



# basic education

Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

## **NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**ELECTRICAL TECHNOLOGY**

**FEBRUARY/MARCH 2011**

**MARKS: 200**

**TIME: 3 hours**

**This question paper consists of 11 pages and 1 formula sheet.**

**INSTRUCTIONS AND INFORMATION**

1. Answer ALL the questions.
2. Sketches and diagrams must be large, neat and fully labelled.
3. ALL calculations must be shown correctly rounded off to TWO decimal places.
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 legibly and present your work neatly.

**QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT**

- 1.1 Describe ONE positive impact that each of the following technologies has on our society:
- 1.1.1 Electrically-powered vehicles (2)
- 1.1.2 Nuclear-powered stations (2)
- 1.2 Explain why you should not come into direct contact with the blood of an injured person, without adequate protection. (2)
- 1.3 Describe TWO skills that are required of a successful entrepreneur. (4)
- [10]**

**QUESTION 2: TECHNOLOGICAL PROCESS**

Sipho has a spaza shop from where he sells items to community members. Sipho has decided to make use of an electronic remote control locking system to secure his spaza shop when it is closed.

Use your knowledge of the technological process and assist Sipho by answering the questions below.

- 2.1 Name TWO possible sources you will consult when researching the design of Sipho's locking system. (2)
- 2.2 List THREE criteria you will consider when designing the locking system. (3)
- 2.3 Name THREE specifications of the locking system. (3)
- 2.4 Name TWO key elements you will consider when you market Sipho's device to other store owners. (2)
- [10]**

**QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY**

- 3.1 Explain why it is important to have sufficient lighting in an electrical technology workshop. (2)
- 3.2 Name and describe ONE precaution that must be taken before changing the connection of any supply lead (connecting wire), on an electric motor starter circuit. (2)
- 3.3 Name and describe ONE unsafe condition that may lead to an electric shock in an electrical technology workshop. (2)
- 3.4 Name and describe ONE unsafe action that may lead to an electric shock in an electrical technology workshop. (2)
- 3.5 Why is it dangerous to use water to extinguish an electrical fire? (2)
- [10]**

**QUESTION 4: THREE-PHASE AC GENERATION**

- 4.1 The phase voltage of an alternator is 6,35 kV. Calculate the line voltage if the alternator is connected in star.

Given:  $V_P = 6\,350\text{ V}$  (3)

- 4.2 Define the term *apparent power*. (3)

- 4.3 State ONE advantage of three-phase generation over single-phase generation. (1)

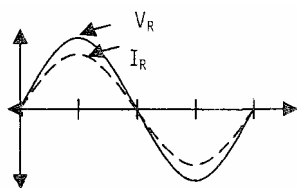
- 4.4 Explain the meaning of the term, a *balanced load*. (2)

- 4.5 State the function of a wattmeter. (1)  
**[10]**

**QUESTION 5: RLC CIRCUITS**

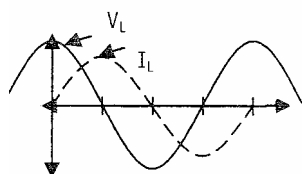
- 5.1 Study the AC wave forms in FIGURE 5.1 below and draw the phasor diagrams that represent each of them.

5.1.1



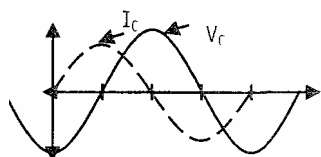
(2)

5.1.2



(2)

5.1.3



(2)

**FIGURE 5.1: AC WAVE FORMS**

- 5.2 A circuit consists of an  $80\ \Omega$  resistor, a pure  $0,4\ \text{H}$  inductor and a  $47\ \mu\text{F}$  capacitor, all connected in parallel across a  $240\ \text{V}$ ,  $50\ \text{Hz}$  supply.

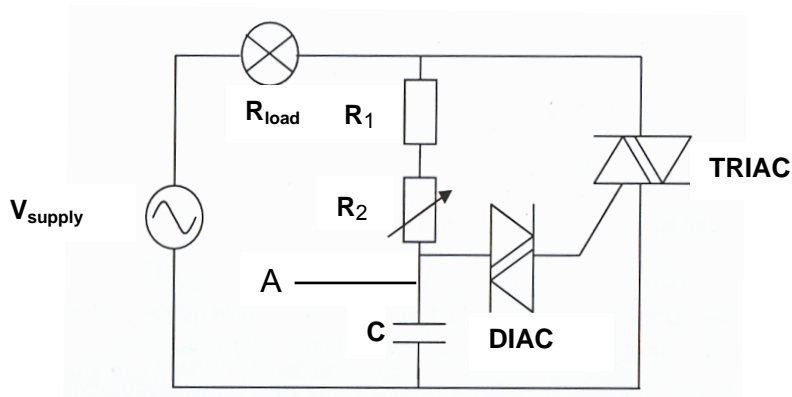
Given:  $R = 80\ \Omega$   
 $L = 0,4\ \text{H}$   
 $C = 47\ \mu\text{F}$   
 $V_s = 240\ \text{V}$   
 $f = 50\ \text{Hz}$

Calculate:

- 5.2.1 The current through the resistor ( $I_R$ ) (3)
- 5.2.2 The inductive reactance ( $X_L$ ) (3)
- 5.2.3 The current through the inductor ( $I_L$ ) (3)
- 5.2.4 The capacitive reactance ( $X_C$ ) (3)
- 5.2.5 The current through the capacitor ( $I_C$ ) (3)
- 5.2.6 The total current drawn from the supply ( $I_T$ ) (3)
- 5.2.7 The impedance of the circuit ( $Z$ ) (3)
- 5.3 If the frequency of the supply connected across an RLC circuit is increased, without any change to the amplitude of the supply, how would this affect the capacitive reactance of the capacitor? Motivate your answer. (3)
- [30]**

**QUESTION 6: SWITCHING AND CONTROL CIRCUITS**

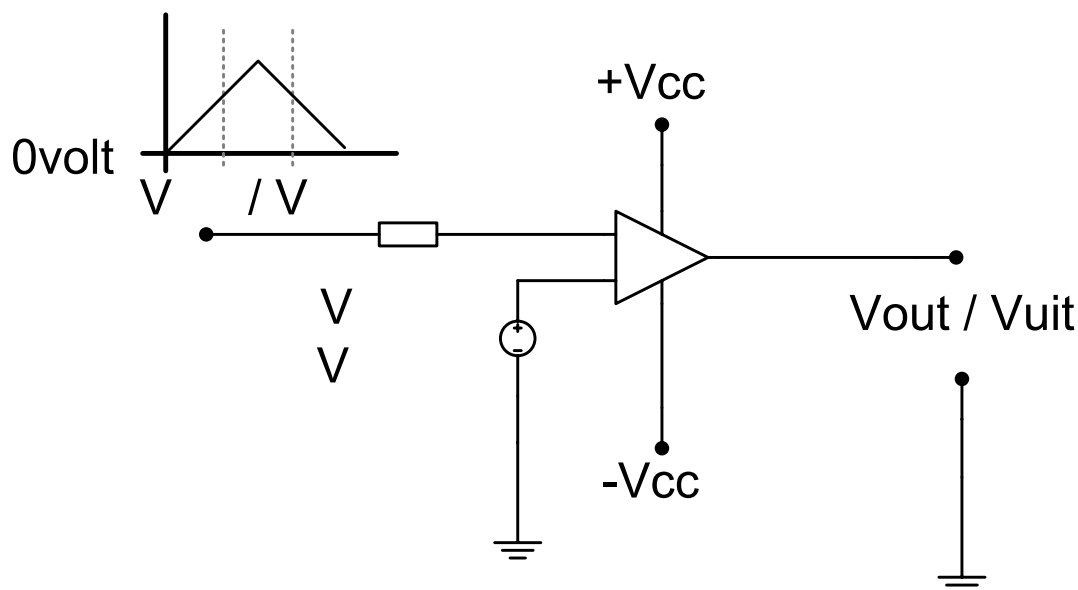
- 6.1 Draw a fully labelled characteristic curve of an SCR (silicon-controlled rectifier). (5)
- 6.2 Describe the operation of an SCR with reference to its characteristic curve. (6)
- 6.3 The lamp dimming circuit in FIGURE 6.1 below is connected to a 240 V, 50 Hz supply.

**FIGURE 6.1: LAMP DIMMING CIRCUIT**

- 6.3.1 If the trigger angle is set to  $60^\circ$ , draw labelled wave forms of the voltage across the lamp and the supply on the same set of axes. Draw ONE full cycle. (4)
- 6.3.2 Explain what will happen to the brightness of the lamp if the value of  $R_2$  is decreased. (3)
- 6.3.3 What is the function of  $R_1$ ? (1)
- 6.3.4 If an open circuit in the RC network occurs at **point A**, will the TRIAC switch on? Give reasons for your answer. (4)
- 6.4 TRIAC devices come in different physical sizes. What determines the physical size of a TRIAC? (2)
- [25]**

**QUESTION 7: AMPLIFIERS**

- 7.1 List THREE characteristics of an ideal operational amplifier. (3)
- 7.2 Draw a fully labelled symbol of an operational amplifier. (5)
- 7.3 With reference to the operational amplifier in FIGURE 7.1 below, answer the questions that follow.

**FIGURE 7.1: OPERATIONAL AMPLIFIER**

- 7.3.1 Name the circuit in FIGURE 7.1. (2)
- 7.3.2 Draw the output wave form with reference to the input wave form. (2)
- 7.3.3 Describe ONE practical application of the circuit in FIGURE 7.1. (3)
- 7.3.4 Explain the working principle of this circuit. (4)
- 7.4 State THREE advantages of negative feedback with reference to amplifiers. (3)
- 7.5 Negative feedback decreases the gain of an amplifier circuit. Is negative feedback in or out of phase with the input of the circuit? Motivate your answer. (3)

**[25]**

reference

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**QUESTION 8: THREE-PHASE TRANSFORMERS**

- 8.1 Name TWO losses that occur in three-phase transformers. (2)
- 8.2 If the secondary circuit of a transformer is open circuit, will current flow in the primary winding of the transformer? Explain your answer. (4)
- 8.3 A three-phase transformer is connected in delta-star. The supply voltage is 11 000 volts and the turns ratio is 46 : 1. The transformer draws 6 amperes at a power factor of 0,84.

Given:  $V_{L(p)} = 11\,000\text{ V}$   
 $N_p : N_s = 46 : 1$   
 $I_{L(p)} = 6\text{ A}$   
 $\cos \theta = 0,84$   
 $\eta = 100\%$

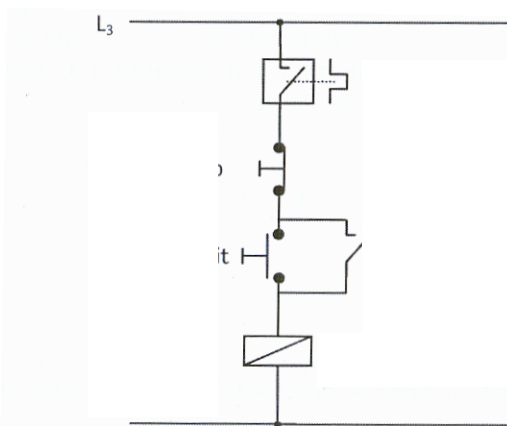
If losses are ignored, calculate at full load the following:

- 8.3.1 Secondary phase voltage (3)
- 8.3.2 The power drawn by the transformer (3)
- 8.3.3 The primary phase current (3)
- [15]**



**QUESTION 9: LOGIC CONCEPTS AND PLCs**

- 9.1 Draw the circuit diagram and ladder diagram symbols of the following:
- 9.1.1 Normally open switch (2)
  - 9.1.2 Normally closed switch (2)
  - 9.1.3 Relay (2)
- 9.2 Describe TWO advantages of programmable logic, when compared to relay logic. (4)
- 9.3 Draw a basic block diagram that illustrates the THREE main working elements of a simple PLC. Label the block diagram. (3)
- 9.4 Give examples of uses for the following terms and devices with reference to the programming of PLCs and the operands used, for example output [Y] can be a light or a buzzer that is used to alert the operator that a process is complete:
- 9.4.1 Timing devices (3)
  - 9.4.2 Counting devices (3)
  - 9.4.3 Internal relays and flag/markers (3)
- 9.5 Draw the ladder logic programme of FIGURE 9.1 below.

**FIGURE 9.1: CONTROL CIRCUIT**

- 9.6 Describe ONE practical application of a PLC and explain how this benefits production. (4)
- 9.7 What is the purpose of the internal memory of the PLC? (2)
- [35]**

**QUESTION 10: THREE-PHASE MOTORS AND CONTROL**

10.1 Basic mechanical and electrical inspections should be carried out on three-phase motors before they are put to use.

10.1.1 State ONE mechanical inspection. (1)

10.1.2 State ONE electrical inspection. (1)

10.2 A three-phase, 12 kW induction motor is connected to a 400 V, 50 Hz supply. The motor is 100% efficient and has a power factor of 0,8.

Given:  $P = 12 \text{ kW}$   
 $V_L = 400 \text{ V}$   
 $f = 50 \text{ Hz}$   
 $\eta = 100\%$   
 $\cos \theta = 0,8$

Calculate:

10.2.1 The current drawn from the supply (3)

10.2.2 The apparent power of the motor (3)

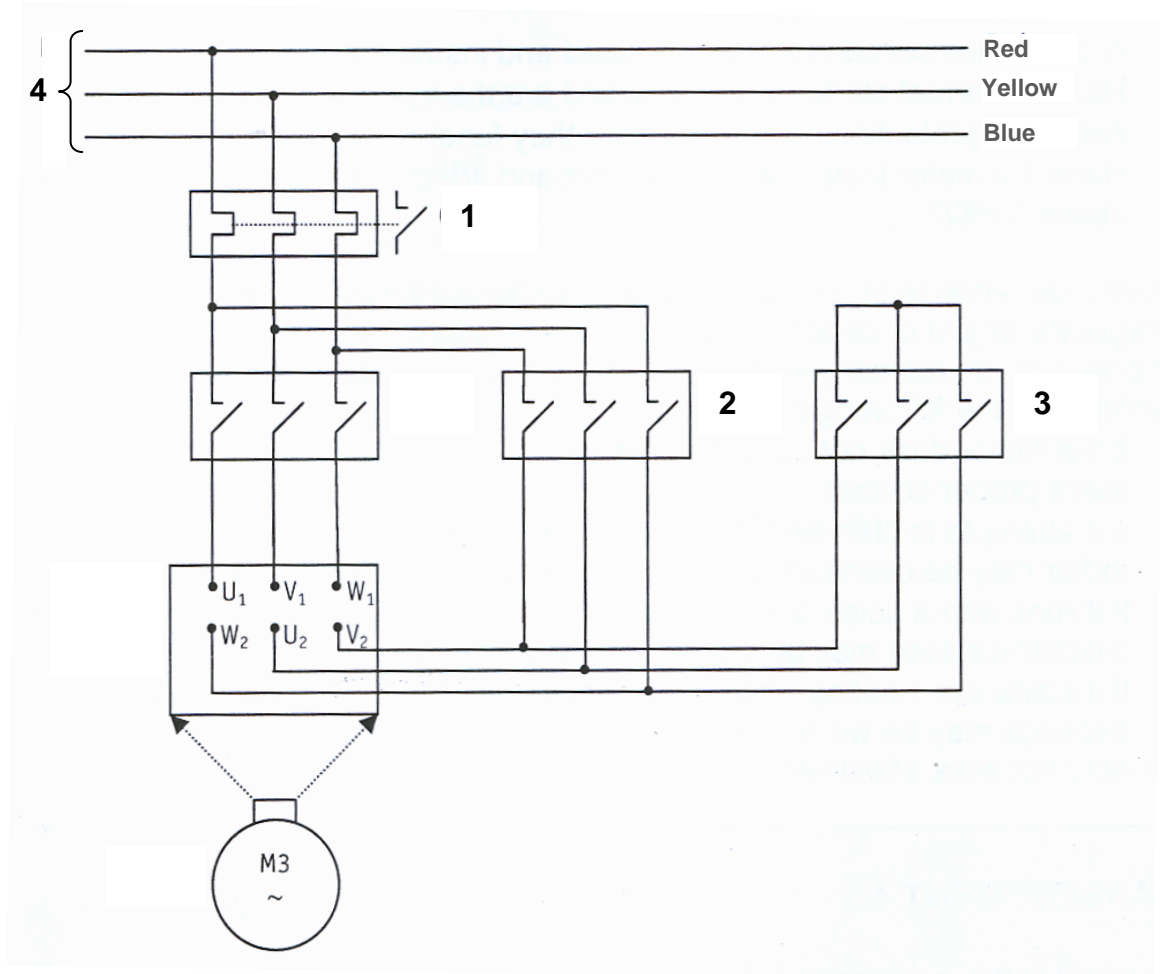
10.3 State, with a reason, what type of power factor a three-phase induction motor has. (3)

10.4 If the power factor of an induction motor is improved after installation, state with a reason, how this will affect the following:

10.4.1 The current drawn by the motor (2)

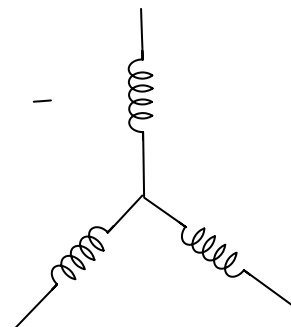
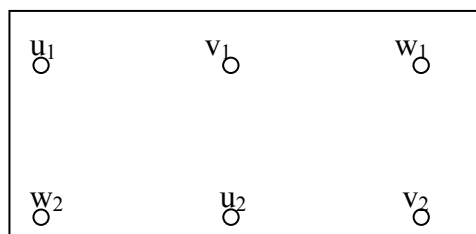
10.4.2 The output power of the motor (2)

- 10.5 With reference to the power circuit of the star-delta starter shown in FIGURE 10.1 below, label 1 to 4.



**FIGURE 10.1: POWER CIRCUIT OF A STAR-DELTA STARTER**

- 10.6 Describe the function of part 1 in FIGURE 10.1. (4)
- 10.7 On which motor is a star-delta starter used and why? (3)
- 10.8 FIGURE 10.2 below shows the terminal box of a three-phase induction motor. Redraw the terminal box, then draw in the three motor coils and the connections so that the motor is connected in star. (3)



**FIGURE 10.2: TERMINAL BOX OF A THREE-PHASE INDUCTION MOTOR**

(5)  
[30]

**TOTAL: 200**

**FORMULA SHEET**

$$X_L = 2\pi FL$$

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

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

$$I_T = \sqrt{I_R^2 + (I_C \cong I_L)^2}$$

$$V_T = \sqrt{V_R^2 + (V_C \cong V_L)^2}$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$Q = \frac{1}{R} \sqrt{\frac{L}{C}}$$

$$Q = \frac{X_L}{R} = \frac{V_L}{V_R}$$

$$\cos \theta = \frac{I_R}{I_T}$$

$$\cos \theta = \frac{R}{Z}$$

$$\left. \begin{array}{l} P = VI \cos \theta \\ S = VI \\ Q = VI \sin \theta \end{array} \right\} \begin{array}{l} \text{Single phase/} \\ \text{Enkelfase} \end{array}$$

$$V_R = IR$$

$$V_L = IX_L$$

$$V_C = IX_C$$

$$\left. \begin{array}{l} P = \sqrt{3} V_L I_L \cos \theta \\ S = \sqrt{3} V_L I_L \\ Q = \sqrt{3} V_L I_L \sin \theta \end{array} \right\} \begin{array}{l} \text{Three phase/} \\ \text{Driefase} \end{array}$$

$$\left. \begin{array}{l} V_L = V_{ph} \\ I_L = \sqrt{3} I_{ph} \end{array} \right\} \text{Delta}$$

$$\left. \begin{array}{l} V_L = \sqrt{3} V_{ph} \\ I_L = I_{ph} \end{array} \right\} \text{Star/Ster}$$

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

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$$

$$\beta = \frac{I_c}{I_b}$$

$$I_b = I_e - I_c$$

