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$= \frac{V_{OC}}{V_c}$

$\mu_{eff} = \mu_r \mu_0$
 $\mu_{eff} = \mu_0 \mu_r$
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$\int = \frac{1}{R}$
 $B = \mu A$

$\phi = \frac{NI}{R}$
 $\frac{\mu NI}{L}$

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 SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY
 DEPARTMENT OF MECHATRONICS ENGINEERING

RAIN SEMESTER 2017/2018 EXAMINATION
 COURSE TITLE: ELECTROMECHANICAL DEVICES COURSE CODE/UNIT: MCE 306/3
 INSTRUCTION: Answer five questions only. TIME: 3 HOURS

Q1(a) (i) Distinguish between Ferromagnetic, Paramagnetic and Diamagnetic materials. (6mks)
 (ii) State the properties of Ferromagnetic materials. (3mks)

(b) A square magnetic core has a mean path length of 55cm, a cross-sectional area of 150cm² and a 200-turns coil of wire wound around one leg of the core. If the core is made of a material whose magnetic field intensity H is 115 A. turns/m, determine:

- (i) The current required to produce 0.012Wb of flux in the core. (5mks)
- (ii) The relative permeability, μ_r of the core at that current level. (4mks)
- (iii) The reluctance of the core. (2mks)

$H = \frac{1}{\mu_0 \mu_r} \cdot \frac{\phi}{A} \cdot l$
 $H = \frac{NI}{L}$
 $H = \frac{I \cdot 200}{0.55}$

$\phi = B \cdot A$
 $H = \frac{I \cdot N}{L}$

Q2. (a) Draw the schematic of a two winding transformer on load; and by exploring the dot convention principle, show that the ratio of the primary current and secondary current is equal to the reciprocal of the transformation ratio. (8mks)

(b) Draw (i) Transformer equivalent circuit referred to the primary side and that referred to the secondary side. (4mks) (ii) the approximate equivalent circuit referred to the primary and secondary side respectively. (4mks)

(c) Describe the losses associated with transformer. (4mks)

Q3. Open circuit and short circuit test performed on a 15KVA, 2300/230V rated Transformer yielded the results shown in Table Q3.

Open-circuit test (from the secondary side)	Short-circuit test (from the primary side)
$V_{OC} = 230V$	$V_{SC} = 47V$
$I_{OC} = 2.1A$	$I_{SC} = 6.0A$
$P_{OC} = 50W$	$P_{SC} = 160W$

- (a) Evaluate the excitation branch parameters and the series impedances of the transformer. (12mks)
- (b) Determine (i) the equivalent circuit parameters of the transformer referred to the primary side. (4mks)
- (ii) The equivalent circuit parameters of the transformer referred to the secondary side. (4mks)

Q4. (a) Distinguish between squirrel cage induction motor and wound - rotor induction motor. (4mks)
 (b) Sketch the torque-speed characteristics of an induction motor, indicate the following regions of operation on the curve: Plugging region, Motoring region and Generating region. (4mks)

(c) A star - connected induction motor rated 5HP, 220 line voltage, 60Hz, four-pole; has the following equivalent circuit parameters: $R_1 = 0.48\Omega$, $R_2' = 0.42\Omega$, $X_m = 30\Omega$, $X_1 = 0.80\Omega$, $X_2' = 0.80\Omega$. If the motor operating slip is 0.04, and $R_c = 0$, determine:

- (i) The slip at which maximum torque occurred. (8mks)
- (ii) The maximum torque (Nm). (4mks)

Q5. (a) (i) Define Power Electronics (2 marks) (ii) Name two examples of Power Electronics. (2 marks) (iii) Name three types of computer simulation programs used to simulate power electronic circuits (3 marks) (iv) Name the three main types of Voltage source inverters (VSI) (3 marks).

(b) (i) What is the purpose of an AC Voltage Controller or AC Regulator. (2 marks) (ii) State the three generally accepted control methods for the AC Voltage controller (3 marks) (iii) State the three converters that are typically used under frequency converters (3 marks) (iv) Differentiate between AC Voltage Controllers (or AC Regulators) and frequency converters for AC to Ac conversion. (2 marks)

Q6. (a) (i) What is smart grid? (3 marks) (ii) How are inverters utilized in renewable applications such as photovoltaic purposes and wind turbines? (4 marks) (iii) What are the three different types, inverters are divided into? (3 marks)

(b) (i) Define Direct torque control (DTC) (2 marks) (ii) State the six key competing VFD control platform. (6 marks) (iii) State two properties of DTC. (2 marks)