Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 11

NOVEMBER 2020

ELECTRICAL TECHNOLOGY: POWER SYSTEMS (EXEMPLAR)

MARKS: **200**

TIME: **3 hours**

This question paper consists of 12 pages, including a formula sheet.

INSTRUCTIONS AND INFORMATION

1. This question paper consists of NINE questions.
2. Sketches and diagrams must be large, neat, and fully labelled.
3. Show ALL calculations and round off answer correctly to TWO decimal places. Show the units for ALL answers of calculations.
4. Number the answers correctly according to the numbering system used in this question paper.
5. You may use a non-programmable calculator.
6. A formula sheet is provided at the end of this question paper.
7. Write neatly and legibly.

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

1.1 Name TWO instances where the user is not required to supply an earth to roofs, gutters, downpipes and wastepipes, on a premise to which electrical energy is supplied. (2)

1.2 Explain how the following environmental factors could impact negatively on a worker in a workshop.

1.2.1 Lack of space (1)

1.2.2 Lighting (1)

1.3 Describe the term *anthropometrics*. (2)
[6]

QUESTION 2: TOOLS AND MEASURING INSTRUMENTS

2.1 What is the purpose of a crimping lug? (1)

2.2 Explain the advantage of a clamp meter over a digital multimeter when measuring current. (2)

2.3 Why is it important to stand aside to allow a grinder wheel to run up to full speed before using it? (2)

2.4 Explain the purpose of a time-base generator in an oscilloscope. (1)
[6]

QUESTION 3: DC MACHINES

3.1 State TWO purposes of the yoke of DC machines. (2)

3.2 Name TWO losses that occur in the iron core of a DC machine. (2)

3.3 Mention TWO disadvantages of DC machines. (2)

3.4 Define *efficiency* in DC machines. (2)

3.5 Draw a neatly, labelled diagram of a compound wound DC machine. (5)

3.6 Explain how an increase in load will affect the speed of a compound wound DC machine. (2)

3.7 A shunt wound machine has armature losses of 425 W and field losses of 225 W. The field circuit resistance is 25 Ω and the output is given as 4 000 W. The rotational losses amount to 300 W.

Given: Armature losses = 425 W
Field losses = 225 W
$R_F = 25\ \Omega$
Output = 4 000 W
Rotational losses = 300 W

Calculate:

3.7.1 The field current (3)

3.7.2 The total losses (3)

3.7.3 The efficiency of the machine (3)

3.8 Explain why series machines are well suited for power tools and automobile starters. (2)
[26]

QUESTION 4: SINGLE-PHASE AC GENERATION

4.1 Define the term *frequency*. (2)

4.2 State the standard operating frequency used in South Africa. (1)

4.3 Mention TWO factors that influence the induced electromotive force during generation. (2)

4.4 Explain the difference between *magnetic lines of flux* and *magnetic flux density.* (2)

4.5 An AC signal has an RMS value of 220 V. The frequency of the wave is 25 kHz.

Given: RMS = 220 V
f = 25 kHz

Calculate:

4.5.1 The maximum value of the waveform (3)

4.5.2 The period of the waveform (3)

4.6 A coil with an area of 2 000 mm^2 is rotated in a magnetic field with a density of 50 mT. It is rotated at 3 000 rpm at right angles to the direction of the flux. The coil has 300 turns.

Given: $A = 2\,000\ mm^2$
$\beta = 50\ mT$
$n = 3\,000\ rpm$
$N = 300\ turns$

Calculate:

4.6.1 The frequency (3)

4.6.2 The maximum EMF generated at right angles to the flux (3)

4.6.3 The instantaneous value of the generated emf at 45° (3)

4.7 Calculate the flux density over an area of 1,5 cm^2, if the total magnetic flux is 20 mWb. (3)
[25]

QUESTION 5: SINGLE-PHASE TRANSFORMERS

5.1 State *Faraday's First Law* of electromagnetic induction. (2)

5.2 Define *magneto motive force (mmf)*. (2)

5.3 Explain why the cores of transformers are constructed using laminations. (2)

5.4 State ONE application of transformers. (1)

5.5 Draw a labelled vector diagram showing the three power components of a transformer. (5)

5.6 Name the TWO basic core constructions used in transformers. (2)

5.7 A circular coil with a circumference of 0,06 m has a magnetic field strength of 8 000 A/m. The coil is wound with 400 turns.

Given: $l = 0{,}06\ m$
$H = 8\,000\ A/m$
$N = 400\ turns$

Calculate:

5.7.1 The magneto motive force (mmf) (3)

5.7.2 The current flowing to create the magnetomotive force (mmf) (3)

5.8 A 20 kVA transformer has a transformer ratio of 50 : 1 and total losses amounting to 800 W. It has a primary voltage of 440 V and 800 turns on the primary winding. The output power at a power factor of 0,901 is 18,02 kW.

Given: $S = 20\ \text{kVA}$
$P_{OUTPUT} = 18{,}02\ \text{kW}$
$\text{T.RATIO} = 50 : 1$
$\text{total losses} = 800\ \text{W}$
$V_P = 440\ \text{V}$
$N_P = 800\ \text{turns}$
$\cos\theta = 0{,}901$

Calculate:

5.8.1 The number of turns on the secondary winding (3)

5.8.2 The primary current (3)
[26]

QUESTION 6: RLC-CIRCUITS

6.1 Mention ONE factor that directly affects the capacitive reactance of an AC circuit with RC components. (1)

6.2 Draw a neatly labelled graph showing the relationship between the inductive reactance and the frequency in an RLC series circuit. (3)

6.3 Study FIGURE 6.3 below and answer the questions that follow.

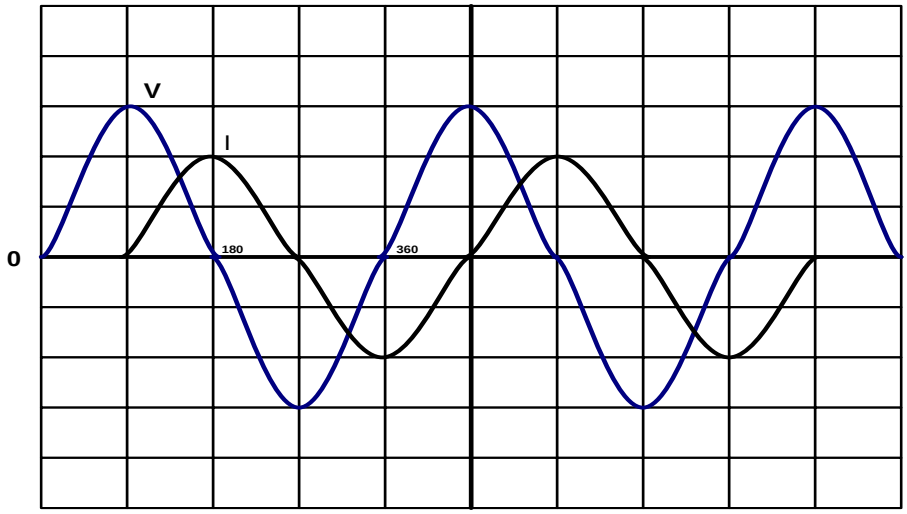

FIGURE 6.3: RL CIRCUIT WAVEFORMS

6.3.1 Describe the relationship between the voltage and the current waveforms. (1)

6.3.2 Explain how an increase in frequency would affect the current waveform. (3)

6.4 Refer to the circuit diagram in FIGURE 6.4 and answer the questions that follow.

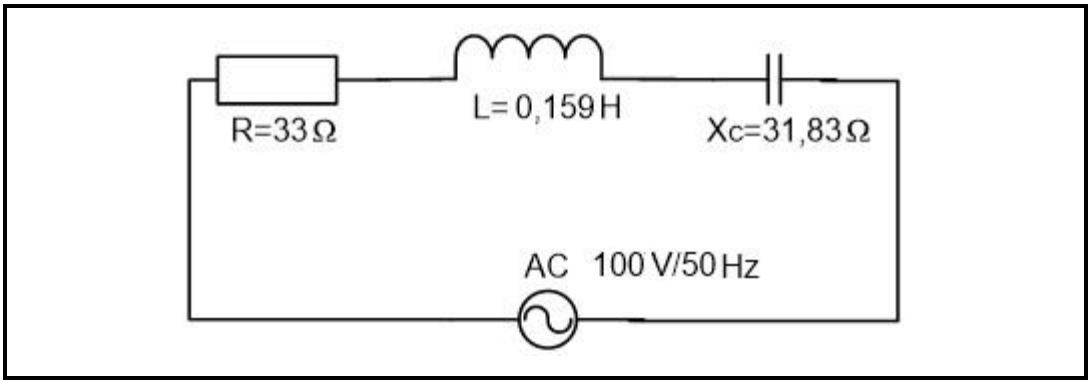

FIGURE 6.4

Given: $R = 33\ \Omega$
$L = 0{,}159\ H$
$X_C = 31{,}83\ \Omega$
$V = 100\ V$
$f = 50\ Hz$

Calculate:

6.4.1 The inductive reactance of the coil (3)

6.4.2 The total impedance of the circuit (3)

6.4.3 The current flowing through the circuit (3)

6.4.4 The value of the capacitor in the circuit (3)
[20]

QUESTION 7: CONTROL DEVICES

7.1 Name the TWO conditions fuses are designed to respond to. (2)

7.2 Explain the function of a no volt coil as used in DOL starters. (3)

7.3 State TWO types of overload relays in use. (2)

7.4 Explain why it is advantageous to use circuit breakers instead of fuses in domestic installations. (2)

7.5 Briefly explain the function of a Direct-On-Line starter. (2)

7.6 Refer to FIGURE 7.6 and explain what happens when the ON button is pushed.

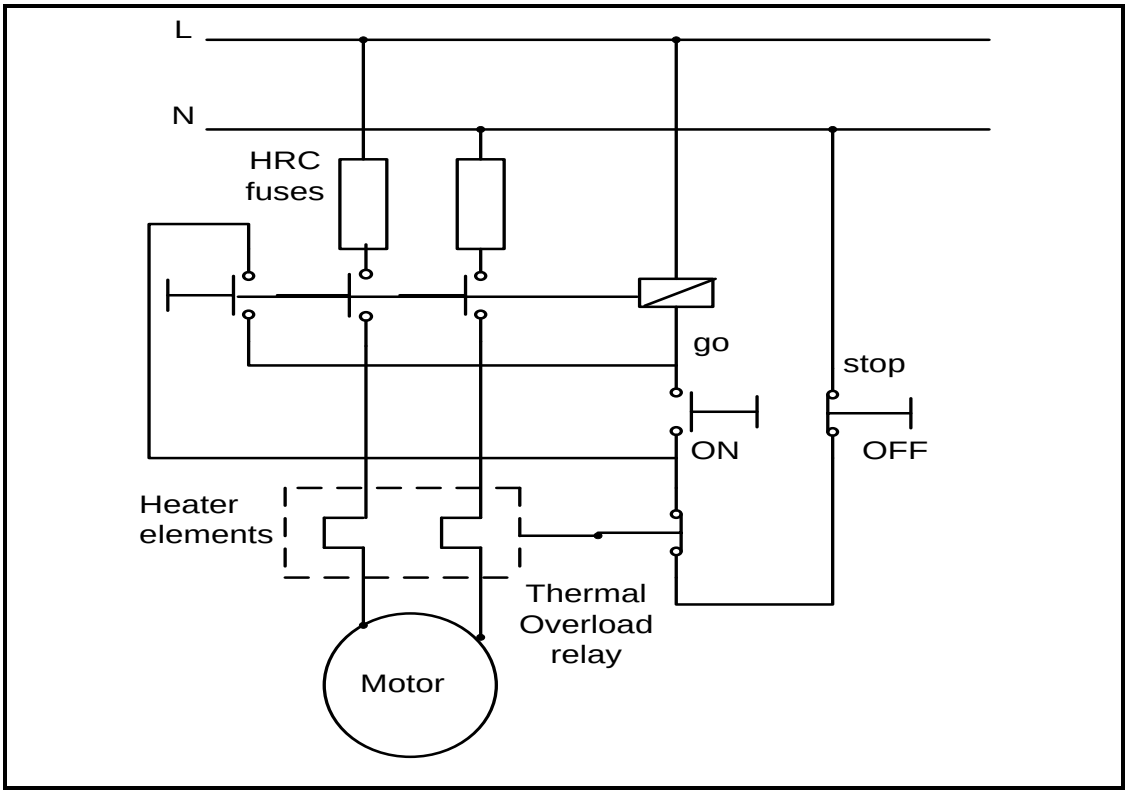

FIGURE 7.6 (4)

7.7 Draw the following ladder diagram logic symbols:

7.7.1 A push-to-make-switch (1)

7.7.2 A normally closed contact (1)

7.8 Explain the following steps of a PLC's scan cycle:

7.8.1 Input scan (2)

7.8.2 Process scan (2)

7.8.3 Output scan (2)

7.9 Name the circuit that makes it possible for an event to remain triggered on, after the activation trigger has been removed. (1)

7.10 Name ONE interconnection system which is used to interconnect and terminate computer systems. (1)

7.11 Refer to FIGURE 7.11 below of the AND logic function and answer the questions that follow.

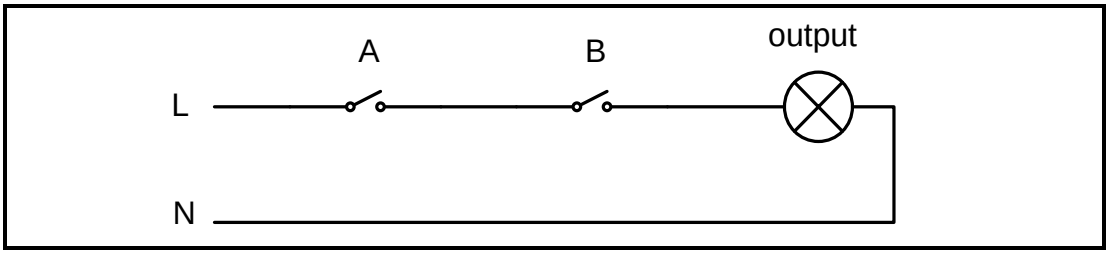

FIGURE 7.11

7.11.1 Draw the logic symbol of the function represented in FIGURE 7.11. (2)

7.11.2 Draw the ladder logic diagram of this circuit. (3)

7.11.3 Redraw and complete the truth table of the logic function represented in your ANSWER BOOK.

A	B	OUTPUT
0	0	
0	1	
1	0	
1	1	

(4)
[34]

QUESTION 8: SINGLE-PHASE MOTORS

8.1 State TWO disadvantages of DC motors when compared to AC motors. (2)

8.2 Mention THREE uses of a universal motor. (3)

8.3 Write down TWO characteristics of a split phase motor. (2)

8.4 Answer the following questions with reference to a capacitor-start, capacitor-run motor:

8.4.1 Mention THREE uses of the capacitor-start, capacitor-run motor. (3)

8.4.2 Explain how the combined capacitance affects this motor. (4)

8.5 Name the TWO main parts of an induction motor. (2)

8.6 Discuss the construction of the following parts of a universal motor:

8.6.1 The field poles (3)

8.6.2 The brushes (3)

8.7 Explain with the aid of the following tests how you would differentiate between the main winding and the start winding of a capacitor-start motor.

8.7.1 Visual test (1)

8.7.2 Continuity test (2)

8.8 Explain fully how you would perform an insulation resistance test between windings and earth, using an insulation tester. (4)

8.9 Explain why it is necessary to test a single-phase motor before it is put into service. (3)

[32]

QUESTION 9: POWER SUPPLIES

9.1 Answer the following questions with reference to a Zener diode.

9.1.1 Draw a labelled circuit symbol. (2)

9.1.2 State TWO unique features of a Zener diode. (2)

9.2 Refer to FIGURE 9.2 of a full wave rectification with centre tap transformer below and answer the questions that follow.

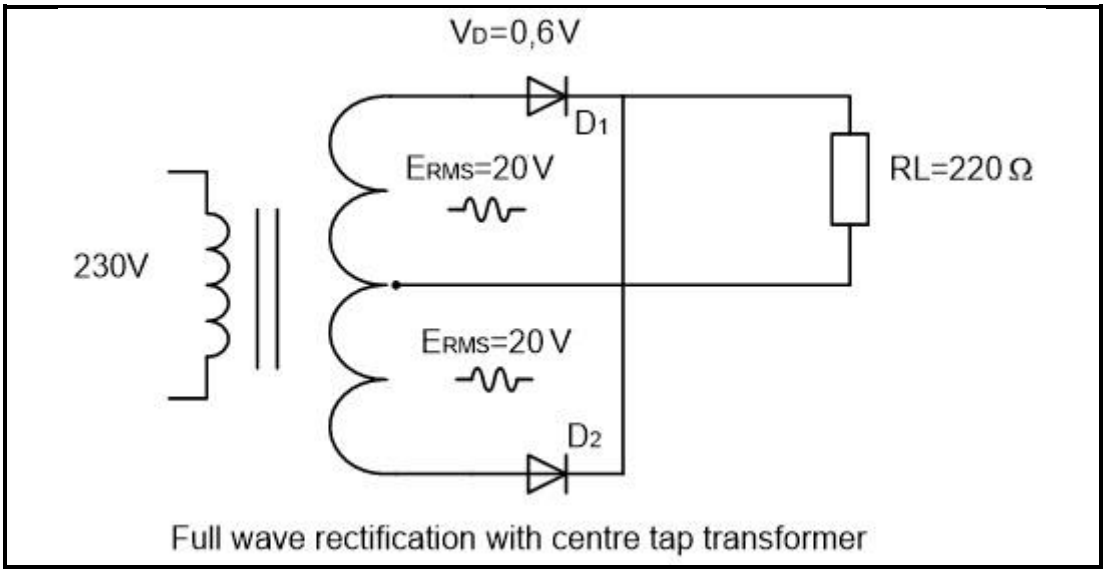

FIGURE 9.2

Calculate:

9.2.1 Determine the peak voltage of each of the secondary half windings (3)

9.2.2 The peak load voltage (3)

9.2.3 The average load voltage (3)

9.2.4 The current drawn by the load (3)

9.2.5 Draw at least two complete waveforms of the voltage across the load resistor. (2)

9.3 Mention TWO types of filter circuits used in power supplies. (2)

9.4 State the purpose of the following components of a standard power supply.

9.4.1 Transformer (1)

9.4.2 Rectifier (1)

9.4.3 Filter (1)

9.4.4 Regulator (1)

9.4.5 Zener diode (1)

[25]

TOTAL: 200

FORMULA SHEET

DC MACHINES

$$\text{Armature losses} = I_{A^2}R_A$$

$$\text{Field losses} = I_{A^2}R_F$$

$$\eta = \frac{\text{output}}{\text{output} + \text{losses}} \times 100$$

$$P_{OUT} = V \times I_L$$

RLC-CIRCUITS

$$X_L = 2\pi fL$$

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

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

SINGLE-PHASE AC GENERATION

$$E = \frac{\Delta\phi}{\Delta T}$$

$$V_{RMS} = V_{MAX} \times 0{,}707$$

$$f = \frac{1}{T}$$

$$V_{MAX} = 2\pi\beta ANn$$

$$v = V_{MAX} \sin\theta$$

POWER SUPPLIES

$$E_{RMS} = E_{PK} \times 0{,}707$$

$$V_{PK} = E_{PK} - V_D$$

$$V_{AVE} = V_{DC} = 0{,}318 \times V_{PK}$$

$$\gamma = \frac{1}{2\sqrt{3}CfR_L}$$

SINGLE-PHASE TRANSFORMERS

$$\text{Transformation ratio} = \frac{N_P}{N_S} = \frac{V_P}{V_S} = \frac{I_S}{I_P}$$