

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

**T470(E)(M30)T
APRIL EXAMINATION**

NATIONAL CERTIFICATE

ELECTRICAL TRADE THEORY N3

(11041263)

**30 March 2015 (Y-Paper)
13:00–16:00**

This question paper consists of 11 pages and 1 formula sheet.

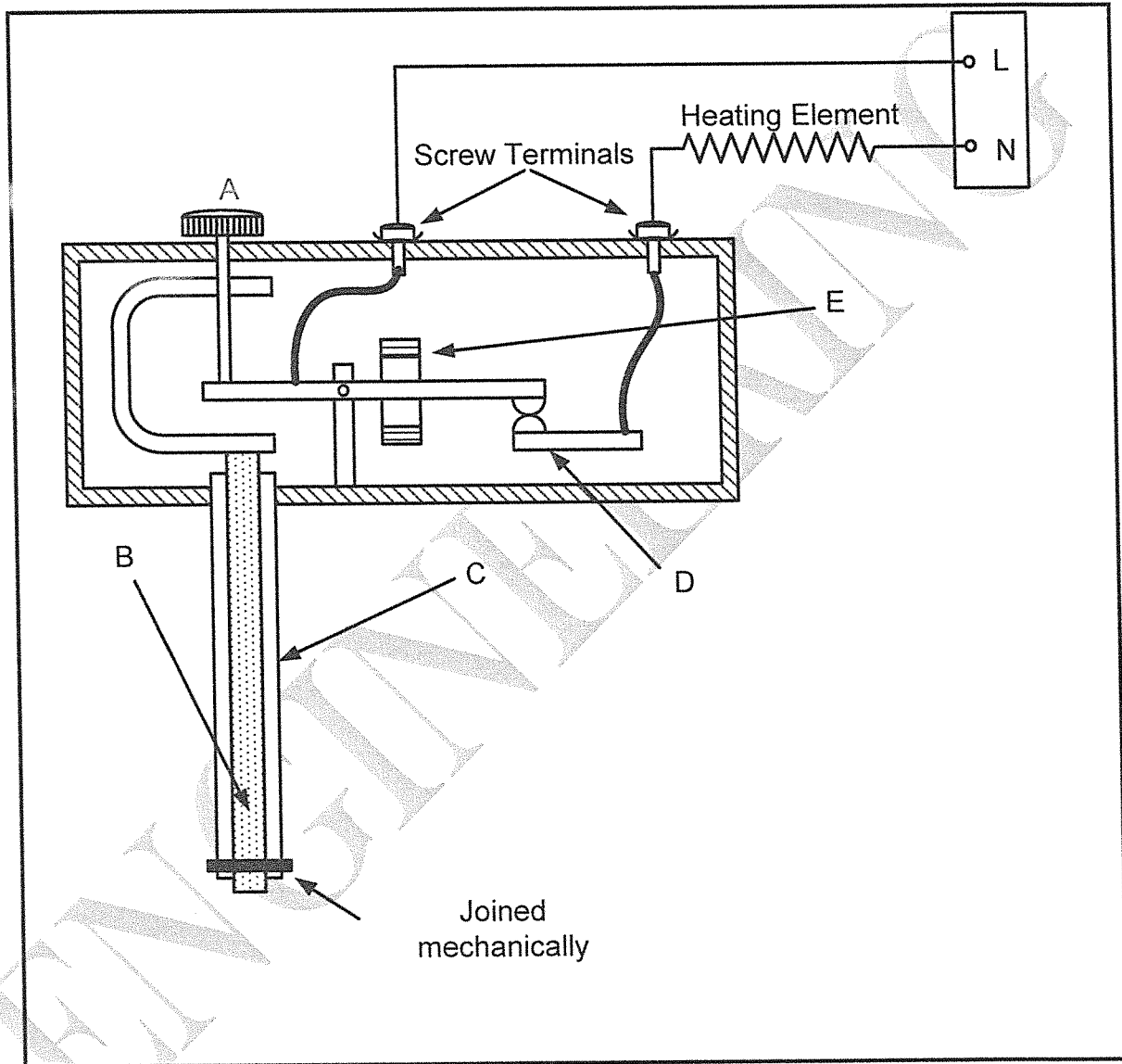
DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA
NATIONAL CERTIFICATE
ELECTRICAL TRADE THEORY N3
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
 2. Read ALL the questions carefully.
 3. Number the answers 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 neat, 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 Draw a neat, fully labelled sketch of a bi-metal thermostat that is used to regulate the temperature of a laundry iron. (5)
- 1.2 Figure 1.1 shows an immersion type thermostat that is used to regulate the temperature of water in a geyser. Identify parts A, B, C, D and E

**FIGURE 1.1: IMMERSION TYPE THERMOSTAT**

QUESTION 2: PROTECTION

- 2.1 Draw a neat, labelled sketch that shows how earthing is achieved from a supply point in a domestic installation to the general mass of the earth.

Your sketch must include the following labels:

- Distribution board
- Earth electrode
- Earth bar
- Earth lead
- Earth continuity conductor

(5 x 1) (5)

- 2.2 Explain the operation of the thermal-magnetic-type circuit breaker on:

2.2.1 Overload

(3)

2.2.2 Short circuit

(2)

[10]

QUESTION 3: ILLUMINATION

- 3.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (3.1.1–3.1.5) in the ANSWER BOOK.

3.1.1 A fluorescent lamp circuit was started. Removing the glow starter at this point will switch the lamp off.

3.1.2 A choke will limit the current in a D.C. supply lamp circuit.

3.1.3 A glow starter actually starts the lamp by opening its contacts.

3.1.4 Cold cathode neon lamps emit a white glow.

3.1.5 Vaporised mercury emits a blue-green light.

(5 x 1) (5)

- 3.2 Study the circuit in FIGURE 3.1. State why this type of circuit is used and explain its operation.

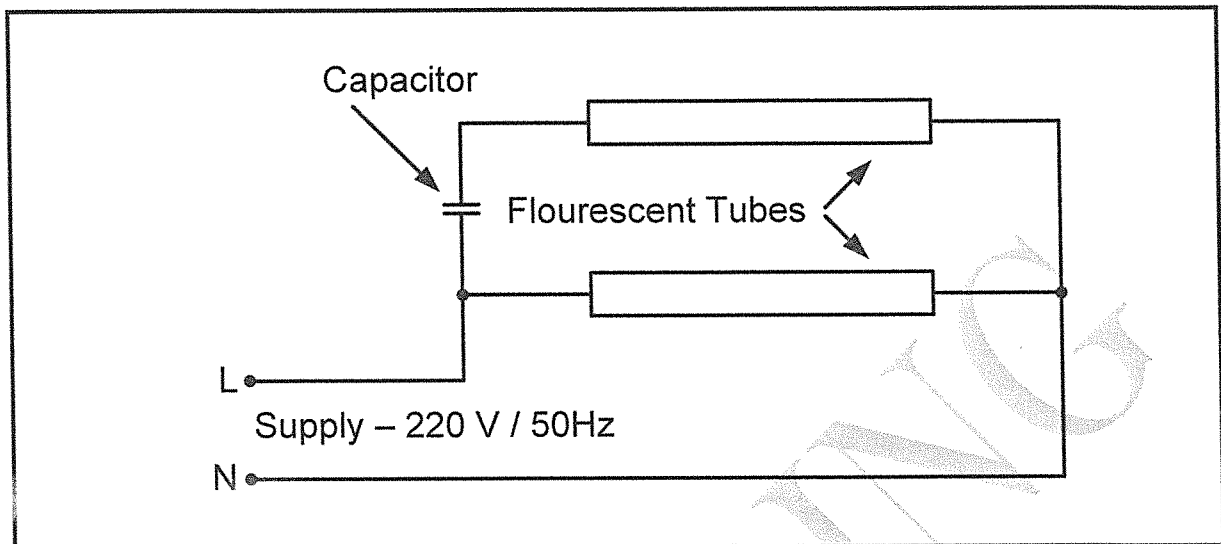


FIGURE 3.1: FLOURESCENT LIGHT CIRCUIT

(3)

- 3.3 Name TWO types of lamps that are ideal for street lighting.

(2)

[10]

QUESTION 4: ALTERNATING CURRENT THEORY

A voltage waveform is represented by $e = 381 \sin(628,32t)$ volts

NOTE: The angle is in radians.

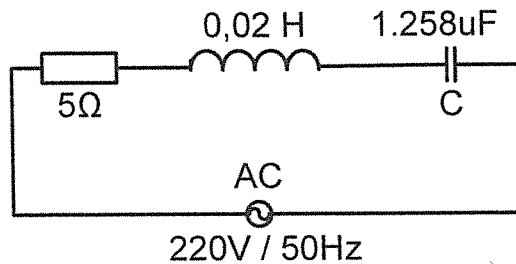
Calculate the following:

- 4.1 Average value (3)
- 4.2 Frequency of the wave (4)
- 4.3 Instantaneous voltage 10 ms after $t = 0$ s (3)

[10]

QUESTION 5: SERIES RLC CIRCUITS

- 5.1 The series RLC circuit in **FIGURE 5.1** has a lagging power factor of 0,8. The component values for R, L and C are 5Ω , 0,02H and $1\,258\mu\text{F}$ respectively. The circuit is supplied with 220 V at 50 Hz.

**FIGURE 5.1: RLC CIRCUIT**

Calculate the:

- 5.1.1 Inductive reactance (3)
- 5.1.2 The circuit impedance (3)
- 5.2 Draw the phasor diagram. (4)
- [10]

QUESTION 6: THREE-PHASE AC SYSTEMS

- 6.1 List TWO advantages of three-phase distribution over single-phase distribution. (2)
- 6.2 A three-phase delta-connected motor draws 250 A from a 380 V supply at a lagging power factor of 0,86.

Calculate the:

- 6.2.1 Input power (3)
- 6.2.2 Apparent power (3)
- 6.2.3 Phase current of the motor winding (2)
- [10]

QUESTION 7: TRANSFORMERS

7.1 Explain the operation of a transformer under the following headings:

- 7.1.1 Type of supply used with this device
- 7.1.2 Method of power transfer from primary to secondary
- 7.1.3 Method of reduction of eddy currents

(3 x 1) (3)

7.2 The three-phase step-down star-delta transformer in FIGURE 7.1 has a primary line voltage of 132 kV and a secondary line voltage of 11 kV.

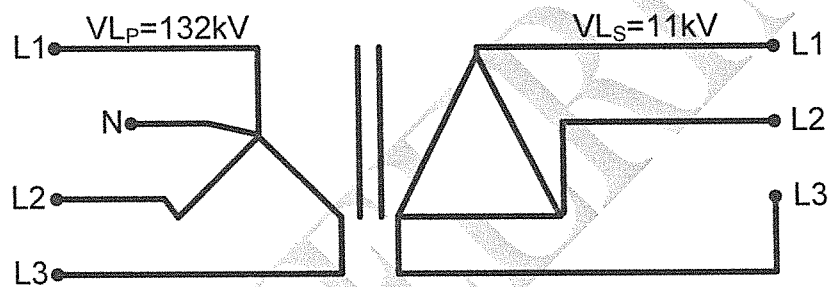


FIGURE 7.1: TRANSFORMER

Ignore losses and calculate the following:

- 7.2.1 Magnitude of primary phase voltages. Show all manipulations of formulae. (4)
- 7.2.2 The turns ratio (3)

[10]

QUESTION 8: DC MACHINES

8.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (8.1.1–8.1.3) in the ANSWER BOOK.

8.1.1 Circuit conductors shall have a current carrying capacity at least equal to the full load rated current of the motor they supply.

8.1.2 For a motor carrying uniform loads, the rated current of the overload protection must exceed the current carrying capacity of the supply cables.

8.1.3 In addition to the over-current protection, a motor must have an integral thermal protector with an accessible reset button.

(3 x 1) (3)

8.2 Draw a neat, fully labelled circuit diagram of a face-plate starter for a series DC motor.

(7)

[10]

QUESTION 9: AC MACHINES

9.1 Name TWO types of rotors found in AC-motors.

(2)

9.2 State the main purpose of the following components of an induction motor:

9.2.1 Stator frame

9.2.2 Stator core

9.2.3 Stator coils

(3 x 1) (3)

9.3 Name TWO properties that the starter circuit of a large 3-phase motor should possess.

(2)

9.4 Study the diagram in FIGURE 9.1 of a starter circuit below and answer the following questions:

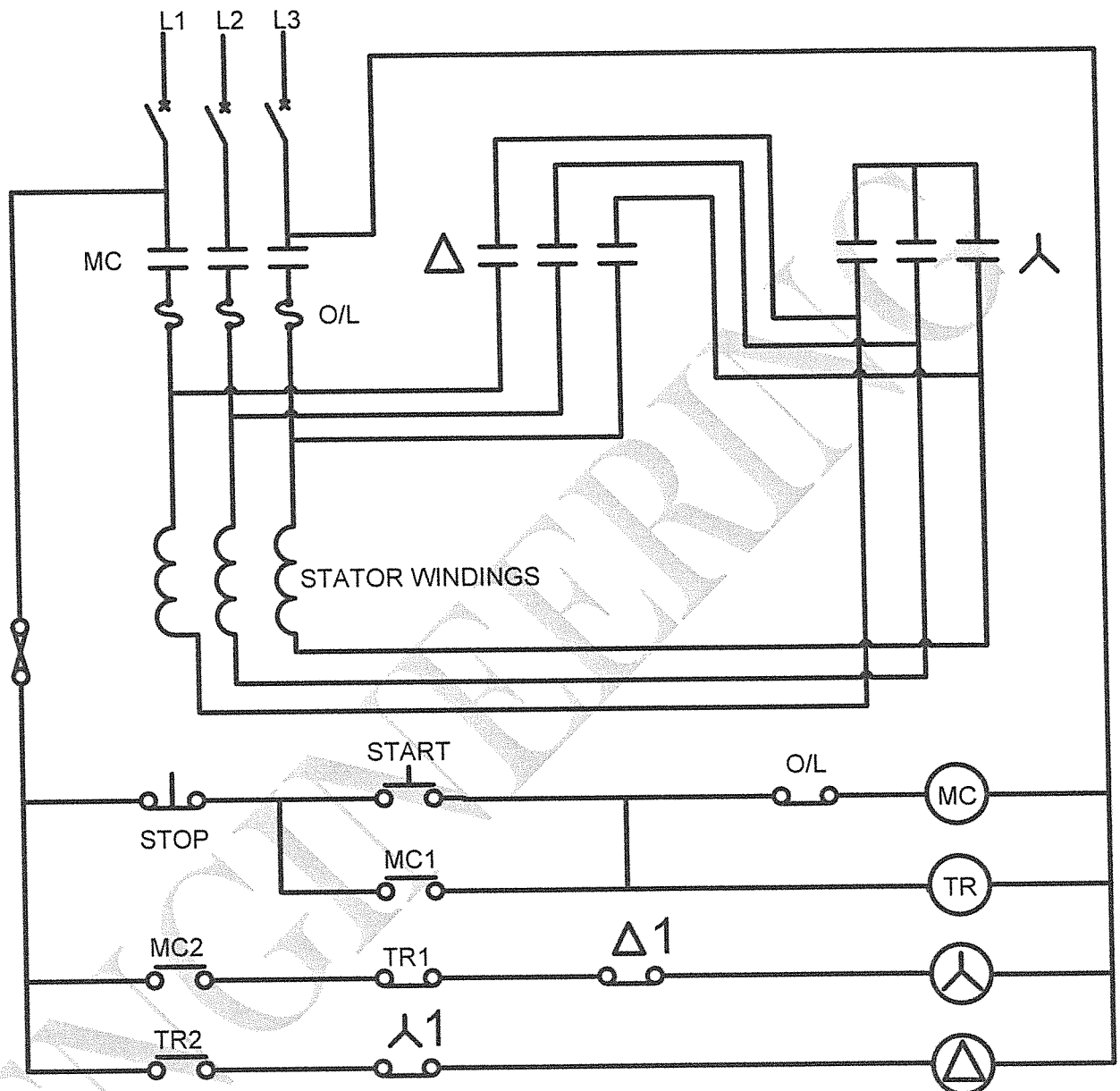


FIGURE 9.1: MOTOR STARTER CIRCUIT

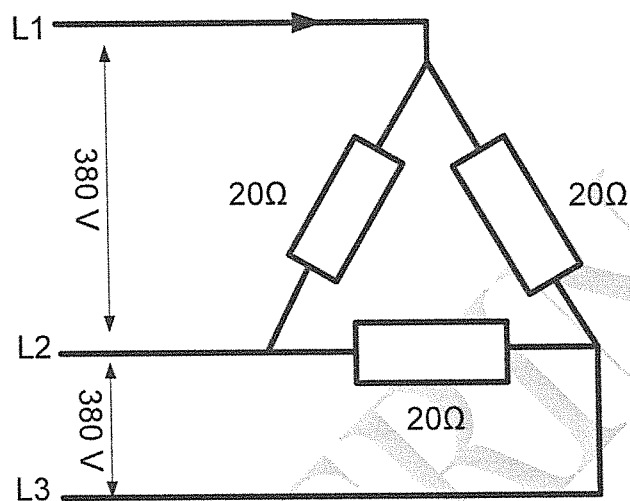
- 9.4.1 State how the relay of the mains contactor (MC) is energised.
- 9.4.2 State why the motor does not stop when you release the start button.
- 9.4.3 State how the simultaneous energising of the Star and Delta contactors are prevented.

(3 x 1)

(3)
[10]

QUESTION 10: MEASURING INSTRUMENTS AND ELECTRONICS

- 10.1 Study the circuit in FIGURE 10.1. Redraw the circuit but add a wattmeter to the diagram to measure the power consumed by one of the $20\ \Omega$ loads. (Do not add any calculations.)



(4)

FIGURE 10.1: DELTA CIRCUIT

- 10.2 Explain the following terms in semiconductor theory:

- 10.2.1 Holes
- 10.2.2 Junction
- 10.2.3 Depletion layer
- 10.2.4 Forward bias

(4 x 1) (4)

- 10.3 Study the circuit in FIGURE 10.2 of a common emitter amplifier using an NPN transistor. Answer the following questions.

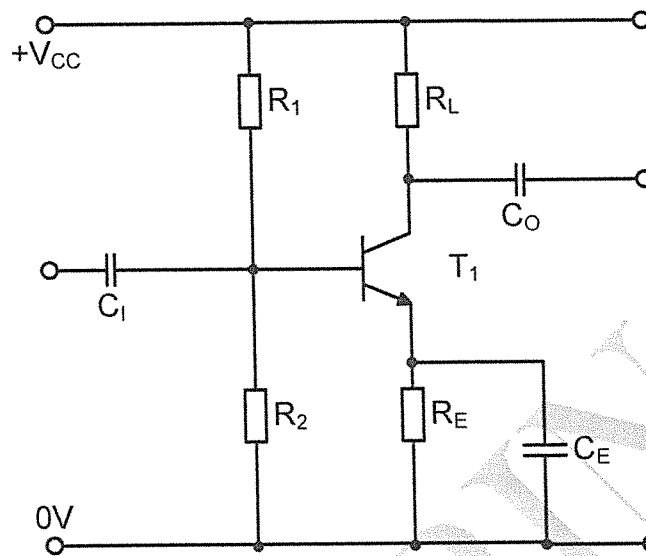


FIGURE 10.2: Common Emmittor Amplifier

- 10.3.1 State the purpose of capacitor C_e connected across resistor R_E .
- 10.3.2 A voltage divider circuit can be used to forward bias the base-emitter region. Identify the components in the diagram that serve this purpose.

(2 x 1) (2)
[10]

TOTAL: 100

FORMULA SHEET/FORMULEBLAD

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

$$I_{ACTIVE/AKTIEWE} = I_T \cos \theta$$

$$I_{REACTIVE/REAKTIEWE} = I_T \sin \theta$$

$$X_L = 2\pi fL$$

$$X_C = \frac{1}{2\pi fC}$$

Series / Serie

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

$$\theta = \cos^{-1} \left[\frac{R}{Z} \right]$$

$$V_R = I_T R$$

$$V_{X_L} = I_T X_L$$

$$V_{X_C} = I_T X_C$$

$$V = \sqrt{V_R^2 + (V_{X_L} - V_{X_C})^2}$$

$$P = I^2 R$$

$$S = VI$$

3-phase / 3-fase

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

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

Delta

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

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

Star / Ster

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

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

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

$$\omega = 2\pi f$$

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

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

The next five formulae are also true for voltage/Die volgende vyf formules geld ook vir spanning

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

$$I_{rms/wgk} = 0,707 I_m$$

$$I_{ave/gem} = 0,637 I_m$$

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

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

Form factor/Vormfaktor

$$= \frac{RMS - value / WGK - waarde}{AVE - value / GEM - waarde}$$

Crest factor/Kruinfaktor

$$= \frac{MAX - value / MAKS - waarde}{RMS - value / WGK - waarde}$$

Series/Serie

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

Parallel

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



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MARKING GUIDELINE

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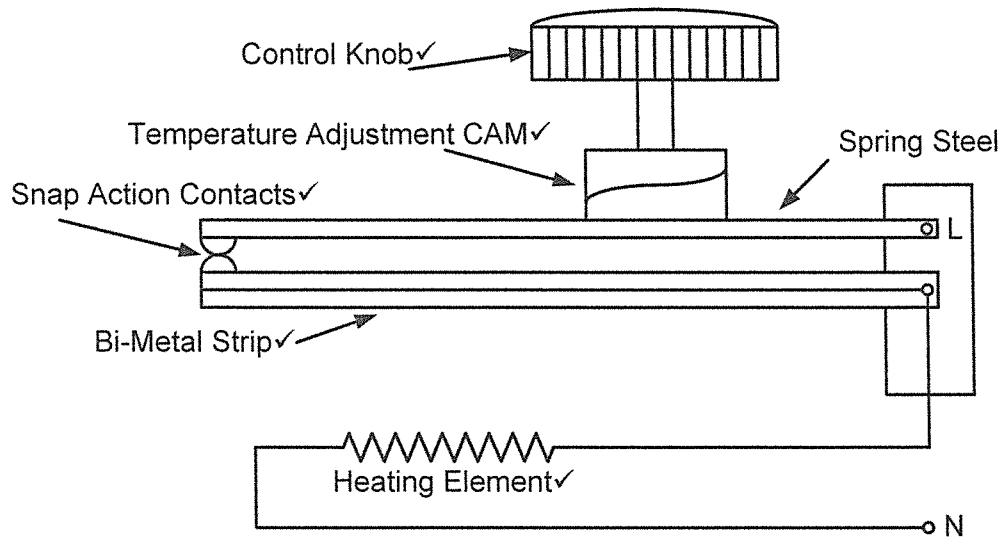
30 MARCH 2015

This marking guideline consists of 8 pages.

QUESTION 1: DOMESTIC APPLIANCES

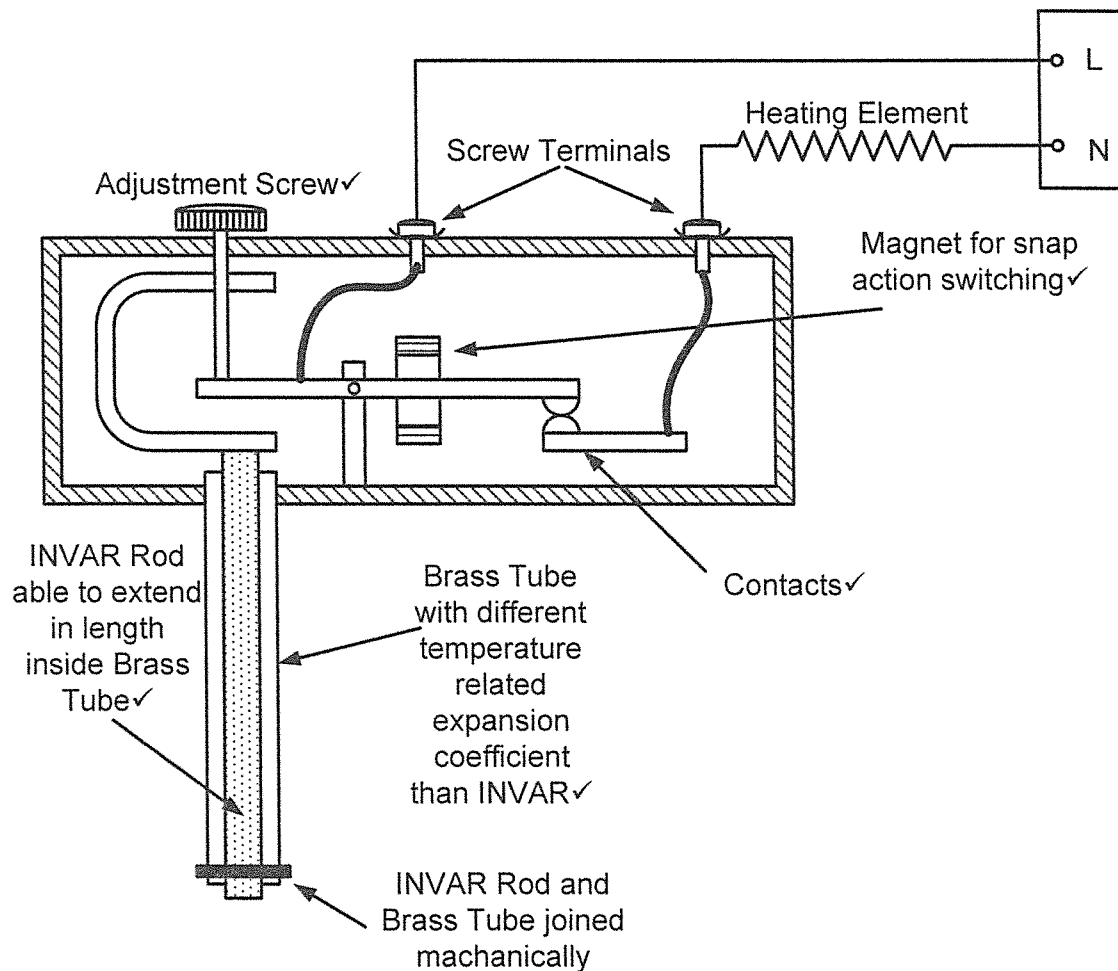
NOTE: There could be more than one answer/method/approach to the questions.
Examiners must use their discretion with regard to students' answers.

1.1



(5)

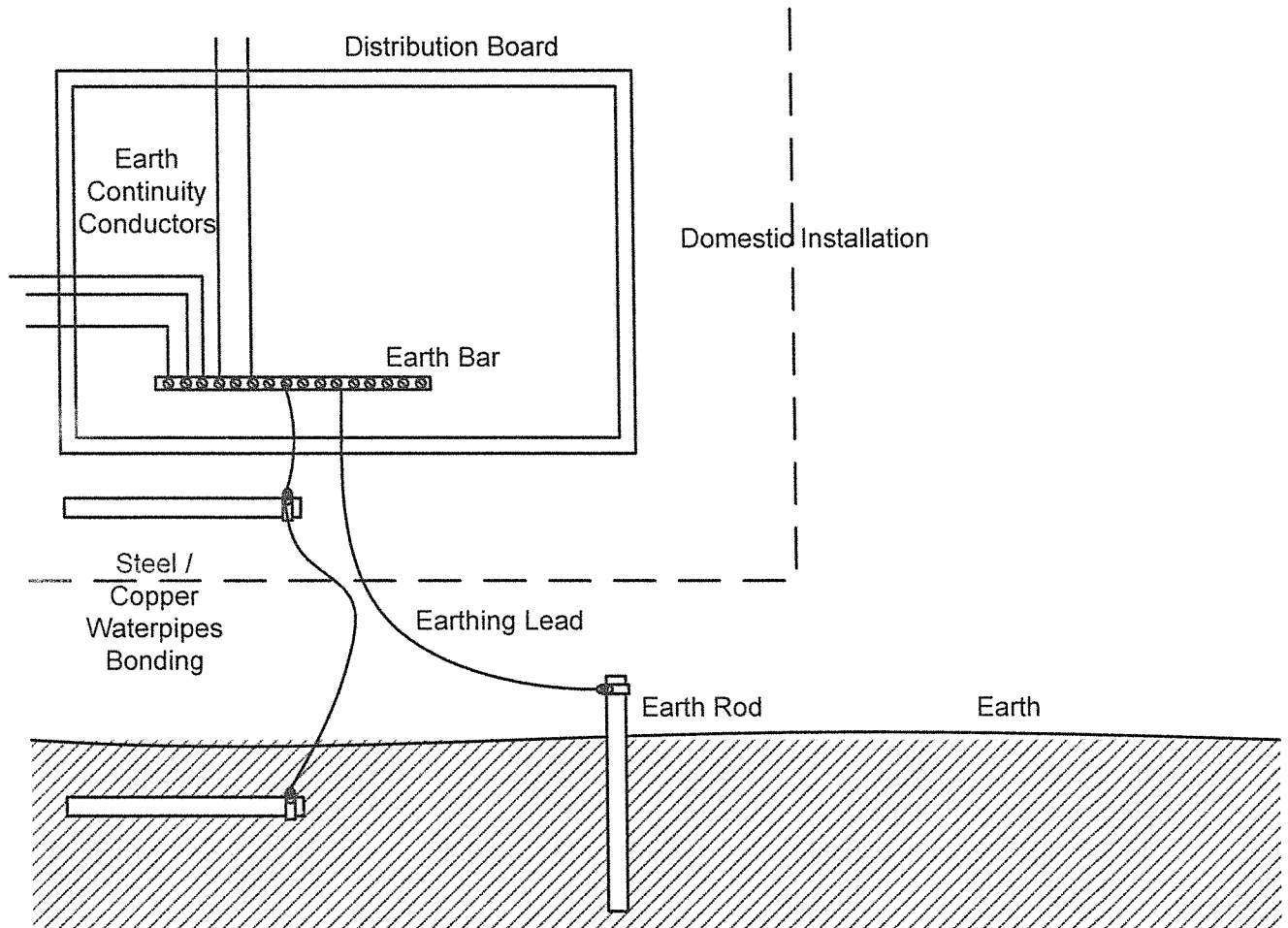
1.2



(5)

QUESTION 2: PROTECTION

2.1



(One mark per label)(5 x 1) (5)

- 2.2 2.2.1 The bi-metal is heated by the overload current. ✓ This bends the bi-metal strip and the mechanical coupling opens the contacts. ✓ This breaks the circuit and current stops. ✓ (3 x 1) (3)
- 2.2.2 The magnetic field becomes strong enough to attract the mechanical coupling without the aid of the bi-metal bending. ✓ This breaks the circuit immediately and current stops. ✓ (Any 2 x 1) (2)
- [10]**

QUESTION 3: ILLUMINATION

- 3.1 3.1.1 False ✓
 3.1.2 False ✓
 3.1.3 True ✓
 3.1.4 False ✓
 3.1.5 True ✓

(5 x 1) (5)

- 3.2 REASON: To minimise the stroboscopic effect ✓

EXPLANATION: The capacitor causes the current in the one lamp circuit to lead the current in the other. ✓ The brightest moments of the two lamps therefore occur at different times. ✓

(3)

- 3.3 High-pressure mercury lamps ✓ and sodium vapour lamps ✓

(2)
[10]**QUESTION 4: ALTERNATING CURRENT THEORY**

- 4.1 $V_{AVG} = 0,637 \times V_{MAX}$ ✓
 $V_{AVG} = 0,637 \times 381$ ✓
 $V_{AVG} = 242,7 \text{ V}$ ✓

(3)

- 4.2 $\omega = 2\pi f$ ✓
 and: $\omega = 628,32$ - given
 therefore
 $f = \frac{\omega}{2\pi}$ ✓
 $f = \frac{628,32}{6,2832}$ ✓
 $f = 100 \text{ Hz}$ ✓

(4)

- 4.3 $e = 381 \sin(628,32 t)$ ✓
 $= 381 \times \sin(628,32 \times 0,01)$ ✓
 $= 381 \times 0,000015$
 $= 0,00559 \text{ V}$ ✓
 $= 0,01 \text{ V}$

(3)

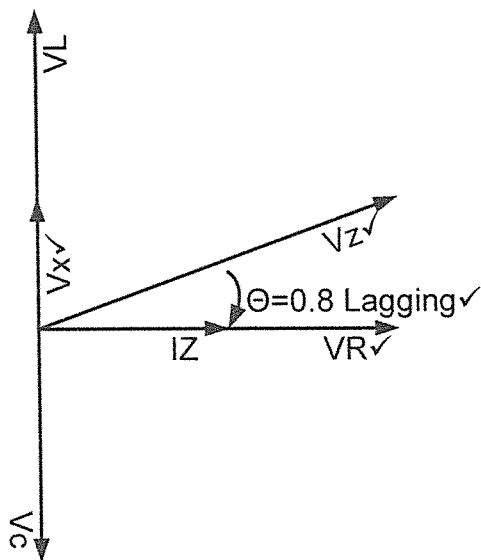
[10]

QUESTION 5: SERIES RLC CIRCUITS

5.1 5.1.1 $X_L = 2\pi fL \checkmark$
 $X_L = 2\pi \times 50 \times 0.02 \checkmark$
 $X_L = 6.283\Omega \checkmark$ (3)

5.1.2 $\cos \Phi = R/Z \checkmark$ OR $Z = \sqrt{R^2 + (X_L - X_C)^2} \checkmark$
 $Z = r/\cos \Phi \checkmark$
 $= 6,25 \Omega \checkmark$ $= \sqrt{5^2 + (6,28 - 2,53)^2} \checkmark$
 $= 6,25 \Omega \checkmark$ (3)

5.2



(4)

[10]**QUESTION 6: THREE-PHASE AC-SYSTEMS**

6.1 Less copper per MVA $\checkmark$ (2)
 Two voltages available $\checkmark$ (2 x 1)

6.2 6.2.1 $P = \sqrt{3} \cdot V_L I_L \cos \Phi \checkmark$
 $= \sqrt{3} \times 380 \times 25 \times 0,86 \checkmark$
 $= 14,15 \text{ kW} \checkmark$ (3)

6.2.2 $S = \sqrt{3} \cdot V_L I_L \checkmark$
 $S = \sqrt{3} \times 380 \times 25 \checkmark$
 $S = 16,45 \text{ kVA} \checkmark$ (3)

6.2.3 $I_{ph} = I_L \checkmark$
 $I_{ph} = 25 \text{ A} \checkmark$ (2)
[10]

QUESTION 7: TRANSFORMERS

7.1

7.1.1 Only alternating current✓

7.1.2 Occurs magnetically through induction✓

7.1.3 Iron core consists of laminated plates✓

(3 x 1)

(3)

7.2

7.2.1 $V_L = \sqrt{3} \times V_P$ ✓

$V_P = \frac{V_L}{\sqrt{3}}$ ✓

$V_P = \frac{132000}{\sqrt{3}}$ ✓

$V_P = 76\,210.23\text{ V}$ ✓

(4)

7.2.2 $T.R = N_1 \div N_2 = V_1 \div V_2$ ✓
 $= 76\,210 \div 11\,000$ ✓
 $= 6,93:1$ ✓

(3)

[10]**QUESTION 8: DC-MACHINES**

8.1 8.1.1 True ✓

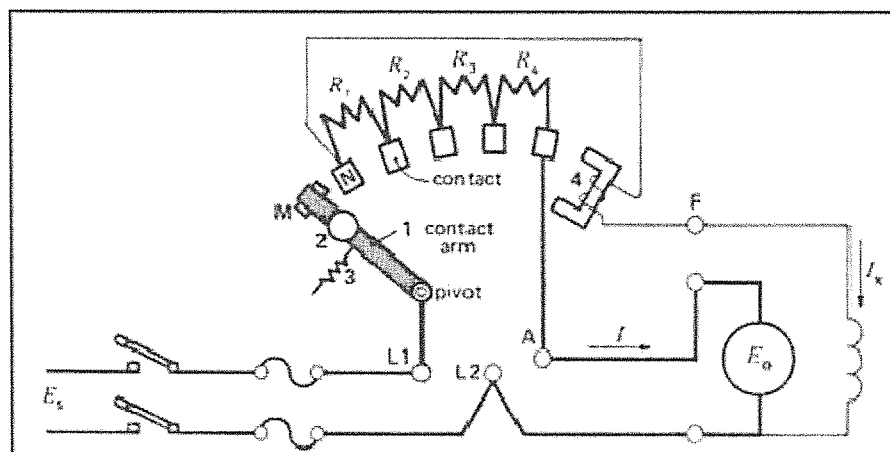
8.1.2 False ✓

8.1.3 False ✓

(3 x 1)

(3)

8.2

✓ resistors
in series✓ contact
arm
removes
resistors
from
circuit✓ tension
spring
returns
arm to
start
position

(Sketch = 4 marks; Any 3 labels = 3 marks)

(7)

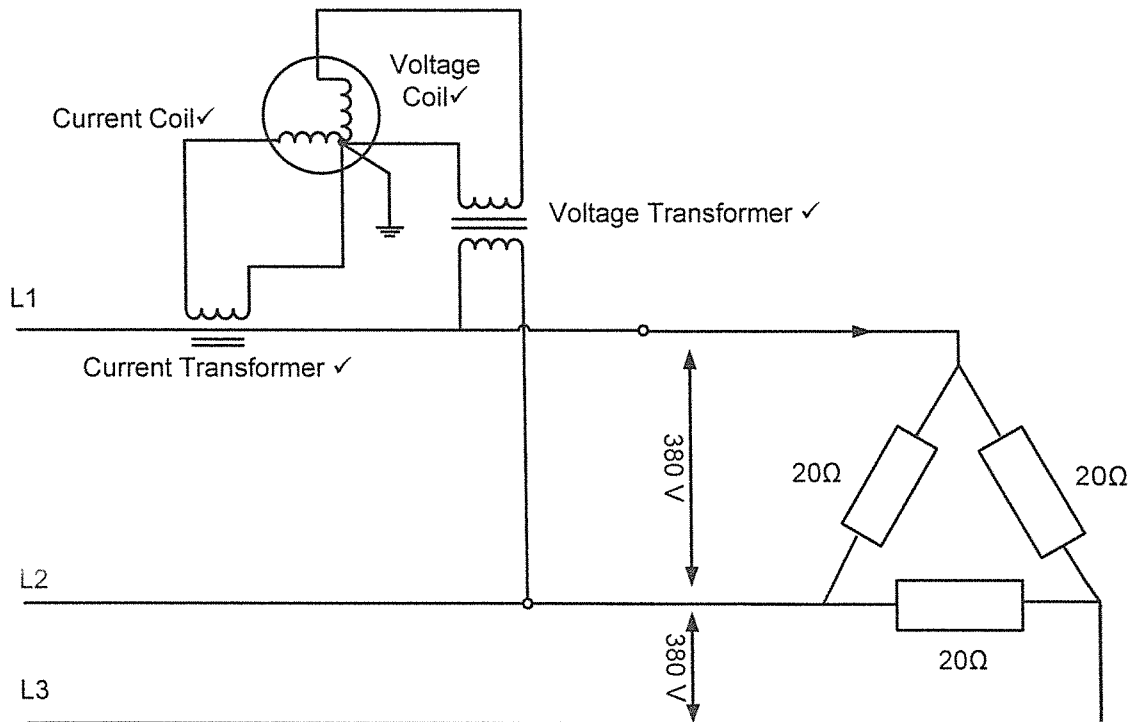
[10]

QUESTION 9: AC MACHINES

- 9.1 A squirrel cage induction motor. ✓
 A wound rotor induction motor. ✓ (2)
- 9.2 9.2.1 Supports/protects the stator core ✓
- 9.2.2 Has slots that house the insulated windings/provide metal path for
 magnetic field ✓
- 9.2.3 Produces the main magnetic field ✓ (3 x 1) (3)
- 9.3 Allows motor to start at a decreased supply current ✓
 Disconnects motor on overcurrent ✓ (2)
- 9.4 9.4.1 When the start button is pressed, it energises the coil of the MC,
 thus closing the contacts. ✓
- 9.4.2 The MC contactor has extra contacts called MC₁ and MC₂. MC₁ is
 bypassing the start button contacts. ✓
- 9.4.3 The Δ contactor has extra normally closed contacts called Δ₁.
 When the Δ contactor is energised, the star contactor de-energises
 because Δ₁ is in series with it. ✓ (3 x 1) (3)
- [10]**

QUESTION 10: MEASURING INSTRUMENTS AND ELECTRONICS

10.1



(4)

- 10.2 10.2.1 Holes are places where electrons can move to or places that the electrons left behind. ✓
- 10.2.2 A junction is the surface where P-type and N-type material come together. ✓
- 10.2.3 Depletion layer lacks holes and free electrons **OR**
Depletion layer is the area where ions have been formed. ✓
- 10.2.4 When a PN junction is forward-biased, current flows through the semiconductor material **OR**
When a PN junction is forward-biased, there is a decreased depletion region. ✓

(4 x 1)

(4)

- 10.3 10.3.1 C_e is an AC bypass capacitor. ✓
- 10.3.2 R_1 and R_2 are the voltage dividers. ✓

(2 x 1)

(2)

[10]

TOTAL: 100