Province of the
EASTERN CAPE
EDUCATION

**NATIONAL
SENIOR CERTIFICATE**

GRADE 11

NOVEMBER 2020

**ELECTRICAL TECHNOLOGY: POWER SYSTEMS
MARKING GUIDELINE
(EXEMPLAR)**

MARKS: 200

INSTRUCTIONS TO MARKERS

1.   All questions with multiple answers imply that any relevant, acceptable answer should be considered.

2.   Calculations:

   2.1   All calculations must show the formulae.

   2.2   Substitution of values must be done correctly.

   2.3   All answers MUST contain the correct unit to be considered.

   2.4   Alternative methods must be considered, provided that the correct answer is obtained.

   2.5   Where an incorrect answer could be carried over to the next step, the first answer will be deemed incorrect. However, should the incorrect answer be carried over correctly, the marker has to re-calculate the values using the incorrect answer from the first calculation. If correctly used, the candidate should receive the full marks for subsequent calculations.

   2.6   Markers should consider that candidates' answers may deviate slightly from the marking guideline depending on how and where in the calculation rounding off was used.

3.   These marking guidelines are only a guide with model answers.

4.   Alternative interpretations must be considered and marked on merit. However, this principle should be applied consistently throughout the marking session.

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

1.1 Where the operating voltage does not exceed 50 V. ✓
Roofs, gutters, downpipes, and wastepipes made of non-conductive material.
On premises which receive electricity by means of underground service connections. ✓
All metallic parts that are not part of the electrical circuit, that can become live, have an insulated covering. (2)

1.2 1.2.1 Lack of space can lead to chances of mistakes or even injury. ✓ (1)

1.2.2 Incorrect lighting can lead to eye strain. ✓ (1)

1.3 It is the study of the human body ✓ and its movement. ✓ (2)
**[6]**

QUESTION 2: TOOLS AND MEASURING INSTRUMENTS

2.1 A crimping lug offers a quick and permanent solution of terminating a cable. ✓ (1)

2.2 The clamp meter is safer and easier to use ✓ because there is no need to connect to the circuit to make measurements. ✓ (2)

2.3 This is the time the bonding of the wheel is liable to disengage and break apart. ✓ Therefore, it is not safe to be standing in the direct path of any pieces that may be thrown out by centrifugal force. ✓ (2)

2.4 The time base generator generates the internal saw tooth waveform to control the horizontal sweep of the trace. ✓ (1)
[6]

QUESTION 3: DC MACHINES

3.1 • Provides protection from moisture, dust, etc. to the rotating and other parts of the machine. ✓
• The iron body provides the path for the flux to complete the magnetic circuit. ✓
• It provides mechanical support for the field poles. (2)

3.2 • Hysteresis losses ✓
• Eddy current losses ✓ (2)

3.3 • High maintenance ✓
• Large and expensive ✓
• Not suitable for high-speed operation due to the commutator and brushes. (2)

3.4   Efficiency is the ratio ✓ of the useful output power to the total input
power ✓ and is expressed as a percentage.   (2)

3.5

Series field ✓   armature ✓   Shunt field ✓

DC Supply + − ✓

Circuit drawn correct ✓
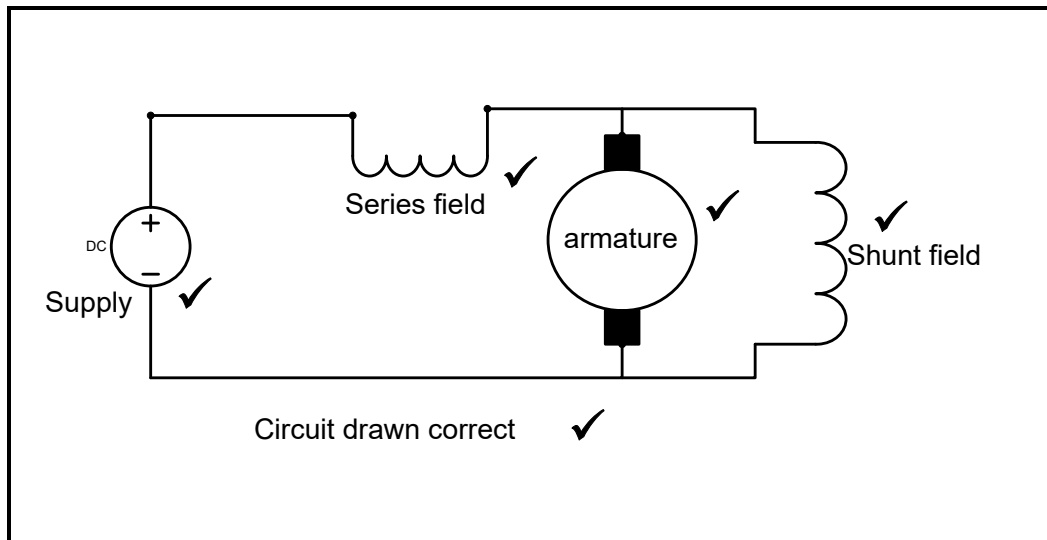
       (5)

3.6   The speed stays virtually constant with an increase in load. ✓ It has the
constant speed of shunt machines and the high starting torque of series
machines. ✓   (2)

3.7   3.7.1 $\text{Field losses} = I_F{}^2 . R_F$

$$I_F = \sqrt{\frac{\text{field losses}}{R_F}} \checkmark$$

$$= \sqrt{\frac{225}{25}} \checkmark$$

$$= 3 \text{ A} \checkmark$$

       (3)

   3.7.2 $\text{Total losses} = \text{copper losses} + \text{rotational losses} \checkmark$

$$= 425 + 225 + 300 \checkmark$$

$$= 950 \text{ W} \checkmark$$

       (3)

   3.7.3 $\eta = \frac{output}{output + losses} \times 100\% \quad \checkmark$

$$= \frac{4\,000}{4000 + 950} \times 100 \quad \checkmark$$

$$= 80{,}81\% \quad \checkmark$$

       (3)

3.8   They have a high starting torque, ✓ which makes them suitable for these
high torque loads. ✓   (2)

       [26]

QUESTION 4: SINGLE-PHASE AC GENERATION

4.1   Frequency is the number of cycles completed ✓ by a loop in one second. ✓   (2)

4.2   50 Hz ✓   (1)

4.3
- The change of magnetic lines of flux. ✓
- The time taken for the change of flux. ✓   (2)

4.4   Magnetic flux refers to the magnetic field lines that exist around a magnet. ✓
Magnetic flux density is a measure of the lines of flux which exist in a given area. ✓   (2)

4.5   4.5.1 $V_{RMS} = V_{MAX} \times 0,707$ ✓
$V_{MAX} = \frac{V_{RMS}}{0,707}$ ✓
$= 311,17 \text{ V}$ ✓   (3)

4.5.2 $T = \frac{1}{f}$ ✓
$= \frac{1}{25\,000}$ ✓
$= 4 \times 10^{-5}\text{s} = 40 \text{ μs}$ ✓   (3)

4.6   4.6.1 $f = \frac{\text{revolutions per minute}}{60}$ ✓
$= \frac{3\,000}{60}$ ✓
$= 50 \text{ Hz}$ ✓   (3)

4.6.2 $V_{MAX} = 2\pi\beta AnN$ ✓
$= 2 \times \pi \times 50 \times 10^{-3} \times 2000 \times 10^{-6} \times 50 \times 300$ ✓
$= 9,42 \text{ V}$ ✓   (3)

4.6.3 $v = V_{MAX} \sin \theta$ ✓
$= 9,42 \times \sin 45$ ✓
$= 6,66 \text{ V}$ ✓   (3)

4.7 $\beta = \frac{\emptyset}{A}$ ✓
$= \frac{20 \times 10^{-3}}{1,5 \times 10^{-4}}$ ✓
$= 133,33 \text{ T}$ ✓   (3)

[25]

QUESTION 5: SINGLE-PHASE TRANSFORMERS

5.1   When there is relative movement between a magnetic field and a
       conductor, ✓ then an emf will be induced in the conductor. ✓   (2)

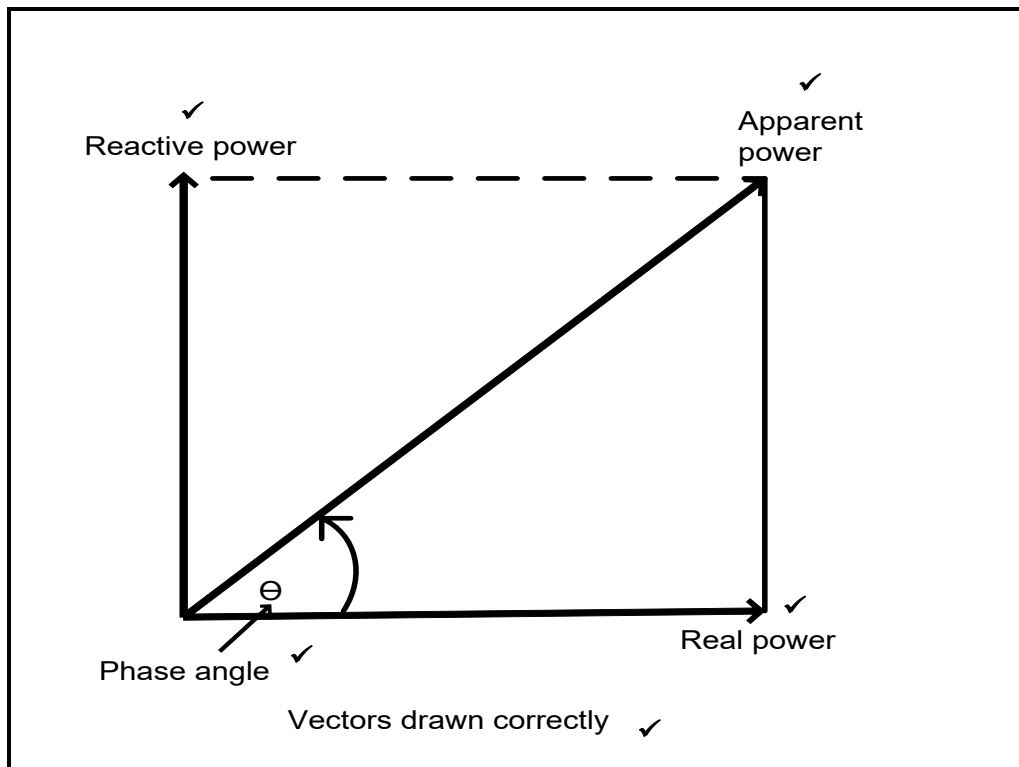5.2   It is a force that develops in a coil ✓ when a current is passed down its
       length. ✓   (2)

5.3   To keep the core losses through eddy currents ✓ down to a minimum. ✓   (2)

5.4   • To raise or lower voltage and current levels in AC circuits. ✓
       • They can prevent DC from passing from one circuit to another.
       • They can be used to isolate two circuits from each other electrically.   (1)

5.5

                                                                            (5)

5.6   • Shell type ✓
       • Closed-core type ✓   (2)

5.7   5.7.1 $F_m = H \times l$ ✓
                $= 8\,000 \times 0{,}06$ ✓
                $= 480$ ampere-turns ✓   (3)

       5.7.2 $F_M = N \times I$
                $I = \dfrac{F_M}{N}$ ✓
                $= \dfrac{480}{400}$ ✓
                $= 1{,}2$ A ✓   (3)

5.8	5.8.1	$\dfrac{N_P}{N_S} = \dfrac{50}{1}$

$N_S = \dfrac{N_P}{50}$	✓

$ = \dfrac{800}{50}$	✓

$ = 16 \text{ turns}$	✓	(3)

5.8.2	$S = V_P I_P$ $\qquad\qquad\qquad\qquad$ $P = V_P I_P \cos\theta$

$I_P = \dfrac{S}{V_P}$	✓	$\qquad\qquad$	$I_P = \dfrac{P}{V_P \cos\theta}$

$ = \dfrac{20\,000}{440}$	✓	**OR**	$ = \dfrac{18\,020}{440 \times 0{,}901}$

$ = 45{,}45 \text{ A}$	✓	$ = 45{,}45 \text{ A}$	(3)

[26]

QUESTION 6: RLC-CIRCUITS

6.1
- The capacitance of the capacitor ✓
- The frequency of the supply   (1)

6.2

(3)
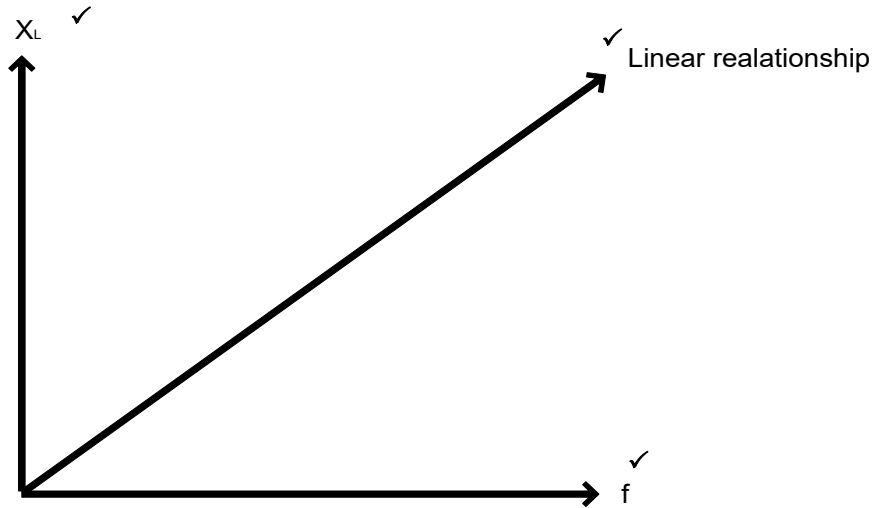
6.3   6.3.1   The current lags the voltage by 90 degrees. ✓   (1)

6.3.2   An increase in frequency causes the inductive reactance to increase. ✓ This will cause the impedance to increase ✓and the maximum value of the current waveform to decrease. ✓   (3)

6.4   6.4.1 $X_L = 2\pi fL$ ✓
$= 2 \times \pi \times 50 \times 0,159$ ✓
$= 49,95\ \Omega$ ✓   (3)

6.4.2 $Z = \sqrt{R^2 + (X_L - X_C)^2}$ ✓
$= \sqrt{33^2 + (49,95 - 31,83)^2}$ ✓
$= 37,65\ \Omega$ ✓   (3)

6.4.3 $I = \dfrac{V}{Z}$ ✓
$= \dfrac{100}{37,65}$ ✓
$= 2,66\ A$ ✓   (3)

6.4.4 $X_C = \dfrac{1}{2\pi fC}$
$C = \dfrac{1}{2\pi fC}$ ✓
$= \dfrac{1}{2 \times \pi \times 50 \times 31,83}$ ✓
$= 1 \times 10^{-4}\ F = 100\ \mu F$ ✓   (3)

[20]

QUESTION 7: CONTROL DEVICES

7.1   • Overload conditions ✓
        • Short circuit conditions ✓   (2)
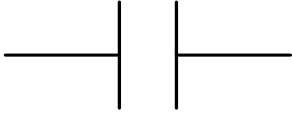
7.2   It does not allow motors to self start after a power outage, ✓ to prevent
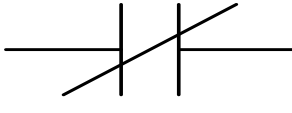   serious injuries ✓ or damage to equipment. ✓   (3)

7.3   • Thermal relay ✓
        • Magnetic relay ✓
        • Electronic relay   (2)

7.4   Circuit breakers are safer as they can be reset, ✓ and there is no risk of
        replacing with the incorrect rating as with fuses. ✓   (2)

7.5   This starter acts as a method of switching the motor ON and OFF, ✓ while at
        the same time offering over current and short circuit protection. ✓   (2)

7.6   The relay coil will be energised from the supply main contactor. ✓
        The energised coil produces a magnetic field and the contactor closes. ✓
        The contactor connects the motor to the supply, ✓ and at the same time
        keeps the relay coil energised. ✓   (4)

7.7   7.7.1

                                                    ✓   (1)

        7.7.2

                                                    ✓   (1)

7.8   7.8.1   Sequentially scans all input terminals to see if the conditions are
                ON or OFF in the correct sequence ✓ and reads each condition to
   the input memory. ✓   (2)

        7.8.2   Executes instructions from the input memory in sequential order. ✓
                This execution result will be stored in sequence into the memory. ✓   (2)

        7.8.3   Activates each output according to the conditions stored in the
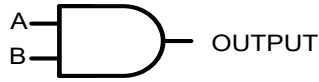   memory, ✓ and the load devices receive the appropriate output. ✓   (2)

7.9   Latching circuit ✓   (1)

7.10   • Twisted-pair cabling ✓
        • Fibre-optic cabling
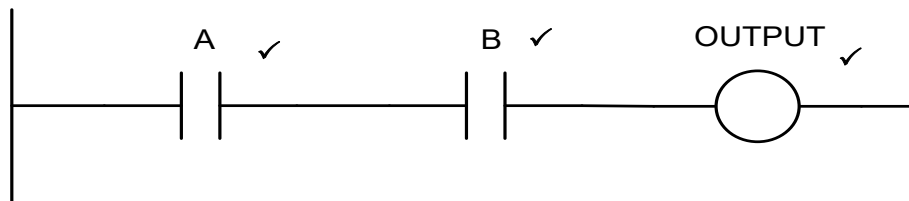   • Parallel communication
        • Serial communication   (1)

7.11   7.11.1
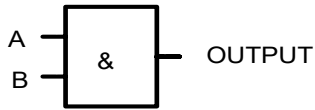
1 Mark for symbol correct ✓
1 mark for labelling ✓

(2)

7.11.2

(3)

7.11.3

A	B	OUTPUT
0	0	0 ✓
0	1	0 ✓
1	0	0 ✓
1	1	1 ✓

(4)

[34]

QUESTION 8: SINGLE-PHASE MOTORS

8.1
- High initial cost ✓
- High operation and maintenance cost due to the brushes and commutator ✓
- Cannot be operated in explosive and hazardous conditions

(2)

8.2
- Electric hand drills ✓
- Vacuum cleaners ✓
- Food mixers ✓
- Sewing machines
- Power tools

(3)

8.3
- Starting torque of 1,5 to 2 times the full load torque ✓
- Low starting current ✓
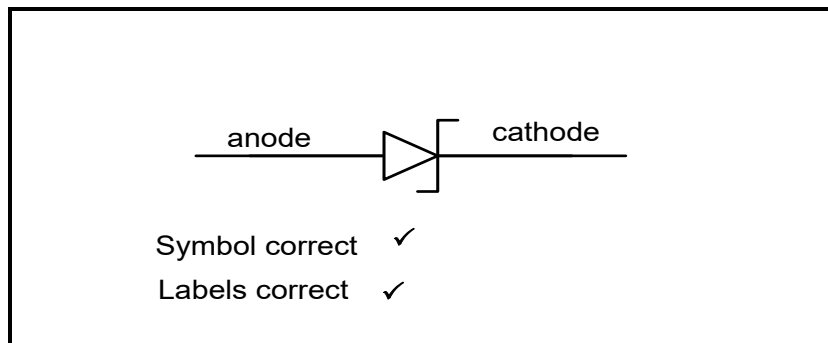- Power ratings of between 60 W and 250 W
- Constant speed motors

(2)

8.4   8.4.1
- Conveyor belt drives ✓
- Power tools ✓
- Washing machines ✓
- Tumble dryers
- Dishwashers
- Vacuum cleaners
- Air conditioners
- Compressors

(3)

8.4.2   On start up it ensures a large starting current ✓ which flows immediately when induced through the rotor, giving it added torque ✓ while at the same time reducing the motor's phase angle ✓ and hence its load demand on the supply. ✓   (4)

8.5
- Stator ✓
- Rotor ✓   (2)

8.6   8.6.1   The field poles are made up of stacks of punched, ✓ laminated sheet metal ✓ with a shape recessed and designed to contain the field coils of the motor. ✓   (3)

     8.6.2   Usually made of carbon ✓ with a tension spring ✓ and flexible connecting wire. ✓   (3)

8.7   8.7.1   The start winding is made of narrower, finer copper conductors. ✓   (1)

     8.7.2   Set the meter to the ohm scale. ✓ The resistance reading of the run winding will be lower than the start winding. ✓   (2)

8.8   Set the meter to the 500 V / MΩ scale. ✓
Take the reading by placing one lead on the earth terminal of the motor and the other on the main winding. ✓
Repeat the process but place the leads on the earth and start winding. ✓
To be acceptable the readings should be at least 1 MΩ. ✓   (4)

8.9   To ensure that the motor is fully operational. ✓ This will prevent unnecessary damage to equipment and assembly lines. ✓ It will also prevent loss of production. ✓   (3)

                                                        [32]

QUESTION 9: POWER SUPPLIES

9.1   9.1.1

        anode   cathode

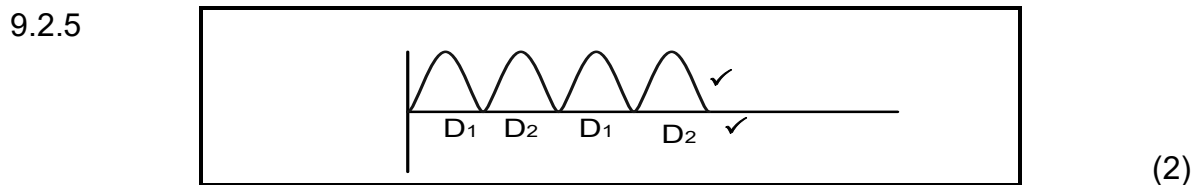   Symbol correct   ✓
        Labels correct   ✓   (2)

     9.1.2   It has a very precise reverse breakdown voltage point. ✓
It maintains the voltage accurately with no change even with rising reverse currents. ✓   (2)

9.2   9.2.1 $E_{RMS} = E_{PK} \times 0{,}707$
$E_{PK} = E_{RMS} \div 0{,}707$ ✓
$= \frac{20}{0{,}707}$ ✓
$= 28{,}29 \text{ V}$ ✓   (3)

       9.2.2 $V_{PK} = E_{PK} - (2 \times V_D)$ ✓
$= 28{,}29 - (2 \times 0{,}6)$ ✓
$= 27{,}09 \text{ V}$ ✓   (3)

       9.2.3 $V_{AVE} = V_{DC} = V_{PK} \times 0{,}636$ ✓
$= 27{,}09 \times 0{,}636$ ✓
$= 17{,}23 \text{ V}$ ✓   (3)

       9.2.4 $I_{DC} = \frac{V_{DC}}{R_L}$ ✓
$= \frac{17{,}23}{220}$ ✓
$= 0{,}07832 \text{ A} = 78{,}32 \text{ mA}$ ✓   (3)

       9.2.5

                (2)

9.3
- π filter ✓
- RC-filter ✓
- LC-filter
- L-filter   (2)

9.4   9.4.1   Steps down the high input AC voltage to a lower AC voltage. ✓   (1)

       9.4.2   Converts the lowered AC voltage into a pulsating DC voltage. ✓   (1)

       9.4.3   Smooths out the pulsating DC voltage. ✓   (1)

       9.4.4   Eliminates any varitions in voltage which are present after filtering. ✓   (1)

       9.4.5   Keeps the output voltage at a fixed value. ✓   (1)

[25]

TOTAL: 200