Techno India NJR Institute of Technology

Course File

Electrical Machine-I (3EE4-07)

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Department of Electrical Engineering

For Techno India NJR Institute of Technology
पंकज पोरवाल
Dr. Pankaj Kumar Porwal
(Principal)

Syllabus:

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

2nd Year - III Semester: B.Tech. (Electrical Engineering)

3EE4-07: Electrical Machine-I

Credit: 3
3L+0T+0P

Max. Marks: 150 (IA:30, ETE:120)
End Term Exam: 3 Hours

SN	CONTENTS	Hours
1.	**Magnetic fields and magnetic circuits** Review of magnetic circuits - MMF, flux, reluctance, inductance; review of Ampere Law and Biot Savart Law; Visualization of magnetic fields produced by a bar magnet and a current carrying coil - through air and through a combination of iron and air; influence of highly permeable materials on the magnetic flux lines.	6
2.	**Electromagnetic force and torque** B-H curve of magnetic materials; flux-linkage v/s current characteristic of magnetic circuits; linear and nonlinear magnetic circuits; energy stored in the magnetic circuit; force as a partial derivative of stored energy with respect to position of a moving element; torque as a partial derivative of stored energy with respect to angular position of a rotating element. Examples - galvanometer coil, relay contact, lifting magnet, rotating element with eccentricity or saliency	9
3.	**DC machines** Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil. Armature winding and commutation – Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation Derivation of back EMF equation, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.	8
4.	**DC machine - motoring and generation** Armature circuit equation for motoring and generation, Types of field excitations – separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, back EMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed. V-I characteristics and torque-speed characteristics of separately excited, shunt and series motors. Speed control through armature voltage. Losses, load testing and back-to-back testing of DC machines.	7

5.	**Transformers** Principle, construction and operation of single-phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency Testing - open circuit and short circuit tests, polarity test, back-to-back test, separation of hysteresis and eddy current losses Three-phase. transformer - construction, types of connection and their comparative features, Parallel operation of single-phase and three-phase transformers, Autotransformers - construction, principle, applications and comparison with two winding transformer, Magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current,Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changing transformers - No-load and on-load tap-changing of transformers, Three-winding transformers. Cooling of transformers.	**12**
	TOTAL	**42**

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Course Overview:

Students will learn about the electrical machine in this 42-hour course. This course includes magnetic fields and magnetic circuits, electromagnetic force and torque, DC machines, Transformers. After going through this course, students will be able to analyse the magnetic circuits used in machines and Transformers. This course will increase the student knowledge regarding the DC machines construction working and different operating conditions and practical applications in industry.

In industries, power conversion plays a vital role as industry machinery operates at different voltage levels. Hence, the study of the transformer becomes very important. Every industry uses electrical machines to do certain work in production, so this course will help students understand the Motion Control industry's requirements. The course is also important for upcoming course subjects and prerequisite for those subjects.

Course Outcome:

CO. NO.	Cognitive Level	Course Outcome
1	Synthesis	Student will be able to explain the construction, working principle, performance and applications of Poly-phase induction machine, Single phase motors, synchronous generator (Alternator) and synchronous motor.
2	Synthesis	Student will be able to identify, formulate and solve the numerical problems related to above machines.
3	Analysis	Students will be able to analyse the performance characteristics for different electrical machines and obtain simple equivalent circuit for the machine.
4	Synthesis	Students will be able to explain and contruct different testing and starting methods for electrical machines so as to identify their applicability in different practical situations.
5	Application	Students will be able to show the purpose for parallel operation of synchronous generators and relate the conditions to be satisfied for this.

Prerequisites:

1. Knowledge of Basic Electrical Technology and elementary calculus.
2. AC and DC electrical theory and a good understanding of magnetism.
3. Students should have at least a basic knowledge of electric circuit analysis and vector calculus.

Course Outcome Mapping with Program Outcome:

Course Outcome	Program Outcomes (PO's)											
CO. NO.	Domain Specific (PSO)					Domain Independent (PO)						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	1	1	-	-	-	-	-	-	-
CO2	1	2	1	2	1	-	-	-	-	-	-	-
CO3	2	1	2	1	1	-	-	-	-	-	-	-
CO4	2	1	2	1	2	-	-	-	-	-	-	-
CO5	1	1	2	2	2	-	-	-	-	-	-	-
1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High)												

Course Coverage Module Wise:

Lect. No.	Unit	Topic
1	**1**	**MAGNETIC FIELDS AND MAGNETIC CIRCUITS**: Review of magnetic circuits - MMF, flux, reluctance, inductance
2	1	Review of Ampere Law and BiotSavart Law
3	1	Visualization of magnetic fields produced by a bar magnet
4	1	Visualization of magnetic fields produced by a current carrying coil through air
5	1	Visualization of magnetic fields produced by a current carrying coil through a combination of iron and air
6	1	Influence of highly permeable materials on the magnetic flux lines
7	**2**	**ELECTROMAGNETIC FORCE AND TORQUE:** B-H curve of magnetic materials and flux-linkage v/s current characteristic of magnetic circuits
8	2	Linear and nonlinear magnetic circuits
9	2	Numerical on linear and nonlinear magnetic circuits
10	2	energy stored in the magnetic circuit
11	2	Force as a partial derivative of stored energy with respect to position of a moving element
12	2	Torque as a partial derivative of stored energy with respect to angular position of a rotating element
13	2	Galvanometer coil, relay contact, lifting magnet
14	2	Rotating element with eccentricity or saliency

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15	**3**	**DC MACHINES**: Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core
16	3	Visualization of magnetic field produced by the field winding excitation with armature winding open
17	3	Air gap flux density distribution
18	3	Flux per pole, induced EMF in an armature coil
19	3	Armature winding: Armature coil, lap and wave winding
20	3	Commutation: construction of commutator , linear commutation
21	3	Armature MMF wave, armature reaction
22	3	Air gap flux density distribution with armature reaction
23	3	Derivation of back EMF equation and torque equation
24	3	Numerical on induced EMF in an armature coil, back EMF and torque
25	**4**	**DC MACHINE - MOTORING AND GENERATION:** Armature circuit equation for motoring and generation,
26	4	Types of field excitations – separately excited, shunt and series
27	4	Open circuit characteristic of separately excited DC generator
28	4	Back EMF with armature reaction
29	4	Voltage build-up in a shunt generator, critical field resistance and critical speed
30	4	V-I characteristics and torque speed characteristics of separately excited, shunt and series motors
31	4	Speed control through armature voltage
32	4	Losses, load testing and back-to-back testing of DC machines
33	4	Numerical on Armature circuit equation for motoring and generation, Losses, load testing
34	**5**	**TRANSFORMERS**: Principle, construction and operation of single-phase transformers
35	5	Equivalent circuit, phasor diagram of single phase transformer
36	5	Voltage regulation, losses and efficiency
37	5	Testing : open circuit and short circuit tests
38	5	Polarity test, back-to-back test
39	5	Separation of hysteresis and eddy current losses
40	5	Parallel operation of single-phase
41	5	Three-phase transformer: construction, types of connection and their comparative features
42	5	Parallel operation of three-phase transformers

43	5	Autotransformers : construction, principle, applications and comparison with two winding transformer
44	5	Magnetizing current, effect of nonlinear B-H curve of magnetic core material
45	5	Harmonics in magnetization current, Phase conversion: Scott connection
46	5	Three-phase to six-phase conversion
47	5	Tap-changing transformers: No-load and on-load tap-changing of transformers
48	5	Three-winding transformers. Cooling of transformers
49	5	Numerical on voltage regulation, losses and efficiency
50	5	Numerical on open circuit and short circuit tests, Autotransformers and Three-phase Transformer

Text/Reference Books:

1. A. E. Fitzgerald, C. Kingsley Jr and Umans, Electric Machinery, 6th Edition McGraw Hill, International Student Edition.
2. Kothari & Nagrath, Electric Machines, 3/e, TMH
3. M. G. Say, The Performance and Design of AC machines, Pit man & Sons.
4. Guru, Electric Machinery, 3e, Oxford 2000
5. R. K. Srivastava, Electrical Machines, Cengage Learning.

Teaching and Learning resources:

NPTEL Course Link	https://nptel.ac.in/courses/108/105/108105017/ https://nptel.ac.in/courses/108/105/108105155/
Quiz	https://quizizz.com/admin/quiz/5eba65fc4dfbc3001c1f9e24/electrical-machine
Notes	https://sites.google.com/site/reddyeeenotes2/home/notes/Machines-1%20full%20notes.pdf?attredirects=0&d=1

Assessment Methodology:

1. Assignments one from each unit.
2. Midterm subjective paper where they have to solve the given problem. (Twice during the semester)
3. Final paper at the end of the semester subjective

Previous Year Question Paper

3E1145

Roll No. _____ Total No of Pages: 3

3E1145

B. Tech. III - Sem. (Main / Back) Exam., Dec. 2019

PCC Electrical & Electronics Engineering

3EX4-07 Electrical Machines-I

EE, EX

Time: 3 Hours **Maximum Marks: 120**

Instructions to Candidates:

Attempt all ten questions from Part A, five questions out of seven questions from Part B and four questions out of five from Part C.

Schematic diagrams must be shown wherever necessary. Any data you feel missing may suitably be assumed and stated clearly. Units of quantities used /calculated must be stated clearly.

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. NIL 2. NIL

PART – A

(Answer should be given up to 25 words only) **[10×2=20]**

All questions are compulsory

Q.1 What is magnetizing current in transformer?

Q.2 What is meant by permeability of material?

Q.3 What is B – H curve of magnetic material?

Q.4 What are linear and non-linear magnetic circuits?

Q.5 Explain induced e.m.f. in an armature coil.

Q.6 What are lap and wave windings?

Q.7 Explain principle of dc motor.

Q.8 What is meant by back e.m.f.?

Q.9 What is armature reaction in d.c. machines?

Q.10 Explain critical field resistance and critical speed in d.c. generator.

PART – B

(Analytical/Problem solving questions) **[5×8=40]**

Attempt any five questions

Q.1 Explain Ampere Law and Biot – Savart Law. Show the magnetic fields produced by bar magnet and by a current carrying coil. Clearly mention the difference between the two.

Q.2 Derive an equation for force developed as a partial derivative of stored energy with respect to motion of a moving element.

Q.3 Derive the equation for torque developed in a d.c. motor.

Q.4 Explain the voltage build -up in a d.c. shunt generator. What are different types of d.c. generators?

Q.5 Sketch the speed – load characteristics of a d.c. -

(i) shunt motor (ii) series motor, and explain them.

Q.6 Explain principle of operation and construction of a single – phase transformer. Derive an expression for the induced e.m.f. of the transformer.

Q.7 Develop the exact equivalent circuit of a 1 – phase transformer. State the various assumptions made.

PART – C

(Descriptive/Analytical/Problem Solving/Design Questions) [4×15=60]

Attempt any four questions

Q.1 (a) State and prove the condition of maximum efficiency of a transformer.

(b) When a 100 kVA, single phase transformer was tested, the following results were obtained:

On open circuit, the power consumed was 1300 W and on short circuit at full load current, the power consumed was 1200W. Calculate the efficiency of transformer on full load and half load, when working at Unity Power Factor.

Q.2 (a) Explain the speed - current, torque – current and speed – torque characteristics of d.c. series motor.

(b) A series motor with total resistance of 0.5Ω, when running at a certain speed takes 60 Amps at 500 Volt. If the load torque varies as the cube of the speed, calculate the resistance required to reduce the speed by 25%.

Q.3 (a) What do you mean by linear communication, under communication and over communication in a d.c. machine? Explain.

(b) Explain why the external characteristics of a d.c. shunt generator is more drooping than that of a separated excited generator.

Q.4 Derive an expression for saving in conductor material in an autotransformer over a two winding transformer of equal rating. State the advantage and disadvantages of autotransformer over two-winding transformers.

Q.5 (a) Explain the influence of highly permeable materials on magnetic flux lines, with the help of diagrams.

(b) Explain Ohm's law for magnetic circuits.
