UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, SECOND SEMESTER MAY 2011

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	FUNDAMENTALS OF POWER ENGINEERING
COURSE CODE:	EE351
TIME ALLOWED:	THREE HOURS

Candidates' Examination Number ....

INSTRUCTIONS:

1. **Write your Examination number in the space provided above.**
2. **Answer all questions. Marks for different questions are indicated at the beginning of each question.**
3. **Write your answers in the space provided on the question paper. If you need more space to complete your answer you may use the space at the back of the question paper or you may use the examination Answer Book. In either case you must mention where using "continued at the back" or "continued in the Answer Book".**
4. **At the end of the Examination put the question paper inside your Answer Book and submit both.**
5. **Rough work may be done in the answer Book and crossed through.**

THIS PAPER SHOULD NOT BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

THIS PAPER CONTAINS SIXTEEN (16) PAGES

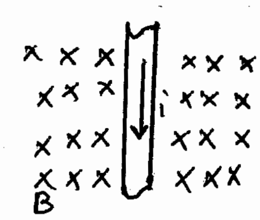
Question 1: Solve the following questions (30 marks):

1-The magnetic field intensity H is 110 AT/m, the core mean path length $l_c = 0.4$ m, what is current in the coil of N=200 turns?
i=

2- The magnetic core mean path length $l_c = 1.5$ m, the core cross section area A=0.2 m^2, the relative permeability of the core material $\mu_r = 2000$, and the relative permeability of the air $\mu_0 = 4\pi * 10^{-7}$. Calculate the reluctance R of the core.
R=

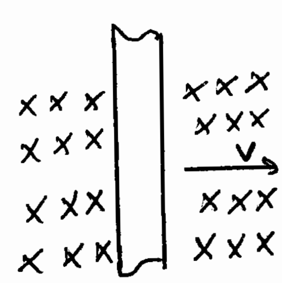
3- A magnetic core has reluctance R= 16000 At/Wb, and has 200 turns coil wrapped around the core. How much flux is produced when a 3 A current flows in the coil?
$\varphi =$

4- What is the magnitude and direction of induced force on a conductor of a length l= 3 m, carrying a current i=2.5 A from up to down and present in uniform magnetic field density B=0.8 T point to page?
$F =$



Direction of $F =$

5- What is the magnitude of induced voltage on a conductor moving with a velocity v=15 m/sec in uniform magnetic field density B=0.6T point to page, the wire length l=2 m?
$E_{ind} =$

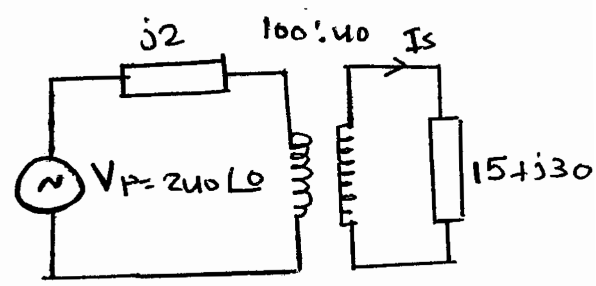


6-In 5 before, mention the direction of the induced voltage, magnetic field density and velocity according to the fingers of the right hand.
Index point to:

Middle point to:

Thump point to:

7- A single phase transformer, has the number of turns in primary N_p=100 turns, number of turn in secondary N_s=40 turns, the primary source voltage $V_p = 240\angle 0$ with source impedance = j2 ohm, and a load impedance in secondary= 15+j30 ohm. Calculate the transformer turns ratio, the primary and secondary currents, the load voltage and the complex, active and reactive power drawn at the load.
(Calculate: a, I_p, I_s, V_{load}, S_{load}, P_{load}, Q_{load})



8- In three phase connected transformer, each of the three transformers has number of turns in primary $N_p = 200$ and number of turns in secondary $N_s = 400$, what will be the ratio between the line to line voltage at the primary to the line to line voltage at the secondary in case of

a) $Y-Y$ **Connected transformer.**

$$\frac{V_{Lp}}{V_{LS}} =$$

b) $Y-\Delta$ **Connected transformer.**

$$\frac{V_{Lp}}{V_{LS}} =$$

c) $\Delta-Y$ **Connected transformer.**

$$\frac{V_{Lp}}{V_{LS}} =$$

9- Three phase $\Delta-Y$ **connected transformer bank steps up the generator voltage from 11 KV (line to line) to 220 KV (line to line). Calculate the primary phase voltage, the secondary phase voltage and the transformer turns ratio. (Calculate:** V_P, V_S, **a)**

10- List three methods that can be used to increase the voltage level in power systems when an under voltage is detected in the system.

11- Draw a simple transmission-distribution system showing an example of the voltage levels at generation, transmission and distribution. What are the advantages of stepping up the voltage in the transmission network?

12- What is the advantage and disadvantage of using delta connected windings in three phase transformers in power systems?

Question 2: In the following (17 marks):

In the following Δ-Δ connection between sources and loads if

$V_{aa'} = 200\angle 0^\circ \quad V$

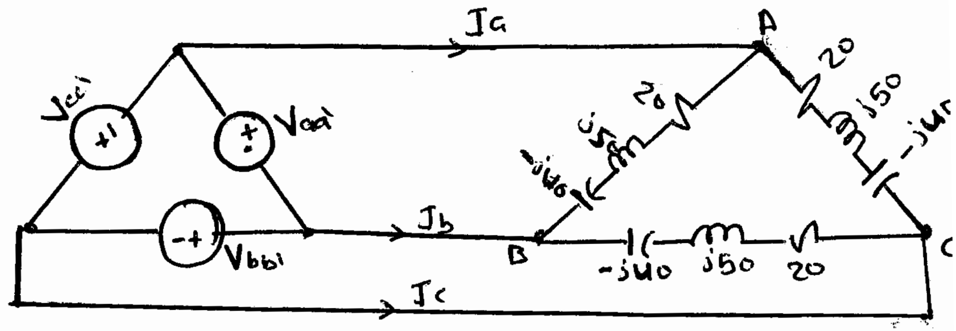
$V_{bb'} = 200\angle -120^\circ \quad V$

$V_{cc'} = 200\angle 120^\circ \quad V$

$Z_\Delta = 20 + j50 - j40 \quad \Omega$

Calculate:

1) The current in each load branch I_{AB}, I_{BC}, I_{CA}.



2) The line current I_a.

3) The total three phase complex, active and reactive power supplied to load. (Calculate: $S_{3\varphi}, P_{3\phi}, Q_{3\varphi}$)

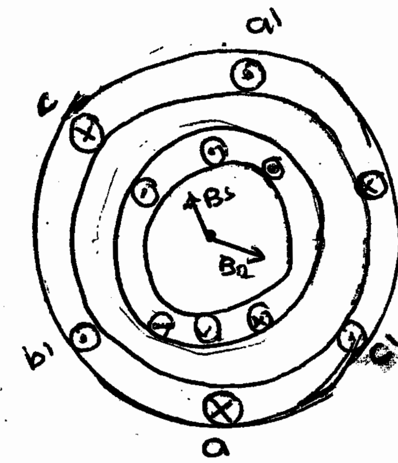
4) The active and reactive power absorbed in the resistor in branch AB. (Calculate: P_R, Q_R)

5) The active and reactive power absorbed/supplied in the inductor in branch AB. (Calculate: P_L , Q_L)

6) The active and reactive power absorbed/supplied in the capacitor in branch AB. (Calculate: P_C , Q_C)

Question 3 (16 marks):

1) Explain briefly the principle of operation of three phase induction motor.



2) What is the effect of increasing mechanical load torque on the induction motor?

3) Explain how you can control the induction motor speed.

Question 4 (37 marks):

A 480V (line to line voltage), 30 hp, 50 Hz, two poles, Y connected induction motor, has the following impedances in ohms per phase referred to stator circuit.

$R_1 = 0.8\Omega$

$R_2 = 0.5\Omega$

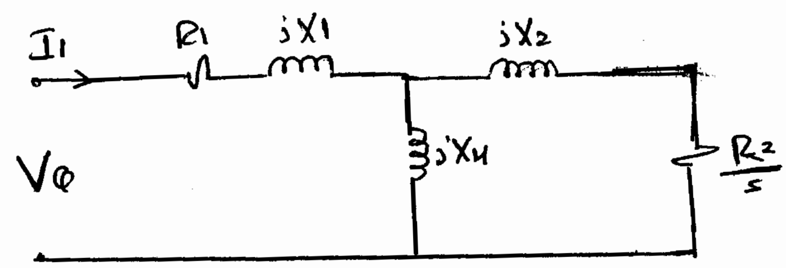
$X_1 = 1.2\Omega$

$X_2 = 0.6\Omega$

$X_M = 40\Omega$

$s = 0.04$

The total rotational losses are 1000W. The motor slip is .04 at rated voltage and rated frequency.



1) Calculate the synchronous speed in rpm (n_{sync}) and rad per sec (ω_{sync}).

2) Calculate the motor speed in rpm (n_m) and rad/sec (ω_m).

3) Calculate the rotor current frequency f_r.

4) Calculate the total impedance of the circuit Z_{tot}.

5) Calculate the stator phase voltage and current.

$V_{\varphi} =$

$I_1 =$

6) Calculate the motor power factor.

$P_f =$

7) Draw the power flow diagram.

12) Calculate the power converted from electrical to mechanical.

$P_{conv} =$

13) Calculate the motor output power.

$P_{out} =$

14) Calculate the induced torque.

$T_{ind} =$

15) Calculate the load torque.

$T_{load} =$

16) Calculate the motor efficiency ς.

$\varsigma =$

8) Calculate the motor input power.

$P_{in} =$

9) Calculate the motor stator copper losses.

$P_{scl} =$

10) Calculate the air gap power.

$P_{ag} =$

11) Calculate the rotor copper losses.

$P_{rcl} =$

17) Calculate the equivalent thevenin voltage as seen from two points where the rotor circuit connects.

$V_{th} =$

18) Calculate the equivalent thevenin resistance and thevenin reactance as seen from two points where the rotor circuit connects.

(Calculate: R_{th}, X_{th})

19) Calculate the rotor current referred to stator I_2.

20) Given the main equation for $s_{\max}$, calculate the slip at which the maximum torque occurs and the corresponding speed in rpm.

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

$$n_{\max} =$$

21) Given the main equation for $T_{\max}$, calculate the maximum induced torque.

$$T_{\max} = \frac{3V_{th}^2}{2\omega_{syn}\left[R_{th} + \sqrt{R_{th}^2 + (X_{th} + X_2)^2}\right]}$$

22) Given the main equation for T_{start}, calculate the starting induced torque.

$$T_{start} = \frac{3V_{th}^2 R_2}{\omega_{syn}\left[(R_{th} + R_2)^2 + (X_{th} + X_2)^2\right]}$$