Purbanchal University

Faculty of Engineering, Biratnagar, NEPAL

Fifth Semester's Course Structure & Syllabus

Program: Bachelor in Electrical Engineering

Effective from 2021 (2078) Batch

Year-III **Semester-V**

S.N.	Course code	Subject	Credit Hours	L	T	P	Total	Internal		Final		Total
								Th.	P	Th.	P	
1		Probability & Statistics	3	3	2	2	7	20	20	60	-	100
2		Advanced Instrumentation	3	3	1	3/2	5.5	40	10	60	15	125
3		Control System Engineering	3	3	1	3/2	5.5	40	10	60	15	125
4		Electric Machine Design	3	3	-	3	6	40	10	60	15	125
5		Power System Analysis-II	3	3	1	3/2	5.5	40	10	60	15	125
6		Synchronous and Special Machine	2	2	1	3/2	4.5	20	10	30	15	75
7		Research Methodology	2	2	1	-	3	20	-	30	-	50
		Total	**19**	**19**	**8**	**11**	**37**					**725**

Note- **L:** Lecture **T:** Tutorial **P :** Practical **Th. :** Theory

Purbanchal University

Faculty of Engineering, Biratnagar, NEPAL

<u>Syllabus</u>

Level: Bachelor
Program: Bachelor in Biomedical /Electrical/Electronics, Com. & Automation Engineering
Subject: Probability and Statistics

Year: III **Semester: V**

Teaching Hours/week				Examination Scheme						Total Marks
				Internal		Final				
				Theory	Practical	Theory		Practical		
Credit Hour	L	T	P			Duration	Marks	Duration	Marks	
3	3	2	2	20	20	3 Hrs.	60	-	-	100

Objectives:

1. To give an exposure to the students the basic concepts of probability and statistical methods and their application.
2. To serve as a foundation to analyze problems in engineering applications through statistical testing methods.

<u>Course contents</u>

Unit1. Descriptive Statistics [6 Hrs]

Measures of location: mean, combined mean, median, mode, partition values and their properties; Measures of dispersion: absolute and relative measure of variation; standard deviation, variance and Coefficient of variation

Unit 2. Correlation and Regression [5 Hrs]

Simple Correlation: Karl Pearson's correlation coefficient and its properties, Simple Linear Regression: Model and assumptions of simple linear regression; Least square estimators of regression coefficients;

properties of regression coefficients; Coefficient of determination

Unit 3 Probability [6 Hrs]

Introduction of probability: Basic terminology in probability: random experiment ,sample space, trial and events, type of events: mutually exclusive events, equally likely events, independent events; Definitions of probability, basic principles of counting; Laws of probability: Additive and multiplicative; Conditional probability; Bayes' Theorem.

Unit 4. Random Variable and Expectation [3 Hrs]

Random Variables: Discrete and continuous random Variables; Probability distribution of random variables; Expected value of discrete & continuous random Variable.

Unit 5. Discrete Probability Distributions [5 Hrs]

Binomial distribution, condition for using for using binomial distribution, properties of binomial distribution, Computing binomial probabilities, Fitting of binomial distribution; poisson distribution, condition for using for using poisson distribution, properties of poisson distribution, Computing poissson probabilities, Fitting of poissson distribution.

Unit 6. Continuous Probability Distributions [7 Hrs]

Normal distribution, standard normal distribution, curve of normal and standard normal distribution, properties of normal distribution, computing normal probabilities, Measurement of areas under the normal curve; student's t-distribution and its application, chi-square distribution and its application

Unit 7. Estimation [4 Hrs]

Concept of sample, population, statistic, parameter, estimation and its types, criteria for good estimator, confidential interval, standard error, confidential interval of mean for mean, confidential interval of mean for the difference of two means, confidential interval of mean for proportion, confidential interval of mean for the difference of two proportions.

Unit 8. Testing of hypothesis [8Hrs]

Concept of hypothesis testing; hypothesis and its types, level of significance, degree of freedom, error in testing of hypothesis, z-test: for single proportion, for the difference of two proportions, for single mean, for the difference of two means, t-test: for single mean, t-test for the difference of two means, paired t-test, chi-square test: for goodness of fit, for independence of attributes, ,validity of chi-square test.

Laboratory

Practical problems to be covered in computer lab using any one of application software(Excel, SPSS, Minitab, etc.)

References:

1. Gupta, S.C.. Fundamental of statistics, Sultan Chand and Sons, delhi
2. Richard A. Johnson, Miller and Freund's probability and Statistics for Engineers, 6th Edition, Indian reprint: Pearson Education, 2001.
3. Ronald E. Walpole, R.H. Myers, S.L. Myers, and K. Ye, Probability and Statistics for Engineers and Scientists, 7th Edition, Indian reprint: Pearson Education, 2005.
4. Gaire, Arjun Kumar,Probability and statistics for Engineers.
5. Poudel , Toya Narayan and Kunwar, Pradeep, Probability and statistics for Engineers, Sukunda publication

Mark Scheme

Chapter	**Mark distribution**
I	**10**
II	**15**
III	**15**
IV	**5**
V	**5**
VI	**10**
VII	**5**
VIII	**15**

Detailed Course Contents of Probability and Statistics

Year: III **Semester: V**

Unit 1. Descriptive Statistics [6 Hrs.]

Measures of location: mean, combined mean, median, mode, partition values(quartiles and percentiles); Measures of dispersion: absolute and relative measure of variation; standard deviation, variance and Coefficient of variation

Unit 2. Correlation and Regression [4 Hrs.]

Simple Correlation: Karl Pearson's correlation coefficient and its properties, Simple Linear Regression: Model and assumptions of simple linear regression; Least square estimators of regression coefficients; properties of regression coefficients; Coefficient of determination

Unit 3. Probability [5 Hrs.]

Introduction of probability: Basic terminology in probability: random experiment ,sample space, trial and events, type of events: mutually exclusive events, equally likely events, independent events; Definitions of probability, basic principles of counting; Laws of probability: Additive and multiplicative(statement only); Conditional probability, Bayes' Theorem(statement only).

Unit 4. Random Variable and Expectation [2 Hrs.]

Random Variables: Discrete and continuous random Variables; Probability distribution of random variables; Expected value of discrete & continuous random Variable.

Unit 5. Discrete Probability Distributions [5 Hrs.]

Binomial distribution, condition for using for using binomial distribution, properties of binomial distribution(without proof), Computing binomial probabilities, Fitting of binomial distribution; poisson distribution, condition for using for using poisson distribution, properties of poisson distribution(without proof), Computing poisson probabilities, Fitting of poissson distribution.

Unit 6. Continuous Probability Distributions [7 Hrs.]

Normal distribution, standard normal distribution, curve of normal and standard normal distribution, properties of normal distribution, computing normal probabilities, Measurement of areas under the normal curve; student’s t-distribution and its application, chi-square distribution and its application

Unit 7. Estimation **[4 Hrs.]**

Concept of sample, sampling , determination of sample size, population, statistic, parameter, estimation and its types, criteria for good estimator, confidential interval, standard error, confidential interval of mean for mean, confidential interval of mean for the difference of two means, confidential interval of mean for proportion, confidential interval of mean for the difference of two proportions.

Unit 8. Testing of hypothesis **[8Hrs.]**

Concept of hypothesis testing; hypothesis and its types, level of significance, degree of freedom, error in testing of hypothesis, z-test: for single proportion, for the difference of two proportions, for single mean, for the difference of two means, t-test: for single mean, t-test for the difference of two means, paired t-test, chi-square test: for goodness of fit, for independence of attributes, ,validity of chi-square test.

PURBANCHAL UNIVERSITY

V th SEMESTER FINAL EXAM – 2024 (MODEL QUESTION)

PROGRAM: B. E. Biomedical /Electrical/Electronics

SUBJECT: Probability & Statistics FULL MARKS: 60

TIME: 03:00 hrs PASS MARKS: 24

Group-A: Long answer type questions

Answer TWO questions [2 X 10 = 20]

1. Three different machines M_1, M_2, and M_3 are used to produce similar electronic components. Machines M_1, M_2, and M_3 produce 20%, 30% and 50% of the components respectively. It is known that the probabilities that the machines produce defective components are 1% for M_1, 2% for M_2, and 3% for M_3. If a component is selected randomly from a large batch, and that component is defective, find the probability that it was produced: (a) by M_2, and (b) by M_3.

2. In trying to evaluate the effectiveness in its advertising campaign, a firm compiled the following information:

Year	2001	2002	2003	2004	2005	2006	2007
Advertising Expenditure(‘000 Rs)	12	14	17	22	35	42	50
Sales(lakh Rs.)	5.1	5.5	5.8	7.0	7.5	8.2	9.5

(a) Obtain the regression equation of sales on advertising expenditure.
(b) Estimate the probable sales when advertisement expenditure is Rs. 65 thousand.

3. In an industry , 200 workers, employed for a specific job, were classified according to their performance and training received/not received to test independence of a specific training and performance. The is summarized as follows:

	Performance		Total
	Good	Not Good	
Trained	100	50	150
Untrained	20	30	50
Total	120	80	200

Use chi-square test of independence at 5% level of significance and write your conclusion.

Group- B: short answer type questions

Answer EIGHT questions [8 X 5 = 40]

4. The following is the frequency distribution of the number of telephone calls received in 245 successive one-minute intervals at an exchange:

No. of calls	0	1	2	3	4	5	6	7
Frequency	14	21	25	43	51	40	39	12

Find mean and variance of number of calls per minute.

5. A company has bid on two large construction projects. The company president believes that the probability of winning the first contract is 0.6, the probability of winning the second contract is 0.4, and the probability of winning both contracts is 0.2.

a) What is the probability that the company wins at least one contract?

b) What is the probability that the company wins the first contract but not the second contract?

6. A random variable X has the following probability distribution:

Value of x	-2	-1	0	1	2	3
P(x)	0.1	K	0.2	2k	0.3	K

(i) Find the value of k.

(ii) Find the expected value and variance of X.

7. A factory produces components of which 1% are defective. The components are packed in boxes of 10. A box is selected at random.

a) Find the probability that the box contains exactly one defective component.

b) Find the probability that there are at least 2 defective components in the box.

8. A random sample of 100 items drawn from a large batch of articles contain 5 defective items. Find 95 % and 99% confidence limits for the proportion of defective items.

9. A random sample of size 50 was drawn and sample mean was found to be 90. Test whether this sample could have come from a normal population with mean 100 and standard deviation 8 at 5% level of significance.

10. A certain type of wooden beam has a mean breaking strength of 1500 kgs and a standard deviation of 100 kgs. Find the relative frequency of all such beams whose breaking strengths lie between 1450 and 1600 kgs.

11. Distinguish between correlation and regression.

12.write short notes on the following

a) Primary and secondary data

b) Estimation

ADVANCED INSTRUMENTATION
(Course Code)

Year III **Semester V**

Teaching Schedule Hours/Week			Examination Scheme				
Theory	Tutorial	Practical	Internal Assessment		Final		Total
			Theory	Practical	Theory	Practical	
3	1	3/2	40	10	60	15	125

Course Objectives: To introduce and apply the knowledge of microprocessor, A/D, D/A converter to design Instrumentation system and to provide the concept of interfacing with microprocessor-based system and circuit design techniques

1. **Microprocessor Based Instrumentation System (5 hours)**
   Basic Features of Microprocessor Based System, Open Loop and Closed Loop Microprocessor Based System, Benefits of Microprocessor Based System, Microcomputer on Instrumentation Design, Interfacing Concept, Review of Address Decoding, Input / Output registers, Programmed I/O, Interrupt Driven I/O and Direct Memory Access (DMA), PC interfacing
2. **Parallel methods of data transfer(3 hours)**
   Simple I/O and strobe I/O, Single Handshake I/O, Double Handshake I/O,
   8255 PPI Device, block diagram, internal structure, initialization and interfacing,
   Microcomputer in instrumentation.
3. **Serial Interfacing with Microprocessor Based System (6 hours)**
   Advantages of Serial Data Transfer over Parallel, Synchronous and Asynchronous Data Transfer, Errors in Serial Data Transfer, Simplex, Half Duplex and Full Duplex Data Communication, Parity and Baud Rates, Introduction Serial Standards RS232, RS423, RS422, Universal Serial Bus, The Standards USB 1.1 and USB 2.0.
4. **Interfacing A/D and D/A Converters (5 hours)**
   Introduction, General Terms Involved in A/D and D/A Converters, Functional block diagram of 8-bit and 12 bit A/D and D/A converters, Assembly language programs for A/D and D/A Interfacing, Selection of A/D and D/A Converters Based on Design Requirements.
5. **Data Acquisition and Transmission (3 hours)**
   Analog and Digital Transmission, Transmission Media, Fiber Optics, Satellite, Data Acquisition System, Data Loggers.

6. **Grounding and Shielding (3 hours)**
   Outline for Grounding and Shielding, Noise, Noise Coupling Mechanism and Prevention, Single Point Grounding and Ground Loop, Filtering and Smoothing, Decoupling Capacitors and Ferrite Beads, Line Filters, Isolators and Transient Suppressors, Different Kinds of Shielding Mechanism, Protecting Against Electrostatic Discharge, General Rules for Design

7. **Circuit Design (3 hours)**
   Converting Requirements into Design, Reliability and Fault Tolerance, High Speed Design, Bandwidth, Decoupling, Ground Bounce, Crosstalk, Impedance Matching, and Timing, Low Power Design, Reset and Power Failure Detection and interface Unit, Redundant architecture, Timings

8. **Circuit Layout (4 hours)**
   Circuits Boards and PCBs, Component Placement, Routing Signal Tracks, Trace Density, Common Impedance, Distribution of Signals and Return, Transmission Line Concerns, Trace Impedance and Matching, and Avoiding Crosstalk, Ground, Returns and Shields, Cables and Connectors, Testing and Maintenance.

9. **Software for Instrumentation And Control Applications (6 hours)**
   Types of Software, Selection and Purchase, Software Models and Their Limitations, Software Reliability, Fault Tolerance, Software Bugs and Testing, Good Programming Practice, User Interface, Embedded and Real Time Software.

10. **Case Study (7 hours)**
   Examples chosen from local industrial situations with particular attention paid to the basic measurement requirements, accuracy, and specific hardware employed environmental conditions under which the instruments must operate, signal processing and transmission, output devices:
   - Instrumentation for a power station including all electrical and non-electrical parameters.
   - Instrumentation for a wire and cable manufacturing and bottling plant.
   - Instrumentation for a beverage manufacturing and bottling plant.
   - Instrumentation for a complete textile plant; for example, a cotton mill from raw cotton through to finished dyed fabric.
   - Instrumentation for a process; for example, an oil seed processing plant from raw seeds through to packaged edible oil product.
   - Instruments required for a biomedical application such as a medical clinic or hospital.
   - Other industries can be selected with the consent of the Subject teacher.

Practical:

The laboratory exercises deal interfacing techniques using microprocessor or microcontrollers. There will be about six lab sessions which should cover at least following:

1. Simple and Handshake data transfer using PPI.
2. Basic I/O device interfacing like keyboard, seven segments, motors etc
3. Analog to Digital interfacing
4. Digital to Analog interfacing

References:

1. D. V. Hall, “Microprocessor and Interfacing, Programming and Hardware” Tata McGraw Hill
2. K.R. Fowler, “Electronic Instrument Design: Architecting for the Life Cycle”, Oxford University Press
3. Ramesh S. Gaonkar, “Microprocessor Architecture, Programming and Application with 8085”, Prentice Hall
4. A.K. Ray & K.M. Bhurchandi, “Advanced Microprocessors And Peripherals”, Tata McGraw Hill
5. E.O. Duebelin, “Measurement System Application And Design”, Tata McGraw Hills
6. John Hyde, "USB Design By Example", Intel Press
7. PCI bus, USB, 8255,Bluetooth datasheets
8. D. M. Consodine, "Process Instruments and Controls Handbook", McGraw-Hill, New York.
9. S. Wolf and R. F. Smith, "Student Reference Manual for Electronic Instrumentation Laboratories", Prentice Hall, Englewood Cliffs, New Jersey.
10. S. E. Derenzo, "Interfacing: A Laboratory Approach Using the Microcomputer for Instrumentation, Data Analysis, and Control", Prentice Hall, Englewood Cliffs, New Jersey.

Marks distribution for Final Examination

SN	Chapter	Lecture hour	Marks distribution	Types of Questions			Remarks
				Very Short	Short	Long	
1	Chapter 1	5	8	✓	✓	✓	(1 long) or (2 short) or (2 very short + 1 short)
2	Chapter 2	3	2	✓	-	-	(1 very short)
3	Chapter 3	6	8	✓	✓	✓	(1 long) or (2 short) or (2 very short + 1 short)
4	Chapter 4	5	6	✓	✓		(1 very short + 1 short)
5	Chapter 5	3	4	✓	✓		(2 very short) or (1 short)
6	Chapter 6	3	4	✓	✓		(2 very short) or (1 short)
7	Chapter 7	3	4	✓	✓		(2 very short) or (1 short)
8	Chapter 8	4	8	✓	✓		(1 long) or (2 short) or (2 very short + 1 short)
9	Chapter 9	6	8		✓	✓	(1 long) or (2 short) or (2 very short + 1 short)
10	Chapter10	7	8		✓	✓	(1 long) or (2 short) or (2 very short + 1 short)
	Total	45	60				

Note: There shall be 4 very short type questions each carrying 2 marks, 7 short questions each carrying 4 marks and 3 long questions each carrying 8 marks

MODEL QUESTION ADVANCED INSTRUMENTATION

FM: 60
PM: 24
Time: 3 hours

Attempt all questions:

Group A 4X2=8

1. What is parity used for? (Chapter 3)
2. What are the advantages of using serial data transfer? (Chapter 3)
3. What is EOC used for in A/D conversion? (Chapter 4)
4. Define single handshake I/O and double handshake I/O. (Chapter 2)

Group B 7X4 =28

5. Discuss noise coupling mechanism and prevention. (Chapter 6)
6. Write in brief about RS232 communication? (Chapter 3)
7. Interface 8 bit D/A converter to 8255 and write program. (Chapter 4)
8. Write in brief about data logger. (Chapter 5)
9. Explain about testing and maintenance. (Chapter 8)
10. What is crosstalk? Explain in brief. (Chapter 8)
11. Explain in brief about redundant architecture. (Chapter 7)

Group C 3X8=24

12. Explain a basic microprocessor based instrumentation system. (Chapter 1)
13. Describe in brief about waterfall model of software development. (Chapter 9)
14. Write a case study on your visit to a nearby power station. (Chapter 10)

Marks distribution of this model set:

SN	Chapters	Number of questions in			Total Marks
		Group A	Group B	Group C	
1	Chapter 1			1	8
2	Chapter 2	1			2
3	Chapter 3	2	1		8
4	Chapter 4	1	1		6
5	Chapter 5		1		4
6	Chapter 6		1		4
7	Chapter 7		1		4
8	Chapter 8		2		8
9	Chapter 9			1	8
10	Chapter 10			1	8
Total					60

Micro syllabus of Advanced Instrumentation

Note: Define(SD), Description(D), Derivation(Dr), Illustration(I), Explanation(E), Application(A), Experimental(Ex), Numerical(N)

Ch No.	Chapter		Subtopic	Depth								Hour	Remarks
				SD	D	DR	I	E	A	EX	N		
1	**Microprocessor Based Instrumentation System**	1.1	Basic Features of Microprocessor Based System	✓	✓			✓				5	
		1.2	Open Loop and Closed Loop Microprocessor Based System	✓	✓			✓					
		1.3	Benefits of Microprocessor Based System	✓	✓			✓					
		1.4	Microcomputer on Instrumentation Design	✓	✓			✓					
		1.5	Interfacing Concept, Review of Address Decoding, Input / Output registers, Programmed I/O, Interrupt Driven I/O and Direct Memory Access (DMA)	✓	✓			✓					
		1.6	PC interfacing	✓	✓			✓					
2	**Parallel methods of data transfer**	2.1	Simple I/O and strobe I/O	✓	✓			✓					

		2.2	Single Handshake I/O	✓	✓			✓					
		2.3	Double Handshake I/O	✓	✓			✓				3	
		2.4	8255 PPI Device, block diagram, internal structure, initialization and interfacing.	✓	✓			✓					
		2.5	Microcomputer in instrumentation	✓	✓			✓					
3	**Serial Interfacing with Microprocessor Based System**	3.1	Advantages of Serial Data Transfer over Parallel	✓	✓			✓				6	
		3.2	Synchronous and Asynchronous Data Transfer	✓	✓			✓					
		3.3	Errors in Serial Data Transfer	✓	✓			✓					
		3.4	Simplex, Half Duplex and Full Duplex Data Communication	✓	✓			✓					
		3.5	Parity and Baud Rates	✓	✓			✓					
		3.6	Introduction Serial Standards RS232, RS423, RS422	✓	✓			✓					
		3.7	Universal Serial Bus	✓	✓			✓					
		3.8	USB 1.1 and USB 2.0										

4	**Interfacing A/D and D/A Converters**	4.1	Introduction	✓	✓			✓				5	
		4.2	General Terms Involved in A/D and D/A Converters	✓	✓			✓					
		4.3	Functional block diagram of 8-bit and 12 bit A/D and D/A converters.	✓	✓			✓	✓				
		4.4	Assembly language programs for A/D and D/A Interfacing	✓	✓			✓	✓				
		4.5	Selection of A/D and D/A Converters Based on Design Requirements	✓	✓			✓	✓				
5	**Data Acquisition and Transmission**	5.1	Analog and Digital Transmission	✓	✓			✓	✓			3	
		5.2	Transmission Schemes	✓	✓			✓					
		5.3	Fiber Optics	✓	✓			✓					
		5.4	Satellite	✓	✓			✓					
		5.5	Data Acquisition System	✓	✓			✓					
		5.6	Data Loggers	✓	✓			✓					
6	**Grounding and Shielding**	6.1	Outline for Grounding and Shielding	✓	✓			✓				3	
		6.2	Noise, Noise Coupling Mechanism and Prevention	✓	✓			✓					

		6.3	Single Point Grounding and Ground Loop	✓	✓			✓					
		6.4	Filtering and Smoothing	✓	✓			✓					
		6.5	Decoupling Capacitors and Ferrite Beads	✓	✓			✓					
		6.6	Line Filters, Isolators and Transient Suppressors	✓	✓			✓					
		6.7	Different Kinds of Shielding Mechanism	✓	✓			✓					
		6.8	Protecting Against Electrostatic Discharge	✓	✓			✓					
		6.9	General Rules for Design	✓	✓			✓					
7	**Circuit Design**	7.1	Converting Requirements into Design	✓	✓			✓				3	
		7.2	Reliability and Fault Tolerance	✓	✓			✓					
		7.3	High Speed Design	✓	✓			✓					
		7.4	Bandwidth, Decoupling, Ground Bounce, Crosstalk, Impedance Matching, and Timing	✓	✓			✓					
		7.5	Low Power Design	✓	✓			✓					
		7.6	Reset and Power Failure Detection and interface Unit	✓	✓			✓					

		7.7	Redundant architecture	✓	✓			✓					
		7.8	Timings	✓	✓			✓					
8	**Circuit Layout**	8.1	Circuits Boards and PCBs	✓	✓			✓					4
		8.2	Component Placement	✓	✓			✓					
		8.3	Routing signal, Tracks, Trace Density, Common Impedance, Distribution of Signals and Return, Transmission Line Concerns, Trace Impedance and Matching, and Avoiding Crosstalk.	✓	✓			✓					
		8.4	Ground, Returns and Shields	✓	✓			✓					
		8.5	Cables and Connectors	✓	✓			✓					

		8.6	Testing and Maintenance	✓	✓			✓					
9	**Software for Instrumentation And Control Applications**	9.1	Types of Software, Selection and Purchase	✓	✓			✓					
		9.2	Software Models and Their Limitations	✓	✓			✓					6
		9.3	Software Reliability	✓	✓			✓					
		9.4	Fault Tolerance	✓	✓			✓					
		9.5	Software Bugs and Testing	✓	✓			✓					
		9.6	Good Programming Practice	✓	✓			✓					
		9.7	User Interface	✓	✓			✓					
		9.8	Embedded and Real Time Software	✓	✓			✓					
10	**Case study**		Examples chosen from local industrial situations with particular attention paid to the basic measurement requirements, accuracy, and specific hardware employed environmental conditions under which the instruments must operate, signal processing and transmission, output devices: • Instrumentation for a power station including all electrical and non-electrical parameters. • Instrumentation for a wire and cable manufacturing and bottling plant. • Instrumentation for a beverage manufacturing and bottling plant. • Instrumentation for a complete textile plant; for example,									

		a cotton mill from raw cotton through to finished dyed fabric. • Instrumentation for a process; for example, an oil seed processing plant from raw seeds through to packaged edible oil product. • Instruments required for a biomedical application such as a medical clinic or hospital. • Other industries can be selected with the consent of the Subject teacher.

CONTROL SYSTEM ENGINEERING
(Subject Code)

Year: III **Semester: V**

Teaching Schedule Hours/Week			Examination Scheme				
Lecture	Tutorial	Practical	Internal Assessment		Final		Total
3	1	3/2	Theory	Practical	Theory	Practical	
			40	10	60	15	125

Course Objectives:

To present the basic concepts on analysis and design of control system and to apply these concepts to typical physical processes.

1. **Control System Background** **(2 hours)**
   History of control system and its importance; Control system: Characteristics and Basic features; Types of control system and their comparison

2. **Component Modeling** **(6 hours)**
   Differential equation and transfer function notations; Modeling of Mechanical Components: Mass, spring and damper in translational and rotational system; Modeling of Electrical components: Inductance, Capacitance, Resistance, DC and AC motor, Transducers and operational amplifiers; Electric circuit analogies (force/torque-voltage analogy and force/torque-current analogy); Linearized approximations of non-linear characteristics

3. **System Transfer Function and Responses** **(6 hours)**
   Combinations of components to physical systems; Block diagram algebra and system reduction; Signal flow graphs; Time response analysis: Types of test signals (Impulse, step, ramp, parabolic), Time response analysis of first order system, Time response analysis of second order system, Transient response characteristics; Effect of feedback on steady state gain, bandwidth, error magnitude and system dynamics

4. **Stability** **(3 hours)**
   Introduction of stability and causes of instability; Characteristic equation, root location and stability; Setting loop gain using Routh-Hurwitz criterion; R-H stability criterion; Relative stability from complex plane axis shifting

5. **Root Locus Technique** **(7 hours)**
   Introduction of root locus; Relationship between root loci and time response of systems; Rules for manual calculation and construction of root locus; Determination of K on root loci; Effect of addition of Poles and Zeros on Root Locus

6. **Frequency Response Techniques** **(8 hours)**
   Frequency domain characterization of the system; Relationship between real and complex frequency response; Bode Plots: Magnitude and phase, Effects of gain and time constant on Bode diagram, Stability from Bode diagram (gain margin and phase margin); Polar Plot and Nyquist Plot: Stability analysis from Polar and Nyquist plot

7. Performance Specifications and Compensation Design (10 hours)

Time domain specification: Rise time, Peak time, Delay time, settling time and maximum overshoot; Static error co-efficient; Frequency domain specification: Gain margin and phase margin; Response with P, PI, PD and PID controller; Design of lead compensators and lag compensators using Bode plot; Design of lead compensators and lag compensators using Root locus; Concept of lead-lag compensation

8. State Space Analysis (3 hours)

Definition of state space; State space representation of electrical and mechanical system; Conversion from state space to a transfer function; Conversion from transfer functions to state space; State-transition matrix.

Practical:

- Study of time domain response of first order and second order system
- Study of Pole and zero plot and root locus plot
- Study of frequency response of first order and second order system
- Study of Bode plot and Nyquist plot
- Study of PID controller

References:

1. Ogata, K., “Modern Control Engineering”, Prentice Hall.
2. Gopal. M., “Control Systems: Principles and Design”, Tata McGraw-Hill.
3. Kuo, B.C., “Automatic Control System”, Prentice Hall, sixth edition.
4. Nagrath & Gopal, “Modern Control Engineering”, New Ages International

Chapter Wise Marks Distribution for Final Examination

SN	Chapter	Lecture hour	Marks distribution	Types of Questions			Remarks
				Very Short	Short	Long	
1	Chapter 2	6	20	✓	✓	✓	Total of 20 marks from Chapters 2, 3 and 4 found in Group A (2 marks question each), Group B (4 marks question each) and Group C (16 marks question each)
2	Chapter 3	6		✓	✓	✓	
3	Chapter 4	3		✓	✓	✓	
4	Chapter 5	8	20	✓	✓	✓	Total of 20 marks from Chapters 5 and 6 found in Group A (2 marks question each), Group B (4 marks question each) and Group C (16 marks question each)
5	Chapter 6	7		✓	✓	✓	
6	Chapter 1	2	20	✓	✓	✓	Total of 20 marks from Chapters 1, 7 and 8 found in Group A (2 marks question each), Group B (4 marks question each) and Group C (16 marks question each)
7	Chapter 7	10		✓	✓	✓	
8	Chapter 8	3		✓	✓	✓	
	Total	45	60				

***Note:* All the questions in very short type must be theoretical questions. There shall be 4 very short questions each carrying 2 marks.**

In Short type questions there can't be any breakdown and question can be theoretical or numerical question. There shall be 5 short questions each carrying 4 marks.

In Long type question there can be some breakdown and questions may be numerical/Derivational/ Theoretical. There shall be 2 long questions each carrying 16 marks.

Model question for Control System Engineering

FM: 60
PM: 24
Time: 3 hours

Attempt all questions

Group-A

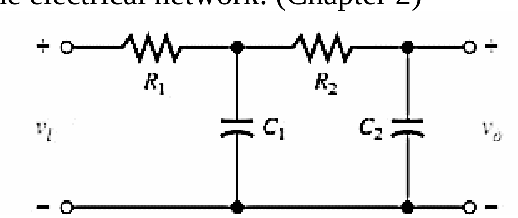
Very Short questions [4×2 = 8]

1. Enumerate advantages of closed loop control system. (Chapter 1)
2. Define state transition matrix. (Chapter 8)
3. What is angle and magnitude condition in Root locus? (Chapter 5)
4. Define centroid and angle of asymptotes. (Chapter 5)

Group-B

Short questions [5×4 = 20]

5. Determine the transfer function of the electrical network. (Chapter 2)



6. Sketch Polar plot of G(s) = $\frac{10}{s(s+1)}$ (Chapter 6)
7. Construct SFG from the following set of equations and determine graph determinant. (Chapter 3)

$$X_2 = A_{21}X_1 + A_{23}X_3$$
$$X_3 = A_{31}X_1 + A_{32}X_2 + A_{33}X_3$$
$$X_4 = A_{42}X_2 + A_{43}X_3$$

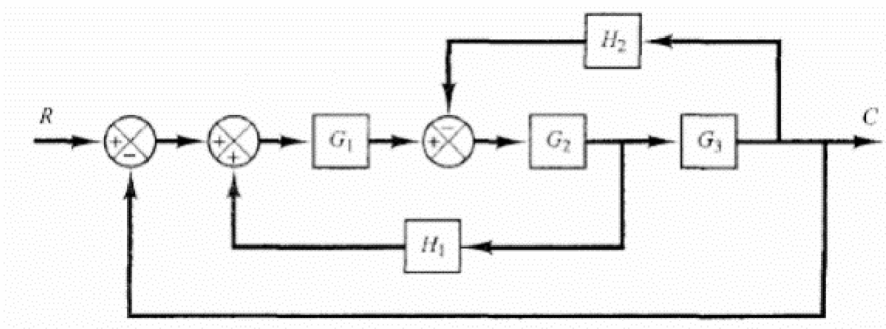
8. Determine breakaway points for the system whose open loop transfer function is $\frac{k(s+1)}{s^2(s+3.6)}$. (Chapter 5)

9. Test the stability of the system with the following characteristic equation: (Chapter 4)
$s^6+3s^5+4s^4+6s^3+5s^2+3s+2=0$. (Chapter 4)

Group C

Long questions [2×16 = 32]

10. a. Determine the transfer function of the system using rules for block diagram reduction. [8] (Chapter 3)



b. Draw the Bode plot for the transfer function $G(s) = \frac{20(1+0.25s)}{s^2(1+0.125s)(1+0.1s)}$ and also determine gain margin and phase margin. [8] (Chapter 6)

11. a. Using root locus, design a lag compensator for a system whose open loop transfer function is
$G(s) = \frac{k}{s(s+1)(s+4)}$ [12] (Chapter 7)

To meet the following specifications
Damping ratio = 0.5
Settling time = 10 sec
Velocity error constant ≥ 5

b. Compute STM when A = $\begin{bmatrix} -1 & 1 \\ 0 & 2 \end{bmatrix}$ [4] (Chapter 8)

Marks distribution of this model set:

SN	Chapters	Marks Distribution in			Total Marks
		Group A	Group B	Group C	
1	Chapter 2	-	4marks (1 question)	-	20
2	Chapter 3	-	4 marks (1 question)	8 marks (1/2 question)	
3	Chapter 4	-	4 marks (1 question)	-	
4	Chapter 5	4 marks (2 questions)	4 marks (1 question)	-	20
5	Chapter 6	-	4 marks (1 question)	8 marks (1/2 question)	
6	Chapter 1	2 marks (1 question)	-	-	20
7	Chapter 7	-	-	12 marks (3/4 question)	
8	Chapter 8	2 marks (1 question)	-	4 marks (1/4 question)	
Total:		8 marks (4 questions)	20 marks (5 questions)	32 marks (2 questions)	60

Micro syllabus of Control System Engineering

Note: Define(SD), Description(D), Derivation(Dr), Illustration(I), Explanation(E), Application(A), Experimental(Ex), Numerical(N)

Ch No.	Chapter		Subtopic	Depth								Hour	Remarks
				SD	D	DR	I	E	A	EX	N		
1	Control System Background	1.1	History of control system and its importance	✓	✓		✓	✓	✓			1	
		1.2	Control system: Characteristics and Basic features	✓	✓	✓	✓	✓	✓				
		1.3	Types of control system and their comparison	✓	✓	✓	✓	✓	✓			1	
2	Component Modelling	2.1	Differential equation and transfer function notations	✓	✓			✓			✓	3	
		2.2	Modeling of Mechanical Components: Mass, spring and damper in translational and rotational system	✓	✓	✓		✓			✓		
		2.3	Modeling of Electrical components: Inductance, Capacitance, Resistance, DC and AC motor, Transducers and operational amplifiers	✓	✓	✓		✓			✓	3	
		2.4	Electric circuit analogies (force/torque-voltage analogy and force/torque-current analogy)	✓	✓	✓		✓			✓		
		2.5	Linearized approximations of non-linear characteristics	✓	✓	✓		✓			✓		

3	System Transfer Function and Responses	3.1	Combinations of components to physical systems	✓	✓		✓	✓			✓	2	
		3.2	Block diagram algebra and system reduction	✓	✓	✓	✓	✓			✓		
		3.3	Signal flow graphs- properties, Construction of SFG from equations and block diagram, Mason's gain formula, Block diagram from signal flow graph	✓	✓		✓	✓			✓	2	
		3.4	Time response analysis: Types of test signals (Impulse, step, ramp, parabolic), Time response analysis of first order system, Time response analysis of second order system, Transient response characteristics	✓	✓	✓	✓	✓			✓	2	
		3.5	Effect of feedback on steady state gain, bandwidth, error magnitude and system dynamics	✓	✓	✓	✓	✓					
4	Stability	4.1	Introduction of stability and causes of instability; Characteristic equation, root location and stability	✓	✓		✓	✓				2	
		4.2	Setting loop gain using Routh-Hurwitz criterion	✓	✓		✓	✓			✓		
		4.3	R-H stability criterion; Relative stability from complex plane axis shifting	✓	✓			✓			✓	1	

5	Root Locus Technique	5.1	Introduction of root locus; Relationship between root loci and time response of systems	✓	✓			✓					
		5.2	Rules for manual calculation and construction of root locus	✓	✓	✓	✓	✓			✓	4	
		5.3	Determination of K on root loci	✓	✓	✓	✓	✓			✓	3	
		5.4	Effect of addition of Poles and Zeros on Root Locus	✓	✓	✓	✓	✓			✓		
6	Frequency Response Techniques	6.1	Frequency domain characterization of the system; Relationship between real and complex frequency response	✓	✓	✓	✓	✓				4	
		6.2	Bode Plots: Magnitude and phase, Effects of gain and time constant on Bode diagram, Stability from Bode diagram (gain margin and phase margin);	✓	✓		✓	✓			✓		
		6.3	Polar Plot and Nyquist Plot: Stability analysis from Polar and Nyquist plot	✓	✓		✓	✓	✓		✓	4	
7	Performance Specifications and Compensation Design	7.1	Time domain specification: Rise time, Peak time, Delay time, settling time and maximum overshoot; Static error co-efficient	✓	✓	✓	✓	✓			✓	2	
		7.2	Frequency domain specification: Gain margin and phase margin	✓	✓	✓	✓	✓			✓		
		7.3	Response with P, PI, PD and PID controller	✓	✓	✓	✓	✓			✓	2	

		7.4	Design of lead compensators and lag compensators using Bode plot									6	
		7.5	Design of lead compensators and lag compensators using Root locus	✓	✓	✓	✓	✓			✓		
		7.6	Concept of lead-lag compensation	✓	✓		✓	✓					
8	State Space Analysis	8.1	Definition of state space; State space representation of electrical and mechanical system	✓	✓	✓	✓	✓	✓		✓	1	
		8.2	Conversion from state space to a transfer function; Conversion from transfer functions to state space	✓	✓	✓	✓	✓			✓	1	
		8.3	State-transition matrix.	✓	✓	✓	✓	✓			✓	1	

Electric Machine Design
(Course Code)

Year III **Semester V**

Teaching Schedule Hours/Week				Examination Scheme				
Credit	Lecture	Tutorial	Practical	Internal Assessment		Final		Total
				Theory	Practical	Theory	Practical	
3	3	-	3	40	10	60	15	125

Course objectives: To impart knowledge on the principle of design of electrical machines like transformers, induction machines and DC machine.

1. **Materials used in electrical equipment (5 hours)**

Review of electrical conducting materials: Various characteristics and comparison between conducting materials, Materials of high conductivity and high resistivity; Magnetic materials: Classification ,characteristics and application of magnetic materials, Materials for steady flux (solid core materials), materials for pulsating fluxes (laminated core materials sheet), Special purpose alloys ,hot rolled and cold rolled steel sheets, sintered power core, Magnetic materials used in transformers, dc machines and ac machines; Insulating materials: Classification ,characteristics ,application, Insulating materials for transformers, dc machines and ac machines, ceramics

2. **Heating and cooling of electric machine (7 hours)**

Review of heat transfer: Conduction, convection and radiation; Internal temperature (hot spots and their calculations); Temperature gradients in iron core; Temperature gradients in conductors placed in slots; Ventilation of electrical machine: Types of enclosure, methods of cooling, schemes of ventilation, Cooling of totally enclosed machines ,cooling circuits ,cooling systems; Temperature rise, heating time constant, final steady temperature rise, cooling time constant; Rating of electric machine based on temperature rise; Calculation of temperature rise in armature, field coils and commutators

3. **Transformer Design (14 hours)**

Review of transformer theory; Types of transformer : Power transformer, distribution transformer, core type and shell type; Design approach: Output equations (single and three phase), Volt per turn, Design of core(square core, stepped and cruciform core), Choice of flux density, Design of winding and choice of current density, Design of insulation, Design of window and window space factor, Design of yoke; Calculation of operating characteristics from design data: Resistance of winding, leakage reactance of winding in core type transformer, iron loss, copper loss, efficiency, regulation.; Design of cooling system: Temperature rise in plain walled tank, design of tank and tubes

4. **Three phase induction motor design (10 hours)**

Review of three phase induction motor theory: Construction and principle of three phase induction motor, Various types of three phase stator winding; Design approach: Output equation, choice of magnetic and electric loading, Choice of stator winding. stator slots and insulation, stator teeth, stator teeth, stator core and stator stamping dimension, Air gap length, rotor design (squirrel cage and slip ring type), Leakage inductance, evaluation of equivalent circuit parameters and operating characteristics from design data.

5. **DC Machine Design (9 hours)**

Armature Winding: Lap and wave winding; Design Approach: Output equation, choice of average gap density, choice of ampere conductors per meter, Choice of no of poles in DC machine, pole proportions, Selection of length of air gap, Choice of armature windings, no of armature conductors, no of coils, no of armature slots, armature conductor selection, Design of commutator, design of brushes, design of compensating winding, Evaluation of operating characteristics from design data

Practical:

1. A detail design of core type power and distribution transformer
    a. orthographic drawing of transformer including winding, tank and tubes
2. A detail design of three phase induction motor
    a. Drawing of three phase stator winding (Mush winding, Lap winding and Wave winding)
3. A detail design of DC armature winding
    a. Drawing of Lap and wave winding used in DC machine armature

References:

1. A.K. Sawhney “A course in Electrical Machine Design”
2. M.G. Say “Performance and design of AC Machines”
3. M.G. Say “Performance and design of DC Machines
4. R.K. Agrawal “Principles of Electrical Machine Design”
5. J. Pyrhonean,T. Jokinen, V. Hrabovcova “ Design of Rotating Electrical Machines”

Chapter Wise Marks Distribution for Final Examinations

SN	Chapter	Lecture hour	Marks distribution	Types of Questions			Remarks
				Very Short	Short	Long	
1	Chapter 1	5	6	✓	✓	-	(1very short+1short)
2	Chapter 2	7	10	✓	✓	✓	(1 very short + 2 short) or (1 very short+1 long)
3	Chapter 3	14	18	✓	✓	✓	(1 very short + 2 long) or (1 Very short + 2 short + 1 long)
4	Chapter 4	10	14	✓	✓	✓	(1very short + 1short + 1 long)

5	Chapter 5	9	12	✓	✓	✓	(2 very short + 1 long) or (1short+1 long)
	Total	45	60				

Note: ***All the questions in very short type must be theoretical questions. There shall be 4 very short questions each carrying 2 marks.***

In Short type questions there can't be any breakdown and question can be theoretical or numerical question. There shall be 7 short questions each carrying 4 marks.

In Long type question there can be some breakdown and questions may be numerical/Derivational/ Theoretical. There shall be 3 long questions each carrying 8 marks.

Model Question of Electric Machine Design

FM: 60
PM: 24
Time: 3 hours

Attempt all questions

Group A (Very short questions) **4x2=8**

1. What are the fundamental requirements of good insulating material? (Chapter 1)
2. Enlist disadvantages of axial ventilating system. (Chapter 2)
3. How the values of current density for different types of transformers varies? (Chapter 3)
4. What are the factors effecting the size of induction machine? (Chapter 4)

Group B (Short questions) **7x4=28**

5. What is meant by "ageing" in magnetic material? Enlist the merits and demerits of addition of silicon with iron. (Chapter 1)
6. Differentiate between natural and artificial convections in electrical machines (Chapter 2)
7. The rise in temperature of a transformer after one hour and two hours of starting from cold condition are 25°C and 40°C respectively. Determine its final steady temperature rise and the heating time constant. If its temperature falls from the final steady value to 45°C in 90 minutes when disconnected from the operation, determine its cooling time constant. The ambient temperature is 30°C. (Chapter 2)
8. Differentiate between core type and shell type transformer on the basis of construction, mechanical design, leakage reactance and cooling. (Chapter 3)
9. Explain in brief about flux density selection in the design of transformer (Chapter 3)
10. Discuss the factor to be considered for selection of magnetic loading in induction machine. (Chapter 4)
11. Explain the factors to be considered while selecting the number of poles in dc machine. (Chapter 5)

Group C (Long questions) **3x8=24**

12. Design a 25 KVA, 11000/433 V, 50 Hz, 3 phase, delta/star core type distribution transformer. (Chapter 3)

The required dare for the design is given below:

Maximum flux density in core = 1 Wb/m^2
Current density in conductor = 2.3 A/mm^2
Constant for output volt per turn, K = 0.45
Core type = cruciform
Window space factor, K_w = 8/(30+kV)
Staking factor = 0.9
Ratio to window height to width = 2.5
Take area of yoke 20% more than area of limb.
Width of LV winding = 9.1mm
Width of HV winding = 26.22mm
Total losses at full load = 901 W

Calculate:

i. Dimension of core, window and yoke
ii. Overall dimension of the frame

13. Determine the main dimension of a 15 kW, 3 phase, 400 V, 50 Hz, 2810 rpm squirrel cage induction motor having efficiency of 0.88 and full load power factor of 0.9. Assume specific magnetic loading = 0.5 Wb/m^2 and specific electrical loading = 25000 A/m. Take rotor peripheral speed as approximately 20 m/s at synchronous speed. (Chapter 4)

14. For a dc machine design show that the minimum number of coil or commutator segments required is EP/15. (Chapter 5)

Marks distribution of this model set

SN	Chapters	Marks Distribution in			Total Marks
		Group A	Group B	Group C	
1	Chapter 1	1	1	-	6
2	Chapter 2	1	2	-	10
3	Chapter 3	1	2	1	18
4	Chapter 4	1	1	1	14
5	Chapter 5	-	1	1	12
Total:		8 marks	28 marks	24 marks	60

Micro syllabus of Electric Machine Design

Note: Define(SD), Description(D), Derivation(Dr), Illustration(I), Explanation(E), Application(A), Experimental(Ex), Numerical(N)

Ch No.	Chapter		Subtopic		Depth								Hour	Remarks
					SD	D	DR	I	E	A	EX	N		
1	Materials used in electrical equipment	1.1	Review of electrical conducting materials											
			1.1.1	Various characteristics and comparison between conducting materials	✓	✓			✓	✓			1	
			1.1.2	Materials of high conductivity and high resistivity	✓	✓			✓	✓				
		1.2	Magnetic materials											
			1.2.1	Classification ,characteristics and application of magnetic materials	✓	✓			✓	✓			2	
			1.2.2	Materials for steady flux (solid core materials), materials for pulsating fluxes (laminated core materials sheet)	✓	✓			✓	✓				
			1.2.3	Special purpose alloys ,hot rolled and cold rolled steel sheets, sintered power core	✓	✓			✓	✓			1	

			1.2.4	Magnetic materials used in transformers, dc machines and ac machines	✓	✓			✓	✓				
		1.3	Insulating materials											
			1.3.1	Classification ,characteristics ,application	✓	✓			✓	✓				
			1.3.2	Insulating materials for transformers, dc machines and ac machines, ceramics	✓	✓			✓	✓			1	
2	Heating and cooling of electric machine	2.1	Review of heat transfer: Conduction, convection and radiation		✓	✓			✓	✓			1	
		2.2	Internal temperature (hot spots and their calculations)		✓	✓	✓		✓	✓		✓	2	
		2.3	Temperature gradients in iron core		✓	✓	✓		✓	✓		✓		
		2.4	Temperature gradients in conductors placed in slots		✓	✓	✓		✓	✓		✓		
		2.5	Ventilation of electrical machine											
			2.5.1	Types of enclosure, methods of cooling, schemes of ventilation	✓	✓			✓	✓			2	
			2.5.2	Cooling of totally enclosed machines ,cooling circuits ,cooling systems	✓	✓			✓	✓				

		2.6		Temperature rise, heating time constant, final steady temperature rise, cooling time constant	✓	✓	✓		✓	✓		✓	2	
		2.7		Rating of electric machine based on temperature rise	✓	✓	✓		✓	✓		✓		
		2.8		Calculation of temperature rise in armature, field coils and commutators	✓	✓	✓		✓	✓		✓		
3	Transformer Design	3.1		Review of transformer theory	✓	✓			✓	✓			1	
		3.2		Types of transformers: Power transformer, distribution transformer, core type and shell type	✓	✓			✓	✓				
		3.3		Design approach										
			3.3.1	Output equations (single and three phase), Volt per turn	✓	✓	✓		✓	✓		✓	1	
			3.3.2	Design of core (square core, stepped and cruciform core)	✓	✓	✓		✓	✓		✓	2	
			3.3.3	Choice of flux density	✓	✓	✓		✓	✓		✓	1	
			3.3.4	Design of winding and choice of current density	✓	✓	✓		✓	✓		✓	2	
			3.3.5	Design of insulation	✓	✓	✓		✓	✓		✓	3	
			3.3.6	Design of window and window space factor	✓	✓	✓		✓	✓		✓		

			3.3.7	Design of yoke	✓	✓	✓		✓	✓		✓		
		3.4	Calculation of operating characteristics from design data											
			3.4.1	Resistance of winding, leakage reactance of winding in core type transformer, iron loss, copper loss, efficiency, regulation.	✓	✓	✓		✓	✓		✓	3	
		3.5	Design of cooling system											
			3.5.1	Temperature rise in plain walled tank, design of tank and tubes	✓	✓	✓		✓	✓		✓	1	
4	Three phase induction motor design	4.1	Review of three phase induction motor theory											
			4.1.1	Construction and principle of three phase induction motor	✓	✓			✓	✓			2	
			4.1.2	Various types of three phase stator winding	✓	✓			✓	✓				
		4.2	Design approach		✓	✓	✓		✓	✓		✓		
			4.2.1	Output equation, choice of magnetic and electric loading	✓	✓	✓		✓	✓		✓	5	
			4.2.2	Choice of stator winding. stator slots and insulation, stator teeth, stator teeth, stator core and stator stamping dimension	✓	✓	✓		✓	✓		✓		

			4.2.3	Air gap length, rotor design (squirrel cage and slip ring type)	✓	✓	✓		✓	✓		✓	3	
			4.2.4	Leakage inductance, evaluation of equivalent circuit parameters and operating characteristics from design data.	✓	✓	✓		✓	✓		✓		
5	DC Machine Design	5.1	Armature Winding											
			5.1.1	Lap and wave winding	✓	✓			✓	✓			1	
		5.2	Design Approach											
			5.2.1	Output equation, choice of average gap density, choice of ampere conductors per meter	✓	✓	✓		✓	✓		✓	3	
			5.2.2	Choice of no of poles in DC machine, pole proportions	✓	✓	✓		✓	✓		✓	2	
			5.2.3	Selection of length of air gap	✓	✓	✓		✓	✓		✓	2	
			5.2.4	Choice of armature windings, no of armature conductors, no of coils, no of armature slots, armature conductor selection	✓	✓	✓		✓	✓		✓	1	
			5.2.5	Design of commutator, design of brushes, design of compensating winding	✓	✓			✓	✓				

			5.2.6	Evaluation of operating characteristics from design data	✓	✓			✓	✓				

Power System Analysis II
(Course Code)

Year III **Semester V**

Teaching Schedule Hours/Week				Examination Scheme				
Credit	Lecture	Tutorial	Practical	Internal Assessment		Final		Total
				Theory	Practical	Theory	Practical	
3	3	1	3/2	40	10	60	15	125

Course objectives: The course aim to deliver the advance analysis of the interconnected power system including load flow, short circuit studies and stability analysis.

1. **Interconnected Power System (6 hours)**
   Interconnected Power System, Real power/ frequency balance, Reactive power/ voltage balance, Node equations, Bus admittance matrixes, Applications of Bus admittance matrixes in Network analysis, Basic concept of Bus impedance Matrixes

2. **Load Flow Analysis (8 hours)**

Basic complex power flow equations for a power system networks, Data for Load flow studies, Iterative approaches for solving power flow equations, Gauss-Seidal method, Newton- Rapshon methods, Introduction to advance techniques e.g. decoupled load flow, Voltage profile and var compensation

3. **Power system fault calculation (5 hours)**

Definition and purpose of fault calculation, Types of faults in power system, Symmetrical fault calculations, Calculation of short circuit MVA

4. **Unbalance System Analysis (6 hours)**

Symmetrical components, Sequence impedances, Sequence components of the voltages and currents, Expression for power in terms of symmetrical components, Transformer voltages and currents

5. **Unsymmetrical faults on Power Systems (10 hours)**

Sequence networks of synchronous generators, Fault calculations of a single synchronous generator, Line to ground faults, Line to line faults, Double line to ground faults, Path for zero sequence currents in Transformers, Fault calculations on a power system networks, Line to ground faults, Line to line faults, Double line to ground faults

6. **Power System Stability (10 hours)**

Operational power balance in a synchronous generator, Classification of power system stability, Swing equation & swing curve for a single machine infinite bus system, Rotor angle stability; steady state, dynamic & transient stability, Equal area criterion, Stability enhancement techniques, Step by step method for solving swing equations by computer methods, Basic concept of voltage stability

Laboratory:

There shall be laboratories on following topics (Using suitable simulation software)

1. Computation of parameters and modelling of transmission lines
2. Formulation of bus admittance matrices and solution of networks
3. Load flow analysis – Using Gauss-Siedel method
4. Load flow analysis – Using Newton Raphson method, Fast de-coupled method
5. Fault analysis- LG, LL, LLG, LLL, LLLG
6. Transient stability analysis – Single machine connected to infinite bus

References:

1. Power System Analysis by W.D. Stevenson, Tata McGraw Hill Publications
2. Modern Power System Analysis by I.J Nagrath and D.P Kothari, Tata McGraw Hill Publications
3. A course in Power Systems by J.B Gupta, SK Kataria and Sons
4. Power System Analysis by Hadi Saadat

Chapter Wise Marks Distribution for Final Examinations

SN	Chapter	Lecture hour	Marks distribution	Types of Questions			Remarks
				Very Short	Short	Long	
1	Chapter 1	6	8	✓	✓	✓	(2Very short+1short) or (2 short) or (1 long)
2	Chapter 2	8	12	✓	✓	✓	(2Very short+2short) or (3 short) or (1short+1 long)
3	Chapter 3	5	6	✓	✓	✓	(1 Very short + 1 short)
4	Chapter 4	6	8	✓	✓	✓	(2Very short+1short) or (2 short) or (1 long)
5	Chapter 5	10	12	✓	✓	✓	(2Very short+2short) or (3 short) or (1short+1 long)
6	Chapter 6	10	14	✓	✓	✓	(1 very short + 1 short + 1 long)
	Total	45	60				

Note: ***All the questions in very short type must be theoretical questions. There shall be 4 very short questions each carrying 2 marks.***

In Short type questions there can't be any breakdown and question can be theoretical or numerical question. There shall be 7 short questions each carrying 4 marks.

In Long type question there can be some breakdown and questions may be numerical/Derivational/ Theoretical. There shall be 3 long questions each carrying 8 marks.

Model question for Power System Analysis II

FM: 60
PM: 24
Time: 3 hours

Attempt all questions

Group A (Very short questions) 4x2=8

1. Enlist the applications of bus admittance matrices. (Chapter 1)
2. What is the main information obtained from load flow analysis? (Chapter 3)
3. How is frequency control related to active power and voltage control related to reactive power? (Chapter 1)
4. What is transient stability limit? (Chapter 6)

Group B (Short questions) 7x4=28

5. List out advantages and disadvantages of interconnected power system over isolated power system. (Chapter 1)
6. Explain the comparison of various load flow methods. (Chapter 2)
7. Breifly explain the types of faults in power system. (Chapter 3)
8. Compute symmetrical components of the three phase voltages. (Chapter 4)

$$V_A = 100\angle 0^0$$
$$V_B = 110\angle -100^0$$
$$V_C = 115\angle 110^0$$

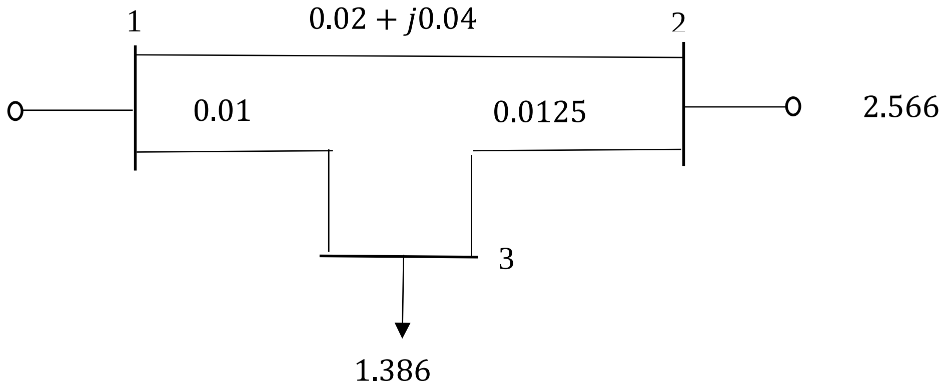
9. Develop a mathematical expression to obtain fault current of a single line to ground fault. (Chapter 5)
10. What are the factors affecting the transient system stability? (Chapter 6)
11. Derive an expression of three phase complex power in terms of symmetrical components of voltage and current. (Chapter 4)

Group C (Long questions)   3x8=24

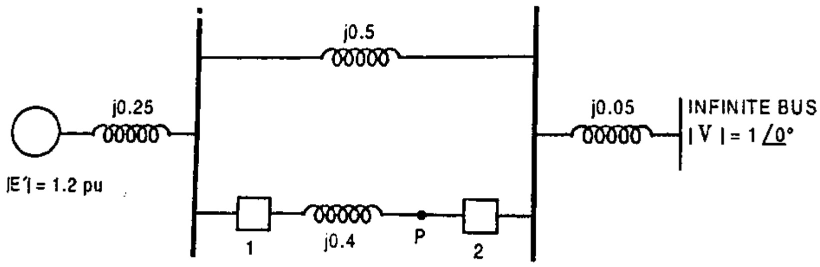
12. The one line diagram of a simple three bus power system with generator at bus 1 is given in the figure below. The line impedances are marked in per unit on 100 MVA base. The voltage obtained by performing load flow are: (Chapter 2)

$$V_1 = 1.05\angle 0^0$$
$$V_2 = 0.9813\angle -3.5035^0$$
$$V_3 = 1.00125\angle -2.8624^0$$

Determine: (i) slack bus power, (ii) complex power flow on line 1-2.



13. A synchronous generator is rated 25 MVA, 11 kV. It is star connected with the neutral point solidly grounded. The generator is operating at no load rated voltage. Its reactances are $X_1 = X_2 = 0.20$ pu and $X_0 = 0.08$ pu. Calculate the symmetrical sub-transient line currents for   (Chapter 5)
    a. Double line to ground fault
    b. Symmetrical three phase fault
14. In the system given in the figure below where a 3-phase fault is applied at the point P as shown. Find the critical clearing angle for clearing the fault with simultaneous opening of the breaker 1 and 2. The reactance values of various components are indicated on the diagram. The generator is delivering 1.0 pu power at the instant preceding the fault.   (Chapter 6)



Marks distribution of this model set

SN	Chapters	Marks Distribution in			Total Marks
		Group A	Group B	Group C	
1	Chapter 1	2	1	-	8
2	Chapter 2	-	1	1	12
3	Chapter 3	1	1	-	6
4	Chapter 4	-	2	-	8
5	Chapter 5	-	1	1	12
6	Chapter 6	1	1	1	14
Total:		8 marks	28 marks	24 marks	60

Micro syllabus of Power System Analysis II

Note: Define(SD), Description(D), Derivation(Dr), Illustration(I), Explanation(E), Application(A), Experimental(Ex), Numerical(N)

Ch No.	Chapter		Subtopic	Depth								Hour	Remarks
				SD	D	DR	I	E	A	EX	N		
1	Interconnected Power System	1.1	Introduction to Interconnected Power System	✓	✓			✓	✓			2	
		1.2	Real power/ frequency balance	✓	✓		✓	✓	✓				
		1.3	Reactive power/ voltage balance	✓	✓			✓	✓				
		1.4	Node equations	✓	✓	✓		✓	✓		✓	2	
		1.5	Bus admittance matrixes	✓	✓	✓		✓	✓		✓	1	
		1.6	Applications of Bus admittance matrixes in Network analysis	✓	✓			✓	✓			1	
		1.7	Basic concept of Bus impedance Matrixes	✓	✓	✓		✓	✓		✓		
2	Load Flow Analysis	2.1	Basic complex power flow equations for a power system networks	✓	✓	✓		✓	✓		✓	1	
		2.2	Data for Load flow studies	✓	✓	✓		✓	✓		✓		

		2.3	Iterative approaches for solving power flow equations	✓	✓	✓		✓	✓		✓	1	
		2.4	Gauss-Seidal method	✓	✓	✓		✓	✓		✓	3	
		2.5	Newton- Rapshon methods	✓	✓	✓		✓	✓		✓	3	
3	Power system fault calculation	3.1	Definition and purpose of fault calculation	✓	✓			✓	✓			1	
		3.2	Types of faults in power system	✓	✓			✓	✓				
		3.3	Symmetrical fault calculations	✓	✓	✓		✓	✓		✓	2	
		3.4	Calculation of short circuit MVA	✓	✓	✓		✓	✓		✓	2	
4	Unbalance System Analysis	4.1	Symmetrical components	✓	✓	✓		✓	✓		✓	1	
		4.2	Sequence impedances	✓	✓	✓		✓	✓		✓		
		4.3	Sequence components of the voltages and currents	✓	✓	✓		✓	✓		✓	1	
		4.4	Expression for power in terms of symmetrical components	✓	✓	✓		✓	✓		✓	3	
		4.5	Transformer voltages and currents	✓	✓	✓		✓	✓		✓	1	
5		5.1	Sequence networks of synchronous generators	✓	✓			✓	✓			1	

		5.2	Fault calculations of a single synchronous generator- Line to ground faults, Line to line faults, Double line to ground faults	✓	✓	✓		✓	✓		✓	4	
	Unsymmetrical faults on Power Systems	5.3	Path for zero sequence currents in Transformers	✓	✓			✓	✓			1	
		5.4	Fault calculations on a power system networks- Line to ground faults, Line to line faults, Double line to ground faults	✓	✓	✓		✓	✓		✓	4	
6	Power System Stability	6.1	Operational power balance in a synchronous generator	✓	✓			✓	✓			1	
		6.2	Classification of power system stability	✓	✓			✓	✓				
		6.3	Swing equation & swing curve for a single machine infinite bus system	✓	✓	✓		✓	✓		✓	3	
		6.4	Rotor angle stability; steady state, dynamic & transient stability	✓	✓			✓	✓			2	
		6.5	Equal area criterion	✓	✓			✓	✓			2	
		6.6	Stability enhancement techniques	✓	✓	✓		✓	✓		✓		
		6.7	Step by step method for solving swing equations by computer methods	✓	✓			✓	✓			2	
		6.8	Basic concept of voltage stability	✓	✓			✓	✓				

Synchronous and Special Machines
(Course Code)

Year III **Semester V**

Teaching Schedule Hours/Week				Examination Scheme				
Credit	Lecture	Tutorial	Practical	Internal Assessment		Final		Total
2	2	1	3/2	Theory	Practical	Theory	Practical	
				20	10	30	15	75

Course Objective: - To impart knowledge on constructional details, operating principle and performance of 3-phase Synchronous Machines, Fractional Horse-Power Motors and some Special Purpose Machines.

1. **Three Phase Synchronous Generator** **[10 hours]**
   Constructional details, Armature windings, Types of Rotors, Exciter; Operating Principle, Rotating Magnetic Field; Emf Equation, pitch factor and distribution factor; Armature reaction and its effects; Alternator with load and its phasor diagram; Voltage regulations; Parallel operation and Synchronization; Operation on infinite bus bar

2. **Three Phase Synchronous Motor** **[10 hours]**
   Principle of operation; Starting methods; No load and Loaded operation, Phasor Diagram; Effect of Excitation and power factor control, V and Inverted V Curves; Power angle characteristics of Cylindrical Rotor Machine; Two reaction Theory for Salient pole machine; Power Angle Characteristic of Salient Pole Machine

3. **Fractional Horse-Power Motors and Special Machines** **[10 hours]**
   Single phase Induction Motors: Construction and Characteristics; Double Revolving Field Theory; Types of Single-phase induction motor - Split phase Induction Motor, Capacitor start motor, Capacitor run motor, Capacitor start capacitor run motor, Shaded pole motor; Single phase Synchronous Motor - Reluctance motor, Hysteresis motor; Universal motor; Special Purpose Machines-Stepper motor, Schrage motor and Servo motor

Practical:
1. To study No-load characteristics of a 3-phase synchronous generator
2. To study load characteristics of synchronous generator with (a) resistive load (b) inductive load and (c) capacitive load
3. To study the effect of excitation on performance of a synchronous motor and to plot V- curve
4. To study the effect of a capacitor on the starting and running of a single-phase induction motor
5. To study the operating characteristics of universal motors

Reference Books:

1. I.J. Nagrath&D.P.Kothari," Electrical Machines", Tata McGraw Hill
2. S. K. Bhattacharya, "Electrical Machines", Tata McGraw Hill
3. Husain Ashfaq ," Electrical Machines", DhanpatRai& Sons
4. A.E. Fitzgerald, C.KingsleyJr and Stephen D. Umans,"Electric Machinery", Tata McGraw Hill
5. P. S. Bhimbra, "Electrical Machines"' Khanna Publishers
6. Irving L.Kosow, "Electric Machine and Tranformers", Prentice Hall of India.
7. M.G. Say, "The Performance and Design of AC machines", Pit man& Sons.
8. Bhag S. Guru and Huseyin R. Hizirogulu, "Electric Machinery and Transformers" Oxford University Press

Chapter Wise Marks Distribution for Final Examination

SN	Chapter	Lecture hour	Marks distribution	Types of Questions			Remarks
				Very Short	Short	Long	
1	Chapter 1	10	10	✓	✓	✓	(1Very short+2short) or (1 Very short + Long)
2	Chapter 2	10	10	✓	✓	✓	(1Very short+2short) or (1 Very short + Long)
3	Chapter 3	10	10	✓	✓	✓	(1Very short+2short) or (1 Very short + Long)
	Total	30	30				

Note: ***All the questions in very short type must be theoretical questions. There shall be 3 very short questions each carrying 2 marks.***

In Short type questions there can't be any breakdown and question can be theoretical or numerical question. There shall be 4 short questions each carrying 4 marks.

In Long type question there can be some breakdown and questions may be numerical/Derivational/ Theoretical. There shall be 1 long question carrying 8 marks.

Model question for Synchronous and Special Machines

FM: 30
PM: 12
Time: 1.5 hours

Attempt all questions

Group-A

Very Short questions [3×2 = 6]

1. Differentiate between cylindrical machine and salient pole machine? (Chapter 1)
2. What do you mean by V curves and inverted V curves? (Chapter 2)
3. List the types of single-phase induction motor. (Chapter 3)

Group-B

Short questions [4×4 = 16]

4. Explain the effect of armature reaction in an alternator having lagging power factor load. (Chapter 1)
5. Explain why a single-phase induction motor with only main winding is unable to produce starting torque. (Chapter 3)
6. Derive the expression of frequency of induced emf of alternator in terms of number of poles and speed of prime mover in RPM. (Chapter 1)
7. Explain the operating principle of Schrage motor. (Chapter 3)

Group C

Long questions [1×8 = 8]

8. A 50 Hz three phase 500 V star connected salient pole synchronous generator has $X_d = 0.2\ \Omega$ and $X_q = 0.075\ \Omega$. If armature winding resistance is $0.2\ \Omega$ and the generator supplies 110 A at 0.9 power factor lag, determine the excitation emf. (Chapter 2)

Marks distribution of this model set:

SN	Chapters	Number of questions in			Total Marks
		Group A	Group B	Group C	
1	Chapter 1	1	2	-	10
2	Chapter 2	1	-	1	10
3	Chapter 3	1	2	-	10
Total		6 marks	16 marks	8 marks	30

Micro-syllabus of Synchronous and Special Machines

Note: Define(SD), Description(D), Derive(Dr), Illustration(I), Explanation(E), Application(A), Experimental(Ex), Numerical(N)

Ch No.	Topic		Subtopic	Depth								Hour	Remarks
				SD	D	DR	I	E	A	EX	N		
1	Three Phase Synchronous Generator	1.1	Constructional details, Armature windings, Types of Rotors, Exciter	✓	✓		✓	✓	✓			1	
		1.2	Operating Principle, Rotating Magnetic Field, Emf equation, pitch factor and distribution factor	✓	✓	✓	✓				✓	1	
		1.3	Armature reaction and its effects	✓	✓	✓	✓	✓				1	
		1.4	Alternator with load and its phasor diagrams	✓	✓		✓	✓				1	
		1.5	Voltage Regulations	✓	✓	✓	✓	✓			✓	2	
		1.6	Parallel operation and Synchronization	✓	✓		✓	✓				2	
		1.7	Operation on infinite bus bar	✓	✓	✓	✓	✓			✓	2	
2	Three Phase Synchronous Motor	2.1	Principle of Operation and starting methods	✓	✓		✓	✓	✓			1	
		2.2	No load and Loaded operation, Phasor diagrams	✓	✓		✓	✓			✓	2	

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		2.3	Effect of Excitation and power factor control, V and Inverted V Curves	✓	✓		✓	✓				2	
		2.4	Power-angle characteristics of cylindrical machine	✓	✓	✓	✓	✓			✓	2	
		2.5	Two reaction theory for Salient Pole Machine	✓	✓	✓	✓	✓			✓	1	
		2.6	Power-angle characteristics of salient pole machine	✓	✓	✓	✓	✓			✓	2	
3.	Fractional Horse Power Motors and Special Machines	3.1	Single Phase induction motors: Construction and Characteristics	✓	✓		✓	✓	✓			4	
		3.2	Double revolving field theory	✓	✓	✓	✓	✓					
		3.3	Types of Single-phase induction motor - Split phase Induction Motor, Capacitor start motor, Capacitor run motor, Capacitor start capacitor run motor, Shaded pole motor	✓	✓			✓	✓				
		3.4	Single Phase Synchronous Motor- Reluctance Motor and Hysteresis motor	✓	✓		✓	✓	✓			2	
		3.5	Universal Motor	✓	✓		✓	✓	✓			1	
		3.6	Special purpose machines- Stepper motor, Schrage motor, Servomotor	✓	✓		✓	✓	✓			3	

Research methodology

Year: III

Semester: V

Teaching Schedule(hours/week)			Examination scheme				
Theory	Tutorial	Practical	Internal evaluation		External evaluation		Total
2	1	-	Theory	Practical	Theory	practical	50
			20	-	30	-	

Course Objectives:

1. To familiarize students with the principles and practices of research methodology in engineering.
2. To develop students' skills in formulating research questions and designing research studies.
3. To equip students with knowledge of various data collection methods and instrumentation techniques relevant to engineering research.
4. To introduce students to statistical analysis methods commonly used in engineering research.
5. To cultivate an understanding of ethical considerations and professionalism in engineering research.
6. To enhance students' abilities in writing research proposals, reports, and presenting research findings effectively.

Course contents

1. **Introduction to Research Methodology – 3 LH**

- Importance of research in engineering
- Overview of the research process

- Types of research (quantitative, qualitative, mixed-methods)
- Role of research in innovation and problem-solving in engineering

2. Research Design - 5 LH

- Formulating research questions and hypotheses in engineering
- Types of research designs (experimental, observational, case studies)
- Sampling techniques in engineering research
- Validity and reliability considerations in engineering research design

3. Data Collection Methods - 5 LH

- Surveys and questionnaires in engineering studies
- Experimental methods and design of experiments
- Case studies and their relevance to engineering investigations
- Use of sensors, data acquisition systems, and instrumentation in engineering research

4. Data Analysis Techniques - 5 LH

- Descriptive statistics for engineering data analysis
- Inferential statistics commonly used in engineering research
- Introduction to statistical software packages for engineering data analysis (e.g., Excel, SPSS)
- Introduction to engineering-specific data analysis tools and techniques

5. Measurement and Instrumentation - 4 LH

- Principles of measurement in engineering
- Types of measurement instruments used in engineering research (sensors, meters, probes)
- Calibration and validation of measurement instruments in engineering experiments
- Data logging and analysis techniques for sensor data in engineering research

6. Research Ethics and Professionalism – 4 LH

- Ethical considerations specific to engineering research
- Professional standards and codes of conduct in engineering research
- Intellectual property rights and patent issues in engineering research
- Responsibilities of engineers in conducting and reporting research ethically

7. Report writing - 4 LH

- Structure and components of engineering research papers and reports
- Technical writing skills for engineering research documents
- Effective presentation techniques for engineering research findings
- Peer review process and publication ethics in engineering research

References:

- Kothari,CR: Reseach Methodology: Methods and Techniques; Wiley Eastern Ltd, 1993.
- Prem R. Panta: " Social Science Research"
- Sekaran, U., & Bougie, R. (2016). Research Methods for Business: A Skill Building Approach. John Wiley & Sons.
- Creswell, J. W., & Creswell, J. D. (2017). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage Publications.
- Leedy, P. D., & Ormrod, J. E. (2014). Practical Research: Planning and Design. Pearson.