7. SUBJECT DETAILS

7.3 POWER SYSTEMS-II

7.3 POWER SYSTEMS-II

7.3.1 OBJECTIVE AND RELEVANCE

This subject covers Transmission lines, design, performance, maintenance, and operation. The main aim of studying this subject is to design a 100% efficient transmission lines in between generating stations and consumers. The complexity in design of transmission lines is more due to increasing power demand. So, to increase the efficiency of a transmission line, we should not only consider efficient design but also other parameters like power factor and voltage regulation. So, in this subject student will learn different types of power factor improvement equipment, cables and insulators.

7.3.2 SCOPE

This subject covers wide spectrum of electrical power systems (transmission lines)and deals with the electrical and mechanical design, performance, maintenance, and operation. There is a wide scope of development and reasearch in the power systems. New trends of implementation of Power electronics and HVDC brought a major chang in the improvement of power quality has been improved. The basics of this subject is required for the implemetatin of computers in the Power systems.

7.3.3 PREREQUISITES

This subject requires the basic understanding of power system modeling and various types of generation, transmission and distribution parameters. A basic course in mathematics, applications of network theorems and matrix analysis are essential. It also requires knowledge of Power systems, Network theory, rigorous but clear treatment of mechanical design of transmission lines, mathematical approach, solvation of differential equations.

7.3.4.1 JNTU SYLLABUS

UNIT-I

OBJECTIVE

This unit deals with calculation of transmission line parameters for various conductor configurations. This unit gives a overview of calculation of resistance, inductance abd capacitance of various types of overhead transmission lines.

SYLLABUS

TRANSMISSION LINE PARAMETERS: Types of conductors - calculation of resistance for solid conductors- calculation of inductance for for single phase and three phase, single and double circuit lines, concept of GMR and GMD, symmetrical and asymmetrical conductor configuration with and without transposition, numerical problems.

Calculation of capacitance for 2 wire and 3 wire systems, effect of ground on capacitance, capacitance calculations for symmetrical and asymmetrical single pahse and three pahse, single and double circuit line and numerical problems.

UNIT-II

OBJECTIVE

The main objective of this unit is to learn the various concepts of OH lines. OH lines are subjected to certain weather conditions and other external interferences, this calls for use of proper mechanical factor for safety in order to ensure the continuity of the operation of the line

The objective of this unit is to understand classification of transmission lines and give a overview of difference between short medium and long transmission lines. It also covers the concept of regulation using nominal Pie, Nominal T and ABCD parameters calculation methods

SYLLABUS

PERFORMANCE OF SHORT AND MEDIUM AND LONG LENGTH TRANSMISSION LINES: Classification of transmission Lines- Short, medium and long line and their model representations, Nominal-T, Nominal-pie and A, B, C,D constants for symmetrical and asymmetrical Networks, Numerical problems. Mathematical Solutions to estimate regulation and efficiency of all type lines, numerical problems

Long Transmission lines, rigorous solution, evaluation of A,B,C,D constants, Interpretation of the long line equations, Incidents, reflected and refracted waves, Surge Impedance and SIL of Long lines, wave length and velocity of propagation of the waves, representation of long lines, equivalent-T and equivalent Pie network models and numerical problems

UNIT-III

OBJECTIVE

The objective of this unit is to study different types of transients that may occur in power systems. It also deals with the concept of termination of lines with different types of conditions and Bewley’s lattice diagram.

The objective of this unit is to understand different types of effect that may occur in OH lines and its effects. It deals with Skin effect, Proximity effect, Ferranti effect and factors affecting these phenomenon.

SYLLABUS

POWER SYSTEM TRANSIENTS AND FACTORS GOVERNING THE PERFORMANCE OF TRANSMISSION LINES: Types of system transients, travelling or propagation of surges, attenuation, distortion, reflection and Refraction coefficients, termination of lines with different types of conditions, open circuited Line, short circuited line, T-junction, lumped reactive junctions numerical problems. Bewely’s lattice diagrams for all the cases mentioned with examples.

Skin and Proximity effects: description and effect of resistance on solid conductors. Ferranti effect: charging current, effect on regulation of the transmission line, shunt compensation. Corona, description of the phenomenon, factors affecting corona, critical voltage and power loss, radio Interference.

UNIT-IV

OBJECTIVE

The objective of this unit is to understand study and analysis of the effects of the overhead insulators in transmission system. It deals with overhead insulators, string efficiency, different types of grading of insulators.

The main objective of this unit is to learn the mechanical concepts of OH lines. It deals with sag and tension calculations of various types of towers with equal heights and unequal a heights. Introduction to Stringing chart and sag template and its applications.

SYLLABUS

OVERHEAD LINE INSULATORS AND SAG, TENSION CALCULATIONS: Types of insulators, string efficiency and methods of improvement, Numerical problems, voltage distribution, calculation of string efficiency, capacitance grading and static shielding.

Sag and Tension calculations with equal and unequal heights of towers, effect of wind and ice on weight of conductor, Numerical problems. Stringing chart and sag template and its applications.

UNIT - V
OBJECTIVE
The objective of this unit is to understand the types of cables and insulating materials and calculattion of insulations resistance and capacitance of the cables. It also deals with introduction to 3 core belted cables and capacitance grading and inters heath grading.

SYLLABUS
UNDERGROUND CABLES: Types of cables, construction, types of insulating materials, calculation of insulation resistance and stress in insulation and numerical problems. Capacitance of of single and three core belted cables, numerical problems.

Grading of cables, capacitance grading, numerical problems, description of inter-sheath grading, HV cables.

7.3.4.2 GATE SYLLABUS

UNIT-I
Steady state performance of overhead lines.

UNIT-II
Transmission line models and performance.

UNIT-III
Transmission line models and performance.

UNIT-IV
Long Transmission Lines & ABCD parameters.

UNIT-V
Corona and radio interference.

UNIT-VI
Insulators.

UNIT-VII
Sag and Tension calculations.

UNIT-VIII
Cable performance.

7.3.4.3 IES SYLLABUS

UNIT-I
Power transmission lines.

UNIT-II
Modeling and performance characteristics.

UNIT-III
Transmission line models and performance.

UNIT-IV
Power system transients.

UNIT-V
Corona and radio interference

UNIT-VI
Insulators.

UNIT-VII
Sag and Tension calculations.

UNIT-VIII
Cable performance.

7.3.5 SUGGESTED BOOKS

TEXT BOOKS

T1 Electrical power systems,PSR Murthy,BS Publications.

T2 Electrical Power Systems, C.L. Wadhwa, New Age International (P) Limited Publishers, 1998.

REFERENCE BOOKS

R1 Power System Analysis, John J Grainger and William D Stevenson, 4th Edn.,Tata McGraw Hill Company.

R2 Power System Analysis and Design, B.R. Gupta, Wheeler Publishing.

R3 Power Sytem Analysis, Hadi Saadat, TMH Edition.

R4 Theory and Problems of Electric Power System, S.A.Nasar, Shaum's Outline Series, McGraw Hill Company, 1990.

R5 Principles of Power Systems, V.K.Mehta, Rohit Mehta, S.Chand Publishers, New Edition.

OUTCOME:

After going through this course students gets a thorough knowledge on calculation of transmission line parameters, performance analysis of short medium long length transmission lines and factors affecting the performance analysis of transmission lines, transients in power systems, operations of different types of overhead line insulators, sag and tension calculation of transmission lines and detailed analysis of underground cables for power transmission and distribution , with which he/she can able to apply the above conceptual thongs to real-world electrical and electronics problems and applications.

7.3.6 WEBSITES

1. www.ntu.ac.sg
2. www.utoronto.ca
3. www.ee.washington.edu
4. www.esca.com
5. www.ne.ac.sg
6. www.iitm.ac.in
7. www.iitb.ac.in
8. www.iitk.ac.in
9. www.annauniv.edu
10. www.vjti.ac.in.
11. www.ieeecss.org
12. www.ieee.com

13. www.iee.com
14. www.google.com

7.3.7 EXPERTS' DETAILS

INTERNATIONAL

1. M. Karimi-Ghartemani,
   Centre for Applied Power Electronics (CAPE),
   Department of Electrical and Computer Engineering,
   University of Toronto,
   Toronto, ON M5S 3GL, Canada,
   Email: masoud@ele.utoronto.ca.

2. M.R.Iravani,
   Centre for Applied Power Electronics (CAPE),
   Department of Electrical and Computer Engineering,
   University of Toronto,
   Toronto, ON M5S 3GL, Canada,
   Email: masoud@ele.utoronto.ca.

NATIONAL

1. Dr. B.L. Mathur,
   Prof. & Head,
   Department of Electrical and Electronics,
   SSN College of Engineering,
   Old Mahabalipuram Road,
   SSN Nagar, Tamilnadu, India,
   Email: info@ssnce.ac.in.

2. D.P. Kothari,
   Centre of Energy Studies,
   Dy. Director, 9 Admn.,
   IIT, Delhi,
   www.iitd.ac.in.

REGIONAL

1. Prof . M. Saidulu,
   Associate Professor,
   Department of Electrical Engg.,
   Natinal Institute of Technology,
   Warangal,
   Andhra Pradesh.

2. Prof. Tulsi Ramdas,
   Principal,
   JNTU College of Engg.,
   Kukatpally, Hyderabad,
   Andhra Pradesh,
   www.jntu.ac.in.

7.3.8 JOURNALS

INTERNATIONAL

1. IEEE Transactions on Power Systems
2. IEEE Transactions on Power Delivery
3. IEEE Transactions on Energy Conversion
4. Institution of Electrical Engineers

NATIONAL

1. Institution of Engineers (India)
2. Electrical Engineering Update
3. power System Society of India
4. Electrical India.

7.3.9 FINDINGS AND DEVELOPMENTS

1. Active management of renewable energy sources for maximizing power production- V. Calderaro G. Conio | V. Galdi | G. Massa | A. Piccolo - May 2014

2. Optimal sizing of battery energy storage for micro-grid operation management using a new improved bat algorithm - Bahman Bahmani-Firouzi | Rasoul Azizipanah- Abarghooee - March 2014

3. Smart electricity meter reliability prediction based on accelerated degradation testing and modeling- Z. Yang | Y.X. Chen | Y.F. Li | E. Zio | R. Kang - March 2014

4. Advances and trends of energy storage technology in Microgrid **-** Xingguo Tan | Qingmin Li | Hui Wang

   January 2013

5. A combination of genetic algorithm and particle swarm optimization for optimal DG location and sizing in distribution systemsVolume 34, Issue 1, January 2012, Pages 66-74Mohammad Hasan Moradi | Mohammad Abedini

6. DG allocation with application of dynamic programming for loss reduction and reliability improvement**- V**olume 33, Issue 2, February 2011, Pages 288-295 -N. Khalesi | Nazkhanom Rezaei | Mahmoud Reza Haghifam

7. Optimal sizing and placement of distributed generation in a network system- Volume 32, Issue 8, March 2010, Pages 849-856 - Sudipta Ghosh | Sakti Prasad Ghoshal | Saradindu Ghosh

8. ANNEPS based protection for power transformer using DGA, Electrical India, Vol. 49, March 2009.

9. Improving energy efficiency industries, Electrical Engineering Update, Vol. 17, Pg. No. 24, Jan-Feb. 2009.

10. New products in insulated cables and HT cables, Electrical Engineering Update, Vol. 17, Pg. No. 24, Jan-Feb. 2009.

11. A Power Analysis toolbox for MATLAB and simulink, Karl Scheder, Amer Hasanovic, Ali Feliachi, Azal hasanovic, IEEE Transactions on Power Systems, Vol. 18. Feb 2003.

12. Integrated software platform to teach different electricity spot market architechture, Marcelino Mardrigal and marcelo Flores, IEEE Transactions on Power Systems, Vol. 18. Feb 2003.

13. Reliability and cost assesment of power transmission networks in the competitive electrical engineering market, Dimitros J. Papakammenos and Evangeles N. dialngas, IEEE Transactions on Power Systems, Vol. 18. Feb 2003.

14. A solution to remote detection of illegal electricity usage via power line communications by Hakki Cavador, IEEE Transactions on Power Systems, Vol. 18, Feb 2003.

7.3.10 i. **SESSION PLAN**

Sl. No.	Topics as per JNTU Syllabus	Modules and Sub-modules	Lecture No.	Suggested Books	Remarks
		UNIT-I			
1	Types of conductors. Calculations of resistance for solid conductors. Calculation of Inductance for single phase circuit lines	Introduction to types of conductors, Calculation of resistance for solid conductors. Inductance, calculation of inductance for single phase circuit lines	L1	T1-Ch2,T2-Ch2 R1-Ch4,R2-Ch2 R3-Ch4,R5-Ch9	
2	calculation of inductance for three phase, single and double circuit lines, concept of GMR and GMD, symmetrical and asymmetrical conductor configuration with and without transposition, numerical problems.	Derivation of Inductance for three phase single and double circuit lines. Concept of GMR and GMD.	L2	T1-Ch2,T2-Ch2 R1-Ch4,R2-Ch2 R3-Ch4,R5-Ch9	
		Problems on the calculation of inductance for single and three phase circuit lines	L3	T1-Ch2,T2-Ch2 R1-Ch4,R2-Ch2 R3-Ch4,R5-Ch9	
		Difference between symmetrical and unsymmetrical spacing of conductors and calculation of the inductance for both the configurations.	L4	T1-Ch2,T2-Ch2 R1-Ch4,R2-Ch2 R3-Ch4,R5-Ch9	
3	Calculation of capacitance for 2 wire and 3 wire systems, Capacitance calculations for symmetrical and	Calculation of capacitance for 2 wire and 3 wire systems derivations. Effect of ground on capacitance	L5	T1-Ch2,T2-Ch2 R1-Ch5,R3-Ch4 R5-Ch9	

	asymmetrical single phase and three phase, single and double circuit line and numerical problems.	Calculation of capacitance for symmetrical and unsymmetrical spacing of single phase lines and problems for both single and double circuit lines	L6	T1-Ch2,T2-Ch2 R1-Ch5,R3-Ch4 R5-Ch9	
		Calculation of capacitance for symmetrical and unsymmetrical spacing of Three phase lines for both single and double circuit lines	L7	T1-Ch2,T2-Ch2 R1-Ch5,R3-Ch4 R5-Ch9	
		Calculation of capacitance for symmetrical and unsymmetrical spacing of Three phase lines for both single and double circuit lines	L8	T1-Ch2,T2-Ch2 R1-Ch5,R3-Ch4 R5-Ch9	
UNIT-II					
4	Classification of transmission Lines- Short, medium and long line and their model representations Nominal-T, Nominal-Pie Mathematical solutions to estimate the regulations and efficiency to all types of lines.	Classification of transmission Lines: Short Transmission Lines Medium Transmission Lines Long Transmission Lines	L9	T1-Ch5,T2-Ch4 R1-Ch6,R2-Ch3 R3-Ch5,R5-Ch10	GATE IES
		Medium transmission Lines: Nominal-T representation Mathematical solutions to estimate the regulations and efficiency Numerical problems	L10	T1-Ch5,T2-Ch4 R1-Ch6,R2-Ch3 R3-Ch5,R5-Ch10	GATE IES
		Nominal Pie Representation Mathematical solutions to estimate the regulations and efficiency Numerical problems	L11	T1-Ch5,T2-Ch4 R1-Ch6, R2-Ch3 R3-Ch5,R5-Ch10	GATE IES

5	A,B,C,D constants for symmetrical and asymmetrical networks, Numerical problems	A,B,C,D constants for symmetrical and asymmetrical networks Mathematical solutions to estimate the regulations and efficiency Numerical problems	L12	T1-Ch5,T2-Ch4 R1-Ch6,R2-Ch3 R3-Ch5,R5-Ch10	GATE IES
		UNIT-III			
6	Long Transmission lines- Rigorous solution, evaluation of A,B,C,D constants	Introduction to long Transmission lines Rigorous Solution methods Calculation of A,B,C,D constants	L13	T1-Ch5,T2-Ch4 R1-Ch6,R2-Ch3 R3-Ch5,R5-Ch10	GATE IES
7	Interpretation of the Long Line equations, Incidents, reflected and refracted waves	Interpretation of the Long Line equations, Introduction to Incidents, reflected and refracted waves in long transmission lines.	L14	T1-Ch5,T2-Ch4 R1-Ch6,R2-Ch3 R3-Ch5,R5-Ch10	GATE IES
8	Surge Impedance and SIL of Long lines, wave length and velocity of propagation of the waves	Introduction to surge impedance SIL of long lines	L15	T1-Ch5,T2-Ch4 R1-Ch6,R2-Ch3 R3-Ch5,R5-Ch10	GATE IES
		wave length and velocity of propagation of the waves	L16	T1-Ch5,T2-Ch4 R1-Ch6,R2-Ch3 R3-Ch5,R5-Ch10	
9	Representation of long lines Equivalent-T and equivalent Pie network models and numerical problems	Representation of long lines equivalent-T representation Numerical problems	L17	T1-Ch5,T2-Ch4 R1-Ch6,R2-Ch3 R3-Ch5,R5-Ch10	GATE IES
		Representation of long lines Equivalent Pie representation	L18	T1-Ch5,T2-Ch4 R1-Ch6,R2-Ch3	

		Numerical problems		R3-Ch5,R5-Ch10	
UNIT-IV					
10	Types of system transients Traveling or propagation of surges, Attenuation, Distortion, reflection and Refraction coefficients	Types of system transients Traveling or propagation of surges Attenuation coefficient	L19	T1-Ch5,T2-Ch12 R1-Ch6,R2-Ch12 R3-Ch5	IES
		Distortion, reflection and Refraction coefficients	L20	T1-Ch5,T2-Ch12 R1-Ch6,R2-Ch12 R3-Ch5	
11	Termination of lines with different types of conditions : Open circuited line, short circuited line	Termination of lines with different types of conditions - Open circuited Line, short circuited line	L21	T1-Ch5,T2-Ch12 R1-Ch6,R2-Ch12 R3-Ch5	IES
12	T-junction, lumped reactive junctions numerical problems	T-junction, lumped reactive junctions numerical problems	L22 L23	T1-Ch5,T2-Ch12 R1-Ch6,R2-Ch12 R3-Ch5	IES
13	Bewely's lattice diagrams for all the cases mentioned with examples.	Introduction to Bewely's lattice diagrams for all the cases mentioned with examples.	L24, L25	T1-Ch5,T2-Ch12 R1-Ch6,R2-Ch12 R3-Ch5	
UNIT-V					
14	Skin and Proximity effects: Description and effect of resistance on solid conductors.	Skin effect and proximity effect and their description. Effect of the above factors in Solid conductors	L26	T1-Ch2,T2-Ch2 R1-Ch4,R2-Ch3 R3-Ch4,R5-Ch9	
15	Ferranti effect : Charging current Effect on regulation of the transmission line	Introduction to Ferranti effect charging current due to the above effect Effect of Ferranti effect on Regulation of transmission	L27	T1-Ch4,T2-Ch5 R1-Ch4,R2-Ch2 R3-Ch4	

	Shunt compensation.	lines			
		Shunt compensation to improve the regulation of the line	L28	T1-Ch4,T2-Ch5 R1-Ch4,R2-Ch2 R3-Ch4	
16	Corona : Description of the Phenomenon Factors affecting corona Critical voltage and power loss Radio Interference.	Corona its description Factors affecting Corona	L29	T1-Ch2,T2-Ch6 R1-Ch4,R2-Ch6 R3-Ch5,R5-Ch8	GATE
		Critical voltage calculations and numerical problems	L30	T1-Ch2,T2-Ch6 R1-Ch4,R2-Ch6 R3-Ch5,R5-Ch8	
		Power loss, radio Interference. Numerical problems	L31	T1-Ch2,T2-Ch6 R1-Ch4,R2-Ch6 R3-Ch5,R5-Ch8	
UNIT-VI					
17	Types of insulators String efficiency	Types of Insulators Pin type Suspension type Shackle type String efficiency and its calculation	L32	T2-Ch8,R2-Ch4 R5-Ch8	
18	Methods of improvement Numerical problems	Methods to improve string efficiency Problems on string efficiency	L33,34	T2-Ch8,R2-Ch4 R5-Ch8	
19	Voltage distribution, calculation of string efficiency,	Voltage distribution in string of insulators and derivations related to that.	L35	T2-Ch8,R2-Ch4 R5-Ch8	
20	Capacitance grading and static shielding.	Methods to improve string efficiency	L36	T2-Ch8,R2-Ch4 R5-Ch8	GATE

		Capacitance grading and static shielding			
		Numerical problems on calculations of string efficiency	L37, L38	T2-Ch8,R2-Ch4 R5-Ch8	GATE
UNIT-VII					
21	Sag and tension Calculations with equal heights	Calculation of the sag, effect of ice and wind loading on e the line. Derivation of related formulae	L39, L40	T2-Ch7,R5-Ch8	GATE
		Problems on Sag calculations with Equal heights	L41	T2-Ch7,R5-Ch8	
22	Sag and tension Calculations with unequal heights	Sag and tension calculations with equal heights	L42	T2-Ch7,R5-Ch8	GATE
		Problems on Sag and tension calculations with unequal heights	L43, L44	T2-Ch7,R5-Ch8	
23	String charts and sag template	Stinging chart use and Sag template	L45	T2-Ch7,R5-Ch8	
UNIT-VIII					
25	Types of cables	Introduction to underground cables: Types of Cables: i) Belted Cables ii) Screened cables iii) Pressure cables	L46	T2-Ch9,R5-Ch11	GATE
26	Insulating materials	Insulating materials used for underground cables: Rubber, Vulcanized Indian rubber, Impregnated paper, PVC, Introduction to construction of the cable	L47 L48	T2-Ch7,R5-Ch11	GATE
27	Calculation of the insulation resistance	Insulation resistance of single core cable and problems related to it	L49	T2-Ch7,R5-Ch11	GATE
28	Stress and capacitance calculations	Capacitance in the cables: Capacitance calculations in Single core cable and Di-electrical stress in Single core	L50	T2-Ch7,R5-Ch11	GATE

		cable			
29	Single and multi core cables Grading of cables	Most economical size of conductor in cable; Grading of cables: Capacitance grading	L51	T2-Ch7,R5-Ch11	GATE
		Inter sheath grading related problems	L52	T2-Ch7, R5-Ch11	GATE
		Capacitance of 3-phase core cables	L53	T2-Ch7,R5-Ch11	GATE
30	Power factor and charging current; thermal characteristics of cables	Heating of cables: Power factor improvement Variation dielectric power factor with voltage	L54	T2-Ch7,R5-Ch11	
31	Sheath current and losses	Sheath loss and sheath circuit currents	L55	T2-Ch7,R5-Ch11	

ii. **TUTORIAL PLAN**

Sl. No.	Topics Scheduled	Salient topics to be discussed
1	Types of conductors. Calculations of resistance for solid conductors. Calculation of Inductance for single phase circuit lines. calculation of inductance for three phase, single and double circuit lines, concept of GMR and GMD, Symmetrical and asymmetrical conductor configuration with and without transposition, numerical problems.	Problems on calculation of inductance for 3 phase double circuit lines including the concept of GMR and GMD.
2	Calculation of capacitance for 2 wire and 3 wire systems, effect of ground on capacitance, capacitance calculations for symmetrical and asymmetrical single phase and three phase, single and double circuit line and numerical problems.	Problems on calculation of capacitance for single and double circuit lines including earth effect on capacitance.
3	Classification of transmission lines: Short, medium and long line and their model representations, Nominal-T, Nominal-pie, Mathematical solutions to estimate the regulations and efficiency to all types of lines. A,B,C,D constants for symmetrical and asymmetrical networks, Numerical problems	Problems on calculation of regulation of medium transmission lines using Nominal-T, Nominal-Pie.
4	Long Transmission lines: Rigorous solution, evaluation of A, B, C, D constants. Interpretation of the Long Line equations, incidents, reflected and refracted waves. Surge Impedance and SIL of Long lines, wave length and velocity of propagation of the waves.	Problems on Calculation of ABCD parameters of long transmission lines using rigorous method.
5	Representation of long lines: equivalent-T and equivalent Pie network models and numerical problems. Types of system transients, traveling or propagation of surges, attenuation, distortion, reflection and refraction coefficients	Problems on calculation of regulation of long transmission lines using different types of representations.
6	Termination of lines with different types of conditions: Open circuited Line, short circuited line T-junction, lumped reactive junctions numerical problems. Bewely's lattice diagrams for all the cases mentioned with examples	Problems on calculation of parameters of transmission lines subjected to transients.

7	Skin and Proximity effects: Description and effect of resistance on solid conductors. Ferranti effect : charging current, effect on regulation of the transmission line, shunt compensation.	Effect of charging current on regulation of transmission lines and its calculation. Problems on shunt compensation.
8	Corona : description of the Phenomenon, factors affecting Corona, critical voltage and power loss, radio Interference.	Problems on calculation of critical voltage and power loss due to corona effect.
9	Types of insulators, string efficiency methods of improvement, numerical problems. Voltage distribution, calculation of string efficiency,	Problems on calculation of string efficiency and voltage distribution in overhead insulators.
10	Capacitance grading and static shielding	Problems on calculation of string efficiency with grading and shielding.
11	Sag and tension calculations with equal heights. Sag and tension calculations with unequal heights	Problems on calculation of sag and tension with equal heights including the effects of ice and wind.
12	Sag and tension calculations with unequal heights string charts and sag template	Problems on calculation of Sag and tension with unequal heights including the effects of ice and wind.
13	Types of cables, insulating materials, calculation of the insulation resistance, stress and capacitance calculations.	Problems on calculation of stress and capacitance of the cables.
14	Single and multi core cables: grading of cables, power factor and charging current: thermal characteristics of cables, sheath current and losses.	Problems on grading of cables, and Calculation of most economical size of cable insulations.

7.3.11 STUDENT SEMINAR TOPICS

1. Active management of renewable energy sources for maximizing power production- V. **Calderaro** G. Conio | V. Galdi | G. Massa | A. Piccolo - May 2014

2 . Optimal sizing of battery energy storage for micro-grid operation management using a new improved bat algorithm - Bahman Bahmani-Firouzi | Rasoul Azizipanah- Abarghooee - March 2014

3. Smart electricity meter reliability prediction based on accelerated degradation testing and modeling- Z. Yang | Y.X. Chen | Y.F. Li | E. Zio | R. Kang - March 2014

4. Advances and trends of energy storage technology in Microgrid - Xingguo Tan | Qingmin Li | Hui Wang January 2013

5. A combination of genetic algorithm and particle swarm optimization for optimal DG location and sizing in distribution systemsVolume 34, Issue 1, January 2012, Pages 66-74Mohammad Hasan Moradi | Mohammad Abedini

6. DG allocation with application of dynamic programming for loss reduction and reliability improvement-**V**olume 33, Issue 2, February 2011, Pages 288-295 -N. Khalesi | Nazkhanom Rezaei | Mahmoud Reza Haghifam

7. Optimal sizing and placement of distributed generation in a network system- Volume 32, Issue 8, March 2010, Pages 849-856 - Sudipta Ghosh | Sakti Prasad Ghoshal | Saradindu Ghosh

8. Effective metering and energy management solutions, Electrical India, Vol. 49, March 2009.

9. Apparent energy metering, Electrical India, Vol. 49, March 2009.

10. Solar cities development, Electrical India, Vol. 49, March 2009.

11. Low intervention strategy for low levels of moisture in power transformers, Electrical India, Vol. 49, March 2009.

12. Standards related to insulation of power transformer, Electrical India, Vol. 49, March 2009.

13. Induction motors starters DOL star delta, Electrical Engineering Update, Vol. 21, Pg. No. 24, Jan-Feb. 2009.

7.3.12 QUESTION BANK

UNIT-I

1. The three conductors of a 3-phase line are arranged in a horizontal plane with a spacing of 4 m between adjacent conductors. The diameter of each conductor is 2.5 cm. Determine the inductance per km per phase of the line assuming that the lines are transposed. **(May 11, 10)**

2. i. What do you understand by the constants of an over head transmission line?
   ii. A single phase transmission line has two parallel conductors 1.5 meters apart, the diameter of each conductor being 0.5 cm. Calculate line to neutral capacitance for a line of 150 km long **(May 11, 10)**

3. Figure shows the spacing's of a double circuit 3-phase over head line. The phase sequence is ABC and the line is completely transposed. The conductor radius is 1.3 cm. Find the inductance per phase per km. **(Nov12, May 11)**

4. A 200 km, 3-phase transmission line has its conductors placed at the corners of an equilateral triangle of 2.5 m side. The radius of each conductor is 2 cm. Calculate:
   i. Line to neutral capacitance of the line
   ii. Charging current per phase if the line is maintained at 66 KV, 50Hz. **(May 11)**

5.* Determine the inductance per km of a 3-phase transmission line having conductors per phase and arranged as shown in figure. **(Nov 13,Nov 10)**

6. Derive an expression for the capacitance per meter length between two long parallel conductors, each of radius r, with axes separated by a distance D, where D>>r, the insulating medium being air. Calculate the maximum potential difference permissible between the conductors if the electric field strength between them is not exceed 25 KV/cm, r being 0.3 cm and D = 35 cm. **(Nov 10)**

7. Derive an expression for the inductance per phase for a 3-phase over head transmission line
   i. Conductors are symmetrically placed
   ii. Conductors are unsymmetrically placed but the lines is completely transposed.
   iii. A three phase, 50 Hz overhead line has regularly transposed conductors equilaterally spaced 4 m apart. The capacitance of such a line is 0.01 micro F/Km. Recalculate the capacitance per Km to neutral when the conductors are in the same horizontal plane with successive spacing of 4 m and are regularly transposed. **(Nov13, May 10)**

8. Show that the inductance per unit length of an over head line due to internal flux linkages is constant and is independent of size of conductor. **(Nov 10)**

9. Find an expression for the flux linkages **(May 10)**
   i. Due to single current carrying conductor
   ii. In parallel current carrying conductors and there by obtain an expression for inductance of line

10. i. Name the important components of an overhead transmission line? **(May 10)**
   ii. Discuss the various conductor materials used for overhead lines. What are their relative advantages and disadvantages?

11. i. What are bundled conductors? Discuss the advantages of bundled conductors, when used for overhead lines.
   ii. Calculate the capacitance (phase-to-neutral) of a three-phase 100 km long double circuit line shown in Figure, with conductors of diameter 2.0 cm each arranged at the corners of an hexagon with sides measuring 2.1 m. **(May 10, Nov 07)**

12. i. What is the effect of earth on the capacitance of the line? Derive an expression for the capacitance per unit length of a 3-phase line completely transposed.
   ii. A single phase 40km long transmission line consists of two parallel long straight conductors each 6mm in diameter and speed is 2.5m apart. If the line voltage is 70kV, 50Hz determine the charging current of the open circuited line. **(Nov 09)**

13. i. Discuss the concept of geometric mean distance. How is this concept used to find the inductance of composite conductor line.
   ii. Calculate the inductance of single-phase double circuit line as shown in Figure. The diameter of each conductor is 2 cm. **(Nov 09)**

14. i. Derive an expression for the inductance per phase for a 3-phase overhead transmission line when conductors are unsymmetrical placed but lines are untransposed.
   ii. Calculate the inductance and reactance of each phase of a three-phase 50Hz overhead high-tension line (HTL) which has conductors of 2.5cm diameter. The distance between the three-phases are
   a. 5m between A and B,
   b. 4m between B and C and
   c. 3m between C and A as shown in Figure. Assume that the phase conductors are transposed regularly. **(Nov 09)**

15. i. Derive from basic considerations an expression for capacitance and charging current per km length of a single phase line made up of two solid round conductors of radius r m and spaced at D m. Neglect the effect of ground.
   ii. The conductors in a single-phase transmission line are 6m above the ground. Taking the effect of the earth into account, calculate the capacitance/km. Each conductor is 2.0 cm in diameter and the conductors are spaced 3.5m apart. **(Nov 09)**

16. i. Briefly discuss the various types of conductor material used for over head transmission lines
   ii. A single phase, two wire transmission line 20km long, is made up of round conductors each 0.9cm in diameter, separated from each other by 45cm.Calculate the equivalent diameter of a fictitious hollow, thin-walled conductor having the same inductance as the original line. What is the value of this inductance? **(Nov 08)**

17. i. How can the inductance of a bundled conductor line be calculated? Derive expressions for geometric mean radii of duplex, triplex and quadruplex arrangement.
   ii. Calculate the inductance per phase of a three-phase, double circuit line as shown in Figure. The diameter of each conductor is 1.5 cm **(Nov 08)**

18. i. Show that the inductance per loop meter of two wire transmission line using solid round conductors is given by L = 4 x 10^{-7} log D/r' henries where D is the distance between the conductors and r' is the GMR of the conductors.
    ii. A single phase overhead line 32km long consists of two parallel conductors each 1cm diameter, 3 meters apart. If the line voltage be 25kV at 50Hz. Determine the charging current with the line open circuited. **(Nov 08)**
19. i. Derive an expression for the inductance per phase for a 3-phase overhead transmission line when conductors are symmetrically placed.
    ii. Calculate the inductance per phase of a three-phase transmission line as shown in Figure. The radius of the conductor is 0.5 cm. The lines are untransposed. **(Nov 08)**

20. i. What is bundled conductor and why it is used?
    ii. A 3-phase, 50 Hz, 66 kV overhead transmission line has its conductors arranged at the corners of an equilateral triangle of 3m sides and the diameter of each conductor is 1.5 cm. Determine the inductance and capacitance per phase, if the length of line is 100 km. And also calculate the charging current. **(Feb 08)**

21. i. Determine the capacitance of a three-phase double circuit line when conductors are placed flat vertical unsymmetrical spacing.
    ii. Three conductors of a 3-phase line are arranged at the corners of a triangle of sides 2m, 3.2m and 4m.The diameter of each conductor is 2.5cm, Calculate the inductance per km of the line. **(Feb 08)**

22. i. Explain the merits and demerits of bundled conductors.
    ii. Calculate the capacitance of a single-phase overhead line consisting of a pair of parallel wires 12mm in diameter and spaced uniformly 2.5 m apart. If the line is 30 km long and its one end is connected to 50 kV, 50 Hz system, what will be charging current when the other end is open circuited? **(Feb 08)**

23. i. Explain briefly classification of transmission lines based on line lengths with neat diagrams. Derive approximate voltage drop for shortline
    ii. Define Voltage regulation of a transmission line and explain clearly the Ferranti effect with a phasor diagram. **(Feb 08)**
24. Calculate the inductance per phase of a 400 kV, three-phase single circuit line that utilizes a bundled conductor arrangement as shown in Figure 1b. The space between the two phases is 15m in a horizontal formation. The sub-conductors of a phase are at the corners of a square of sides 0.5m, each sub-conductor having a diameter of 3cm. **(Nov 07)**

25. i. Distinguish between AC and DC resistances of a conductor? Why the two differ?
    ii. Calculate the capacitance of a conductor per phase of a three-phase 400 km long line, with the conductors spaced at the corners of an equilateral triangle of side 4 m and the diameter of each conductor being 2.5cm. **(Nov 07)**
26. i. What is bundled conductor and why it is used?
    ii. A 3-phase, 50 Hz, 66 kV overhead transmission line has its conductors arranged at the corners of an equilateral triangle of 3m sides and the diameter of each conductor is 1.5 cm. Determine the inductance and capacitance per phase, if the length of line is 100 km. And also calculate the charging current. **(Nov 07)**

27. Input to a single-phase short line is 2000kW at 0.8 lagging power factor. The line has a series impedance of (0.4 + j 0.4) ohms. If the load voltage is 3kV, find the receiving end power factor and supply voltage. **(Nov 07)**
28. Derive an expression for the inductance per phase for a 3-phase overhed transimission line when
    i. Conductors are symmetrically placed
    ii. Conductors are unsymmetrically placed but the line is completely transposed. **(Nov 07)**

29. i. Derive from first principles the capacitance per km to neutral of a 3-phase overhead transmission line with unsymmetrical spacing of conductors assuming transposition. **(Apr 05)**

ii. A single phase overhead line 32km long consists of two parallel conductors each 1 cm diameter, 3 meters apart. If the line voltage be 25kV at 50HZ, determine the charging current with the line open circuited.

30. i. Derive from basic considerations an expression for the capacitance and charging current per km length of a single phase line made up of two solid round conductors of radius rmeters and spaced at D meters. Neglect the effect of ground.
ii. Determine the capacitance per km of a pair of parallel conductors 1.5cm in dia and spaced informing 65 cm apart in air. Also find charging current per km 1cm if line is working at 110KV. **(Apr 05)**

31. i. A 3 phase 50km long single circuit 66Kv, 50 Hz transposed overhead line has horizontal spacing with 3 meters between adjacent conductors and 6 meters between outer conductor. The conductor diameter is 2 cm. Find the capacitive admittance and the chagrining current per phase when he line is energized at 66 KV.
ii. Explain the method of images for finding the capacitance of transmission line with ground. **(Apr 05)**

32. Determine the inductance per phase per km of a double circuit 3-phase line. The radius of each conductor is 20mm and the conductors are placed on the circumference of an imaginary circle of radius 7m forming a regular hexagonal figure. **(Apr 05)**

33. i. Distinguish between a.c. and d.c. resistance of a conductor. Why the two differ? Explain fully.
ii. Show that the inductance per loop meter of two-wire transmission line using solid round conductors is given by $L = 4 \times 10^{-7} \log_e D_r$ Henries. Where D is the distance between the conductors and is the G.M.R. of the conductors. **(Apr 05)**

34. i. Prove that the inductance of a groups of parallel wires carrying current can be represented in terms of their geometric distances. Explain the meaning of the term self G.M.D and mutual G.M.D.
ii. A conductor is composed of seven identical copper strands each having a radius or. Find the GMR of the conductor. **(Apr 05)**

35. Find the loop inductance and reactacnce per km of a single phase overhead line consisting of two conductors each 1.213 cm diameter. The spacing between conductors is1.25 m and frequency is50 Hz. **(Nov, June 03)**

36. i. Derive an expression for line to neutral capacitance for a 3 phase line when conductors are symmetrically placed.
ii. What is transposition? Explain the method of transposition of 3 phase line over length. **(Nov 03)**

37. i. How do we find line to neutral capacitance in a 3-phase system ?
ii. The three conductors R, Y and B of a 3-phase line are arranged in a horizontal plane with D_{RY} =1.5M; D_{YB} = 2m and D_{BR} =2m and D_{BR} =3.5m. Find line to neutral capacitance per km if dia of each conductor is 1.2cm. The conductors are transposed at regular intervals. Also calculate line capacitance per km length. **(Nov 03)**

38. i. Write a short notes on overhead line conductors.
ii. What is bundled conductor? Why it is used? Give the few configurations commonly employed.
ii. Find the loop inductance and reactance of single pahse OH line consisting of two conductors , each 1.3Cm diameter. the spacing between conductors is 1.4m and frequency is 50 Hz **(Nov 03)**

39. What is symmetrical and asymmetrical spacing of conductors ? What is the signficance of symmetrical spacing of conductors? **(June 03)**

40. i. What factors must be taken into account while calculating the resistance of Overhead line conductors ? How are these factors accounted for ?
ii. What is equivalent spacing of a 3-phase line ? What is its significance ?
iii. A 3-phase 50km long single circuit 66KV transposed overhead line has horizontal spacing with 3 metres between adjacent conductors and 6 meters between outer conductors. The conductor diameter is 2cm. Find the inductance per phase. **(June 03)**

41. i. How can the inductance of a two-conductor bundled conductor single phase line be calculated ? Derive expressions for GMR and GMD of the arrangement.
    ii. A 3-phase transposed line has conductors of diameter 2cm and spaced at distance of 3, 5 and 8 metre between the centers. Calculate the inductance per phase per km of line length. **(June 03)**

42. Derive an expression for line to neutral capacitance for a 3-phase line when conductors are :
    i. Symmetrically placed
    ii. Unsymmetrically placed but transposed **(June 03)**

43. i. Develop an expression for the inductance of a single phase transmission line taking into account the internal flux linkages. Assume the conductors are solid.
    ii. Calculate the inductance per km per phase of a 3-phase transposed line. With distance between any two conductors being 4m, 4m and 8 meter respectively. **(June 03, Nov 02)**

44. What is method of images ? Derive an expression for the capacitance per unit length of a 3-phase line completely transposed. What is the effect of earth on the capacitance of the line ? **(Nov 02)**

45. i. Clearly explain what you understand by GMR and GMD of a transmission line.
    ii. Derive the expression for inductance per km of a 3 phase line with marginal spacing between the conductors.
    iii. Calculate the inductance /km/ph for a 3 phase transmission live with D_{ab}=D_{bc}=4mand D_{ca}=8m.The radius of the conductor is 0.25m.The line is transposed. **(Nov 02)**

46. i. Derive the expression for capacitance of a 3-phase, uncomposed transmission line with an equal spacing section the conductors.
    ii. What do you understand by transposition of lines. What is its effect on the performance of the lines. **(Nov 02)**

47. i. Explain the concept of G.M.R and G.M.D.
    ii. A 3-phase, 50 Hz overhead transmission line has each conductor of 3 cm diameter. The distance between the three phases are: between A and B is 6 meters, B and C is 5 meters and C and A is 4 metres. Calculate the inductance of each line. If the lines are transposed regularly, determine the inductive reactance per km. **(June N.R. 02)**

48. i. Derive an expression for the capacitance of a three phase transmission line with unequal spacing assuming uniform transposition.
    ii. A 110 KV double circuit line has its conductors place on the vertices of a regular hexagon of side 4.5 m with the conductors of same phase being placed diametrically opposite. If the radius of each conductor is 1 cm, what is the charging current per km of line length? **(June 01)**

49. Derive the formula for Inductance for loop metre of a two-wire transmission line using solid round conductors. **(Nov N.R. 01)**

50. Consider a long, two-wire line composed of solid round conductors. The radius of both conductors is 0.25 cm and the distance between their centers is 1m. If this distance is doubled, then the inductance per unit length.
    i. doubles
    ii. halves
    iii. increases but does not double
    iv. decreases but does not halve **(GATE 02)**

51. A long wire composed of a smooth round conductor runs above and parallel to the ground (assumed to be a large conducting plane). A high voltage exists between the conductor and the ground. The maximum electric stress occurs at
    i. the upper surface of the conductor
    ii. the lower surface of the conductor
    iii. the ground surface

iv. midway between the conductor and ground **(GATE 02)**

52. The conductors of a 10 km long, single phase, two wire line are separated by a distance of 1.5m. The diameter of each conductor is 1 cm. If the conductors are of copper, the inductance of the circuit is
i) 50.0 mH ii) 45.3 mH iii) 23.8 mH iv) 19.6 mH **(GATE 01)**

53. The load carrying capability of a long AC transmission line is:
i. always limited by the conductor size
ii. limited by stability considerations
iii. reduced at a low ambient temperatures
iv. decreased by the use of bundled conductors of single conductors **(GATE 99)**

54. A 6.6 kV, 50 Hz, single core lead-sheathed cable has the following data:
Conductor diameter: 1.5 cm, length:4 km
Internal diameter of the sheath : 3 cm
Resistivity of insulation : 1.3 x 1012 n-m
Relative permittivity of insulation : 3.5 Calculate:
i. the insulation resistance
ii. the capacitance and
iii. the maximum electric stress in the insulation **(GATE 99)**

55. Bundled conductors are employed to improve the **(GATE 97)**
i. appearance of the transmission line
ii. mechanical stability of the line
iii. decreases system stability
iv. increases the short circuit current

56. Show that the inductance per unit length of an overhead line due to internal flux linkages is constant and is independent of size of conductor. **(T1-Ch2)**

57. Derive expressions for the inductance of a 3-phase line with conductors untransposed. What is the significane of imaginary term in the expression for inductance ? Hence derive the expression for inductance for a completely transposed line. **(T1-Ch2)**

58. Derive an expression for the flux linkages of one conductor in a group of n conductors carrying currents whose sum is zero. Hence derive an expression for inductance of composite conductors of a 1-phase line consisting of m strands in one conductor and n strands in the other conductor.
(T1-Ch2)

59. A single circuit 3-phase line operated 50 Hz is arranged in form of triangle with equally spaced of 1.5 m apart. The conducted diameter is 0.6 cm determine the inductance and inductive reactance per km. Prove the formula used. **(T1-Ch2)**

60. What do you understand by the constants of an overhead transmission line. **(R5-Ch9)**

61. Find the expression for the flux linkages.
i. Due to a single current carrying conductor ii. In parallel current carrying conductors
(R5-Ch9)

62. What do you understand by electric potential ? Derive an expression for electric potential at a charged single conductor. **(R5-CH9)**

63. i. Why do we find line to neutral capacitance in a 3-phase system ?
ii. Will capacitance of a transmission line depend upon the ground effect. **(R5-CH9)**

UNIT-II

1. The generalized circuit constants of a transmission line are
$A = 0.93 + j0.016$
$B = 20 + j140$
The load at the receiving end is 60 MVA, 50 HZ, 0.8 p.f. lagging. The voltage at the supply end is 220 KV. Calculate the load voltage. **(May 11)**

2. A medium length power transmission line is represented as a nominal-equivalent circuit with lumped parameters. The total series impedance of the line is Z Ω and the total shunt capacitance is Y = jωC siemens. Derive equations for the sending end voltage and current and there from determine the ABCD constants of the line. Prove that AD-BC = 1.**(May 11)**

3. Find the following for a single circuit transmission line delivering a load of 50 MVA at 110 KV and 0.8 p.f. lagging:
   i. sending end voltage
   ii. sending end current
   iii. sending end power
   iv. efficiency of transmission

   Given $A = D = 0.986\angle 4^0$; $B = 1106\angle 75^0$ ohm; $C = 0.00056\angle 80^0$ siemen. **(May 11)**

4. A 3-phase, 50 Hz transmission line has conductors of cross section 90 mm^2 and effective diameter of 1 cm and are placed at the vertices of an equilateral triangle of side 1 m. The line is 20 km long and delivers a load of 10 MW at 33KV and p.f. 0.8. Neglect the capacitance and assume temperature of 200C. Determine the efficiency and regulation of the line. **(May 11)**

5. Two 3-phase lines have the following constants:
$A1 = D1 = 0.986\angle 2^0$, $B1 = 286\angle 69^0$ ohms, $C1 = 0.00026\angle 80^0$ siemens
$A2 = D2 = 0.956\angle 3^0$, $B2 = 406\angle 85^0$ ohms, $C2 = 0.00046\angle 90^0$ siemens
The two lines are connected in cascade. Find
   i. ABCD constants for the composite system.
   ii. Sending end voltage, current and power factor if the composite system delivers 200 A at 110 KV and 0.95 p.f. lagging. **(May 11)**

6. What is the justification in neglecting line capacitance in short transmission lines? **(Nov 10)**

7. Explain the variation of current and voltage on an overhead line when one end of the line is
   i. short circuited and
   ii. open circuited and at the other end a source of constant emf V is switched in **(Nov 10)**

8. Evaluate the generalized circuit constants for **(Nov 10)**
   i. Short transmission line
   ii. Medium line nominal T method
   iii. Medium line nominal π method.

9. Find the A, B, C, D parameters of a 3-phase, 80 km, 50 Hz transmission line with series impedance (0.15 + j0.78)Ω per km and a shunt admittance of $j5.0 \times 10^{-6}$ mho per km.**(Nov 10)**

10. i. What do you understand by long transmission lines? How capacitance effects are taken into account in such lines?
    ii. What is the justification in neglecting line capacitance in short transmission lines?

(May 10)

11. A short 3-phase transmission line has a series line impedance per phase of (20 + j50)Ω. The line delivers a load of 50 MW at 0.7 p.f. lag. Determine the regulation of the line and A, B, C, D parameters of the line. If the same load is delivered at 0.7 p.f. lead, determine the regulation of the line. System voltage is 220 KV. **(May 10)**

12. i. Differentiate between a nominal-T and equivalent-T representation of transmission line.
    ii. Deduce an expression for voltage regulation of a short transmission line, giving the vector diagram.

(May 10)

13. i. Explain clearly the `Ferranti effect' with a phasor diagram.
    ii. What is the purpose of an over head transmission line? How are these lines classified?
    iii. Discuss the terms voltage regulation and transmission efficiency as applied to transmissionline.

(May 10)

14. An overhead transmission line with surge impedance 400Ω is 300 km long. One end of this line is short circuited and at the other end a source of 11KV is suddenly switched on. Calculate the current at source end 0.005 sec after the voltage is applied. **(May 10)**

15. A (medium) single phase transmission line 100km long has the following constants:
    Resistance/km = 0.25 ohm
    Reactance/km = 0.8 ohm
    Susceptance/km = 14×10^{-6} mho
    Receiving end line voltage = 66,000 V
    Assume that the total capacitance of the line is localized at the receiving end alone; determine
    i. the sending end current
    ii. the sending end voltage
    iii. regulation and
    iv. supply power factor. The line is delivering 15000kW at 0.8 power factor lagging. Draw the vector diagram to illustrate your calculations. **(May 10)**

16. i. What is meant by Nominal π method of solution for the performance of long transmission lines? Draw a phasor diagram with the receiving-end voltage as reference.
    ii. A three-phase, 50 Hz and 250 km long line whose resistance per km is 0.015Ω and inductance per km is 0.8mH and capacitance per km is 0.01μF. Determine the network constants of a long transmission line while neglecting the conductance of the line. **(May 10, Nov 09)**

17. i. Explain the difference between nominal and equivalent T and π representation of transmission line.
    ii. A 3-phase transmission line, 200km long has the following constants:
    Resistance per phase per km =0.3 ohm
    Reactance per phase per km =0.4ohm
    Shunt admittance per phase per km =1.9×10^{-6} mhos Determine the sending end voltage and current by rigorous method when the line is delivered a load of 30MVA at 0.707 p.f lagging. The receiving end voltage is kept constant at 132kV. **(Nov 09)**

18. i. Show how regulation and transmission efficiency are determined for medium lines using end condenser method and illustrate your answer with suitable vector diagram.
    ii. A three phase transmission line is 135 km long. The series impedance is Z=0.04 + j 0.95 ohms per phase per km, and shunt admittance is Y=j 5.1×10^{-6} mhos per phase per km. The sending end voltage is 132 kV, and the sending end current is 154 A at 0.9 power factor lagging. Determine the voltage, current and power at the receiving end and the voltage regulation using medium line-T model.

(Nov 09)

19. i. *Define regulation of a short 3-phase transmission system and develop an expression for approximate voltage regulation.
    ii. A balanced 3-phase load of 30MW is supplied at 132kV, 50Hz and 0.85 p.f. lagging by means of a transmission line. The series impedance of a single conductor is (20 + j52) ohms and the total phase-neutral admittance is 315×10^{-6} ohm. Using nominal-T method, determine:
    a. The A, B, C and D constants of the line,
    b. Sending end voltage,
    c. Regulation of the line. **(Nov12, Nov 09)**

20. i. Show how regulation and transmission efficiency are determined for medium lines using end condenser method and illustrate your answer with suitable vector diagram.
    ii. A three phase transmission line is 135 km long. The series impedance is Z=0.04 + j 0.95 ohms per phase per km, and shunt admittance is Y=j 5.1×10^{-6} mhos per phase per km. The sending end voltage is 132 kV, and the sending end current is 154 A at 0.9 power factor lagging. Determine the voltage, current and power at the receiving end and the voltage regulation using medium line-T model.
    (Nov 08)

21. i. What do you understand by the terms 'nominal-T' and 'nominal-π' circuits.
    ii. A 220 kV, 50 Hz, three-phase transmission line is 50 km long. The resistance per phase is 0.15 ohms/km and the inductance per phase is 1.33 mH per km and the shunt capacitance is negligible. Use the short line model to determine
    a. the voltage and power at the sending end,
    b. voltage regulation and efficiency when the line is supplying a three-phase load of 400 MVA, 220 kV at a power factor of 0.8 lagging. **(Nov 08)**

22. i. What do you understand by medium transmission lines? How capacitance effects are taken into account in such lines?
    ii. A three phase transmission line is 140 km long. The resistance per phase is 0.04 ohms per km and the inductance per phase is 0.95 mH per km. The shunt capacitance is 0.0105 nF per km. The receiving end load is 90 MVA with 0.85 power factor lagging at 110 kV. Determine the voltage, powers at the sending end, voltage regulation and efficiency by using nominal - π model. **(Nov 08)**

23. i. Draw the phasor diagram for a nominal-π circuit of a transmission line and derive expressions for sending end voltage and current.
    ii. A three-phase, 50Hz, 11kV transmission line delivers a load of 2400kW at power factor of 0.8 lag over a distance of 20km. The line conductors are placed at the corners of an equilateral triangle of 2m side. The line losses are 10%. Calculate the sending end power factor. **(Nov 08)**

24. i. Show how regulation and transmission efficiency are determined for medium lines using nominal - π method and illustrate your answer with suitable vector diagram.
    ii. An overhead 1-phase delivers a load of 1.5kW at 33kV at 0.9 p.f. lagging. The total resistance and inductance of the over head transmission line is 8ohms and 15ohms respectively. Determine the following: **(Feb 08)**
    a. Percentage of voltage regulation
    b. Sending end power factor
    c. Transmission efficiency.

25. i. Define regulation of a short 3-phase transmission system and develop an expression for approximate voltage regulation.
    ii. A balanced 3-phase load of 30MW is supplied at 132kV, 50Hz and 0.85 p.f. lagging by means of a transmission line. The series impedance of a single conductor is (20 + j52)

ohms and the total phase-neutral admittance is 315 × 10^{-6} mho. Using nominal-T method, determine:
a. The A, B, C and D constants of the line,
b. Sending end voltage,
c. Regulation of the line. **(Feb 08, Nov 07)**

26. i. How do you classify transmission lines?
ii. A short transmission line has impedance of (0.2+j0.45) ohm/per phase. The sending-end voltage being 3.3 kV (L-L) and the load at the receiving end being 250 kW per phase at a p.f of 0.8 lagging, calculate
a. the receiving-end voltage b. the line current, and c. efficiency. **(Feb 08)**

27. i. Define A, B,C and D constants of a transmission line? What are their values in short lines?
ii. A 3-phase, 3km long line delivers 3000kW at a power factor of 0.8 lagging to a load. If the voltage at the supply end is 11kV, determine the voltage at the load end, percentage regulation, sending end power factor and the efficiency of transmission. The resistance and reactance per km of each conductor are 0.4 ohm and 0.3 ohm respectively. **(Feb 08)**

28. i. Explain the physical significance of the generalized circuit constants A, B,C and D of a transmission line? Find the values of A, B,C and D in the nominal method interms of Z and Y.
ii. A 3-phase overhead line has a resistance of 2 ohms per phase and a reactance of 6 ohms per phase. It supplies a load of 10MVA at a p.f. of 0.8 leading at 33kV between lines at far end. Find:
a. Sending end voltage; b. Percentage regulation;
c. Sending end power factor; d. Transmission efficiency. **(Nov 06)**

29. i. Explain the effect of power factor on regulation and efficiency.
ii. A single-phase, 11 kV line with a length of 15 km is to transmit 500 kVA. The inductive reactance of the line is 0.6 ohms per km and the resistance is 0.25ohms per km. Calculate the efficiency and regulation for a p.f of 0.75 lag. **(Nov 06)**

30. Find the ABCD parameters of a 3-phase, 80Km, 50Hz transmission line with series impedance of (0.15 + j 0.28) ohms per Km and a shunt admittance of j 5x10^{-4} ohm per Km for the both Π and T networks.
(Feb 08, 07, Nov 07, 06,05,03)

31. i. Input to a single-phase short line is 200kW at 0.8 lagging power factor. The line has a series impedance of (0.4 + j 0.4) ohms. If the load voltage is 3kV, find the receiving end power factor and supply voltage.
ii. Derive the equivalent ABCD parameters considering nominal T network. **(Nov 06)**

32. Using the nominal π method, find the sending end voltage and voltage regulation of a 250Km, 3-phase, 50Hz, transmission line delivering 25MVA at 0.8 power factor to a balanced load at 132kV. The line conductors are spaced equilaterally 3m apart. The conductor resistance is 0.11ohms/Km and its effective diameter is 1.6cm.Neglect leakage. **(Mar 06)**

33. A 3-phase, 50Hz transmission line has resistance, inductance and capacitance per phase of 10ohms, 0.1H and 0.9μF respectively and delivers a load of 35 MW at 132 kV and 0.8 p.f lagging. Determine the efficiency and regulation of the line using
i. Nominal T method
ii. Nominal PI method **(Nov 05)**

34. Determine the sending end voltage, current, power factor of a 1-phase, 50Hz, 76.2kV transmission line delivering a load of 12 MW at 0.8 pf lagging. The line constant are

R=25ohms, L=200mH and Capacitance between lines 2.5µF. Also determine the regulation and efficiency of transmission. Use nominal p method. Draw phasor diagram. **(Nov 05)**

35. i. Derive the ABCD parameters of a nominal T represented medium length transmission line with neat phasor diagram. **(Feb 08, Nov 05, 04)**
    ii. Find the ABCD parameters of a 3-phase, 100 Km, 50 Hz transmission line with series impedance of (0.10 + j 0.3) ohms per Km and a shunt admittance of j 4 x 10-4 mho per Km.

36. A 3-phase, 50Hz transmission line has resistance, inductance and capacitance per phase of 1ohms, 0.3H and 0.01µF respectively and delivers a load of 35 MW at 132 kV and 0.8 p.f lag. Determine the efficiency and regulation of the line using nominal PI method. **(Nov 04)**

37. i. Discuss why equivalent π circuit of a long line is preferred over the equivalent T circuit.
    ii. A three phase 50Hz transmission line is 150 km long and delivers 25MW at 0.85 power factor lagging and at 110KV. The resistance and reactance of the line per conductor per km are 0.3 ohms and 0.9 ohms respectively. The line charging admittance is 0.3 x 10^{-6} mho per km per phase. Compute by applying the nominal π method the voltage regulation and transmission efficiency **(Nov, Jun 03)**

38. i. Why transmission lines are of three phase three wire type and distribution lines are of three phase four wire type?
    ii. Differentiate between a nominal T and equivalent T representation of a transmission line.
    iii. Input to a single phase short line is 2000KW at 0.8pf lagging. The line has a series impedance of 0.4 + j0.4 ohms. If the load voltage is 3KV, find the load and receiving end power factor. Also find supply voltage and supply power factor **(Nov 03)**

39. i. Discuss the effect of load power factor on voltage regulation and efficiency of a transmission line.
    ii. A 10km long 3 phase line delivers 1 MW at 0.8 lagging power factor. The series impedance of the line is 0.5 +j0.56 ohms per km per phase. The ending end voltage is 11KV. Find the line current, receiving end voltage and transmission efficiency. **(Nov 03)**

40. i. Discus why the receiving end voltage of a unloaded long line may be more than the sending end voltage.
    ii. A single phase transmission line 100Km long has the following constants R/phase=0.25 ohms and X/phase=0.8 ohms. Susceptance per Km is 14 micro ohms. Receiving end voltage is 66kV. Assuming that the total capacitance of the line is localized at the receiving end only, Determine sending end V, I, regulation, efficiency, power factor. The line is delivering 15MW at 0.8 lagging power factor. Draw the vector diagram to illustrate your calculations. **(Jun 03, Nov 02)**

41. A 345 KV 3 phase transmission line is 130km long. The resistance per phase =0.036ohm/km and inductance per phase =0.8mH/km. The shunt capacitance per phase is 0.0112 micro Farad/km. the receiving end load is 270MVA with 0.8 pf lagging at 325kV. Find the voltage regulation and power at sending end. Use Nominal –T method, Nominal Pie method and ABCD Constants. Compare the result. **(Jun 03)**

42. i. Draw the phasor diagram of a medium transmission lines represented by a T model and derive the expression for voltage regulation.
    ii. Determine the efficiency and regulation of a 3 phase, 50 Hz transmission line having resistance, inductance and capacitance of 10 ohms, 0.1 H and 0.9 micro farads respectively. The line delivers a load of 35MW at 132 KV and 0.8 p.f. lag. Use nominal T method. **(Jun 03)**

43. i. How do you classify the transmission lines ?

ii. A 220KV, 3 phase transmission line is 40 km long. The resistance per phase is 0.15 ohms/ km and the inductance per phase is 1.3263 mH per km. The shunt capacitance is negligible. Use the short line model to find the voltage and power at the sending end and the voltage regulation and efficiency when the line is supplying a 3 phase load of :
a. 381 MVA at 0.8 power factor lagging at 220 KV.
b. 381 MVA at 0.8 power factor leading at 220 KV. **(Jun 03)**

44. The generalized circuit constants of a transmission line are
A = 0.93 + j0.016 B = 20+j140
The load at the receiving end is 60 MVA, 50Hz, 0.8 power factor lagging. The voltage at the supply end is 220KV. Calculate the load voltage. **(Nov 02)**

45. i. Draw the vector diagrams of nominal Π and nominal T models.
ii. A single phase 50 Hz generator supplies an inductive load of 5MW at a power factor 0.707 by means of an overhead line of 20km long. The line resistance and inductance are 0.0195 ohms and 0.63 mH per Km respectively. The voltage at the receiving end is to be kept at 10KV. Find
i. Voltage regulation and ii. Efficiency of the transmission **(Nov 02)**

46. i. Explain the physical significance of the generated constants A, B, C & D.
ii. The sending end voltage and receiving end voltages of the 3 phase Tr. Line are maintained at 70 KV and 66kV respectively. The line impedance per phase is 20+ j60 ohms. Calculate the Max power obtaining at receiving end. **(Jun 02)**

47. A 10km long 3 phase line delivers 1 MW at 0.8 lagging power factor. The series impedance of the line is 0.5 +j0.56 ohms per km per phase. The sending end voltage is 11KV. Find the line current, receiving end voltage and transmission efficiency? **(Jun 02)**

48. i. Explain the physical signigicane of the generalized constants A,B,C and D.
ii. The sending end and receiving end voltages of a 3-phase transmission line are maintained at 70 kV and 66 kV respectively. The line impedance per phase is (20 + j60) ohms. Calculate the maximum power obtained at the receiving end.
iii. A 50 Hz three phase transmission line is 280 km long. It has a total series impedance of 35 + j140 ohms and a shunt admittance of 930 X 10^{-6} ohm. It delivers 40 Mwat 220 kV 90% power factor lagging. Find the sending end voltage, voltage regulation, transmission efficiency by nominal T method approximation. **(Jun 01)**

49. Consider the model shown in Fig. of a transmission line with a series capacitor at its mid-point. The maximum voltage on the line is at the location

a) P_1 b) P_2 c) P_3 d) P_4 **(GATE 01)**

50. Using the nominal Pie method, find the sending end voltage, and voltage regulation of a 250 KM, 3-ph, 50 Hz, transmission line, delivering 25 MVA at 0.8 lagging power factor to a balanced load at 132 KV. The line conductors spaced equilaterally 3m apart. The conductor resistance is 0.11/Km and its effective dia is 1.6 cm. **(GATE 2000)**

51. Input to a single phase short line shown below is 2000KW at 0.8 lagging p.f. The line has a series impedance of (0.4 + j0.4) . If the load voltage is 3KV, find the load and receiving end power factor. Also find the supply voltage. **(GATE 99)**

52. A 66 kV, 3 phase, 50 hz, 150 km long overhead transmission line is open circuited at the receiving end. Each conductor has a resistance of 0.25 Ohm/Km, an inductive reactance of 0.52 Ohm/Km and a capacitive admittance to neutral of 0.04 x 10-4 S/km.
i. Draw the nominal Pie equivalent circuit and indicate the value of each parameter.
ii. Calculate the receiving end voltage if the sending end voltage is 66 kV. **(GATE 99)**

53. A 220 kV, 20 km long, 3-phase transmission line has the following A, B, C, D constants. A = D = 0.96 |__3°,
B = 55|__65°ohm/phase, C = 0.5E - 04|__80°S/phase. Its charging current per phase is:
i) b) 11A c) 220A d) **(GATE 99)**

54. A 220 KV, 20 KM long 3-phase transmission line has the following A, B, C, D constants: A = D = 0.9|__63o; B = 55|__65o phase; C = 0.5 |__0.48o siemens/phase. What is the charging current/phase?
(IES 97)

55. The ABCD constants of a nominal? network representing a three phase transmission line are
A=D=0.950 |__1.27°, B =92.4 |__76.87° Ohm and C = 0.0006|__90°S Find steady state limit if both the sending end and the receiving end voltages are held at 130 KV, I) with the given ABCD constants and ii) with series resistance and shunt admittance neglected. **(IES 97)**

56. The sending end voltage and receiving end voltages of the 3 phase Tr. Line are maintained at 110 KV and 66kV respectively. The line impedance per phase is 10+ j10 ohms. Calculate the Max power obtaining at receiving end______ **(GATE 92)**

57 a) What is the maximum power that can be transmitted over a three phase short line having per phase impedance of (0.3+j0.4) ohm if the receiving end voltage is 635V per phase and voltage regulation not to exceed 5%? Calculate also the receiving end p.f and the total line losses when supplying maximum power.

b) A three phase, 50 Hz overhead transmission line has the following distributed constants per phase: Resistance =28 ohm; Inductance reactance =63 ohm, capacitive succeptance=0.04micro mho. If the load at the receiving end is 75 MVA at 0.8 p.f
lagging with 132 kV between lines , calculate (i) voltage (ii) Power factor at the receiving end (iii) regulation and (iv) Efficiency of transmission line. Use nominal T method**.** **(Nov 13)**

UNIT-III

1. A square wave voltage surge of magnitude E0 and length D is travelling at speed ? on a transmission line of surge impedance Zs. A capacitor C is connected between line and ground at the mid point of the line. Derive analytically the expression for the voltage surge that travels along the line beyond the point where the capacitor is connected. Also sketch the voltage waveform. **(May 11)**

2. Evaluate the generalized circuit constants for long transmission lines. **(May 11)**

3. Discuss the phenomenon of wave reflection and refraction. Derive expressions for reflection and refraction coefficients. **(May 11)**

4. A surge of 120 KV travels on a line of surge impedance 450Ω and reaches the junction of the line with two branch lines. The surge impedance of branch lines are 400Ω and 40Ω. Find the transmitted voltage and currents. **(May 11)**

5. What do you understand by long transmission lines? How capacitance effects are taken into account in such lines? **(Nov 10)**

6. A surge of 200 KV traveling on a line of surge impedance 400Ω reaches a junction of the line with two branch lines of surge impedance 600Ω and 400Ω respectively. Find the surge

voltage and current transmitted into each branch line. Also find the reflected surge voltage and current. **(Nov 10)**

7. Derive the expressions for the ABCD constants for a lossless long transmission line. Assume distributed parameters for the line. **(Nov 10)**

8. A long overhead line has surge impedance of 500Ω and effective resistance of 6Ω per km. If a surge of 400 KV enters the line at certain point, calculate the magnitude of this surge after it has traversed 100 km and calculate the power loss and heat loss of the wave over this distance. Assume velocity of wave is 3 x 10^8 m/sec. **(Nov 10)**

9. A 500 KV surge travels on an over head line of surge impedance 400 towards its junction with a cable which has a surge impedance of 40. Find **(May 10)**
   i. transmitted voltage
   ii. transmitted current
   iii. Reflected voltage
   iv. Reflected current

10. A step wave of magnitude E travels on a line of surge impedance Za and reaches the end of the line where the line is terminated by a resistance R and inductance L in series. Find an expression for the current in the terminating impedance. **(Nov11, May 10)**

11. i. What is the purpose of an overhead transmission line? How are these lines classified?
   ii. A balanced 3-phase load of 30 MW is supplied at 132 kV, 50Hz and 0.85 p.f lag by means of a transmission line. The series impedance of a single conductor is (20+j40) ohms and the total phase-neutral admittance is 315×10^{-6} ohms.
   Use nominal - to determine
   a. A, B, C, D constants of the line,
   b. Vs and
   c. regulation of the line. **(Nov 09)**

12. i. Define precisely the regulation of a transmission line and discuss qualitatively its dependence on the load power factor. Show that the regulation is zero when $\phi_r = (0-\pi/2)$ where ϕ_r is the load power factor angle and is the line impedance angle. Can the regulation is negative? If so, under what conditions? State clearly the assumptions made?
   ii. An overhead 3-phase transmission line delivers 5000kW at 22kV at 0.8 p.f. lagging. The resistance and reactance of each conductor is 3 and 4 ohms respectively. Determine:
   a. Sending end voltage;
   b. Percentage regulation and
   c. Transmission efficiency. **(Nov 09)**

13. i. Explain about surge impedance and surge impedance loading of transmission lines.
   ii. A 3-phase transmission line, 160km long has the following constants:
   Resistance per phase per km =0.2 ohm
   Reactance per phase per km =0.3127ohm
   Shunt admittance per phase per km =1.875×10^{-6} S
   Determine the sending end voltage and current by rigorous method when the line is delivered a load of 25MVA at 0.8 p.f lagging. The receiving end voltage is kept constant at 110kV. **(Nov 09)**

14. i. Discuss why Ferranti effect is significant only in medium and long lines.
   ii. In a 3- phase line with 132 kV at the receiving end, the ABCD constants are $A=D=0.98\angle 3^0$, $B=110\angle 75^0$ohms; $C=0.0005\angle 88^0$ohms.If the load at the receiving end is 40MVA at 0.8 lagging p.f, determine
   a. The sending end voltage.

b. The loading MVAr for this load at the receiving end if the sending end voltage is 140kV.

(Nov 09)

15. i. Explain the evaluation of transmission line constants.

ii. A three - phase overhead transmission line has series impedance per phase of 250 $\angle 80^0$ ohms and a total shunt admittance of 0.0019 $\angle 90^0$ siemen per phase. The line delivers a load of 100MW at 0.8 pf lagging and 200kV between the lines. Calculate the sending-end voltage and current by the rigorous method. **(Nov 08)**

16. A three-phase, 50 Hz, 150 km long transmission line has three conductors each of 0.7 cm radius spaced at the corners of triangle of sides 2 m, 3.5m and 4.5m. The resistance of each conductor is 0.4 ohms per km and the line delivers 50 MVA at 132 kV and at a lagging p.f. of 0.85. Determine ABCD constants as long line (both real and complex angle methods) **(Nov 08)**

17. i. Starting from first principles derive an expression for the sending end voltage and current of a long transmission line interms of the line parameters and receiving end voltage and current.

ii. A three - phase overhead transmission line has series impedance per phase of 120 $\angle 75^0$ ohms and a total shunt admittance of 0.002 $\angle 90^0$ siemen per phase. The line delivers a load of 125MW at 0.85 pf lagging and 132kV between the lines. Calculate the sending-end voltage and current by the rigorous method. **(Nov 08)**

18. i. Derive the equivalent ABCD constants of a transmission line connected in series with an impedances at both ends.

ii. The per-unit-length parameters of a 215kV, 400km, 60Hz, three phase long transmission line are y = j3.2 × 10^{-6} mhos per km per phase and z = (0.1+ j 0.5) ohm/km. The line supplies a 150 MW load at unity power factor. Determine **(Feb 08)**

a. the voltage regulation b. the sending-end power and c. the efficiency of transmission.

19. A three-phase, 200 km long transmission line has the following constants. Resistance/ ph/ km = 0.15 ohm, reactance / ph/km = 0.20 ohm, shunt admittance/ph/km = 1.2×10^{-6} mho. Calculate by rigorous method, the sending end voltage and current when the line is delivering a load of 20 MW at 0.8 p.f lagging. The receiving-end voltage is kept constant at 110 kV. **(Feb 08)**

20. i. What is an equivalent T circuit of a long line? Derive an expression for parameters of this circuit in terms of line parameters.

ii. The line constants of a three-phase long line are: A = 0.85 $\angle 2.3^0$; B = 180$\angle 75^0$; C = 0.0014$\angle 90^0$. Determine the sending-end voltage, the current and power factor when the open-circuit voltage at receiving end of the line is 220kV. **(Feb 08)**

21*. i.Using rigorous method, derive expressions for sending end voltage and current for a long transmission line.

ii. A 3-phase transmission line is 480km long and serves a load of 400MVA, 0.8p.f lag at 345kV. The ABCD constants of the line are A=D=0.818 $\angle 1.3^0$; B=172.2 $\angle 84.2^0$; C=0.001933 $\angle 90.4^0$ mhos.

a. Determine the sending end line to neutral voltage, the sending end current and the percent voltage drop at full load.

b. Determine the receiving end line to neutral voltage at no load, the sending end current at load and the voltage regulation. **(Nov12, Feb 08)**

22. i. Derive equations which represent the performance of a long transmission line with its electrical parameters uniformly distributed along its length.

ii. The per-unit-length parameters of a 132kV, 350km, 50Hz, three phase long transmission line are y=j2.5×10^{-6} mhos per km per phase and z = (0.2 + j 0.4) ohm/km. The line supplies a 130 MW load at 0.8 power factor lagging. Determine
a. the voltage regulation, b. the sending-end power and c. the efficiency of transmission. **(Nov 07)**

23. i. Prove that the impedance at any point of transmission line is proportional to the hyperbolic tangent of the position angle.
ii. A 400kV, 3-phase transmission line has an impedance per phase of (50+j100)ohms and an admittance of 0+j002mho. Using the convergent series method determine
a. the sending end voltage and
b. the sending end current when the receiving end current is 150Amps at 0.8 p.f lagging. **(Nov 07)**

24. i. Derive the expressions for voltage and current distribution over a long line. Explain the significance of characteristic impedance loading in connection with the long lines. Deduce the above voltage and current relations in the hyperbolic form and obtain the element values of an equivalent to represent the long lines.
ii. Determine the auxiliary constants of a 3-phase, 50Hz. 200km long transmission line having resistance, inductance and capacitance per phase per km of 0.15 ohm, 3.5mH and 0.009µF respectively. **(Nov 07)**

25. i. When the transmission line is terminated by the capacitive load, how do you find out the expressions of reflected voltage and current wave.
ii. An under ground cable having an inductance of 0.3mH per km and a capacitance of 0.4µF per km is connected in series with an overhead line having an inductance of 2.0mH per km and a capacitance of 0.014µF per km. Calculate values of reflected and transmitted wave of voltage and current at junction due to a voltage surge of 110kV travelling to a junction along the cable. **(Nov 07)**

26. Derive the equivalent ABCD parameters considering nominal T network. **(Nov 07)**

27. The ABCD constants of a 3-phase transmission line are A = D = 0.936 $\angle 0.98^0$, B = 142 $\angle 76.4^0$ ohms and C = (-5.18 + J914)x10^{-6}mhos. The load at the receiving end is 50 MW at 220 kV with a power factor of 0.9 lagging. Find the magnitude of the sending end voltage and the voltage regulation also draw the vector diagram. **(Nov 07)**

28. A series capacitor bank is to be installed at the mid point of the 300 Km line. The ABCD constants for 150 Km of the line areA = D = 0.9534 $\angle 0.3^0$ B = 90.33 $\angle 84.1^0$ ohms, and C = 0.001014 $\angle 90.1^0$ mhos. The ABCD constants of the series capacitor bank are A = D = 1 |0 0,B = 146.6 $\angle -90^0$ohms, C = 0. Determine the equivalent ABCD constants of the series combination of the line-capacitance-line. **(Nov 07, 05)**

29. i. Derive the ABCD constants for long transmission lines.
ii. Explain briefly classification of transmission lines based on line lengths with Neat diagrams.
(Nov 05, 04)

30. Derive the equivalent ABCD parameters when two different transmission lines are connected is Cascade. **(Nov 04)**

31. Discuss why equivalent Pie circuit of a long line is preferred over the equivalent T circuit. **(Jun 03)**

32. A three phase 50Hz transmission line is 150 km long and delivers 25MW at 0.85 power factor lagging and at 110KV. The resistance and reactance of the line per conductor per km are 0.3 ohms and 0.9 ohms respectively. The line charging admittance is 0.3 x 10^{-6} mho

per km per phase. Compute by applying the nominal " method the voltage regulation and transmission efficiency **(Jun 03)**

33. A 3 phase 50 Hz , 100 Km long Transmission line delivers a load of 20000kW at 110kV 0.9 p.f. Lagging The copper conductors of the line are 1.2 cm in diameter and are spaced equilaterally , so that the distance between them is 2 m. Using Nominal Pi method, Calculate the dending end voltage, current, power factor, regulation & efficiency of line. Neglect the leekage **(Jun 03)**

34. i. What is an equivalent Π circuit of a long line? Derive the expression for the parameters of the circuit in terms of line parameters?
 ii. A 60 Hz short line has a resistance of 0.5 ohm/ph and inductance of 90 mH/ph. the line supplies to the star connected load at 100kW at 0.9 pf lag and at 215Kv. Calculate the sending end voltage **(Jun 01)**

35. Two transmission lines are connected in cascade, whose ABCD parameters are respectively. Find the resultant ABCD parameters.
 i .A 100 MVA generator with 10% reactance and a 200 mVA generator with 8% reactance (reactances on their own bases) are connected as shown in Figure. The fault level on bus 1 is to be restricted to 1500 MVA. Calculate, on 100 MVA base. **(GATE 2000)**
 ii. The reactance of bus bar reactor X.
 iii. Fault level of Bus 2
 iv. MVA rating of circuit breaker C.

36. With reference to long transmission lines, give physical interpretation of the terms 'characteristics impedance' and 'propagation constant'. What is meant by "surge impedance"? **(IES 98)**

37 a) Determine A, B, C, D constants for a long having the following distributed parameters: l=1.20 mH/Km, c=8×10 r=0.15 ohm/Km and g=0.
 b) What is the physical significance of SIL?
 What is surge impedance and surge impedance loading of a transimission line? **(Nov 13)**

UNIT-IV

1. **Starting from first principles show that surges behave as traveling waves. Find expressions for surge impedance and wave velocity. **(Nov12, May 11, 10, Nov 09)**

2. i. Step wave of 100 KV travels on a line having a surge impedance of 400Ω. The line is terminated by an inductance of 4000μH. Find the voltage across the inductance and the reflected voltage wave.
 ii. Write short notes on Bewleys lattice diagram. **(May 11)**

3. A unit step voltage surge is travelling on a long line of surge impedance Z_1. It reaches the junction with a cable of finite length whose far end is open. The cable has a surge impedance of Z_2 and the time of one-way wave travel on it is T. Draw the Bewley lattice diagram and find from it the value of voltage at the junction at time 4T after the surge reaches the line-cable junction. **(May 11)**

4. A 3-phase single circuit transmission line is 400 km long. If the line is rated for 220 KV and has the parameters R = 0.1 ohm/km, L = 1.26 mH/km, C = 0.009μF/km and G = 0, find
 i. the surge impedance and
 ii. the velocity of propagation neglecting the resistance of the line. If a surge of 150 KV and innitely long tail strikes at one end of the line, what is the time taken for the surge to travel to the other end of the line? **(Nov 10)**

5. A 400 m long cable is short circuited at the remote end. A pulse source having resistance of 150Ω drives a 100 V pulse, having duration of 6µs. If the characteristic resistance of the cable is 50Ω and the pulse velocity is 200m/s, sketch the voltage profile for first 8µs at the input of the line.
(Nov 10)

6. Two towers of height 30 and 90 m respectively support a transmission line conductor at water crossing. The horizontal distance between the towers is 500m.If the tension in the conductor is 1600 kg. Find the minimum clearance of the conductor and water and clearance at a point mid-way between the supports. Weight of the conductor is 1.5 kg/m. Bases of the towers can be considered to be at water level. **(Nov 10)**

7. A system consists of long line of surge impedance 400 Ω, a cable of length 300 m, surge impedance 50 Ω, a line of length 300 m, surge impedance 400 Ω, a cable of length 300 m, surge impedance 50 Ω and a long line of surge impedance 400 Ω.
The velocity of propagation of wave is 300 m/sec in line and 150 m/sec in cable. A step wave of 100 KV travels along one of the long lines. Draw the Bewley lattice diagram and plot voltage versus time at the junction of long line and cable for 10 sec. **(Nov 10)**

8. Develop equivalent circuit for analyzing the behaviour of traveling waves at transition point on transmission lines. **(May 10)**

9. Draw equivalent circuit for finding the transmitted voltage and current surges on a forked line. Derive expressions for the transmitted voltage and currents. **(May 10)**

10. Explain the variation of current and voltage on an overhead line when one end of the line is
   i. short circuited and
   ii. open circuited and at the other end a source of constant emf V is switched in. **(May 10)**

11. i. What is a traveling wave? Explain the development of such a wave on an over headline.
   ii. An overhead line with surge impedance 400 ohm is 300 Km long. One end of this line is short circuited and at the other end a source of 11 kV is suddenly switched on. Calculate the current at the source end 0.005 sec after the voltage is applied **(Nov 13, May 10)**

12. i. What is travelling wave? What do you mean by incident and reflected voltage wave and current wave.
   ii. A 200 kV, 3 sec, rectangular surge travels on a line of surge impedance of 400Ω. The line is terminated in a capacitance of 3000pF. Find an expression for voltage across the capacitance. **(May 10)**

13. Obtain the law for the behavior of voltage surge with vertical wave front which after travelling in a transmission line of inductance L and capacitance C per unit length, reaches a fork where the line splits into two sections having line constants L_1;C_1 and L_2, C_2 respectively. Neglect resistance and attenuation and obtain the distribution of voltage and current immediately after the wave front has reached the front.
   ii. An 500kV, 2µSec rectangular surge travels along the line terminated by an capacitance of 2500pF. Determine the voltage across the capacitance and reflected voltage wave if the surge impedance of the line is 400 ohms. **(Nov 09)**

14. i. Derive the travelling wave equations in a lossless transmission line.
   ii. The ends of two long transmission lines, A and C are connected by a cable B, 1km long. The surge impedances of A, B, C are 400, 50 and 500 ohms respectively. A rectangular voltage wave of 25 kV magnitude and of infinite length is initiated in A and travels to C, determine the first and second voltages impressed on C. **(Nov 09)**

15. i. What is the outcome of the transient in the transmission lines? Develop the differential equation for the transient in the transmission system.
 ii. A 500 kV, 2 sec, duration rectangular surge passes through a line having surge impedance of 350Ω and approaches a station at which the concentrated earth capacitance is 3×10^3 pF. Calculate the maximum value of surge transmitted to the second line. **(Nov 09)**

16. A 220 kV surge travels on a line of 400Ω surge impedance and reaches a junction where two branch lines of surge impedances 550Ω and 350Ω respectively are connected with the transmission line. Find the surge voltage and current transmitted into each branch line. Also find the reflected voltage and current. **(Nov 09)**

17. i. Explain surge impedance loading.
 ii. A three-phase, 50 Hz, 160 km long transmission line has three conductors each of 0.75 cm radius spaced at the corners of triangle of sides 2.5 m, 3m and 3.5m. The resistance of each conductor is 0.3 ohms per km and the line delivers 30 MVA at 132 kV and at a lagging p.f. of 0.95. Determine ABCD constants as
 a. long line (both real and complex angle methods) and
 b. Parameters of equivalent T representations of long lines. **(Nov 08)**

18. i. Develop an equivalent circuit for the analysis of the behavior of travelling waves at transition points on a transmission line.
 ii. The ends of two long transmission lines, A and C are connected by a cable B, km long. The surge impedances of A, B, C are 500, 70 and 600 ohms respectively. A rectangular voltage wave of 20 kV magnitude and of infinite length is initiated in A and travels to C. Determine the first and second voltages impressed on C. **(Nov 08)**

19. i. What is the outcome of the transient in the transmission lines? Develop the differential equation for the transient in the transmission system.
 ii. A 500 kV, 2 μsec, duration rectangular surge passes through a line having surge impedance of 350 ohms and approaches a station at which the concentrated earth capacitance is 3 x 10^3 pF. Calculate the maximum value of surge transmitted to the second line. **(Nov 08)**

20. i. Starting from first principles show that surges behave as travelling wave.
 ii. An over head line with inductance and capacitance per km length of 1.24 mH and 0.087 μF respectively is connected in series with an ungrounded cable having inductance and capacitance of 0.185 mH / km and 0.285 μF / km respectively. Calculate the values of reflected and refracted waves of voltage and current at the junction due to a voltage surge of 110 kV traveling to the junction
 a. along the line towards the cable, and
 b. along the cable towards the line. **(Nov 08, 07)**

21. i. Deduce expressions for surge impedance and velocity of propagation.
 ii. A 200 kV surge travels on line of 400ohms surge impedance and reaches a junction where two branch lines of serge impedances of 500ohms and 300ohms are connected with the transition line. Find the surge voltage and current transmitted into each branch line. Also find the reflected voltage and current.**(Feb 08)**

22. i. Show that a traveling wave moves with a velocity of light on the overhead line and its speed is proportional to 1/ ε_r.on a cable with dielectric material of permittivity ε_r.
 ii. Two stations are connected together by an underground cable having a surge impedance of 60 ohms joined to an overhead line with a surge impedance of 400 ohms. If a surge having a maximum valve of 100 kV travels along the cable towards the junction with the overhead line, determine the value of the reflected and transmitted wave of voltage and current at the junction. **(Feb 08)**

23. Discuss the wave length and velocity of propagation. **(Feb 08)**

24. i. Explain the surge phenomena.

ii. A voltage having a crest value of 3000 kV is traveling on a 750 kV line. The protective level is 1700 kV and the surge impedance of the line is 300ohms. Calculate
a. the current in the line before reaching the arrester
b. current through the arrester
c. the value of arrester resistance for this condition
d. reflect voltage. Verify the reflection and refraction coefficient. **(Nov 07)**

25. i. Derive reflection and refraction coeffcient of transmission line when receiving end is open circuited.
ii. An overhead line has a surge impedance of 450 ohms. A surge voltage V= 250($e^{0.05t}$ -e^{-t}) kV, where t is in msec, travels along the line. The termination of the line is connected to two parallel overhead line transformer feeders. The surge impedance of the feeder is 350 ohms. These two transformers are protected by surge diverters each of surge impedance being 40 ohms. Determine the maximum voltage which would initially appear across the feeder end windings of each transformer due to the surge. Assume the transformer to have infinite surge impedance. **(Nov 07)**

26. i. Staring from first principle show that surges behaves as travelling wave.
ii. An overhead line is connected to a terminal apparatus through a length of single phase cable, the characteristic impedance being 300 and 60 ohms respectively. A travelling wave of vertical front and infinite tail of 110kV magnitude originates in the overhead line and travels towards the junction with the cable. Determine the energy transmitted into the cable during a period of 3μ Sec after the arrival of the wave at the junction. What voltage is reflected back into the line. **(Nov 07)**

27. i. Starting from first principles show that surges behave as travelling waves. Find expressions for surge impedance and wave velocity.
ii. A step wave of 110 kV travels through a line having a surge impedance of 350 ohms. The line is terminated by an inductance of 5000 μH. Find the voltage across the inductance and reflected voltage wave.**(Nov 07)**

28. i. When the transmission line is terminated by the capacitive load, how do you find out the expressions of reflected voltage and current wave.
ii. An under ground cable having an inductance of 0.3mH per km and a capacitance of 0.4μF per km is connected in series with an overhead line having an inductance of 2.0mH per km and a capacitance of 0.014μF per km. Calculate values of reflected and transmitted wave of voltage and current at junction due to a voltage surge of 110kV travelling to a junction along the cable. **(Nov 07)**

29. Given an RL circuit with a sudden 50 Hz sinusoidal voltage applied where R=20 ohms, L=0.36 H and voltage V=220V.
i. The switch is closed at such a time as to permit maximum transient current . What is the instantaneous value of voltage upon closing the switch?
ii. What is the maximum values of current in part (i)?
iii. Let the switch be closed so as to yield minimum transient current. What instantaneous values of V and x correspond to this instant of closing the switch? **(T2-Ch12)**

30. Determine the relative attenuation occurring in two cycles in the over voltage surge set up on a 132KV cable fed through an air blast breaker when the breaker opens on a system short circuit. The breaker uses critical resistance switching. The network parameters are R=10 ohms, L=8 mH and C=0.8 μF.**(T2-Ch12)**

31. Explain with neat diagrams two different theories of charge generation and separation in a thunder cloud. **(T2-Ch12)**

32. Explain with neat sketches the mechanism of lightning discharge. **(T2-Ch12)**

33. Differentiate between a hot lightning stroke and a cold lighting stroke. **(T2-Ch12)**

34. Explain the variation of current and voltage on an overhead line when one end of the line is
i. short-circuited, and
ii. open-circuited and at the other end a source of constant e.m.f. V is switched in. **(T2-Ch12)**

35. What is a traveling wave ? Explain the development of such a wave on an over-head line. **(T2-Ch12)**

36. An overhead transmission line with surge impedance 400 ohms is 300 km long. One end of this line is short-circuited and at the other end a source of 11kv is suddenly switched in. Calculate the current at the source end 0.005sec after the voltage is applied. **(T2-Ch12)**

37. Explain why a short length of cable is connected between the dead end tower and the terminal apparatus in a station. An overhead line with surge impedance 400 ohms is connected to a terminal apparatus through a short length of cable of surge impedance 40 ohms. **(T2-Ch12)**

38. An overhead line with surge impedance 400 ohms bifurcates into two lines of surge impedance 400 ohms and 40 ohms respectively. If a surge of 20KV is incident on the overhead line, determine the magnitudes of voltage and current which enter the bifurcated lines. **(T2-Ch12)**

39. A long overhead line has a surge impedance of 500 ohms and an effective resistance of 6 ohms per km. If a surge of 400 KV enters the line at a certain point, calculate the magnitude of this surge after it has traversed 100km and calculate the power loss and heat loss of the wave over this distance. Assume velocity of wave as $3*10^8$m/sec. **(T2-Ch12)**

40. A rectangular surge of 2 μsec duration and magnitude 100kv travels along a line of surge impedance 500 ohms. The latter is connected to another line of equal impedance through an inductor of 500 μH. Calculate the maximum value of surge transmitted to the second line. **(T1-Ch12)**

41. The effective inductance and capacitance of a faulted system as viewed from the contacts of a breaker are 2.5 mG and 600 pF respectively. Determine the restricting voltage across the breaker contacts when a fault current of 150 amps is chopped. **(T2-Ch12)**

42. What is arcing ground? Explain its effect on the performance of a power system. **(T2-Ch12)**

43. What is "capacitance switching"? Explain its effect on the performance of the circuit breaker. **(T2-Ch12)**

44. Derive an expression for the restricting voltage across the circuit breaker contacts. The system consists of an unloaded alternator with neutral solidly grounded. **(T2-Ch12)**

45. Explain clearly the variation of current and impedance of an alternator when a 3-phase sudden short circuit takes place at its terminals. **(T2-Ch12)**

46. An overhead line with inductance and capacitance per km of 1.24 mH and 0.087 MF respectively is connected in series with an underground cable having inductance and capacitance of 0.185 mH/km and 0.285 mF/km. Calculate the values of transmitted and reflected waves of voltage and current at the junction due to a voltage surge of 110 kv traveling to the junction(i) along the line towards the cable, and (ii) along the cable towards the line. **(T2-Ch12)**

47. A 3-phase transmission line has conductors 1.5 cms in diameter spaced 1 metre apart in equilateral formation. The resistance and leakage reactance negligible, Calculate
   i. The natural impedance of the line
   ii. The line current if a voltage wave of 11 kv travels along the line
   iii. The rate of energy absorption, the rate of reflection and the state and the form of reflection if the line is terminated through a star connected load of 1000 ohm per phase. **(T2-Ch12)**

48. A 3-phase transmission line has conductors 1.5 cms in diameter spaced 1 metre apart in equilateral formation. The resistance and leakage reactance negligible, Calculate
   i. The value of the terminating resistance for no reflection .

ii. The amount of reflected and transmitted power if the line is connected to a cable extension with inductance and capacitance per phase per cm of 0.05 nanoH and 1 pico F respectively. **(T2-Ch12)**

49. A surge of 15 kv magnitude travels along a cable towards its junction with an overhead line. The inductance and capacitance of the cable and ovrhead line are respectively 0.3 mH, 0.4 micro F and 1.5 mH, 0.012 micro F per km. Find the voltage rise at the junction due to the surge. **(T2-Ch12)**

UNIT-V

1. Explain the following in terms with reference to corona? **(Nov 13, May 11)**
   i. Critical disruptive voltage
   ii. Visual critical voltage
   iii. Power loss due to corona.

2. What is Ferranti effect? Deduce a simple expression for the voltage rise of an unloaded line. Also draw the corresponding vector diagram. **(Nov 13, May 11)**

3*. i. What are the factors which effect corona?
   ii. Describe the various methods for reducing corona effect in an overhead transmission line? **(Nov12, May 11, 10)**

4.* i. What is corona?
   ii. Explain the theory of corona formation in detail? **(Nov12, May 11, 10)**

5. What is skin effect? Why is it absent in the D.C system? **(May 11, Nov13)**

6. i. Define disruptive critical voltage and derive the expression for it? **(Nov 13)**
   ii. A three phase 220KV 50Hz transmission line consists of 1.2cm radius conductor spaced 2 meters apart in equilateral triangular formation. Find the disruptive critical voltage between the lines if the temperature is 20^0C and atmospheric pressure is 72.2cm. Take m_o=0.96.Dielectric strength of air=21.1KV (rms)/cm? **(May 11)**

7. Determine the corona characteristics of a 3-phase, 50 Hz, 130 kv transmission line 100 km long running through terrain at an altitude of 600 meters, temp of 30^0C and barometric pressure 73 cm. The conductors are 1.5 cm diameter and spaced with equilateral spacing of 2.75 meters. Assume surface irregularity factor of 0.9 and m_y=0.75. **(Nov 10)**

8. i. What are the factors which effect corona?
   ii. A single phase transmission line has conductors of diameter 1.25 cm and spaced 2.5 meters apart. Derive an expression for the potential gradient at any point on a line joining the centre of the conductors if the operating voltage of line is 60 kv. Calculate the voltage at which corona will start. **(Nov 10)**

9. i. Explain the advantages and disadvantages of corona?
   ii. A three phase line has conductors 2cm in diameter spaced equilaterally 1m apart .If the dielectric strength of air is 33KV (max). Per cm. Find the disruptive critical voltage for the line .Take air density factor δ=0.952 and irregularity factor m_o=0.85? **(Nov 10)**

10. i. What are the factors which effect corona? **(Nov 10)**
   ii. A 3-phase, 50 Hz, 132 kV transmission line consists of conductors of 1.17 cm dia and spaced equilaterally at a distance of 3 meters. The line conductors have smooth surface with value for m = 0.96. The barometric pressure is 72 cm of Hg and temperature. Determine the fair and four weather corona loss per km per phase.

11. i. Discuss the different factors affecting corona?
    ii. Derive the expression of critical disruptive voltage and visual critical voltage? **(May 10)**

12. A three phase 220KV 50Hz transmission line consists of 1.5cm radius conductor spaced 2 meters apart in equilateral triangular formation. If the temperature is 40^0C and atmospheric pressure is 76cm.calculate the corona loss per km of the line. Take m_0=0.9? **(May 10)**

13. i. What do you mean by corona ? What are the demerits of corona? How do you improve them?
    ii. A three phase 220kV, 50Hz transmission line consists of 1cm radius conductors spaced 2.5m at the corners of an equilateral triangle. Find out the corona loss per km of the line. The temperature of weather is 220C and barometric pressure is 73cm. The irregularity factor is 0.96. **(May 10)**

14. i. Write a short notes on radio interference due to corona.
    ii. Determine the disruptive critical voltage and the visual critical voltages for local and general corona on a 3-phase overhead transmission line consisting of three stranded copper conductors spaced at 2.5 meters apart at the corners of an equilateral triangle. Air temperature and pressure are 210C and 73.5 cm of Hg respectively. Conductor diameter is 1.8 cm, irregularity factor (m_0) 0.85, and surface factors (m_v) is 0.7 for local and general corona are 0.7 and 0.8 respectively. Breakdown strength of air is 21.1 kV (r.m.s) / cm. **(Nov 09, 08)**

15. i. What is corona loss? How can it be reduced?
    ii. A 110 kV, 3 Phase, 50 Hz transmission line, 175 km long consists of three 1.2 cm diameter stranded copper conductors spaced in 2 m delta arrangement. Temperature taken at 25^0C and barometric pressure as 74 cm. Assume surface irregularity factor m = 0.85 (Roughness factor), mv for local corona= 0.72 and mv for general corona = 0.82. Find
    a. Disruptive voltage
    b. Visual corona voltage for local corona
    c. Visual corona voltage for general corona and
    d. Power loss due to corona using Peek's formula under fair weather and wet conditions. **(Nov 09, Feb 08)**

16. i. Briefly describe the current distortion effects.
    ii. An overhead transmission line operates at 220 kV between phases at 50 Hz. The conductors are arranged in a 4-meter delta formation. What is the maximum diameter of the conductor that can be used for no corona loss under fair weather conditions? Assume an air density factor of 0.95 and irregularity factor of 0.85. The critical voltage is 230 kV. Find also the power loss under stormy conditions. **(Nov 09)**

17. i. Explain the methods of reducing corona loss.
    ii. Find the disruptive critical voltage and critical voltages for visual corona of a 3-phase, 200 km long line consisting of three stranded copper conductors (7/4.75) mm, area 120 mm^2 spaced in a 4 metre delta arrangement, temperature 32^0C and barometric pressure 73 cm. If this line operates on 200kV at 50 Hz. Calculate fair weather and storm loss for the line. Assume any additional data, if required. **(Nov 09)**

18. Determine the disruptive critical voltage and the critical voltages for local and general corona on a 3-phase overhead transmission line, consisting of three stranded copper conductors, spaced 3 meters apart at the corners of an equilateral triangle. Air temperature and pressure are 21^0C and 73.5 cm of mercury respectively. Conductor diameter is 2.2 cm. Take air density factor 3.92 b/(273 + t), irregularity factor (m) = 0.82 and surface factors (m_v) for local and general corona = 0.7 and 0.8 respectively. Break down strength of air is 21.21 kV (r.m.s) per cm. **(Nov 08)**

19. i. Describe the phenomenon of corona? Discuss the factors which affect corona loss.
    ii. A 3-phase line has conductors of radius 1.0 cm, spaced at the corners of an equilateral triangle of side 2.5 m apart. If the dielectric strength of air is 30kV/cm, determine the disruptive critical voltage at which corona will occur. Take relative air density factor δ =0.96 and irregularity factor m_0 = 0.94.
    (Nov 08)
20. i. What is corona loss? Why is it different in different weather conditions? How can it be estimated?
    ii. A 132kV overhead line conductor of radius 1cm is built so that corona takes place if the line voltage is 210 kV (r.m.s). If the value of voltage gradient at which ionization occurs can be taken as 21.21 kV (r.m.s) per cm, determine the spacing between the conductors. **(Nov 08)**

21. i. Derive an equation for calculating the maximum electric intensity on the con- ductor surface of a 3-phase single circuit horizontal configuration line with two sub-conductors per phase.
    ii. In a 3-phase overhead line, the conductors have an overall diameter of 3.0 cm each and are arranged in delta formation. Assuming a critical disruptive voltage of 250 kV between lines and an air density factor of 0.90 and m0 = 0.95, find the minimum spacing between conductors allowable, assume fair weather conditions. **(Feb 08)**

22. i. Explain the surge phenomena.
    ii. A voltage having a crest value of 3000 kV is traveling on a 750 kV line. The protective level is 1700 kV and the surge impedance of the line is 300ohms. Calculate
    a. the current in the line before reaching the arrester
    b. current through the arrester
    c. the value of arrester resistance for this condition
    d. reflect voltage. Verify the reflection and refraction coefficient. **(Feb 08)**

23. i. Give brief description of corona phenomenon.
    ii. Derive the expression for potential gradient at the surface of a conductor of 1-phase transmission line. **(Feb 08, Mar 06, Nov 07, 06,05,04)**

24. i. What is corona and what are the factors affecting corona loss? Discuss them briefly.
    ii. An overload transmission line operates at 210 kV between phases at 50 Hz. The conductors are arranged in a 3.5 metre delta formation. What is the maximum diameter of conductor that can be used for no corona loss under fair weather conditions? Assume an air density factor of 0.9 and irregularity factor of 0.82. The critical voltage is 230 kV. Find also the power loss under storm conditions. **(Nov 07)**

25. i. What is meant by the disruptive critical voltage and visual critical voltage? State the effects of conductor size, spacing and condition of the surface of conductors on these voltages.
    ii. A certain 3-phase equilaterally spaced transmission line has a total corona loss of 55 kW at 110 kV and a loss of 110 kW at 120 kV. What is the disruptive critical voltage between lines? What is the corona loss at 125 kV?

26. i. What is corona loss? Give the Peek?s corona loss formula and specify the terms.
    ii. Determine the corona loss for a 3-phase 110kV,50Hz,160km long line , with conductor diameter 1.036cm, 2.44m delta spacing, air temperature 26.670C and pressure of 73.15cm. **(Nov 07)**

27. Explain the effect of shunt compensation on transmission lines. **(Nov 07)**

28. i. What is critical disruptive voltage? Derive the expression for it.

ii. Give brief description about the factors a"ecting the critical disruptive voltage. **(Nov 07)**

29. i. Determine the critical disruptive voltage and corona loss for a 3-phase line space operating at 110kv which has conductors of 1.25cm diameter arranged in a 3.05m delta spacing. Assume air density factor of 1.07 and the dielectric strength of air to be 21kv/cm.

ii. Explain in brief the disadvantages of corona and different methods of reducing corona loss.

(Feb,Nov 07, 05)

30. i. What do you mean by critical visual disruptive voltage?

ii. Find the critical disruptive voltage and the critical voltages for local and general corona on a 3-phase overhead transmission line, consisting of three stranded copper conductors spaced 2.5m apart at the corners of an equilateral triangle. Air temperature and pressure are 21^0C and 73.6 cm Hg respectively. Take conductor dia 10.4mm, irregularity factor 0.85, local and general surface factors 0.7 and 0.8 respectively. **(Nov 07, 05)**

31. Discuss the effect of load power factor on voltage regulation and efficiency of a transmission line. What are skin and proximity effects? **(Nov 05)**

32. A single phase overhead line has two conductors of dia 1 cm with a spacing of 1m between centers. If the dielectric strength of air is 21kV/cm, determine the line voltage for which corona will commence on the line. Derive the formula used. **(Jun 04)**

33. Define Voltage regulation of a transmission line and explain clearly the Ferranti effect with a phasor diagram. **(Nov 04)**

34. i. What is Proximity effect?

ii. Why transmission lines are transposed? Explain the procedure of Transposation? **(Nov 07, Jun 03)**

35. How a corona formation does affect the efficiency of the line? Give Peterson's formula to determine the power loss due to corona? **(Nov 03)**

36. i. Discuss why Ferranti effect is significant only in medium and long lines?

ii. What are tuned power lines? **(Jun 03)**

37. What is Skin effect? **(Jun 03)**

38. i. Define disruptive critical voltage?

ii. A 110kv , 3 hase,50 Hz transmission line, 175km long consists of three 1cm diameter stranded copper conductors spaced in 3m delta arrangement. Temperature taken at 26^0C and barometric pressure as 74 cm. Assume surface irregularity factor m=0.85,(rougness factor) m_v for local corona=0.72 and m_v for general corona=0.82. Find

a. Disruptive voltage

b. Visual corona voltage for local corona

c. Visual corona voltage for general corona

d. Power loss dure to corona using Peek's formula under fair weather and wet conditions.

e. Power loss due to corona using Peterson's formula under fair weather and wet conditions.

(Nov 02)

39. i. Describe the phenomena of corona.

ii. Find the disruptive critical voltage and visual corona voltage (local corona as well as general corona) for a 3 phase 220KV line consisting of 22.26mm diameter conductors spaced in a 6m delta configuration. The following data can be assumed. Temperatrue 25^0C, Pressure 73cm of mercury, surface factor 0.84, irregularity factor for local corona 0.72, irregularity factor for general corona 0.82. **(Nov 02)**

40. i. Explain 'Corona'.
    ii. A certain 3 phase equilaterally spaced transmission line conductor has a total corona loss of 53 Kw at 106 KV and a loss of 98 Kw at 110KV. What is the disruptive critical voltage between lines? What is the corona loss at 113KV. **(Nov 02)**

41. i. Explain the phenomena of corona . How it is influenced by atmospheric conditions and conductor geometry
    ii. 3 phase 220KV 50 Hz transmission line has equivalent triangular spacing of side 1.38m. The conductor diameter is 3.2cm. the air density factor and irregularity factor are 0.95 & 0.83 respectively. Find the critical disruptive voltage and corona loss per Km. assume required data **(Apr 02)**

42. i. What are the disadvantages of corona? Explain how corona considerations affect the design of a line?
    ii. Find the critical disruptive voltage 7 visual voltage for a 3 phase line having 10mm dia conductors spaced in delta arrangement spaced at 3 m. Assume temperature of 25 Deg. Centigrade and pressure of 70 cm of mercury . Assume surface irregularity factor 0.72 and 0.82 for general corona. **(Aug 01)**

43. Bundled conductors are mainly used in high voltage overhead transmission lines to **(GATE 03)**
    i. reduce transmission line losses
    ii. increase mechanical strength of the line
    iii. reduce corona
    iv. reduce sag

44. The corona loss on a particular system at 50 Hz is IkW/km per phase. The corona loss at 60 Hz would be
    i. IkW/km per phase
    ii. 0.83kW/km per phase
    iii. 1.2kW/km per phase
    iv. 1.13kW/km per phase **(GATE '00)**

45. Corona losses are minimized when **(GATE 99)**
    i. conductor size is reduced
    ii. smooth conductor is reduced
    iii. sharp points are provided in the line hardware
    iv. current density in conductors is reduced

46. Derive an expression for disruptive critical (corona) voltage of single – phase overhead line. Show that the result can be extended to a 3 phase line. Explain how bundle conductors help to raise disruptive critical voltage of transmission line. **(IES 94)**

47. Determine the corona characteristics of a 3-phase, 50 Hz, 132kV transmission line 100 km long running through terrain at an altitude of 600 metres, temp. of 30^0C and barometric pressure 74cm. The conductors are 1.5 cm diameter and spaced with equilateral spacing of 2.75 metres. Assume surface irregularity factor of 0.9 and m_v=0.75. **(T2-Ch6)**

48. A 3-phase, 50 Hz, 132kV transmission line consists of conductors of 1.17 cm dia and spaced equilaterally at a dostamce pf 3 metres. The line conductors have smooth surface with value for m=0.96. The barometric pressure is 72 cm of Hg and temperature of 20^0C. Determine the fair and foul weather corona loss per km per phase. **(T2-Ch6)**

49. A 3-phase, 50 Hz, 138 kv transmission line has conductors in equilateral formation spaced 2.5 metres apart. The conductor diameter is 1.04cm and the surface factor is 0.85. The air pressure and temperature are 74cm of Hg and 21^0C respectively. Determine the critical

visual voltage for corona and the corona loss per km per phase of the line, m_v=0.72.**(T2-Ch6)**

50. Explain clearly the "Ferranti effect" with a phasor diagram. **(T2-Ch4)**

51. Explain clearly the "Skin effect" and "proximity effect" when referred to overhead lines. **(T2-Ch2)**

52. What are bundled conductors? Discuss the advantages of bundled conductors when used for overhead lines. **(T2-Ch2)**

UNIT-VI

1. Each line of a three phase system is suspended by a string of 4 similar insulators. If the voltage across the second unit is 15 kv and across the third unit is 27.0KV. Calculate the voltage between conductors e and string efficiency? **(May 11)**

2. A 1-core cable has a core diameter of 8 mm and a diameter under the sheath of 2 cm. The relative permittivity of the dielectric is 4. The power factor on open circuit is 0.03. Calculate for 1 km length of the cable **(May 11)**
   i. the capacitance
   ii. its equivalent insulation resistance
   iii. the charging current
   iv. the dielectric loss when the cable is connected to 10 kv, 1-phase 50 Hz supply system.

3. Each of the three insulators forming a string has a self capacitance of C farad. The shunt capacitance of each insulator is 0.2C to earth and 0.1C to line. A guard ring increases the capacitance of line of metal work of the lowest insulator to 0.3C.calculate the string efficiency of the arrangement with and without guard firing. **(May 11)**

4. The three bus bar conductors in an outdoor sub-station are supplied by units of post insulators. Each unit consists of stack of 3-pin insulators fixed one on the top of the other. The voltage across the lowest insulator is 8.45kv and that across the next is 7.25Kv.Find the bus-bar voltage of the station?
(May 11, Nov 10)

5. i. Define and explain string effciency. Can its value be equal to 100%?
   ii. Give the reasons for unequal potential distribution over a string of suspension insulators?
   iii. Explain how the electric break down can occur in an insulator? **(May 11, 10)**

6. A string of 5 insulators has self-capacitance equal to 5 times the pin to earth capacitance. calculate
   i. the voltage distribution across various units as a percentage of total voltage across the string and
   ii. string efficiency. **(Nov 10)**

7. A string of 4 insulators has self-capacitance equal to 5 times pin to earth capacitance. Calculate
   i. the voltage distribution across various units as a percentage of total voltage across the string and
   ii. string efficiency. **(Nov 10)**

8. A string of 4 insulators is connected across a 285kV line. The self capacitance of each unit is equal to 5 times pin to earth capacitance. Calculate the potential difference across each unit and string efficiency? **(Nov 10)**

9. In a three phase over head system, each line is suspended by a string of 3 insulators. The voltage across the top unit (near the tower) and middle unit are 10KV and 11KV respectively. Calculate
   i. The ratio of shunt capacitance to self capacitance of each insulator
   ii. The string efficiencyand line voltage? **(May 10)**

10. A string of six insulators is to be graded to obtain uniform distribution of voltages across the string. If the capacitance of the top unit is 10 times the capacitance to ground of each unit, determine the capacitance of remaining five units? **(May 10)**

11. i. What are the points to be remembered during the manufacture of the transmission line insulator?
   ii. The self capacitance of each unit in a string of three suspension insulators is C. The shunting capacitance of connecting metal work of each insulator to earth is 0.25 C while for line it is 0.3 C. Determine the following: **(May 10)**
   a. the voltage across each insulator as the percentage of the line voltage to earth and
   b. String efficiency.

12*i. Explain the use of grading rings and arcing horns on suspension insulators.
   ii. A string of suspension insulators consists of 6 units. If the maximum peak voltage per unit is 33 kV, calculate
   a. the maximum voltage for which this string can be used,
   b. Voltage across the third unit from the bottom
   c. the string efficiency. Assume capacitance between each pin and earth as 12 percent of the self-capacitance of each unit. **(Nov 13, Nov 09)**

13. i. Name the different types of insulators used for transmission and distribution systems.
   ii. Determine the voltage across each unit of sting suspension insulators consisting of 3 similar units. The voltage between the line and earth is 33 kV and the ratio of the capacitance of each unit and capacitance between pin to earth is 8:1. **(Nov 09)**

14. i. Explain the use of grading rings and arcing horns on suspension insulators.
   ii. A string consisting of seven suspension discs is fitted with a grading ring. Each pin to earth capacitance is C. If the voltage distribution is uniform, determine the values of line to pin capacitance.

(Nov 09)

15. i. Explain with neat sketch, the constructional features of pin type insulator.
   ii. A string of suspension insulators consisting of 5 units each having capacitance C. The capacitance between each unit and earth is 1/4th of C. nd the voltage distribution in the each insulator in the string as a percentage of voltage of conductor to earth. If the insulators in the string are designed each to withstand 30 kV maximum. Find the operating voltage of the line where 5 suspension insulator strings can be used. **(Nov 09)**

16. i. Explain why the potential distribution is not, in general, uniform over the string in suspension type of insulators.
   ii. A string of suspension insulator consists of four units and the capacitance to ground is 12 percent of its mutual capacitance. Determine the voltage across each unit as a fraction of the operating voltage. Also determine the string efficiency. **(Nov 08)**

17. i. List the characteristics which the insulator should posses.
   ii. Each conductor of a 3-phase high voltage transmission line is suspended from cross arm of steel tower by a string of 4 suspension type disc insulators. If the voltage across the

second unit is 13.2 kV and that across the third unit is 20 kV. Calculate the voltage between the conductors. **(Nov 08)**

18. i. List the advantages of suspension type insulators over pin type insulators.
    ii. A string of 5 insulator units has a self-capacitance equal to 11 times the pin to earth capacitance. Find the string efficiency? **(Nov 08)**

19. i. What do you mean by string efficiency? How can it be improved?
    ii. A 3-phase overhead transmission line is being supported by three discs suspension insulators. The potential across the first and second insulators are 11 kV and 13.2kV respectively. Calculate
    a. the line voltage and
    b. string efficiency. **(Nov12, Nov 08)**

20. i. What is guard ring which is being used in the suspension string type insulator? Deduce the relation for determining the capacitance formed by the ring.
    ii. A three phase over head line is being supported by tree discs suspension insulators, the potential across the first and second insulators are 12 and 18 kV respectively. Calculate
    a. the line voltage,
    b. the ratio of capacitance between pin and earth to self-capacitance of each unit,
    c. the string efficiency. **(Feb 08)**

21. i. Write a short notes on different types of insulators used for overhead lines and their applications.
    ii. Find the potential difference across each unit of over head suspension insulators connecting of four similar units. The potential between the line conductor and the earth is 58 kV and the ratio of capacity of each insulator to the capacity relative to earth, of each intermediate section of connecting work is 6:1. it is assumed that no leakage takes place. Also find the string efficiency. **(Feb 08)**

22. i. Give reasons for unequal potential distribution over a string of suspension insulators.
    ii. Each line of a 3-phase system is suspended by a string of 3 similar insulators. The voltage across the unit nearer to the line conductor is 12 kV. Calculate the line to neutral voltage. Assume the shunt capacitance between each insulator and earth is 1/6 capacitance of the insulator itself. Also find the sting efficiency. **(Feb 08)**

23*. i.Explain why suspension type of insulators are preferred for high voltage overhead lines. Sketch a sectional view of one unit of the suspension type insulator and describe the construction.
    ii. An insulator string containing five units has equal voltage across each unit by using disc of different capacitances. If the top unit has a capacitance of C and pin to tower capacitance of all units is 20 percent of the mutual capacitance of top unit. Calculate mutual capacitance of each disc in a string. **(Nov12, Feb 08, Nov 07)**

24. i. List various methods of improving string efficiency.
    ii. In a string of three insulator units the capacitance of each unit is C, from each conductor to ground is C/3, and from each connector to the line conductor is C/5. Calculate the voltage across each unit as a percentage of the voltage. To what value the capacitance between the connector of the unit and the line has to be increased by a grard ring to make the voltage across it equal to that across the next higher unit? **(Feb 08, 07, Nov 06)**

25. i. What are overhead line insulators? Explain briefly different types of insulators based on their applications and operating voltage levels with neat diagram.
    ii. Each conductor of a three phase overhead line is suspended from a cross arm of a steel tower by a string of 4 suspension insulators. The voltage across the second unit is 13.2kV

and across the third 19.5kV. Find the voltage between the conductors and the string efficiency. **(Feb 08, 07)**

26. Find the voltage distribution and string efficiency of three unit suspension insulator string if the capacitance of the link pins to earth and to the line are respectively 20% and 10% of the self capacitance of each unit. If a guard ring increases the capacitance to the line of lower link pin to 35% of the self capacitance of each unit, find the redistribution of voltage and string efficiency. **(Feb 08, Mar 06)**

27. i. Define string efficiency. Why is it necessary to have high string efficiency? How can it be achieved?
    ii. A string of suspension insulators consists of 5 units each having capacitance C. The capacitance between each unit and earth is 1/8 of C. Determine the voltage distribution across each insulator in the string as a percentage of voltage of conductor to earth .If the insulators in the string are designed to withstand 36 kV maximum, calculate the operating voltage of the line where 5 suspension insulator strings can be used. **(Nov 07)**

28. i. Explain why the voltage across the insulator string is not equal and describe practical methods to improve them.
    ii. A three phase over head transmission line is suspended by a suspension type insulator which consists of three units. The potential across top unit and middle unit are 7 kV and 10 kV respectively. Calculate
    a. The ratio of capacitance between pin and earth to the self capacitance of the each unit
    b. The line voltage and
    c. String efficiency. **(Nov 07)**

29. i. Discuss the method of grading the string unit in insulations?
    ii. In a 33 kV over head line there are three units in the string of insulators. The capacitance between each insulator pin and earth is 13% of self capacitance of each insulator. Find
    a. The distribution of voltage over three insulators
    b. String efficiency. **(Nov 07)**

30. A string of suspension insulator consists of four units. The capacitance between each pin and earth is one tenth of the self capacitance of the unit. The voltage between the line conductor and earth is 100 kv. Fine the voltage distribution across the each unit and string efficiency. **(Feb 07, Nov, Mar 06)**

31. i. Give brief description of corona phenomenon.
    ii. Derive the expression for potential gradient at the surface of a conductor of 1-phase transmission line. **(Nov 06)**

32. i. What are the basic tests to be carried out on insulators.
    ii. A three-phase overhead transmission line is being supported by three-disc suspensions insulators, the potentials across the first and second insulator are8 KV and 11 KV respectively. Calculate
    a. line voltage
    b. ratio of the capacitance between pin and earth to self-capacitance of each unit and
    c. the string efficiency. **(Mar 06)**

33. i. Mention different types of insulating materials used in underground cables.Give brief explanation.
    ii. Determine the economical size of a single core cable working on 220kV, 3-phase system. The maximum permissible stress in the dielectric is not to exceed 250kV/cm. **(Mar 06)**

34. i. Each conductor of a 33 KV, 3-phase system is suspended by a string of three similar insulators, the capacitance of each disc is nine times the capacitance to ground. Calculate the voltage across each insulator. Determine the string efficiency.

ii. A string of eight suspension insulators is to be graded to obtain uniform distribution of voltage across the string. If the capacitance of the top unit is 10 times the capacitance to ground of each unit, determine the capacitance of the remaining seven units. **(Nov 05)**

35. Each conductor of a three phase overhead line is suspended from a cross arm of a steel tower by a string of 4 suspension insulators. The voltage across the second unit is 14.2kV and across the third 20kV. Find the voltage between the conductors and the string efficiency. **(Apr 05)**

36. An overhead line is supported between two towers having heights of 30m and 70m from the datum level. If the horizontal distance between them is 300m, find the height of the conductor from the datum level between the supports. Assume maximum tension of 1720kgf and weight per meter run is 0.727kgf. **(Nov 04)**

37. i. Explain different methods of improving voltage distribution across the insulating disc.
ii. A string of suspension insulator consists of four units. The capacitance between each pin and earth is one tenth of the self capacitance of the unit. The voltage between the line conductor and earth is 100kV. Find
a. The Voltage distribution across the each unit
b. the string efficiency. **(Nov 04)**

38. i. Explain the reason why the insulating disc nearer to the conductor is more stressed?
ii. What is string efficiency of an overhead line insulators. Give its significance. **(Apr 04)**

39. A string of eight suspension insulators is to be graded to obtain uniform distribution of voltage across the string. If the capacitance of the top unit is 10 times the capacitance to ground of each unit, determine the capacitance of the remaining seven units? **(Nov 03)**

40. A string of suspension insulators consists of 8 units. If the maximum peak voltage per unit is 33KV. Calculate
i. The maximum voltage for which this string can be used
ii. The string efficiency. Assume capacitance between each link pin and earth as 15 percent of the self capacitance of each unit **(Nov 03)**

41. In a 5 insulator disc string capacitance between each unit and earth is 1/6 of the mutual capacitance. Find the voltage distributions across each insulator in the string as percentage of voltage of the conductor to earth. Find string efficiency. How is this efficiency affected by rain? **(Jun 03)**

42. Each conductor of a 33KV, 3-phase system is suspended by a string of three similar insulators; the capacitance of each disc is nine times the capacitance to ground. Calculate the voltage across each insulator. Determine the string efficiency? **(Nov 02)**

43. A three phase overhead Transmission line is supported on 4 disc suspension insulators. The voltage across the second and third discs are 13.2kv and 18KV respectively. Calculate the line voltage and mention the nearest standard voltage in practice **(Nov 02)**

44. i. Explain grading methods of string insulators ?
ii. Each conductor of a 3-phase H.V. transmission line is separated by a string of 4 insulator discs. If the potential difference across the second from to is 13.2KV and across 3rd from top is 18KV, determine the voltage between conductor. **(Nov 02)**

45. i. What are the advantages and disadvantages of suspension type insulators over pin type insulators.
ii. Determine the voltage across each disc of suspension insulators as a percentage of the line voltage to earth. The self and capacitance to ground of each disc is C and 0.2C

respectively. The capacitance between link pin and the guard ring is 0.1C. If the capacitance to the line of the lower link pin were increased to 0.3C by means of guard ring, determine the redistrictbution of voltage. Also determine the string efficient in each case. **(Nov 02)**

46. A 3 phase overhead transmission line is being supported by 3 disc suspension insulators. The potentials across the first and second insulator are 8KV and 11KV respectively. Calculate:
    i. The line voltage
    ii. String efficiency. (**Nov 01)**

47. i. A string of 6 insulators unit has a self capacitance of 10 times the pinto-earth capacitance. Find the string efficiency.
    ii. Discuss the method of grading of string unit in insulators **(Jun 01)**

48. i. Show that the voltage distribution across the units of string insulator is not uniform
    ii. What is string efficiency? Explain the methods of improving the same **(O.R. 02)**

49. In a transmission line each conductor is at 20 kV and is supported by a string of 3 suspension insulators. The air capacitance between each cap-pin junction and tower is one fifth of the capacitance C of each insulator unit. A guard ring, effective only over the line-end insulator unit is fitted so that the voltages on the two units nearest the line-end are equal.
    i. Calculate the voltage on the line end unit.
    ii. Calculate the value of capacitance C_s required. **(GATE 01)**

50. Determine the voltage across each disc of suspension insulators as a percentage of the line voltage to earth. The self and capacitance to ground of each disc is C and 0.2C respectively. The capacitance between the link pin and the guard ring is 0.1C. **(T2-Ch8)**

51. Determine the voltage across each disc of suspension insulators as a percentage of the line voltage to earth. The self and capacitance to ground of each disc is C and 0.4C respectively. If the capacitance to the line of the lower link pin were increased to 0.3C by means of a guard ring, determine the redistribution of voltage. Also determine the string efficiency in each case. **(T2-Ch8)**

UNIT-VII

1. A transmission line has a span of 200m between level supports. The cross sectional area of the conductor is1.29 cm^2 weighs 1170Kg/Km and has breaking stress of 4218Kg/cm^2. Calculate the sag for a factor of safety of 5, allowing wind pressure of 122 Kg per square meter of projected area. What is the vertical sag? **(May 11, Nov 10)**

2. An over head transmission line at a river crossing is supported from two towers of heights of 40m and 90 at the water crossing. The horizontal distance between the towers is 500m. If the maximum allowable tension is 1650 Kg and the conductor weighs 1 kg/m. find the minimum clearance of the conductor and water at a point mid-way between the supports. Bases of the towers can be considered to be at water level. **(May 11)**

3. An over head transmission line at a river crossing is supported from two towers of heights of 50m and 100m above the water level. The horizontal distance between the towers is 400m. If the maximum allowable tension is 1800 Kg and the conductor weighs 1 kg/m. find the clearance between the conductor and water at appoint mid-way between the supports. **(May 11)**

4. A transmission line has a span of 150m between level supports. The cross sectional area of the conductor is 2cm^2.The tension in the conductor is 2000Kg/ cm^2.and safety factor is 5. The specific gravity of the material is 9.9 gm/cm^3. If the wind pressure is 1.5Kg/m.Calculate the height of the conductor above the ground level at which it should be supported if a minimum clearance of 7m is to be left between the ground and the conductor. **(May 11, 10, Nov 10)**

5. An overhead line has a span of 260m.the weight of the line conductor is 0.68kg per meter run. Calculate the maximum sag in the line. The maximum allowable tension in the line is 1550Kg.
(May 10)

6. A transmission line has a span of 250m between the level supports. The cross sectional area of the conductor is 1.29 cm^2. The ultimate strength is 4220 kg/cm^2 and the factor of safety is 2. If the wind pressure is 40 Kg/cm^2. Calculate the height of the conductor above ground level at which it should be supported if a minimum clearance of 7m is to be kept between the ground and the conductor.
(Nov 10)

7. A transmission line has a span of 150m between the level supports. The cross sectional area of the conductor is 2 cm^2. The ultimate strength is 5000kg/cm^2.The specific gravity of the material is 8.9 gm/cm3.If the wind pressure is 1.5Kg/m length of the conductor, calculate the sag at the center of the conductor if factor of safety is 5. **(May 10)**

8. Two towers of height 40 and 30 m respectively support a transmission line conductor at water crossing. The horizontal distance between the towers is 300m.If the tension in the conductor is 1590 kg. Find the clearance of the conductor at a point mid-way between the supports. Weight of the conductor is 0.8 kg/m. Bases of the towers can be considered to be at the water level. **(May 10)**

9. i. Prove transmission line conductor between two supports at equal heights takes the form of a catenary.
ii. A transmission line conductor at a river crossing is supported by two towers at heights of 50 and 80 meters above water level. The horizontal distance between the towers is 300 meters. If the tension in the conductor is 2000 kg, determine the clearance between the conductors and water at a point midway between the towers. **(May 10, Nov 09, 08)**

10. i. What are disadvantages of providing too much or too small sag in a transmission line? Name different types of line supports with their place of use.
ii. A transmission line conductor with diameter 14.77 mm, cross-sectional area of 120 mm^2, weighing 1118 kg/km has a span of 200 meters. The supporting structures being level. The conductor has an ultimate tensile stress of 42.2 kg/mm^2 and allowable tension is not to exceed ¼ of ultimate strength.
Determine the following:
a. Sag in still air
b. Sag with a wind pressure of 60 kg/m^2 and an ice coating of 10 mm. Also calculate the vertical sag under this condition. Assume density of ice as 0.915 gm/c.c **(Nov 09)**

11. i. Deduce expressions for calculating sag and conductor length of an overhead line when the supports are at the same level?
ii. An overhead conductor consists of seven strands of silicon-bronze having cross-sectional area of 2.0 cm2 and ultimate strength of 10000 kg/cm2. When connected between supports 650 m apart and having a 20 m difference in level, determine the vertical sag, which must be allowed such that the factor of safety shall be 5. Assume the wire weight 2 kg/m, ice loading is 1 kg/m and wind loading is 1.75 kg/m. **(Nov 09)**

12. i. What is a sag template? Explain how this is useful for the location of towers and the stringing of power conductors.
    ii. A transmission line conductor consists of a hard drawn copper 240mm^2 cross-section and has a span of 160m between level supports. The conductor has an ultimate tensile stress of 42.2 kg/mm^2 and allowable tension is not to exceed 1/5th of ultimate tensile strength. Determine
    a. the sag,
    b. the sag with a wind pressure of 1.35kg/m and an ice coating of 1.0 cm thickness,
    c. the vertical sag. Take the specific gravity of hard drawn copper as 8.9 gm/cc and the weight of ice as 915 kg/m^3. **(Nov 09)**

13. i. Explain the necessity of a stringing chart for a transmission line and show how such a chart can be constructed.
    ii. Two towers of height 40 and 90 meters respectively support a transmission line conductor at a water crossing. The horizontal distance between the towers is 500 m. If the allowable tension in the conductor is 1600kg, find the minimum clearance of the conductor and the clearance of the conductor mid-way between the supports. Weight of the conductor is 1.1kg/m. Bases of the towers can be considered to be at the water level. **(Nov 08)**

14. i. Show that the sag on level supported line conductor of span L, weight per unit length W kgs, and minimum tension in the line conductor T_0 is given by; $s = wL^2/8T_0$. What will be the sag if level difference is of h meters?
    ii. An overhead line has the following data: span length 185 m, difference in levels of supports 6.5 m, conductor diameter 1.82 cm, weight per unit length of conductor 1.5kg/m, wind pressure 39 kg/m^2 of projected area. Maximum tensile strength of the conductor is 4250 kg/cm^2, factor of safety is 5. Calculate the length of the lower support. **(Nov 08)**

15. i. Describe the vibration of power conductors and explain the methods used to damp out these vibrations.
    ii. Determine the sag of an overhead line for the following data: span length 160 meters, conductor diameter 0.95 cm, weight per unit length of the conductor 0.65 kg/meter. Ultimate stress 4250 kg/cm^2, wind pressure 40 kg/cm^2 of projected area, Factor of safety 5. **(Nov 08)**

16. i. Assuming that the shape of an overhead line can be approximated by a parabola, deduce expressions for calculating sag and conductor length. How can the effect of wind and ice loadings be taken into account.
    ii. A transmission line has a span of 150m between level supports. The line conductor has a cross-sectional area of 1.25 sq.cm and it weighs 120 kg per 100 meters. If the breaking stress of the copper conductor is 4220 kg per sq.cm. Calculate the maximum sag for a safety factor of 4. Assume a maximum wind pressure of 90 kg per square meter of projected surface. **(Feb 08)**

17. i. What are the factors affecting sag?
    ii. A transmission line conductor at a river crossing is supported from two towers at heights of 60 and 80 meters above water level. The horizontal distance between the towers is 300m. If the tension in the conductor is 2000kg, find
    a. the maximum clearance between the conductor and water,
    b. the clearance between the conductor and water at a point mid way between the towers. Weight of conductor is 0.844 kg/m. Assume that the conductor takes the shape of a parabola. **(Nov 12, Feb 08)**

18. i. What are the various types of line supports? Discuss the suitability of each with reference to system voltage and span.
    ii. Determine the maximum sag of an overhead line conductor having a diameter of 19.5 mm weighs 0.85 kg/m. The span length is 275 meters, wind pressure is 40 kg/m2 of projected

area with ice coating of 13 mm. The ultimate strength of the conductor is 8000 kg, the factor of safety is 2 and ice weighs 910 kg/m^3. **(Feb 08)**

19\. i. What is a stringing chart? Explain clearly the procedure adopted for stringing the power conductors on the supports.

ii. A transmission line conductor at a river crossing is supported from two towers at heights of 50m and 75m above sea level. The span length is 275m. Weight of the conductor 0.75kg/m. Determine the clearance between the conductor and water at a point midway between towers if the tension in the conductor is 2000 kg. **(Nov13, Feb 08)**

20\. An overhead line has a span of 160m of copper conductor between level supports. The conductor diameter is 1.0cm and has a breaking stress of 35kgf/mm^2. Calculate

i. The deflecting sag

ii. The vertical sag. The line is subjected to a wind pressure of 40kgf/m^2 of Projected area and radial ice coating of 9.53 mm thickness. The weight of ice is 913.5kgf/m^3. Allow a factor of safety of 2 and take the density of copper as 8.9g/cm^3.**(Feb 08, Mar 06)**

21\. A transmission line has a span of 180m between level supports. The conductor has a cross-section area of 129mm^2, weights 1.17 kgf/m and has a breaking stress of 42kgf/mm^2. Calculate the sag for a factor of safety of 5, allowing for a maximum wind pressure of 125kgf/m^2 of projected surface.
(Feb 08, Nov 07, 05, Mar 06)

22\. A transmission line conductor at a river crossing is supported from two towers at heights of 45m and 75m above sea level. The span length is 300m. Weight of the conductor 0.85kg/m. Determine the clearance between the conductor and water at a point midway between towers if the tension in the conductor is 2050 kg. **(Feb 08, Nov 05)**

23\. i. What is a sag template? Explain how this is useful for loading of towers and stringing of power conductors.

ii. A transmission line has a span of 200m between level supports. The conductor has a cross-section area of 130mm^2, weights 1.2 kgf/m and has a breaking stress of 40kgf/mm^2. Calculate the sag for a factor of safety of 5, allowing for a maximum wind pressure of 125kgf/m2 of projected surface.
(Feb 08, Nov 05)

24\. i. Discuss the consideration which govern the selection of span and conductor configuration of a high voltage line.

ii. An overhead transmission line has a span of 220 meters, the conductor weighing 804 kg/km. Calculate the maximum sag if the ultimate tensile strength of the conductor is 5,758 kg. Assume a safety factor of 2. **(Nov 07)**

25\. i. Derive an equation to calculate the conductor tension under erection conditions if the conductor tension and loading under bad weather conditions are known.

ii. A transmission line has a span of 150 m between supports, the supports being at the same level. The conductor has a cross-sectional area of 2 cm^2. The ultimate strength is 5,000 kg/cm^2. The specific gravity of the material is 8.9 gm/cm^3. If the coating of ice is 1.0 cm, calculate the sag at the center of the conductor if factor of safety is 5. **(Nov 07)**

26\. i. Explain how the effect ice and wind can be included in sag calculations of transmission lines.

ii. An overhead line has a span of 250 metres. Find the weight of conductor if the ultimate strength is 5758kg, sag is 1.5 metres and factor of safety is 2. **(Nov 12, Nov 07)**

27\. An overhead transmission line conductor on a hill side is supported between two points separated by a horizontal distance of 400m and at heights of 1150m and 900m above sea level respectively. The weight of the conductor is 1.492kgf/m and the tension is 3935kgf.

Determine the vertical clearance between the conductor and a point on the hill side at a height of 970m and a horizontal distance of 175m from the lower support. Assume parabolic configuration. **(Nov 07)**

28. In a transmission line the line conductor has an effective diameter of 19.53mm, weights 844kgf/km, and has an ultimate breaking strength of 7950kgf. Calculate the height above the ground at which a conductor with a span of 275m must be supported in order that the total tension shall not exceed half the ultimate strength and with a 12.7mm radial coating of ice and a horizontal wind pressure of 380N/m2 of projected area. The ground clearance required is 6.7m. Weight of ice is 913.5kgf/m^3. **(Nov 07, Mar 06)**

29. i. Describe the vibration of power conductors and explain the methods used to damp out these vibrations.
    ii. An overhead line at a river crossing is supported from two towers of heights 30metresand 90 meters above water level with a span of 300 metres. The weight of the conductor is 1 Kg/metre and the working tension is 2000 Kg. Determine the clearance between the conductor and the water level midway between the towers. **(Mar 06)**

30. Calculate maximum sag of a line with copper conductor 7/0.295 cm size, are 0.484 sq.cm, overall diameter 0.889 cm, weight 428 kg/km and breaking strength 1,975kg. Assume factor of safety 2. Span 200 meters. Level supports:
    i. Due to weight of the conductor
    ii. Due to additional weight of ice loading of 1cm thickness
    iii. Due to both a) and b) plus wind acting horizontally at a pressure of 39 kg per sq.m. **(Nov 05, 03)**

31. An overhead line has the following data: span length 185m, difference in levels of supports 6.5m, conductor dia 1.82cm, weight per unit length of conductor 2.5kg/m, wind pressure 49kg/m^2 of projected area. Maximum tensile stress of the conductor 4250kg/cm^2. Factor of safety 5. Calculate the allowable sag in meters at the lower support. **(Apr 05)**

32. An overhead transmission line conductor on a hill side is supported between two points separated by a horizontal distance of 400m and at heights of 1150m and 900m above sea level respectively. The weight of the conductor is 1.492kgf/m and the tension is 3935kgf. Determine the vertical clearance between the conductor and a point on the hill side at a height of 970m and a horizontal distance of 175m from the lower support. Assume parabolic configuration. **(Apr 05)**

33. An overhead transmission line has a span of 240m between level supports. Calculate the maximum sag if the conductor weights 727kgf/km and has a breaking strength of 6880kgf. Allow a factor of safety of 2. Neglect wind and ice loading. Derive the formula used. **(Apr 05)**

34. An overhead line has a span of 160m of copper conductor between level supports. The conductor diameter is 1.0cm and has a breaking stress of 35kgf/mm^2. Calculate
    i. The deflecting sag
    ii. The vertical sag. The line is subjected to a wind pressure of 40kgf/m^2 of projected area and radial ice coating of 9.53 mm thickness. The weight of ice is 913.5kgf/m^2. Allow a factor of safety of 2 and take the density of copper as 8.9g/cm^3. **(Nov 04)**

35. An overhead line has a conductor of cross section 2.5 cm^2 hard drawn copper and a span length of 150 m. Determine the sag which must be allowed if the tension is not to exceed one fifth of the ultimate strength of 4175 kg/cm^2
    i. in still air, and
    ii. with a wind pressure of 1.3kg/m and an ice coating of 1.25cm.
    Determine also the vertical sag in the latter case. **(Nov 04, Jun 03)**

36. An overhead conductor consists of 7 strands of silicon-bronze having an ultimate strength of 10000 kg/cm^{2}and an area of 2.5 cm^2 when erected between supports 650m apart and having a 20m difference in level, determine the vertical sag which must be a allowed so that the factor of safety shall be 5. Assume the wire weights 2kg/m, ice loading 1 kg/m and wind loading is 1.75kg/m **(Nov 04)**

37. i. What is a sag-template? Explain how this is useful for location of towers and stringing of power conductors.
ii. What is a stringing chart? Explain clearly the procedure adopted for stringing the power conductors on the supports. **(Nov 03)**

38* Derive the expressions for sag and tension when the supports are at unequal heights. **(Nov13, Nov 03)**

39. A transmission line conductor having a dia of 19.5mm weighs 0.85kg/m. The span is 275 meters. The wind pressure is 40kg/m2 of projected area with ice coating of 13mm. The ultimate strength of the conductor is 8000Kg. Calculate the maximum sag, if the factor of safety is 2 and ice weighs 91 Okg/m3. **(Jun 03)**

40. i. Deduce expressions for calculating sag and conductor length for an OH line when the supports are at same level.
ii. What is sag template? What is its use? **(Nov 12, O.R. 02)**

41. i. Develop the expression for sag of a transmission line assuming the line configuration to a parabola. Take the supports to be at the same level
ii. A Transmission line has a span of 120m between the line supports. The line conductors have a cross sectional area of 1.25 sq.cm. each and weight of 100 kg/ 100 m . The breaking stress of the copper conductor is 4220 kg per sq.cm. Calculate the maximum sag for the safety factor of 4. Assume max. Wind pressure of 100kg/sq.m. of projected area **(Nov 01)**

42. Find the critical disruptive voltage and the critical voltages for local and general corona on a 3-phase over head transmission line, consisting or three standard copper conductors spaced 2.5m apart at the corners of an equilateral triangle. Air temperature and pressure are 21oC and 13.6Cm Hg respectively. The conductor diameter, irregularity factor and surface factors are 10.4mm, 0.85, 0.7 and 0.8 respectively. **(IES 98)**

UNIT-VIII

1. i. What is meant by capacitance grading of a cable ? **(May 11, Nov 10)**
ii. Derive expressions for capacitance of and maximum potential gradient in two (or more) dielectric of a graded cable in terms of a dielectric constants and radius of core and overall radius etc.

2. i. Show that in a capacitance graded cable the position of different layers is decided by the product ε_r g Where ε is the relative permittivity of the dielectric and g is the dielectric strength (potential gradient) and that for a cable with overall radius R having (say) 3 dielectrics with all dielectrics working at the same maximum potential gradient $\varepsilon_{r1}r = \varepsilon_{r2}r_1 = \varepsilon_{r3}r_2$ where r, r_1, r_2 are the radii of conductor, inner and middle dielectric respectively.
ii. Write a short note on single core cable with a neat diagram? **(May 11, Nov 10)**

3. Show that in a three-core (belted type) cable the neutral capacitance of each conductor Cn is equal to where Ce + 3 Cc are the capacitance of each conductor to sheath and to each other respectively. Explain how these capacitance can be measured experimentally. **(May 11)**

4. A 1-core lead sheath cable joint has a conductor of diameter 8 mm and two layers of different insulating materials each 8 mm thick. The relative permittivity are ω_{r1} =3(inner) ωr_2 =2.5(outer). Calculate the potential gradient at surface of the conductor when are p.d. Between the conductor and lead sheath is 50 kv. **(Nov 10)**

5. i. Write a short note on pressure cables.
   ii. Calculate the insulation resistance for a 5 km length of a 1-core cable. Resistance of insulation (impregnated paper) is 5*1014 ohm-cm, insulation thickness is 1 cm and radius of conductor is 1.25 cm. **(Nov 10)**

6. i. Deduce the expression for capacitance of a single core cable ?
   ii. Write a short note on oil-filled cables ? **(May 10)**

7. Describe the various methods of laying underground cables. What are the relative advantages and disadvantages of each method? Compare the merits and demerits of underground cables versus overhead system. **(May 10)**

8. Compare the merits and demerits of underground cables versus overhead system The insulation resistance for a 1-core cable is 495micro ohms per km. If the core diameter is 3.5 cm and receptivity of insulation is4.5 *1014 ohm-cm. Find the insulation thickness. **(May 10)**

9. i. State the classification of cables (according to voltage) and discuss their general construction
   ii. Explain carefully the constructional difference between and application of
   a. deleted
   b. screened (H type)
   c. S.L and
   d. H.S.L types of cables.
   iii. Write a short note on pressure cables. **(May 10)**

10. i. Find the radius of the intersheaths and the potential at which it must be maintained for a single core metal sheathed cable such that the overall radius of the cable is minimum. The operating voltage of the cable is V, its core and intersheath diameters are d and D respectively. Show also that D=3.76 V/g_{max}.
    ii. A 3-phase, 6 km long belted cable has capacitance per km of 0.5 F between the two cores with the third core connected to the lead sheath. Calculate the charging current taken by of this cable when connected to a 3-phase, 50 Hz, 11 kV supply. **(May 10)**

11. i. Explain the intersheath grading of cable.
    ii. A cable has intersheath grading that satisfies the equation, $R/r_1 = r_1/r = \alpha$. The core and cable radii are r =1.2 cm and R = 3 cm. Determine the location of the intersheath and also calculate the ratio of maximum electric field strengths with and without intersheath grading. **(Nov 09)**

12. i. In which method a homogeneous dielectric is used for cable grading? Prove that dielectric stress in each layer is the same.
    ii. A 3-phase,66 kV, single core cable of conductor diameter 2.5 cm and lead sheath of diameter 6cm and diameters of two inter sheaths are 3cm and 5cm are introduced in-

between the core and lead sheath. If the maximum stress in layers is the same. Find the voltages on the inter sheaths. **(Nov 09)**

13. i. Describe the general construction of an underground cable with a neat sketch.
    ii. A single core lead sheathed cable has the core diameter of 1.2 cm and is graded by using two dielectrics of relative permittivity 3.5 (inner) and 3.0 (outer). The thickness of each being 1 cm, system voltage is 66 kV, 3phase. Determine the potential gradient at the surface of the conductor and at the other points. **(Nov 09)**

14. i. Describe briefly some commonly used insulating materials for cables.
    ii. A 12.5 kV single-core cable has an outside diameter of 8 cm. Determine the radius of the core and the electric field strength that must be withstand by the insulating material in the most economical (optimal-ratio) configuration. **(Nov 09)**

15. i. Derive the formula for insulation resistance of a cable.
    ii. Determine the economical core diameter of a single core cable working on 22 kV, single phase system. The maximum permissible stress in the dielectric is not to exceed 33 kV/cm. **(Nov 08)**

16. i. Derive a formula for capacitance of a single core cable.
    ii. Determine the economical core diameter of a single core cable working on 210 kV, 3-phase system. The maximum permissible stress in the dielectric is not to exceed 230 kV/cm. **(Nov 08, 07)**

17. i. Derive a relation between the conductor radius and inside sheath radius of a single core cable so that the electric stress of the conductor surface may be minimum.
    ii. A cable has been insulated with two insulating materials having permittivity of 6 and 4 respectively. The inner and outer diameter of a cable is 3 cms and 7 cms. If the dielectric stress is 50 kV/cm and 30 kV/cm, calculate the radial thickness of each insulating layer and the safe working voltage of the cable. **(Nov 08)**

18. i. What are the causes of cable breakdown? What are voids? How are they formed? Why do voids lead to cable failure?
    ii. A single core lead sheathed cable is graded by using two dielectrics of relative permittivity 3.8 (inner) and 2.8 (outer), the thickness of each being 0.75cm. The core diameter is 1 cm; system voltage is 66 kV, 3-phase. Determine the maximum stress in two dielectrics. **(Nov 08)**

19. i. Show that for the same dimensions of a cable with an intersheath can with stand a working voltage of 33% higher than a non-intersheath cable. Assume same homogeneous dielectric and most economical designs for both cables.
    ii. A 3-phase, single core 66 kV cable has a conductor diameter of 3 cm and a sheath of inside diameter 6 cm. If two intersheaths are introduced in such a way that the stress varies between the same maximum and minimum in the three layers. Find
    a. Positions of intersheaths
    b. voltage on the intersheaths
    c. Maximum and minimum stress. **(Feb 08)**

20* i. Compare the merits and demerits of underground system and overhead system.
    ii. Determine the thickness of insulation and operating voltage of a single core cable if the maximum and minimum stress in the dielectric is 38 kV/cm (r.m.s) and 12 kV/cm (r.m.s) respectively and the diameter of core is 3 cm. **(Nov12, Feb 08)**

21. i. Discuss the methods of grading of cables. Why are they not used generally?
    ii. A three-phase, single core, lead covered cable has radius of core 0.5 cm and internal diameter of sheath 6 cm. Its 3 insulating materials A, B, and C have relative permittivity

of 4, 4, and 2.5 with maximum permissible stress of 50, 40, and 30 kV/cm respectively. Find the operating voltage of the cable. **(Feb 08)**

22. i. What do you understand by grading of cable? Explain why grading is more of theoretical interest than practical? What is the modern practice adopted to avoid grading?
    ii. Determine the maximum and minimum stress in the insulation of a 33 kV single core cable which has a core diameter of 1.5 cm and a sheath of inside diameter 5 cm. **(Feb 08, Nov 07)**

23. A 66kV concentric cables with two inter sheaths has a core diameter 1.8 cm. Di-electric material 3.5 mm thick constitutes the three zones of insulation. Determine the maximum stress in each of the three layers if 20kV is maintained across each of the inner two layers. **(Feb 08, May 05)**

24. i. Derive the formula fpr insulation resistance of a UG cable.
    ii. In a coaxial cable the conductor diameter is 10 mm and the inner shath diameter is 50mm. There are two layers of insulation, the inner layer of dielectric constant 4 and a maximum working gradient of 6kV/mm has a radial thickness of 4.6 mm; the outer layer has dielectric constant 2.5 and maximum voltage gradient 5kV/mm. Calculate the maximum working voltage for the cable. **(Feb 08, Nov 07)**

25. i. A single core cable has an inner diameter of 5cms and a core diameter of 1.5cm. Its paper dielectric has a working maximum dielectric stress of 60kV/cm. Calculate the maximum permissible line voltage when such cables are used on a 3-phase power system.
    ii. A 66kV concentric cable with two inter sheaths has a core diameter 1.8 cm. Dielectric material 3.5mm thick constitutes the three zones of insulation. Determine the maximum stress in each of the three layers if 20kV is maintained across each of the inner two layers. **(Feb 08, Nov 07, 06, Mar 06)**

26. A single core cable has an inner diameter of 5cms and a core diameter of 1.5cm. Its paper dielectric has a working maximum dielectric stress of 60 kV/cm. Calculate the maximum permissible line voltage when such cables are used on a 3-phase power system. **(Feb 08, Nov 04)**

27. i. Derive the formula for dielectric stress in an UG cable.
    ii. Single-core, lead covered cable is to be designed for 66kV to earth. Its conductor radius is 10mm and its three insulating materials A,B and C have relative permittivities of 5,4 and 3 respectively and corresponding maximum permissible stresses of 3.8, 2.6 and 2.0 kV/mm (rms) respectively. Find the minimum diameter of the lead sheath. **(Feb 08, Nov 04)**

28* i. Show that in a three core belted cable the neutral capacitance to each conductor C^u is equal to C_S+3C_C where C_S and C_C are capacitance of each conductor to sheath and to each other respectively.
    ii. A single core 11 kV, 50Hz , 5 km long cable has a core diameter of 1.5 cm and diameter of under sheath 3.0 cm. The relative permittivity of the insulating material is 2.5. The power factor on open circuit is 0.04. Determine
    a. the capacitance of the cable
    b. charging per conductor
    c. dielectric loss
    d. The equivalent insulation resistance. **(Nov 13, Nov 07)**

29. i. Derive a formula for calculating the current rating of a cable.
    ii. Single core, lead covered cable is to be designed for 66 kV to earth. Its conductor radius is 10 mm and its three insulating materials A, B, and C have relative permittivity of 6, 5, and 4 respectively and the corresponding maximum permissible stress of 4.0, 3.0, and 2.0 kV/mm respectively. Find the maximum diameter of the lead sheath. **(Nov 07)**

30. i. Explain briefly intershedts grading of an UG cable.
ii. A circuit, 10km long, consists of three single core cables is connected to a 33kV, 3-phase, 50 Hz supply. The core of each cable is 10 mm diameter and the dielectric of relative permittivity 2.25, has a radial thickness of 6mm. If the total dielectric loss in the circuit is 10.5 kW and the capacitance to neutral of each cable is 2.55 μF, determine the loss angle of the dielectric. **(Nov 07)**

31. i. Give the list of various types of UG cables.
ii. Determine the operating voltage of a single core cable of diameter 2 cm and having three insulating material of permittivites 5, 4, 3. The overall diameter of the cable is 5cm and the maximum working stress is 40kV/cm. Compare the operating voltage with the voltage if the cable were not graded and the material with same working stress was used. **(Nov 06)**

32. i. Give merits and demerits of UG cables.
ii. The test results for 1km of a 3-phase metal sheathed belted cable gave a measured capacitance of 0.7μF between one conductor and the other two conductors bunched together with the earth sheath and 1.2μF measured between the three bunched conductor and the sheath. Find
a. the capacitance between any pair of conductors, the sheath being isolated
b. the charging current when the cable is connected to 11kV, 50Hz supply **(Nov 06)**

33. i. What do you mean by grading of cables? Explain briefly different types of grading of cables
ii. A conductor of 1 cm diameter passes centrally through a porcelain cylinder of internal diameter 2cms and external diaeter 7cms. The cylinder is surrounded by a tightly fitting metal sheath. The permittivity of porcelain is 5 and the peak voltage gradient in air must not exceed 34kV/cm. Determine the maximum safe working voltage. **(Nov 06)**

34. What are the limitations of solid type cables? How are these overcome in pressure Cables?

(June 06, 03, Nov 03)

35. i. What is the relation between the conductor diameter and breakdown potential of a cable while voltage of the cable and its overall diameter are fixed? Derive the same.
ii. The capacitance per kilometer of a 3 phase belted cable is 0.25μF between the two cores with the third core connected to the lead sheath. Calculate the charging current taken by five kilometers of this cable when connected to a 3 phase, 50Hz, 11kV supply. **(Mar 06)**

36. A single core lead covered cable is to be designed for 66kV to earth. Its conductor radius is 0.5cm and its three insulating material A,B and C have relative permittivities 4, 4.5 and 2.5 with maximum permissible stresses of 50,40 and 30 kV/cm respectively. Find the minimum internal diameter of the lead sheath. **(Mar 06)**

37. Determine the economical size of a single core cable working on 220kV, 3-phase system. The maximum permissible stress in the dielectric is not to exceed 250kV/cm. **(Mar 06)**

38. i. Explain with neat sketch, the general construction of a 3-conductor cable.
ii. Test results on a 25 km, 2-core single-phase metal-sheathed cable are as follows.
a. Capacitance per km between the cores bunched and the sheath is 100 μF.
b. With the sheath insulated, capacitance per km between the cores is 0.5μF.
c. Calculate the core-to-core capacitance assuming equal capacitance between each core and the sheath.
d. Also estimate the total charging current required for the cable when connected to 1 kw, 50 Hz supply mains. **(Mar 06)**

39. A single core cable has an inner diameter of 5cms and a core diameter of 1.5cm. Its paper dielectric has a working maximum dielectric stress of 60 kV/cm. Calculate the maximum permissible line voltage when such cables are used on a 3-phase power system. **(Nov 05, 04)**

40. i. What are the different types of losses taking place in Cables? Give brief account of them.
    ii. A single-core cable 5km long has an insulation resistance of 0.4 MW. The core diameter is 20 mm and the diameter of the cable over the insulation is 50mm. Calculate the resistivity of the insulating material. Derive the formula used. **(Nov 05)**

41. With a neat diagram, show the various parts of a high voltage single core cable. **(Nov05, 03)**

42. i. Explain the factors which decides the rating of a cable.
    ii. Classify the under ground cables according to various parameters. **(Nov 04)**

43. Single-core, lead sheathed cable joint has a conductor of 10mm diameter and two layers of different insulating materials, each 10mm thick. The relative permittivities are 3(inner) and 2.5(outer). Calculate the potential gradient at the surface of the conductor when the potential difference between the conductor and the lead sheathing is 60kV. **(Nov 04)**

44. Find the diametral dimensions for the I-core, metal-sheathed cable giving the greatest economy of insulating material for a working voltage of 85 kv, if a dielectric stress of 60 kv per cm can be allowed. **(Nov 03)**

45. i. A single core cable has conductor diameter of 40mm and the internal diameter of the lead sheath of 90mm. The cable is provided with two different insulating materials having relative permittivity 4.5 (inner), and 3.5 (outer) respectively. The corresponding maximum permissible electric stresses are 4.5 and 3.5 kv/mm.
    ii. Determine the radial thickness of the insulating materials required to confirm with the above specifications. Also find the safe operating voltage of the cable. **(Nov 03)**

46. Derive the expression for the insulation resistance of a single core cable. A 11kv, 50Hz, single-phase cable has a diameter of 10mm and an internal sheath radius of 15mm. If the dielectric has a relative permittivity of 24, determine for a 2.5 km length cable (i) the capacitance (ii) the charging current. **(Nov 03)**

47. Derive an expression for the capacitance of a single core cable. **(Nov 03, 02)**

48. The insulation resistance of a single core cable is 495M Ohms/km. If the core diameter is 2.5cm and resistivity of insulation is 4.5x1014 Ohm-cm. Find the insulation thickness. **(Nov 03)**

49. i. What are all insulating materials used in UG cables? Explain in detail about the different kinds of insulating materials
    ii. Determine the economical size of a single core cable working on 220 KV, 3 phase system, the maximum permissible stress in dielectric is not to exceed 250kV/cm **(Jun 03)**

50. i. What is the relation between the conductor diameter and break down potential of a cable while voltage of the cable and its overall diameter are fixed? Prove the same.
    ii. The capacitance per Km of a 3 phase belted cable is 0.25 micro farads between the two core with the third core connected to the lead sheath. Calculate the charging current taken by five Km of the cable when connected to a 3 phase, 50 Hz supply. **(Jun 03)**

51. i. Classify the underground cables according to various parameters.

ii. A 3-core, 11 kV Cable supplies a load of 1500 KW at 0.85 pf lag for 280 days in a year at an average of 9 hours per day. The capital cost per KM of the cable is Rs 8000a+20000. The resistance per Km of a cable of cross sectional area of 1 sq. cm is 0.173 ohms. If the energy loss cost per unit is 2 paisa and the rate of interest and depreciation is 12%.Calculate the most economical current density and dia of conductor. **(Jun 03)**

52. A single core cable is to be designed for 66kV to earth. Its conductor radius is 0.5 cm and its three insulating materials A, B and C have relative permittivity of 4, 4.5 and 2.5 with max. Permissible stresses of 50, 40 and 30 kV/cm respectively. Find the min internal diameter of the lead sheath. **(Jun 03)**

53. i. Describe with neat sketch the construction of 3-core belted cable. Discuss the limitation s of such a cable.
    ii. A 66 kV single core cable has a conductor diameter of 2.5cm and a sheath of inside diameter 6cm. Calculate the max stress. It is desired to reduce this stress by using two inter sheaths. Determine their best positions, the maximum stress and voltage on each. **(Nov 02)**

54. i. Prove that for a concentric cable of given dimension and given maximum potential gradient in the dielectric, the maximum permissible voltage between the core and the sheath is independent of the permittivity of the insulating material.
    ii. A single core 66kV cable working on a 3 phase system has a conductor diameter of 2 and a sheath inside diameter 5.5 cm. If the two inter sheath are introduced in such a way that the varies between the same maximum and minimum in the three layer find:
    a. Positions of the inter sheath
    b. Voltage on the inter sheath
    c. Maximum and minimum sheath **(Nov 02)**

55. i. Derive the expression for capacitance in the 3 phase cable?
    ii. cable has insulated with two insulating materials having permittivity of 6 and 4 respectively. The inner and outer dia of the cable are 3 and 7 cms. The dielectric stresses of 58 KV/cm and 28 KV/cm. Calculate the radial thickness of each insulating material and the safe working voltage of the cable
    (Nov 02)

56. i. Find the expression for capacitance and dielectric stress of a single core cable?
    ii. Derive expression for power in 3 phase in a 3 phase circuit using symmetrical components?**(Nov 02)**

57. The L/C ratio for 132 KV and 400 KV lines are tropically 160 x 103 and 62.5 x 103 respectively. That the natural 3-phase loading for the two lines? **(GATE 01)**

58. A 6.6kV, 50 hz single core lead-sheath cable has the following data:
    Conductor diameter: 1.5 cm, length : 4 km
    Internal diameter of the sheath : 3 cm
    resistivity of insulation : $1.3\text{x}10^{12}$ ohm-m
    Relative permittivity of insulation : 3.5
    Calculate
    i. insulation resistance
    ii. the capacitance
    iii. Themaximum electric stress in the insulation **(GATE 99)**

59. An overhead line is having a surge impedence of 400 ohm is connected in series with an underground cable having a surge impedence of 100 ohm. If a surge of 50KV travels from the line end towards the line cable junctions, the value of trasmitted voltage at the junction is ? **(GATE 99)**

60. The cable has the following charecteristics L=0.201 micro H/m and C=196.2pF/m. The velocity of the wave propagation through the cable is **(GATE 98)**

61. Why shunt capacitors are preferred over series capacitors for improvement of power factor in distribution systems? **(IES 03)**

62. Two long overhead transmission lines A and B having surge impedances of 400 ohms and 420 ohms respectively, are connected by a short underground cable C of surge impedance 50 ohms. A rectangular surge of magnitude 100 kV and of infinite length travels along A towards the cable C. Find out the surge voltage which is transmitted into the cable at the junction of A and C when the first reflected wave from the junction of C and B reaches the former junction. **(IES 02)**

Assignment Questions

Unit I

1. Derive an expression for the inductance per phase for a 3-phase over head transmission line
   i. Conductors are symmetrically placed
   ii. Conductors are unsymmetrical placed but the lines is completely transposed.
   iii. A three phase, 50 Hz overhead line has regularly transposed conductors equilaterally spaced 4 m apart. The capacitance of such a line is 0.01 micro F/Km. Recalculate the capacitance per Km to neutral when the conductors are in the same horizontal plane with successive spacing of 4 m and are regularly transposed.

2.. i. Name the important components of an overhead transmission line?
   ii. Discuss the various conductor materials used for overhead lines. What are their relative advantages and disadvantages?

3. What is symmetrical and asymmetrical spacing of conductors? What is the significance of symmetrical spacing of conductors?

4. i. How can the inductance of a bundled conductor line be calculated? Derive expressions for geometric mean radii of duplex, triplex and quadruplex arrangement.
   ii. Calculate the inductance per phase of a three-phase, double circuit line as shown in Figure. The diameter of each conductor is 1.5 cm

5. Find the loop inductance and reactacnce per km of a single phase overhead line consisting of two conductors each 1.213 cm diameter. The spacing between conductors is1.25 m and frequency is50 Hz.

Unit II

1. i. Explain clearly the `Ferranti effect' with a phasor diagram.
   ii. What is the purpose of an over head transmission line? How are these lines classified?
   iii. Discuss the terms voltage regulation and transmission efficiency as applied to transmission line.
2. A medium length power transmission line is represented as a nominal-equivalent circuit with lumped parameters. The total series impedance of the line is Z Ω and the total shunt capacitance is Y = jωC siemens. Derive equations for the sending end voltage and current and there from determine the ABCD constants of the line. Prove that AD-BC = 1.

3. i. Show how regulation and transmission efficiency are determined for medium lines using nominal - π method and illustrate your answer with suitable vector diagram.
   ii. An overhead 1-phase delivers a load of 1.5kW at 33kV at 0.9 p.f. lagging. The total resistance and inductance of the over head transmission line is 8ohms and 15ohms respectively. Determine the following: **(Feb 08)**
   a. Percentage of voltage regulation
   b. Sending end power factor
   c. Transmission efficiency.

4. i. Define regulation of a short 3-phase transmission system and develop an expression for approximate voltage regulation.
   ii. A balanced 3-phase load of 30MW is supplied at 132kV, 50Hz and 0.85 p.f. lagging by means of a transmission line. The series impedance of a single conductor is (20 + j52) ohms and the total phase-neutral admittance is 315 × 10^{-6} mho. Using nominal-T method, determine:
   a. The A, B, C and D constants of the line,
   b. Sending end voltage,
   c. Regulation of the line. **(Feb 08, Nov 07)**

Unit III

1. Evaluate the generalized circuit constants for long transmission lines.

2 Discuss the phenomenon of wave reflection and refraction. Derive expressions for reflection and refraction coefficients.

3. A surge of 120 KV travels on a line of surge impedance 450Ω and reaches the junction of the line with two branch lines. The surge impedance of branch lines are 400Ω and 40Ω. Find the transmitted voltage and currents.

4. What do you understand by long transmission lines? How capacitance effects are taken into account in such lines?

5. A surge of 200 KV traveling on a line of surge impedance 400Ω reaches a junction of the line with two branch lines of surge impedance 600Ω and 400Ω respectively. Find the surge voltage and current transmitted into each branch line. Also find the reflected surge voltage and current.

Unit IV

1. Starting from first principles show that surges behave as traveling waves. Find expressions for surge impedance and wave velocity.

2. i. Step wave of 100 KV travels on a line having a surge impedance of 400Ω. The line is terminated by an inductance of 4000μH. Find the voltage across the inductance and the reflected voltage wave.
   ii. Write short notes on Bewleys lattice diagram.

3. A unit step voltage surge is travelling on a long line of surge impedance Z_1. It reaches the junction with a cable of finite length whose far end is open. The cable has a surge impedance of Z_2 and the time of one-way wave travel on it is T. Draw the Bewley lattice diagram and find from it the value of voltage at the junction at time 4T after the surge reaches the line-cable junction. **(May 11)**

4. A 3-phase single circuit transmission line is 400 km long. If the line is rated for 220 KV and has the parameters R = 0.1 ohm/km, L = 1.26 mH/km, C = 0.009μF/km and G = 0, find

i. the surge impedance and
ii. the velocity of propagation neglecting the resistance of the line. If a surge of 150 KV and innitely long tail strikes at one end of the line, what is the time taken for the surge to travel to the other end of the line?

5. Derive reflection and refraction coefficient of transmission line when receiving end is open circuited.

Unit V

1. What is Ferranti effect? Deduce a simple expression for the voltage rise of an unloaded line. Also draw the corresponding vector diagram.

2. i. What are the factors which effect corona?
ii. Describe the various methods for reducing corona effect in an overhead transmission line?

3. i. What is corona?
ii. Explain the theory of corona formation in detail?

4. i. What is skin effect? Why is it absent in the D.C system?
ii. Determine the corona characteristics of a 3-phase, 50 Hz, 130 kv transmission line 100 km long running through terrain at an altitude of 600 meters, temp of 30^0C and barometric pressure 73 cm. The conductors are 1.5 cm diameter and spaced with equilateral spacing of 2.75 meters. Assume surface irregularity factor of 0.9 and m_y=0.75.

5. i. Define disruptive critical voltage and derive the expression for it?
ii. A three phase 220KV 50Hz transmission line consists of 1.2cm radius conductor spaced 2 meters apart in equilateral triangular formation. Find the disruptive critical voltage between the lines if the temperature is 20^0C and atmospheric pressure is 72.2cm. Take m_o=0.96.Dielectric strength of air=21.1KV (rms)/cm?

Unit VI

1. i. Name the different types of insulators used for transmission and distribution systems.
ii. Determine the voltage across each unit of sting suspension insulators consisting of 3 similar units. The voltage between the line and earth is 33 kV and the ratio of the capacitance of each unit and capacitance between pin to earth is 8:1.

2. i. Explain the use of grading rings and arcing horns on suspension insulators.
ii. A string consisting of seven suspension discs is fitted with a grading ring. Each pin to earth capacitance is C. If the voltage distribution is uniform, determine the values of line to pin capacitance.

3. i. Explain with neat sketch, the constructional features of pin type insulator.
ii. A string of suspension insulators consisting of 5 units each having capacitance C. The capacitance between each unit and earth is 1/4th of C. nd the voltage distribution in the each insulator in the string as a percentage of voltage of conductor to earth. If the insulators in the string are designed each to withstand 30 kV maximum. Find the operating voltage of the line where 5 suspension insulator strings can be used.

4. i. Explain why the potential distribution is not, in general, uniform over the string in suspension type of insulators.

ii. A string of suspension insulator consists of four units and the capacitance to ground is 12 percent of its mutual capacitance. Determine the voltage across each unit as a fraction of the operating voltage. Also determine the string efficiency.

5. i. List the advantages of suspension type insulators over pin type insulators.
   ii. A string of 5 insulator units has a self-capacitance equal to 11 times the pin to earth capacitance. Find the string efficiency?

Unit VII

1. i. Prove transmission line conductor between two supports at equal heights takes the form of a catenary.
   ii. A transmission line conductor at a river crossing is supported by two towers at heights of 50 and 80 meters above water level. The horizontal distance between the towers is 300 meters. If the tension in the conductor is 2000 kg, determine the clearance between the conductors and water at a point midway between the towers.
2. i. What are disadvantages of providing too much or too small sag in a transmission line? Name different types of line supports with their place of use.
   ii. A transmission line conductor with diameter 14.77 mm, cross-sectional area of 120 mm^2, weighing 1118 kg/km has a span of 200 meters. The supporting structures being level. The conductor has an ultimate tensile stress of 42.2 kg/mm^2 and allowable tension is not to exceed ¼ of ultimate strength.
   Determine the following:
   a. Sag in still air
   b. Sag with a wind pressure of 60 kg/m^2 and an ice coating of 10 mm. Also calculate the

3. Derive the expressions for sag and tension when the supports are at unequal heights.

4. A transmission line conductor having a dia of 19.5mm weighs 0.85kg/m. The span is 275 meters. The wind pressure is 40kg/m2 of projected area with ice coating of 13mm. The ultimate strength of the conductor is 8000Kg. Calculate the maximum sag, if the factor of safety is 2 and ice weighs 91 Okg/m3.

5. i. Deduce expressions for calculating sag and conductor length for an OH line when the supports are at same level.
   ii. What is sag template? What is its use?

Unit VIII

1. What is meant by capacitance grading of a cable ?
2. Explain the factors which decide the rating of a cable.
3. Classify the under ground cables according to various parameters

4. i.State the classification of cables (according to voltage) and discuss their general construction
   ii.Explain carefully the constructional difference between and application of
   a. deleted
   b. screened (H type)
   c. S.L and
   d. H.S.L types of cables.
   iii.Write a short note on pressure cables.

5. i) Explain the intersheath grading of cable.

ii.A cable has intersheath grading that satisfies the equation, $R/r_1 = r_1/r = \alpha$. The core and cable radii are r =1.2 cm and R = 3 cm. Determine the location of the intersheath and also calculate the ratio of maximum electric field strengths with and without intersheath grading.