UNIVERSITI TUN HUSSEIN ONN MALAYSIA

PEPERIKSAAN AKHIR
SEMESTER II
SESI 2008/2009

NAMA MATAPELAJARAN	: MESIN ELEKTRIK & PEMACU
KOD MATAPELAJARAN	: BEE 4123
KURSUS	: 4 BEP, BET, BEM, BER
TARIKH PEPERIKSAAN	: APRIL / MEI 2009
JANGKAMASA	: 3 JAM
ARAHAN	: JAWAB SEMUA SOALAN BAHAGIAN A DAN MANA-MANA TIGA (3) SOALAN DARIPADA BAHAGIAN B

KERTAS SOALAN INI MENGANDUNGI TUJUH (7) MUKA SURAT

SECTION A

Q1 (a) Explain clearly the differences between fringing flux and leakage flux.

(6 marks)

(b) An electromagnet of rectangular cross-section shown in Figure Q1(b) has a tightly wound coil with 500 turns. The inner and the outer radii of the magnetic core are 10 cm and 12.5 cm, respectively and its thickness being 2 cm. The length of the air-gap is 1 mm. If the current (I) in the coil is 3 A and produces a flux density (B) of 1.2 *Tesla* in the air-gap (no fringing effect), determine:

(i) The magnetic field intensity in the magnetic core (H_c) and in the air-gap (H_g)

(ii) The relative permeability of the magnetic material of the core (μ_r)

(iii) The total reluctance ($\Re_{total}$) of the magnetic core and air-gap

(9 marks)

(c) Figure Q1(c) shows a simple application of electromagnetic concept in crane. The core of the crane is made of silicon steel, for which the B-H relationship is given as:

$$B = 6.1643(1 - e^{-H/300})\ Tesla$$

It has a uniform cross-sectional area of 0.2 m^2 and a mean path length of 6 m. Coils 1, 2, and 3 carry 5 A, 10 A, and 2 A, respectively in the directions as depicted in the figure. Coils 1 and 2 have 350 and 750 turns, respectively. In order to carry the load as shown in the figure, a total flux of 1 *Weber* need to be established in the core. Determine the number of turns of coil 3 so that the crane has enough minimum power to carry the load.

(10 marks)

SECTION B

Q2 (a) (i) Name the two principle parts of a transformer
(ii) Explain how a voltage is induced in the secondary winding of a transformer
(iii) Identify the losses produced in a transformer

(8 marks)

(b) A 15 kVA, 2300/230 V, 50 Hz transformer is to be determined. The open-circuit and the short-circuit tests were performed on the primary side of the transformer, and the following data were taken:

Open-Circuit test (on primary)	Short-circuit test (on primary)
$V_{OC} = 2300$ V	$V_{SC} = 47$ V
$I_{OC} = 0.21$ A	$I_{SC} = 6.0$ A
$P_{OC} = 50$ W	$P_{SC} = 160$ W

Deduce and produce:
(i) The approximate equivalent circuit referred to the primary side
(ii) The approximate equivalent circuit referred to the secondary side

(17 marks)

Q3 (a) Explain why is it impossible for an induction motor to operate at synchronous speed?

(6 marks)

(b) A three-phase, 25 hp, 460 V, 50 Hz, 1960 rpm, wound-rotor induction motor has the following equivalent circuit parameters:

$R_1 = 0.25\ \Omega$ $X_1 = 1.2\ \Omega$
$R_2' = 0.2\ \Omega$ $X_2' = 1.1\ \Omega$
$X_M = 35\ \Omega$

The motor is connected to a three-phase, 460 V, 50 Hz, supply.

(i) Calculate the number of poles of the machine
(ii) Calculate the starting torque
(iii) Calculate the value of the external resistance required in each phase of the rotor circuit such that the maximum torque occurs at starting

(19 marks)

Q4 (a) Explain, using phasor diagrams, what happens to a synchronous motor as its field current is increased.

(9 marks)

(b) A 440 V, three-phase, 50 Hz, Δ-connected, synchronous motor has a synchronous reactance of 36 Ω/phase. Its armature winding resistance is negligible. When the motor runs at a speed of 188.5 rad/s, it consumes 9 kW and the excitation voltage is 560 V. Calculate:

(i) Line current
(ii) Power factor
(iii) Torque angle
(iv) Torque induced by the motor

(16 marks)

Q5 (a) (i) Identify the major advantages of DC motors.
(ii) Sketch the equivalent circuit for any 3 types of DC motors.

(10 marks)

(b) A 230 V, 15 hp, 1800 rpm dc shunt motor has a full load armature current of 60 A when operating at rated conditions. It's characteristic are:

$R_A = 0.15\,\Omega$
$R_F = 80\,\Omega$
$R_{adj} = 0 \sim 200\,\Omega$ (Currently set to 90 Ω)

Armature reaction is ignored. Tabular form below is the magnetization curve of this motor and taken at a speed of 1800 rpm.

E_A, V	8.5	150	180	215	221	226	242
I_F, A	0.00	0.80	1.00	1.28	1.35	1.44	2.88

Calculate:

(i) The speed of this motor when running at rated conditions
(ii) The output torque of this motor when the output power is 7.5 hp at rated conditions
(iii) The copper losses and rotational losses in this motor at full load (ignore stray losses)
(iv) The efficiency of this motor at full load
(v) What would happen to this motor if its field circuit were to open? And what it is speed under this condition? Ignore the armature reaction

(15 marks)

Q6 (a) List any four advantages of electric drives.

(4 marks)

(b) Typically in motion control of electric drives, it has four types of closed-loop control. Sketch any three of their block diagram and interpret the main function of each control respectively.

(21 marks)

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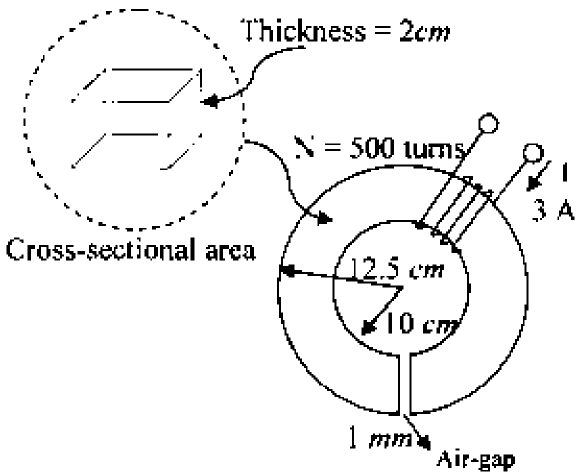

Figure Q1(b)

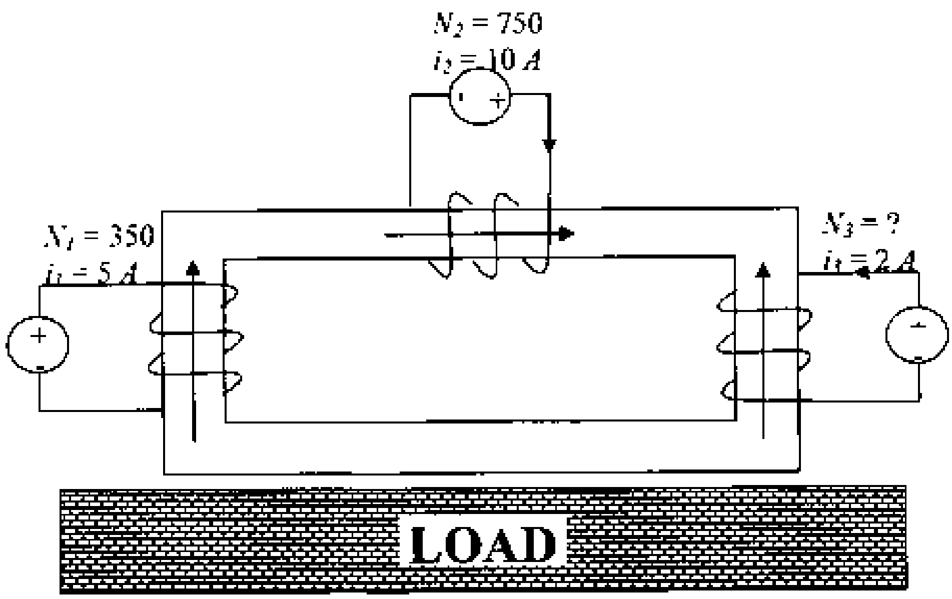

Figure Q1(c)

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Formulae

Magnet:

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

Synchronous machine:

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

$P = \dfrac{3V_\phi E_A \sin\delta}{X_S}$ $\qquad \tau_{ind} = \dfrac{3V_\phi E_A \sin\delta}{\omega_m X_S}$

Induction motor:

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

$\tau_{ind} = \dfrac{P_{AG}}{\omega_{sync}}$ $\qquad \tau_{load} = \dfrac{P_{OUT}}{\omega_m}$

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

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

DC motor:

$E_A = K\phi\omega$ $\qquad \tau_{ind} = K\phi I_A$

$P_{conv} = E_A I_A = \tau_{ind}\omega_m$ $\qquad I_F^* = I_F + \dfrac{N_{SE}}{N_F} I_A - \dfrac{\Im_{AR}}{N_F}$

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