UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2010/2011

COURSE NAME	:	ELECTRICAL MACHINES AND DRIVE
COURSE CODE	:	BEE 4123
PROGRAMME	:	4 BEE
EXAMINATION DATE	:	NOVEMBER/DECEMBER 2010
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE** (5) QUESTIONS ONLY.

THIS PAPER CONSISTS OF TEN (10) PAGES

Q1 (a) The flow of magnetic flux induced in the ferromagnetic core can be made analogous to an electrical circuit. Sketch and labels the analogous relationships that exist between an electric circuit and a magnetic circuit.

(5 marks)

(b) A ferromagnetic core with a relative permeability of 1500 is shown in Figure Q1(b). Both width and depth of the core are 5 cm. To find the means length of the core, this formula can be used; $L = 2\Pi r$ where its radius, r is 10 cm. The air gaps on the left and right sides of the core are 0.07 cm and 0.05 cm respectively. Because of fringing effects, the effective area of the air gaps is 6 percent larger than their physical size. If there are 400 turns in the coil wrapped around the center leg of the core and if the current in the coil is 2 A, determine:

(i) The equivalent magnetic circuit.
(ii) The total flux in the core.
(iii) The total flux density.

(12 marks)

(c) A wire shown in the Figure Q1(c) which is moving in the presence of the magnetic field. With the information given in the figure, determine the magnitude and direction of the induced voltage, e_{ind} in the wire.

(3 marks)

Q2 (a) (i) Draw and labels the equivalent circuit of a real transformer referred to its secondary voltage level.
(ii) Explain briefly function of open-circuit test and short-circuit test of a transformer. Show all clearly with the aid of appropriate diagrams.

(5 marks)

(b) A 1000-VA 230/115-V transformer has been tested to determine its equivalent circuit. The results of the tests are shown below.

Open- circuit test
$V_{OC} = 230V$
$I_{OC} = 0.55A$
$P_{OC} = 30W$

All data given for open circuit test were taken from the secondary side of the transformer and the value of $R_{eq} = 0.6\Omega$ and $X_{eq} = 2.13\Omega$ were taken from the primary side of the transformer.

(i) Determine the values of R_c and X_m.
(ii) Determine the values of series impedances, R_{eq} and X_{eq}.

(iii) Draw and labels the equivalent circuit of this transformer referred to the low-voltage side of the transformer.

(iv) Determine the transformer's voltage regulation at rated conditions and

(a) 0.85 PF lagging

(b) 0.85 PF leading.

(v) Determine the transformer's efficiency at rated condition 0.85 PF lagging

(11 marks)

(c) (i) From results Q2(b)(iv), compare the relationship between the values of voltage regulation and the power factor.

(ii) Efficiency of the transformer depends on the P_{out} and P_{in}. Propose two (2) methods to ensure the transformer efficiency's is higher.

(4 marks)

Q3 (a) Briefly explain five (5) reasons of impossibility for the induction motor to operate at synchronous speed.

(5 marks)

(b) A 440V, 50Hz two-pole, Y-connected induction motor is rated at 75 kW. The equivalent circuit parameters and the losses are

$R_1 = 0.075\Omega$	$R_2 = 0.065\ \Omega$	$X_M = 7.2\ \Omega$
$X_1 = 0.17\ \Omega$	$X_2 = 0.17\ \Omega$	
$P_{core} = 1.1\text{kW}$	$P_{F\&W} = 1.0\text{ kW}$	$P_{misc} = 150\text{ W}$

For a slip of 0.04, find

(i) The line current, I_L

(ii) The stator power factor

(iii) The stator copper losses, P_{SCL}

(iv) The air-gap power, P_{AG}

(v) The power converted from electrical to mechanical form, P_{conv}

(vi) The induced torque, τ_{ind}

(vii) The load torque, τ_{load}

(viii) The overall machine efficiency, η

(15 marks)

Q4 (a) Identify four (4) factors that cause internal generated voltage, E_A not usually the voltage that appears at the terminal voltage, V_ϕ of the synchronous generator.

(5 marks)

(b) A three-phase Y-connected synchronous motor has specifications as follow:

Line Voltage = 415 V, 50 Hz, Power Factor = 0.8 leading Output Power = 20 Hp Pole = 2	Armature Resistance, RA = 0.2 ohms Synchronous Reactance, XS = 3 ohms Friction and Windage Losses = 20 kW Core Losses = 15 kW

Based on the information given, answer the following questions.

(i) Sketch and label a single-phase equivalent circuit of synchronous motor.
(ii) By considering the related factor, estimate the value of three-phase copper losses, P_{copper} and armature current, I_A at unity power factor and full-load condition.
(iii) Calculate the required value of three-phase internal generated voltage, E_A and identify the required field current, I_F.
(iv) Sketch and label phasor diagram of the motor at unity power factor and full-load condition.
(v) Compute the motor efficiency, η_m at unity power factor and full-load condition by considering copper losses, P_{copper} effect.
(vi) Determine the maximum torque, τ_m at unity power factor and full-load condition by considering copper losses, P_{copper} effect.
(vii) Determine the maximum torque, τ_m at 0.8 leading power factor by considering copper losses, P_{copper} effect.
(viii) Sketch and labels the phasor diagram of the motor at 0.8 leading power factor.

(15 marks)

Q5 (a) (i) List any four (4) categories of losses that occur in DC machines.
(ii) Briefly explain two (2) methods to control the speed of compounded DC motor.

(5 marks)

(b) Refer the following dc motor characteristics:

P_{rated} = 20hp	$I_{L,rated}$ = 60A
V_T = 240V	N_F = 3000 turns per pole
n_{rated} = 1200rpm	N_{SE} = 30 turns per pole
R_A = 0.40Ω	R_F = 100 Ω
R_S = 0.04Ω	R_{adj} = 50 to 500 Ω

Rotational losses = 1800 at full load conditions

Assume that the motor described above can be connected in shunt as shown in Figure Q5(b)(i). The magnetization curve as shown in Figure Q5(b)(ii).

(i) If the resistor R_{adj} is adjusted to 200Ω, find the rotational speed of the motor at no-load conditions.

(ii) Assuming no armature reaction at full-load condition,

  (a) Find the speed of the motor.

  (b) Find the speed regulation of motor.

(iii) If the motor is operating at full-load condition and if its variable resistance R_{adj} is increased to 300Ω, find the new speed of the motor

(iv) From the results between Q5(b)(ii)(a) and Q5(b)(iii), compare the relationship between the armature current and the speed of motor

(v) If R_{adj} can be adjusted from 50 to 500Ω, find the maximum and minimum speeds possible with this motor in no-load condition.

(15 marks)

Q6 (a) (i) List four (4) advantages of electric drive.

(ii) Draw and labels the one (1) block diagram of the motion control in an electrical drive system.

(5 marks)

(b) Figure Q6(b) show an electric drive for an elevator with the motor rated speed, n_m is 3000rpm and the efficiency of gearing system, η is 0.85.

(i) Find the total inertia (reduced to motor shaft), torque and power without counterweight.

(ii) Find the torque and power with counterweight.

(iii) From the results between Q6(b)(i) and Q6(b)(ii), compare the relationship between the torque and the power of the motor.

(iv) If the mass cabin, m_c is increased to 1400kg with counterweight, find the new torque and power of the motor.

(v) From the results between Q6(b)(ii) and Q6(b)(iv), compare the relationship between the mass, the torque and the power of the motor.

(15 marks)

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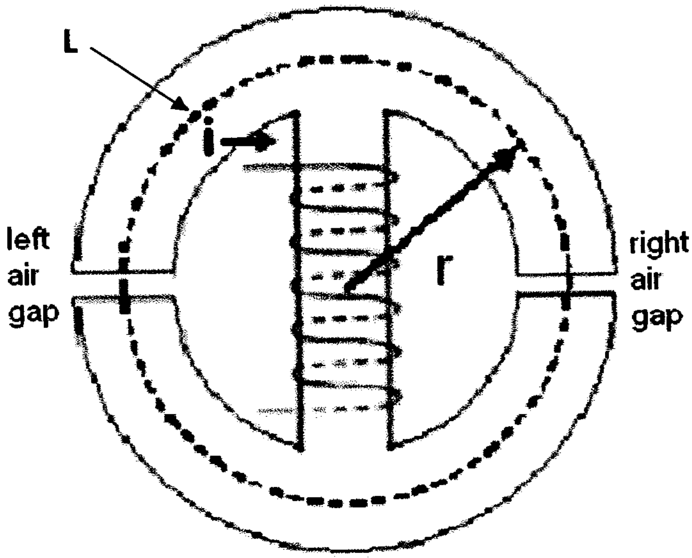

Figure Q1(b)

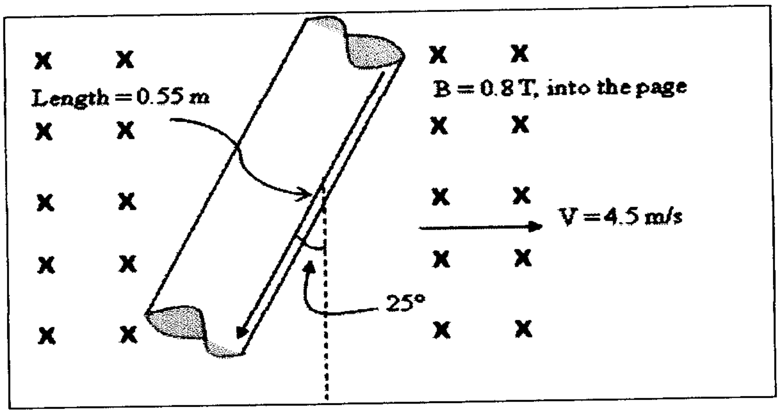

Figure Q1(c)

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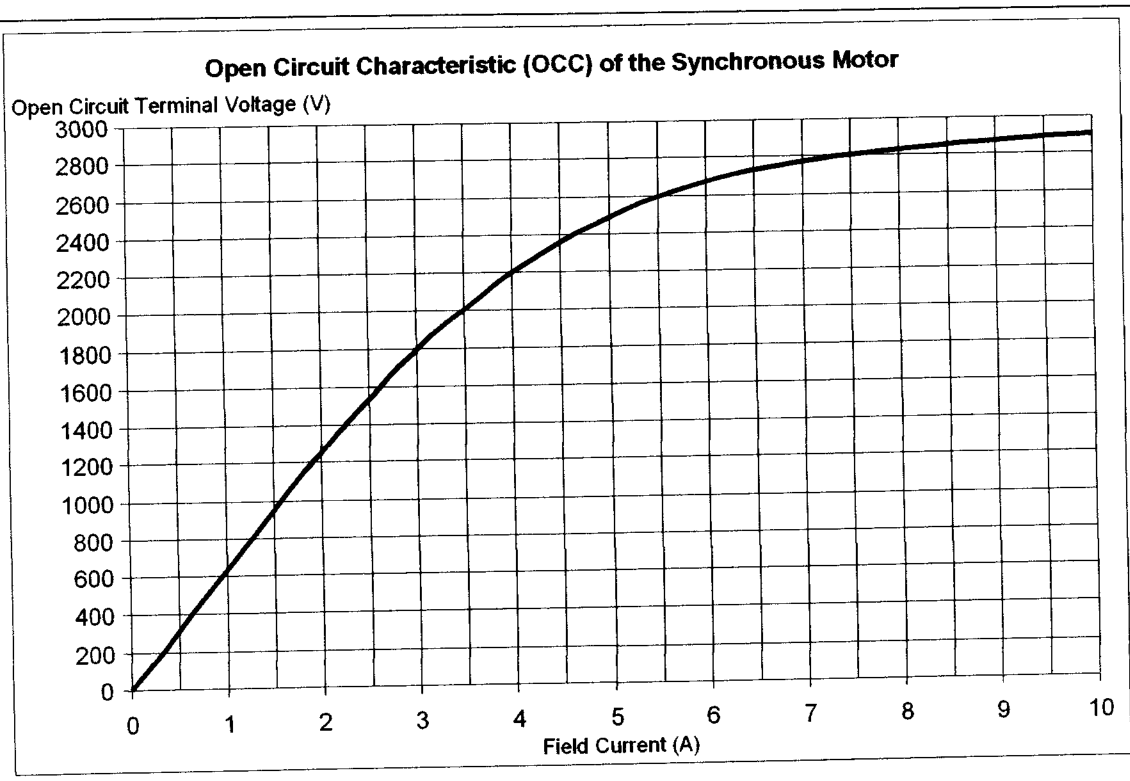

Figure Q4(b)

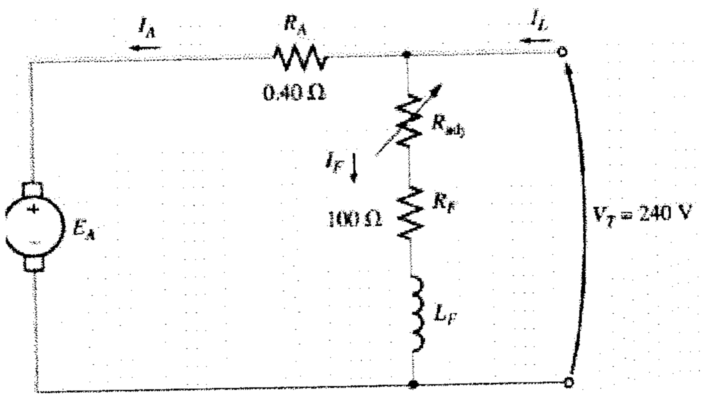

Figure Q5(b)(i)

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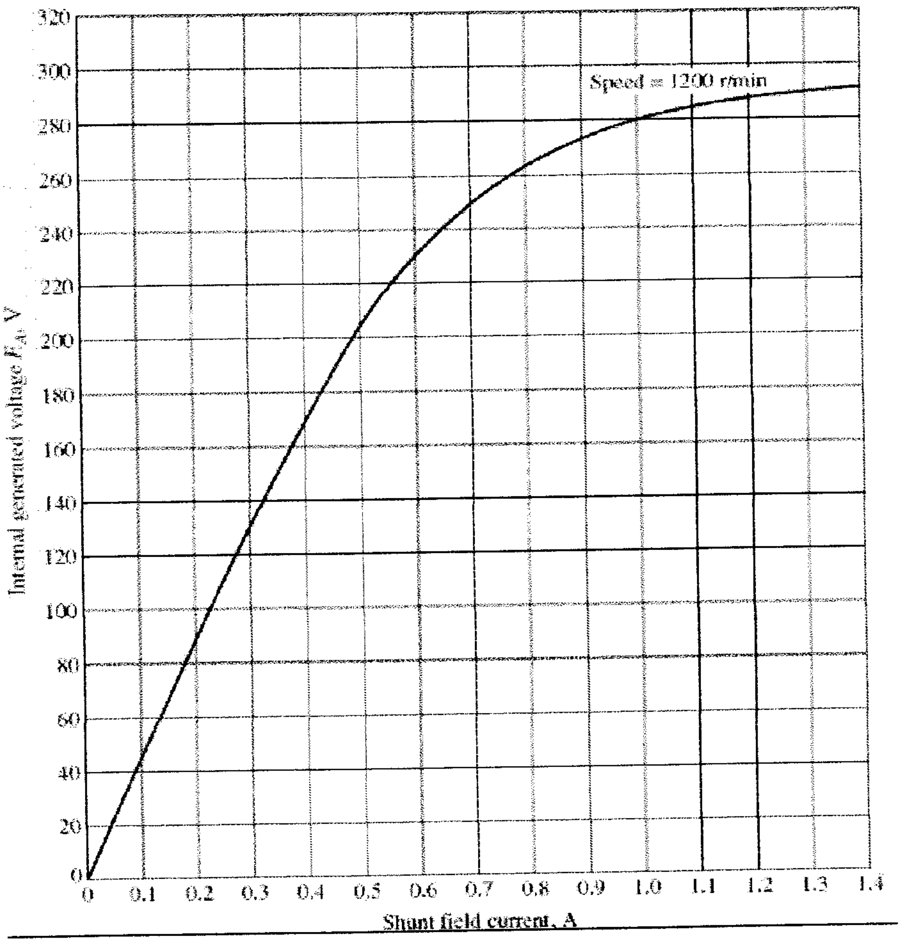

Figure Q5(b)(ii)

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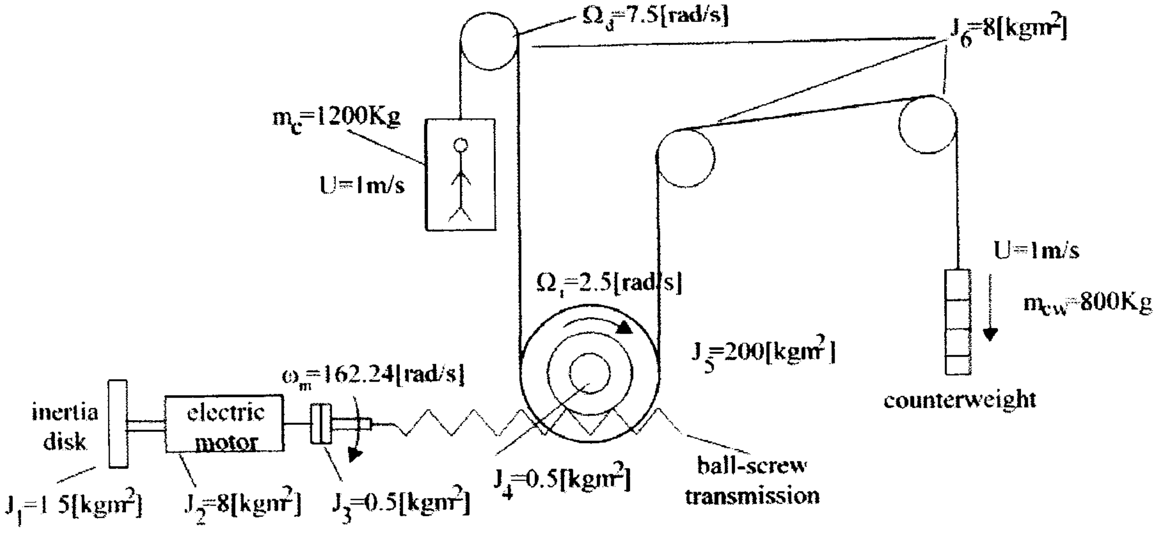

Figure Q6(b)

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Formula

Magnet:

$$\mu_0 = 4\pi \times 10^{-7}\, H/m$$

Synchronous machine:

$$P_{conv} = \tau_{ind}\omega_m = 3E_A I_A \cos\gamma$$

$$P = \frac{3V_\phi E_A \sin\delta}{X_S}$$

$$\tau_{ind} = \frac{3V_\phi E_A \sin\delta}{\omega_m X_S}$$

Induction motor:

$$P_{conv} = 3I_2^2 R_2\left(\frac{1-s}{s}\right)$$

$$P_{AG} = 3I_2^2 \frac{R_2}{s}$$

$$\tau_{ind} = \frac{P_{AG}}{\omega_{sync}}$$

$$\tau_{load} = \frac{P_{OUT}}{\omega_m}$$

$$\tau_{ind} = \frac{3V_{TH}^2\, R_2/s}{\omega_{sync}\left[\left(R_{TH} + R_2/s\right)^2 + \left(X_{TH} + X_2\right)^2\right]}$$

$$s_{max} = \frac{R_2}{\sqrt{R_{TH}^2 + \left(X_{TH} + X_2\right)^2}}$$

DC motor:

$$E_A = K\phi\omega$$

$$\tau_{ind} = K\phi I_A$$

$$P_{conv} = E_A I_A = \tau_{ind}\omega_m$$

$$I_F^* = I_F + \frac{N_{SE}}{N_F} I_A - \frac{\Im_{AR}}{N_F}$$

$$\omega = \frac{V_T}{K\phi} - \frac{R_A}{(K\phi)^2}\tau_{ind}$$