



# higher education & training

---

Department:  
Higher Education and Training  
**REPUBLIC OF SOUTH AFRICA**

## **MARKING GUIDELINE**

**NATIONAL CERTIFICATE**

**ELECTROTECHNICS N4**

**29 July 2025**

**This marking guideline consists of 8 pages.**

## QUESTION 1: PRINCIPLES OF ELECTRICITY

- 1.1
  - 1.1.1 Free electrons
  - 1.1.2 Ampere
  - 1.1.3 Permeability
  - 1.1.4 Kirchhoff's first law
  - 1.1.5 Ion
  - 1.1.6 Michael Faraday
  - 1.1.7 Dielectric
  - 1.1.8 Faraday's law
  - 1.1.9 Self-induction
  - 1.1.10 Faraday's law and Lenz's law

(10 × 1) (10)

- 1.2 Data:
  - $R_1 = 8\Omega$
  - $R_2 = 6\Omega$
  - $E_1 = 2V$ ,
  - $r_1 = 1\Omega$
  - $E_2 = 1,5V$ ,
  - $r_2 = 0,5\Omega$

1.2.1  $R_T = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{(8 \times 6)}{(8+6)} = 3,429\Omega \checkmark$

$$r_T = r_1 + r_2 = 1 + 0,5 = 1,5\Omega \checkmark$$

$$E_T = E_1 + E_2 = 2 + 1,5 = 3,5 V \checkmark$$

$$E_T = I(R_T + r_T)$$

$$3,5 = I(3,429 + 1,5)$$

$$I = 0,710A \checkmark$$

Alternate solution:

$$\begin{aligned} R_T &= \frac{R_1 \times R_2}{R_1 + R_2} \\ &= \frac{(8 \times 6)}{(8+6)} + 1 + 0,5 = 4,929 \Omega \checkmark \checkmark \end{aligned}$$

$$I_T = \frac{E_T}{R_T} = \frac{3,5}{4,929} = 0.710 A \checkmark \checkmark$$

Current through both cells is equal ( $I = 0,710 A$ ), since it's a series connection.

1.2.2 The current through each coil:

$$E_T = V + (I_T \cdot r_T)$$

But  $R_p = R_t$

$$V = 3,5 - (0,710 \times 1,5)$$

$$V = 2,435 \text{ V} \checkmark \checkmark$$

**OR**

$$V_P = I_P \cdot R_P = 0,710 \times 3,429 = 2,435 \text{ V} \checkmark \checkmark$$

$$I_{R1} = \frac{V_P}{R_1} = \frac{2,435}{8} = 0,304 \text{ A} \checkmark$$

$$I_{R2} = \frac{V_P}{R_2} = \frac{2,435}{6} = 0,406 \text{ A} \checkmark$$

(4)

1.2.3  $E_1 = V_1 + I r_1$

$$2 = V_1 + (0,710 \times 1)$$

$$V_1 = 1,29 \text{ V} \checkmark$$

$$E_2 = V_2 + I r_2$$

$$1,5 = V_2 + (0,710 \times 0,5)$$

$$V_2 = 1,145 \text{ V} \checkmark$$

(2)

1.3

**Given:**

| Aluminium                           | Copper                               |
|-------------------------------------|--------------------------------------|
| $p = 0,028 \times 10^{-6} \Omega m$ | $p = 0,0018 \times 10^{-6} \Omega m$ |
| $d = 2mm$                           | $d = ?$                              |
| $l = 5m$                            | $l = 10m$                            |
| $I = 4A$                            | $I = 3A$                             |
| $I_T = 7A$                          |                                      |

$$R_{al} = \frac{\rho l}{A} = \frac{0,028 \times 10^{-6} \times 5}{\frac{\pi \times (2 \times 10^{-3})^2}{4}} = 0,045 \Omega \checkmark \checkmark$$

$$V_p = I_{al} R_{al} = 4 \times 0,045 = 0,18 \text{ V} \checkmark \checkmark$$

$$R_{cu} = \frac{V_p}{I_{cu}} = \frac{0,18}{3} = 0,06 \Omega \checkmark \checkmark$$

$$A_{cu} = \frac{\rho l}{R_{cu}} = \frac{0,0018 \times 10^{-6} \times 10}{0,06} = 3 \times 10^{-7} m^2 \checkmark \checkmark$$

$$d_{cu} = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4 \times 3 \times 10^{-7}}{\pi}} = 0,618 \text{ mm} \checkmark \checkmark$$

(10)

## QUESTION 2: DC MACHINES

2.1 **Given:**

$$\begin{aligned} p &= 4 \\ c &= 2 \times 4 = 8 \\ N &= 450 \text{ r/p} \\ E &= 250 \text{ V} \\ \Phi &= 0,05 \text{ Wb} \end{aligned}$$

$$E = \frac{2ZNp\phi}{60c}$$

$$Z = \frac{60 \times 250 \times 8}{2 \times 450 \times 4 \times 0,05} \checkmark \checkmark$$

$$Z = 666,667 = 667 \checkmark \checkmark$$

$$\text{Conductors / slot} = \frac{\text{Conductors}}{\text{Slots}} = \frac{667}{120} = 5,558 = 6 \text{ conductors per slot} \checkmark \checkmark \quad (6)$$

2.2 **Given:**

$$\begin{aligned} R_a &= 0,3 \, \Omega \\ R_{se} &= 0,125 \, \Omega \\ R_{sh} &= 130 \, \Omega \\ I_L &= 45 \text{ A} \\ V &= 450 \text{ V} \end{aligned}$$

$$I_{sh} = \frac{V}{R_{sh}} = \frac{450}{130} = 3,462 \text{ A} \checkmark \checkmark$$

$$I_a = I_L + I_{sh} = 45 - 3,462 = 41,538 \text{ A} \checkmark$$

$$\begin{aligned} E &= V - I_a R_a - I_a R_{se} \\ &= 450 - (41,538 \times 0,3) - (41,538 \times 0,125) \checkmark \checkmark \\ &= 432,346 \text{ V} \checkmark \quad (6) \end{aligned}$$

2.3

- A – Interpole
- B – Pole core
- C – Shaft
- D – Field windings
- E – Commutator
- F – Armature conductors
- G – Pole shoe
- H – Frame/Yoke

(8)

[20]

### QUESTION 3: AC THEORY

#### 3.1 Data:

$$R = 6 \, \Omega \quad V = 250 \, V$$

$$L = 28 \, mH \quad f = 50 \, Hz$$

$$C = 180 \, \mu F$$

$$3.1.1 \quad X_L = 2\pi fL = 2\pi \times 50 \times 28 \times 10^{-3} = 8,796 \, \Omega \checkmark$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 180 \times 10^{-6}} = 17,684 \, \Omega \checkmark$$

$$Z^2 = R^2 + (X_L - X_C)^2 = 6^2 + (8,888)^2 = 115$$

$$\therefore Z = 10,734 \, \Omega \checkmark$$

$$I = \frac{V}{Z} = \frac{250}{10,734} = 23,290 \, A \checkmark$$

(4)

$$3.1.2 \quad (Z_{Coil})^2 = R^2 + (X_L)^2 = 6^2 + (8,796)^2 = 113,369 \checkmark$$

$$\therefore Z = 10,647 \, \Omega \checkmark$$

$$V_{Coil} = IZ_{Coil} = 23,290 \times 10,647 = 247,969 \, V \checkmark$$

(3)

$$3.1.3 \quad P = I^2 R = (23,290)^2 (6) = 3,245 \, k \, W \checkmark$$

(1)

#### 3.2 Instantaneous values:

$$i = 35 \sin 315t$$

$$i = I_m \sin \omega t = I_m \sin 2\pi f t$$

$$3.2.1 \quad I_{rms} = 0,707 I_m = 0,707 \times 35 = 24,745 \, A \checkmark$$

(1)

$$3.2.2 \quad 2\pi f = \omega$$

$$2\pi f = 315$$

$$f = 50 \, Hz \checkmark$$

(1)

$$3.2.3 \quad i = ?$$

$$t = 1,4 \, ms = 0,0014 \, sec$$

$$i = 35 \sin 315t (180/\pi) \checkmark$$

$$i = 35 \sin 315 (0,004)(180/\pi) \checkmark$$

$$i = 33,323 \, A \checkmark$$

(3)

3.3 **Data:**

$$\begin{aligned} n &= 110 \text{ Turns} \\ A &= 120 \times 10^{-4} \text{ m}^2 \\ N &= 3\,000 \text{ r/m} \\ B &= 1,6 \text{ T} \end{aligned}$$

$$3.3.1 \quad f = \frac{Np}{60} = \frac{3\,000}{60} = 50 \text{ Hz} \checkmark \quad (2)$$

$$\begin{aligned} 3.3.2 \quad E_m &= 2\pi BANn \\ &= 2\pi(1,6)(120 \times 10^{-4}) \left( \frac{3\,000}{60} \right) (110) \checkmark \checkmark \\ &= 663,504 \text{ V} \checkmark \quad (3) \end{aligned}$$

$$\begin{aligned} 3.3.3 \quad E_{rms} &= 0,707 E_m = 0,707 \times 663,504 = 469,097 \text{ V} \checkmark \\ E_{ave} &= 0,637 E_m = 0,637 \times 663,504 = 422,652 \text{ V} \checkmark \quad (2) \end{aligned}$$

[20]

**QUESTION 4: TRANSFORMERS**

**Given:**

$$\begin{aligned} V_1 &= 230 \text{ V} & A &= 0,05 \text{ m}^2 \\ f &= 50 \text{ Hz} & d &= 2,7 \text{ mm} \\ B &= 1,5 \text{ T} & I/mm^2 &= 3 \text{ A} \end{aligned}$$

$$\begin{aligned} 4.1 \quad \phi_m &= BA \\ &= (1,5 \times 0,05) = 0,075 \text{ Wb} \checkmark \checkmark \end{aligned}$$

$$\begin{aligned} N_1 &= \frac{E_1}{4,44 f \phi_m} \\ &= \frac{230}{4,44 \times 50 \times 0,075} = 13,813 = 19 \text{ Turns} \checkmark \checkmark \quad (4) \end{aligned}$$

$$\begin{aligned} 4.2 \quad A &= \frac{\pi d^2}{4} \\ &= \frac{\pi (2,7)^2}{4} = 5,726 \text{ mm}^2 \checkmark \checkmark \end{aligned}$$

$$\begin{aligned} I &= (I/mm^2)A \\ &= 3 \times 5,726 = 17,178 \text{ A} \checkmark \checkmark \end{aligned}$$

$$\begin{aligned} S &= V_1 I_1 \\ &= 230 \times 17,178 = 3,959 \text{ kVA} \checkmark \checkmark \end{aligned}$$

## QUESTION 5: AC MACHINES

5.1 **Given:**

$$V = 1200 \text{ V}$$

$$f = 50 \text{ Hz}$$

$$N = 1300 \text{ r/m}$$

$$\% \text{ slip} = 35\%$$

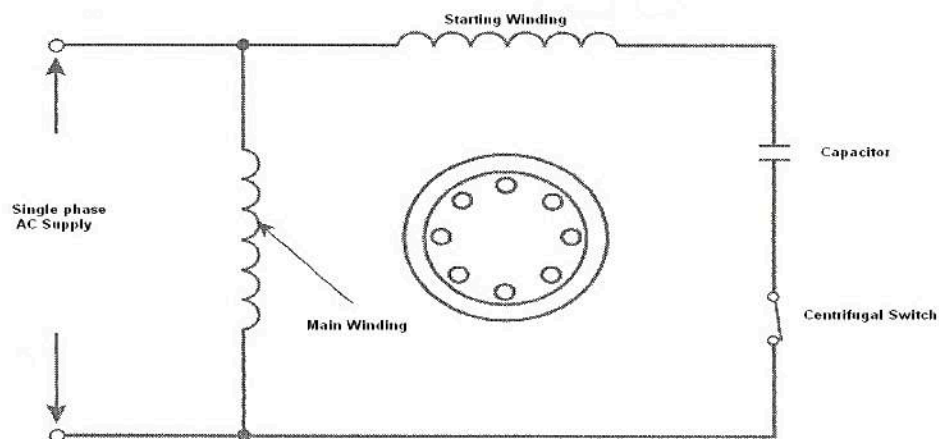
$$\begin{aligned} \% \text{ Slip} &= \frac{N_s - N}{N_s} \times 100 \% \\ 35 &= \frac{N_s - 1300}{N_s} \times 100\% \checkmark \checkmark \\ &= 2000 \text{ r/m} \checkmark \end{aligned}$$

$$N_s = \frac{60f}{p}$$

$$p = \frac{60 \times 50}{2000} = 1,5 = 3 \text{ poles} \checkmark \checkmark$$

(5)

5.2



(Any 3 × 1)

(Correct labels)(3 marks)

(Correct circuit diagram)(2 marks)

(5)

[10]

### QUESTION 6: GENERATION AND SUPPLY OF AC POWER AND MEASURING INSTRUMENTS

- 6.1
- Coal power stations
  - Nuclear power stations
- (2)

- 6.2
- To reduce transport costs
  - To reduce serious traffic problems on the roads
  - To keep pollution away from densely populated areas
- (3)

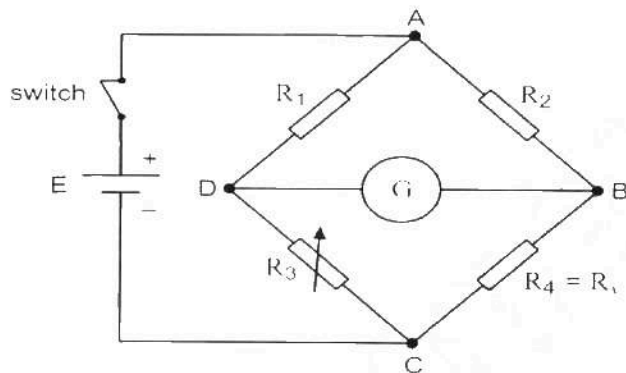
6.3 **Given:**

$$R_1 = 70 \, \Omega$$

$$R_2 = 700 \, \Omega$$

$$R_3 = 400 \, \Omega$$

$$R_4 = R_X = ?$$



$$R_1 R_4 = R_2 R_3$$

$$R_4 = R_X = \frac{R_2 R_3}{R_1} = \frac{700 \times 400}{70} = 4000 \, \Omega \checkmark \checkmark \checkmark$$

(Correct circuit diagram)(2 marks)

(Calculation)(3 marks)

(5)

[10]

**TOTAL: 100**