PURNEA COLLEGE OF ENGINEERING
PURNEA

COURSE FILE

OF

POWER SYSTEM-I

(100507)

Faculty Name:

Mr. Tabish Shanu
Assistant Professor
Department of Electrical Engineering

VISION & MISSION OF THE INSTITUTE

Vision of The Institute

To consistently strive for excellence in engineering education by producing skilled, trained and knowledge-driven engineers who fit into the current and future requirements of industries, organizations, and society thereby contributing to the sustainable growth of the country.

Mission of The Institute

M1: To improve teaching-learning process while making the existing curriculum more contemporary and in keeping with the requirements of the industry.

M2: To create an environment for fostering research and development.

M3: To develop students' soft skills, ethical values, leadership qualities, reasoning and analytical abilities and motivate them to address engineering needs of neighboring area.

VISION & MISSION OF THE DEPARTMENT

Vision of the Department

To produce competent electrical engineers with ethical values addressing the challenges in the field of education, industry, and research for the sustainable growth of nation.

Mission of the Department

M1: To create an environment for quality technical education and produce engineers who will contribute meaningfully to the growth and development of the country.

M2: To engage the students in research & development in cutting edge and sustainable technologies.

M3: To develop professional skills, ethical values, and leadership qualities to address the needs of neighbouring areas in terms of engineering and technical support.

Programme Outcomes (PO)

PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEO (Program Educational Objective)

Graduates of the program will be able to:

PEO1: Establish their careers in the field of Electrical Engineering and related areas, providing innovative and effective solutions.

PEO2: Establish themselves as entrepreneur, work in research and development organization and pursue higher education.

PEO3: Manage projects catering to current societal and industrial needs in an ethical manner as a member/leader of multidisciplinary teams.

PSO (Program Specific Outcome)

Upon satisfactory completion of the program, a student will be able to:

PSO-1: Identify, analyze, and solve real-life problems by applying the knowledge in Electrical Engineering.

PSO-2: Design and develop electrical systems with the help of automation tools to excel in the field of Electrical engineering.

PSO-3: Find solutions to the issues faced by society through engineering and technological innovations while upholding professional ethics and social values.

COURSE OBJECTIVE AND COURSE OUTCOMES:

Institute / College Name :	Purnea College of Engineering		
Program Name	**B. Tech (Electrical Engineering)**		
COURSE CODE	100507		
COURSE NAME	**POWER SYSTEM-I**		
Lecture / Tutorial / Practical (per week):	3-0-2	**Course Credits**	5
Course Coordinator Name	Mr. Tabish Shanu		

Course Objectives: Power Systems–I

The course provides an understanding of modern power systems, including their evolution, structure, and components such as generation sources, grids, and energy storage. It covers transmission and distribution systems, three-phase circuits, power transfer, and effects like skin and Ferranti. The course also focuses on transmission lines, cables, and performance improvement techniques. It introduces transformers, synchronous machines, load characteristics, and per-unit analysis. Additionally, it explains over-voltages, surge protection, and insulation coordination. Finally, it covers DC transmission and the integration of renewable energy systems like solar PV and wind with power electronic interfaces.

Course outcomes (CO):

CO1	Able to understand the Generation, transmission and Distribution of Power System
CO2	Able to understand the various Power system components
CO3	Able to understand the concept of Power System Network
CO4	Able to understand the basic protection scheme and insulation coordination
CO5	Able to understand the concepts of HVDC Power transmission and renewable energy sources

MAPPING OF COs AND POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	2	2	1	1	0	0	0	0	1	3	2	1
CO2	2	1	2	2	1	1	1	0	0	0	0	1	3	2	2
CO3	2	2	2	2	2	1	1	0	0	0	0	1	3	2	2
CO4	1	2	2	2	1	1	0	0	0	0	0	1	3	1	3
CO5	2	2	1	1	1	1	1	0	0	0	0	1	2	2	3

Correlation level: 1- slight (Low) 2- moderate (Medium) 3-substantial (High)

COURSE OUTCOMES:

COURSE OUTCOMES		POs / PSOs	Classroom Session (Hrs)
CO1	To understand the structure and operation of modern power systems including generation, microgrids, and energy storage	PO-1,2,3,4,5,6,7,12 PSO-1,2,3	13
CO2	To apply three-phase circuit concepts, power flow in transmission and distribution systems.	PO-1,2,3,4,5,6,7,12 PSO-1,2,3	8
CO3	To analyze transmission line parameters, performance, and compensation techniques.	PO-1,2,3,4,5,6,7,12 PSO-1,2,3	8
CO4	To evaluate the performance of transformers and synchronous machines using equivalent and per-unit models.	PO-1,2,3,4,5,6,12 PSO-1,2,3	5
CO5	To understand and assess solutions for over-voltage protection, HVDC transmission, and renewable energy integration.	PO-1,2,3,4,5,6,7,12 PSO-1,2,3	8

PO'S / PSO'S ADDRESSED BY COS & MAPPING STRENGTH WITH COURSE

PO/PSO	CO	No. of Sessions	% of session	Mapping Strength
PO1	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PO2	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PO3	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PO4	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PO5	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PO6	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PO7	CO1, CO2, CO3, CO5,	13+8+8+8	88	3
PO8	-	-	0	1
PO9	-	-	0	1
PO10	-	-	0	1
PO11	-	-	0	1
PO12	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PSO1	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PSO2	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PSO3	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3

S. No.	Percentage of Session	Mapping Strength
1	> 70	3
2	30 - 70	2
3	< 30	1

PS-I (100507)	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
Mapping Strength	3	3	3	3	3	3	3	1	1	1	1	3	3	3	3

SYLLABUS:

Topics	Number of Lectures	Weightage (%)
Basic Concepts Evolution of Power Systems and Present-Day Scenario. Structure of a power system: Bulk Power Grids and Micro-grids. Generation: Conventional and Renewable Energy Sources. Distributed Energy Resources. Energy Storage.	**6**	14
Transmission and Distribution Systems Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems). Synchronous Grids and Asynchronous (DC) interconnections. Review of Three-phase systems. Analysis of simple three-phase circuits. Power Transfer in AC circuits and Reactive Power. Skin effect and Ferranti effect.	**7**	17
Power System Components Overhead Transmission Lines and Cables: Electrical and Magnetic Fields around conductors, Corona. Parameters of lines and cables. Capacitance and Inductance calculations for simple configurations. Travelling-wave Equations. Sinusoidal Steady state representation of Lines: Short, medium and long lines. Power Transfer, Voltage profile and Reactive Power. Characteristics of transmission lines. Surge Impedance Loading. Series and Shunt Compensation of transmission lines.	**8**	19
Transformers Three-phase connections and Phase-shifts. Three-winding transformers, auto transformers, Neutral Grounding transformers. Tap-Changing in transformers. Transformer Parameters. Single phase equivalent of three-phase transformers. Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus. Real and Reactive Power Capability Curve of generators. Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits. Loads: Types, Voltage and Frequency Dependence of Loads. Per-unit System and per-unit calculations	**8**	19
Over-voltages and Insulation Requirements Generation of Over-voltages: Lightning and Switching Surges. Protection against Over-voltages, Insulation Coordination. Propagation of Surges. Voltages produced by traveling surges. Bewley Diagrams.	**5**	12
Introduction to DC Transmission & Renewable Energy Systems DC Transmission Systems: Line-Commutated Converters (LCC) and Voltage Source Converters (VSC). LCC and VSC based dc link, Real Power Flow control in a dc link. Comparison of ac and dc transmission. Solar PV systems: I-V and P-V characteristics of PV panels, power electronic interface of PV to the grid. Wind Energy Systems: Power curve of wind turbine. Fixed and variable speed turbines. Permanent Magnetic Synchronous Generators and Induction Generators. Power Electronics interfaces of wind generators to the grid.	**8**	19
Total``	**42**	100%

TIME TABLE

B.Tech. 5th Semester, Electrical Engineering Department

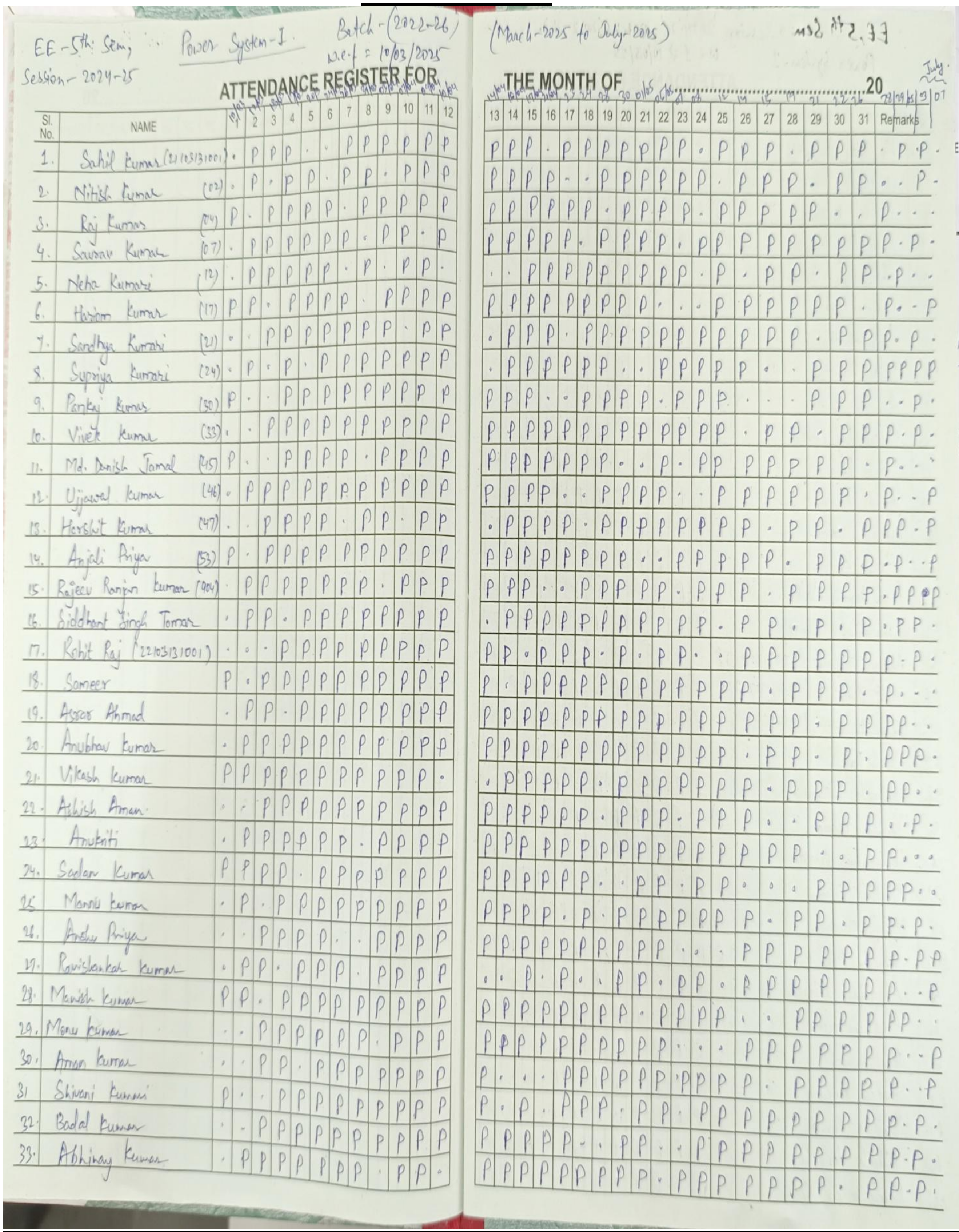
ROOM NO. 208, wef- 10/03/2025, Batch-2022-26						
	10:00 - 10:50	10:50 - 11:40	11:40 - 12:30	12:30 – 1: 20	1:20 – 2:00	2-4:30pm
MON	PS-I				R	
TUES					E	PS-I Lab
WED			PS-I		C	
THUR		PS-I			E	
FRI					S	
SAT		PS-I Lab			S	
Faculty Name : Tabish Shanu						

List of Students-

Sl No	Name	Registration No
1	Sahil Kumar	21103131001
2	Nitish Kumar	21103131002
3	Raj Kumar	21103131004
4	Saurav Kumar	21103131007
5	Neha Kumari	21103131012
6	Hariom Kumar	21103131017
7	Sandhya Kumari	21103131021
8	Supriya Kumari	21103131024
9	Pankaj Kumar	21103131030
10	Vivek Kumar	21103131033
11	Md Danish Jamal	21103131045
12	Ujjwal Kumar	21103131046
13	Harshit Kumar	21103131047
14	Anjali Priya	21103131053
15	Rohit Raj	22103131001
16	Sameer	22103131002
17	Asrar Ahmad	22103131003
18	Anubhav Kumar	22103131004
19	Vikash Kumar	22103131006
20	Ashish Aman	22103131008
21	Anukriti	22103131009
22	Sadan Kumar	22103131010
23	Mannu Kumar	22103131011
24	Anshu Priya	22103131012
25	Ravishankar Kumar	22103131013
26	Manish Kumar	22103131014
27	Monu Kumar	22103131015
28	Aman Kumar	22103131017
29	Shivani Kumari	22103131018
30	Badal Kumar	22103131019
31	Abhinay Kumar	22103131020
32	Anushka Singh	22103131023
33	Utkarsh Jha	22103131025
34	Komal Kumar	22103131027
35	Soni Priya	22103131029
36	Ghanshyam Kumar	22103131030

37	Suman Kumar	22103131032
38	Shivam Kumar	22103131033
39	Vijay Kumar	22103131034
40	Ashish Kumar	22103131035
41	Ankit Raj Prince	22103131036
42	Nisha Kumari	22103131037
43	Rohit Kumar	22103131038
44	Sakshi Suman	22103131039
45	Aryan Kumar	22103131040
46	Pintu Kumar Yadav	22103131042
47	Parmeshwari Bharti	22103131043
48	Abhay Kumar	22103131044
49	Rajeev Ranjan Kumar	22103131904
50	Siddhant Singh Tomar	22103131907
51	Silki Kumari	22103131911
52	Neha Kumari	23103131901
53	Yash Raj	23103131902
54	Satimala Kumari	23103131903
55	Avinash Kumar	23103131904
56	Priyanshu Bharti	23103131905
57	Shivani Kumari	23103131906
58	Vijay Kumar	23103131907
59	Khushi Anand	23103131908
60	Anupriya Kumari	23103131909
61	Muskan Kumari	23103131910
62	Rajlakshmi	23103131911
63	Shweta Kumari	23103131912
64	Yamika Bharti	23103131913
65	Ritesh Kumar	23103131914
66	Ramesh Kumar Sah	23103131915
67	Krishan Kumar	23103131916
68	Kundan Kumar Yadav	23103131917
69	Kanhaiya Kumar	23103131918
70	Vikas Kumar Ram	23103131919

ATTENDANCE



EE - 5th Sem, Power System - I. Batch - (2022-26)
w.e.f = 10/03/2025
Session - 2024-25

ATTENDANCE REGISTER FOR THE MONTH OF .... 20 (March-2025 to July-2025)

Sl. No.	NAME	1	2	3	4	5	6	7	8	9	10	11	12
1.	Sahil Kumar (21103131001)	.	P	P	P	.	.	P	P	P	P	P	P
2.	Nitish Kumar (02)	.	P	.	P	P	.	P	P	.	P	P	P
3.	Raj Kumar (04)	P	.	P	P	P	P	.	P	P	P	P	P
4.	Saurav Kumar (07)	.	P	P	P	P	P	P	.	P	P	.	P
5.	Neha Kumari (12)	.	P	P	P	P	P	.	P	.	P	P	.
6.	Hariom Kumar (17)	P	P	.	P	P	P	P	.	P	P	P	P
7.	Sandhya Kumari (21)	.	.	P	P	P	P	P	P	P	.	P	P
8.	Supriya Kumari (24)	.	P	.	P	.	P	P	P	P	P	P	P
9.	Pankaj Kumar (30)	P	.	.	P	P	P	P	P	P	P	P	P
10.	Vivek Kumar (33)	.	.	P	P	P	P	P	P	P	P	P	P
11.	Md. Danish Jamal (45)	P	.	.	P	P	P	P	.	P	P	P	P
12.	Ujjawal Kumar (46)	.	P	P	P	P	P	P	P	P	P	P	P
13.	Harshit Kumar (47)	.	.	P	P	P	P	.	P	P	.	P	P
14.	Anjali Priya (53)	P	.	P	P	P	P	P	P	P	P	P	P
15.	Rajeev Ranjan Kumar (904)	.	P	P	P	P	P	P	P	.	P	P	P
16.	Siddhant Singh Tomar	.	P	P	.	P	P	P	P	P	P	P	P
17.	Rohit Raj (22103131001)	.	.	.	P	P	P	P	P	P	P	P	P
18.	Sameer	P	.	P	P	P	P	P	P	P	P	P	P
19.	Asrar Ahmad	.	P	P	.	P	P	P	P	P	P	P	P
20.	Anubhav Kumar	.	P	P	P	P	P	P	P	P	P	P	P
21.	Vikash Kumar	P	P	P	P	P	P	P	P	P	P	P	.
22.	Ashish Aman	.	.	P	P	P	P	P	P	P	P	P	P
23.	Anukriti	.	P	P	P	P	P	P	.	P	P	P	P
24.	Sadan Kumar	P	P	P	P	.	P	P	P	P	P	P	P
25.	Monnu Kumar	.	P	.	P	P	P	P	P	P	P	P	P
26.	Anshu Priya	.	.	P	P	P	P	.	.	P	P	P	P
27.	Ravishankar Kumar	.	P	P	.	P	P	P	.	P	P	P	P
28.	Manish Kumar	P	P	.	P	P	P	P	P	P	P	P	P
29.	Monu Kumar	.	.	P	P	P	P	P	P	.	P	P	P
30.	Aman Kumar	.	.	P	P	.	P	P	P	P	P	P	P
31	Shivani Kumari	P	.	.	P	P	P	P	P	P	P	P	P
32.	Badal Kumar	.	.	P	P	P	P	P	P	P	P	P	P
33.	Abhinay Kumar	.	P	P	P	P	P	P	P	.	P	P	.

Sl. No.	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Remarks
1.	P	P	P	.	P	P	P	P	P	P	P	.	P	P	P	.	P	P	P	. P . P .
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3.	P	P	P	P	P	P	.	P	P	P	P	.	P	P	P	P	P	.	.	P . . .
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5.	.	.	P	P	P	P	P	P	P	P	P	.	P	.	P	P	.	P	P	. P . .
6.	P	P	P	P	P	P	P	P	P	.	.	.	P	P	P	P	P	P	.	P . - P
7.	.	P	P	P	.	P	P	P	P	P	P	P	P	P	P	P	.	P	P	P . P .
8.	.	P	P	P	P	P	P	.	.	P	P	P	P	P	.	.	P	P	P	P P P P
9.	P	P	P	.	.	P	P	P	P	.	P	P	P	.	.	.	P	P	P	. . P .
10.	P	P	P	P	P	P	P	P	P	P	P	P	P	.	P	P	.	P	P	P . P .
11.	P	P	P	P	P	P	P	.	.	P	.	P	P	P	P	P	P	P	.	P . . .
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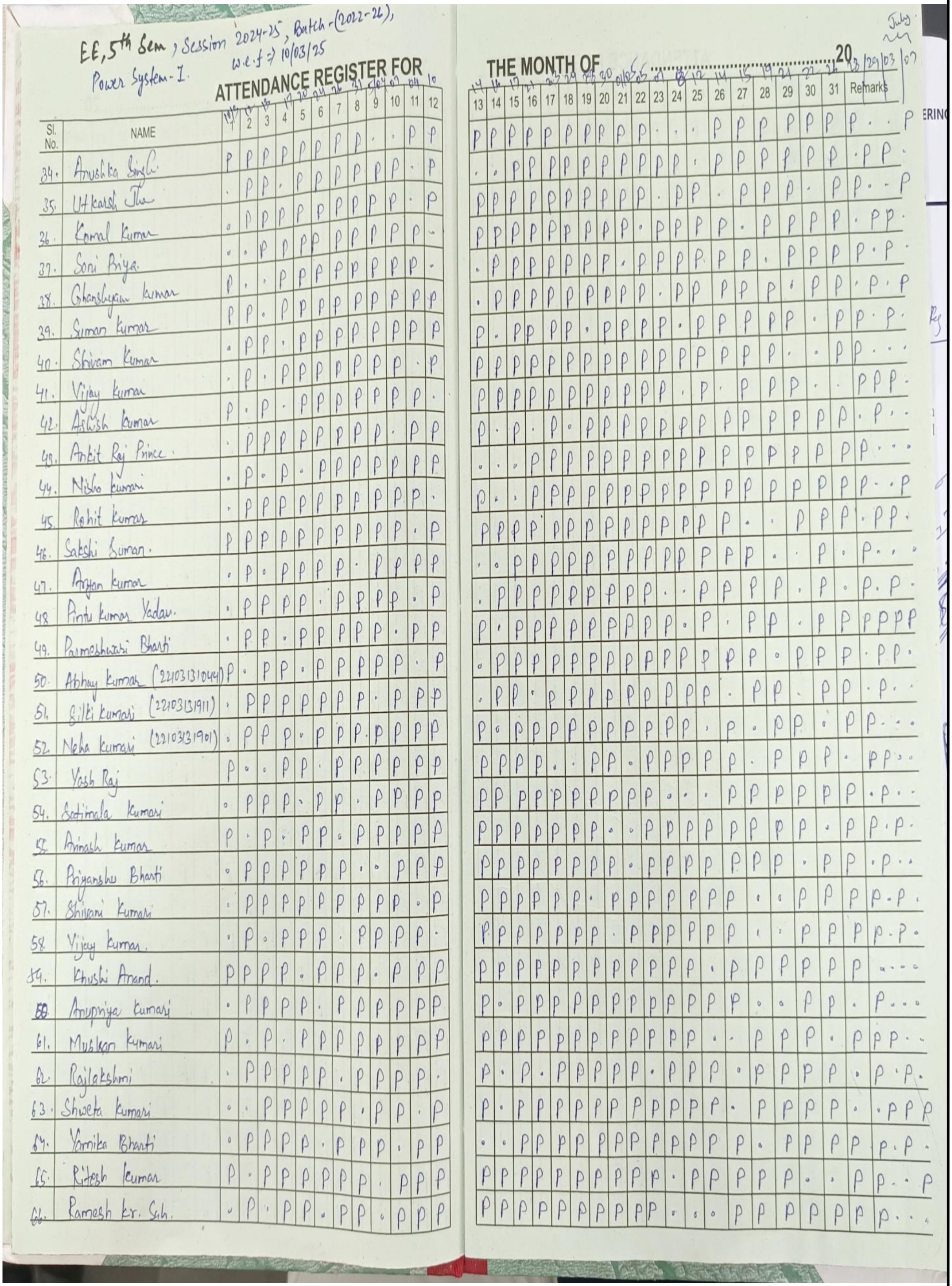
13.	.	P	P	P	P	.	P	P	P	P	P	P	P	P	.	P	P	.	P	P P . P
14.	P	P	P	P	P	P	P	P	.	.	P	P	P	P	P	.	P	P	P	. P . . P
15.	P	P	P	.	.	P	P	P	P	P	.	P	P	P	.	P	P	P	P	. P P P P
16.	.	P	P	P	P	P	P	P	P	P	P	P	.	P	P	.	P	.	P	. P P .
17.	P	P	.	P	P	P	.	P	.	P	P	.	.	P	P	P	P	P	P	P . P .
18.	P	.	P	P	P	P	P	P	P	P	P	P	P	P	.	P	P	P	.	P . . .
19.	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	.	P	P	P P . .
20.	P	P	P	P	P	P	P	P	P	P	P	P	P	.	P	P	.	P	.	P P P .
21.	.	P	P	P	P	P	.	P	P	P	P	P	P	P	.	P	P	P	.	P P . .
22.	P	P	P	P	P	P	.	P	P	P	.	P	P	P	.	.	P	P	P	. . P .
23.	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	.	.	P	P	P . . .
24.	P	P	P	P	P	P	.	.	P	P	.	P	P	.	.	.	P	P	P	P P . .
25.	P	P	P	P	.	P	.	P	P	P	P	P	P	P	.	P	P	.	P	P . P .
26.	P	P	P	P	P	P	P	P	P	P	.	.	.	P	P	P	P	P	P	P . P P
27.	.	.	P	.	P	.	.	P	P	.	P	P	.	P	P	P	P	P	P	P . . P
28.	P	P	P	P	P	P	P	P	.	P	P	P	P	.	.	P	P	P	P	P P . .
29.	P	P	P	P	P	P	P	P	P	P	.	.	.	P	P	P	P	P	P	P . . P
30.	P	.	.	.	P	P	P	P	P	P	P	P	P	P	.	P	P	P	P	P . . P
31	P	.	P	.	P	P	P	.	P	P	.	P	P	P	P	P	P	P	P	P . P .
32.	P	P	P	P	P	.	.	P	P	.	.	P	P	P	P	P	P	P	P	P . P .
33.	P	P	P	P	P	P	P	P	P	.	P	P	P	P	P	P	P	.	P	P . P .



EE, 5th Sem, Session 2024-25, Batch-(2022-26),
Power System-I.
w.e.f ⇒ 10/03/25

ATTENDANCE REGISTER FOR THE MONTH OF .... 20..

Sl. No.	NAME
34.	Anushka Singh
35.	Utkarsh Jha
36.	Komal Kumar
37.	Soni Priya.
38.	Ghanshyam kumar
39.	Suman Kumar
40.	Shivam Kumar
41.	Vijay kumar
42.	Ashish kumar
43.	Ankit Raj Prince.
44.	Nisha kumari
45.	Rohit kumar
46.	Sakshi Suman.
47.	Aryan kumar
48	Pintu kumar Yadav.
49.	Parmeshwari Bharti
50.	Abhay kumar (22103131044)
51.	Silki kumari (22103131911)
52.	Neha kumari (22103131901)
53.	Yash Raj
54.	Satimala Kumari
55.	Avinash kumar
56.	Priyanshu Bharti
57.	Shivani Kumari
58	Vijay kumar.
59.	Khushi Anand.
60.	Anupriya kumari
61.	Muskan Kumari
62.	Rajlakshmi
63.	Shweta kumari
64.	Yamika Bharti
65.	Ritesh kumar
66.	Ramesh kr. Sah.

ATTENDANCE REGISTER FOR THE MONTH OF 20

July

Sl. No.	NAME	1	2	3	4	5	6	7	8	9	10	11	12
		10/12	12	13	17	20	24	26	31	2/01	07	09	10
67.	Krishan kumar	P	P	P	P	P	P	P	P	·	·	P	P
68.	Kundan kr.	·	P	P	P	P	P	P	·	P	P	P	·
69.	Kanhaiya kr.	P	P	·	P	P	P	P	·	P	P	·	P
70.	Vikas kr. Ram (919)	P	·	P	P	·	P	P	P	·	·	·	P

Sl. No.	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Remarks
	14	16	17	21	23	24	28	30	01/05	06	07	08	12	14	15	19	21	22	26	28 / 29 / 03 / 07
67.	P	P	P	·	P	P	P	P	P	P	P	·	P	P	P	P	P	P	P	· · · ·
68.	P	P	P	P	·	P	P	·	·	P	P	P	P	P	P	P	P	·	P	P · · ·
69.	·	P	P	P	·	·	P	P	P	P	P	P	·	·	P	P	P	P	P	· P · ·
70.	P	P	P	P	P	P	P	P	P	·	·	P	P	P	P	P	P	·	·	P P · P

Lecture Plan

Text/ Reference:-

1. J. Grainger and W. D. Stevenson, "Power System Analysis", McGraw Hill Education, 1994.
2. O. I. Elgerd, "Electric Energy Systems Theory", McGraw Hill Education, 1995.
3. A. R. Bergen and V. Vittal, "Power System Analysis", Pearson Education Inc., 1999.
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Lecture No.	Topics
1-2	Evolution of Power Systems and Present-Day Scenario
3	Structure of a power system: Bulk Power Grids and Micro-grids
4-6	Generation: Conventional and Renewable Energy Sources. Distributed Energy Resources. Energy Storage.
7-8	Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems).
9-10	Synchronous Grids and Asynchronous (DC) interconnections. Review of Three-phase systems.
11-12	Analysis of simple three-phase circuits. Power Transfer in AC circuits and Reactive Power.
13	Skin effect and Ferranti effect.
14-15	Overhead Transmission Lines and Cables: Electrical and Magnetic Fields around conductors, Corona. Parameters of lines and cables.
16-17	Capacitance and Inductance calculations for simple configurations.
18-19	Travelling-wave Equations. Sinusoidal Steady state representation of Lines: Short, medium and long lines.
20-21	Power Transfer, Voltage profile and Reactive Power. Characteristics of transmission lines. Surge Impedance Loading. Series and Shunt Compensation of transmission lines.
22-23	Three-phase connections and Phase-shifts. Three-winding transformers, auto transformers, Neutral Grounding transformers. Tap-Changing in transformers. Transformer Parameters. Single phase equivalent of three-phase transformers.
24-27	Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus. Real and Reactive Power Capability Curve of generators. Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits.
28-29	Loads: Types, Voltage and Frequency Dependence of Loads. Per-unit System and per-unit calculations
30-31	Generation of Over-voltages: Lightning and Switching Surges. Protection against Over-voltages, Insulation Coordination.
32-34	Propagation of Surges. Voltages produced by traveling surges. Bewley Diagrams.
35-37	DC Transmission Systems: Line-Commutated Converters (LCC) and Voltage Source Converters (VSC). LCC and VSC based dc link, Real Power Flow control in a dc link. Comparison of ac and dc transmission.
28-40	Solar PV systems: I-V and P-V characteristics of PV panels, power electronic interface of PV to the grid. Wind Energy Systems: Power curve of wind turbine. Fixed and variable speed turbines.
41-42	Permanent Magnetic Synchronous Generators and Induction Generators. Power Electronics interfaces of wind generators to the grid.

Topics	Lecture Covered	CO covered
Evolution of Power Systems and Present-Day Scenario.	1	CO1
Present-Day Scenario	2	CO1
Structure of a power system	3	CO1
Bulk Power Grids and Micro-grids.	4	CO1
Generation: Conventional and Renewable Energy Sources	5	CO1
Distributed Energy Resources. Energy Storage.	6	CO1
Line diagrams	7	CO2
transmission and distribution voltage levels and topologies (meshed and radial systems)	8	CO2
Synchronous Grids	9	CO2
Asynchronous (DC) interconnections.	10	CO2
Review of Three-phase systems	11	CO2
Analysis of simple three-phase circuits.	12	CO2
Power Transfer in AC circuits and Reactive Power. Skin effect and Ferranti effect.	13	CO2
Overhead Transmission Lines and Cables	14	CO3
Electrical and Magnetic Fields around conductors, Corona.	15	CO3
Parameters of lines and cables.	16	CO3
Capacitance and Inductance calculations for simple configurations.	17	CO3
Travelling-wave Equations. Sinusoidal Steady state representation of Lines: Short, medium and long lines.	18	CO3
Power Transfer, Voltage profile and Reactive Power	19	CO3
Characteristics of transmission lines.	20	CO3
Surge Impedance Loading.	21	CO3
Series and Shunt Compensation of transmission lines.	22	CO4
Three-phase connections and Phase-shifts.	23	CO4
Three-winding transformers, auto transformers, Neutral Grounding transformers.	24	CO4
Tap-Changing in transformers. Transformer Parameters. Single phase equivalent of three-phase transformers.	25	CO4
Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus.	26	CO4
Real and Reactive Power Capability Curve of generators.	27	CO4
Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits.	28	CO4
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Protection against Over-voltages, Insulation Coordination.	32	CO5
Propagation of Surges. Voltages produced by traveling surges.	33	CO5

Bewley Diagrams.	**34**	**CO5**
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Line-Commutated Converters (LCC) and Voltage Source Converters (VSC).	**36**	**CO5**
LCC and VSC based dc link, Real Power Flow control in a dc link.	**37**	**CO5**
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Fixed and variable speed turbines. Permanent Magnetic Synchronous Generators and Induction Generators.	**41**	**CO5**
Power Electronics interfaces of wind generators to the grid.	**42**	**CO5**

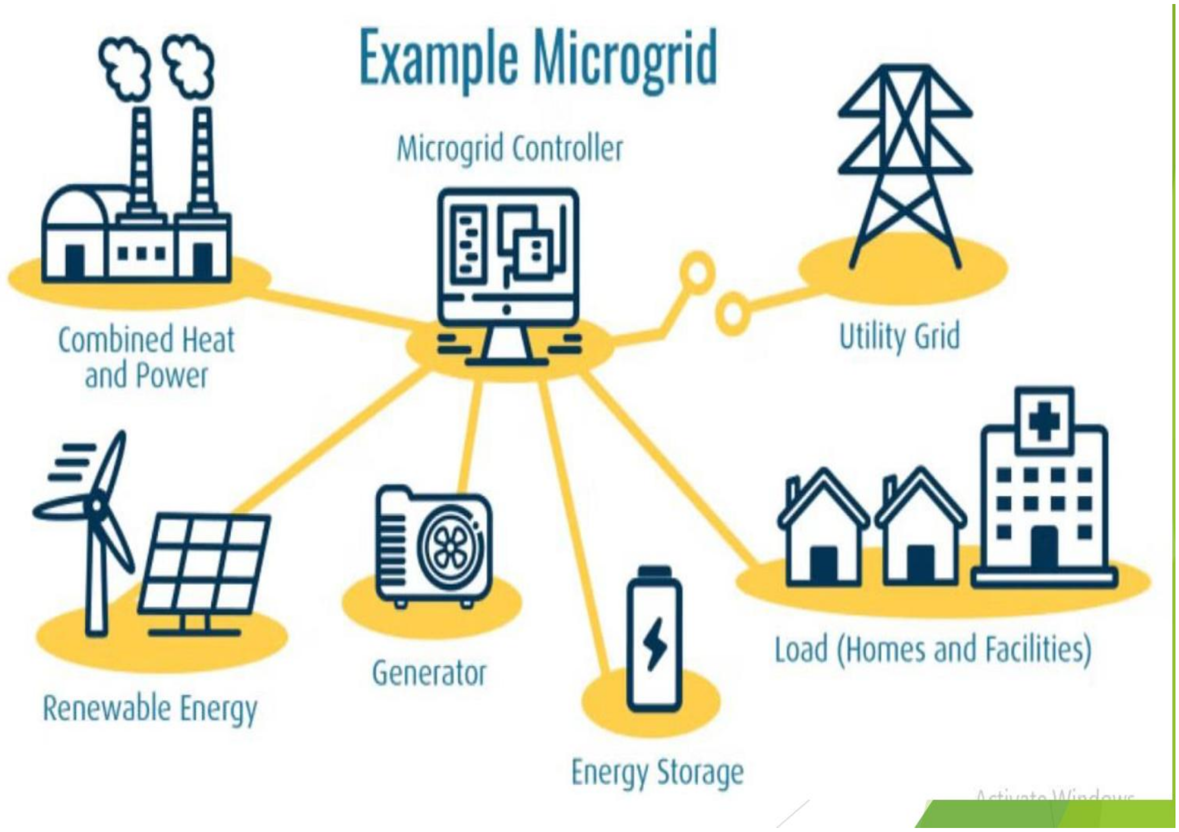
Lecture Notes

	Category		Installed Generation Capacity (GW)		% Share in Total
Fossil Fuel	Coal		210.970		47.4%
Fossil Fuel	Lignite		6.620		1.5%
Fossil Fuel	Gas		24.818		5.6%
Fossil Fuel	Diesel		0.589		0.1%
Fossil Fuel	**Total Fossil Fuel :**		**242.997**		**54.6%**
Non-Fossil Fuel	RES (Incl. Hydro)		193.580		43.5%
Non-Fossil Fuel	Hydro	46.928		10.6%	
Non-Fossil Fuel	Wind, Solar & Other RE	146.652		33.0%	
Non-Fossil Fuel	Wind	46.422		10.4%	
Non-Fossil Fuel	Solar	84.277		18.9%	
Non-Fossil Fuel	BM Power/Cogen.	10.355		2.3%	
Non-Fossil Fuel	Waste to Energy	0.591		0.1%	
Non-Fossil Fuel	Small Hydro Power	5.005		1.1%	
Non-Fossil Fuel	Nuclear		8.180		1.8%
Non-Fossil Fuel	**Total Non-Fossil Fuel :**		**201.760**		**45.4%**
	Total Installed Capacity (Fossil Fuel & Non-Fossil Fuel)		**444.757**		**100%**

- Nuclear power is the seventh-largest source of electricity in India.
- As of November 2024, India has 25 nuclear reactors in operation in 8 nuclear power plants, with a total installed capacity of 8,180 MW.

Bulk power grid-

- A bulk power grid, also known as a bulk power system (BPS), is a large, interconnected network of electrical generation, transmission, and distribution facilities designed to supply electricity to a large area or entire nation, transporting high-voltage electricity from power plants to substations.
- The facilities and control systems are necessary for operating an integral electric energy transmission network and maintaining transmission system reliability. Together these components generate and deliver electricity to customers



Microgrid

- A **microgrid** is a small, localized power grid that can operate independently or in conjunction with the main electrical grid. It consists of **distributed energy resources (DERs)** such as solar panels, wind turbines, batteries, and backup generators, along with **smart controls** to manage electricity flow efficiently.

Key Features of a Microgrid--

- **Self-Sufficient** – Can function autonomously (off-grid mode) or connect to the main grid (grid-tied mode).
- **Distributed Generation** – Uses local energy sources like solar, wind, or diesel generators.
- **Energy Storage** – Often includes batteries for backup and load balancing.
- **Smart Control Systems** – Monitors energy production, consumption, and grid stability.

Types of Microgrids

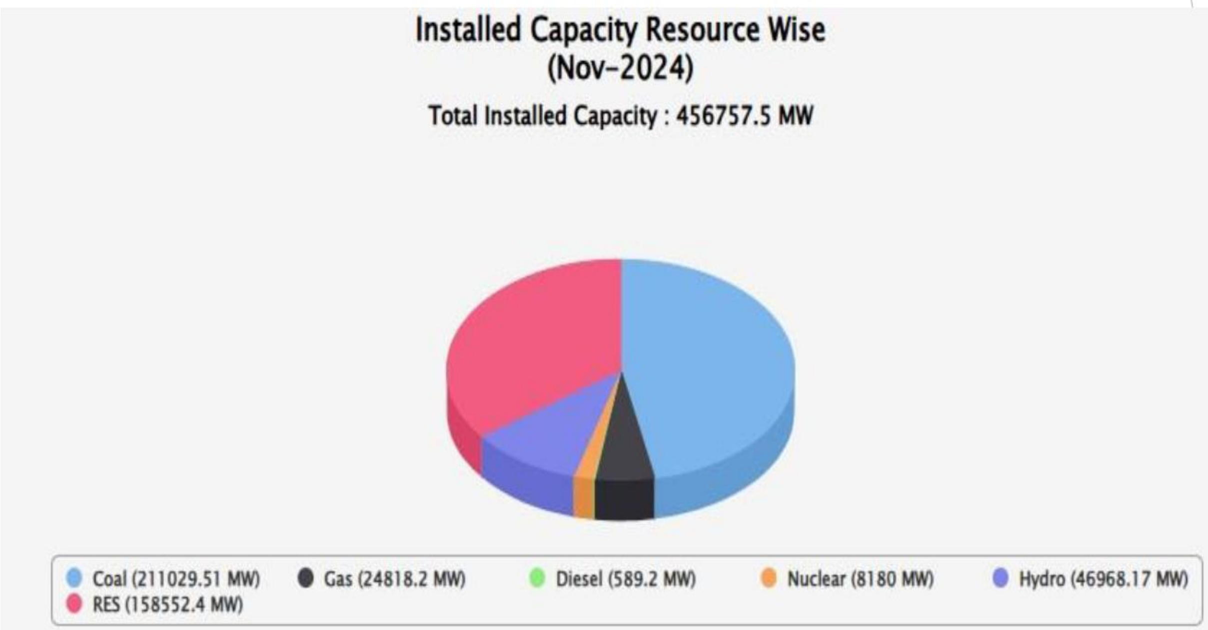
- Grid-Connected Microgrids – Work alongside the main power grid but can disconnect during outages.
- Off-Grid Microgrids – Completely independent, used in remote areas without access to national grids.
- Hybrid Microgrids – Use multiple energy sources (renewables + diesel generators) for reliability.

Benefits of Microgrids

- Enhanced Energy Reliability – Provides backup power during grid failures.
- Integration of Renewable Energy – Supports cleaner and more sustainable energy use.
- Energy Independence – Useful in remote or disaster-prone areas.
- Reduced Transmission Losses – Localized generation means less energy lost in transmission.

Microgrids are widely used in rural electrification, military bases, industrial parks, hospitals, and smart cities, offering a resilient and sustainable power solution.

Generation



Conventional Energy Sources

1. Thermal Power Generation (Coal, Oil, and Gas)

- Thermal power plants **burn fossil fuels** (coal, oil, or natural gas) to produce heat, which converts water into steam to rotate turbines and generate electricity.

(a) Coal-Based Power Plants

Major Contributor: ~50% of India's electricity generation.

Examples:

- **Vindhyachal Super Thermal Power Station** (Madhya Pradesh) – Largest in India (~4,760 MW).
- **Korba Super Thermal Power Station** (Chhattisgarh).- 2600MW

(b) Oil-Based Power Plants

- Less common due to high costs and dependence on imports.
- Mostly used in remote locations and as backup power.

Examples:

- Barauni Thermal Power Station (Bihar). – 720MW

(c) Natural Gas-Based Power Plants

- **Cleaner than coal but limited availability**.
- Uses **gas turbines** instead of steam turbines.
- **Examples**:
  - **Dabhol Power Plant** (Maharashtra).
  - **Kawas Gas Power Plant** (Gujarat).

2. Nuclear Power Generation

- Uses nuclear fission (splitting uranium/plutonium atoms) to produce heat, generating steam to drive turbines.
- Only 3% of India's total electricity .

Examples:

  - Kudankulam Nuclear Power Plant (Tamil Nadu) – 2000MW.
  - Tarapur Nuclear Power Plant (Maharashtra).- 1400MW.

3. Hydroelectric Power Generation

- Uses the flow of water to turn turbines and generate electricity.
- About 10% of India's electricity comes from large hydro projects.

Examples:

  - Bhakra Nangal Dam (Punjab/Himachal Pradesh).- 1325MW
  - Tehri Dam (Uttarakhand) - 1000MW.

Challenges of Conventional Electricity Generation in India

Advantages: Reliable, large-scale power production.

Disadvantages: Pollution (coal/oil), resource depletion, high costs, and environmental concerns.

Sector	Cumulative Achievements (as on 28.02.2025)
I. Installed RE Capacity (Capacities in MW)	
Wind Power	48588.56
Solar Power*	102566.02
Small Hydro Power	5100.55
Biomass (Bagasse) Cogeneration	9821.32
Biomass(non-bagasse)Cogeneration	921.79
Waste to Power	309.34
Waste to Energy (off-grid)	401.95
Total	**167709.53**

***Solar Power (Cumulative) : 102.57 GW**
•Ground Mounted Solar Plant : 78.47 GW
•Grid Connected Solar Rooftop: 16.66 GW
•Hybrid Projects(Solar Component) : 2.85 GW
•Off-Grid Solar: 4.59 GW

Non-Conventional Energy Sources

1. Solar Energy

- **Process**: Solar panels convert sunlight into electricity using photovoltaic (PV) cells.
- **Capacity**: ~102 GW (as of 2025).
- **Major Solar Power Plants**:
  - Bhadla Solar Park (Rajasthan) – World's largest (~2,245 MW).
  - Pavagada Solar Park (Karnataka).

2. Wind Energy

- **Potential**: India has a wind energy potential of around 302 GW, particularly in states like Tamil Nadu, Gujarat, Maharashtra, and Karnataka.
- **Installed Capacity**: Over 48 GW as of 2025.
- Muppandal Wind Farm (Tamil Nadu) - Largest in India (~1,500 MW).

3. Hydropower (Small and Mini Hydel Projects)

- Small and mini hydel projects (up to 25 MW capacity).
- **Installed Capacity**: Over 5.1 GW from small hydro projects.

4. Biomass Energy

- Large amounts of agricultural and organic waste, which can be used for biomass energy.
- **Installed Capacity**: Around 19 GW.

5. Geothermal Energy

- Limited but identified in regions like the Himalayas and the West Coast.
- **Installed Capacity**: Still in the research and development phase.

6. Tidal and Wave Energy

- Identified along the coasts of Gujarat and West Bengal.
- **Installed Capacity**: Experimental projects are underway.

7. Waste-to-Energy

  - **Potential**: Urban and industrial waste can be converted into energy.
  - **Installed Capacity**: Around 700 MW.

Distributed Energy Resources

- **Types of Distributed Energy Resources (DERs)**

1. Solar Photovoltaic (PV) Systems:

  - Rooftop solar panels or small-scale solar farms.
  - Generate electricity directly from sunlight.

2. Wind Turbines:

  - Small-scale wind turbines for localized power generation.

3. Battery Storage Systems:

  - Store excess energy generated by DERs for later use.
  - Examples: Lithium-ion batteries, flow batteries.

4. Microgrids:

  - Localized grids that can operate independently or in conjunction with the main grid.
  - Often integrate multiple DERs for reliable power supply.

5. **Combined Heat and Power (CHP) Systems:**
   - Generate electricity and useful heat simultaneously, improving efficiency.
6. **Fuel Cells:**
   - Generate electricity through electrochemical reactions, often using hydrogen.
7. **Small Hydropower Plants:**
   - Small-scale hydroelectric systems for localized power generation.
8. **Biomass Generators:**
   - Convert organic waste into electricity or heat.

Transmission and Distribution voltage levels

1. High Voltage (HV) Transmission

- 33kV - Last-mile transmission to distribution substations
- 66 kV - -Used in some state transmission networks (e.g., rural electrification, older systems).
- 110 kV - Found in regional grids (less common, mostly in legacy systems).

2. Extra High Voltage (EHV) Transmission

- 132 kV - Common in state transmission networks (e.g., intra-state power transfer).
- 220 kV - Widely used for inter-state power transmission and sub-transmission.
- 400 kV - Primary voltage for national grid (ISTS – Inter-State Transmission System).Connects regional grids (Northern, Southern, Western, Eastern, and North-Eastern).

3. Ultra High Voltage (UHV) Transmission

- **765 kV**
  - Used for **long-distance bulk power transfer** (e.g., from pithead coal plants in Chhattisgarh to distant states).
  - Operated by **Power Grid Corporation of India (PGCIL)**.
- **HVDC (High Voltage Direct Current) ±800 kV**
  - Used for **very long-distance transmission** (e.g., Raigarh (Chhattisgarh) to Pugalur (Tamil Nadu) – 1,830 km).
  - Reduces transmission losses over AC for distances >800 km.

4. Future & Experimental Levels

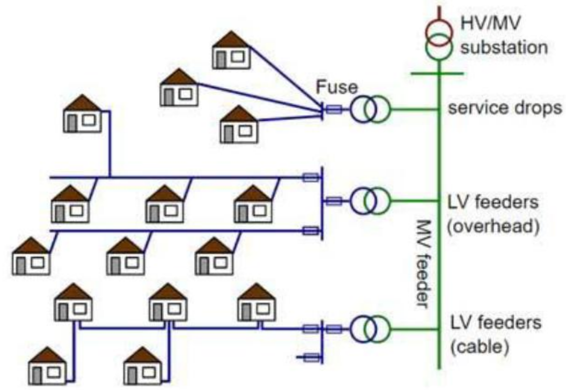
- **1,200 kV (UHVAC – Under Pilot Testing)**
  - India is testing **1,200 kV AC transmission** (world's highest voltage level) for future ultra-long-distance power transfer.

Used for direct distribution to industries, commercial areas, and consumers.

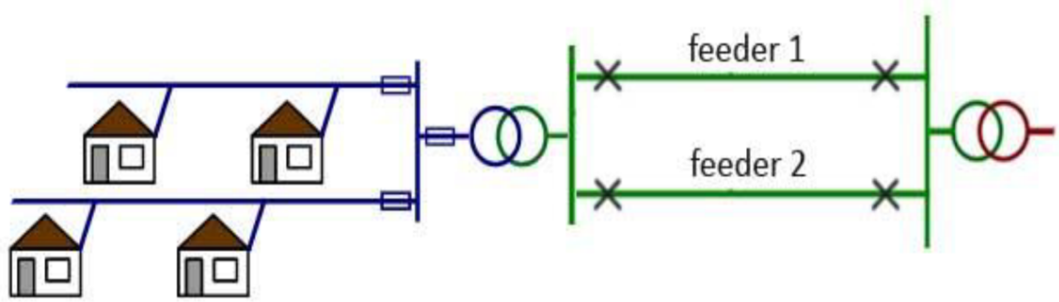
Voltage Level	Usage
11 kV	Supplies power to small industries, rural feeders
6.6 kV / 3.3 kV	Industrial loads, mines, and special consumers
415 V (3-phase) / 230 V (1-phase)	Domestic, commercial, and small-scale users

Topologies

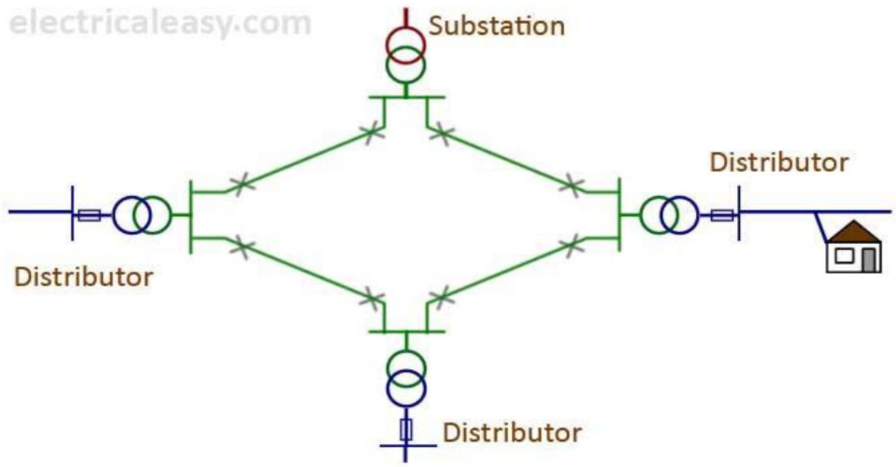
- **Radial distribution system**
- This system is used only when substation or generating station is located at the center of the consumers. In this system, different feeders radiate from a substation or a generating station and feed the distributors at one end. Thus, the main characteristic of a radial distribution system is that the power flow is in only one direction.
- A major drawback of a radial distribution system is, a fault in the feeder will result in supply failure.



- **Parallel feeders distribution system**
- The disadvantage of a radial system can be minimized by introducing parallel feeders. The initial cost of this system is much more as the number of feeders is doubled. Such system may be used where reliability of the supply is important or for load sharing where the load is higher.



- **Ring main distribution system**
- A similar level of system reliability to that of the parallel feeders can be achieved by using ring distribution system. Here, each distribution transformer is fed with two feeders but in different paths. The feeders in this system form a loop which starts from the substation bus-bars, runs through the load area feeding distribution transformers and returns to the substation bus-bars.



- **Interconnected/Meshed distribution system**
- When a ring main feeder is energized by two or more substations or generating stations, it is called as an interconnected distribution system. This system ensures reliability in an event of transmission failure. Also, any area fed from one generating stations during peak load hours can be fed from the other generating station or substation for meeting power requirements from increased load.

Key Differences

Parameter	Radial System	Meshed System
Reliability	Low	High
Cost	Low	High
Complexity	Simple	Complex
Scalability	Poor	Excellent
Voltage Control	Challenging (voltage drops)	Efficient
Fault Recovery	Manual restoration	Automatic rerouting

Conclusion

•Radial - Cheap but unreliable (good for small-scale power supply).

•Meshed -Expensive but robust (essential for large-scale, reliable power transmission and distribution).

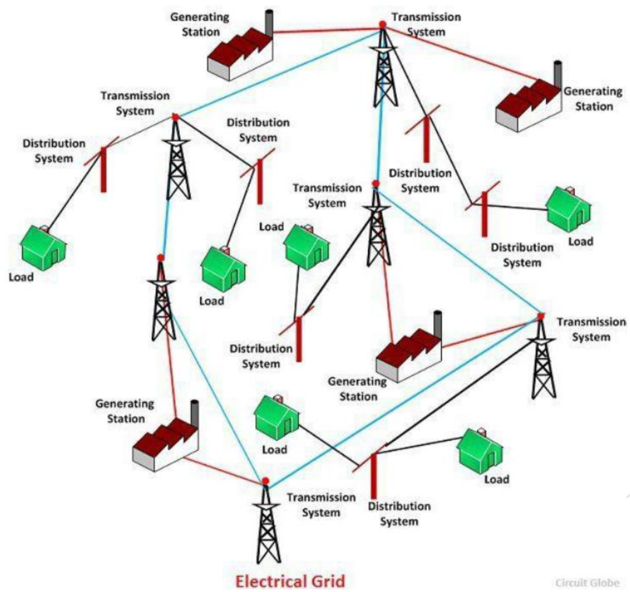
Grid

- Electrical grid or power grid is defined as the network which interconnects the generation, transmission and distribution unit. It supplies the electrical power from generating unit to the distribution unit. A large amount of power is transmitted from the generating station to load centre.

The electrical grid is mainly classified into two types. They are-

- **Regional Grid** – The Regional grid is formed by interconnecting the different transmission system of a particular area through the transmission line.
- **National Grid** – It is formed by interconnecting the different regional grid.

- **Reason for an Interconnection-**
- The interconnection of the grid provides the best use of power resource and ensures great security to supply. It makes the system economical and reliable. The generating stations are interconnected for reducing the reserve generation capacity in each area.



HVAC (High Voltage Alternating Current) Interconnection

- In HVAC link the two AC systems are interconnected by an AC link. For interconnecting the AC system, it is necessary that there should be sufficiently close frequency control on each of the two systems.
- For the 50Hz system, the frequency should lie between 48.5 Hz and 51.5 Hz. Such an interconnection is known as synchronous interconnection or synchronous tie.

Disadvantages-

- The frequency disturbances in one system are transferred to the other system.
- The power swings in one system affect the other system. Large power swing in one system may result in frequent tripping due to which major fault occurs in the system. This fault causes complete failure of the whole interconnected system.
- There is an increase in the fault level if an existing AC system is connected with the other AC system with an AC tie line. This is because the additional parallel line reduces the equivalent reactance of the interconnected system.

Skin effect

- The skin effect is a phenomenon where alternating current (AC) tends to flow mostly near the outer surface (skin) of a conductor, rather than uniformly across its cross-section. This effect increases the effective resistance of the conductor at higher frequencies.

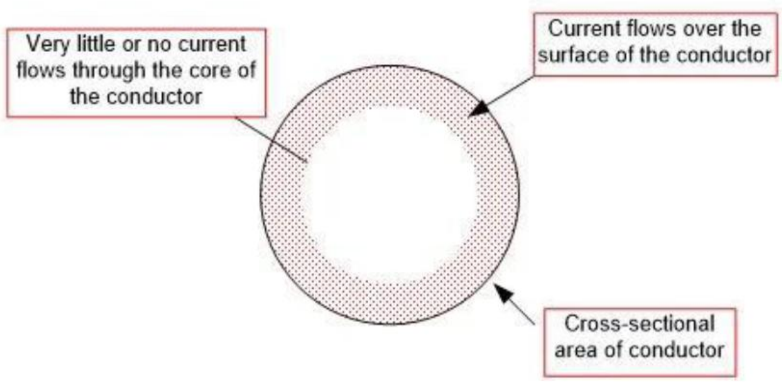


Fig. : Cross-sectional view of a conductor having Skin Effect

Cause of Skin Effect

1. AC Current Creates a Changing Magnetic Field

- When AC flows through a conductor, it generates a time-varying magnetic field around and inside it (Faraday's Law).
- This changing field induces eddy currents inside the conductor (Lenz's Law).

2. Eddy Currents Oppose the Main Current

- The induced eddy currents oppose the original current flow (due to Lenz's Law).
- Near the center of the conductor, this opposition is strongest, pushing electrons outward.

3. Current is Forced Toward the Surface

- The resulting current density becomes highest near the surface and weakest at the center.
- This means most of the current flows in a thin "skin" layer, while the inner part of the conductor

- Skin Depth (δ)
  - The depth at which current density drops to 1/e (~37%) of its surface value.
  - Formula:

$$\delta = \sqrt{\frac{2\rho}{\omega\mu}}$$

    - ρ = Resistivity of conductor (Ω·m)
    - $\omega = 2\pi f$ = Angular frequency (rad/s)
    - μμ = Permeability (H/m)

Effects of Skin Effect

- Increased Resistance (AC resistance > DC resistance).

  Reduced Effective Conductor Area (less metal is used efficiently).

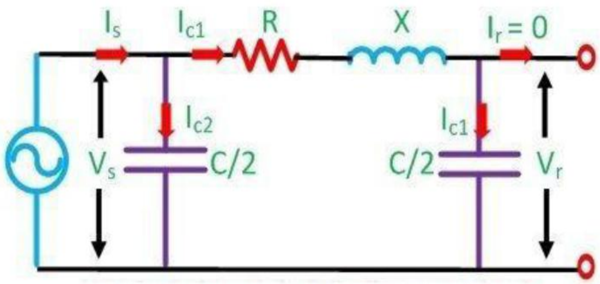
  Higher Power Losses (I^2R losses increase with frequency).

Practical Implications

Application	Impact of Skin Effect	Solution
Power Transmission (50/60 Hz)	Moderate increase in resistance	Use stranded conductors (ACSR)
High-Frequency Circuits (MHz-GHz)	Severe resistance increase	Litz wire, hollow tubes
Transformer Windings	Losses increase with frequency	Laminated or foil windings

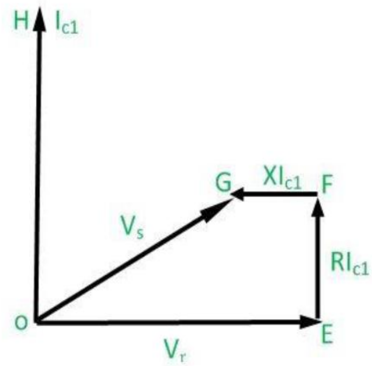
Ferranti effect

- The effect in which the voltage at the receiving end of the transmission line is more than the sending voltage is known as the Ferranti effect. Such type of effect mainly occurs because of light load or open circuit at the receiving end.
- Long transmission lines (typically over 200-300 km) have significant capacitance between the conductors and ground or between the conductors themselves. This capacitance acts like a capacitor in the circuit. On such transmission lines, the capacitance is not concentrated at some definite points. It is distributed uniformly along the whole length of the line.
- When the voltage is applied at the sending end, the current drawn by the capacitance of the line is more than current associated with the load. Thus, at no load or light load, the voltage at the receiving end is quite large as compared to the constant voltage at the sending end.



Nominal pi model of the line at no load.

Circuit Globe



Phasor Diagram

Circuit Globe

Characteristics

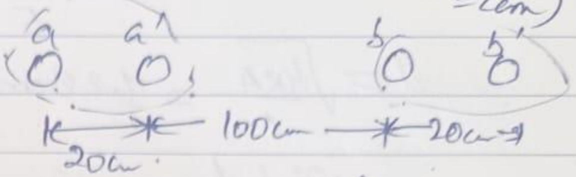
- Occurs in long EHV/UHV lines (>250 km for HVAC, >500 km for HVDC).
- More severe in underground cables (higher capacitance than overhead lines).
- Worsens with higher voltage levels (e.g., 400 kV, 765 kV).

Effects of Ferranti Effect

- Overvoltage at Receiving End
  - Can damage transformers, circuit breakers, and insulation.
- Increased Reactive Power Demand
  - Requires shunt reactors to absorb excess VARs.
- Voltage Instability
  - May lead to uncontrolled voltage surges in weak grids.

(4). In a 1-φ line cond^rs. a & a' are in parallel form one circuit while cond^rs. b & b' in parallel form the return path. Calculate total inductance of the line per km assuming that current is equally shared by the 2-parallel cond^rs. (Dia = 2cm)

Sol^n:



$$D_m = (1.2 \times 1.4 \times 1 \times 1.2)^{1/4}$$

$$= 1.19m.$$

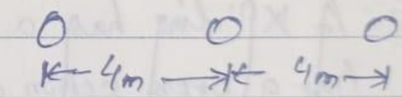
$$D_s = \left(0.7788 \times \frac{1}{100} \times 0.2 \times 0.7788 \times \frac{1}{100} \times 0.2\right)^{1/4}$$

$$= 3.94cm = 0.0394m.$$

$$L = 4 \times 10^{-4} \ln \frac{1.19}{0.0394} = 1.36 \text{ mH/km}.$$

(5) A 3φ, 50Hz, 132kV overhead line has a cond^rs placed in a horizontal plane 4m apart. Cond^r. diameter is 2cm. If the length is 100km, calculate the charging current per phase assuming complete transposition

Ans :-



$$C_n = \frac{2\pi\epsilon_0}{\ln\left(\frac{D_{eq}}{r}\right)} = \frac{2\pi\epsilon_0}{\ln\left(\frac{5.04}{1 \times 10^{-2}}\right)}$$

$$= 0.00885 \ \mu F/km$$

$$C \text{ for } 100km = 0.885\mu F, \quad V_{ph} = \frac{132 \times 10^3}{\sqrt{3}} = 76210 V$$

$$I_c = \frac{V_{ph}}{X_c} = \omega C V_{ph} = 21.18 A.$$

(6) A X^n line has a span of 200m b/w the supports. The cond^r. has a cross-section area of 1.29cm² weighs 1170 kg/km & has a breaking stress of 4218 kg/cm². Calculate the sag for a safety factor 5, allowing wind pressure of 122kg per

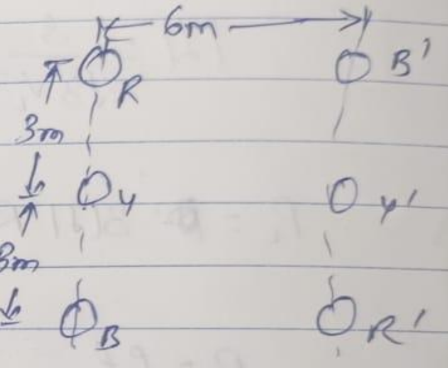
Mutual GMD, $D_m = \sqrt[4]{25 \times 103 \times 103 \times 25} = 50.74\,m.$

$\sqrt{100^2 + 25^2} = 103$

$L = 2 \times 10^{-7} \ln\left(\frac{D_m}{D_s}\right) = 0.42\,mH/km.$

Loop Inductance $= 2 \times 0.42 = 0.84\,mH/km.$

(3) A 3φ double ckt. line having cond^n radius 1.3cm is shown below. Find L.



Sol^n $r' = 0.7788 \times 1.3 = 1.01\,cm$

$D_{RY'} = \sqrt{6^2 + 3^2} = 6.7\,m.$

$D_{RR'} = \sqrt{6^2 + 6^2} = 8.48\,m.$

$D_S = \sqrt[3]{D_{S1} \times D_{S2} \times D_{S3}}$

$D_{S1} = (0.0101 \times 8.48 \times 0.0101 \times 8.48)^{1/4}$
$= 0.292\,m = D_{S3}.$

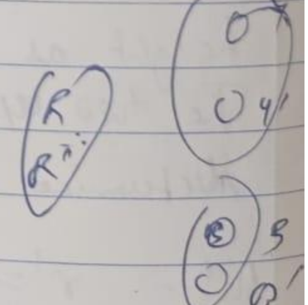
$D_{S2} = (0.0101 \times 6 \times 0.0101 \times 6)^{1/4} = 0.246\,m$

$D_S = 0.275\,m.$

mutual GMD $= (D_{m1} D_{m2} D_{m3})^{1/3}$

$D_{m1} = (D_{RY} D_{RY'} D_{RB} D_{RB'})^{1/4} = 4.48\,m = D_{m3}$

$D_{m2} = 6\,m$



$L = 2 \times 10^{-7} \ln \frac{D_m}{D_s} = 0.57\,mH/km.$

Types of conductors :- ① AAC (All Aluminium conductor) - , Aluminium → 60% conductivity as compared to copper & density 0.303 times as that of copper.

④ · ACSR (Aluminium condr. Steel reinforced). → its core consists of galvanized steel in order to prevent rusting.

→ steel core takes greater percentage of mechanical stresses while the aluminium carries the bulk of current.

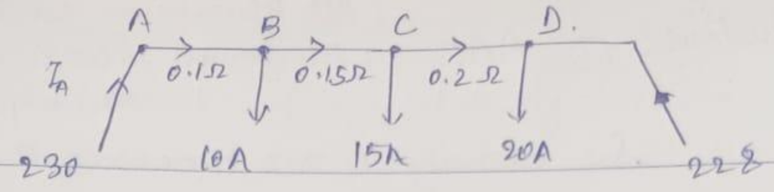
→ cos of the use of larger span, the no. of line supports may be reduced by about 25%. Thus the overall cost of supports, foundations, insulators & erection is considerably reduced.

② ACAR (Aluminium condr. Aluminium reinforced).
- expensive

③ AAAC - all Aluminium alloy condr.
- same as AAC except the alloy.
- Strength is equivalent to ACSR but it is lighter in weight due to the absence of steel.
- Expensive (alloy composition).
- lesser sag than AAC.
- longer spans can be used as compared to AAC condr.

* Characteristics of ideal condr :-
① max. electrical conductivity.
② It should have high tensile strength.
③ Less density (~~so as~~ for light weight).
④ It should have least cost without sacrificing other factors.

*Ex :-



Min. potential point. ??

$I_{AB} = I_A$, $I_{BC} = I_A - 10$, $I_{CD} = I_A - 10 - 15$

$V_A = 230$, $V_D = 228$

$\Rightarrow 230 - 0.1 I_A - 0.15(I_A - 10) - 0.2(I_A - 25) = 228$

$\Rightarrow I_A = 18.91A$.

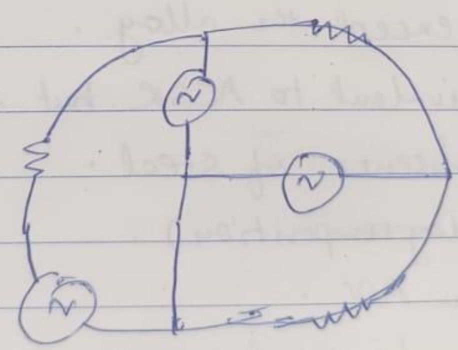
$I_{AB} = 18.91A$, $I_{BC} = 8.91A$, $I_{CD} = 18.91 - 25 = -6.09A$.
reverse direction.

C ⇒ min. potential point.

$V_C = 230 - 18.91 \times 0.1 - 8.9 \times 0.15 = 226.7V$ Ans

→ Less reliability, cheap, different voltage at consumer end.

② Ring Feeder :-



Advantages :- Reliable power supply.
Uniform voltage to all consumers.

Disadvantages :- Complex, costly.

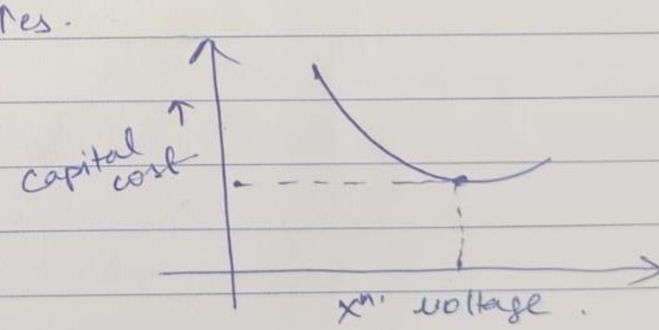
Economic choice of X^n ~~to~~ voltage :-

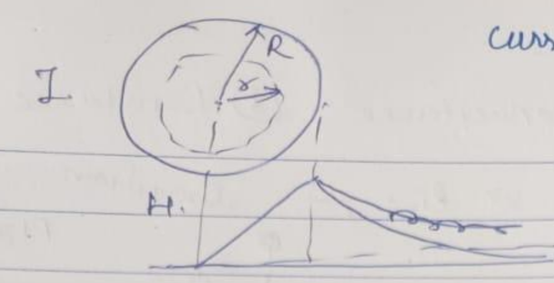
- ~~Capital~~ choice of voltage directly influences various other factors such as supporting structures, cond^r size, insulators, transformers used in X^n.
- it will closely influence economics of power X^n.
  (~~i.e.~~ initial investment).

Advantages :-

- Efficient transmission
- Cost saving.
- Improved voltage regn. $\left(\frac{V_S - V_R}{V_S}\right) \times 100$ (V_S → sending end, V_R → receiving end.)
  - (it should be as less as possible).

- Limitations :-
- cost of insulators, X^{rs}, lighting arrestors, structures, towers ~~etc~~ ↑es.
- switchgears, ~~tow~~ etc ↑es.





current per unit area. (Current density)

$$\frac{I}{\pi R^2} \cdot \pi r^2 = I'$$

$$\oint H' dl = I'$$

$$\Rightarrow H'(2\pi r) = I \left(\frac{r}{R}\right)^2$$

$$\Rightarrow H' = \frac{Ir}{2\pi R^2}$$

for. cond^r ⇒ (1) Internal flux linkage.

$$H' = \frac{Ir}{2\pi R^2} \Rightarrow$$

$B' = \mu H'$ [Here, $\mu_r = 1$ so, $\mu = \mu_0$].

$$B' = \mu_0 H'$$

$$B' = \frac{\mu_0 I}{2\pi R^2} \cdot r$$

Now, $d\varphi = B' \cdot dA$.

$= B' \cdot dr \cdot l$ ⇒ (Here $l = 1m$, to calculate per unit length inductance)

$$d\varphi = \frac{\mu_0 I}{2\pi R^2} r\,dr.$$

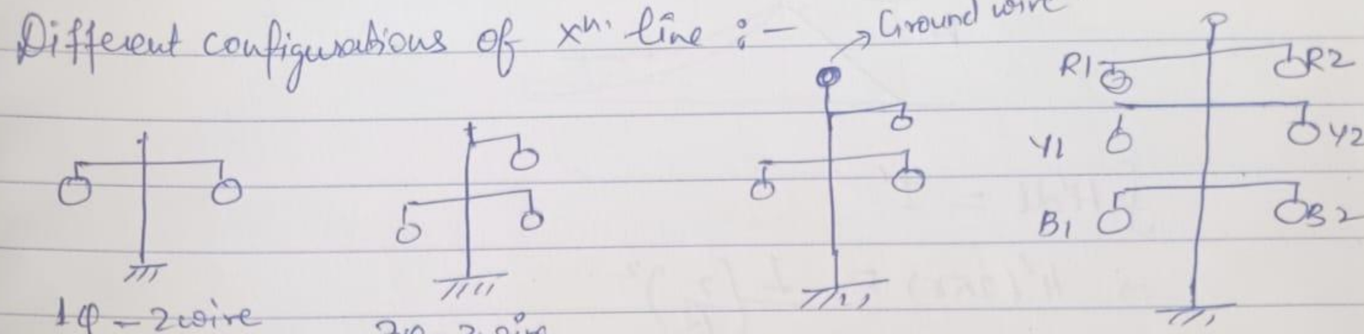
Flux linkage = Flux × No. of turns.

Only a part of cond^r i.e $r < R$ is being enclosed by ~~cond^r~~ flux lines $d\varphi$.

$$d\psi = d\varphi \left(\frac{r}{R}\right)^2.$$

(1) Inductance (2) Capacitance (3) Resistance.

Different configurations of x^n line :-



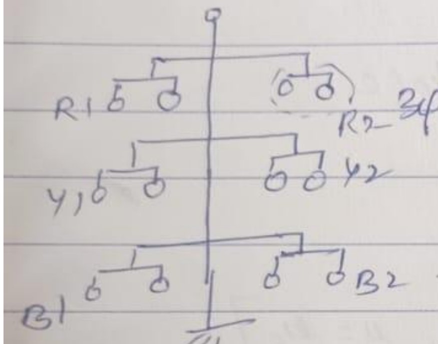
1φ – 2wire (distribution side)

3φ – 3wire (Local distribution) side.

3φ – 4wire (x^n line)

3φ – double Circuit line

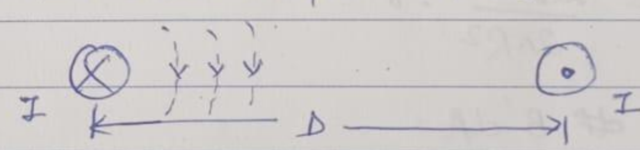
3 Line & 1 neutral



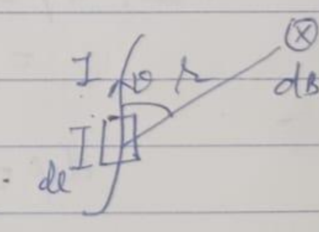
3φ – double ckt bundled cond^r.

(1)

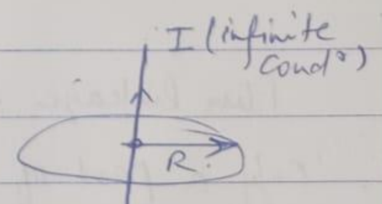
Inductance of two wire 1-φ x^n line :-



Biot Savart's law :- $dB = \frac{\mu}{4\pi} \frac{I\,dl \sin\theta}{r^2}$



$\mu = \mu_r \mu_0$ $\qquad B = \frac{\mu_0 I}{4\pi r^2} \int dl \sin\theta$



for ∞ length conductor → $B = \frac{\mu I}{2\pi R}$

$\Rightarrow \oint B \cdot dl = \mu I.$

$\frac{B}{\mu} = H$

$B = \mu H$

Ampere circuital → $\oint H \cdot dl = I$

Avg. Inductance, $L = \frac{L_A + L_B + L_C}{3}$

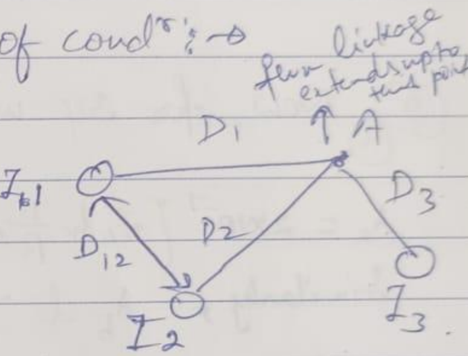
$\lambda_a + \lambda_b + \lambda_c = 2\times10^{-7}\left[2\left(I_a \ln\frac{1}{R'} + I_b \ln\frac{1}{R'} + I_c \ln\frac{1}{R'}\right)\right.$

$+ I_c \ln b + I_b \ln c + I_a \ln c + I_c \ln a$

$+ I_a \ln b + I_b \ln a.$

$= 2\times10^{-7}[$

Flux linkage of a cond^{r} in a group of cond^{rs} :→



$\lambda_1 = 2\times10^{-7} I_1 \ln\frac{D_1}{R_1'}$ → due to I_1

$\lambda_2 = 2\times10^{-7} I_2 \ln\frac{D_2}{D_{12}}$

$\lambda_3 = 2\times10^{-7} I_3 \ln\frac{D_3}{D_{13}}$

$$\lambda = 2\times10^{-7}\left[I_1 \ln\frac{D_1}{R_1'} + I_2 \ln\frac{D_2}{D_{12}} + I_3 \ln\frac{D_3}{D_{13}}\right]$$

$I_1 + I_2 + I_3 = 0$

Now, $\lambda = 2\times10^{-7}\left[I_1 \ln\frac{1}{R_1'} + I_2 \ln\frac{1}{D_{12}} + I_3 \ln\frac{1}{D_{13}}\right.$

$\left. + I_1 \ln D_1 + I_2 \ln D_2 + I_3 \ln D_3\right]$.

$\Rightarrow \lambda = 2\times10^{-7}[\text{same}] + I_1 \ln D_1 + I_2 \ln D_2 + (-I_1 \ln D_3$

$- I_2 \ln D_3]$

$\lambda = 2\times10^{-7}\{[\text{Same}] + I_1 \ln\left(\frac{D_1}{D_3}\right) + I_2 \ln\left(\frac{D_2}{\ }\right)$

Now, $\lambda = \int_0^R d\lambda = \frac{\mu_0 I}{2\pi R^2} \cdot \int_0^R r\,dr \left(\frac{r}{R}\right)^2$

$$= \frac{\mu_0 I}{2\pi R^4} \cdot \int_0^R r^3 dr = \frac{\mu_0 I}{8\pi} \quad \text{—(I)}$$

∴ Total Internal flux linkage $= \frac{\mu_0 I}{8\pi}$

It is independent of size of cond^r.

#

Now External flux linkage :- $R \le r < D$.

$$H = \frac{I}{2\pi r} \Rightarrow B = \frac{\mu_0 I}{2\pi r}.$$

$d\varphi = B \cdot dr \cdot 1$

$d\lambda = d\varphi \cdot 1 = \frac{\mu_0 I}{2\pi r} dr$

$$\Rightarrow \lambda = \int_R^{D-R} d\lambda = \int_R^{D-R} \frac{\mu_0 I}{2\pi} \frac{dr}{r}$$

$$\Rightarrow \lambda = \frac{\mu_0 I}{2\pi} \ln\left(\frac{D-R}{R}\right)$$

∵ $D >> R$, $D - R \simeq D$.

$$\Rightarrow \lambda = \frac{\mu_0 I}{2\pi} \ln\left(\frac{D}{R}\right) \quad \text{—(II)}$$

Hence :- Total flux linkage due to one cond^r $= \frac{\mu_0 I}{8\pi} + \frac{\mu_0 I}{2\pi} \ln\left(\frac{D}{R}\right)$

Flux linkage due to both cond^{rs} = 2 × "

$$= \frac{\mu_0 I}{4\pi} + \frac{\mu_0 I}{\pi} \ln \frac{D}{R}$$

$$\lambda = 2\times10^{-7}\,[\text{same}] + I_1 \ln\left[\frac{D_1}{D_3}\right] + I_2 \ln\left[\frac{D_2}{D_3}\right].$$

for large distance of point A from cond^n

$$\frac{D_1}{D_3} \approx 1, \quad \frac{D_2}{D_3} \approx 1$$

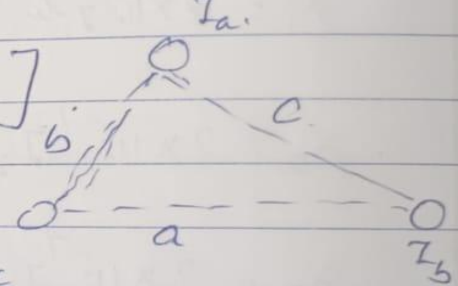
(Wb-turns/m)

$$\text{So, } \lambda = 2\times10^{-7}\left[I_1 \ln\frac{1}{R'} + I_2 \ln\frac{1}{D_2} + I_3 \ln\frac{1}{D_3}\right]$$

↓

flux linkage of 1st cond^r. due to all other cond^rs.

(2)(a) Now, for 3φ unsymmetrically placed cond^rs :—



$$\lambda_a = 2\times10^{-7}\left[I_a \ln\frac{1}{R'} + I_b \ln\frac{1}{c} + I_c \ln\frac{1}{b}\right].$$

Similarly, λ_b & λ_c

Now, $I_b = \alpha I_a$, $I_c = \alpha^2 I_c$

$$\alpha = -0.5 + j0.866$$

$$\lambda_a = 2\times10^{-7}\Big[I_a \ln\frac{1}{R'} + I_a\left(-0.5 + \frac{\sqrt{3}}{2}j\right)\left(\ln\frac{1}{c}\right)$$
$$+ I_a\left(-0.5 - \frac{\sqrt{3}}{2}j\right)\left(\ln\frac{1}{b}\right)\Big].$$

$$\lambda_a = 2\times10^{-7}[I_a]\Big[\ln\frac{1}{R'} - 0.5\ln\frac{1}{c} - 0.5\ln\frac{1}{b}$$
$$+ j\frac{\sqrt{3}}{2}\ln\frac{1}{c} - j\frac{\sqrt{3}}{2}\ln\frac{1}{b}\Big].$$

$$\lambda_a = 2\times10^{-7} I_a\left[\ln\frac{1}{R'} - \ln\frac{1}{\sqrt{bc}} - j\frac{\sqrt{3}}{2}\ln\frac{c}{b}\right].$$

Similarly, λ_b & λ_c

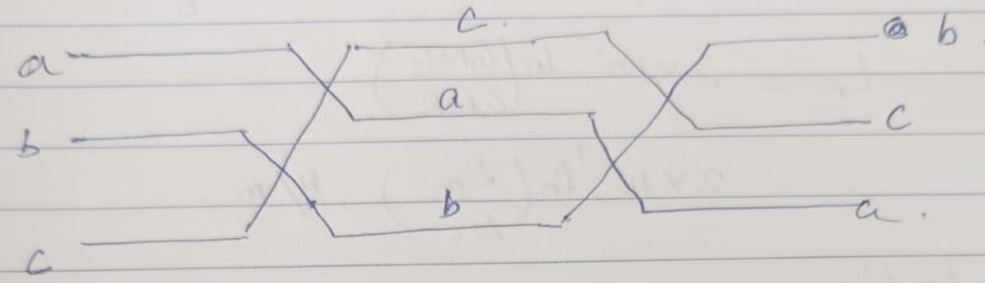
$$\frac{\lambda_a}{I_a} = L_a, \quad \frac{\lambda_b}{I_b} = L_b$$

If x^m line is transposed,

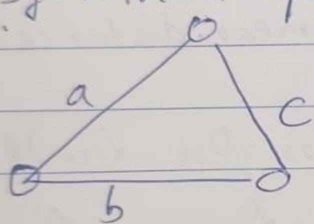
$$L = \frac{L_a + L_b + L_c}{3} = \frac{1}{3}\left[2\times10^{-7}\left[3\ln\frac{1}{R'} - \ln\frac{1}{abc} - j\frac{\sqrt{3}}{2}\omega 1\right]\right]$$

$$\boxed{L = 2\times10^{-7}\ln\frac{\sqrt[3]{abc}}{R'} \quad H/m}$$

Transposition.



(5) for symmetrical spacing:-



if $a = b = c = d$.

$$L = 2\times10^{-7}\ln\frac{d}{R'} \quad H/m.$$

$D_{11} = r \; [= D_{22} = D_{33} \cdots = D_{77}]$, $D_{13} = D_{15} = \sqrt{16r^2 - 4r^2}$

$D_{12} = D_{16} = D_{17} = 2r$ $= \sqrt{D_{14}^2 - D_{43}^2}$

$D_{14} = 4r$ $= 2\sqrt{3}r$.

$D_{S1} = D_{S2} = D_{S3} \cdots = D_{S6} = (r . 2r . 2\sqrt{3}r . 4r . 2\sqrt{3}r . 2r . 2r)$

$= 384 r^7$.

$D_{S7} = (2r . 2r . \cdots 2r) = 64 r^7$

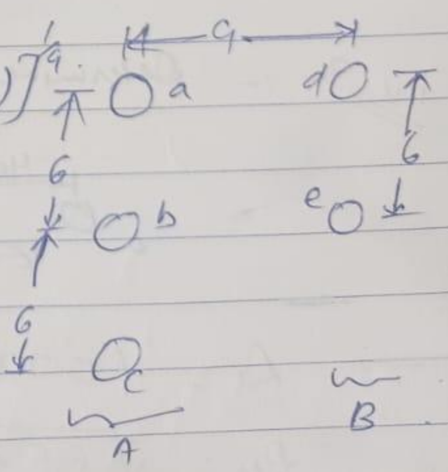
Now, $D_S = \left[(384 r^7)^6 . (64 r^7) \right]^{\frac{1}{49}}$

$= (384^6 . 64)^{\frac{1}{49}} . r$

$D_S = 2.176 r$.

$r' = 0.7788 \times \frac{2.5}{1000} = 0.001947$

* **(Ex = 2)** Determine the inductance of 1-φ x^n line consisting of 3 cond^rs. of 2.5mm radii in 'go' cond^r. & 2 cond^rs. of 5mm radii in the return cond^r.



$\Rightarrow D_{SA} = \left[(r'.6.12)(r'.6.6)(r'.6.12) \right]^{\frac{1}{9}}$

$3.85 (r')^{\frac{1}{3}}$

$= \cancel{0.001947 m}$. 3.85×0.01249

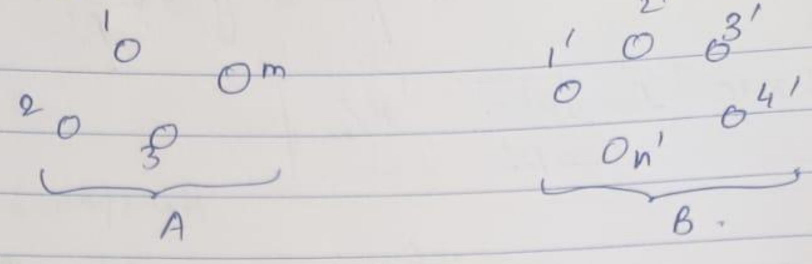
$r' = 0.001947$

$D_{SA} = 0.4809 m$.

$D_{SB} = 0.1528 m$.

$D_{mA} = D_{mB} = 10.74 m$.

③ Inductance of composite conductors :-



$$L_A = 2\times10^{-7}\ln\left(\frac{GMD}{GMR}\right)$$

$$= 2\times10^{-7}\ln\left(\frac{D_m}{D_s}\right)\ H/m.$$

$L = L_A + L_B$.

GMD = Geometric mean distance.

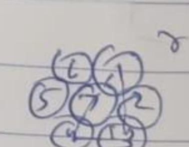
$$GMD_A = \left[(D_{11'}\cdot D_{12'}\cdot D_{13'} \dots D_{1n'})(D_{21'}\, D_{22'}\cdot D_{23'}\dots D_{2n'}) \dots (D_{m1'}\, D_{m2'} \dots D_{mn'})\right]^{\frac{1}{mn}}$$

GMR_A = Geometric mean radius.

$$= \left[(R'\cdot D_{12}\cdot D_{13}\dots D_{1m})(R'\cdot D_{21}\cdot D_{23}\dots)\dots(R' D_{m1}\, D_{m2}\dots)\right]^{\frac{1}{m^2}}$$

Ex. ① A cond^r consists of 7 identical strands each having radius r. Determine the factor by which r should be multiplied to get self GMD.

Ans :-



$$GMR = D_s = \Big[\underbrace{(D_{11} D_{12} D_{13} \dots D_{17})}_{D_{s_1}}\underbrace{(D_{21} D_{22} \dots D_{27})}_{D_{s_2}} \dots\Big]^{\frac{1}{7^2}}$$

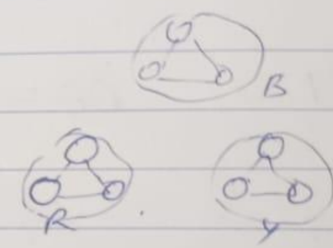
$$L_A = 2\times10^{-7} \ln \frac{10.74}{0.4809} = 0.62 \text{ mH/Km}$$

$$L_B = 2\times10^{-7} \ln \frac{10.74}{0.1528} = 0.8 \text{ mH/km}.$$

$$L = L_A + L_B = 1.42 \text{ mH/Km}$$

Assignment :- Inductance of Double ckt 3φ-line.
(on notebook in next lecture)

Bundled Cond^rs :-

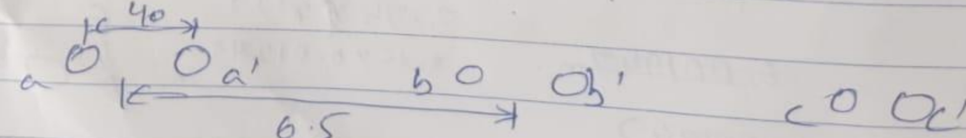


1. Reduced reactance.
2. Reduced voltage gradient
3. Reduced corona loss
4. " radio interference.
5. " surge impedance.
6. ↑ Z_c = surge impedance = $\sqrt{L/C}$ as L↑, C↓es.

∴ max. power transmitted ↑es. $P_{max} = \frac{V_L^2}{Z_c}$

$L \propto \frac{1}{GMR}$, GMR ↑es for bundled cond^r.

Ex. 3 :- Determine L, of 460kV cond^r. having dia 5cm.

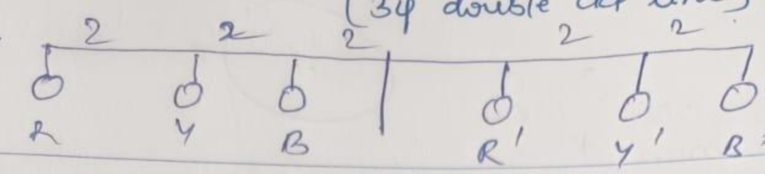


$$D_s = (0.7788 \times 0.025 \times 0.4)^{1/2} = 0.08825$$

$$D_m = \sqrt[3]{6.5\times13\times6.5} = 8.19$$

$$L = 0.906 \text{ mH/km}$$

Ex :→ (3φ double ckt line) (Transposed)



$r = 12\,mm = 0.012\,m$

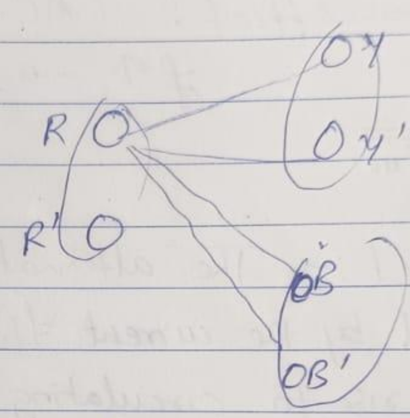
Transposed line :-

Inductance per phase $= L_{ph} = L_R = 2\times10^{-7} \ln \left[\dfrac{D_{mR1}\, D_{mR2}\, D_{mR3}}{D_{sR1}\, D_{sR2}\, D_{sR3}}\right]^{1/3}$

H/m/phase.

~~$D_{mR1} = [D_{RR'} D_{RY'} D_{RB'}$~~

~~D_{mR1}~~ $= [$



$D_{mR1} = \left[(D_{RY} D_{RY'} D_{RB} D_{RB'})(D_{R'Y} D_{R'Y'} D_{R'B} D_{R'B'})\right]^{\frac{1}{2\times4}}$

$= \left[(2\times8\times4\times10)(4\times2\times2\times4)\right]^{\frac{1}{8}}$

$= 3.77\,m$

$D_{mR2} = \left[(D_{YR} \cdot D_{YB} \cdot D_{YR'} D_{YB'})(D_{Y'B'} D_{Y'R'} D_{Y'R} D_{Y'B})\right]^{\frac{1}{2\times4}}$

$= \left[(2\times2\times4\times8)(2\times2\times8\times4)\right]^{1/2\times4} = 3.36$

D_{mR3} = Similarly $= 3.77$

$D_{sR1} = D_{sR2} = D_{sR3} = \left[D_{RR}\times D_{RR'} D_{R'R'} D_{R'R}\right]^{\frac{1}{2^2}}$

$= \left[0.7788r \times 6 \times 0.7788r \times 6\right]^{\frac{1}{4}}$

$= 0.236\,m$

per phase

$L_{ph} = 0.546$ mH/km/phase.

* Skin Effect :→

Flux linkage in inner cross section area is more than out filament of condr.

Due to this the inner filament will have higher inductance as compared to that of outer filament. ~~leads~~ It leads to higher current in outer strands of condr. This effect is called skin effect. (AC).

f ↑ → skin effect ↑es.

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}}$$

* Proximity effect :→ The alternating magnetic flux in a condr. caused by the current flowing in a neighbouring condr. gives rise to circulating currents which cause an apparent increase in the resistance of condr. This is called as proximity effect. The effective resistance is ↑ed due to non-uniform distribution of current. This is pronounced in case of cables where the distance b/w condrs is small.

$\mu = \mu_0 \mu_r$ → permeability of material.

σ = conductivity.

δ → skin depth , skin effect $\propto \frac{1}{\delta}$

(3) for Bundled cond^r :- $C_n = \dfrac{2\pi\epsilon_0\epsilon_r}{\ln\left(\frac{D_m}{D_s}\right)}$

(4) 3φ Double ckt line :- $C_n = \dfrac{2\pi\epsilon_0\epsilon_r}{\ln\left(\frac{D_{mR_1} D_{mR_2} D_{mR_3}}{D_{sR_1} D_{sR_2} D_{sR_3}}\right)^{1/3}}$

Points :- Capacitive reactance :- $X_C = \dfrac{1}{2\pi f C_n}$ Ω/m/phase

→ Susceptance $= B = \dfrac{1}{X_C} = 2\pi f C_n$

→ Charging current $= I_C = \dfrac{V_{ph}}{X_C} = 2\pi f C_n V_{ph}$ A/m/ph

→ Reactive power $= \dfrac{V_{ph}^2}{X_C} = 2\pi f C_n V_{ph}^2$ VAR

* Horizontal configuration

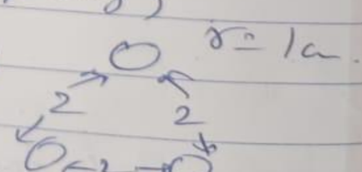
(1) Ex :- $r = 1$ cm, $d = 2$ m, $C_{ph} = ?$

(R) — (Y) — (B).

$C_{ph} = \dfrac{2\pi\epsilon_0\epsilon_r}{\ln\left(\frac{(D_1 D_2 D_3)^{1/3}}{r}\right)} = 10\,pF/m/phase$ → C_1

(2) Same for triangular configuration. (equal spacing)

$C_{ph} = \dfrac{2\pi\epsilon_0\epsilon_r}{\ln(D/r)} = 10.5\,pF/m/ph$ → C_2



$C_2 > C_1$ → 1st observation

Also, $L_2 < L_1$ ⇒ 2nd obs"

Max. power transferred can be ↑ed.

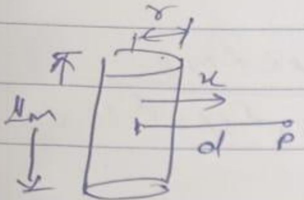
Now, $Z = \sqrt{L/C}$

C↑, L↓, Z↓

loading $\left(\frac{V^2}{Z}\right)$ ↑

Capacitance :—

→ Gauss Law , $\oint D \cdot ds = Q$.



$$D \cdot (2\pi x l) = Q.$$

$$\Rightarrow D = \frac{Q/l}{2\pi x} = \frac{q}{2\pi x}$$

$$E = \frac{D}{\epsilon_0 \epsilon_r} = \frac{q}{2\pi \epsilon_0 \epsilon_r \cdot x}$$

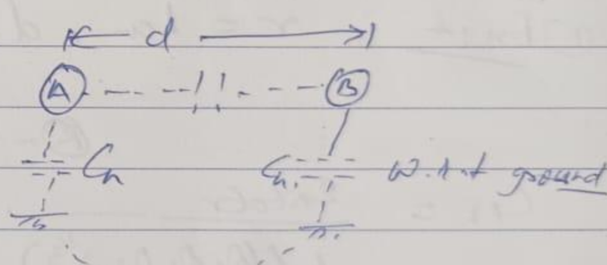
$$V = -\int_d^r E \cdot dx = -\int_d^r \frac{q}{2\pi\epsilon_0\epsilon_r x}\, dx = \frac{q}{2\pi\epsilon_0\epsilon_r} \ln\left(\frac{d}{r}\right)$$

$$\Rightarrow C = \frac{q}{V} = \frac{2\pi\epsilon_0\epsilon_r}{\ln\left(\frac{d}{r}\right)} \quad F/m.$$

$\epsilon_0 = 8.854 \times 10^{-12}$, $\epsilon_r = 1$ for free space.

(1). 1-φ - 2wire :-

$$C_{AB} = \frac{\pi\epsilon_0\epsilon_r}{\ln\left(\frac{d}{r}\right)}$$



$$C_{AB} = \frac{C_n}{2} \quad , \quad C_n = \frac{2\pi\epsilon_0\epsilon_r}{\ln\left(\frac{d}{r}\right)}$$

↑ per phase

(2) 3-φ transposed line :- $C_n = \dfrac{2\pi\epsilon_0\epsilon_r}{\ln\left(\frac{(D_1 D_2 D_3)^{1/3}}{r}\right)}$ F/m/phase

(a) unsymmetrical spacing.

(b) symmetrical spacing :- $C_n = \dfrac{2\pi\epsilon_0\epsilon_r}{\ln\left(D/r\right)}$

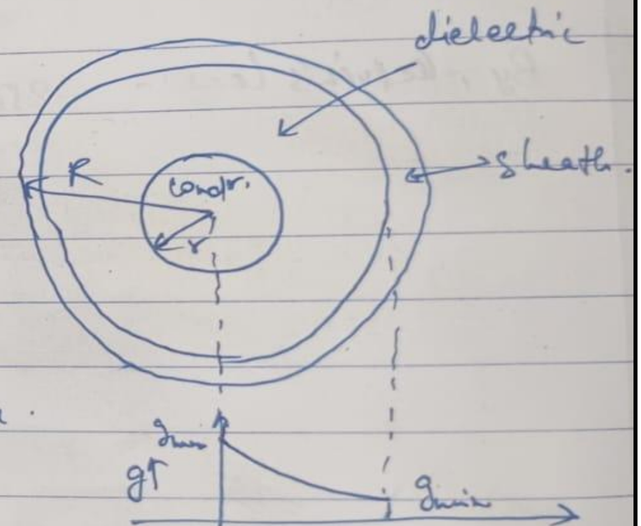
Underground Cables :→

Requirements :-

1. High insulation resistance.
2. High dielectric strength.
3. Good mechanical property i.e tenacity & elasticity (strong, rugged)
4. It should not be affected by chemicals around it.
5. It should be non-hygroscopic because the dielectric strength of any material goes very much down with moisture content.

Insulation material :- (1) Vulcanized Rubber (2) PVC (3) Polythene (4) Paper

Stress in single core cable :-



$g = E$ = Electric field intensity

$= \frac{\lambda}{2\pi\epsilon x}$, $\lambda \rightarrow$ Charge per unit length

$$V = -\int_R^r E \cdot dx = \int_r^R \frac{\lambda}{2\pi\epsilon x} dx$$

$$V = \frac{\lambda}{2\pi\epsilon} \ln\left(\frac{R}{r}\right) \quad , \quad g = \frac{\lambda}{2\pi\epsilon x} = \text{gradient}$$

$$V = g x \ln\left(\frac{R}{r}\right) \Rightarrow \boxed{g = \frac{V}{x \ln\left(\frac{R}{r}\right)}}$$

Grading of Cables :- It is the distribution of dielectric material such that the difference b/w the max. gradient & the min. gradient is reduced, thereby a cable of same size ~~cannot~~ could be operated at higher voltages or for same operating voltage size of the cable is small.

1. Capacitance grading :- different layers of dielectric material is used.
2. Intersheath grading :- Same dielectric material is used but potentials at certain radii are held to certain values.

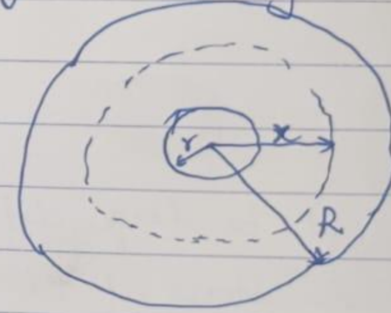
Capacitance Grading :-

$$\epsilon = \frac{K}{x}$$

varying permittivity w.r.t x.

Now, $g = \dfrac{\lambda}{2\pi \epsilon x}$

$$= \frac{\lambda}{2\pi \frac{K}{x} \cdot x} = \frac{\lambda}{2\pi K}.$$



$$\Rightarrow g = \text{constant}$$

- It is like infinite number of dielectric material ~~put over~~ with varying permitivities are put over one another.
- For a particular operating voltage the overall size of cable is minimum.
- It is practically impossible.

$$g_{max}\Big|_{x=r} = \frac{V}{r\ln\left(\frac{R}{r}\right)} \quad , \quad g_{min}\Big|_{x=R} = \frac{V}{R\ln\left(\frac{R}{r}\right)}$$

to find out min. value of g_{max} so as to keep overall size of ~~condr.~~ a cable fixed to a particular value of radius of conductor.

$$g_{max} = \frac{V}{r\ln\left(\frac{R}{r}\right)}$$

$$f(r) = r\ln\left(\frac{R}{r}\right) \longrightarrow \text{maximize.}$$

$$f'(r) = 0 \Rightarrow r\cdot\left(\frac{r}{R}\right)\cdot\left(-\frac{1}{r^2}\right) + \ln\left(\frac{R}{r}\right) = 0.$$

$$\Rightarrow \ln\left(\frac{R}{r}\right) = 1$$

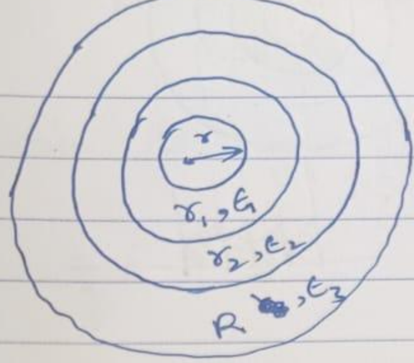
$$\Rightarrow \frac{R}{r} = e \qquad \Rightarrow \frac{R}{r} > e$$

$$\text{or. } \frac{r}{R} < \frac{1}{e}$$

There will be large difference b/w stress at the surface of condr. & stress at the inner radius of sheath.

→ So normally 2 or 3 materials are used.

(a)



g_1 = working stress = $\frac{G_1}{f}$ ← safety factor

Gradient at the surface of condr. :→

Now, $g_1 = \frac{\lambda}{2\pi\epsilon_1 r} = \frac{G_1}{f}$

Gradient at the surface of r_1 → $g_2 = \frac{\lambda}{2\pi\epsilon_2 r_1} = \frac{G_2}{f}$.

Gradient at the surface of r_2 → $g_3 = \frac{\lambda}{2\pi\epsilon_3 r_2} = \frac{G_3}{f}$.

Now →

$$\lambda = 2\pi\epsilon_1 r \frac{G_1}{f} = 2\pi\epsilon_2 r_1 \cdot \frac{G_2}{f} = 2\pi\epsilon_3 r_2 \frac{G_3}{f}.$$

$$\Rightarrow \epsilon_1 r G_1 = \epsilon_2 r_1 G_2 = \epsilon_3 r_2 G_3$$

Since, $r < r_1 < r_2$ ∴→ $\epsilon_1 G_1 > \epsilon_2 G_2 > \epsilon_3 G_3$

Material having highest permitivity will be kept nearest to the conductor.

(b) When all the materials are subjected to the same max. stress.

$$g_{max.} = \frac{\lambda}{2\pi\epsilon_1 r} = \frac{\lambda}{2\pi\epsilon_2 r_1} = \frac{\lambda}{2\pi\epsilon_3 r_2}$$

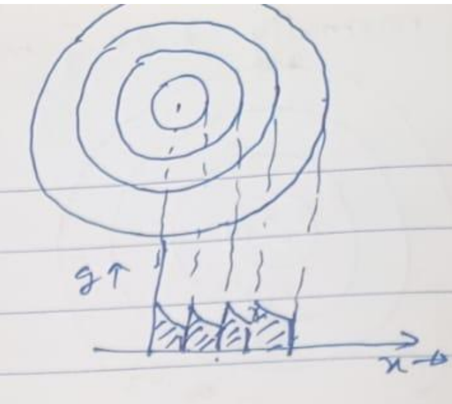
$$\Rightarrow \epsilon_1 r = \epsilon_2 r_1 = \epsilon_3 r_2$$

$r < r_1 < r_2$, $\Rightarrow \epsilon_1 > \epsilon_2 > \epsilon_3$

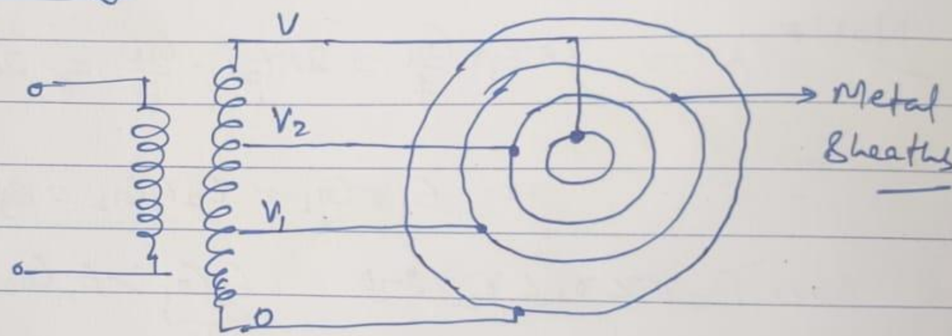
→ # Highest permitivity material will be kept nearest to the conductor.

operating voltage :-

$$V = g_{max} \cdot r \ln\left(\frac{r_1}{r}\right) + g_{max} r_1 \ln\left(\frac{r_2}{r_1}\right) + g_{max} r_2 \ln\left(\frac{R}{r_2}\right) \text{ Volts.}$$



Intersheath Grading :-



- Here an auxillary X^r is used to maintain the metal sheath & the power cond^r at certain potentials.
- The gradient with intersheath will be smaller than the gradient without intersheath for the same overall radius & operating voltage.

Numericals :-

(1) A 3φ X^n line is designed to deliver 190.5 MVA at 220KV over a distance of 63 km. The total X^n line loss is not to exceed 2.5% of the rated MVA. If the resistivity of the condr. material is $2.84 \times 10^{-8}\ \Omega$-m. Determine the required condr. diameter & the condr. size in

Solⁿ :-

$$P_L = \frac{2.5}{100}(190.5) = 4.7625\ MW$$

$$|I| = \frac{S}{\sqrt{3}V_L} = \frac{(190.5)\times 10^3}{\sqrt{3}\times 220} = 500A.$$

$$P_L = 3|I|^2R \Rightarrow R = \frac{4.7625\times 10^6}{3\times (500)^2} = 6.35\ \Omega.$$

$$R = \rho\frac{l}{A}, \quad A = 2.81764\times 10^{-4}\ m^2,$$

$$= \pi r^2 = \frac{\pi d^2}{4}.$$

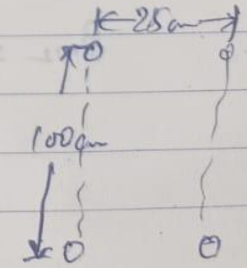
$$\Rightarrow d = 1.894\ cm$$

(2) Two condrs. of a 1-φ line each of 1cm dia, are arranged in a vertical plane with 1 conductor mounted 1m above the other. A second identical line is mounted at the same height as the 1st & spaced horizontally 0.25 apart from it. The two upper & two lower conductors are connected in parallel. Determine the inductance per km of the resulting double ckt line.

Solⁿ ⇒ $r' = 0.389\ cm$.

$$D_S = \sqrt[4]{(0.389\times 100\times 0.389\times 100)}$$

$$= 6.23\ cm = 0.0623\ m.$$



*

Advantages of Higher x^{n} voltage :→

① Power x^{r} Capacity of x^{n} line ↑es. , $P_{max} \propto V^2$

$$P = \frac{V_s V_R}{X} \sin\delta$$

② x^{n} line losses will be minimized :→ $P = VI\cos\varphi$

$$P_L = I^2 R = \frac{P^2 R}{V^2 \cos^2\varphi} \quad \therefore P_L \propto \frac{1}{V^2}.$$

$I \propto \frac{1}{V}$ (Keeping P & $\cos\varphi$)

③ Area & volume of the cond^{r} is reduced :→ $R = \frac{\rho l}{A}$, $A \propto \frac{1}{R}$.

$$P_L = I^2 R$$

$$R = \frac{P_L}{I^2}$$

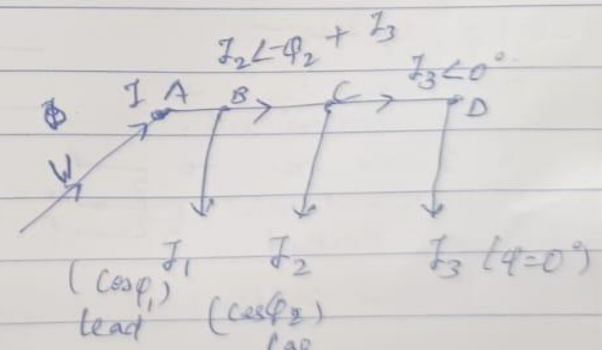
$$A = \frac{P^2}{P_L V^2 \cos^2\varphi}$$

$$R = \frac{P_L}{(P/V\cos\varphi)^2} = \frac{P_L V^2 \cos^2\varphi}{P^2} \propto \frac{1}{A}, \quad A \propto \frac{P^2}{P_L V^2 \cos^2\varphi}$$

④ $I^2 \propto \frac{1}{V^2}$, $P_L \propto \frac{1}{V^2}$, η ↑es.

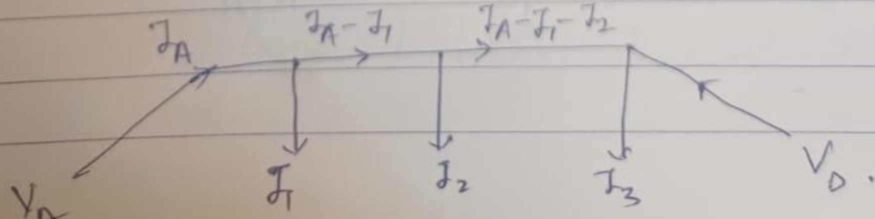
Feeders :- ① Radial :-

ⓐ Source fed at one end :-



$$I = I_1 \cos\angle\varphi_1 + I_2\angle-\varphi_2 + I_3.$$

ⓑ Source is feeding from both ends :-



Assignment-I

1. Write down the following in descending order of their installed capacity (in MW).

a) Five Coal fired thermal power plants in India.

b) Five Hydro electric power plants in India.

c) Five Solar power plants in India.

d) All the nuclear power plants in India.

2. Explain the generation scenario of India in detail.

3. What is a microgrid ? Describe its types, key features and benefits.

4. Write down all the conventional and non conventional energy sources.

5. Explain all the energy storage systems used in India.

Assignment-II

1. Explain the difference between radial and meshed transmission systems. Discuss their advantages, disadvantages, and typical applications in power systems.

2. What is the significance of synchronous grids and asynchronous (DC) interconnections? Explain how HVDC links help in interconnecting different power systems.

3. A balanced three-phase load is connected to a supply. Derive the expression for power in a three-phase system, and explain the role of reactive power in AC circuits.

4. Define skin effect and Ferranti effect in transmission lines. Explain their causes and impact on system performance, along with methods to reduce their effects.

5. Classify transmission lines into short, medium, and long lines. Explain the modeling of each type and derive the expressions for voltage regulation and power transfer in a medium transmission line.

Moderation Form

पूर्णियाँ अभियंत्रण महाविद्यालय
पूर्णियाँ - ८५४३०३

PURNEA COLLEGE OF
ENGINEERINGPURNEA-854303

MODERATION FORM
MID-SEMESTER QUESTION PAPER QUALITY ANALYSIS

Faculty Name: Tabish Shams		Sem: 5th.	
Subject Name: Power System-I.		Max. Marks: 20	
Subject Code: 100507		Duration: 2 hrs.	
DEPARTMENT: Electrical Engg.			
S.No.	**Assessment Parameters**	**Remarks**	
1	Are the Course Outcomes defined for course, met in the questions asked	Yes ✓ / No	
2	Are the CO in-line with Blooms Taxonomy level and specified in the Question Paper	Yes ✓ / No	
3	Is the weightage of questions set for COs specified in the QP appropriate	Yes / No	**remarks**
		CO 1	✓ Yes
		CO 2	✓ Yes
		CO 3	✓ Yes.
		CO 4	
		CO 5	
4	Rate the strength of questions set	**STRENGTH**	**remarks**
		Easy	30%.
		Medium	50%.
		Tough	20%.
5	Time specified is sufficient for the students to attempt them comfortably	Yes / No	Yes
6	Does the QP includes mandatory question	Yes / No	Yes
7	Does the QP includes innovative question	Yes / No	Yes
8	Does the QP is in line with University QP format	Yes / No	Yes.
Any Other Remarks	—		

[signature] 19/05/2025	[signature] 19/05/25	[signature] 19/05/25
Name & Signature of QP setting Faculty	Name & Signature of Moderating Faculty	Name & Signature of Departmental Academic Co-ordinator

Mid-Semester Examination

Duration: 2 Hrs	Semester: 5^{th} (EE)	Date: 23/05/2025	Time: 3:00-5:00pm
Full Marks: 20	Subject: PS-I (100507)	Session-2024-25	Batch- 2022-26

CO1	To understand the structure and operation of modern power systems including generation, microgrids, and energy storage
CO2	To apply three-phase circuit concepts, power flow in transmission and distribution systems.
CO3	To analyze transmission line parameters, performance, and compensation techniques.
CO4	To evaluate the performance of transformers and synchronous machines using equivalent and per-unit models.
CO5	To understand and assess solutions for over-voltage protection, HVDC transmission, and renewable energy integration.

(*Answer any four question. Each question carries five marks.*)

1. Describe bulk power grid and microgrid in detail. Explain key features, types and benefits of microgrid. CO1

2. Write down the conventional and non-conventional energy resources with their examples and percentage of contribution in total power generation in India. CO1

3. Define Energy Storage Systems (ESS) and discuss their classification in detail, highlighting the working principles and applications of each type. CO1

4. Illustrate and explain typical line diagrams of a power system. Discuss the transmission and distribution voltage levels and elaborate on the differences between meshed and radial system topologies. CO2

5. Explain Ferranti effect, skin effect and corona effect in overhead transmission lines. Describe their causes, effects and mitigation methods. CO2

6. Derive the expression for inductance of a single-phase overhead transmission line. CO3

Previous Year Question Paper (2020)

Code : 100507

B.Tech 5th Semester Exam., 2020

(New Course)

POWER SYSTEMS—I

Time : 3 hours *Full Marks* : 70

Instructions :

(i) *The marks are indicated in the right-hand margin.*

(ii) *There are* **NINE** *questions in this paper.*

(iii) *Attempt* **FIVE** *questions in all.*

(iv) *Question No.* **1** *is compulsory.*

1. Answer any *seven* of the following questions : 2×7=14

(a) What is the difference between bulk power grid and microgrid?

(b) What do you understand by synchronous grids and asynchronous (DC) interconnections?

(c) What is meant by series compensation of transmission lines? Give example for the same.

(d) What is corona in power system and how is it caused?

(e) Draw the Bewley diagram for overvoltage issue.

253 *(Turn Over)*

(f) Which type of fault would be severe among the line to ground fault or symmetrical fault, when the fault occurs near to the generator? Consider that the neutral for the generator is solidly grounded, also, $X_1 = X_2 << X_0$.

(g) Consider that in a power system network, the frequency has been reduced significantly. What should be done in the generator to improve the frequency in the power system network?

(h) What is a back up protection and why is it required?

(i) Draw the *I-V* and *P-V* characteristics of PV panels.

(j) What is a differential protection?

2. A generator transformer unit is connected to a line through a circuit breaker. The unit ratings are

Generator : 10 MVA, 6·6 kV, $X_d'' = 0{\cdot}1$ p.u., $X_d' = 0{\cdot}2$ p.u. and $X_d = 0{\cdot}8$ p.u.

Transformer : 10 MVA, 6·9/33 kV, reactance = 0·08 p.u.

AK-21/253 *(Continued)*

The system is operating at no load at a line voltage of 30 kV, when a three-phase fault occurs on the line just beyond the circuit breaker. Find—

(a) the initial symmetrical r.m.s. current in the breaker;

(b) the maximum possible d.c. offset current in the breaker;

(c) the momentary current rating of the breaker;

(d) the current to be interrupted by the breaker and the interrupting kVA;

(e) the sustained short circuit current in the breaker. 14

3. A single-phase 50 Hz generator supplies an inductive load of 5 MW at a power factor of 0·866 lagging by means of an overhead transmission line 20 km long. The line resistance and inductance are 0·0195 ohm and 0·63 mH per km. The voltage at the receiving end is required to be kept constant at 10 kV.

(a) Find the sending end voltage and voltage regulation of the line.

AK-21/253 *(Turn Over)*

(b) Find the value of the capacitors to be placed in parallel with the load such that the regulation is reduced to 50% of that obtained in part (a).

(c) Compare the transmission efficiency in parts (a) and (b). 14

4. Discuss in detail about the line commutated converters and voltage source converters for DC transmission systems. Also, discuss in detail about advantages and disadvantages of individual converters for DC transmission systems. 14

5. Explain the working of (a) vacuum circuit breaker and (b) SF_6 circuit breaker. 14

6. (a) The line currents in amperes in phases *a*, *b* and *c* respectively are 500 + *j*150, 100 − *j*500 and −300 + *j*500 referred to the same reference vector. Find the symmetrical components of the currents. 7

(b) What is a neutral grounding? Explain the methods of neutral grounding. 7

7. Discuss in detail about the tap changing transformers. Explain how tap changing transformer is superior than other voltage control methods and also discuss the disadvantage of the tap changing transformer.

AK-21/253 *(Continued)*

8. Explain about the following : 14

(a) Sphere gap arrester

(b) Horn gap arrester

(c) Maximum discharge current

(d) Coefficient of earthing

(e) Ferranti surge absorber

9. Discuss in detail about the steady state performance characteristics of a synchronous machine operation, when connected to infinite bus and also real and reactive power capability curve of the generators. 14

* * *

Previous Year Question Paper (2021)

Code : 100507

B.Tech 5th Semester Exam., 2021

(New Course)

POWER SYSTEMS—I

(Apparatus and Modelling)

Time : 3 hours *Full Marks* : 70

Instructions :

(i) *The marks are indicated in the right-hand margin.*

(ii) *There are* ***NINE*** *questions in this paper.*

(iii) *Attempt* ***FIVE*** *questions in all.*

(iv) *Question No.* ***1*** *is compulsory.*

1. Answer any *seven* of the following questions : 2×7=14

(a) What is the difference between radial and mesh systems?

(b) Draw the one-line diagram of the typical power system.

(c) Consider that in a power system network the voltage has been reduced significantly. What should be done in the generator to improve the voltage in the power system network?

(d) Which type of fault would be severe among the line to ground fault or symmetrical fault, when the fault occurs near to the generator when $X_1 = X_2 >> X_0$ and $X_1 = X_2 << X_0$? Consider the neutral of the generator is solidly grounded.

(e) What is the difference between a lightning arrester and surge absorber?

(f) What is meant by protective angle? Give its value for reliable protection.

(g) What are symmetrical components and why are they required?

(h) What is a neutral grounding and why is it required?

(i) Which type of circuit breaker is used for more than 400 kV?

(j) Mention the advantages of DC transmission system over AC transmission system.

2. A generator transformer unit is connected to a line through a circuit breaker. The unit ratings are :

Generator : 15 MVA, 11 kV, $X''_d = 0 \cdot 3$ p.u., $X'_d = 0 \cdot 3$ p.u., $X_d = 0 \cdot 6$ p.u.

Transformer : 15 MVA, 12·7/66 kV, reactance = 0·06 p.u.

The system is operating at no load at a line voltage of 66 kV, when a three-phase fault occurs on the line just beyond the circuit breaker. Find—

(a) the initial symmetrical r.m.s. current in the breaker;

(b) the maximum possible d.c. offset current in the breaker;

(c) the momentary current rating of the breaker;

(d) the current to be interrupted by the breaker and the interrupting kVA;

(e) the sustained short-circuit current in the breaker. 14

3. A single-phase 50 Hz generator supplies an inductive load of 8 MW at a power factor of 0·707 lagging by means of an overhead transmission line 15 km long. The line resistance and inductances are of 0·023 ohm and 0·56 mH per km. The voltage at the receiving end is required to be kept constant at 11 kV.

(a) Find the sending end voltage and voltage regulation of the line.

(b) Find the value of the capacitors to be placed in parallel with the load such that the regulation is reduced to 60% of that obtained in part *(a)*.

(c) Compare the transmission efficiency in parts *(a)* and *(b)*. 14

4. Discuss in detail about the over-current and directional protection scheme. Also, discuss in detail about the advantages and disadvantages of both the protection schemes and mention their applications. 14

5. Discuss in detail about the permanent magnet synchronous generator and induction generator for power generation through wind energy. Also discuss why there is a requirement of using two types of generators. What is the advantage of using one over the other generator? 14

6. *(a)* Draw the sequence diagrams of all types of connections of a transformer. 5

(b) A synchronous machine *1* generating 1 p.u. voltage is connected through a Y/Y transformer of reactance of 0·1 p.u. to two transmission lines in parallel. The other ends of the lines are connected through a Y/Y transformer of reactance of 0·15 p.u. to a machine *2* generating 1 p.u. voltage. For both transformers $X_1 = X_2 = X_0$.

Calculate the current fed into a double line to ground fault on the line side

terminals of the transformer fed from machine 2. The star points of machine *1* and of the two transformers are solidly grounded. The reactance (p.u.) of the machines and lines referred to a common base are as follows : 9

Machine *1* : $X_1 = 0 \cdot 45$, $X_2 = 0 \cdot 35$, $X_0 = 0 \cdot 05$

Machine 2 : $X_1 = 0 \cdot 40$, $X_2 = 0 \cdot 30$, $X_0 = 0 \cdot 04$

Line each : $X_1 = 0 \cdot 30$, $X_2 = 0 \cdot 30$, $X_0 = 0 \cdot 64$

7. Explain in detail about the sinusoidal steady-state representation of short, medium and transmission lines. 14

8. *(a)* Describe the construction, principle of operation and application of *(i)* rod gap and *(ii)* expulsion gap. 9

(b) Explain clearly how the rating of lightning arrester is selected. What is the best location of lightning arrester and why? 5

Previous Year Question Paper (2022)

Bihar Engineering University, Patna
End Semester Examination - 2022

Course: B.Tech. | *Semester: V* | *Time: 03 Hours*
Code: 100507 | *Subject: Power System-I(Apparatus and Modelling)* | *Full Marks: 70*

Instructions:-
(i) The marks are indicated in the right-hand margin.
(ii) There are NINE questions in this paper.
(iii) Attempt FIVE questions in all.
(iv) Question No. 1 is compulsory.

Q.1 *Choose the correct answer of the following (Any seven question only):* [2 x 7 = 14]

(a) Ferranti effect on long overhead line is experienced when it is
(i) lightly loaded (ii) on full load at unity pf
(iii) on full load at 0.8pf lead (iv) on any load.

(b) For the flue gas flow, tick the correct sequence
(i) Boiler – ID Fan – Air preheater – Economizer – chimney
(ii) Boiler – Air preheater – Economizer – ID Fan –chimney
(iii) Boiler – Economizer – Air preheater – ID Fan – chimney
(iv) None of the above.

(c) Single line diagram does not represents:
(i) Ratings of machines (ii) Neutral wire of transmission lines
(iii) Delta connection of transformer winding (iv) Star connection of transformer winding

(d) The function of a surge tank is :
(i) To supply water at constant pressure
(ii) To relieve water hammer pressures in the penstock pipe
(iii) To provide surge in the pipeline (iv) None of the above.

(e) The length of medium Transmission line
(i) 0 – 80 Km (ii) 80 – 160 Km. (iii) more than 160 km (iv) None of the above.

(f) Bundled conductors are used for EHV transmission lines primarily for reducing the:
(i) Corona loss (ii) Surge impedance
(iii) Voltage drop (iv) Skin effect

(g) The inductance of the line is minimum when:
(i) GMD is low (ii) GMD is high
(iii) GMD is constant (iv) None of these.

(h) Transient in synchronous generator is similar to which of the following circuit?
(i) Parallel RLC circuit (ii) Series RL circuit
(iii) Series RLC circuit (iv) Parallel RL circuit

(i) A 25 MVA, 33 KV transformer has a p.u. impedance of 0.9. The p.u. impedance at a new base 50 MVA at 11 KV would be _______
(i) 10.4 (ii) 12.2 (iii) 14.4 (iv) 16.2

(j) Which type of Resistor is used for over voltage protection.
(i) Sensistors (ii) Thermistors (iii) Varistors (iv) Inductor.

Q.2 (a) Three generators are rated as follows: Generator 1 – 100 MVA, 33 KV, reactance 10%, generator 2 – 150 MVA, 32kV, reactance 8%, Generator 3 – 110 MVA, 30 KV, reactance 12%. Determine the reactance of the generator corresponding to base values of 200 MVA, 35 KV. [7]

(b) Find the A,B,C & D parameters of Nominal –T transmission line. Also draw its phasor diagram. [7]

Q.3 (a) The 3 conductor of a 3-ϕ transmission lines are arranged in horizontal and 2m apart. The diameter of each conductor is 3cm. Determine inductance per km of each phase. [7]

(b) Derive the expression of capacitance for a 1- ϕ transmission line. Explain the effect of Earth on the capacitance calculation of the overhead transmission line. [7]

Q.4 (a) Explain the working of Thermal power based electricity generation with proper diagram. [7]

(b) What are the advantages of three-phase system. Explain the role of Reactive power in AC circuit. [7]

Q.5 (a) How DC transmission system works? Explain with suitable connection diagram along with the function line-commutated converters and voltage source converters. [7]

(b) Draw the I-V and P-V characteristics of PV pannels. Also draw the power curve of wind turbine with their application. [7]

Q.6 (a) What are the possible connections for a 3-phase transformer bank? State the significance of the three-phase transformer group. [7]

(b) Explain the working of Tap-changing transformers. Write its application in power system. [7]

Q.7 Discuss in detail about the steady state performance characteristics of a synchronous machine operation, when connected to infinite bus and also real and reactive power capability curve of the generators. [14]

Q.8 A generator transformer unit is connected to a line through a circuit breaker. The u ratings are:

Generator : 15MVA, 11kV, $X_d'' = 0\cdot3\,p.u.$, $X_d' = 0\cdot3\,p.u.$, $X_d = 0\cdot6\,p.u.$

Transformer : $15\,MVA, 12\cdot7/66kV$, $reactance = 0\cdot06\,p.u.$

List of Weak Students

LIST OF WEEK STUDENTS			
Sl No	**Registration No**	**Name**	**Mid Term Marks (20)**
1	Raj Kumar	21103131004	6
2	Supriya Kumari	21103131024	6
3	Raj Kumar	21103131004	6
4	Supriya Kumari	21103131024	6
5	Shivani Kumari	22103131018	6
6	Abhinay Kumar	22103131020	6
7	Satimala Kumari	23103131903	6

COURSE END SURVEY

Power System-I (2022-26 batch)

Sl No	Name	Registration No.	COURSE END SURVEY					Signature
			CO1	CO2	CO3	CO4	CO5	
1	Sahil Kumar	21103131001	5	5	5	5	5	Sahil Kumar.
2	Nitish Kumar	21103131002	4	4	4	5	5	[illegible]
3	Raj Kumar	21103131004	5	5	5	5	5	Raj Kumar
4	Saurav Kumar	21103131007	4	4	4	4	4	Saurav Kumar
5	Neha Kumari	21103131012	4	5	5	5	5	Neha Kumari
6	Hariom Kumar	21103131017	4	4	4	5	5	
7	Sandhya Kumari	21103131021	5	5	5	5	5	Sandhya Kumari
8	Supriya Kumari	21103131024	4	4	4	4	4	Supriya Kumari
9	Pankaj Kumar	21103131030	5	4	5	5	5	Pankaj
10	Vivek Kumar	21103131033	5	5	4	4	4	Vivek Kumar
11	Md Danish Jamal	21103131045	4	5	5	5	5	Md Danish Jamal
12	Ujjwal Kumar	21103131046	4	4	4	5	5	Ujjwal kr.
13	Harshit Kumar	21103131047	5	5	5	5	5	Harshit Kumar
14	Anjali Priya	21103131053	5	4	4	5	5	Anjali Priya
15	Rohit Raj	22103131001	5	5	5	5	5	Rohit Raj
16	Sameer	22103131002	5	5	4	4	4	Sameer
17	Asrar Ahmad	22103131003	4	4	5	5	5	Asrar Ahmad
18	Anubhav Kumar	22103131004	5	5	4	4	4	
19	Vikash Kumar	22103131006	5	4	4	4	4	
20	Ashish Aman	22103131008	4	5	5	5	5	
21	Anukriti	22103131009	5	4	4	5	5	
22	Sadan Kumar	22103131010	5	5	5	5	5	Sadan Kumar
23	Mannu Kumar	22103131011	4	5	4	4	4	Mannu Shah

24	Anshu Priya	22103131012	5	5	5	5	5	Anshu Priya
25	Ravishankar Kumar	22103131013	4	5	4	5	5	Ravishankar kumar
26	Manish Kumar	22103131014	5	5	5	5	5	
27	Monu Kumar	22103131015	5	4	4	4	4	Monu Kumar
28	Aman Kumar	22103131017	4	5	5	5	5	Aman kumar
29	Shivani Kumari	22103131018	5	4	4	5	5	Shivani Kumari
30	Badal Kumar	22103131019	5	5	5	5	5	
31	Abhinay Kumar	22103131020	5	4	4	4	4	Abhinay Kumar
32	Anushka Singh	22103131023	4	5	5	5	5	Anushka Singh
33	Utkarsh Jha	22103131025	4	5	4	4	4	Utkarsh Jha
34	Komal Kumar	22103131027	4	4	5	5	5	
35	Soni Priya	22103131029	4	4	4	5	5	Soni Priya
36	Ghanshyam Kumar	22103131030	5	5	5	5	5	Ghanshyam Kumar
37	Suman Kumar	22103131032	5	4	4	5	5	Suman Kumar
38	Shivam Kumar	22103131033	4	5	5	5	5	Shivam Kumar
39	Vijay Kumar	22103131034	4	5	4	5	5	Vijay Kumar
40	Ashish Kumar	22103131035	5	5	5	5	5	Ashish Kumar
41	Ankit Raj Prince	22103131036	4	5	4	4	4	Ankit Ray
42	Nisha Kumari	22103131037	5	5	5	5	5	Nisha Kumari
43	Rohit Kumar	22103131038	5	4	4	5	5	Rohit kumar
44	Sakshi Suman	22103131039	5	5	5	5	5	Sakshi Suman
45	Aryan Kumar	22103131040	4	4	4	4	4	Aryan Kumar
46	Pintu Kumar Yadav	22103131042	4	5	5	5	5	Pintu Yadav
47	Parmeshwari Bharti	22103131043	4	4	4	5	5	Parmeshwari Bharti
48	Abhay Kumar	22103131044	5	5	5	5	5	Abhay Kumar

CO ATTAINMENT ANALYSIS AND PO/PSO ATTAINMENT

CO Attainment through Mid Semester Exam

CO		CO1	CO1	CO1	CO2	CO2	CO3	Total Marks
QUES		**1**	**2**	**3**	**4**	**5**		
Name	**Reg. No.**							**(20)**
Sahil Kumar	**21103131001**	4	2			2		8
Nitish Kumar	**21103131002**			2	1	3	3	9
Raj Kumar	**21103131004**	1				2	3	6
Saurav Kumar	**21103131007**		4		4	5	5	18
Neha Kumari	**21103131012**	1	1			4	4	10
Hariom Kumar	**21103131017**		1	1		4	2	8
Sandhya Kumari	**21103131021**	5	4		3	4		16
Supriya Kumari	**21103131024**	2			2	2		6
Pankaj Kumar	**21103131030**		4		2	4	5	15
Vivek Kumar	**21103131033**	4	3	2		2		11
Md Danish Jamal	**21103131045**		3		2	4	2	11
Ujjwal Kumar	**21103131046**	3	2		3	3		11
Harshit Kumar	**21103131047**	2			2	2	2	8
Anjali Priya	**21103131053**	3	2	2		1		8
Rohit Raj	**22103131001**	3				3	3	9
Sameer	**22103131002**	1	2			2	5	10
Asrar Ahmad	**22103131003**	3	2		2	4		11
Anubhav Kumar	**22103131004**	4		5		4	5	18
Vikash Kumar	**22103131006**	4		4		5	5	18
Ashish Aman	**22103131008**	5	5	5		4		19
Anukriti	**22103131009**		4		3	4	4	15
Sadan Kumar	**22103131010**		2	1		5	5	13
Mannu Kumar	**22103131011**			5	3	5	5	18
Anshu Priya	**22103131012**			4	5	5	5	19
Ravishankar Kumar	**22103131013**	3	1			3	5	12

Manish Kumar	**22103131014**	2	3			5	2	12
Monu Kumar	**22103131015**	3		2	2	4		11
Aman Kumar	**22103131017**	5	2	3		4		14
Shivani Kumari	**22103131018**					1	5	6
Badal Kumar	**22103131019**	4			1	4	4	13
Abhinay Kumar	**22103131020**	4					2	6
Anushka Singh	**22103131023**	3	4			5	4	16
Utkarsh Jha	**22103131025**	5	4	4			5	18
Komal Kumar	**22103131027**	2	2			3		7
Soni Priya	**22103131029**		5		5	5	5	20
Ghanshyam Kumar	**22103131030**	4				2	1	7
Suman Kumar	**22103131032**	2	3			4	5	14
Shivam Kumar	**22103131033**	4	3			5	5	17
Vijay Kumar	**22103131034**			3	1	5	5	14
Ashish Kumar	**22103131035**	3			1	4	5	13
Ankit Raj Prince	**22103131036**	3		4		4	4	15
Nisha Kumari	**22103131037**	3	5			5	4	17
Rohit Kumar	**22103131038**	3	2			5	5	15
Sakshi Suman	**22103131039**	2	1			5	5	13
Aryan Kumar	**22103131040**		3	4		4	5	16
Pintu Kumar Yadav	**22103131042**		1			3	4	8
Parmeshwari Bharti	**22103131043**	3		4		3	4	14
Abhay Kumar	**22103131044**	4		2		3	5	14
Rajeev Ranjan Kumar	**22103131904**	2			4	4	5	15
Siddhant Singh Tomar	**22103131907**		2		3	3	5	13
Silki Kumari	**22103131911**	5		3		5	5	18
Neha Kumari	**23103131901**	3	3		4	5		15
Yash Raj	**23103131902**		3	4		5	5	17
Satimala Kumari	**23103131903**	1	1		2	2		6
Avinash Kumar	**23103131904**		2		2	3	5	12

Priyanshu Bharti	**23103131905**	5	3		4	5		17
Shivani Kumari	**23103131906**		2		2	2	5	11
Vijay Kumar	**23103131907**	4	3			2	5	14
Khushi Anand	**23103131908**		4		4	5	5	18
Anupriya Kumari	**23103131909**		2			3	2	7
Muskan Kumari	**23103131910**			4	5	4	5	18
Rajlakshmi	**23103131911**	5		5		4	5	19
Shweta Kumari	**23103131912**	5			5	5	5	20
Yamika Bharti	**23103131913**	4	2		4	5		15
Ritesh Kumar	**23103131914**	3	3	2		3		11
Ramesh Kumar Sah	**23103131915**		3		4	5	5	17
Krishan Kumar	**23103131916**	4	2		3		3	12
Kundan Kumar Yadav	**23103131917**	5	5			5	5	20
Kanhaiya Kumar	**23103131918**	4	4	2			5	15
Vikas Kumar Ram	**23103131919**	4	3	4		4		15

CO ATTAINMENT THROUGH ASSIGNMENT

Name	**Reg. No.**	Assignment marks (5)
Sahil Kumar	**21103131001**	5
Nitish Kumar	**21103131002**	5
Raj Kumar	**21103131004**	0
Saurav Kumar	**21103131007**	5
Neha Kumari	**21103131012**	5
Hariom Kumar	**21103131017**	5
Sandhya Kumari	**21103131021**	5
Supriya Kumari	**21103131024**	5
Pankaj Kumar	**21103131030**	5
Vivek Kumar	**21103131033**	5
Md Danish Jamal	**21103131045**	5
Ujjwal Kumar	**21103131046**	5

Harshit Kumar	**21103131047**	5
Anjali Priya	**21103131053**	5
Rohit Raj	**22103131001**	5
Sameer	**22103131002**	5
Asrar Ahmad	**22103131003**	5
Anubhav Kumar	**22103131004**	5
Vikash Kumar	**22103131006**	5
Ashish Aman	**22103131008**	5
Anukriti	**22103131009**	5
Sadan Kumar	**22103131010**	5
Mannu Kumar	**22103131011**	5
Anshu Priya	**22103131012**	5
Ravishankar Kumar	**22103131013**	5
Manish Kumar	**22103131014**	5
Monu Kumar	**22103131015**	5
Aman Kumar	**22103131017**	5
Shivani Kumari	**22103131018**	5
Badal Kumar	**22103131019**	5
Abhinay Kumar	**22103131020**	5
Anushka Singh	**22103131023**	5
Utkarsh Jha	**22103131025**	4
Komal Kumar	**22103131027**	5
Soni Priya	**22103131029**	4
Ghanshyam Kumar	**22103131030**	5
Suman Kumar	**22103131032**	5
Shivam Kumar	**22103131033**	5
Vijay Kumar	**22103131034**	5
Ashish Kumar	**22103131035**	5
Ankit Raj Prince	**22103131036**	5
Nisha Kumari	**22103131037**	5
Rohit Kumar	**22103131038**	5

Sakshi Suman	**22103131039**	5
Aryan Kumar	**22103131040**	5
Pintu Kumar Yadav	**22103131042**	5
Parmeshwari Bharti	**22103131043**	5
Abhay Kumar	**22103131044**	5
Rajeev Ranjan Kumar	**22103131904**	5
Siddhant Singh Tomar	**22103131907**	5
Silki Kumari	**22103131911**	5
Neha Kumari	**23103131901**	5
Yash Raj	**23103131902**	5
Satimala Kumari	**23103131903**	5
Avinash Kumar	**23103131904**	5
Priyanshu Bharti	**23103131905**	5
Shivani Kumari	**23103131906**	5
Vijay Kumar	**23103131907**	5
Khushi Anand	**23103131908**	5
Anupriya Kumari	**23103131909**	5
Muskan Kumari	**23103131910**	5
Rajlakshmi	**23103131911**	5
Shweta Kumari	**23103131912**	4
Yamika Bharti	**23103131913**	5
Ritesh Kumar	**23103131914**	5
Ramesh Kumar Sah	**23103131915**	5
Krishan Kumar	**23103131916**	5
Kundan Kumar Yadav	**23103131917**	4
Kanhaiya Kumar	**23103131918**	5
Vikas Kumar Ram	**23103131919**	5

CO ATTAINMENT THROUGH ATTENDANCE

Name	**Reg. No.**	**Attendance Marks (5)**
Sahil Kumar	**21103131001**	5

Nitish Kumar	**21103131002**	5
Raj Kumar	**21103131004**	0
Saurav Kumar	**21103131007**	4
Neha Kumari	**21103131012**	5
Hariom Kumar	**21103131017**	5
Sandhya Kumari	**21103131021**	4
Supriya Kumari	**21103131024**	5
Pankaj Kumar	**21103131030**	5
Vivek Kumar	**21103131033**	5
Md Danish Jamal	**21103131045**	5
Ujjwal Kumar	**21103131046**	5
Harshit Kumar	**21103131047**	5
Anjali Priya	**21103131053**	5
Rohit Raj	**22103131001**	5
Sameer	**22103131002**	5
Asrar Ahmad	**22103131003**	5
Anubhav Kumar	**22103131004**	4
Vikash Kumar	**22103131006**	4
Ashish Aman	**22103131008**	4
Anukriti	**22103131009**	5
Sadan Kumar	**22103131010**	5
Mannu Kumar	**22103131011**	4
Anshu Priya	**22103131012**	4
Ravishankar Kumar	**22103131013**	5
Manish Kumar	**22103131014**	5
Monu Kumar	**22103131015**	5
Aman Kumar	**22103131017**	5
Shivani Kumari	**22103131018**	5
Badal Kumar	**22103131019**	5
Abhinay Kumar	**22103131020**	5
Anushka Singh	**22103131023**	4

Utkarsh Jha	**22103131025**	5
Komal Kumar	**22103131027**	5
Soni Priya	**22103131029**	4
Ghanshyam Kumar	**22103131030**	5
Suman Kumar	**22103131032**	5
Shivam Kumar	**22103131033**	4
Vijay Kumar	**22103131034**	5
Ashish Kumar	**22103131035**	5
Ankit Raj Prince	**22103131036**	5
Nisha Kumari	**22103131037**	5
Rohit Kumar	**22103131038**	5
Sakshi Suman	**22103131039**	5
Aryan Kumar	**22103131040**	5
Pintu Kumar Yadav	**22103131042**	5
Parmeshwari Bharti	**22103131043**	5
Abhay Kumar	**22103131044**	5
Rajeev Ranjan Kumar	**22103131904**	5
Siddhant Singh Tomar	**22103131907**	5
Silki Kumari	**22103131911**	4
Neha Kumari	**23103131901**	5
Yash Raj	**23103131902**	5
Satimala Kumari	**23103131903**	5
Avinash Kumar	**23103131904**	5
Priyanshu Bharti	**23103131905**	5
Shivani Kumari	**23103131906**	5
Vijay Kumar	**23103131907**	5
Khushi Anand	**23103131908**	4
Anupriya Kumari	**23103131909**	5
Muskan Kumari	**23103131910**	5
Rajlakshmi	**23103131911**	4
Shweta Kumari	**23103131912**	4

Yamika Bharti	**23103131913**	5
Ritesh Kumar	**23103131914**	5
Ramesh Kumar Sah	**23103131915**	5
Krishan Kumar	**23103131916**	5
Kundan Kumar Yadav	**23103131917**	4
Kanhaiya Kumar	**23103131918**	5
Vikas Kumar Ram	**23103131919**	5

PO'S / PSO'S ADDRESSED BY COS & MAPPING STRENGTH WITH COURSE

PO/PSO	CO	No. of Sessions	% of session	Mapping Strength
PO1	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PO2	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PO3	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PO4	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PO5	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PO6	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PO7	CO1, CO2, CO3, CO5,	13+8+8+8	88	3
PO8			0	1
PO9			0	1
PO10			0	1
PO11			0	1
PO12	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PSO1	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PSO2	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3
PSO3	CO1, CO2, CO3, CO4, CO5,	13+8+8+5+8	100	3

S. No.	Percentage of Session	Mapping Strength
1	> 70	3
2	30 - 70	2
3	< 30	1

CLASS AVERAGE IN CONTINUOUS INTERNAL EVALUATION				
CO	Mid Term Exam (20)	Assignment (5)	Attendance (5)	Class Average(%)
CO1	5.3	2.4	4.7	55.21%
CO2	4.8	2.4	4.6	67.58%
CO3	3.2	0.0	4.6	78.34%
CO4	0.0	0.0	4.6	91.82%
CO5	0.0	0.0	4.6	91.82%

PS-I (100507)	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
Mapping Strength	3	3	3	3	3	3	3	1	1	1	1	3	3	3	3

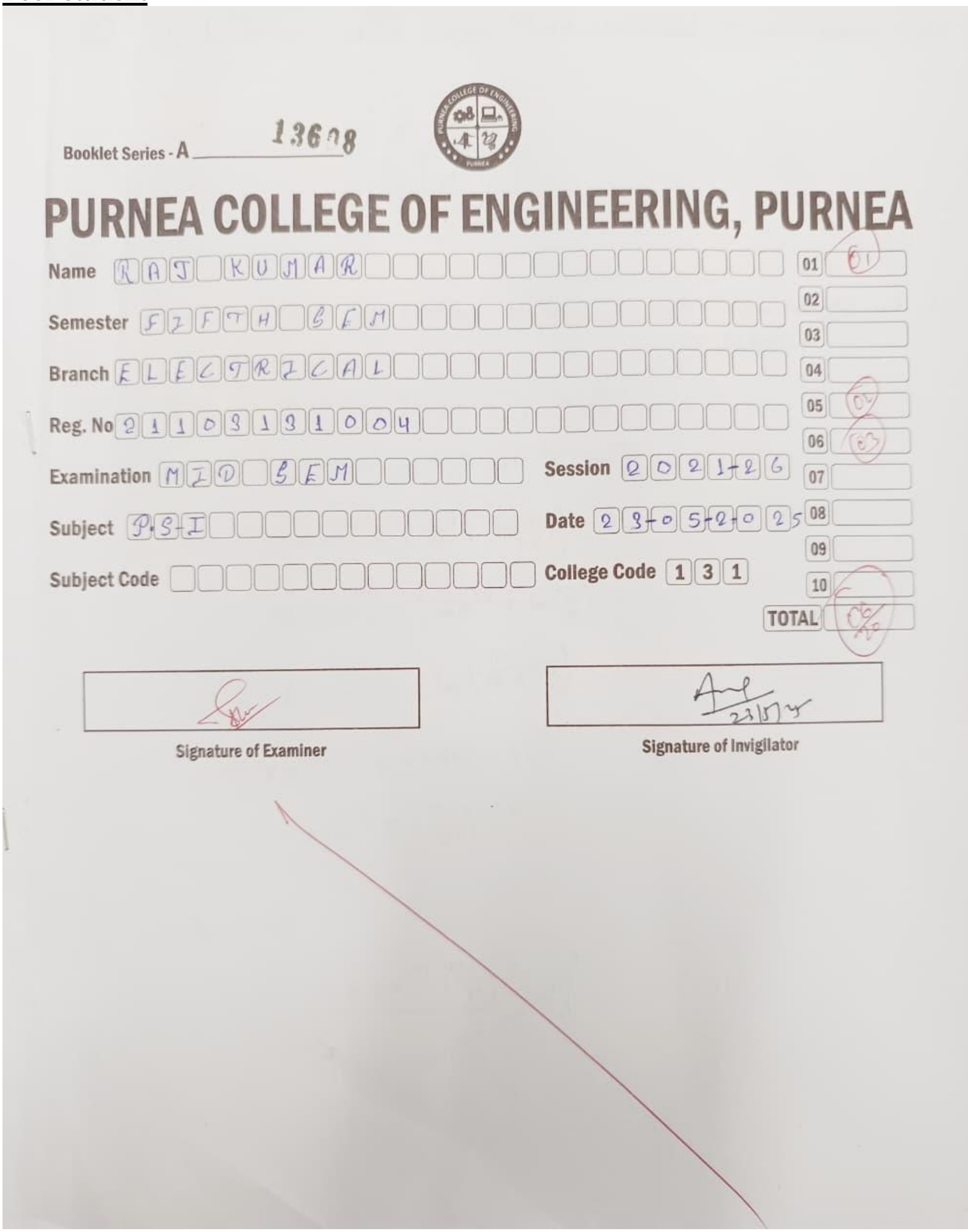
COURSE OUTCOME TARGET	
CO	Target %
CO1	60%
CO2	60%
CO3	65%
CO4	70%
CO5	70%

Direct CO Attainment			
(30% of Continuous internal evaluation + 70 % of end semester exam)			
CO	CIE (Class Avg. %)	ESE (Class Avg. %) (Same Value Assumed for all Cos)	Direct CO Attained (.30 OF CIE + .70 OF ESE)
CO1	55.21%	59.33%	**58.09%**
CO2	67.58%	59.33%	**61.80%**
CO3	78.34%	59.33%	**65.03%**
CO4	91.82%	59.33%	**69.07%**
CO5	91.82%	59.33%	**69.07%**
Total CO Attainment			
(90% of Direct CO Attainment + 10 % of			

Indirect CO Attainment)			
CO	Direct attained CO %	Indirectly Attained CO % (Course End Survey)	Total CO Attained%
CO1	58.09%	90.57%	61.34%
CO2	61.80%	91.43%	64.77%
CO3	65.03%	90.29%	67.56%
CO4	69.07%	94.29%	71.60%
CO5	69.07%	94.29%	71.60%

CO Attainment Analysis					
CO	Target %	Attained %	Attainment gap (%)	Action Proposed to bridge the gap	Modification of target where achieved
CO1	60.00%	61.34%	-1.34%	Defined	61.34%
CO2	60%	64.77%	-5%	Attained	64.77%
CO3	65%	67.56%	-3%	Defined	67.56%
CO4	70%	71.60%	-2%	Defined	71.60%
CO5	70%	71.60%	-2%	Defined	71.60%

Poor student



Booklet Series - A 13698

PURNEA COLLEGE OF ENGINEERING, PURNEA

Name: RAJ KUMAR

Semester: FIFTH SEM

Branch: ELECTRICAL

Reg. No: 21103131004

Examination: MID SEM

Session: 2021-26

Subject: P.S.I

Date: 23-05-2025

Subject Code:

College Code: 131

01 02 03 04 05 06 07 08 09 10 TOTAL

Signature of Examiner

Signature of Invigilator

(6) Inductance of a single-Phase overhead transmission line.

flux Linkage = Inner flux linkage + outer flux linkage up to D distance.

$$\psi = 0.5\times10^{-7} I + 2\times10^{-7} I \ln\left(\frac{D}{r}\right)$$

$$= \frac{1}{4}\left(2\times10^{-7} I\right) + 2\times10^{-7} I \ln\left(\frac{D}{r}\right)$$

$$= 2\times10^{-7} I \left[\frac{1}{4} + \ln\left(\frac{D}{r}\right)\right]$$

$$= 2\times10^{-7} I \left(\ln e^{1/4} + \ln\frac{D}{r}\right)$$

$$= 2\times10^{-7} I \ln\left(\frac{D}{r e^{-1/4}}\right)$$

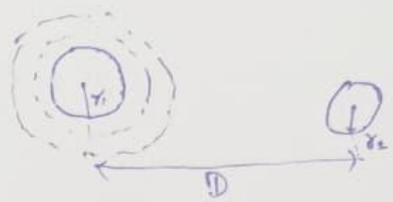
$$r e^{-1/4} = 0.7788 = r'$$

$$= 2\times10^{-7} I \left(\frac{D}{r'}\right)$$

$$L = \frac{\psi}{I}$$

$$L = 2\times10^{-7}\left(\frac{D}{r'}\right)$$

1-φ Inductance ~~for~~ of two wire.



$L = L_1 + L_2.$

$L_1 = 2\times10^{-7}\left(\frac{D}{r_1'}\right)$

$L_2 = 2\times10^{-7}\left(\frac{D}{r_2'}\right)$

$= 2\times10^{-7}\left(\frac{D}{r_1'}\right) + 2\times10^{-7}\left(\frac{D}{r_2'}\right)$

$= 2\times10^{-7}\left(\frac{D}{r_1'} + \frac{D}{r_2'}\right)$

$= 2\times10^{-7}\left(\frac{D^2}{r_1' \cdot r_2'}\right)$

$= 2\times10^{-7}\left(\frac{D}{\sqrt{r_1' \cdot r_2'}}\right)^2$

$r_1 = r_2 = r$

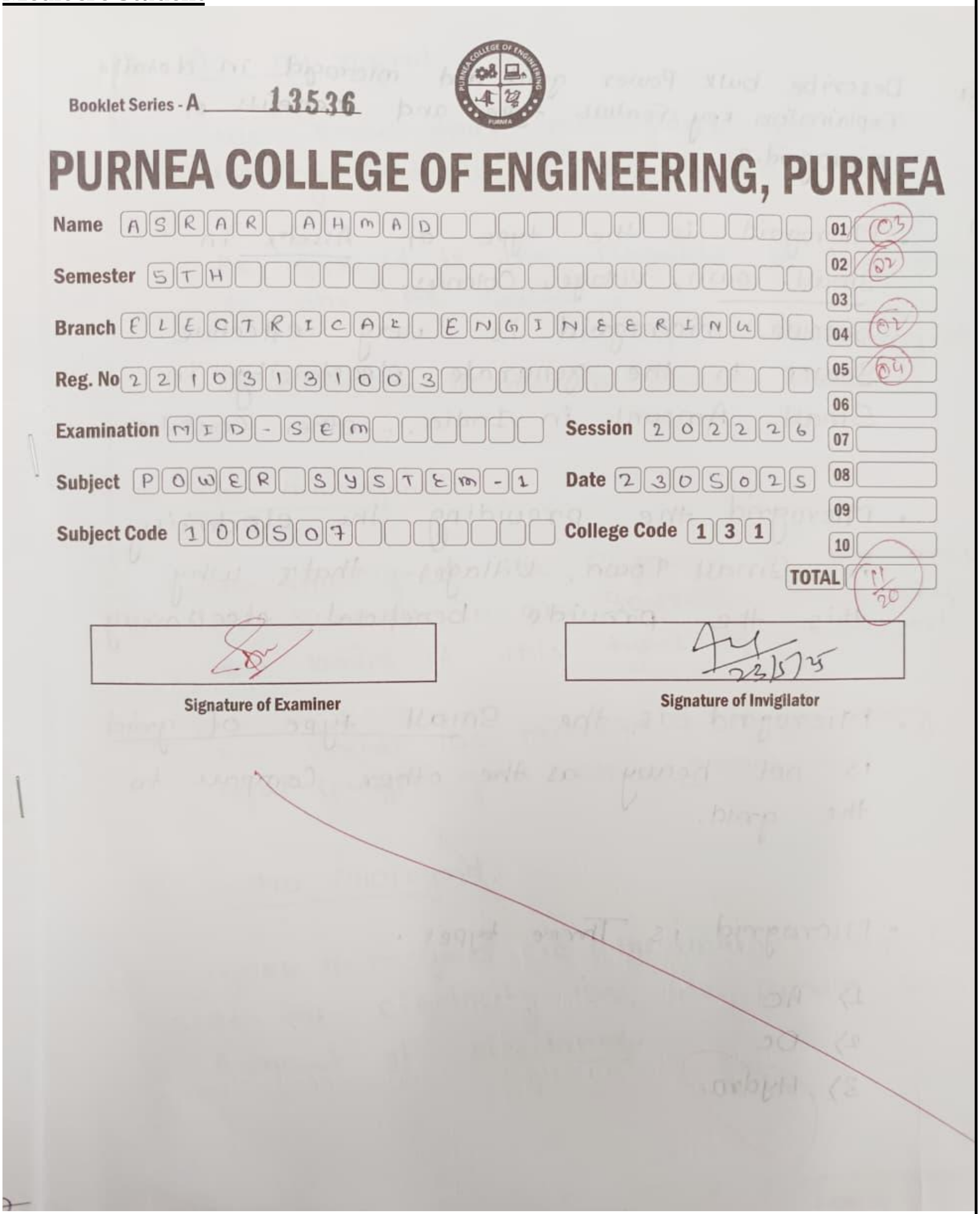
$r_1' = r_2' = r'$

$L = 4\times10^{-7}\left(\frac{D^2}{r'}\right)$

L.

03

Mediocre Student



Booklet Series - A 13536

PURNEA COLLEGE OF ENGINEERING, PURNEA

Name: ASRAR AHMAD

Semester: 5TH

Branch: ELECTRICAL ENGINEERING

Reg. No: 22103131003

Examination: MID-SEM

Session: 202226

Subject: POWER SYSTEM-1

Date: 23052025

Subject Code: 100507

College Code: 131

01	03
02	02
03	
04	02
05	04
06	
07	
08	
09	
10	
TOTAL	11/20

Signature of Examiner

Signature of Invigilator 23/5/25

Q1 Describe bulk Power grid and microgrid in details Explaination key Feature type and benefits of microgrid.?

Sol

- Microgrid is the type of Assets in Small. Town, Village, Colonies. ... becouse microgrid is very effective Source to the generate eleectricity in Small Amount in India. ... other Countries

- Microgrid the providing the electricity in Small Town, Villages. that's why this the provide beneficial eleectrically.

- Microgrid is the Small type of grid is not heavy as the other Compare to the grid.

- Microgrid is Three types.

1) AC
2) DC
3) Hydro.

1) Ac micrognid.

we know that microgid's type and working Principle of the System.

Ac microgid is the Capable to the provid to the Ac Sourc,

why? Ac micrognid Construction to the Ac provid- Sourc.

2) Dc micrognid.

Dc micrognid the Capable to the provid Dc Sources in our Societies. that's why we build it this types of micrognid

we know Dc micrognid is the very Hight weyth grid other them

3) Hydro micrognid.

Hydro micrognid is the main " Larg Sources of the electricity. so, we provid larg Amount of elcectricity.

Hydro microgrid is Size in Small but we provide Larg Amount of the electricity

we Know, India take % electricity in Larg % of Hydro_

Hydro electricity = 10% Approx

03

Bes

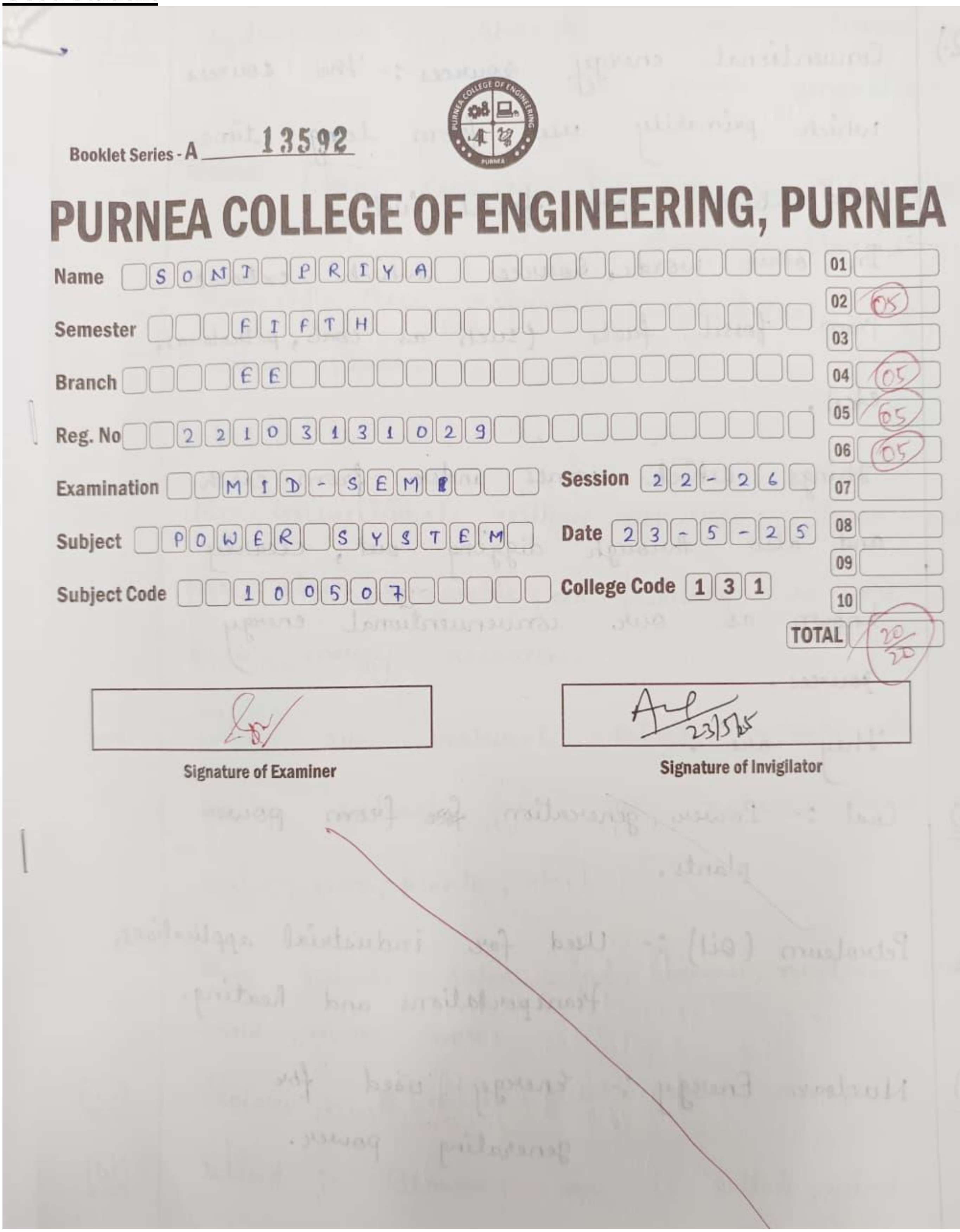
Q2 Write down the Conventional and non-Convantional. _

Conventional	non- Convantional.
• Coil	• Renewable energy.
• Gas.	• wave (genrative energy)
• wood.	• Bio
• Hydro.	• thermal.
•	• Air (generating energy through)

→ we Know about Convantional energy So, those made it Coil, Gas, wood, Hydro.

this types of energy Conventional energy.

Good Student



Booklet Series - A 13592

PURNEA COLLEGE OF ENGINEERING, PURNEA

Name	SONI PRIYA	01	
Semester	FIFTH	02	05
Branch	EE	03	
Reg. No	22103131029	04	05
Examination	MID-SEM	05	05
Session	22-26	06	05
Subject	POWER SYSTEM	07	
Date	23-5-25	08	
Subject Code	100507	09	
College Code	131	10	
		TOTAL	20/20

Signature of Examiner

Signature of Invigilator 23/5/25

2.) Conventional energy sources :- The sources which primarily used from long time and based upon fossil fuels.
In other words, Sources which extract from fossil fuels (such as coal, petroleum, etc.).

Things which comes under from earth and also through digging out, clearly known as our convenuentional energy sources.

They are :-

(a.) Coal :- Power generation ~~for~~ from power plants.

(b.) Petroleum (Oil) :- Used for industrial applications, transportations and heating.

(c.) Nuclear Energy :- Energy used for generating power.

(d.) Hydropower :- Through hydrogen source, we get the power generation.

→ ~~Solar~~ Dams, Reservoirs [Sardar Dam, Tehri Dam, and Sarovar Dam]

Through these resources, conventional energy comes under.

Now,

★ Non-conventional energy resources :- These resources are clean, renewable, eco-friendly to the conventional energy resources.

→ They are natural things which we can easily extract from our nature (such as water, sun, plants, etc.)

They include solar, wind, biomass, nuclear energy and many more.

(a.) Solar :- Which gives solar energy.

(b.) Wind :- Blowing air is called, wind.

(c.) Biomass :- Comes from biomolecules
(Such as biomass, biogas, etc.)

(d.) Nuclear energy :- Energy used for power generation.

So, these are some features which comes under non-conventional energy.

Total power generation in India is contributed among partical areas.
In other words, generating of electricity from generation to distributed. And hence, provide ~~a~~ power supply ~~from general~~ is transmitted from generating to the load centre.

These system of power which generates electricity is in the form of Generation, Transmission and Distribution.

Remedial Action for Weak Students

1. Teaching Methodologies

- Simplified teaching
- Visual aids
- Peer learning
- Mentoring

2. Outcome of Remedial Classes

- Improved performance
- Better understanding
- Increased confidence

3. Challenges Faced

- Attendance issues
- Time constraints

4. Suggestions for Improvement

- Continuous remedial classes
- Use of technology
- Increased mentoring