each ,Total 4 Marks)** **1) Earth switch: -** Its function is to discharge the ground capacitance when line is opening for maintenance purpose by isolator. 2) Relay: It sense the faults & gives signal to trip circuit of C.B. to open. **3) Lightning Arrester: -** It is provided for protection of substation against lightning stroke . **4) Auxiliary Transformer (Station transformer): -** Its function is to step down the input voltage (11 KV) to distribution voltage (3-ph,400V) to give supply to control room, area lighting, staff quarters etc,

Q.4 **Attempt any FOUR of the following :** **16 Marks**

a) **Compare Pin type and suspension insulators on given points (i) Position of insulator on cross arm (ii) Position of conductor on insulator (iii) Reaction on cross arm (iv) Possibility of flash over due to large birds (v) Maintenance/Replacement cost (vi) Maximum voltage level (vii) Effect on height of supporting structure (viii) Life**

Ans: **(Each Point : 1/2 Mark ,Total 4 Marks)**

S.No	Points	Pin Type insulator	Suspension or Disc Type insulator
1	**Position of insulator on cross arm**	It is fixed on top of cross arm by using galvanized steel pin. So it is called as pin type insulator.	These insulators are hanging below the cross arm hence its name is suspension type insulator.
2	**Position of conductor on insulator**	On the top of the insulator	Conductor is clamped at the bottom of the insulator in a string
3	**Reaction on cross arm**	More	Less
4	**Possibility of flash over due to large birds**	Due to large birds, flash over is possible because distance between two insulators is less than suspension insulator	As insulators are suspended & distance between two conductors is more than pin type insulator so there is no possibility of flash over due to large birds or similar object.
5	**Maintenance /replacement cost**	If pin type insulator of existing line break down (failure) by any reason. Then it should be replaced by new one	If any insulator in the string of suspension insulator break down/fails then only that insulator/disc in the string require to be replace by new one instead of replacement of whole string unit.
6	**Maximum voltage level**	Maximum voltage level for which pin type insulator is designed is 33KV	Maximum voltage level for which one suspension insulator type insulator is designed is 11KV
7	**Effect on height of supporting structure**	Conductor is fixed on the top of insulator so to maintain minimum ground clearance height of pole required as compared to suspension type insulator is less	As insulators are suspended below the cross arm & conductor is clamped below the insulator so to maintain minimum ground clearance height of pole increase.
8	**Life**	Less	More

b) State four advantages of ACSR conductor. State four trade names of ACSR conductor.

Ans: **(Advantages 2 Marks and Trade names of ACSR 2 Marks, Total 4 Marks)**

Advantages of ACSR Conductors:- (Any Four expected: 1/2 mark each ,Total 2 Marks)

1. Due to steel re-enforcement, mechanical strength of conductor increases
   - So we can increase distance between two poles i.e. Span.
   - So number of poles require reduces for same transmission distance.
   - As an effect transmission line cost reduces
2. As the mechanical strength is more ACSR conductors produces small Sag.
   - So height of pole to maintain ground clearance can be reduced.
   - So cost of pole reduces, as its height reduces
   - Hence transmission cost reduces.
3. It takes advantages of Skin effect. So skin effect is minimized.
4. Corona Loss reduces.
5. It is 50% stronger & 20% Lighter than copper.
6. It is cheaper than copper.

Following are the trade names of ACSR conductor:

(Any Four expected: 1/2 mark each ,Total 2 Marks)

S.No	Brand/Trade name	S. No	Brand/Trade name
1	Mole	16	Tiger
2	Squirrel	17	Wolf
3	Gopher	18	Lynx
4	Weasel	19	Panther
5	Ferret	20	Lion
6	Rabbit	21	Bear
7	Mink	22	Goat
8	Horse	23	Sheep
9	Beaver	24	Koo Doo
10	Raccoon	25	Deer
11	Otter	26	Zebra
12	Cat	27	Elk
13	Dog	28	Camel
14	Leopard	29	Moose
15	Coyote		

c) A single phase 11kV short transmission line delivers 1000 kW power at 0.8 P.F. lagging total resistance and inductive reactance of the line are 5 ohm and 5.6 ohm. Determine: (i) Sending end voltage (ii) Percentage regulation of transmission line

Ans: $\therefore Cos\phi_R = 0.9 \ \therefore \ \sin\phi_R = 0.6$ Resistance 0.5 ohm Reactance 5.6 ohm

Step 1: To calculate Sending end voltage:

Power P = $VI\cos\phi$.---------- **(1/2 Mark)**

$$I \equiv \frac{P}{V\cos\phi}, \quad I \equiv \frac{1000\times10^3}{11\times10^3\times0.8}$$

$I \equiv 113.6363 \ amp$.---------- **(1/2 Mark)**

Step 2: To calculate Sending end voltage:

Vs = $V_R + I(R_T \cos\phi_R - X_T \sin\phi_R)$.---------- **(1 Mark)**

$= 11\times10^3 + 113.6363(5\times0.8 - 5.6\times0.6)$

= **11000 +72.7272**

= 11072.7272 volt

Vs = 11.07272 KV .---------- **(1/2 Mark)**

Step 4:To calculate voltage regulation:

% Voltage Regulation = $\frac{V_S - V_R}{V_R}\times100$.---------- **(1 Mark)**

$$= \frac{11072.7272 - 11000}{11000}\times100$$

. ---------- **(1 /2 Mark)**

= **0.6611 %**

d) State two reasons the transposition of conductor. Draw figure of transposition of conductor.

Ans: **(Reasons the transposition 2 Marks and Figure of transposition 2 Marks, Total 4 Marks)**

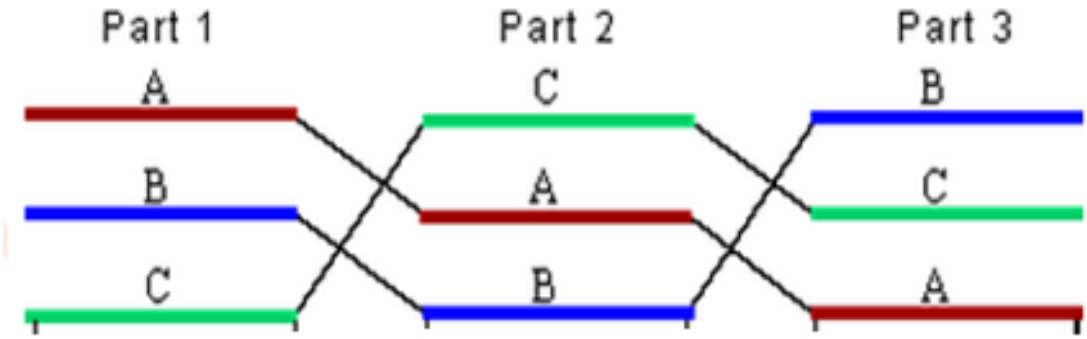
Reasons the transposition of conductor: (Any Two points expected) **(2 Mark)**

1. Due transposition of conductor inductance of each line is same $L_A = L_B = L_C$, So drop due to inductive reactance in each line is same so voltage at receiving end between any two line become same.
2. So to obtain same voltage in any two line at receiving end ($V_{RY} = V_{YB} = V_{RB}$)

transposition is necessary.

3. Radio interferences are less due to transposition.

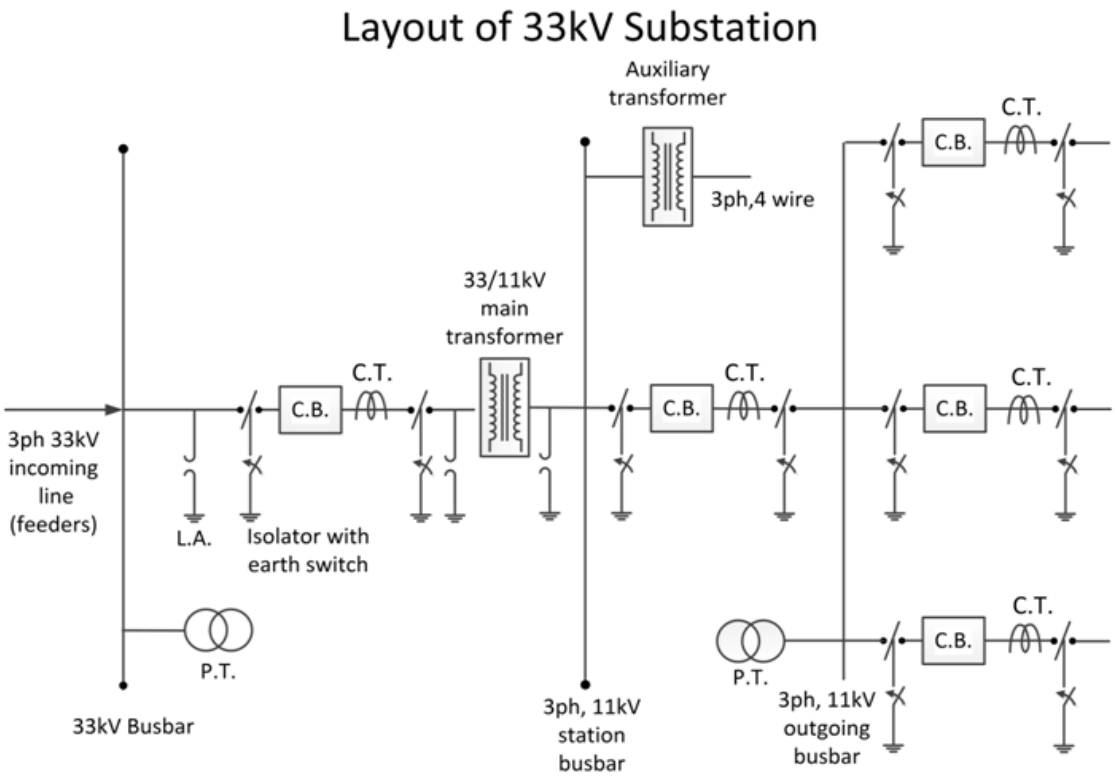
Figure of transposition of conductor: **(2 Mark)**



e) Draw layout of 33/11 kV sub-station and label it.

Ans:

Layout of 33/11 kV sub-station and label: **(4 Marks)**



or equivalent figure

f) Compare indoor and outdoor substation on given points

(i) Capital cost (ii) Time required for completion (iii) Availability of natural light (iv) Space required

Ans:

(Each Point : 1 Mark, Total 4 Marks)

Sr. No.	Points	Indoor substation	Outdoor substation
i)	**Capital cost**	High, as construction work cost is more.	Less, as construction work cost is less.
ii)	**Time required for completion**	More, as construction work is more.	Less, as construction work is less.
iii)	**Availability of natural light**	Natural light is not available even in day time, so there is need of illumination even during a day time. which increases energy consumption charges due to indoor installation	Natural light is available in day time, so there is no need of illumination during day time. So it saves electrical energy & its cost
iv)	**Space Require**	Less	More

Q.5 **Attempt any FOUR of the following :** **16 Marks**

a) **State the four methods of laying of cable. State precaution while laying of underground cable in the situation:**
(i) Minimum clearance between cable and water pipe line when running in parallel.
(ii) Minimum clearance between cable and gas/petroleum oil pipe line when running in parallel
(iii) If cable is laid through pipe what should be diameter of pipe
(iv) When more than one cable is to be laid in the same trench, what should be minimum spacing between two cables.

Ans:

(Methods of laying of cable 2 Marks and Precaution while laying 2 Marks, Total 4 Marks)

Following are the different methods of Laying of cable:- (1/2 Mark each, Total 2 Marks)

1. Direct laying cable
2. Draw- in system
3. Solid System
4. Cable laid in tray

Following precaution while laying of underground cable in the situation:

(1/2 Mark each, Total 2 Marks)

i) Minimum clearance between cable and water pipeline **when running in parallel should be 0.5 m**

	ii) Minimum clearance between cable and gas/petroleum oil pipeline **when running in parallel should be 1 mtr** iii) **Diameter of pipe is 2 to 3 cm**, greater than cable diameter for easy handling of cable. iv) When more than 1 cable is to be laid in the same trench, **then minimum 30 cm spacing is provided**
b)	**Give the classification of cables: (i) According with voltage levels (ii) According to numbers of core**
Ans:	**(Classification of cables: (i) According with voltage levels 2 Marks and Classification of cables(ii) According to numbers of core 2 Marks, Total 4 Marks)** **1. Classification of cables with their voltage levels:** **(Any Four points 1/2 Mark each, Total 2 Marks)** 1. Low voltage (tension) cable/LT cable: for operating voltage 1.1 KV. 2. High voltage (tension) cable/HT cable: for operating voltage 11 KV. 3. Super tension cable/ST cable: for operating voltage 22 KV to 33 KV. 4. Extra-Super tension cable: for operating voltage 33 KV to 66 KV. 5. Extra-high tension cable (EHT): for operating voltage up to 132 KV 6. Extra-super voltage power cables**:** for operating voltage beyond 132 KV **2. Classification of cables According to numbers of cores:** **(Any Four points 1/2 Mark each, Total 2 Marks)** 1. Single Core cable 2. Two core cable 3. Three core cable. 4. Three & half core cable. 5. Four core cable 6. Six core cable 7. Multi core cable

c) An overhead three phase transmission line -delivers 5000 kW at 22 kV at 0.8 lagging P.F. The resistance and reactance per phase is 4 ohm and 6 ohm respectively. Determine (i) sending end voltage (ii) percentage regulation of transmission line

Ans:

Given Data:-

$P_R = 5000KW$ $V_R = 22KV$ P.F. = 0.8 lag $R_{ph} = 4$ ohm $X_{ph} = 6$ ohm

Step 1: To calculate current:

Power P = $\sqrt{3}\, V_L\, I_L \cos\phi \quad for\ 3-ph$ ---------- **(1/2 Mark)**

$$I \equiv \frac{P}{\sqrt{3}\ V_{LR} \times \cos\phi}, \qquad I \equiv \frac{5000}{\sqrt{3} \times 22 \times 0.8}$$

$$I \equiv 164.01996\, amp$$ ---------- **(1/2 Mark)**

Step 2: **To calculate value of sin** :

$$\therefore Cos\phi_R = 0.8; \quad \sin\phi_R = 0.6$$

$$V_{Rph} \equiv \frac{V_{RL}}{\sqrt{3}}$$

$$V_{Rph} \equiv \frac{22}{\sqrt{3}}$$

$$V_{Rph} \equiv 12.7017\ KV \ or\ V_{Rph} = 12.7017 \times 10^3\ V$$ ---------- **(1/2 Mark)**

Step 3: To calculate Sending end voltage:

Sending end phase voltage **(** V_{Sph}**)** =

$= V_{Rph} + I\,(R_{Ph} \text{ Cos } Ø_R + X_{Ph} \text{ Sin } Ø_R)$ ---------- **(1/2 Mark)**

$= 12.7017 \times 10^3 + 164.01996\,(4 \times 0.8 + 6 \times 0.6)$

$= 13817.03573V$

$= 13.81703$ KV ----------**(1/2 Mark)**

Sending End Line Voltage = $\therefore V_{SL} = \sqrt{3} \times V_{sph}$

$$V_{SL} = \sqrt{3} \times 13.81703$$

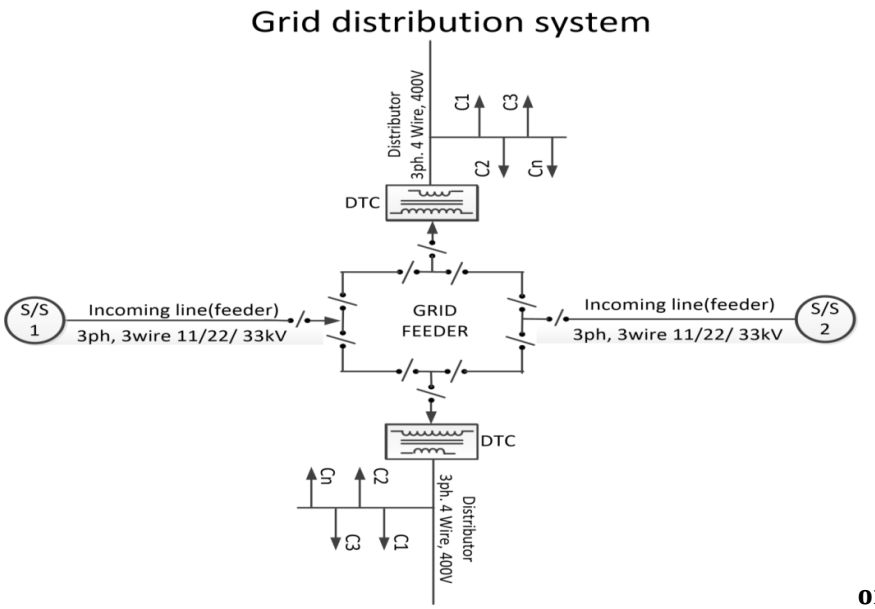
= 23.9317 KV ---------- **(1/2 Mark)**

Step 4:To calculate voltage regulation:

% Voltage Regulation $= \frac{V_{S\,Ph} - V_{R\,Ph}}{V_{R\,Ph}} \times 100$ - ---------- **(1/2 Mark)**

$$= \frac{13.81703 - 12.7017}{12.7017} \times 100$$

= 8.7809 % ---------- **(1/2 Mark)**

d)	**While calculating performance of medium transmission line, what assumptions are made in case of : (i) Noming 'T' method (ii) Nominal 'n' method**
Ans:	**(Assumptions: (i) Noming 'T' method 2 Marks and Assumptions: (ii) Nominal 'n' method 2 Marks, Total 4 Marks)** **i) Noming 'T' method Equivalent circuit:-** **Assumptions:** **1.** It is assume that line capacitance is connected at centre of transmission line. **2.** It is assume that half of the resistance & reactance per phase are divided in either side of capacitance. **(ii) Nominal π (pi) Method Equivalent circuit :** **Assumption:** **1.** It is assumed that capacitance of transmission line is divided into half of the line capacitance is connected at receiving end & half of capacitance is connected at sending end. **2.** It is assumed that transmission line resistance & reactance per phase is connected in between two half transmission line capacitance
e)	**Draw layout of grid or interconnected distribution system. State two advantages and two applications of this system.**
Ans:	**(Layout 2 Marks, Advantages 1 Marks and application 1 Mark, Total 4 Marks)**  **or equivalent figure**

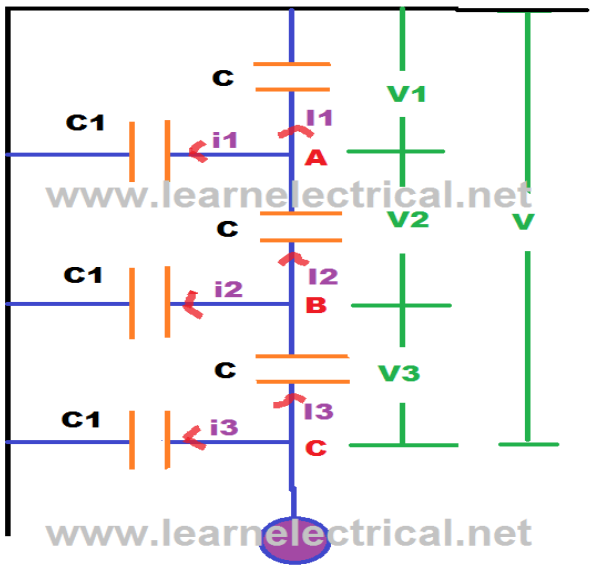
	Advantages: **(Any Two points expected) (1 Mark)** 1. Supply to distribution transformer centre is given through two different generating stations or major generating stations 2. It has highest reliability to maintain supply even when there is a fault on any one feeder 3. It has highest reliability to maintain supply even when there was maintenance on any one feeder. **Applications:** **(Any Two points expected) (1 Mark)** It is used where continuity of supply is most important: - e.g. Electric traction, TV broadcasting centre, AIR, Capital airline, Telephone exchange, Major hospitals, Important government buildings and Major industries etc.
f)	**Classify distribution system : (i) According to nature of current (ii) According to method of construction (iii) According to scheme of connection**
Ans:	**Classification of distribution system:** **1) According to nature of Current :** **(1 Mark)** 1) DC Distribution System 2) AC Distribution System **2) According to Method of construction: -** **(1 Mark)** 1) Overhead distribution system 2) Underground distribution system **3) According to scheme of connection: -** **(2 Mark)** a) Radial (Tree) distribution system b) Ring mains (Loop) distribution system c) Grid (interconnected) distribution system
Q.6	**Attempt any FOUR of the following :** **16 Marks**
a)	**State any eight requirements or properties of the line supports used in transmission and distribution.**
Ans:	**Following are the requirements of the line supports used in transmission and distribution:** **(1/2 Mark each requirements or properties ,Total 4 Marks)** **1. High mechanical strength:-** It should have high mechanical strength to withstand against -

	➢ Wind pressure ➢ Load of fabrication ➢ Weight of Insulator ➢ Weight of conductor etc. **2. Light in weight:-** It should be light in weight to reduce- ➢ Transportation cost ➢ Handling, loading, unloading cost and ➢ Erection cost. 3. **Effect of atmospheric conditions:** It should be withstand even at bad atmospheric condition. 4. **High resistance to corrosion:** It should have high resistance to corrosion to avoid rusting. 5. **Initial & Maintenance cost:** It should be less. 6. **Easy access:** It should be easily accessible for wireman for line work and maintenance work. or They must be easily accessible for point and erection of line conductors 7. **Life:** It should have longer life. 8. **Appearance:** It should have good appearance or They must be of pleasing shape
b)	**State any four factors to be considered while selecting type of line support.**
Ans:	**(Any Four points expected 1 Mark each, Total 4 Marks)** Following are the different factors to be consider while selecting type of Line support: 1. Voltage level 2. Span 3. Application i.e. In urban or rural area 4. Atmospheric condition of area 5. Whether it is used for Transmission or Distribution purpose 6. Whether it is used Temporary purpose or permanent.

c)	Derive the expression for voltage distribution along a string of three suspension insulators.

Ans:

String of three suspension insulator & the voltage distribution:- (4 Marks)



Mathematical expression for String Efficiency

Mathematical proof:

Where,

C_1 = Shunt capacitance **C = Self capacitance**

$$m = K = \frac{C_1}{C} \qquad C_1 = mc$$

Step- I: Applying KCL to node 'A'

$$I_2 = I_1 + i_1$$

$$V_2\,\omega C = V_1\,\omega C + V_1\,\omega C_1 \qquad But\,,\, C_1 = mc$$

$$V_2\,\omega C = V_1\,\omega C + V_1\,\omega mc$$

$$\therefore\ V_2 = V_1\ + V_1\,m$$

$$\therefore\ V_2 = V_1\ (1+m)\text{----------}equation-I$$

Step- II: Applying KCL to node 'B'

$$I_3 = I_2 + i_2$$

$$V_3\,\omega C = V_2\,\omega C + (V_1 + V_2)\,\omega C_1 \qquad But, C_1 = mc \;\; \& V_2 = (m+1)V_1\omega$$

$$V_3\,\omega C = V_1\,(1+m)\,\omega C + V_1\,\omega mc + V_1\,(1+m)\,\omega C$$

$$V_3 = V_1\,(1+m) + V_1\,m + V_1\,(1+m)\,m$$

$$V_3 = V_1\,(1+m+m+m+m^2)$$

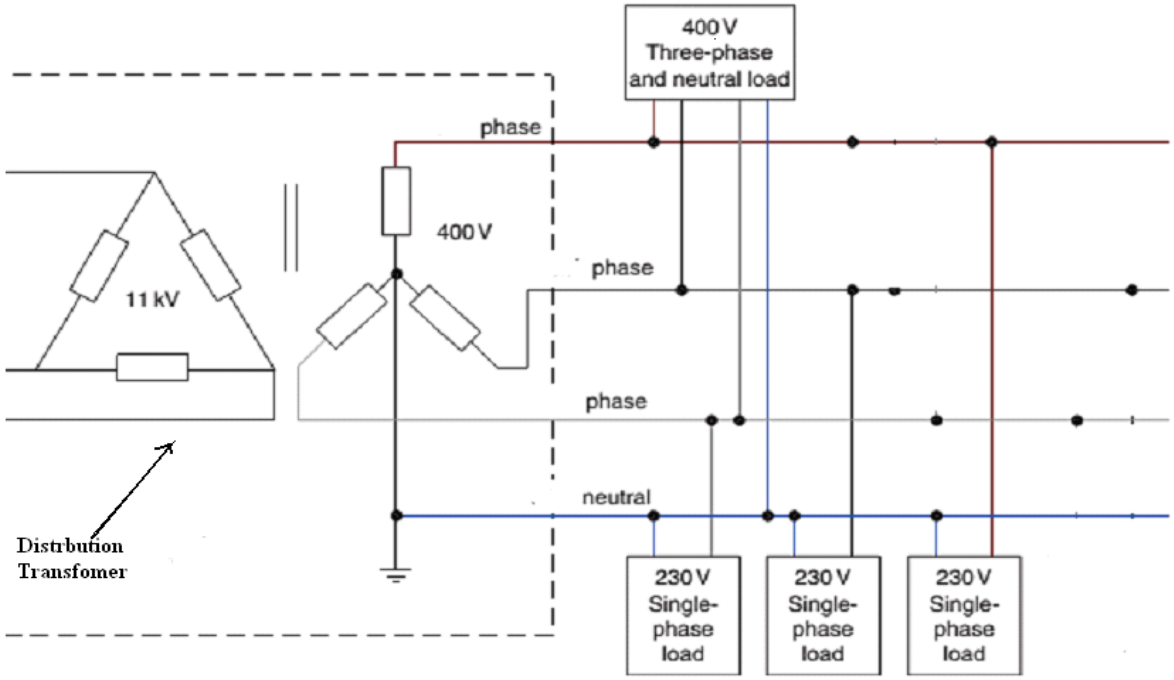
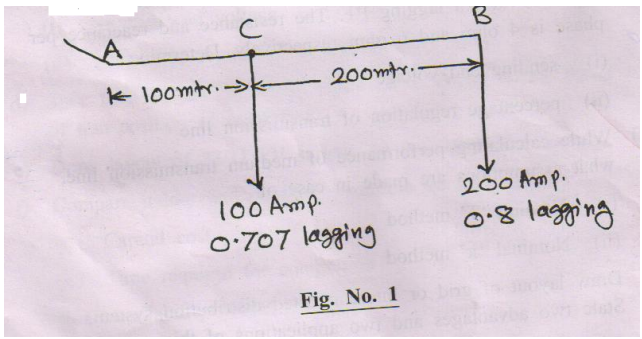
$$V_3 = V_1\,(1+3m+m^2) \quad ---------- equation - II$$

$$V = V_1 + V_2 + V_3$$

d) Compare on any four points feeder and distributor in case of transmission and distribution.

Ans: **(Any Four point expected : 1 Mark each, Total 4 Marks)**

Sr.No.	Feeder	Distributor
1	It is link between receiving substation & distribution transformer	It is link between distribution transformer substation & consumer
2	It is also called as a High Tension Line	It is also called as a low Tension Line
3	It is a 3-Ph, 3 wire system.(R-Y-B)	It is a 3-Ph, 4 wires system. (R-Y-B-N)
4	Feeder voltage is 11KV/22KV/33KV depending upon load	Distributor voltage is for 3-ph consumer- 400V and 1-Ph consumer- 230V
5	Feeder is high capacity conductors.	Distributors are low capacity conductors
6	Feeder forms the primary distribution system	Distributors forms secondary distributor system.
7	While designing feeder its current carrying capacity is important	While designing distributor its voltage drop calculation is important.
8	Feeder is not tapped along its length	Distributors are tapped throughout its length.
9	Its loading point is at substation only	Distributors loading point is throughout its length.

e)	**Draw typical A.C. distribution system showing primary distribution system, distribution transformer and secondary distribution system.** **(4 Marks)**
Ans:	 Phase to phase voltage = 400 V Phase to neutral voltage = 230 V **or equivalent figure**
f)	**A single phase distribution AB 300 mtr. long is fed from end A and is loaded as shown in Figure No.l. The total resistance and reactance of distributors is 0.2 ohm/km. and reactance 0.1 ohm/km. Calculate total voltage drop in distributor.**
Ans:	**Given data:**  Fig. No. 1 R = 0.2 ohm/km X = 0.1 ohm/km $\therefore Z = (0.2 + j0.1)\Omega/km$

Section Impedance:-

$$Z_{CB} = \frac{200}{1000}(0.2 + j0.1) -$$

$$= 0.04 + j0.02$$

$$= 0.0447 \angle 26.57^0 \ ohm$$ ---------- **(1/2Marks)**

$$Z_{AC} = \frac{100}{1000}(0.2 + j0.1)$$

$$= 0.02 + j0.01$$

$$= 0.022 \angle 26.57^0 \ ohm$$ ---------- **(1/2Marks)**

Section Current:

Given, I_C = 100A, 0.707 lag

$$100 \angle -45^0$$

$$70.71 - j\,70.71 \ Amp$$ ---------- **(1/2Marks)**

Given, I_B = 200A, 0.8 lag

$$200 \angle -36.87^0$$

$$160 - j\,120 \ Amp$$ ---------- **(1/2Marks)**

Section Current: $I_{CB} = I_B$

$$= 200 \angle -36.87^0$$

$$160 - j\,120 \ Amp$$

Section Current: $I_{AC} = I_C + I_B$

$$= (70.71\text{-}j70.71) + (160\text{-}j120)$$

$$= 230.71\text{-}j190.71$$

$$= 299.3282 \angle -39.5778 \ Amp$$ ---------- **(1/2Marks)**

Voltage drop in section CB:-

$$= I_{CB} \ X \ Z_{CB}$$

$$= (200 \angle -36.87^0)(0.0447 \angle 26.57)$$

$= 8.94 \angle -10.305 \quad Volts$

$= 8.7959 - j\,1.5984 \quad Volts$ ---------- **(1/2Marks)**

Step III:

Voltage drop in section AC:-

$$V_{AC} = I_{AC} \times Z_{AC}$$
$$= (299.3282 \angle -39.5778)\ (0.022 \angle 26.57)$$
$$= 6.5852 \angle -13.0078\, V$$
$$= 6.4162 - j\,1.4822\, V$$ ---------- **(1/2 Mark)**

Total Voltage drop:-

Voltage drop in section CB + Voltage drop in section AC

$$= (8.7959 - j\,1.5984) + (6.4162 - j\,1.4822)$$
$$= 15.2121 - j\ 3.0806\ Volt$$ ---------- **(1/2 Mark)**
$$= 15.5208 \angle -11.4481\, Volt$$

----------**END**----------