Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 11

NOVEMBER 2022

ELECTRICAL TECHNOLOGY: POWER SYSTEMS (EXEMPLAR)

MARKS: **200**

TIME: **3 hours**

This question paper consists of 16 pages, including a formula sheet.

INSTRUCTIONS AND INFORMATION

1. This question paper consists of TEN 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: MULTIPLE-CHOICE QUESTIONS

Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.15) in the ANSWER BOOK, for example 1.16 D.

1.1 Ergonomics can be defined as ...

A economically providing earthing to an installation.
B the science of fitting tasks, equipment and the surroundings to the end user to make them more comfortable.
C providing signs in a workshop.
D keeping the floors clean and clear of rubbish, rags and dirt. (1)

1.2 The purpose of a function generator is to …

A generate different types of waveforms as its output across a range of frequencies.
B check the functionality of generators.
C serve as a power supply for oscilloscopes.
D generate electricity for power stations. (1)

1.3 Eddy currents are reduced in the core of DC machines by:

A Manufacturing a solid core for the armature
B Making the core of carbon
C Using compensating windings
D Making the armature of thin laminated steel disks (1)

1.4 Shunt wound DC machines are:

A Constant speed machines
B High torque machines
C Variable speed machines
D A combination of constant speed and high torque (1)

1.5 The standard frequency in South Africa is …

A 60 Hz.
B 110 Hz.
C 50 Hz.
D 220 Hz. (1)

1.6 The graph of an alternating current waveform is a … waveform.

A cosine
B tangent
C sine
D exponential (1)

1.7 Energy is transferred in transformers by …

A mutual inductance.
B electrical connections.
C self-inductance.
D eddy currents. (1)

1.8 Types of iron losses are …

A heat losses and copper losses.
B eddy current losses and hysteresis losses.
C dielectric losses and corrosion.
D stray losses and I^2R losses. (1)

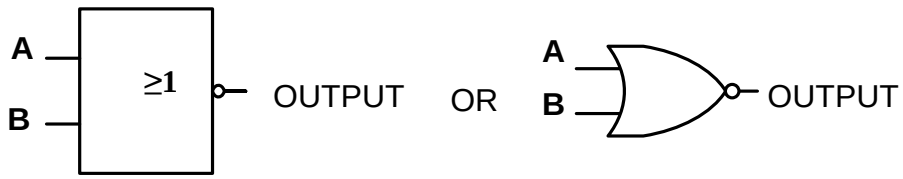
1.9 All phasors rotate in a/an … direction.

A anticlockwise
B clockwise
C linear
D haphazard (1)

1.10 In a capacitive RLC circuit, the …

A voltage leads the current.
B voltage and current are in phase.
C current lags the voltage.
D current leads the voltage. (1)

1.11 The logic symbol below represents:



A A NOR gate
B An OR gate
C An AND gate
D An exclusive OR gate (1)

1.12 A latch makes it possible for a circuit to …

A be isolated from other circuits.
B be reset after operation.
C remain energised after the activation trigger is off.
D be closed. (1)

1.13 The universal motor is a type of electrical motor that …

A works on AC supplies only.
B works on DC supplies only.
C does not need a supply to work.
D can work on both AC and DC supplies. (1)

1.14 When testing the insulation resistance between windings and earth, the reading should be …

A less than 1 MΩ.
B at least 1 MΩ.
C at least 500 V.
D at least 100 Ω. (1)

1.15 The rectifier circuit of a power supply …

A reduces the input AC voltage.
B regulates the output voltage.
C converts the AC voltage to a pulsating DC voltage.
D smooths out the pulsating DC voltage. (1)

[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 State ONE example of each of the following categories of ergonomics in the workplace:

2.1.1 Workplace circumstances (1)

2.1.2 Environmental factors (1)

2.2 Describe how inadequate lighting is considered as an unsafe condition. (2)

2.3 State why it is necessary to wear personal protective clothing in the workplace. (2)

2.4 Explain the purpose of yellow, triangular safety signs. (2)

2.5 Explain why regulations are necessary in the workplace. (2)

[10]

QUESTION 3: TOOLS AND MEASURING INSTRUMENTS

3.1 State the care and maintenance required for a function generator. (3)

3.2 FIGURE 3.2 below represents an oscilloscope which shows two full cycles of a sine wave. The vertical volts per division is set to 5 V/div and the horizontal time per division is set to 2 ms/div.

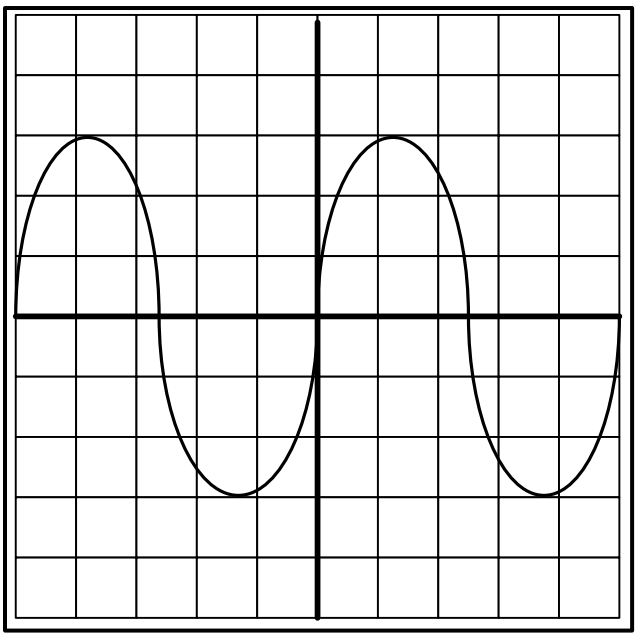


FIGURE 3.2

Given: V/div = 5 V
T/div = 2 ms

Calculate:

3.2.1 The maximum voltage of the waveform (3)

3.2.2 The frequency of the waveform (4)

[10]

QUESTION 4: DC MACHINES

4.1 Briefly explain the main difference between a *generator* and a *motor.* (2)

4.2 State the function of the brushes in DC motors. (1)

4.3 Mention TWO differences stepper motors have when compared to other DC motors. (2)

4.4 Explain why a series motor should not be started without a load. (2)

4.5 Refer to FIGURE 4.5 and answer the questions that follow.

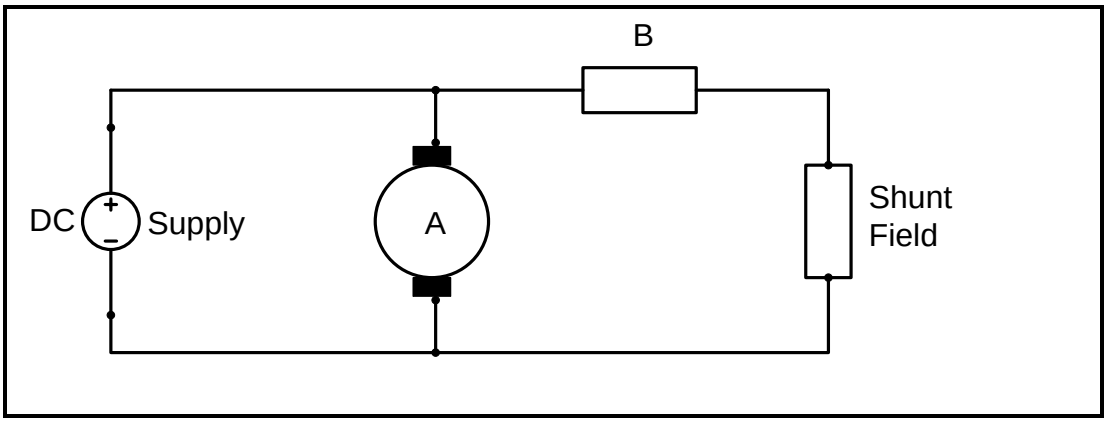


FIGURE 4.5

4.5.1 Identify the motor shown in FIGURE 4.5. (1)

4.5.2 Label the parts marked **A** and **B**. (2)

4.5.3. Describe the characteristics of this motor. (3)

4.5.4 State ONE application of this motor. (1)

4.6 Draw a labelled diagram of a speed-torque characteristic curve of a servo motor. (5)

4.7 Explain how the following components reduce armature reaction:

4.7.1 Compensating windings (3)

4.7.2 Interpoles (3)

[25]

QUESTION 5: SINGLE PHASE AC GENERATION

5.1 Define the following terms:

5.1.1 *Direct current* (1)

5.1.2 *Faraday's Law* (2)

5.1.3 *Fleming's Right-Hand Rule* (4)

5.2 Draw a neat, labelled waveform of an AC voltage signal showing ONE full waveform. Also indicate the maximum voltage, peak-to-peak voltage and the period of the waveform. (4)

5.3 A sine wave has a period of 10 ms. Calculate its frequency.

Given: T = 10 ms (3)

5.4 A meter was used to measure the voltage in an AC circuit. The reading taken was 22,6 V.

Given: V_{RMS} = 22,6 V

Calculate:

5.4.1 The maximum value of the voltage (3)

5.4.2 The average value of the voltage (3)

5.5 A coil with 150 turns and a cross-sectional area of 3 000 mm^2 is rotated in a magnetic field with a flux density of 50 mT. Calculate the instantaneous value 75° after zero if it rotates at 3 000 rpm.

Given: N = 200 turns
A = 3 000 mm^2
β = 50 mT
θ = 75°
n = 3 000 rpm (5)

[25]

QUESTION 6: SINGLE PHASE TRANSFORMERS

6.1 Mention TWO factors that influence the size of the magneto motive force in a coil. (2)

6.2 Briefly discuss the construction of a transformer. (2)

6.3 Explain why the coils of a transformer are wound around a soft iron core. (2)

6.4 State TWO types of iron losses that occur in transformers. (2)

6.5 Fully describe the process that occurs when an AC voltage is connected to the primary side of a transformer. (4)

6.6 A 240 V/32 V transformer has 225 primary turns and a secondary current of 15 A.

Given: $V_P = 240$ V
$V_S = 32$ V
$N_P = 225$ turns
$I_S = 15$ A

Calculate:

6.6.1 The transformer ratio (2)

6.6.2 The rating of the transformer (3)

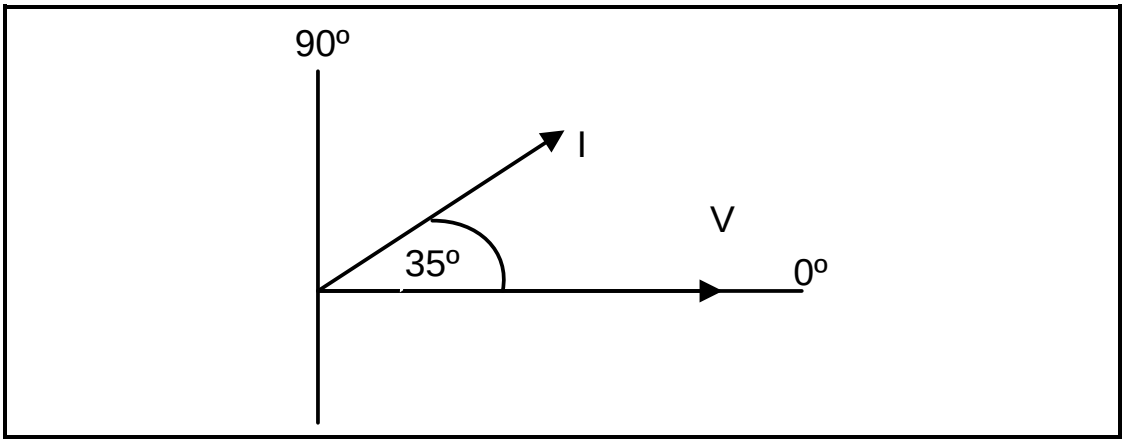
6.6.3 The primary current (3)
[20]

QUESTION 7: RLC CIRCUITS

7.1 State the relationship between the current and the voltage in an AC circuit, when the capacitive reactance is larger than the inductive reactance. (1)

7.2 Explain how an increase in frequency will affect the inductive reactance of a circuit. (1)

7.3 Draw the waveforms which will represent the phasor diagram below.



(2)

7.4 Define the term *power factor*. (2)

7.5 Explain how an increase in frequency will affect the current flow in a RC circuit if the supply voltage remains constant. (3)

7.6 A series RLC circuit has an apparent power of 5 VA and a power factor of 0,75. Determine the true power of the circuit.

Given: $S = 5$ VA
$\cos\theta = 0,75$ (3)

7.7 Refer to the circuit diagram in FIGURE 7.7 and answer the questions that follow.

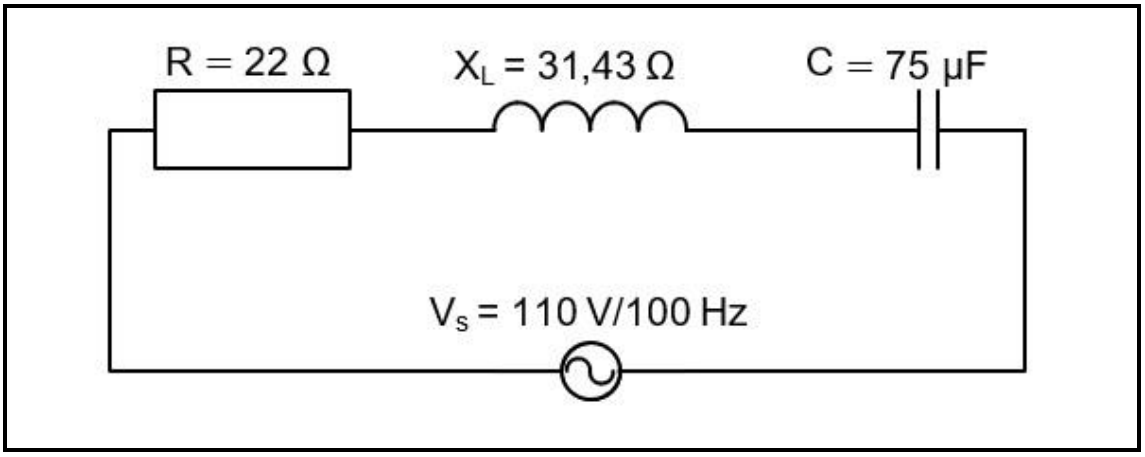


FIGURE 7.7

Given: R = 22 Ω
X_L = 31,43 Ω
C = 75 µF
V_S =110 V
f = 100 Hz

Calculate:

7.7.1 The capacitive reactance (3)

7.7.2 The impedance of the circuit (3)

7.7.3 The current flowing through the circuit (3)

7.7.4 The apparent power (3)

7.7.5 The value of the inductor in the circuit (3)

7.7.6 The power factor if the real power is 400 W (3)
[30]

QUESTION 8: CONTROL DEVICES

8.1 State TWO causes of over-currents. (2)

8.2 Fully explain the purpose of a circuit breaker. (3)

8.3 Answer the following questions with reference to a direct-on-line starter.

8.3.1 State the function of the contactor. (2)

8.3.2 Explain why the start button is a push button switch. (2)

8.3.3 Describe how the circuit remains energized after the start button is released. (2)

8.4 Briefly explain the meaning of software in a PLC. (2)

8.5 Draw the logic symbol of a NOT gate. (2)

8.6 Refer to FIGURE 8.6 and answer the questions that follow.

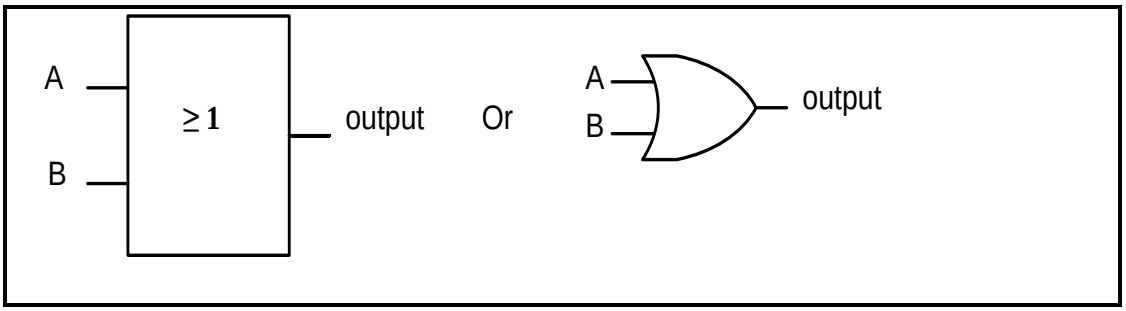


FIGURE 8.6

8.6.1 Identify the logic gate shown in FIGURE 8.6. (1)

8.6.2 Draw the truth table of the logic function in FIGURE 8.6. (4)

8.6.3 Draw the ladder diagram for the logic function in FIGURE 8.6. (3)

8.7 Describe the term *interface cables*. (2)

[25]

QUESTION 9: SINGLE PHASE MOTORS

9.1 Refer to FIGURE 9.1 and answer the questions that follow.

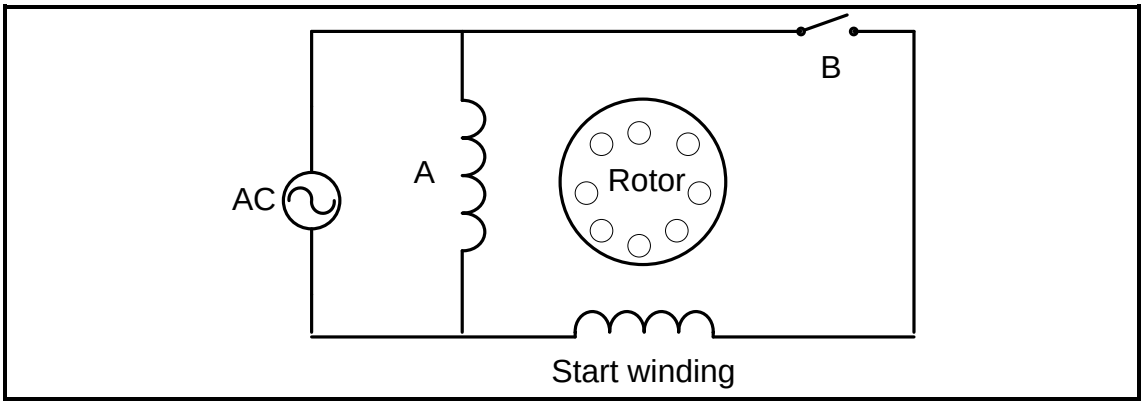


FIGURE 9.1

9.1.1 Identify the single phase motor drawn in FIGURE 9.1. (1)

9.1.2 Label the parts marked **A** and **B**. (2)

9.1.3 State TWO applications of the motor in FIGURE 9.1. (2)

9.1.4 Discuss the construction and purpose of the start winding. (4)

9.1.5 Show by means of labelled phasors what the relationship between the various currents and the applied voltage is. (4)

9.2 State THREE advantages of AC induction motors when compared to DC motors. (3)

9.3 Explain why single phase AC motors are not self starting. (2)

9.4 Explain the reasons why the following tests are performed on motors before they are put into service.

9.4.1 Visual test (2)

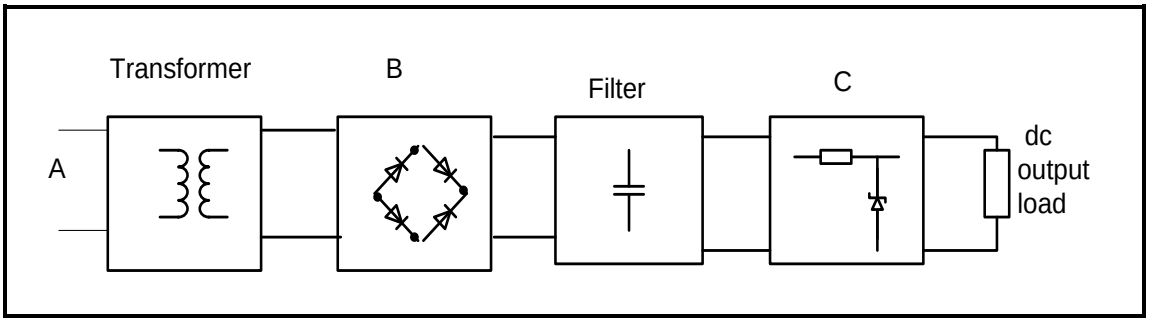
9.4.2 Electrical tests (3)

9.4.3 Mechanical tests (2)

[25]

QUESTION 10: POWER SUPPLIES

10.1 Refer to the block diagram below and answer the questions that follow.



BLOCK DIAGRAM OF A POWER SUPPLY

10.1.1 Label the parts marked **A**, **B** and **C**. (3)

10.1.2 Draw the output waveform after the filter in the power supply. (2)

10.1.3 Describe the function of the zener diode in the part marked **C**. (2)

10.2 Explain what is meant by *forward biasing* in diodes. (3)

10.3 Mention TWO types of circuits used to obtain full wave rectification. (2)

10.4 Calculate the value of the load resistor of a 50 Hz half wave rectifying circuit if it has a ripple factor of 115% when using a capacitor with a value of 100 µF.

Given: f = 50 HZ
γ = 115%
C = 100 μF (3)

[15]

TOTAL: 200

FORMULA SHEET

MEASURING INSTRUMENTS

V_{max} = V/div. × no. of divisions

T = T/div. × no. of divisions

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

RLC-CIRCUITS

$X_L = 2\pi fL$

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

$I_T = I_R = I_L = I_C$

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

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

$\cos\theta = \frac{R}{Z}$ and $\cos\theta = \frac{P}{S}$

SINGLE-PHASE TRANSFORMERS

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

$S = V_P I_P$ or $S = V_S I_S$

SINGLE-PHASE AC GENERATION

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

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

$V_{MAX} = V_{AVE} \times 0{,}637$

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

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

POWER SUPPLIES

Half wave

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

Full wave

$\gamma = \frac{1}{4\sqrt{3}CfR_L}$