Province of the
EASTERN CAPE
EDUCATION

# NATIONAL SENIOR CERTIFICATE

## GRADE 11

## NOVEMBER 2019

# ELECTRICAL TECHNOLOGY: POWER SYSTEMS

**MARKS:** **200**

**TIME:** **3 hours**

*IELTTE1*

This question paper consists of 11 pages including a formula sheet.

## INSTRUCTIONS AND INFORMATION

1. Sketches and diagrams must be large, neat and fully labelled.

2. Show ALL calculations and round off answers correctly to TWO decimal places. Show the units for ALL answers of calculations

3. Number the answers correctly according to the numbering system used in this question paper.

4. You may use a non-programmable calculator.

5. A formula sheet is provided at the end of this question paper.

6. Write neatly and legibly.

## QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

1.1 Describe the term *regulation* with respect to the Occupational Health and Safety Act (OHS). (2)

1.2 Name TWO unsafe acts that may result in an injury in an electrical workshop. (2)

1.3 Explain the term *ergonomics*. (2)
**[6]**

## QUESTION 2: TOOLS AND MEASURING INSTRUMENTS

2.1 Explain TWO purposes of an oscilloscope. (2)

2.2 Describe the purpose of a jigsaw. (2)

2.3 State the maximum distance between the tool rest and the grinding wheel. (1)

2.4 Give ONE advantage of using a power factor meter. (1)
**[6]**

## QUESTION 3: DC MACHINES

3.1 Name TWO types of windings used for the armature in DC machines. (2)

3.2 Briefly discuss the construction of the commutator of a DC machine. (4)

3.3 Refer to FIGURE 3.3 and answer the following questions.

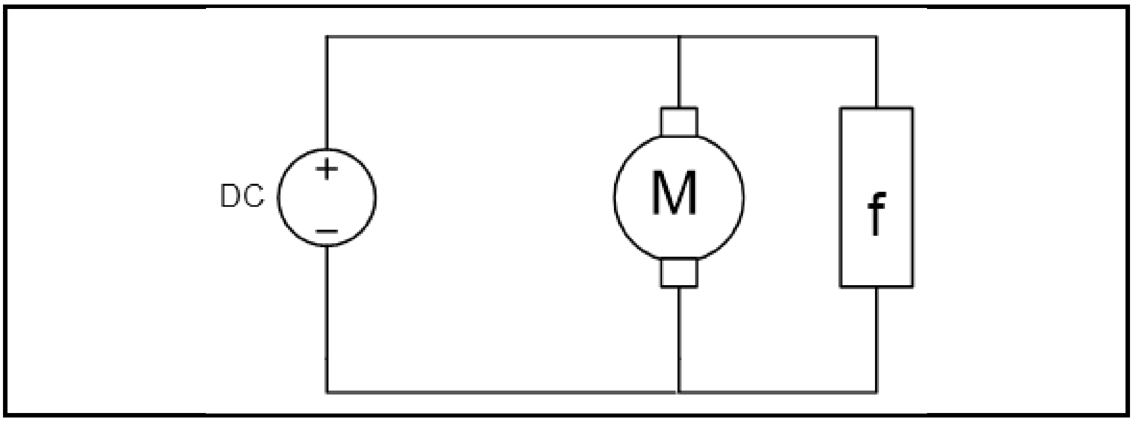



**FIGURE 3.3**

3.3.1 Identify the DC machine. (1)

3.3.2 Discuss how an increase in load will affect the machine. (2)

3.3.3 Redraw the machine with the direction of rotation reversed. (2)

3.3.4 State ONE application of the machine. (1)

3.4 An armature has a resistance of 0,6 Ω and its losses amount to 480 W. The field circuit resistance is 60 Ω and the field current is 2,5 A. The output is given as 3,6 kW and the efficiency is 78, 43%.

Given: $R_A$ = 0,6 Ω
$R_F$ = 60 Ω
Armature losses = 480 W
$I_F$ = 2,5 A
Output = 3,6 kW
$\eta = 78{,}43\%$

Calculate:

3.4.1 The armature current (3)

3.4.2 The field losses (3)

3.4.3 The total losses (3)

3.5 An eight-pole lap wound armature has 50 conductors per path and a terminal voltage of 125 V. Determine the number of parallel paths if the machine was:

3.5.1 Lap wound (2)

3.5.2 Wave wound (1)

3.6 Explain why the armature of a DC machine would be lap wound. (2)

**[26]**

## QUESTION 4: SINGLE-PHASE AC GENERATION

4.1 State TWO reasons why AC is preferred to DC. (2)

4.2 Illustrate the difference between AC and DC by means of waveforms drawn on the same set of axes. (2)

4.3 Mention THREE factors that determine the magnetic field strength of an electromagnet. (3)

4.4 An EMF of 200 mV is induced when a conductor cuts through a magnetic field of 100 mWb. Determine the time taken for the conductor to cut through the magnetic field.

Given: $E = 200\ mV$
$\phi = 100\ mWb$ (3)

4.5 An oscilloscope is used to measure the maximum value and the period time of a voltage waveform. The readings were 12 V and 25 ms respectively.

Given: $\mathrm{V_{MAX}} = 12\ \mathrm{V}$
$\mathrm{T} = 25\ \mathrm{ms}$

Calculate:

4.5.1 The RMS value of the waveform (3)

4.5.2 The frequency of the waveform (3)

4.6 A coil with 150 turns has a cross-sectional area of 60 $cm^2$ and rotates at a frequency of 25 Hz in a magnetic field with a flux density of 0,5 T.

Given: $N = 150 \text{ turns}$
$A = 60 \text{ cm}^2$
$n = 25 \text{ rev/s}$
$\beta = 0{,}5 \text{ T}$

Calculate:

4.6.1 The maximum voltage (3)

4.6.2 The instantaneous value when the coil reaches 68° (3)

4.6.3 The angle in degrees when the instantaneous value reaches 30 V (4)
**[26]**

## QUESTION 5: SINGLE-PHASE TRANSFORMERS

5.1 Define *Lenz's Law* with regard to magnetic induction. (2)

5.2 Name TWO basic forms of construction used for transformer cores. (2)

5.3 Answer the following questions with reference to an auto transformer.

5.3.1 Draw a neat, labelled diagram of a step-down auto transformer connected to its supply and with a load resistor on its secondary side. (5)

5.3.2 State TWO applications of an auto transformer. (2)

5.3.3 Describe how an auto transformer differs from an ideal transformer. (2)

5.3.4 Explain why a transformer will not operate when connected to a DC supply. (3)

5.4 A 220/32 V transformer has 440 turns on the primary side draws a secondary current of 17,19 A.

5.4.1 State whether the transformer is step up or step down. (1)

5.4.2 Calculate the primary current. (3)

5.4.3 Determine the transformation ratio of the transformer. (3)

5.4.4 Explain what could happen if the load connected to the transformer keeps on increasing. (3)
**[26]**

## QUESTION 6: RLC-CIRCUITS

6.1 Define the term *vector*. (1)

6.2 Define the term *impedance*. (2)

6.3 Explain what will happen to the following reactances if the frequency of the supply voltage decreases:

6.3.1 Capacitive reactance (1)

6.3.2 Inductive reactance (1)

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

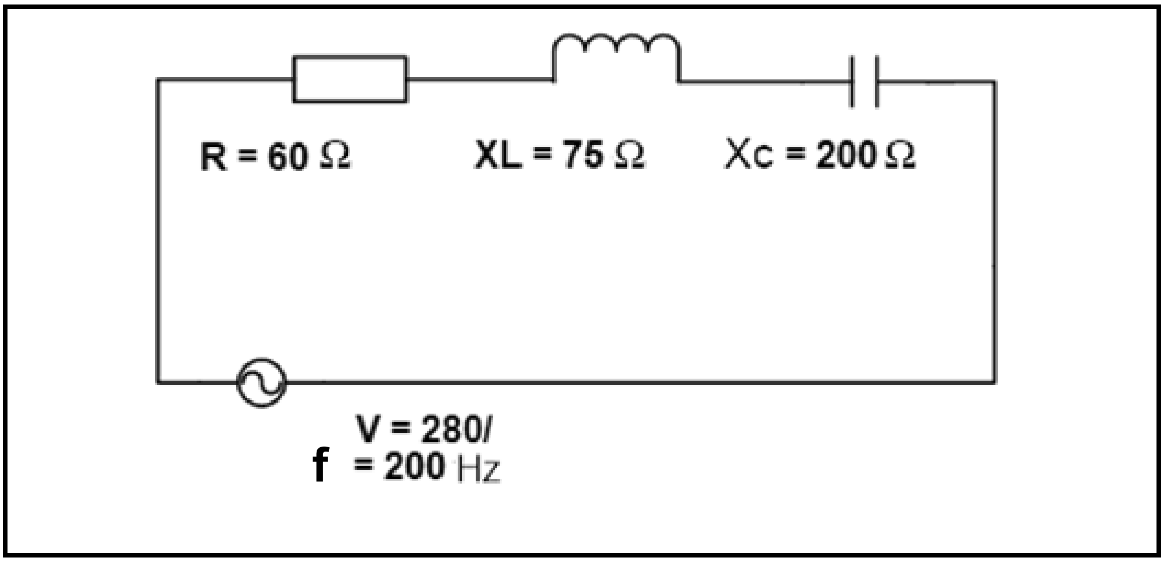



**FIGURE 6.4**

Given: R = 60 Ω
$X_L$ = 175 Ω
$X_C$ = 200 Ω
V = 280 V
f = 200 Hz

Calculate:

6.4.1 The impedance of the circuit (3)

6.4.2 The supply current (3)

6.4.3 The true power (3)

6.4.4 The reactive power (3)

6.4.5 Apparent power (3)
**[20]**

## QUESTION 7: CONTROL DEVICES

7.1 Mention TWO operating factors that large motors need protection against. (2)

7.2 Explain what a motor controller is. (1)

7.3 State TWO actions a motor controller would perform. (2)

7.4 Explain the operation and working principle of an over current sensor. (5)

7.5 State the purpose of the following Direct-on-Line (DOL) starter components:

7.5.1 The contactor (2)

7.5.2 The overload relay (2)

7.6 Draw the symbol used for a start button in a DOL starter. (1)

7.7 Explain why under voltage relays are installed in starters. (3)

7.8 Name the THREE steps of a PLC's scan cycle. (3)

7.9 Refer to FIGURE 7.9 and answer the questions that follow.

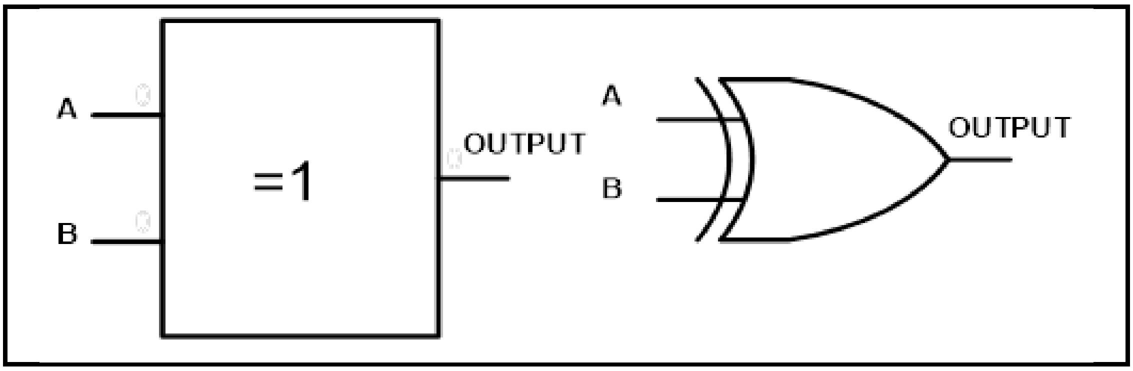



**FIGURE 7.9**

7.9.1 Redraw and complete the truth table of the logic function for FIGURE 7.9 in your ANSWER BOOK.

| A | B | OUTPUT |
|---|---|---|
| 0 | 0 | |
| 0 | 1 | |
| 1 | 0 | |
| 1 | 1 | |

(4)

7.9.2 Draw the ladder logic diagram for this function. (5)

7.10 Explain the purpose of a latch in a circuit. (2)

**[32]**

## QUESTION 8: SINGLE-PHASE MOTORS

8.1 State TWO uses of each of the following motors:

8.1.1 The universal motor (2)

8.1.2 The capacitor-start, capacitor-run motor (2)

8.2 Describe how the split phase system in a split phase motor is obtained. (4)

8.3 Refer to the circuit diagram of the capacitor-start motor in FIGURE 8.3 and answer the following questions.

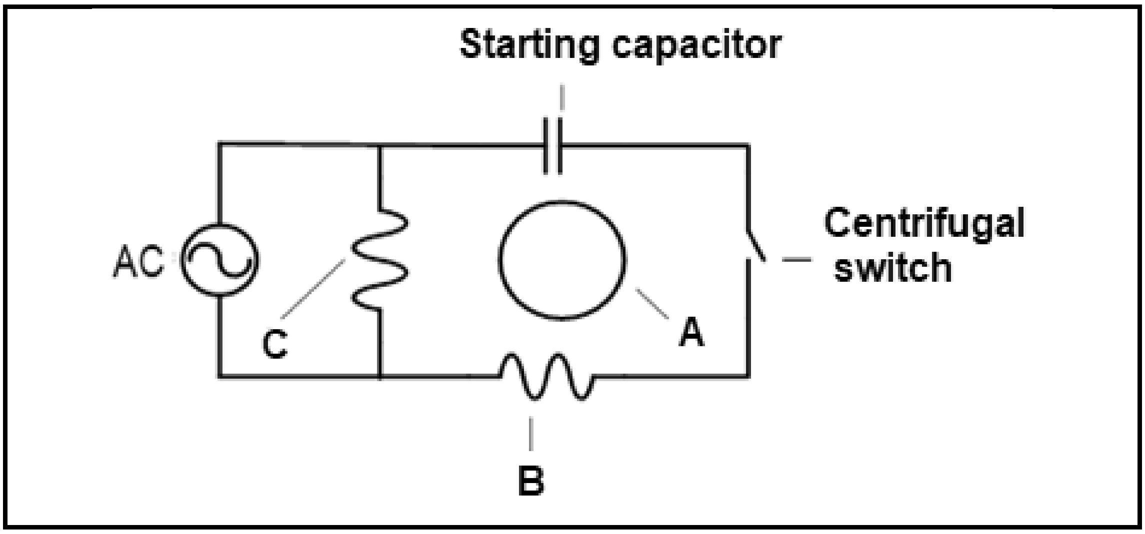



**FIGURE 8.3**

8.3.1 Label the parts marked A–C. (3)

8.3.2 Explain the purpose of the centrifugal switch in the motor. (2)

8.3.3 Fully describe the function of the starting capacitor in the motor. (6)

8.3.4 Draw a labelled phasor diagram indicating the different currents of the capacitor-start motor shown in FIGURE 8.3. (4)

8.4 Explain how the direction of rotation of a split-phase induction motor is changed. (3)

8.5 Discuss the construction of the following parts of an induction motor:

8.5.1 The stator (3)

8.5.2 The rotor (3)
**[32]**

## QUESTION 9: POWER SUPPLIES

9.1 Answer the following questions with reference to a PN-junction diode.

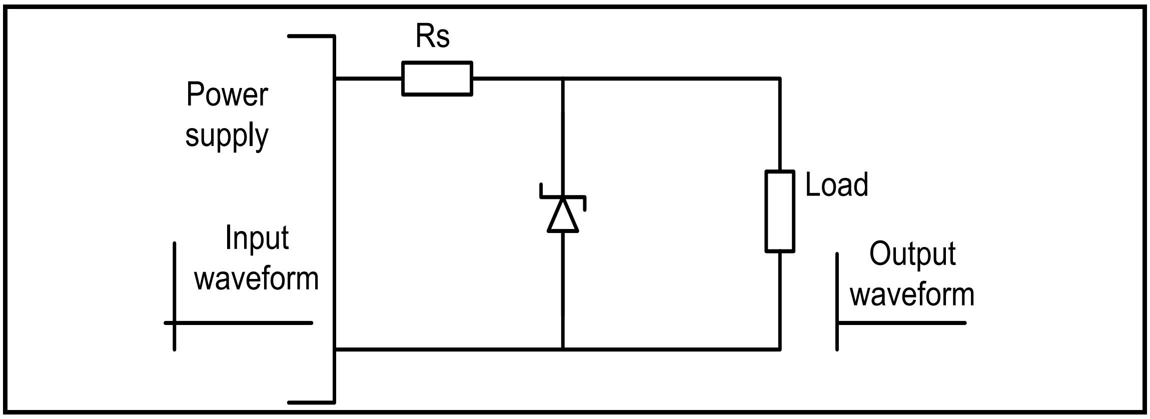
9.1.1 Draw a labelled circuit symbol. (2)

9.1.2 Define the term *doping.* (2)

9.1.3 Draw a labelled electrical characteristic of a silicon diode. (6)

9.2 Explain the difference between a *Zener diode* and a *normal PN-junction diode*. (2)

9.3 Draw the input and output waveforms of the Zener regulator circuit in FIGURE 9.3.




(2)

**FIGURE 9.3**

9.4 Draw a labelled symbol of an NPN transistor. (2)

9.5 A 50 Hz half wave rectifier circuit has a ripple factor of 115, 47% when using a smoothing capacitor working into a resistor load of 50 Ω. Calculate the value of the capacitor in microfarad.

Given: $\gamma = 115{,}47\%$
$R_L = 50\ \Omega$
$f = 50\ \text{Hz}$ (4)

9.6 Draw a fully labelled circuit diagram of a full-wave rectifier circuit using a centre tap transformer with a secondary voltage of 24 $V_{RMS}$ and silicon diodes connected to a 220 Ω load. (5)

9.6.1 What forward breakdown voltage is expected across the diodes? (1)

**[26]**

**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

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