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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

**T490(E)(N13)T
NOVEMBER EXAMINATION
NATIONAL CERTIFICATE
ELECTRICAL TRADE THEORY N3**

(11041263)

**13 November 2014 (Y-Paper)
13:00–16:00**

This question paper consists of 9 pages and 1 formula sheet.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA
NATIONAL CERTIFICATE
ELECTRICAL TRADE THEORY N3
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
 2. Read ALL the questions carefully.
 3. Number the answers correctly according to the numbering system used in this question paper.
 4. Where applicable, answers MUST be in accordance with the SABS (SANS) Code of Practice SANS 10142-1:2003 for the Wiring of Premises.
 5. Sketches MUST be neatly labelled and large enough to show the required detail.
 6. Answers MUST be given to TWO decimal places.
 7. Write neatly and legibly.
-

QUESTION 1: DOMESTIC APPLIANCES

1.1 Study the sketch of an oven thermostat in FIGURE 1.

Identify the labelled parts and write only the name of each part next to the question number (1.1.1–1.1.5) in the ANSWER BOOK.

Do NOT redraw the sketch.

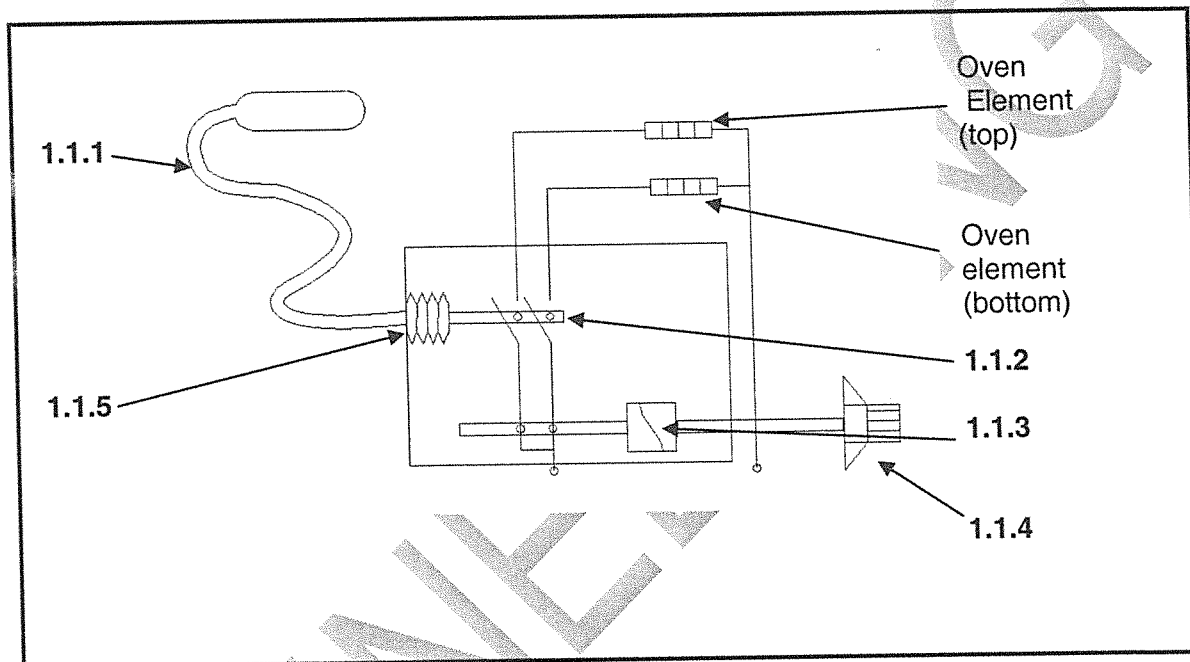


FIGURE 1

1.2 Explain the operation of the oven thermostat as shown in QUESTION 1.1.

(5)

(5)
[10]

QUESTION 2: PROTECTION

2.1 State whether the following household appliances/components need 'to BE earthed' or 'NOT earthed':

2.1.1 Metal light fittings for fluorescent tubes that are 2,4 m or above the floor.

2.1.2 The metal taps that are connected by PVC water pipes to the water supply.

2.1.3 Metal conduits used for house wiring.

(3 × 1) (3)

2.2 Name TWO methods of checking if the earth-leakage relay is operating correctly.

(2)

2.3 State the approximate value of the fault current that should activate the earth leakage.

(1)

2.4 Describe the operation of a thermal-magnetic miniature circuit breaker under the following headings:

2.4.1 Overload protection

2.4.2 Short circuit protection

(2 × 2)

(4)

[10]

QUESTION 3: ILLUMINATION

3.1 State TWO advantages of sodium-vapour discharge lamps.

(2)

3.2 State ONE disadvantage of sodium-vapour discharge lamps.

(1)

3.3 Explain how the glow starter in a fluorescent lamp circuit starts the lamp.

(2)

3.4 Study the circuit below in **FIGURE 2.1**. Label the parts numbered (a) – (e) in your answer script.

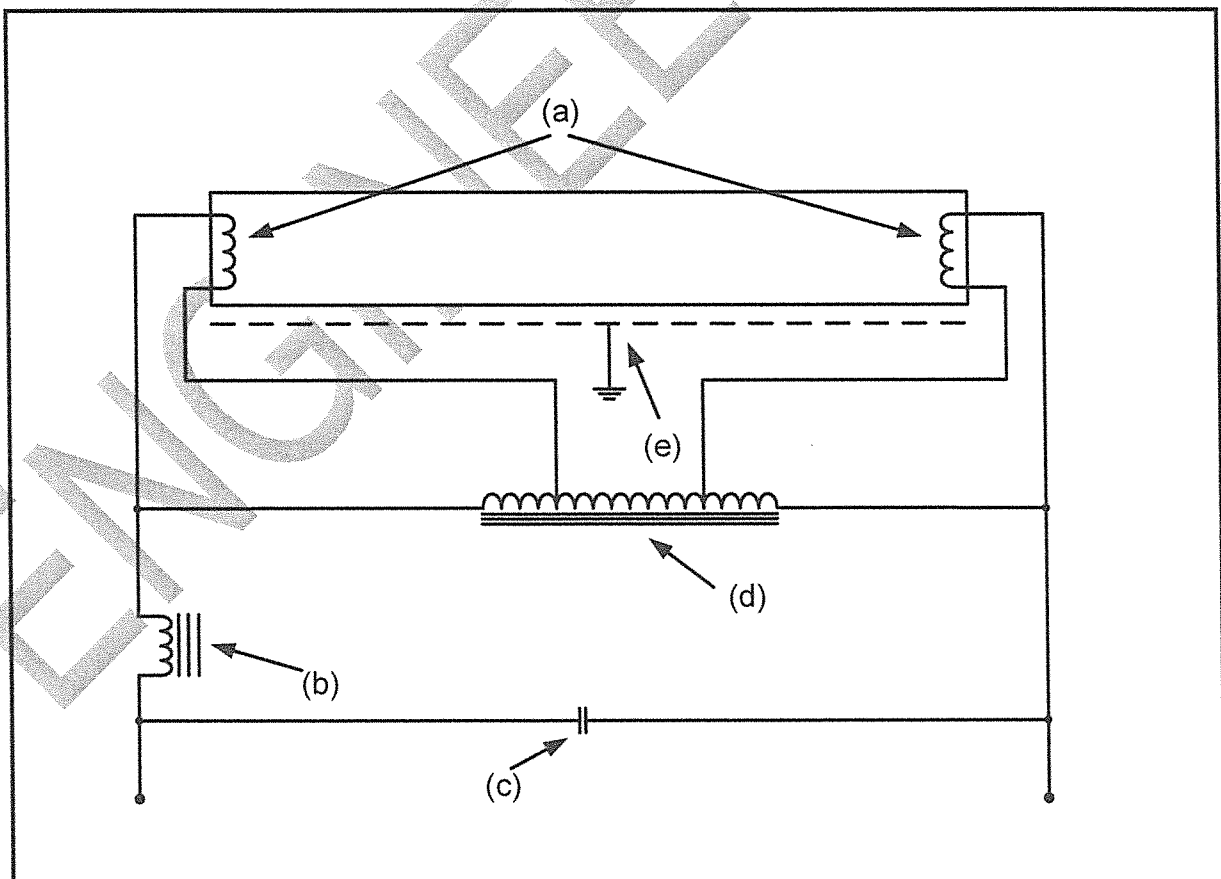


FIGURE 2.1: LIGHT FITTING

(5)

[10]

QUESTION 4: ALTERNATING CURRENT THEORY

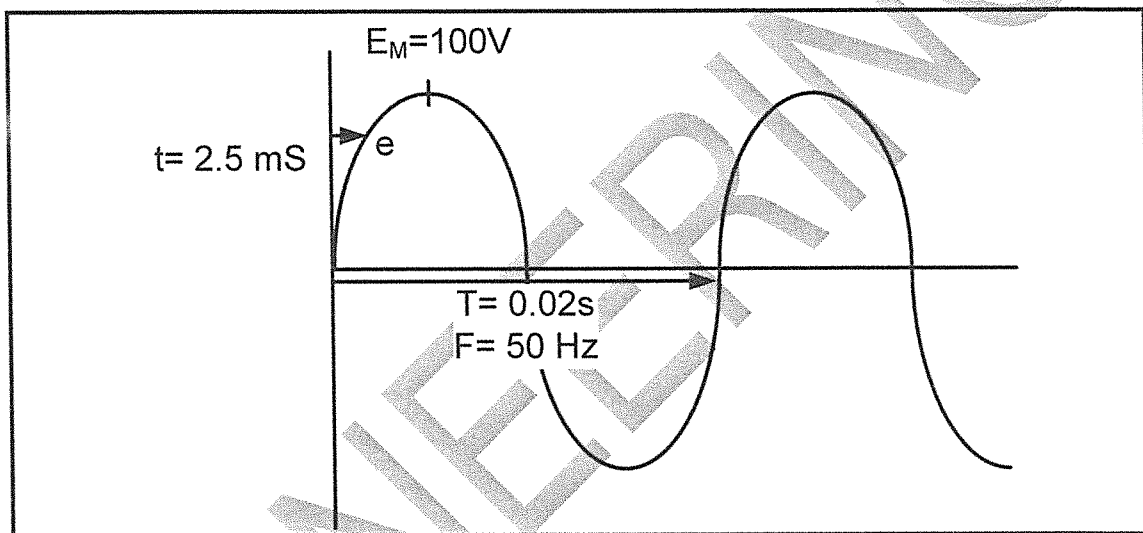
4.1 Draw a sine wave on which you indicate the following:

- 4.1.1 The RMS Value
- 4.1.2 Amplitude
- 4.1.3 Peak to Peak Value
- 4.1.4 1 Cycle

(4 x 1) (4)

4.2 With reference to **FIGURE 4.1** calculate the instantaneous value of e at 2.5 mS.

(3)

**FIGURE 4.1: SINE WAVE**

4.3 Calculate the RMS value of a sine wave with the following equation:

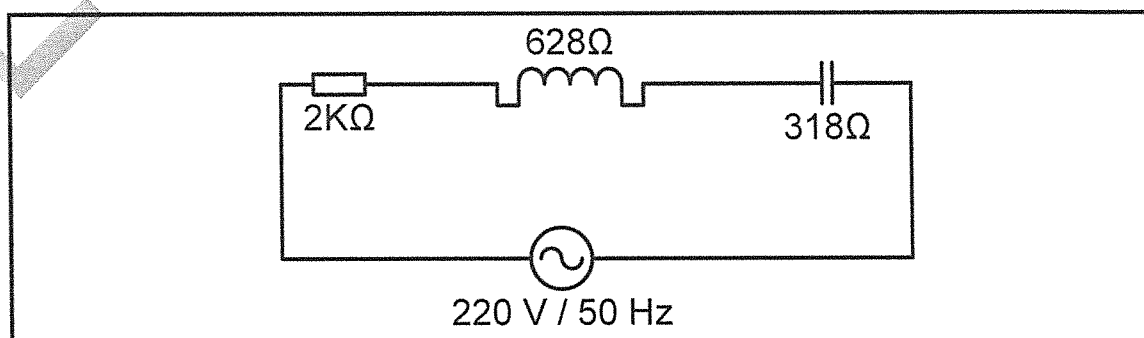
$$e = 285 \sin 2\pi ft$$

(3)

[10]

QUESTION 5: SERIES RLC CIRCUITS

5.1 Study the circuit in **FIGURE 5.1** and answer the following questions.

**FIGURE 5.1: SERIES RLC CIRCUIT**

5.1.1 Calculate the impedance of the circuit

(3)

5.1.2 Calculate the total current in the circuit

(3)

- 5.2 Draw the phasor diagram of the circuit in **Figure 5.1** showing I_R , I_{X_L} , I_{X_C} and I_Z . The drawing need not be to scale.

(4)
[10]

QUESTION 6: THREE-PHASE AC-SYSTEMS

- 6.1 **FIGURE 6.1** shows a 3-phase system. Calculate the line voltage if the voltage across ONE phase and neutral is 220 V.

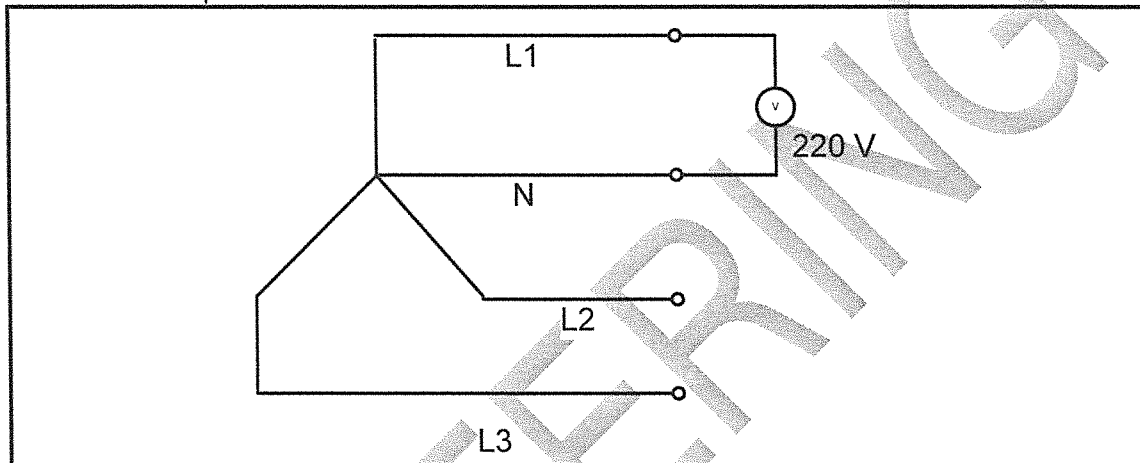


FIGURE 6.1: 3-PHASE AC SYSTEM

(3)

- 6.2 A 3-phase motor rated at 25kW draws a full-load current of 42,2 A from a 380 V supply at a power factor of 0,8. Calculate the:

- 6.2.1 Output Power of the motor (3)
- 6.2.2 Efficiency of the motor. (3)
- 6.2.3 State ONE type of loss that would explain why the output of a motor is lower than the power supplied to it (1)

[10]

QUESTION 7: TRANSFORMERS

FIGURE 7.1 shows a three Phase Transformer. The circuit is connected to a 3-phase 380 V supply at contact points A, B and C. Also, a current of 2 kA, at a power factor of 0,8 is drawn from the supply when the transformers are connected to a balanced 3-phase load at points 1, 2, 3 and 4.

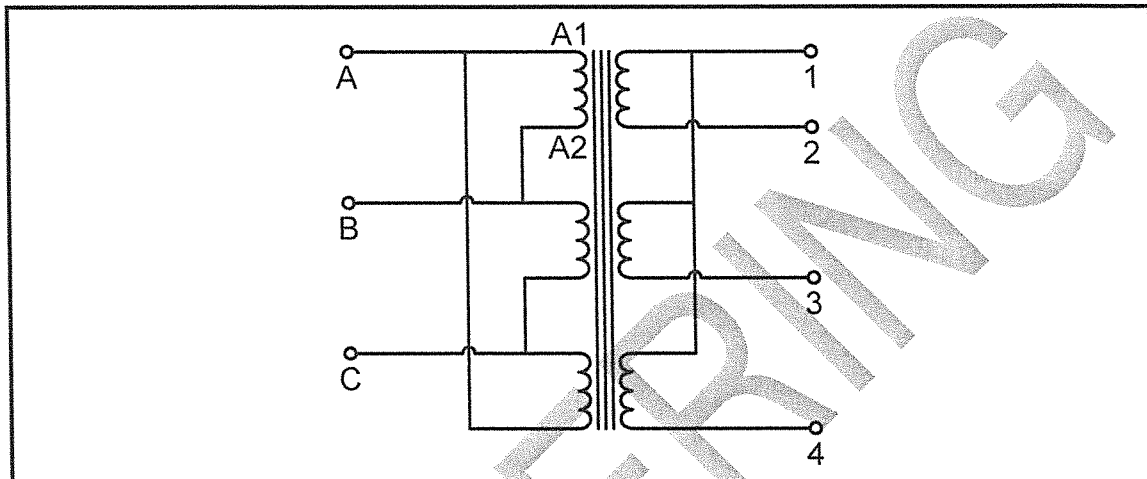


FIGURE 7.1: THREE PHASE TRANSFORMER

- 7.1 Identify the configuration of the PRIMARY windings (1)
- 7.2 Identify the configuration of the secondary windings (1)
- 7.3 Determine the voltage between A1 and A2 (1)
- 7.4 Calculate the output voltage at between 2 and 3 if the transformer has a turns ratio of 1 : 10. (3)
- 7.5 Calculate the total power consumed. (3)
- 7.6 Identify the Neutral point on the secondary winding of the transformer (1)

[10]

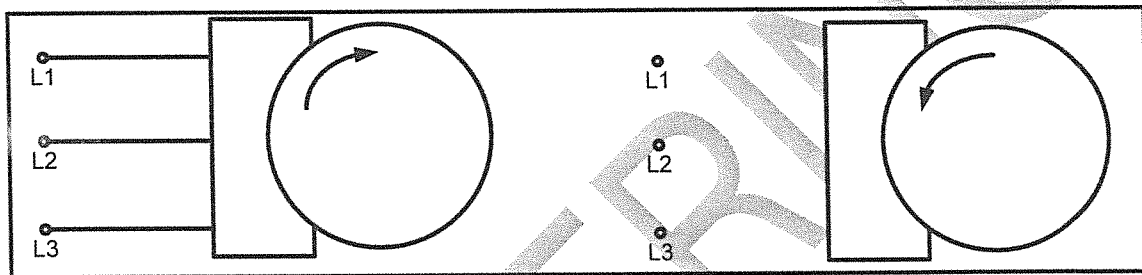
QUESTION 8: DC MACHINES

- 8.1 With reference to DC motors, explain the term "armature reaction" (2)
- 8.2
 - 8.2.1 Draw a graph of the load characteristics of a cumulatively compounded DC motor as compared to a shunt motor to show how speed changes as the load increases. Label all aspects of the graph. (4)
 - 8.2.2 With reference to its torque characteristics, explain what happens to a series motor if the speed increases. (1)
- 8.3 Briefly explain, during starting, how you would couple a very large DC motor so that it is NOT damaged by overcurrent. (3)

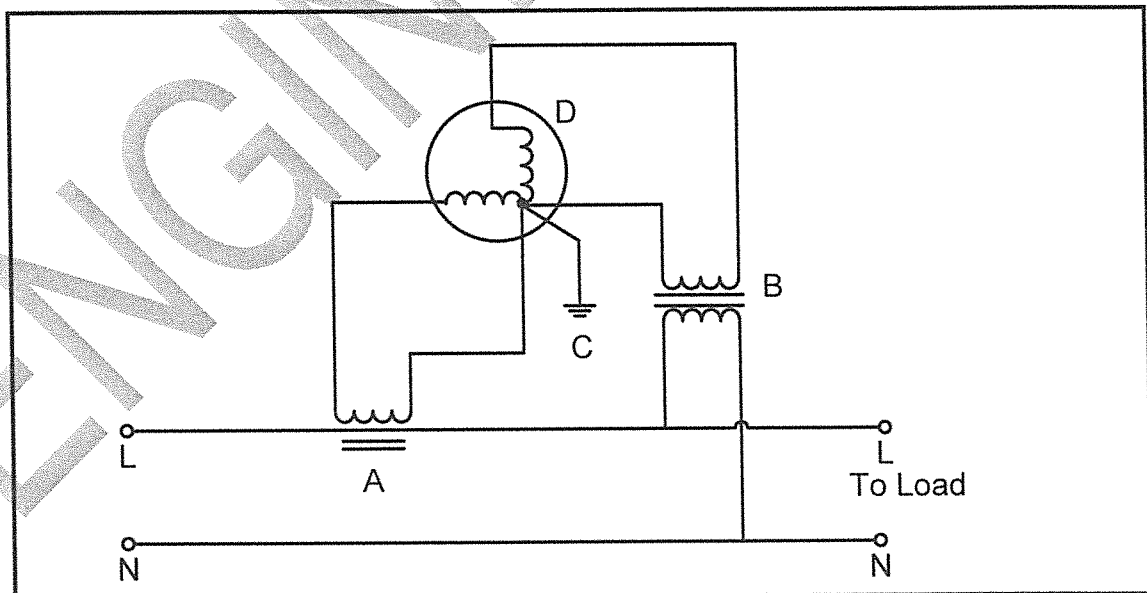
[10]

QUESTION 9: AC MACHINES

- 9.1 Calculate the speed of a four pole induction motor that is connected to 380 V/50 Hz (3)
- 9.2 Draw a neat, fully labelled circuit diagram of a single phase resistance-start split-phase motor. (5)
- 9.3 With reference to FIGRE 9.1, show how the direction of rotation of a 3-Phase motor will be changed. Redraw the figure in your ANSWER BOOK and indicate the changes made. (2)

**FIGURE 9.1: DIRECTION OF ROTATION****(2)**
[10]**QUESTION 10: MEASURING INSTRUMENTS AND ELECTRONICS**

- 10.1 Study the circuit in FIGURE 10.1 and answer the following questions.

**FIGURE 10.1: POWER MEASUREMENT**

- 10.1.1 Identify the Parts A, B, C and D (4)
- 10.1.2 State the purpose of parts A and B (1)

10.2 In FIGURE 10.2 below, study the sketch of the circuit and answer the questions that follow.

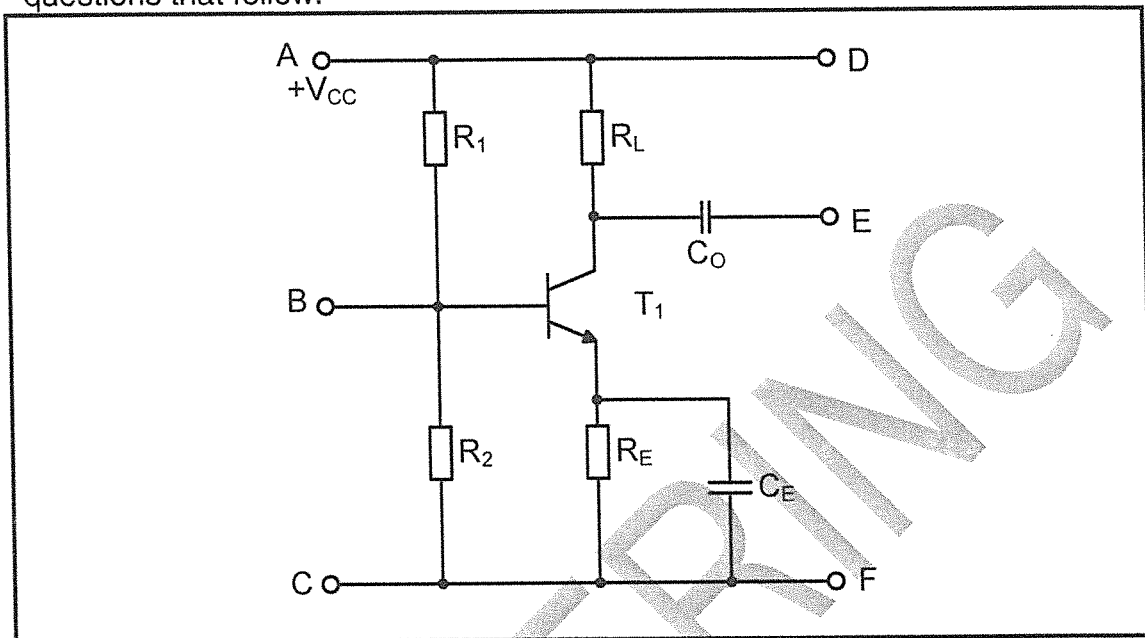


FIGURE 10.2: AMPLIFIER

- 10.2.1 Identify the type of transistor being used
- 10.2.2 State in which configuration is the transistor coupled
- 10.2.3 Identify the point where the input signal should be connected
- 10.2.4 Identify the point where the amplified signal appears
- 10.2.5 In order for this circuit to operate it needs a D.C-source. Identify the point where the negative of the battery should be coupled.

(5)
(5 × 1) [10]

TOTAL: 100

FORMULA SHEET

$$I_T = \frac{V}{Z}$$

$$I_{\text{ACTIVE}} = I_T \cos \phi$$

$$I_{\text{REACTIVE}} = I_T \sin \phi$$

$$X_L = 2\pi f L$$

$$X_C = \frac{1}{2\pi f C}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\phi = \cos^{-1} \left(\frac{R}{Z} \right)$$

$$V_R = I_T R$$

$$V_{XL} = I_T X_L$$

$$V_{XC} = I_T X_C$$

$$V = \sqrt{V_R^2 + (V_{XL} - V_{XC})^2}$$

$$P = I^2 R$$

$$S = VI$$

3-phase

$$P = \sqrt{3} V_L I_L \cos \phi$$

$$S = \sqrt{3} V_L I_L$$

DELTA

$$V_L = V_{PH/F}$$

$$I_L = \sqrt{3} I_{PH/F}$$

STAR

$$V_L = \sqrt{3} V_{PH/F}$$

$$I_L = I_{PH/F}$$

$$\frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{I_s}{I_p}$$

$$\omega = 2\pi f$$

$$N = \frac{f \cdot 60}{p}$$

$$s = \frac{n - n_r}{n}$$

The next five formulae are true for voltage.

$$i = I_m \sin(\omega t)$$

$$I_{\text{rms}} = 0,707 I_m$$

$$I_{\text{ave}} = 0,637 I_m$$

$$I_{\text{rms}} = \sqrt{\frac{i_1^2 + i_2^2 + \dots + i_n^2}{n}}$$

$$I_{\text{ave}} = \frac{i_1 + i_2 + \dots + i_n}{n}$$

$$\text{Form factor} = \frac{\text{RMS value}}{\text{AVE value}}$$

$$\text{Crest factor} = \frac{\text{MAX value}}{\text{RMS value}}$$

SERIES

$$R_T = R_1 + R_2 + \dots + R_n$$

PARALLEL

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}$$



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MARKING GUIDELINE

**NATIONAL CERTIFICATE
NOVEMBER EXAMINATION
ELECTRICAL TRADE THEORY N3**

13 NOVEMBER 2014

This marking guideline consists of 8 pages.

INSTRUCTIONS AND INFORMATION

NOTE: There is not only one answer or one method (approach) of answering the questions. This memorandum gives only one answer or one possible method (approach). Examiners are advised to analyse the student's solution in order to determine if the question has been answered and they must not adhere so strictly to the solutions in this memorandum as to disadvantage the candidate.

QUESTION 1: DOMESTIC APPLIANCES

- | | | | |
|-----|-------|----------------------------|-----|
| 1.1 | 1.1.1 | Gas filled capillary tube✓ | |
| | 1.1.2 | Micro-switch✓ | |
| | 1.1.3 | Temperature adjusting cam✓ | |
| | 1.1.4 | Control (adjust) knob✓ | |
| | 1.1.5 | Expansion bellows✓ | (5) |
-
- | | | | |
|-----|---|--|-----------------------------------|
| 1.2 | <ul style="list-style-type: none"> • When oven cold, bellows contracted and micro-switches closed. ✓ • Current flows in upper and lower heating element. ✓ • Gas in tube expands with temperature. • Cam adjusts contacts so that a larger movement is required to open them.✓ • When desired temperature reached, both contacts opened by bellow movement. ✓ • As oven cools, the bottom element's switch closes and keeps oven at temperature.✓ | | (Any 5 × 1)
(5)
[10] |
|-----|---|--|-----------------------------------|

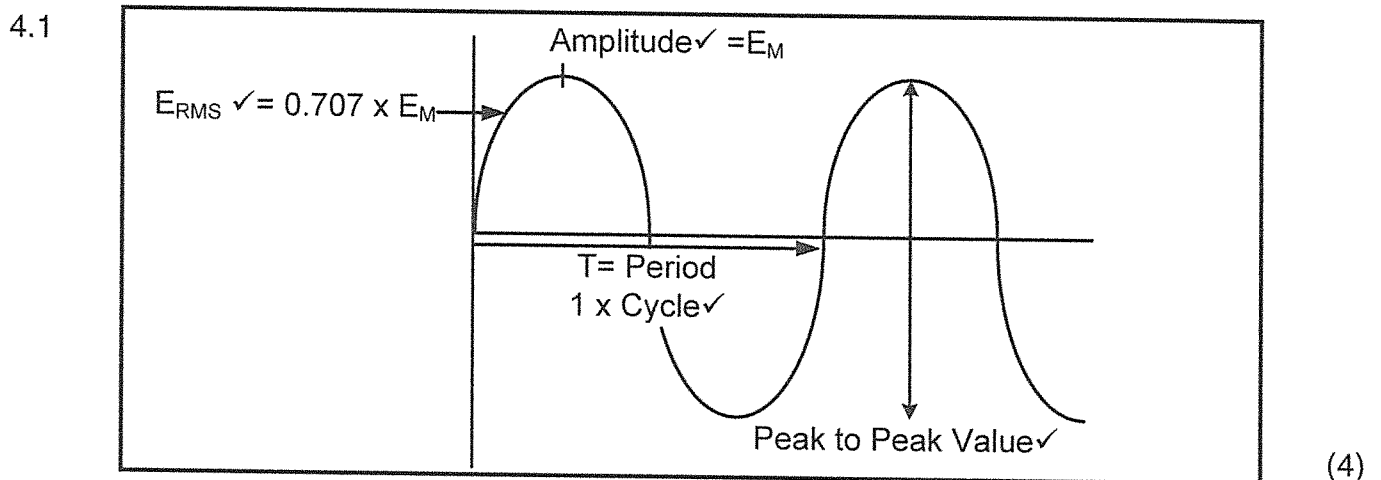
QUESTION 2: PROTECTION

- | | | | |
|-----|-------|------------------------|----------------|
| 2.1 | 2.1.1 | Need to be earthed. ✓ | |
| | 2.1.2 | Need not be earthed. ✓ | |
| | 2.1.3 | Need to be earthed. ✓ | (3 × 1)
(3) |
-
- | | | | |
|-----|---|--|-----|
| 2.2 | <ul style="list-style-type: none"> • Use the test button on the relay.✓ • Connect a tester at an outlet between earth and live that draws no more than 20 mA. ✓ | | (2) |
|-----|---|--|-----|
-
- | | | |
|-----|----------------------|-----|
| 2.3 | Above 15 to 20 mA. ✓ | (1) |
|-----|----------------------|-----|

- 2.4 2.4.1 When the current exceeds the rated value, the current will heat the bi-metal to a high enough temperature ✓ to activate the thermal mechanism that opens the contacts. ✓ (2)
- 2.4.2 When the current is very large, ✓ the magnetic flux around the coil causes the circuit to trip before the bi-metal bends, thus relying on magnetism for fast reaction. ✓ (2)
(Any 2 × 1) [10]

QUESTION 3: ILLUMINATION

- 3.1
- Efficiency is high. ✓
 - Does not need to be cool before restarting. ✓ (2)
- 3.2 Light is yellow. ✓ (1)
- 3.3 The glow starter heats up and thus opens. ✓ This causes the field around the choke to collapse and a voltage surge occurs across the tube. ✓ (2)
- 3.4
- (a) Filaments ✓
 - (b) Choke ✓
 - (c) Capacitor ✓
 - (d) Autotransformer
 - (e) Earthed Enclosure ✓ (5)
- [10]

QUESTION 4: ALTERNATING CURRENT THEORY

- 4.2
- $$e = 100 \sin(2\pi ft)$$
- $$e = 100 \sin(314.159 \times 0.0025) \checkmark$$
- $$e = 100 \sin(0.785 \text{ rad}) \checkmark$$
- $$e = 100 \times 0.706$$
- $$e = 70.6 \text{ Volt} \checkmark$$
- (3)

$$4.3 \quad V_{RMS} = V_M \times 0.707 \checkmark$$

$$V_{RMS} = 285 \times 0.707 \checkmark$$

$$V_{RMS} = 201.495 \text{ Volt} \checkmark$$

(3)
[10]**QUESTION 5: SERIES RLC CIRCUITS**

$$5.1 \quad 5.1.1 \quad Z = \sqrt{R^2 + (X_L - X_C)^2} \checkmark$$

$$Z = \sqrt{2000^2 + (628 - 318)^2} \checkmark$$

$$Z = \sqrt{4000000 + 96100} \checkmark$$

$$Z = 2023.882 \Omega \checkmark$$

(3)

$$5.1.2 \quad I = \frac{V}{Z} \checkmark$$

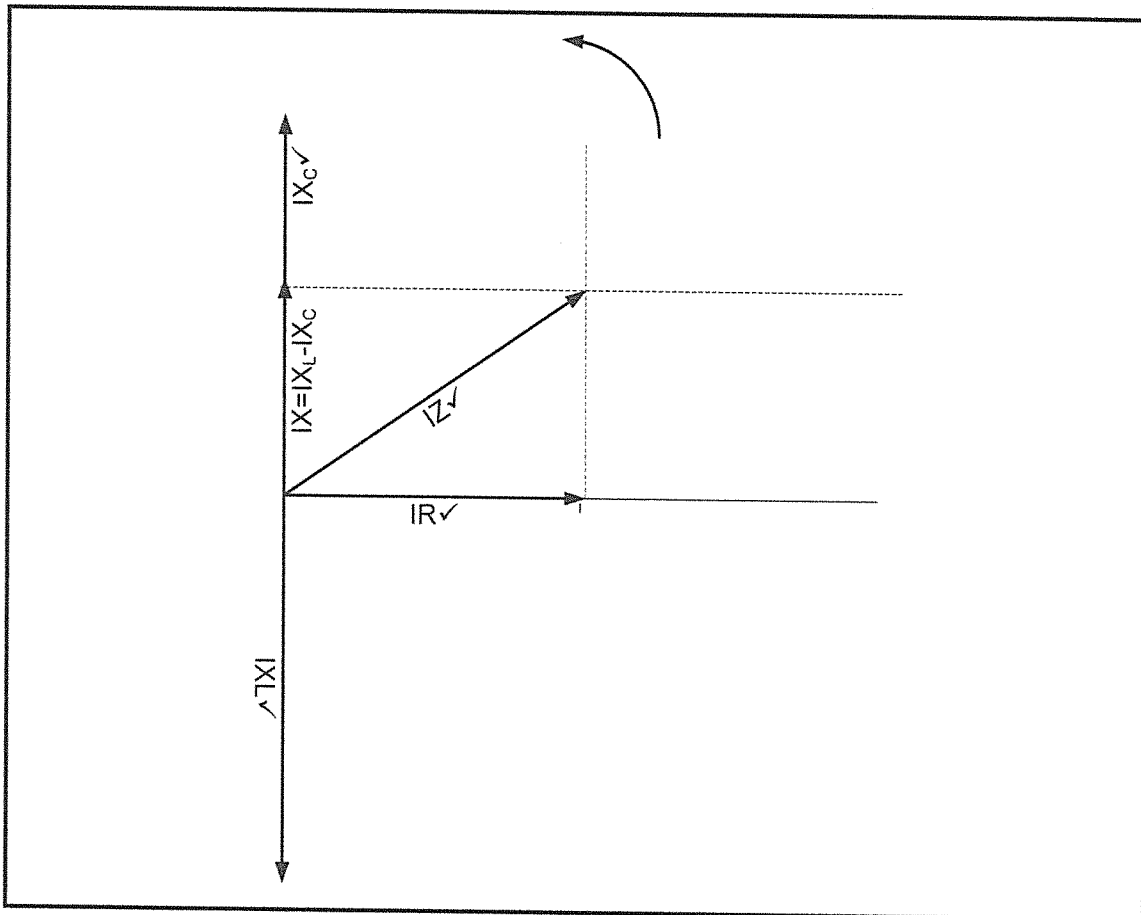
$$I = \frac{220}{2023.882} \checkmark$$

$$I = 0.108 \text{ A} \checkmark$$

$$I = 108 \text{ mA}$$

(3)

5.2

(4)
[10]

QUESTION 6: THREE-PHASE AC SYSTEMS

- 6.1 $V_L = \sqrt{3} \times V_{ph} \checkmark$
 $V_L = \sqrt{3} \times 220 \checkmark$
 $V_L = 381 \text{ V} \checkmark$ (3)
- 6.2 6.2.1 $P_{OUT} = \sqrt{3} V_L I_L \cos \Phi \checkmark$
 $P_{OUT} = \sqrt{3} \cdot 380 \cdot 42,2 \cdot 0,8 \checkmark$
 $P_{OUT} = 22,22 \text{ kW} \checkmark$ (3)
- 6.2.2 $\eta = \frac{P_{OUT}}{P_{IN}} \times 100\% \checkmark$
 $\eta = \frac{22\,200}{25\,000} \times 100\% \checkmark$
 $\eta = 0,88 \times 100\%$
 $\eta = 88\% \text{ efficient} \checkmark$ (3)
- 6.2.3 Mechanical Losses $\checkmark$
Phase Angle
Copper and Iron Losses
 I^2R Losses (1)
- [10]

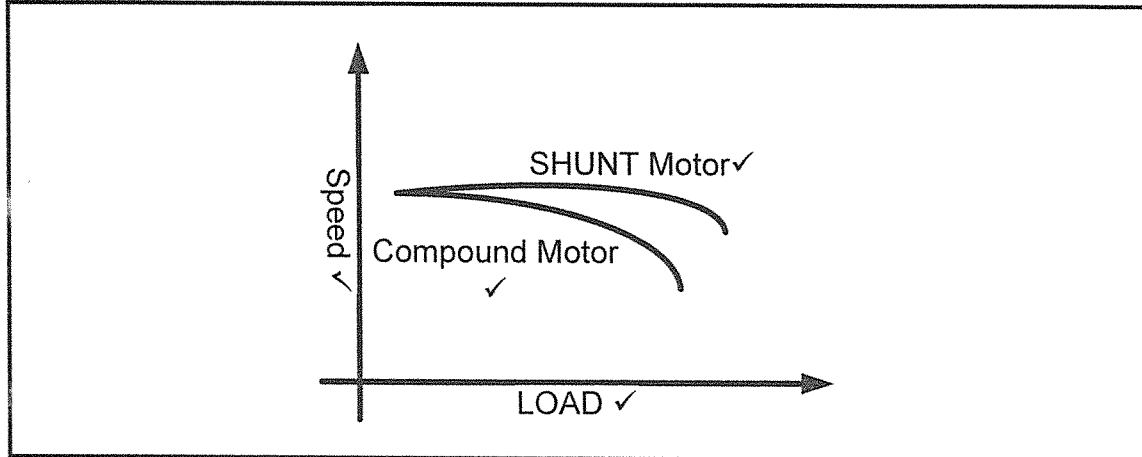
QUESTION 7: TRANSFORMERS

- 7.1 Delta $\checkmark$ (1)
- 7.2 Star $\checkmark$ (1)
- 7.3 $V_{P \text{ phase}} = V_{P L}$
 $= 380 \text{ V} \checkmark$ (1)
- 7.4 Turns ratio: $\frac{N_1}{N_2} = \frac{V_1}{V_2} \checkmark$
 $\frac{1}{10} = \frac{380}{V_2} \checkmark$
Turns ratio: $V_2 = 380 \times 10$
Turns ratio: $V_2 = 3800 \text{ Volt} \checkmark$ (3)
- 7.5 $P = \sqrt{3} V_L I_L \cos \phi \checkmark$
 $P = \sqrt{3} \times 380 \times 2000 \times 0,8 \checkmark$
 $P = 1053 \text{ Watt} \checkmark$ (3)
- 7.6 4 = Neutral $\checkmark$ (1)
- [10]

QUESTION 8: DC MACHINES

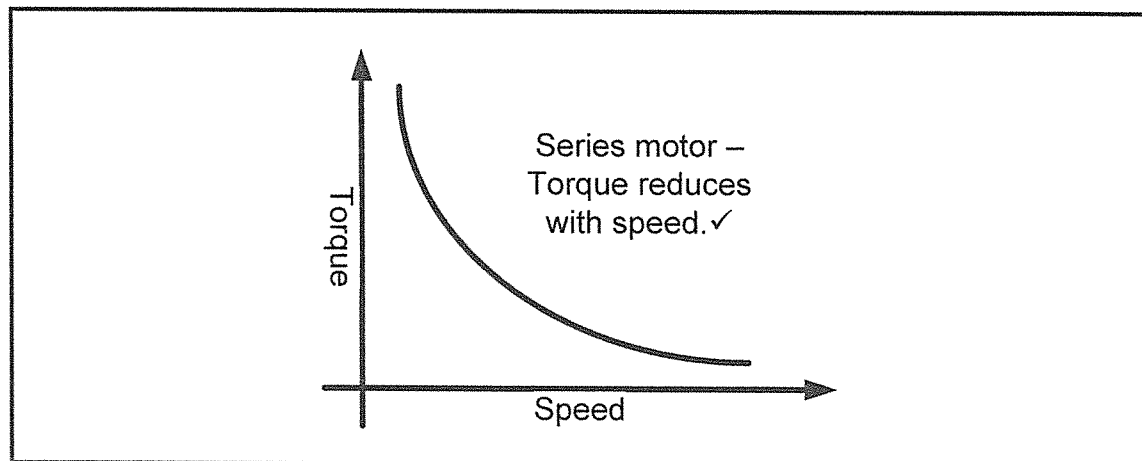
- 8.1 Armature reaction is the effect of the armature ampere-turns ✓ upon the value and distribution of the magnetic flux entering and leaving the armature core ✓. The result is a distorted magnetic field. (2)

8.2 8.2.1



(4)

8.2.2



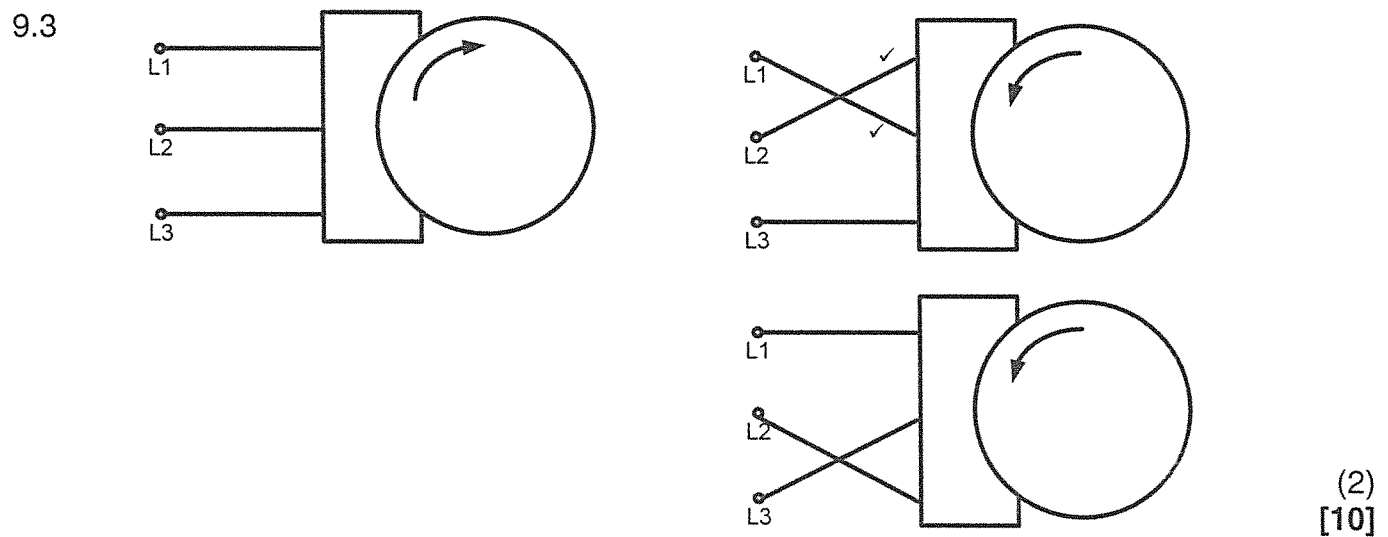
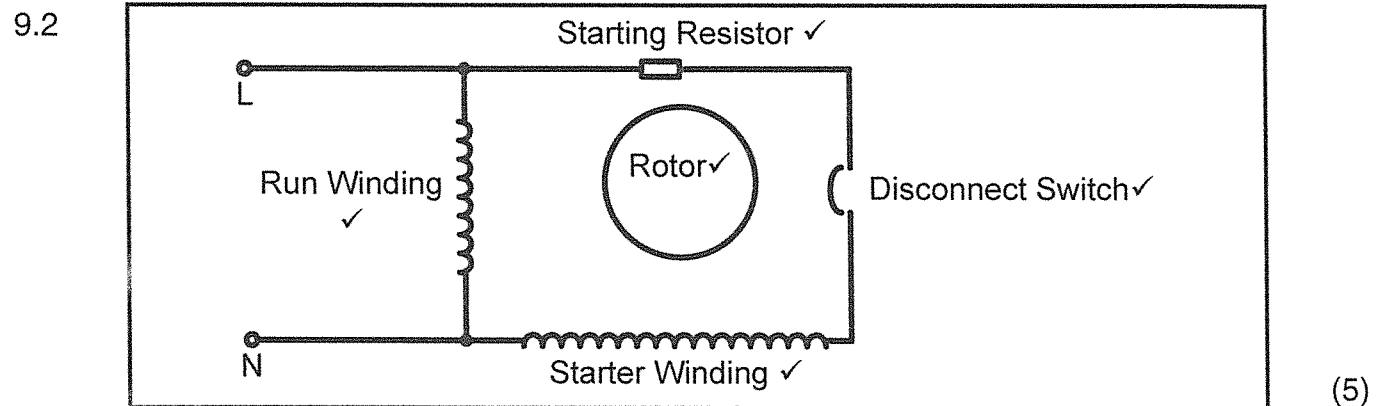
(1)

- 8.3 Insert a resistor bank in series with the armature and gradually reduce this resistor value as the back EMF increases. ✓

(3)
[10]

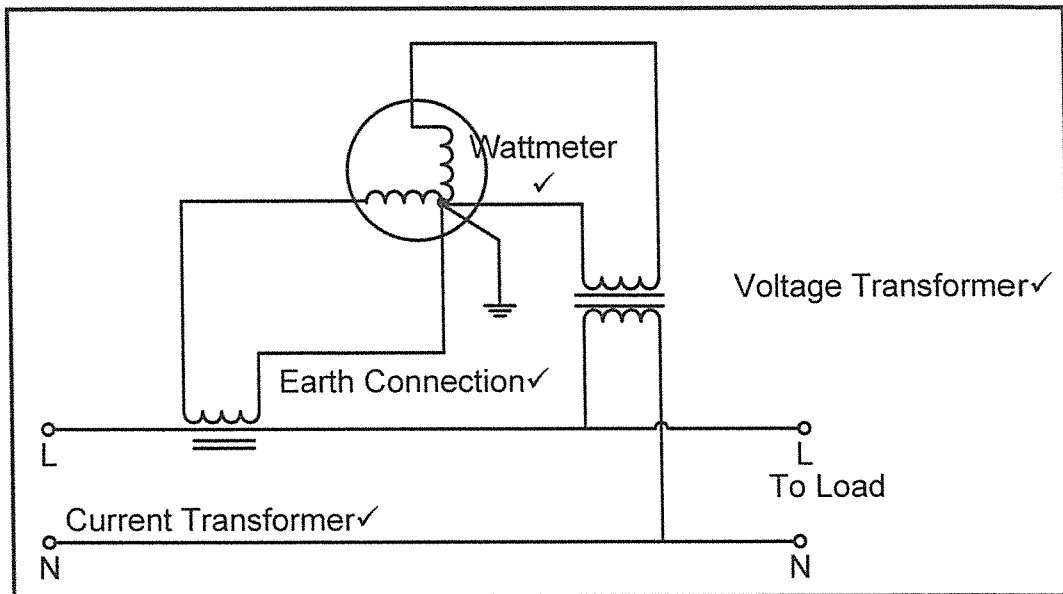
QUESTION 9: AC MACHINES

- 9.1 $f = np$
 $n = f/p$ ✓
 $= 50 \div 2$ ✓
 $= 25 \text{ r.p.s or } 1\,500 \text{ r.p.m}$ ✓ (3)



QUESTION 10: MEASURING INSTRUMENTS AND ELECTRONICS

10.1 10.1.1



(4)

10.1.2 Instrument transformers reduce the voltage to a safe value for measurement.

(1)

10.2 10.2.1 NPN. ✓

10.2.2 Common emitter. ✓

10.2.3 Between B and C. ✓

10.2.4 Between E and F. ✓

10.2.5 On the CF line or at C or at F. ✓

(5 × 1)

(5)

[10]**TOTAL:****100**