UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
MAY 2012 SEMESTER

COURSE	:	**EBB2133 – ELECTRICAL MACHINES I**
DATE	:	**30TH AUGUST 2012 (THURSDAY)**
TIME	:	**9.00 AM – 12.00 NOON (3 hours)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions from the Question Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions.
5. Do not open this Question Booklet until instructed.

Note : There are **SEVEN (7)** pages in this Question Booklet including the cover page.

1. a. The magnetic fields are the fundamental mechanism by which energy is converted from one form to another in transformers, generators and motors. Four basic principles describe how magnetic fields are used in these devices. Construct the idea and briefly describe these four basic principles.

[8 marks]

b. A 10-kVA, 480/120-V conventional transformer is to be connected to form a step-up autotransformer. The series resistance and reactance of the conventional transformer are 1 % and 8 % on 10 kVA base and 480 V base at the high voltage side, respectively. A primary voltage of 480 V is applied to the transformer.

i. Construct the diagram of the step-up autotransformer and label all parameters.

[3 marks]

ii. Calculate the secondary voltage of the autotransformer.

[3 marks]

iii. Calculate the rating-advantage of this autotransformer connection over the transformer rating in conventional 480/120-V operation.

[3 marks]

iv. Analyze the data given of the transformer and calculate the autotransformer series impedance in per-unit.

[3 marks]

2. A 20-kVA, 8000/240-V 50-Hz transformer is tested to determine its equivalent circuit. The results of the tests are shown in **TABLE Q2**.

TABLE Q2

Open-circuit test	Short-circuit test
V_{OC} = 8000 V	V_{SC} = 489 V
I_{OC} = 0.214 A	I_{SC} = 2.5 A
P_{OC} = 400 W	P_{SC} = 240 W

All data are taken from the primary side of the transformer.

a. Construct the equivalent circuit of this transformer referred to the high voltage side of the transformer.

[8 marks]

b. Analyze the branch impedance and series impedance in **part (i)** to its per unit value.

[4 marks]

c. Analyze the voltage regulation of the transformer at rated conditions and 0.8 power factor lagging.

[4 marks]

d. Calculate the efficiency of the transformer at rated conditions and 0.7 power factor lagging.

[4 marks]

3. A 2300-V, 1000-kVA, 0.8 power factor lagging, 60-Hz, two-pole Y-connected synchronous generator has a synchronous reactance of 1.1 Ω and an armature resistance of 0.15 Ω. At 60 Hz, its friction and windage losses are 24 kW, and its core losses are 18 kW. The field circuit has a DC voltage of 200 V and the maximum I_F is 10 A. The resistance of the field circuit is adjustable over the range from 20 Ω to 200 Ω. The open circuit characteristic (OCC) of this generator is shown in **FIGURE Q3**.

a. Analyze from the above generator specifications and determine the field current requires to make V_T equal to 2300 V when the generator is running at no load.

[3 marks]

b. Analyze the condition in **part (a)** and determine the internal generated voltage of this machine at rated.

[7 marks]

c. Calculate the field current required to make V_T equal to 2300 V when the generator is running at rated conditions.

[5 marks]

d. Calculate the power and torque must the generator's prime mover be capable of supplying.

[5 marks]

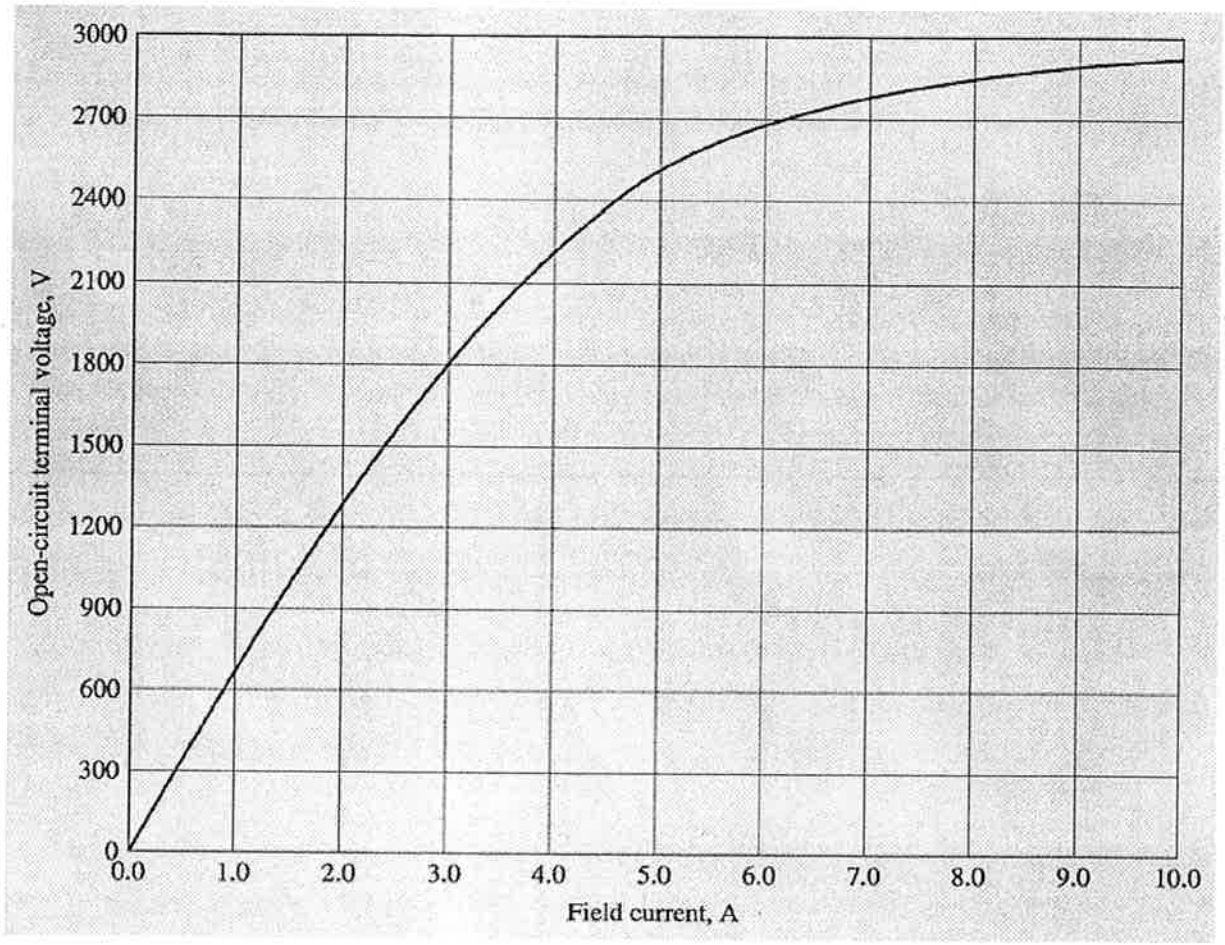
Open-circuit terminal voltage, V
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Field current, A

FIGURE Q3

4. a. Construct the equivalent circuit of an induction motor and outline the procedures to determine the value of rotor resistance, R_2, in the equivalent circuit.

[5 marks]

b. A 440-V, 50-Hz, two-pole, Y-connected squirrel cage induction motor is rated at 75 kW. The equivalent circuit parameters are

$R_1 = 0.075\ \Omega$ $R_2 = 0.065\ \Omega$

$X_M = 7.2\ \Omega$ $X_1 = X_2 = 0.17\ \Omega$

The friction and windage losses, stray losses and core losses are 1.0 kW, 150 W and 1.1 kW, respectively. The motor is running at the speed of 2800 rpm.

Analyze

i. the slip of the motor,

[3 marks]

ii. the line current,

[3 marks]

iii. the total losses in the motor, and

[6 marks]

iv. the overall efficiency.

[3 marks]

5. A DC generator has the following parameters:

Full load current	= 120 A
Rated speed	= 1500 rpm
Armature resistance	= 0.10 Ω
Shunt field resistance	= 110 Ω
Rated field current	= 1 A
Rated armature current	= 32 A
Core and mechanical losses	= 640 W

If the machine is to be operated as a self-excited DC generator and the terminal voltage is 240 V, analyze

a. the voltage drop and e.m.f. generated in the armature,

[4 marks]

b. the total losses in the generator assuming the brush losses and stray losses are negligible,

[4 marks]

c. the mechanical torque, and

[4 marks]

d. the efficiency of the generator.

[4 marks]

e. If the machine is operated as a separately-excited DC generator at 1500 rpm with rated field current, determine the terminal voltage at full load. It is also known that the open circuit voltage is 100 V. Neglect the effect of armature reaction.

[4 marks]

-END OF PAPER-