UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2014/2015

COURSE NAME	:	ELECTRICAL MACHINE
COURSE CODE	:	BNR 22903
PROGRAMME	:	2 BNE
EXAMINATION DATE	:	JUNE 2015/JULY 2015
DURATION	:	2 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **ELEVEN (11)** PAGES

Q1 (a) As an experienced technologist, describe **THREE (3)** SI units in a table with suitable parameter; Physical units, Units and Symbols based on IEEE standards.

(3 marks)

(b) Based on magnetic fields fundamental, elaborate about magnetic flux density.

(4 marks)

(c) If the flux density in a certain magnetic material is 2.3 T and the area of the material is 245×10^{-6} m^2, determine the flux through the material.

(2 marks)

(d) Magnetic fields are the fundamental mechanism by which energy is converted from one form to another in motors, generators and transformers. State **FOUR (4)** basic principles of magnetic fields commonly used in these device applications.

(4 marks)

(e) Three sides of this core are of uniform width, while the fourth side is somewhat thinner. The depth of the core (into the page) is 10 cm, and the other dimensions are shown in the **FIGURE Q1(e)**, ferromagnetic core. There is a 200 turn coil wrapped around the left side of the core. Assuming relative permeability μ_r of 2500, with 1.0 A input current.

Calculate:

(i) Reluctance of the first region.
(ii) Reluctance of the second region.
(iii) Total reluctance in core.
(iv) Total magnetic force.
(v) Total flux in the core.

(12 marks)

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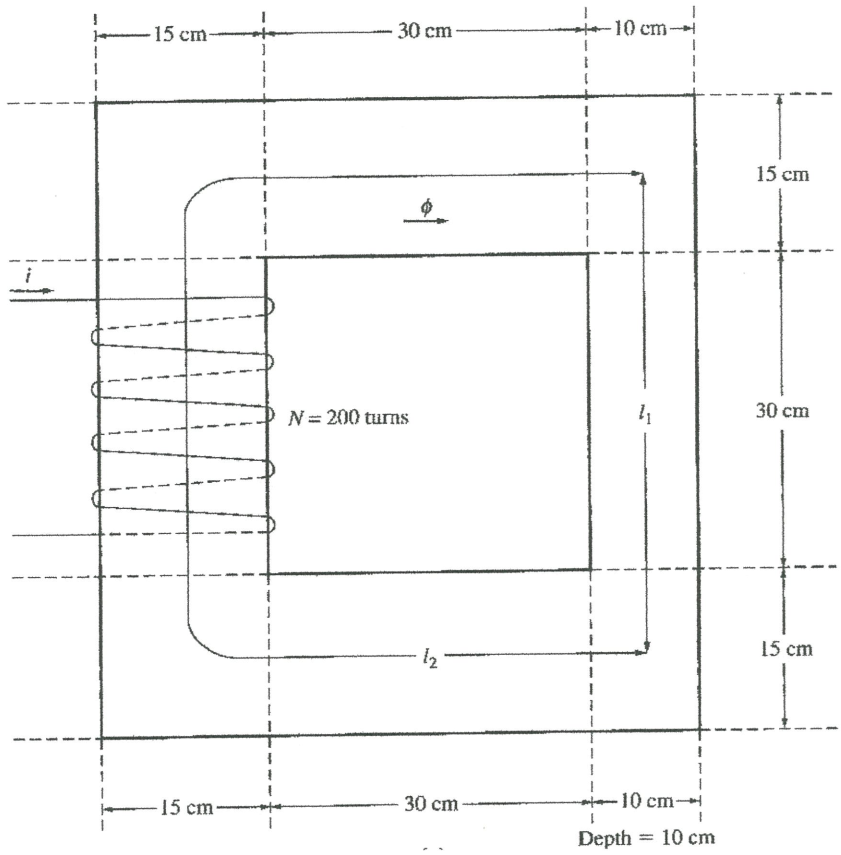

FIGURES Q1(e)

Q2 (a) Based on DC machines applications, state **FIVE (5)** major types of DC motors in general use.

(5 marks)

(b) Analyze, draw and describe briefly the comparison between the equivalent circuits of a DC motor with its simplified equivalent circuit, based on their related parameters.

(5 marks)

(c) A 2000 kW, 500 V, variable-speed motor is driven by a 2500 kW generator, using Ward-Leonard control system shown in **FIGURE Q2(c)** . The total resistance of the motor and generator armature circuit is 10mΩ.The motor turns at a nominal speed 300 r/min, when E_0 is 500V.

Calculate the motor torque and speed when $E_S = 400$ V and $E_0 = 380$ V.

(5 marks)

(d) A shunt motor rotating at 1500 r/min is fed by a 120 V source on **FIGURE Q2(d).** The line current is 51 A and the shunt-field resistance is 120 Ω. If the armature resistance is 0.1Ω,

Calculate:

(i) The current in the armature.
(ii) The counter-emf.
(iii) The mechanical power developed by a motor.

(10 marks)

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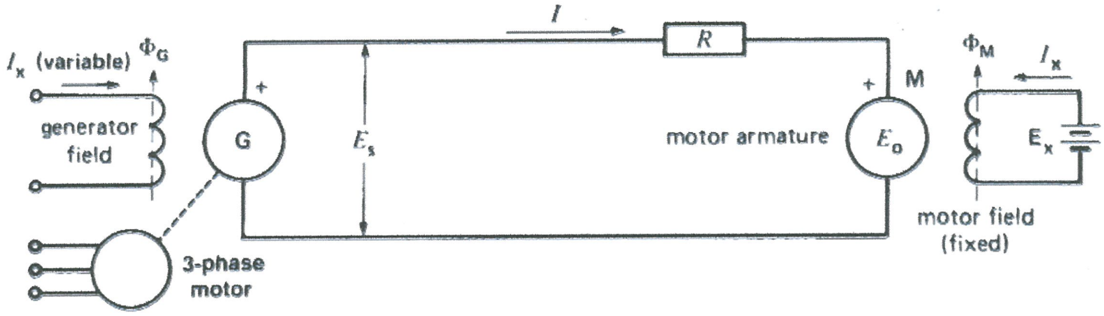
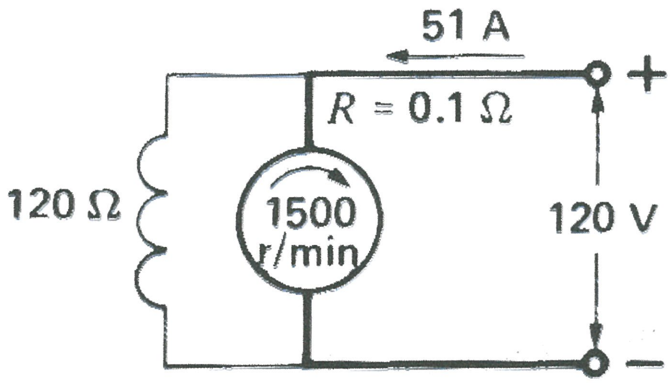


FIGURES Q2(c)



FIGURES Q2(d)

Q3 (a) Classify **FIVE (5)** single-phase induction motor of split-phase with suitable diagrams.

(10 marks)

(b) Based on **FIGURE Q3(b)** of view of a 5 Hp, 1725 r/min, 60 Hz single-phase capacitor-start motor, calculate the speed of the 4-pole single-phase motor shown if the slip at full-load is 3.4%.The line frequency is 60 Hz.

(5 marks)

(c) Develop a table showing the speed of magnetic field rotation in AC machines of 2, 4, 6, 8, 10, 12, and 14 poles operating at frequencies of 50, 60, and 400 Hz.

(10 marks)

Q4 (a) Draw an overall schematic diagram for delta-delta connection for three-phase transformer.

(5 marks)

(b) Three single-phase transformer are connected in delta-delta to step down a line voltage of 138 kV to 4160 V to supply power to a manufacturing plant. The plant draws 21 MW at a lagging power factor of 86%.

Calculate:

(i) The apparent power drawn by the plant.
(ii) The apparent power furnished by the HV line.
(iii) The current in the HV line.
(iv) The current in the LV line.

(9 marks)

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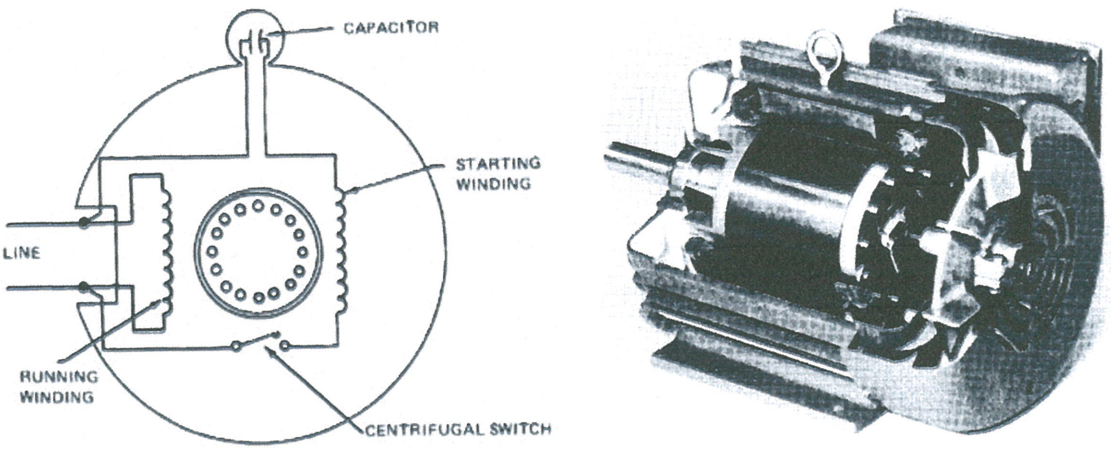

FIGURES Q3(b)

Q4 (c) Three single phase step-up transformer rated at 40 MVA , 13.2 kV are connected in delta-wye on a 13.2 kV transmission line such in **FIGURE Q4(c),** delta-wye connection. If they feed a 90 MVA load.

Calculate:

(i) The secondary line voltage.
(ii) The currents in the transformer windings.
(iii) The current in the HV line.
(iv) The current in the LV line.

(10 marks)

Q5 (a) Analyze and draw instantaneous values of current and position of the flux application by three-phase induction motor.

(6 marks)

(b) Calculate the synchronous speed of a 3-phase induction motor having 20 poles when it is connected to a 50 Hz source.

(3 marks)

(c) 3-phase induction motor having a synchronous speed of 1200 r/min draws 80 kW from from 3-phase feeder. The copper losses and iron losses in the stator amount to 5 kW. If the motor runs at 1152 r/min.

Calculate:

(i) The active power transmitted to the rotor.
(ii) The rotor I^2R losses.
(iii) The mechanical power developed.
(iv) The mechanical power delivered to the load, knowing that the windage and friction losses are equal to 2 kW.
(v) The efficiency of the motor.

(16 marks)

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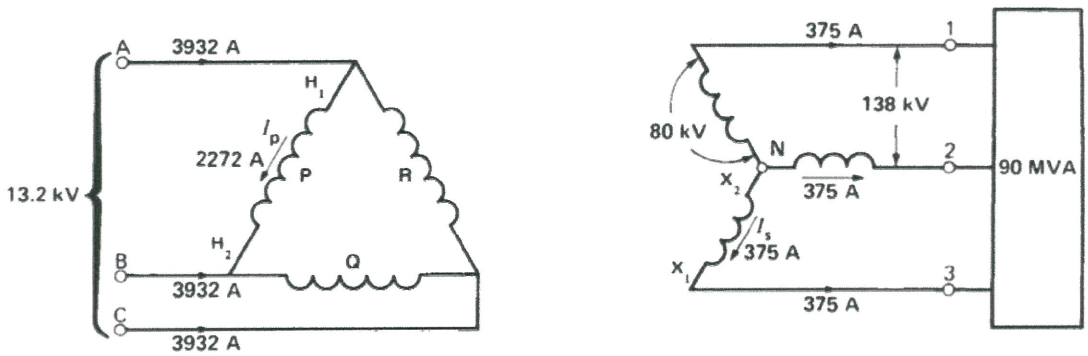

FIGURES Q4(c)

Q6 (a) Calculate the number of salient poles on the rotor of the synchronous motor rated 3000 kW, 200 r/min, 6.9 kV, 60 Hz.

(4 marks)

(b) Define clearly about synchronous generator including related diagram to support the answers.

(4 marks)

(c) A hydraulic turbine turning at 200 r/min is connected to a synchronous generator. If the induced voltage has a frequency of 60 Hz.

(i) Define formula of frequency of generator.
(ii) Calculate how many poles does the rotor have.

(4 marks)

(d) A 3-Phase synchronous generator produces an open circuit line voltage of 6928 V when exciting current is 50 A.

Calculate:

(i) The synchronous reactance per-phase.
(ii) The terminal voltage if the three 12Ω resistors are connected in wye across the terminals.

(13 marks)

- END OF QUESTION -

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LIST OF FORMULA

General

$S_{1\text{-}\phi} = V_\phi I_A$	Y connected : $V_\phi = \frac{V_T}{\sqrt{3}}$ $I_\phi = I_L$
$P_{1\text{-}\phi} = V_\phi I_A \cos\theta$	Δ connected : $V_\phi = V_T$ $I_\phi = \frac{I_L}{\sqrt{3}}$
$Q_{1\text{-}\phi} = V_\phi I_A \sin\theta$	1 hp = 746 W
$S_{3\emptyset} = 3V_\emptyset I_\emptyset = \sqrt{3}V_T I_L$	efficiency, $\eta = \frac{P_{out}}{P_{out}+P_{loss}}$ x 100
$P_{3-\emptyset} = 3V_\emptyset I_\emptyset \cos\theta = \sqrt{3}V_T I_L \cos\theta$	$Q_{3-\emptyset} = 3V_\emptyset I_\emptyset \sin\theta = \sqrt{3}V_T I_L \sin\theta$

Synchronous Generator and Synchronous Motor

$P = \frac{3V_\varphi E_A \sin\delta}{X_S}$	$\tau_{ind} = \frac{3V_\varphi E_A \sin\delta}{\omega_m X_S}$	$P_{max} = \frac{3V_\varphi E_A}{X_S}$	$\tau_{max} = \frac{3V_\varphi E_A}{\omega_m X_S}$

Shunt/Separately Excited DC Motor

$\tau_{ind} = \frac{E_A I_A}{\omega_m}$	$I_F{}^* = I_F - \frac{\mathcal{F}_{AR}}{N_F}$	$\frac{E_A}{E_{A0}} = \frac{\eta}{\eta_0}$

Induction Motor

$f_r = sf_e$	$n_{sync} = \frac{120 f_e}{P}$	$n_m = (1-s)n_{sync}$

$$\tau_{ind} = \frac{3V_{TH}^2 \, {}^{R_2}/_s}{\omega_{sync}\left[\left(R_{TH}+{}^{R_2}/_s\right)^2 + (X_{TH}+X_2)^2\right]}, \text{where..,} \left\{ \begin{array}{l} V_{TH} = V_\emptyset \frac{jX_M}{R_1+jX_1+jX_M} \\ Z_{TH} = \frac{jX_M(R_1+jX_1)}{R_1+j(X_1+X_M)} \end{array} \right\}$$

$s_{max} = \frac{R_2}{\sqrt{R_{TH}^2 + (X_{TH}+X_2)^2}}$	$\tau_{max} = \frac{3V_{TH}^2}{2\omega_{sync}\left[R_{TH} + \sqrt{R_{TH}^2 + (X_{TH}+X_2)^2}\right]}$