Three Phase Machines

Time allowed – 90 minutes

14 Pages in this Question Booklet

Student Feedback **TOTAL MARKS AVAILABLE**

				SECTION	Possible Marks	Actual Marks
The results of my performance have been discussed and explained to me.				**A**	20	
Student:		**Date:**		**B**	20	
If you would like to request a review of your results or if you have any concerns about your results, contact your teacher or head teacher.				**C**	20	
				D	20	
Teacher:		**Date:**		**TOTAL**	80	

Instructions to Students:

Electronic devices are to be turned off and removed from your person.
You cannot access an electronic device during this examination.

1. All questions are to be answered in the space provided in this Question Booklet.
   Answers to Section A – Multi-choice Questions, are to be recorded on the Answer Sheet attached to this Question Booklet.
- You are not to use any reference book in this examination.
- The whole of this Question Booklet is to be handed to the Supervisor upon completion.
- No aids supplied by college

Aids permitted where indicated:

Standard Dictionaries	Bilingual Dictionaries	Technical Dictionaries	Programmable Calculators	Non-programmable Calculators	Mobile Phones	MP3 Players
No	**Yes**	**No**	**No**	**Yes**	**No**	**No**

SECTION A Multiple Choice (20 Marks)

In the following statements one of the suggested answers is the most correct. Place the letter corresponding to this answer in the space provided on the answer sheet.

1. As load on an induction motor increases, the power factor of the stator supply usually:

   A. remains unchanged
   B. increases the rotor power factor
   C. increases
   D. Decrease

2. The resistance of the insulation between windings and motor core should be:

   A. Greater than 1MΩ
   B. Less than 1MΩ
   C. Greater than 1Ω
   D. Less than 1Ω

3. The speed of a squirrel cage induction motor:

   A. decreases with load
   B. increases with load
   C. is constant irrespective of load
   D. is inversely proportional to the frequency of the supply

4. Slots on a stator or rotor of an induction motor may be skewed to:

   A. provide a smoother starting torque
   B. reduce starting current
   C. increase the speed
   D. increase the starting torque

5. Rotor currents in an induction motor operating at normal speed are:

   A. low frequency
   B. high frequency
   C. supply frequency
   D. stator frequency

6. Service & Installation rules NSW sets limitations on maximum starting currents for motors to prevent;

A. excessive demand during peak times
B. excessive strain on distribution transformers
C. fluctuations on supply voltages
D. non compliance with environmental & sustainability policy

7. A slip ring induction motor may often be used in preference to a squirrel cage induction motor because of its:

A. low maintenance factor
B. higher starting torque
C. higher running torque
D. greater simplicity

8. When resistance is added to the rotor circuit of a slip ring induction motor driving a constant load, the speed will:

A. remain the same and supply more torque
B. remain the same and draws more current
C. be reduced
D. be increased

9. Failure of one phase of a 3phase supply while a motor is running will cause it to;

A. run normally
B. over speed
C. overheat
D. increase the supply voltage

10. The setting on a thermal overload is adjusted to:

A. the full load current of the motor
B. 150% of the motor full load current
C. 200% of the motor full load current
D. anywhere within the adjustment range

11. The maximum efficiency of an induction motor usually occurs:

A. when the stator losses equal the rotor losses
B. at starting
C. at almost full load
D. when slip is 50%

12. The rotor field of a three phase induction motor is due to:

A. DC excitation
B. electromagnetic induction
C. rotor reactance
D. rotor resistance

13. The rotating magnetic field of an induction motor has:

A. constant speed but strength decreases with more load
B. a speed loss and a loss in strength with increased load
C. constant strength and speed
D. constant strength but speed decreases with greater load

14. If the setting on a thermal overload is set to the maximum possible adjustment, the overload will:

A. operate correctly
B. not provide effective protection
C. only protect on low currents
D. protect for short circuits as well

15. The frequency of the rotor currents in an induction motor:

A. Increases when the speed increases
B. Decreases when the slip increases
C. Increases when the slip increases
D. Decreases when the load increases

16. If a three phase 415 volt 50 hertz induction motor is connected to a 415 volt 100 hertz supply the:

A. speed of the rotating magnetic field will double
B. speed of the rotating magnetic field will not be affected
C. speed of the rotating magnetic field will be halved
D. synchronous speed will be less than the actual speed

17. The stator core is constructed from silicon sheet steel to reduce:

A. any magnetic locking
B. friction losses
C. hysteresis losses
D. eddy currents

18. What feature does a differential thermal overload relay have over a conventional type:

A. incorporates a time delay
B. senses unbalanced currents in each phase
C. operates magnetically
D. operates on single and three phase

19. The maximum torque produced by an induction motor occurs when the:

A. rotor resistance is greater than rotor reactance
B. rotor reactance is maximum
C. rotor resistance is minimum
D. rotor reactance equals rotor resistance

20. The most suitable test instrument used to measure the insulation between the "U" winding and the "W" winding of a three phase motor with all connections removed would be:

A. an insulation resistance tester set to 1000 volts
B. an insulation resistance tester set to 500 volts
C. a digital multimeter set on MΩ
D. an analogue multimeter set on ohms

SECTION B – Short Answer (20 Marks)

1. What is the minimum number of phases required to produce a rotating magnetic field in the stator of a three phase induction motor?

2. Name the **2** factors that govern the speed of rotation of the rotating magnetic field produced by a three phase induction motor.

3. Name two types of overload protection relays?

4. Name a thermistors coefficient when used to give thermal protection, and where is it placed

5. Name the **2** fields that interact to provide torque.

6. What are the **2** major components of a three phase induction motor?

7. Name the **2** metals commonly used for the rotor bars of squirrel cage rotors.

8. Name two types of ‘reduced voltage starters’ which can be used to limit the motors starting current.

9. How can the direction of a three phase motor be reversed?

10. What advantage does a double cage rotor have compared to a single cage rotor?

Section C- Drawings & Diagrams (20 Marks)

1. Inspect the graph in figure 1 and determine

   a. Approximately at what percentage does the motor reach maximum torque?
   _____(2 Marks)

   b. Does the graph show a variable or constant torque machine?
   _____(1 Mark)

   c. What type of squirrel cage motor does the graph represent?
   _____(2 Marks)

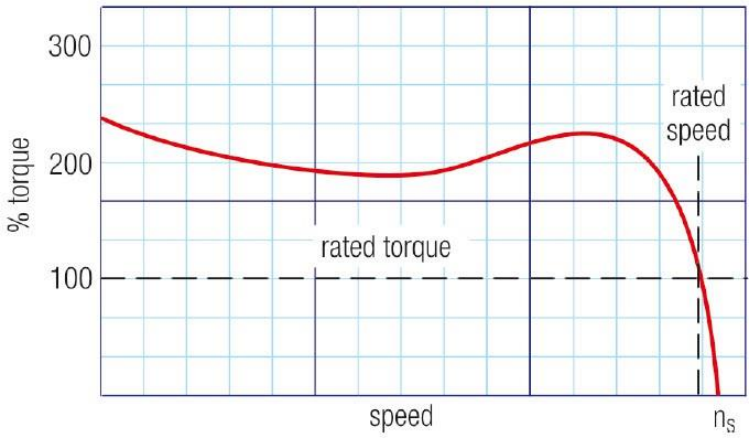


Figure 1

2. Inspect the graph in figure 2 and determine

   a. Explain why the torque is remaining constant at each stage? (3Marks)
   _____
   _____
   _____

   b. What type of motor does the graph represent? (2 Marks)
   _____

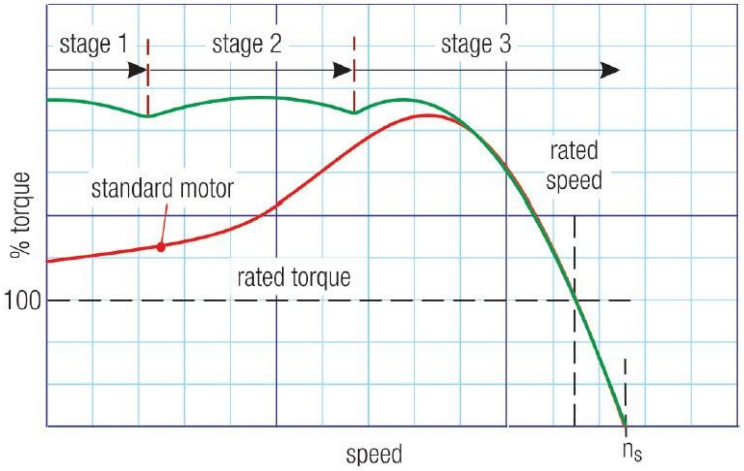
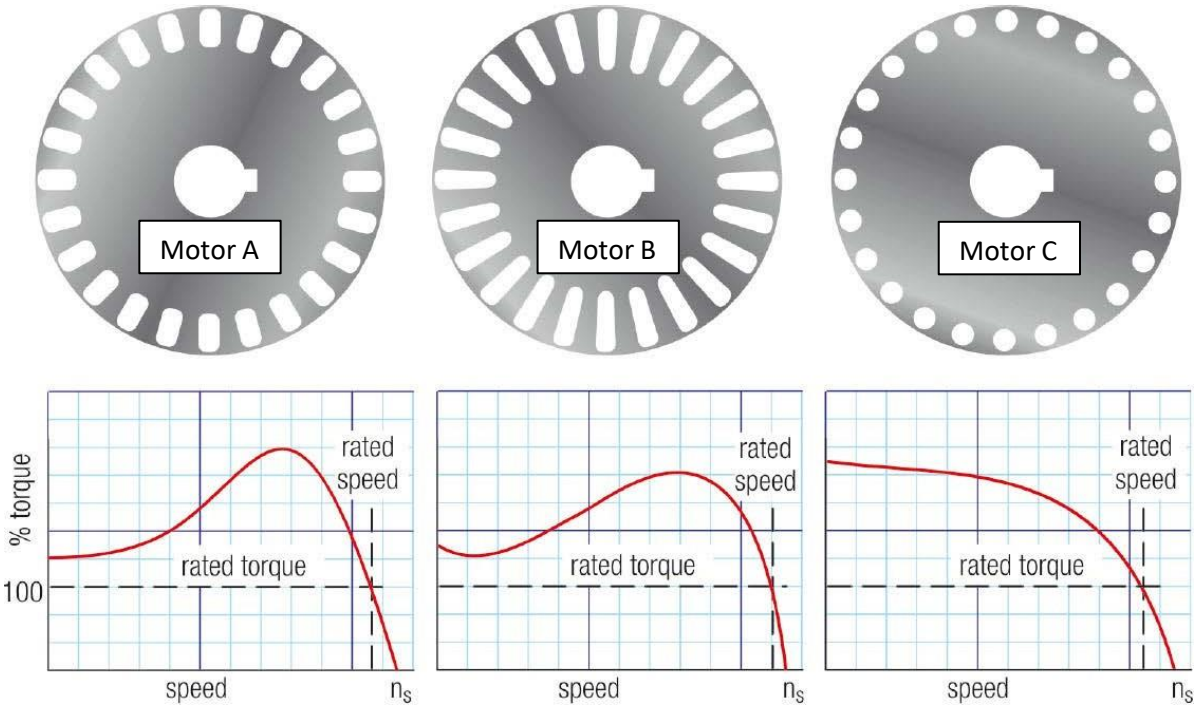


Figure 2

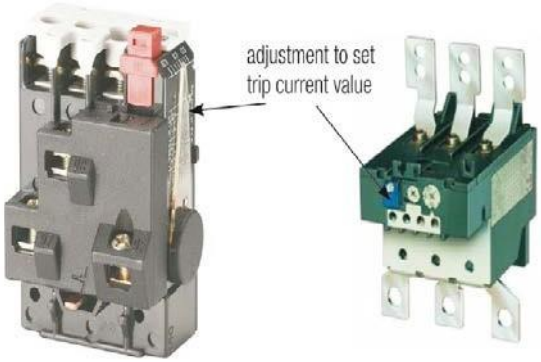
3. Inspect the figure 3 below and match the design characteristics with the appropriate description.



a. Which motor has the highest inductive reactance _____(2)
b. Which motor has the highest resistance _____ (2)
c. Which motor has both low reactance and resistance _____ (2)

4. Name the following components

a. _____(2 Marks)



b. _____

_____(2 Mark)

SECTION D – Calculations. (20 Marks)

All working must be shown as marks are allocated for correct working.

1. Calculate the number of poles required if the synchronous speed of a 50Hz induction motor is 1500rpm.

Answer: _____ (3 Marks)

2. If an eight pole, 50 Hz induction motor has a full load slip of 6%, what is the full load rotor speed?

Answer: _____ (4 Marks)

3. An induction motor has a synchronous speed of 1500rpm and a rotor speed of 1440rpm, calculate the %slip.

Answer: _____ (3 Marks)

4. If a 50 Hz induction motor operates with a slip % of 5%, calculate the frequency of the rotor current.

Answer: _____ (3 Marks)

5. Three phase induction motor on full voltage develops a starting torque at 210Nm Determine the torque developed if the supply voltage is 70% of the rated value.

(3 marks)

6. A 50Hz, induction motor is operating at 1460 rpm driving a compressor. If the driving torque is 45Nm determine:

(a) Output power

(b) Efficiency if the input power is 8kW.

(4 marks)

Note: The symbols used on this sheet follow AS1046 pt 1. There are alternate recognised symbols in use. The list does not contain every equation used in the course. Transposition of equations will be necessary to solve problems

$$Q = It \qquad v = \frac{s}{t} \qquad a = \frac{\Delta v}{t}$$

$$F = ma \qquad W = Fs \qquad W = mgh$$

$$W = Pt \qquad \eta\% = \frac{output}{input} \times \frac{100}{1} \qquad I = \frac{V}{R}$$

$$P = VI \qquad P = I^2R \qquad P = \frac{V^2}{R}$$

$$R_2 = \frac{R_1 A_1 l_2}{A_2 l_1} \qquad R_h = R_c(1 + \alpha \Delta t) \qquad R = \frac{\rho l}{A}$$

$$R_T = R_1 + R_2 + R_3 \qquad V_T = V_1 + V_2 + V_3 \qquad \frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$I_T = I_1 + I_2 + I_3 \qquad V_2 = V_T \frac{R_2}{R_1 + R_2} \qquad I_2 = I_T \frac{R_1}{R_1 + R_2}$$

$$R_x = \frac{R_A R}{R_B} \qquad C = \frac{Q}{V} \qquad \tau = RC$$

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \qquad C_T = C_1 + C_2 + C_3 \qquad C = \frac{A \varepsilon_o \varepsilon_r}{d}$$

$$F_m = IN \qquad H = \frac{F_m}{l} \qquad B = \frac{\Phi}{A}$$

$$\Phi = \frac{F_m}{S} \qquad S = \frac{l}{\mu_o \mu_r A} \qquad V = N \frac{\Delta \Phi}{\Delta t}$$

$$e = Blv \qquad L = \frac{\mu_o \mu_r A N^2}{l} \qquad L = N \frac{\Delta \Phi}{\Delta I}$$

$$V = L \frac{\Delta I}{\Delta t} \qquad \tau = \frac{L}{R} \qquad F = Bil$$

$$T = Fr \qquad E_g = \frac{\Phi Z n P}{60a} \qquad P = \frac{2\pi n T}{60}$$

$$t = \frac{1}{f} \qquad f = \frac{np}{120} \qquad V = 0.707 V_{\max}$$

$$I = 0.707 I_{\max} \qquad V_{ave} = 0.637 V_{\max} \qquad I_{ave} = 0.637 I_{\max}$$

$$v = V_{\max} \sin \phi \qquad i = I_{\max} \sin \phi \qquad I = \frac{V}{Z}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \qquad X_L = 2\pi f L \qquad X_C = \frac{1}{2\pi f C}$$

$$\cos\phi = \frac{P}{S} \qquad \cos\phi = \frac{R}{Z} \qquad S = \sqrt{P^2 + Q^2}$$

$$S = VI \qquad P = VI\cos\phi \qquad Q = VI\sin\phi$$

$$f_o = \frac{1}{2\pi\sqrt{LC}} \qquad V_L = \sqrt{3}V_P \qquad I_L = \sqrt{3}I_P$$

$$S = \sqrt{3}V_L I_L \qquad P = \sqrt{3}V_L I_L \cos\phi \qquad Q = \sqrt{3}V_L I_L \sin\phi$$

$$\tan\phi = \sqrt{3}\left(\frac{W_2 - W_1}{W_2 + W_1}\right) \qquad Q = mC\Delta t$$

$$V' = 4.44\Phi f N \qquad \frac{V_1}{V_2} = \frac{N_1}{N_2} \qquad \frac{I_2}{I_1} = \frac{N_1}{N_2}$$

$$N_{syn} = \frac{120f}{p} \qquad s\% = \frac{(n_{syn} - n)}{n_{syn}} \times \frac{100}{1} \qquad f_r = \frac{s\% \times f}{100}$$

$$V_{reg}\% = \frac{(V_{NL} - V_{FL})}{V_{FL}} \times \frac{100}{1} \qquad V_{reg}\% = \frac{(V_{NL} - V_{FL})}{V_{NL}} \times \frac{100}{1} \qquad T = \frac{\Phi ZIP}{2\pi a}$$

$$I_{ST} = \frac{1}{3} \times I_{DOL} \qquad T_{ST} = \frac{1}{3} \times T_{DOL} \qquad I_{ST} = \frac{V_{ST}}{V} \times I_{DOL}$$

$$T_{ST} = \left(\frac{V_{ST}}{V}\right)^2 \times T_{DOL} \qquad I_{motor\,st} = \frac{\%TAP}{100} \times I_{DOL} \qquad I_{line\,st} = \left(\frac{\%TAP}{100}\right)^2 \times I_{DOL}$$

$$E = \frac{\Phi_v}{A} \qquad E = \frac{I}{d^2} \qquad \eta_v = \frac{\Phi_v}{P}$$

$$V_L = 0.45V_{ac} \qquad V_L = 0.9V_{ac} \qquad V_L = 1.17V_{phase}$$

$$V_L = 1.35V_{line} \qquad PRV = \sqrt{2}V_{ac} \qquad PRV = 2\sqrt{2}V_{ac}$$

$$PRV = 2.45V_{ac} \qquad V_{ripple} = \sqrt{2}V_{ac} \qquad V_{ripple} = 0.707V_{phase}$$

$$V_{ripple} = 0.1895V_{line}$$

Student Name:_____

Class : _____

Date : _____

ANSWER SHEET

Section A (Multi-choice Questions)

Instructions:

Enter your personal details in the top right hand corner of this sheet.

Place an **X** in box of your choice. If you make a mistake, circle your answer ⊗ and choose again.

Question	A.	B.	C.	D.
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
Totals				

Question	A.	B.	C.	D.
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
Totals				