



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

24 March 2026

This marking guideline consists of 8 pages.

QUESTION 1: PRINCIPLES OF ELECTRICITY

- 1.1 1.1.1 Reduced
 1.1.2 Faraday's laws
 1.1.3 Capacitor
 1.1.4 Electromotive
 1.1.5 Insulating
 1.1.6 Series
 1.1.7 Movement
 1.1.8 Negative
 1.1.9 Faraday's law
 1.1.10 Voltage

(10 × 1) (10)

1.2 Data:

$$E_1 = 150 \text{ V}$$

$$r_1 = 0,6 \, \Omega$$

$$I_1 = ?$$

$$E_2 = 75 \text{ V}$$

$$r_2 = 0,4 \, \Omega$$

$$I_2 = ?$$

$$R_L = 30 \, \Omega$$

$$V_L = ?$$

$$I_1 + I_2 = ?$$

Consider loop AC DFA:

$$E_1 = I_1 r_1 + (I_1 + I_2) R$$

$$150 = 0,6 I_1 + 30 I_1 + 30 I_2$$

$$150 = 30,6 I_1 + 30 I_2 \dots \dots \dots (1) \checkmark \checkmark$$

Consider loop BC DEB:

$$E_2 = I_2 r_2 + (I_1 + I_2) R$$

$$75 = 0,4 I_2 + 30 I_1 + 30 I_2$$

$$75 = 30 I_1 + 30,4 I_2 \dots \dots \dots (2) \checkmark \checkmark$$

$$(1) \times 30,4: \quad 4\,560 = 930,24 I_1 + 9\,12 I_2 \dots \dots \dots (3) \checkmark$$

$$(2) \times 30: \quad 2\,250 = 9\,00 I_1 + 9\,12 I_2 \dots \dots \dots (4) \checkmark$$

$$(3) - (4): \quad 2\,310 = 30,24 I_1$$

$$I_1 = 76,38 \text{ A} \checkmark$$

Substitute I_1 into (1):

$$150 = 30,6 I_1 + 30 I_2$$

$$150 = (30,6 \times 76,38) + 30 I_2$$

$$I_2 = -72,908 \text{ A} \checkmark$$

$$\therefore (I_1 + I_2) = (76,38 - 72,908) = 3,472 \text{ A} \checkmark$$

$$V_L = (I_1 + I_2) R$$

$$= 3,472 \times 30$$

$$= 104,16 \text{ V} \checkmark \checkmark$$

(11)

1.3 Given:

$$R_1 = 120 \, \Omega$$

$$t_1 = 20 \, ^\circ\text{C}$$

$$\alpha_0 = ?$$

$$R_2 = 165 \, \Omega$$

$$t_2 = 45 \, ^\circ\text{C}$$

$$\frac{R_1}{R_2} = \frac{R_0(1 + \alpha_0 t_1)}{R_0(1 + \alpha_0 t_2)}$$

$$\frac{140}{154} = \frac{1 + \alpha_0(18)}{1 + \alpha_0(43)}$$

$$120(1 + 45\alpha_0) = 165(1 + 20\alpha_0) \checkmark$$

$$120 + 5400\alpha_0 = 165 + 3300\alpha_0 \checkmark$$

$$2100\alpha_0 = 45$$

$$\alpha_0 = 0,0214 \checkmark$$

(3)

1.4 1.4.1 The PD across the combination:

$$Q_1 = VC_1 = 120 \times 12 = 1440 \, \mu\text{C} \checkmark$$

$$Q_T = Q_1 + Q_2 = 1440 + 0 = 1440 \, \mu\text{C} \checkmark$$

$$C_T = C_1 + C_2 = 12 + 10 = 22 \, \mu\text{F} \checkmark$$

$$Q_T = Q_1 + Q_2$$

$$1440 = VC_1 + VC_2$$

$$1440 = V(C_1 + C_2)$$

$$1440 = V(22)$$

$$V = 1440/22$$

$$V = 65,45 \, \text{V} \checkmark$$

(4)

1.4.2 $Q_1 = VC_1 = 65,45(12) = 785,4 \, \mu\text{C} \checkmark$

$Q_2 = VC_2 = 65,45(10) = 654,5 \, \mu\text{C} \checkmark$

(2)

[30]

QUESTION 2: DC MACHINES

2.1 Given:

$$\begin{aligned} p &= 3 \\ c &= 2p = 6 \\ I_L &= 60 \text{ A} \\ V &= 250 \text{ V} \\ R_a &= 0,2 \Omega \\ R_{sh} &= 125 \Omega \\ \phi &= 60 \text{ mWb} \\ \text{No. of conductors} &= 820 \end{aligned}$$

$$I_{sh} = \frac{V}{R_{sh}} = \frac{250}{125} = 2 \text{ A} \checkmark$$

$$I_a = I_L + I_{sh} = 60 + 2 = 62 \text{ A} \checkmark$$

$$\begin{aligned} E &= V - I_a R_a \\ &= 250 + (62 \times 0,2) = 262,4 \text{ V} \checkmark \checkmark \end{aligned}$$

$$\begin{aligned} N &= \frac{60Ec}{2Zp\phi} \\ &= \frac{60 \times 262,4 \times 6}{2 \times 820 \times 3 \times 60 \times 10^{-3}} \checkmark \checkmark \\ &= 960 \text{ r/m} \checkmark \end{aligned}$$

(7)

2.2 Given:

$$\begin{aligned} I_L &= I_{se} = 55 \text{ A} \\ V &= 380 \text{ V} \\ R_{se} &= 0,2 \Omega \\ R_{sh} &= 230 \Omega \\ R_a &= 0,18 \Omega \\ E &= 410 \text{ V} \end{aligned}$$

$$E = V + I_a R_a + I_{se} R_{se} + I_a R_b \checkmark$$

$$V_{se} = I_{se} R_{se} = (55)(0,2) = 11 \text{ V} \checkmark$$

$$V_{sh} = V - V_{se} = 380 - 11 = 369 \text{ V} \checkmark$$

$$I_{sh} = \frac{V}{R_{sh}} = \frac{380}{230} = 1,652 \text{ A} \checkmark$$

$$I_a = I_{sh} + I_{se} = 1,652 + 55 = 56,652 \text{ A} \checkmark$$

$$\begin{aligned} I_a R_b &= E - V - I_a R_a - I_{se} R_{se} \\ &= 410 - 380 - (56,652)(0,18) - (55)(0,2) \checkmark \checkmark \\ &= 8,803 \text{ V} \checkmark \end{aligned}$$

2.3 Given:

$$R_{start} = ?$$

$$V = 410 \text{ V}$$

$$P = 15 \text{ kW}$$

$$I_{start} = 1,6 I_{FL}$$

$$R_a = 0,32 \Omega$$

$$I_{FL} = \frac{P}{V} = \frac{15\,000}{410} = 36,585 \text{ A} \checkmark$$

$$I_{start} = 1,6 I_{FL} = 1,6 \times 36,585 = 58,536 \checkmark$$

$$R_T = \frac{V}{I_{start}} = \frac{410}{58,536} = 7,004 \Omega \checkmark$$

$$R_{start} = R_T - R_a = 7,004 - 0,32 = 6,684 \text{ A} \checkmark \checkmark$$

(5)
[20]

QUESTION 3: AC THEORY

3.1 Given:

$$P = ?$$

$$V = 240 \text{ V}$$

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

$$I = 15 \text{ A}$$

$$\cos \phi = 0,8$$

$$P = VI \cos \phi = 240 \times 15 \times 0,8 = 2,880 \text{ kW} \checkmark \checkmark$$

(2)

3.2 Given:

$$N = 3\,600 \text{ r/m}$$

$$\therefore n = \frac{3\,600}{60} = 60 \text{ r/s}$$

$$V_m = 36 \text{ V}$$

$$3.2.1 \quad f = \frac{3\,600}{60} = 60 \text{ Hz}$$

(1)

$$\begin{aligned} 3.2.2 \quad V &= V_m \sin \omega t \\ &= 36 \sin (2 \pi f t) \\ &= 36 \sin (2 \pi \times 60 \times 0,006 \times 57,3) = 25,93 \text{ V} \checkmark \checkmark \end{aligned}$$

(2)

$$\begin{aligned} 3.2.3 \quad V &= V_m \sin \omega t \\ 24 &= 36 \sin (2 \pi \times 60 \times 57,3 t) \checkmark \\ 0,6 &= \sin (21\,601,591 t) \checkmark \\ 21\,601,591 t &= \sin^{-1} 0,6 \checkmark \\ t &= \frac{\sin^{-1} 0,6}{21\,601,591} = 2,979 \text{ sec} \checkmark \checkmark \end{aligned}$$

3.3 Given:

$$\begin{aligned} R &= 25 \, \Omega \\ L &= 52 \, mH \\ C &= 320 \, \mu F \\ V &= 220 \, V \\ f &= 50 \, Hz \end{aligned}$$

$$\begin{aligned} 3.3.1 \quad X_L &= 2\pi fL = 2\pi \times 50 \times 52 \times 10^{-3} = 16,336 \, \Omega \checkmark \\ X_C &= \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 320 \times 10^{-6}} = 9,947 \, \Omega \checkmark \end{aligned} \quad (2)$$

$$\begin{aligned} 3.3.2 \quad Z^2 &= R^2 + (X_L - X_C)^2 = 25^2 + (9,947 - 16,336)^2 = 584,181 \\ \therefore Z &= 24,169 \, \Omega \checkmark \checkmark \end{aligned}$$

$$I = \frac{V}{Z} = \frac{220}{24,169} = 9,102 \, A \checkmark$$

$$V_R = IR = 9,102 \times 25 = 227,55 \, V \checkmark$$

$$V_L = IX_L = 9,102 \times 16,336 = 148,690 \, V \checkmark$$

$$V_{coll} = V_R^2 + V_L^2 = (227,55)^2 + (148,690)^2 = 271,823 \, V \checkmark \checkmark \quad (7)$$

$$3.3.3 \quad V_C = I_C X_C = 9,102 \times 9,947 = 90,538 \, V \quad (1)$$

[20]

QUESTION 4: TRANSFORMERS

4.1 Given:

$$I_m = 3,220 \, A$$

$$I_c = 1,2 \, A$$

$$4.1.1 \quad I_o = \sqrt{I_m^2 + I_c^2} = \sqrt{(3\,220)^2 + (1,2)^2} = 3,436 \, A \checkmark \checkmark \quad (2)$$

$$4.1.2 \quad \cos \phi_o = \frac{I_c}{I_o} = \frac{1,2}{3,436} = 0,349 \quad (1)$$

$$4.1.3 \quad P_o = VI_o \cos \phi_o = (1\,100)(3,436)(0,349) = 1\,319,080 \, W \checkmark \checkmark \quad (2)$$

4.2 Data:

$$E_1 = 3\,000\text{ V}$$

$$E_2 = 220\text{ V}$$

$$I_0 = 20\text{ A}$$

$$\text{p.f.} = 0,4$$

$$N_1 = 140$$

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

$$\begin{aligned} 4.2.1 \quad E_1 &= 4,44 f \phi_m N_1 \\ 3\,000 &= 4,44 \times 50 \times 140 \phi_m \\ \phi_m &= 96,525\text{ mWb} \checkmark \checkmark \end{aligned} \quad (2)$$

$$4.2.2 \quad P_{\text{loss}} = V_1 I_0 \cos \phi_0 = (3\,000)(20)(0,4) = 24\text{ kW} \quad (1)$$

$$\begin{aligned} 4.2.3 \quad I_c &= \frac{\text{core loss}}{V_p} = \frac{24\,000}{3\,000} = 8\text{ A} \checkmark \\ I_m^2 &= I_0^2 - I_c^2 \\ I_m &= \sqrt{I_0^2 - I_c^2} = \sqrt{20^2 - 8^2} = 18,330\text{ A} \checkmark \end{aligned} \quad (2)$$

[10]

QUESTION 5:

5.1 5.1.1 Data:

$$V = 600\text{ V}$$

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

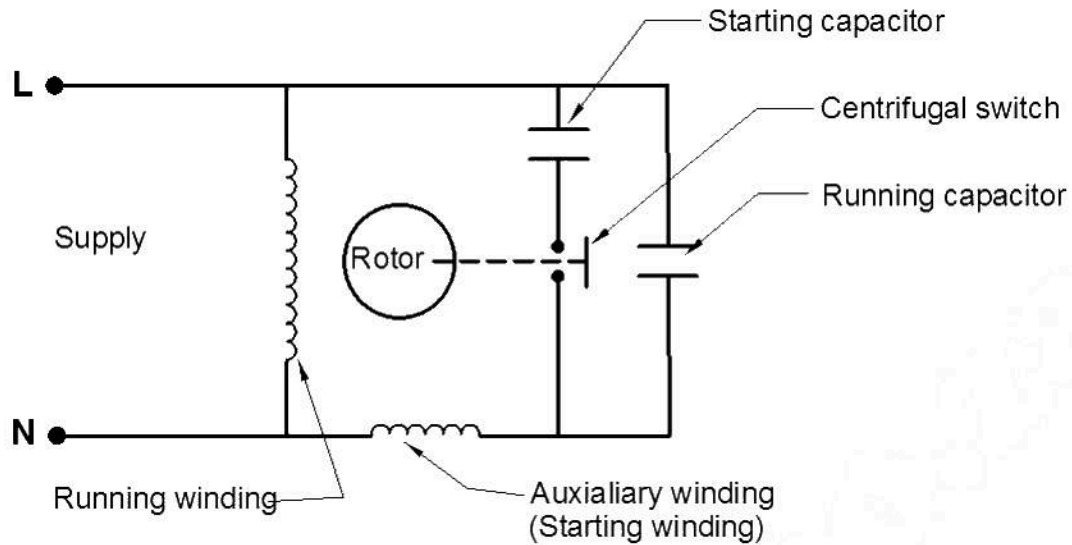
$$N_s = 1\,300\text{ r/m}$$

$$\% \text{ slip} = 0,3$$

$$N_r = N_s(1 - s) = 1\,300(1 - 0,3) = 910\text{ r/min} \checkmark \checkmark$$

$$\begin{aligned} 5.1.2 \quad N_s &= \frac{60f}{p} \\ p &= \frac{60 \times 50}{910} = 3,297 = 3\text{ pole pairs} = 6\text{ poles} \checkmark \checkmark \end{aligned} \quad (2 \times 2) \quad (4)$$

5.2



(Any SIX correct labels)

(6)
[10]

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

- 6.1 A: Coal
B: Boiler/Furnace
C: Steam
D: Turbine
E: Transmission lines

(5)

6.2 Data:

$$R_V = R_T = 700 \, \Omega$$

$$I = 2,5 \, A$$

$$V = 120 \, V$$

6.2.1
$$R_{app} = \frac{V}{I} = \frac{120}{2,5} = 48 \, \Omega$$
 (1)

6.2.2
$$I_V = \frac{V}{R_V} = \frac{120}{700} = 0,171 \, A \checkmark$$

$$R_X = \frac{V}{I - I_T} = \frac{120}{2,5 - 0,171} = 51,524 \, \Omega \checkmark$$
 (2)

6.2.3
$$\% \text{ error} = \frac{R_X - R_{app}}{R_X} = \frac{51,524 - 48}{51,524} = 6,839 \% \checkmark \checkmark$$
 (2)
[10]

TOTAL: 100