COURSE OUTLINE

Academic Year	AY2021-22	**Semester**	2
Course Coordinator	Click here to access EEE Course Coordinator's List		
Course Code	EE2005 (previously EE3010)		
Course Title	Electrical Devices and Machines		
Pre-requisites	EE2101/EE2001 Circuit Analysis		
No of AUs	3		
Contact Hours	Online Lecture (26 hours); Tutorial (18 hours); Face-to-face Briefing (1.5 hours); Laboratory (6 hours)		
Proposal Date	May 2020; latest update on 17 March 2022		

Course Aims

The objective of the first module is to introduce students to electromagnetic principles and actuators including magnetic circuits and energy conversion devices. The second module focuses on the operating principles of single-phase and three-phase transformers and their applications in power supply systems. The third module furthers the students' knowledge on AC electrical machinery such as induction motors, which are widely used in industry. The final module enables students to understand the basic concepts of DC machines with particular focus on their fundamentals and operating characteristics. Applications of these concepts in solving engineering problems will also be covered.

Intended Learning Outcomes (ILO)

By the end of this course, you should be able to:

1. Develop magnetic equivalent circuits to analyse and solve magnetic circuit problems using the basic electromagnetic principles.
2. Analyse the performance of electrical transformers and describe their applications in power supply systems.
3. Experiment on electrical transformers and analyse their equivalent circuits for parameter determination and performance evaluation.
4. Apply the principles of induction motors to electric drive systems.
5. Experiment on induction motors to determine the equivalent circuit parameters and analyse the performance characteristics.
6. Apply concepts of DC machines to analyse the performance characteristics of DC generators and motors and solve DC machinery problems.

Course Content

Electromagnetic Principles and Actuators. Transformers. AC Machines. DC Machines.

Course Outline

This course is developed as a second-year electrical engineering course and is designed to provide the basic theory along with introduction to most common machines without going into rigorous details of machine theory. The first topic is to introduce students to electromagnetic principles and actuators such as solenoids, relays, and inductors. The second topic enables students to grasp fundamentals and applications of electrical transformers. The third and fourth topics introduce knowledge on AC and DC

electrical machines which are used extensively in industry. This course is a requisite for high-level courses in electrical engineering. Prior knowledge of circuit analysis (EE2001), simple vector algebra and complex number manipulation would be helpful.

S/N	Topic	Lecture Hours	Tutorial Hours
1	<u>Electromagnetic Principles and Actuators</u> Magnetic fields. Magnetic materials and magnetization curves. Magnetic equivalent circuits. Electromagnetic induction. Sinusoidal excitation. Magnetic losses. Electromechanical energy conversion. Solenoids, relays and inductors.	6	4.5
2	<u>Transformers</u> Ideal transformer. Equivalent circuits. Voltage regulation and efficiency. Determination of parameters. Autotransformers. Three-phase transformers. Instrument transformers. Transformer-rectifier units.	7	6.0
3	<u>AC Machines</u> Three-phase induction motors. Construction. Operating principles. Equivalent circuits. Performance calculations. Torque-speed characteristics. Losses and efficiency. Determination of equivalent circuit parameters. Speed control. Three-phase induction generators. Synchronous machines, wound rotor, and permanent magnet types.	8	4.5
4	<u>DC Machines</u> Operating principles. Construction and classification. Voltage and torque equations. Operation and characteristics. Losses and efficiency. Speed control.	5	3.0

Lab Description **(6 hours)**

Two lab modules are incorporated in this course.

Lab Module 1 (L2005A/L3010A): Testing and Operation of a Transformer. A transformer is very common equipment in an electric power system. This experiment deals with two fundamental aspects of a transformer: (i) tests conducted to determine the equivalent circuit parameters of a transformer, and (ii) investigations into performance characteristics of a transformer. The background theory for this experiment is outlined in the lab manual. After completing this experiment, students should be able to determine the equivalent circuit parameters and the performance characteristics of a transformer.

Lab Module 2 (L2005B/L3010B): Operation and Speed Control of Induction Motors. Three-phase induction motors are very commonly used in industries. The objective of this experiment is to deal with three fundamental aspects of a three-phase induction motor: (i) tests conducted to determine the equivalent circuit parameters of a three-phase induction motor, (ii) investigations into performance characteristics of a three-phase induction motor under load conditions, and (iii) speed control of a three-phase induction motor under no-load condition. The background theory for this experiment is outlined in the lab manual. After completing this experiment, students should be able to determine the equivalent circuit parameters of a three-phase induction motor and calculate the performance of the motor through

the equivalent circuit. The students will also understand the technique of controlling the speed of a three-phase induction motor.

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weightage	Team /Individual	Assessment Rubrics
1. Final examination	1-6	EAB SLO a, b, c	60%	Individual	
2. Continuous Assessment 1 (CA1): Quiz 1	1-3	EAB SLO a, b, c	10%	Individual	
3. Continuous Assessment 2 (CA2): Quiz 2	4-6	EAB SLO a, b, c	10%	Individual	
4. Continuous Assessment 3 (CA3): Home Assignment	1-3	EAB SLO a, b, c	10%	Individual	
5. Continuous Assessment 4 (CA4): Lab Experiment L2005A	3	EAB SLO a, b, d, i, j	5%	Individual	
6. Continuous Assessment 5 (CA5): Lab Experiment L2005B	5	EAB SLO a, b, d, i, j	5%	Individual	
Total			100%		

Mapping of Course SLOs to EAB Graduate Attributes (new requirement to update School database)

Course Student Learning Outcomes	Cat	EAB's 12 Graduate Attributes*											
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
EE2005 (EE3010) Electrical Devices and Machines	EE2005 – Core; EE3010 - MPE	●	◐	●	◐		○			○	○		○

1. Develop magnetic equivalent circuits to analyse and solve magnetic circuit problems using the basic electromagnetic principles.	EAB SLO* a, b, l
2. Analyse the performance of electrical transformers and describe their applications in power supply systems.	EAB SLO* a, b, l
3. Experiment on electrical transformers and analyse their equivalent circuits for parameter determination and performance evaluation.	EAB SLO* a, b, d, i, j
4. Apply the principles of induction motors to electric drive systems.	EAB SLO* a, b, l
5. Experiment on induction motors to determine the equivalent circuit parameters and analyses the performance characteristics.	EAB SLO* a, b, d, i. j
6. Apply concepts of DC machines to analyse the performance characteristics of DC generators and motors and solve DC machinery problems.	EAB SLO* a, b, l

Legend: ● Fully consistent (contributes to more than 75% of Student Learning Outcomes)
◐ Partially consistent (contributes to about 50% of Student Learning Outcomes)
○ Weakly consistent (contributes to about 25% of Student Learning Outcomes)
Blank Not related to Student Learning Outcomes

Formative feedback

Students will be able to receive the feedback through:

Quiz scores and answers.

Home assignment scores and answers.

Laboratory assessments.

Examination results; and

Markers' report on overall examination performance.

Learning and Teaching approach

Approach	**How does this approach support students in achieving the learning outcomes?**
Lecture	The video lectures provide important conceptual background for the knowledge and skills that students will develop in Learning Outcomes 1 to 6. The video lectures comprise explanations of theories and have many worked examples for students to practice.
Tutorial	The tutorials provide an opportunity for students to discuss problems and ask questions on the video lectures that can help them to understand how to apply the knowledge and theories learnt to solve engineering problems, thus helping them to achieve Learning Outcomes 1 to 6.
Laboratory	The laboratories provide a hands-on experience for students to conduct experiments with transformers and induction motors and then perform analysis and solve practical engineering problems, thus achieving Learning Outcomes 3 and 5.

Reading and References

TEXTBOOK

1. Guru Bhag S and Hiziroglu Huseyin R, Electric Machinery and Transformers, 3rd Edition, Oxford University Press, 2001. (TK2000.G981.2001 & e-book avail)
2. Chapman Stephen J, Electric machinery fundamentals, 5th Edition, McGraw-Hill, 2012. (TK2000.C466 2012)

REFERENCES

1. Sen Paresh Chandra, Principles of Electric Machines and Power Electronics, 3rd Edition, John Wiley & Sons, 2014. (TK2000.S474p2014)

Course Policies and Student Responsibilities

(1) General

Students are required to complete all assigned pre-class readings and online lectures before coming to the corresponding tutorial sessions, attend all tutorial classes punctually and take all scheduled assignments and tests by due dates. Students are required to take responsibility to follow up with course notes, assignments, and course related announcements throughout the course. Students are required to participate in all tutorial discussions and activities.

(2) Continuous assessments and laboratories

Students are required to attend all continuous assessments and laboratory sessions.

(3) Absenteeism

Continuous assessments and laboratories make up a significant portion of students' course grade. Absence from continuous assessments and laboratories without officially approved leave will result in no marks and affect students' overall course grade.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
The contact info will be provided to students at the beginning of each semester.			

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Magnetic fields. Magnetic materials and magnetization curves. Magnetic equivalent circuits.	1	No tutorial in Week 1. A face-to-face briefing on online lectures, learning outcomes, continuous assessments, laboratory assessments and final examination.
2	Electromagnetic induction. Sinusoidal excitation. Magnetic losses.	1	Lecture summary, face-face discussion and Tutorial 1.
3	Electromechanical energy conversion. Solenoids, relays and inductors.	1	Lecture summary, face-face discussion and Tutorial 2.
4	Ideal transformer. Practical transformer. Equivalent circuits.	2	Lecture summary, face-face discussion and Tutorial 3.
5	Voltage regulation and efficiency. Determination of parameters.	2	Lecture summary, face-face discussion and Tutorial 4.
6	Autotransformers. Three-phase transformers.	2, 3	Lecture summary, face-face discussion and Tutorial 5. Lab Experiment L2005A/L3010A
7	Three-phase transformers/ Introduction to principles of AC Machines	2, 3, 4	Lecture summary, face-face discussion and Tutorial 6. Lab Experiment L2005A/L3010A
8	AC Machines	4	Lecture summary, face-face discussion, and Tutorial 7. Quiz 1
9	AC Machines	4	Lecture summary, face-face discussion and Tutorial 8. Home Assignment
10	AC Machines/ Introduction to principles of DC Machines	4, 6	Lecture summary, face-face discussion, and Tutorial 9.
11	DC Machines	6	Lecture summary, face-face discussion, and Tutorial 10.
12	DC Machines	5, 6	Lecture summary, face-face discussion, and Tutorial 11. Quiz 2 and Lab Experiment L2005B/L3010B
13	DC Machines	5, 6	Lecture summary, face-face discussion and Tutorial 12. Lab Experiment L2005B/L3010B