FIJI NATIONAL UNIVERSITY

COLLEGE: COLLEGE OF ENGINEERING, SCIENCE & TECHNOLOGY (CEST)

SCHOOL: SCHOOL OF ELECTRICAL & ELECTRONICS ENGINEERING

PROGRAMME: CERTIFICATE IV IN ELECTRICAL ENGINEERING-STAGE 4

UNIT CODE: EEE447

TITLE: ELECTRICAL MACHINES 1

FINAL EXAMINATION – PENSTER 2, 2015

DAY/DATE: THURSDAY/21/05/2015 ROOM: AS PER TIMETABLE
TIME: 9:00 – 11:10 AM

INSTRUCTIONS TO STUDENTS

1. You are allowed 10 minutes extra reading time during which you are NOT to write.
2. Begin each SECTION on a fresh page and use both sides of the sheet.
3. Write your candidate number at the top of each attached sheet.
4. Insert all written foolscaps, graph paper, drawing paper, etc. in their correct sequence and secure with a string.
5. For all sheets of paper on which rough/draft work has been done, cross it through and ATTACH these to your answer scripts.
6. Write clearly the number(s) of the question(s) attempted on the top of each sheet.
7. Use of programmable calculator(s) is prohibited.
8. **ANSWER ALL QUESTIONS**
9. Show all working where necessary.72
10. **ALWAYS CHECK YOUR WORK BEFORE YOU LEAVE THE EXAM ROOM**.

QUESTION 1 DC MACHINES (25 MARKS)

1.1.1 Motors and generators generally operate on the same principle where magnetism and current effects take place. In aid of labeled diagram explain how the rotating torque is produced in an electrical motor. (8 marks)

1.2 Briefly explain the functions of the following parts including the material the part is made up of in reference to a motor:

(a) Brushes (2 marks)
(b) Yoke (2 marks)
(c) Armature (2 marks)

1.3 A dc shunt-connected 20kW generator has 4 poles and lap wound armature rotates at 450 RPM in useful maximum flux of 20miliWebers per pole. Also it has 400 armature conductors with effective resistance (Ra) of 0.18 Ω and the shunt field (R_{sh}) has a resistance of 100 Ω. Calculate the:

(a) generated voltage.
(b) full load current
(b) field current.
© total armature current

(8 marks)

1.4 Draw a circuit diagram showing the method of reversing the rotation of a dc shunt motor.

(3 marks)

QUESTION 2 THREE PHASE INDUCTION MOTORS (25 MARKS)

2.1 Outline four (4) advantages of three phase induction motors over counterparts.

(4 marks)

2.2 What does the rotor construction of an induction motor consists of?

(3 marks)

2.3 Creating a rotating magnetic field is an outmost necessity in motors. Explain with the aid of supply phase voltage waveforms how the rotating magnetic field in three phase motor is produced in one complete cycle.

(9 marks).

2.4 Induction motors are available in many different body enclosures, depending on the task allotted to them. List any three different types of enclosures used in the above motors.

(3 marks)

2.5 A four pole induction motor running at 1420 rpm when connected to a 50 Hz supply. Determine the:

a) synchronous speed
b) slip speed
c) frequency of rotor induce voltage

(6 marks)

QUESTION 3 SINGLE PHASE INDUCTION MOTORS (25 MARKS)

3.1 Compare the load characteristics of a single phase motor with a three phase motor.

(4 marks)

3.2 Draw the circuit connections and label your diagram of the following single phase motors:

a) Capacitor start motor (4 marks)

b) capacitor start, capacitor run motor (4 marks)

c) series motor (3 marks)

3.3 List down the two functions of the run capacitor in a capacitor start-capacitor run motor.

(4 marks)

3.4 Explain the two methods of reversing the rotation of shaded pole motors.

(3 marks)

3.5 Outline the essential three differences between the two sets of stator windings (start and run) in a single phase, split phase motor.

(3 marks)

QUESTION 4 MOTOR STARTERS & SOFT STARTER (25MARKS)

4.1 Outline the four(4) factors to be considered when selecting motor starters.
(4 marks)

4.2 List four (4) applications for star – delta starters.
(4 marks)

4.3 What are four(4) major characteristics of autotransformer starters?
(4 marks)

4.4 Draw a single line diagram of a forward and reverse starter for three phase induction motor.
(11 marks)

4.5 Name two typical soft start applications.
(2 marks)

%%%%%%%%%%%%%% END OF PAPER %%%%%%%%%%%%%%

MARKING SCHEME/SOLUTION GUIDE

College:.....**CEST**.....

School/Department:**SEEE**...

Programme:**SCHOOL OF ELECTRICAL & ELECTRONICS ENG.**

Unit Code/Title:**EEE447- ELECTRICAL MACHINES**

Date of Exam:2**1th,MAY,2015**

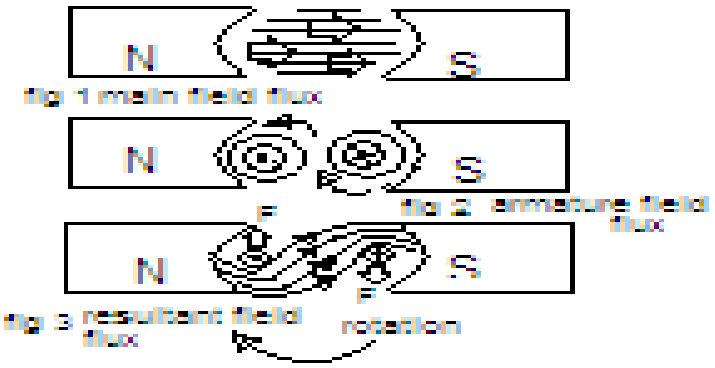
Time: **9:00 AM – 11:10 AM**

Examiner's Name: **MORITIKEI RAVULALA**

Signature:……

QUESTION 1 DC MACHINES (25 MARKS)

1.1 The production of rotating torque



(4 marks)

The main field flux is evenly spaced and straight lines of magnetic force established between the opposite magnetic poles as shown in fig 1 and the arrowheads are in the direction of magnetic force.

In fig 2 shows the concentric magnetic lines of force established with two surrounding arrows that for the directions when the two conductors of a single loop coil carrying current. Also at the centre position of opposite poles the conductor's cross section marked dot and cross that represent an arrow head and tail that for the direction of current flow.

The interaction of both magnetic field fluxes as shown in fig 3 causes deflection and strengthening of resultant flux on lower side and weakening of flux on the other lower side of two sides of a single loop coil.

So when deflection resultant flux tend to straighten up due to elastic property causes the armature conductor a rotational torque as shown in fig 3 (4 marks)

1.2 a) Brushes – Sliding electrical contacts used to provide a connection between the armature and the external circuit. It is made of either carbon or graphite (2 marks)

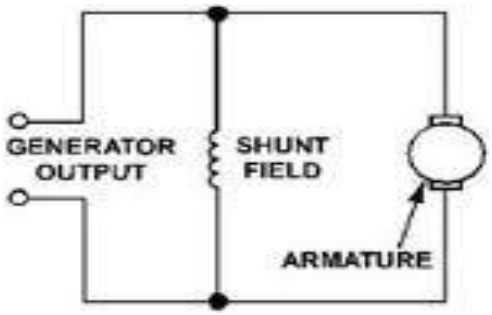
b) Field frame or yoke – it carries the field poles and also provides a magnetic path between them. It is made of rolled mild steel (2 marks)

c) Armature – it has pole teeth and slots which embedded with coil side conductors. It is made up of laminations of iron core, mounted on shaft and rotates in magnetic field

d) End shields – the purpose of end shields is to support the bearing in which the armature rotates it also has provision for mounting the brush gear. (2 marks)

c) Bearings – Enables the rotor to rotate in the magnetic field by supporting the shaft. (2 marks)

1.3



Vt

Ra = 0.18 Ω
Vt = ?
Rsh = 100 Ω

Eg = $2\phi ZNP / 60c$ = $2x20x10^{-3}$x 400 x450x 2 / 60 x 4 = 6**0V** (2 marks)
Let Eg = V at no load

IFL = P/V 20000/60 = 33**3.3Amps** (2 Mark)

Ish = 60/100 = 0**.6 Amps** (1 Mark)

Total Armature Current It = I FL + Ish

= 333.3 + 0.6

= **333.9 Amps** (1 Mark)

1.4

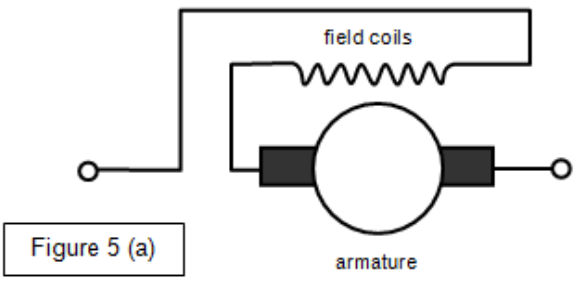


Figure 5 (a)

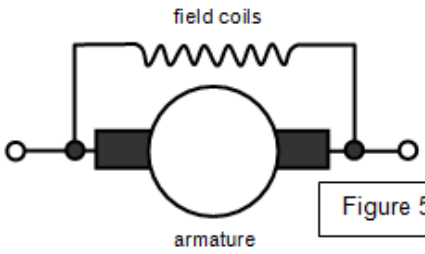


Figure 5 (b)

(3 marks)

QUESTION 2 THREE PHASE INDUCTION MOTORS (25 MARKS)

2.1 Three phase induction motors are ;

i) very simple
ii) efficient
iii) rugged
iv) have a high degree of reliability.

(4 marks)

2.2 The rotor of an induction motor consists of:

i) a shaft with bearings
ii) a laminated iron core
iii) rotor conductors
iv) short circuit end rings (3 marks)

2.3

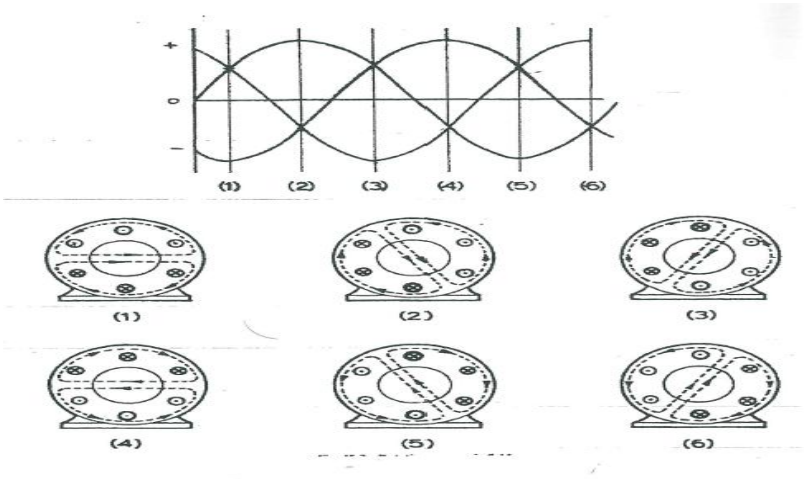


Figure 2: Rotating magnetic field

(5 marks)

The results of this rotating magnetic field on the stator windings that for voltage points 0 to 6 as shown in fig 2 marked along the horizontal axis (0^0 to 360^0) graph of the three sinusoidal voltage waveforms.

At point 0 to 1 voltage in single loop coil of phase A is zero with polarities as shown. At the same time the voltage in single loop coil of phase C is maximum and in the positive polarity also the voltage in single loop of coil phase B is negative with polarity shown. Also the resultant magnetic field flux direction along horizontal axis as shown.

At point1 to 2 voltages in single loop coil of phase A is positive same as phase C with polarities as shown. At the same time the voltage with single loop coil of phase B is maximum and is negative polarity. Also the resultant magnetic field flux direction has rotated 60^0 angle clockwise away from horizontal axis.

As each next 4 voltage points analysis it can be seen that the resultant magnetic field flux has rotated at an angle of 60^0 clockwise direction.

When the three voltages completes one full cycle (point 0 to 6) the resultant magnetic field flux has rotated 360^0around the stator inner periphery.

(4 marks).

2.4 Types of enclosures used.

a) Open
b) Totally enclosed
c) Duct or force-ventillated
d) Flameproof
e) Weatherproof
f) Submersible
g) Explosion proof

(3 marks)

(Any 3 carries one mark each)

2.5 Determine the slip four pole induction motor running at 1420 rpm when connected to a 50 Hz supply.

(a) $N_{syn} = \frac{120f}{P}$

$= \frac{120 \times 50}{4}$

$= \frac{6000}{4}$

$= \mathbf{\underline{1500\ rev/min}}$ (2 marks)

(b) Slip Speed = Nsyn - Rotor Speed

= 1500 - 1420

= **80 rev/min** (2 marks)

(c) Rotor frequency = $\frac{(1500 - 1420)}{1500} \times 50$

= **2 .7Hz** (2 marks)

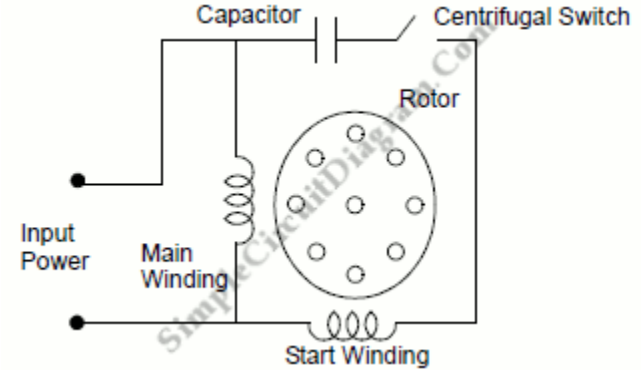
QUESTION 3 SINGLE PHASE INDUCTION MOTORS (25 MARKS)

3.1 The single phase motor:

i) Has a characteristic vibration at twice the supply frequency
ii) Is noisier than a three phase motor
iii) Has a rather high no-load current at low power factor
iv) Has a power factor that improves with the addition of load.
v) Requires special starting techniques
vi) Has several versions based on the method of starting
(one mark each).

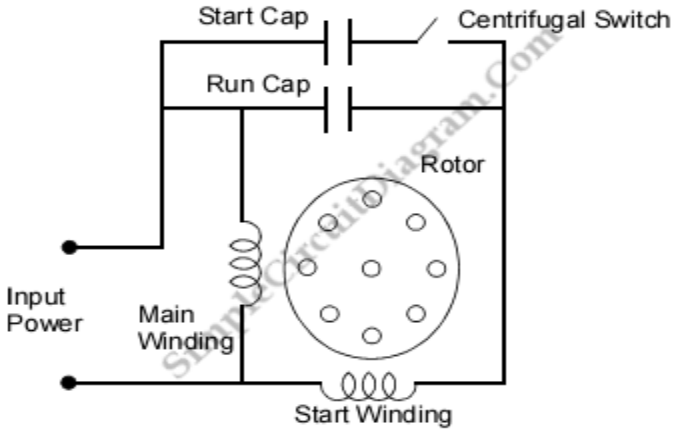
(4 marks)

3.2 a) **capacitor start motor**



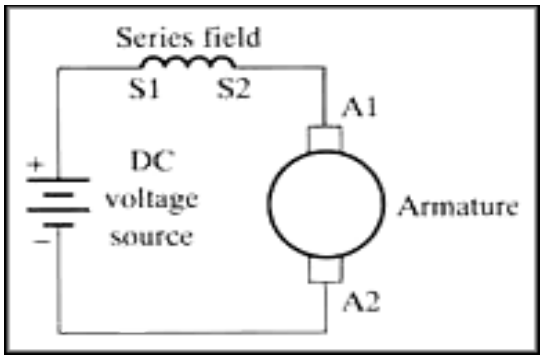
(4 marks)

b) **capacitor start, capacitor run motor**



(4 marks)

c) **series motor**



(3 marks)

3.3 The run capacitor :

i) Increases the breakdown torque
ii) Improves full load efficiency and power factor
iii) Reduces operational noise
iv) Increases locked rotor torque.
.

(4 marks)

3.4 To reverse the direction of rotation requires either changing the shading ring from one side to the other or swapping the placement of the stator in the frame.
or rotor inserted in stator in the opposite end

(3 marks)

3.5

Start winding	Run Winding
-Smaller gauge wire -Placed at the top of the slot -Around 25% less turn than run winding -has higher resistance and Lower reactance than run winding	-Heavy gauge wire -placed at the bottom of the stator slot -has lower resistance and higher reactance than the start winding

(3 marks)

QUESTION 4 MOTOR STARTERS & SOFT STARTER (25MARKS)

4.1 Factors to be considered when selecting motor starters:

- protection of the motor against overloads and over heating
- isolation of the motor in the eventy of faults
- provision of interlocking the motors operation with that of other motors and machines
- motor reversal
- speed control
- motor braking

(4 marks)

4.2 Applications for star – delta starters.

- Centrifugal pumps
- Farm dam pumps
- Lathes with a clutch
- Large fans and blowers

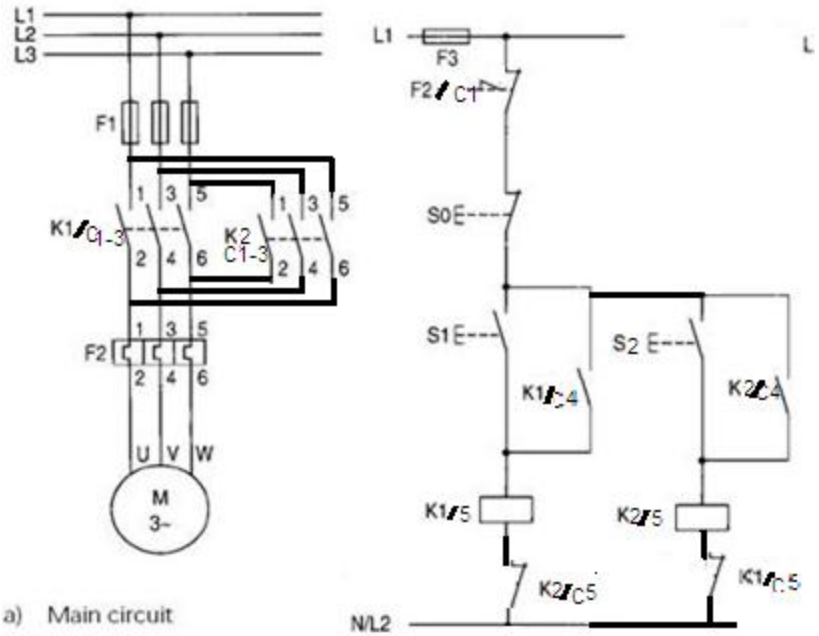
(4 marks)

4.3 Major characteristics of autotransformer starters:

- Low line current
- Low line power
- Low power factor
- Open circuit transition periods
- Acceleration in a series of steps,notcontinous

(4 marks)

4.4 Draw a single line schematic diagram of a Forward and Reverse starter with label correct components labels



(11 marks)

4.5 Typical soft start applications:

- Centrifugal fans
- Printing presses
- Crop driers, forge blowers, irrigation pumps, manure agitators
  High rated motors from 10 to 75HP

(2 marks)

%%%%%%%%%END OF MARKING SCHEME%%%%%%%%%%