Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 11

NOVEMBER 2019

ELECTRICAL TECHNOLOGY: POWER SYSTEMS MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 15 pages.

INSTRUCTIONS TO THE 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 Regulations refer in general to the physical conditions of the work environment. ✓ including: thermal requirements, lighting, windows, ventilation, housekeeping, precautions against flooding and fire precautions and evacuation procedures ✓ (2)

1.2 Faulty tools or equipment ✓
Missing guards on machinery ✓
Poor housekeeping ✓
Excessive noise ✓
Poor ventilation ✓
Congestion in the workshop ✓ (Any TWO are correct) (2)

1.3 Ergonomics is the science of fitting task, ✓equipment and surroundings to the end user to make their work more comfortable and to assist in their overall performance. ✓ (2)
[6]

QUESTION 2: TOOLS AND MEASURING INSTRUMENTS

2.1 It is used to present a visual display ✓ of voltage being measured at its inputs. ✓ (2)

2.2 A jigsaw is used for the cutting ✓and shaping of materials ✓ (2)

2.3 Maximum distance between the tool rest and the grinding wheel is 3 mm ✓ (1)

2.4
- Better utilisation of electrical machines ✓
- Better utilisation of electrical lines
- Reduction of losses
- Reduction of harmonics
- Reduction of voltage drops (1)

[6]

QUESTION 3: DC MACHINES

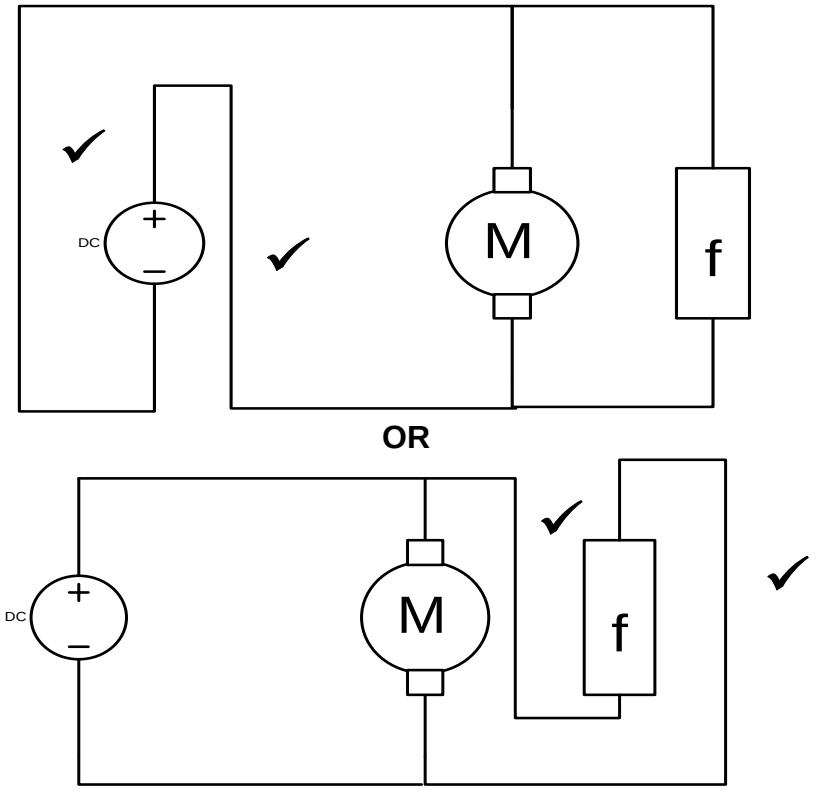
3.1 Lap wound ✓
Wave wound ✓ (2)

3.2 Consists of radial copper segments ✓ separated by an insulating material, usually mica. ✓ It has a cylindrical drum ✓ mounted on the shaft with the armature core. ✓ (4)

3.3 3.3.1 Shunt wound machine ✓ (1)

3.3.2 There will be a decrease in speed ✓ with an increase in load. This is due to the combined effect of the armature resistance and armature reaction. ✓ (2)

3.3.3



(2)

3.3.4
- Lathes ✓
- Drills
- Milling machines
- Planing machines
- Golf cart batteries
- Wheelchair batteries

(1)

3.4 3.4.1 $\text{Armature losses} = I_{A^2} R_A$

$$I_A = \sqrt{\frac{\text{Armature losses}}{R_A}} \checkmark$$

$$= \frac{480}{0,6} \checkmark$$

$$= 28,28 \text{ A} \checkmark \quad (3)$$

3.4.2 $\text{Field losses} = I_{A^2} R_F \checkmark$

$$= (2,5)^2 \times 60 \checkmark$$

$$= 375 \text{ W} \checkmark \quad (3)$$

3.4.3 $\eta = \frac{\text{output}}{\text{output+losses}} \times 100$

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

$$= \frac{100 \times 3600}{78,43} - 3600 \checkmark$$

$$= 990,08 \text{ W} \checkmark \quad (3)$$

3.5 3.5.1 parallel paths = 2p ✓

= 2 x 4 = 8 ✓ (2)

3.5.2 parallel paths = p = 4 ✓ (1)

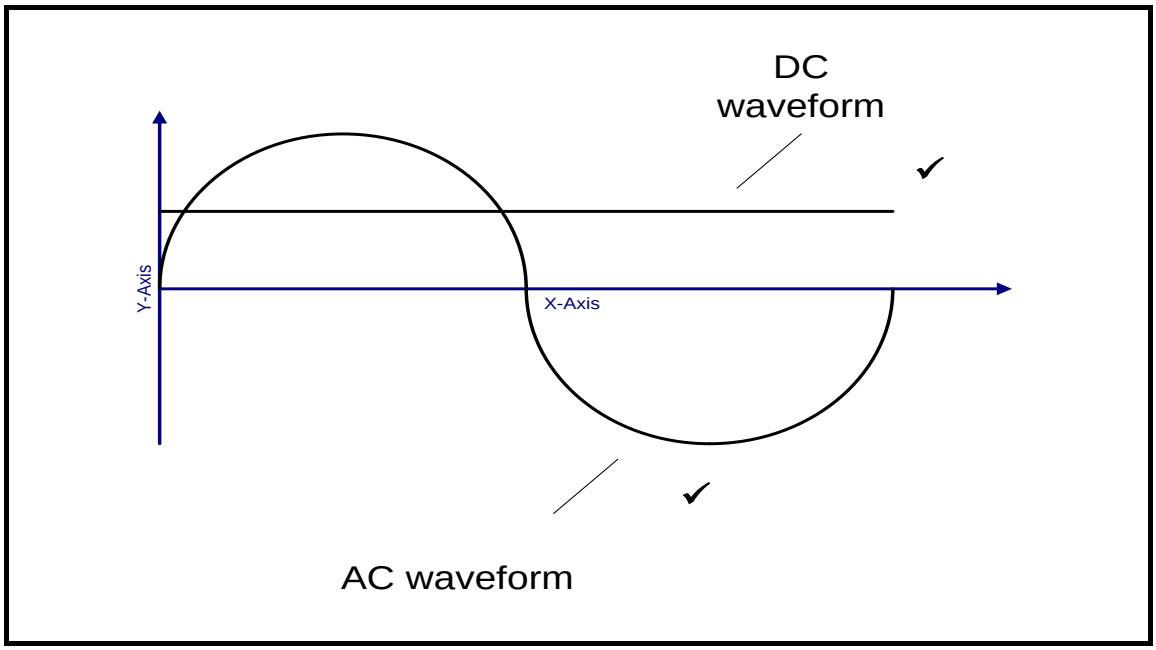
3.6 An armature is lap wound in machines designed for low voltage ✓ and high current. ✓ (2)

[26]

QUESTION 4: SINGLE-PHASE AC GENERATION

4.1 Easily available at wall sockets ✓
Voltage can be stepped up or down ✓
Easy to generate with an AC generator
Can easily be rectified to DC
Can be used as a frequency reference (2)

4.2



(2)

4.3 Number of turns ✓
The current ✓
The length of the core ✓ (3)

4.4 $\mathrm{E} = \frac{\Delta\phi}{\Delta\mathrm{T}}$

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

$= \frac{100\times10^{-3}}{200\times10^{-3}}$ ✓

$= 0{,}5\ \mathrm{s}$ ✓ (3)

4.5.1 $V_{RMS} = V_{MAX} \times 0{,}707$ ✓

$= 12 \times 0{,}707$ ✓

$= 8{,}48\ V$ ✓ (3)

4.5.2 $\mathrm{f} = \frac{1}{\mathrm{T}}$ ✓

$= \frac{1}{25\times10^{-3}}$ ✓

$= 40\ \mathrm{Hz}$ ✓ (3)

4.6 4.6.1 $\mathrm{V_{MAX}} = 2\pi\beta\mathrm{ANn}$ ✓

$= 2\pi \times 0{,}5 \times 60 \times 10^{-4} \times 150 \times 25$ ✓

$= 70{,}69\ \mathrm{V}$ ✓ (3)

4.6.2 $v = V_{MAX} \sin \theta$ ✓
$= 70{,}69 \times \sin 68°$ ✓
$= 65{,}54\ V$ ✓ (3)

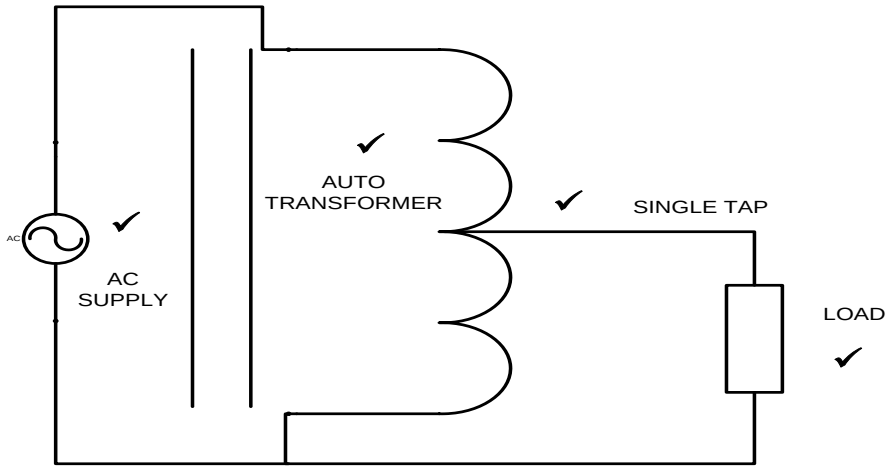
4.6.3 $v = V_{MAX} \sin \theta$
$\sin \theta = \frac{v}{V_{MAX}}$ ✓
$= \frac{30}{70{,}69}$ ✓
$\theta = \sin^{-1}\left(\frac{30}{70{,}69}\right)$ ✓
$= 25{,}11°$ ✓ (4)
[26]

QUESTION 5: SINGLE-PHASE TRANSFORMERS

5.1 When an EMF is generated in a coil, its polarity is always opposite ✓ to the change which produced it. ✓ (2)

5.2 Shell type construction ✓
Closed-core type construction ✓ (2)

5.3 5.3.1



✓ For diagram drawn correctly (5)

5.3.2 Testing and repair of equipment ✓
Hot-wire cutting of styrofoam ✓
Dimming of incandescent lights
Speed control of fans (2)

5.3.3 Auto transformers only have one winding. ✓ The secondary winding is taken as a single tap from the same winding. ✓ (2)

5.3.4 A transformer is a static device (no moving parts). ✓ A DC supply has a constant polarity and cannot produce the changing magnetic field ✓required for electromagnetic induction to take place. ✓ (3)

5.4 5.4.1 A step-down transformer ✓ (1)

5.4.2 $\frac{V_P}{V_S} = \frac{I_S}{I_P}$

$I_P = \frac{V_S \times I_S}{V_P}$ ✓

$= \frac{32 \times 17{,}19}{220}$ ✓

$= 2{,}5\ A$ ✓ (3)

5.4.3 $\text{Transformation ratio} = V_P : V_S$ ✓

$= 220 : 32$ ✓

$= 6{,}88 : 1$ ✓ (3)

5.4.4 When the load increases, the secondary current also increases. ✓ If the increase exceeds the rated current value, the windings will heat due to copper losses ✓ and the winding insulation will eventually be damaged. ✓ (3)

[26]

QUESTION 6: RLC CIRCUITS

6.1 A vector is a line that identifies a quantity that shows both magnitude and direction. ✓ (1)

6.2 It is the total opposition to current flow in an AC circuit ✓ with R, L and C components ✓ (2)

6.3 6.3.1 Capacitive reactance will increase ✓ (1)

6.3.2 Inductive reactance will decrease ✓ (1)

6.4 6.4.1 $Z = \sqrt{R^2 + (X_C - X_L)^2}$ ✓

$Z = \sqrt{60^2 + (200 - 175)^2}$ ✓

$Z = 54{,}54\ \Omega$ ✓ (3)

6.4.2 $IT = \frac{VT}{ZT}$ ✓

$IT = \frac{280}{54.54}$ ✓

$IT = 5{,}134\ A$ ✓ (3)

6.4.3 $P = I^2R$ ✓

$P = 5{,}133^2 \times 60$ ✓

$P =$ 1,580,86 W ✓ (3)

6.4.4 $Pr = I^2 \times (XC - XL)$ ✓

$Pr = 5{,}133^2 \times (200 - 175)$ ✓

$Pr = 658{,}69\ VAR$ ✓ (3)

6.4.5 $P = I^2Z$ ✓

$P = (5{,}133)^2 \times 54{,}54$ ✓

$P = 1437{,}002$ VA ✓ (3)

[20]

QUESTION 7: CONTROL DEVICES

7.1 Bearing failure ✓
Motor overheating ✓
Motor winding failure
Reversing of rotation (2)

7.2 It is a device or circuit that is able to control the performance of an electric motor. ✓ (1)

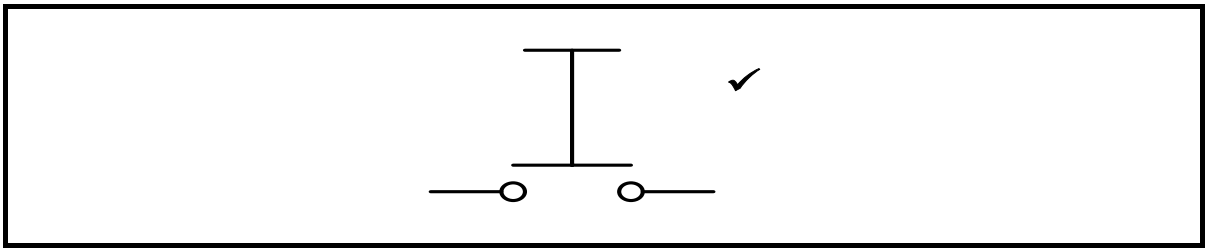
7.3 Examples include: starting, ✓stopping, ✓ controlling direction of rotation and protection. (2)

7.4 The over current sensor is operated by a bi-metallic strip. ✓ As the current increases, it causes the heating element to gradually heat up. ✓ The heating element steadily heats up the bi-metallic strip. ✓ If set correctly, the bi-metallic strip bends to unlatch a mechanism which toggles the circuit breaker to the OFF position. ✓This opens the contacts of the circuit breaker and breaks the circuit. ✓ (5)

7.5 7.5.1 They are electromagnetically operated switches ✓ that provide a safe and convenient means of connecting and interrupting circuits. ✓ (2)

7.5.2 It prevents serious damage to the motor ✓ by disconnecting the supply when the rated current is exceeded. ✓ (2)

7.6



(1)

7.7 To remove the motor from service when a low voltage condition develops. ✓ This stops the motor from drawing excessive currents ✓that could cause damage. ✓ (3)

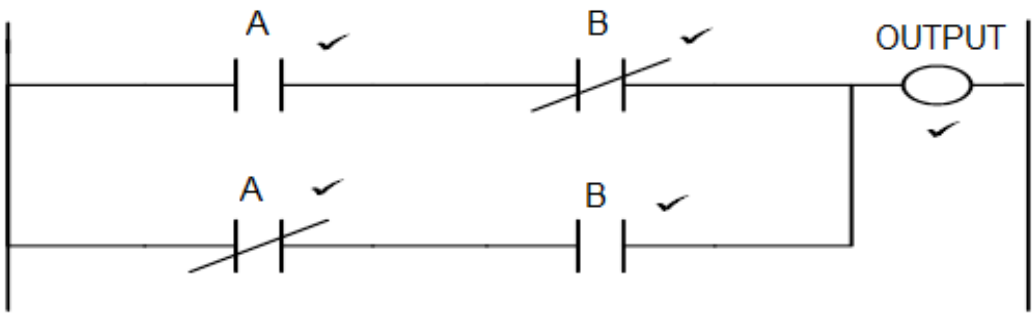
7.8 Input scan ✓
Process scan ✓
Output scan ✓ (3)

7.9 7.9.1

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

(4)

7.9.2



(5)

7.10 A latch makes it possible for an event to remain triggered on ✓ regardless of whether the activating trigger is on or off. ✓ (2)

[32]

QUESTION 8: SINGLE-PHASE MOTORS

8.1 8.1.1 Electric hand drills ✓
Vacuum cleaners ✓
Food mixers
Sewing machines
Power tools (2)

8.1.2 Conveyor belt drives ✓
Power tools ✓
Washing machines
Tumble dryers
Dishwashers
Air conditioners
Compressors (2)

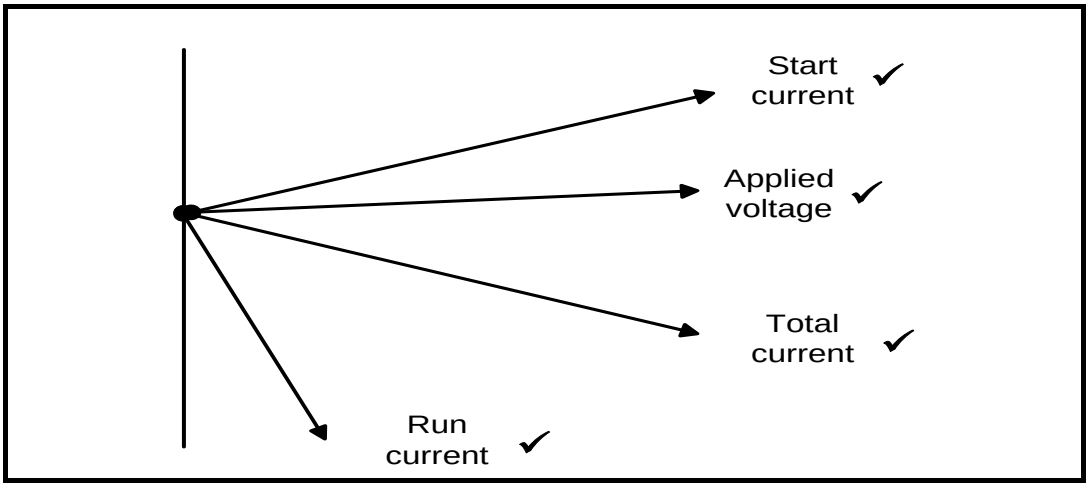
8.2 A start or auxiliary winding is placed at right angles to the main or run winding. ✓ It works only during the short start up period. ✓ To ensure that the phase shift is as wide as possible, the run winding has a low resistance and a high inductance, ✓while the starting winding has a high resistance to reactance ratio. ✓ (4)

8.3.1 A – Rotor ✓
B – Starting winding ✓
C – Run winding ✓ (3)

8.3.2 The centrifugal switch disconnects the starting capacitor and the starting winding from the supply ✓ once the motor reaches 70% of its rated speed. ✓ (2)

8.3.3 The capacitor is added to the start winding to make it have a capacitive reactance. ✓ This advances the current in that branch to lead the applied voltage. ✓ At the same time the run winding is more inductive and lags the voltage. ✓ On switch-on the capacitive part causes a higher initial current to flow. ✓ This instantly develops a strong rising field in its coil. ✓ The rotor responds sooner to the rotating field and rotates with it. ✓ (6)

8.3.4



(4)

8.4 By reversing the connections to either the start winding ✓ or the run winding ✓ but not both. ✓ (3)

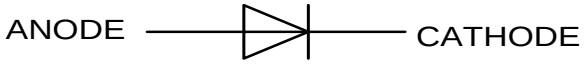
8.5 8.5.1 The stator is wound with a ring of electromagnets arranged around its inner wall. ✓ The coils are wired to produce a constantly rotating magnetic field when powered with an AC supply. ✓ The pole pairs are fixed when the stator is wound in the factory. ✓ (3)

8.5.2 The rotor is made of a number of solid conductive copper or aluminium bars ✓ connected at their ends by copper rings to form a short-circuited hollow cylinder, ✓ all supported by a solid central metal axle. ✓ (3)

[32]

QUESTION 9: POWER SUPPLIES

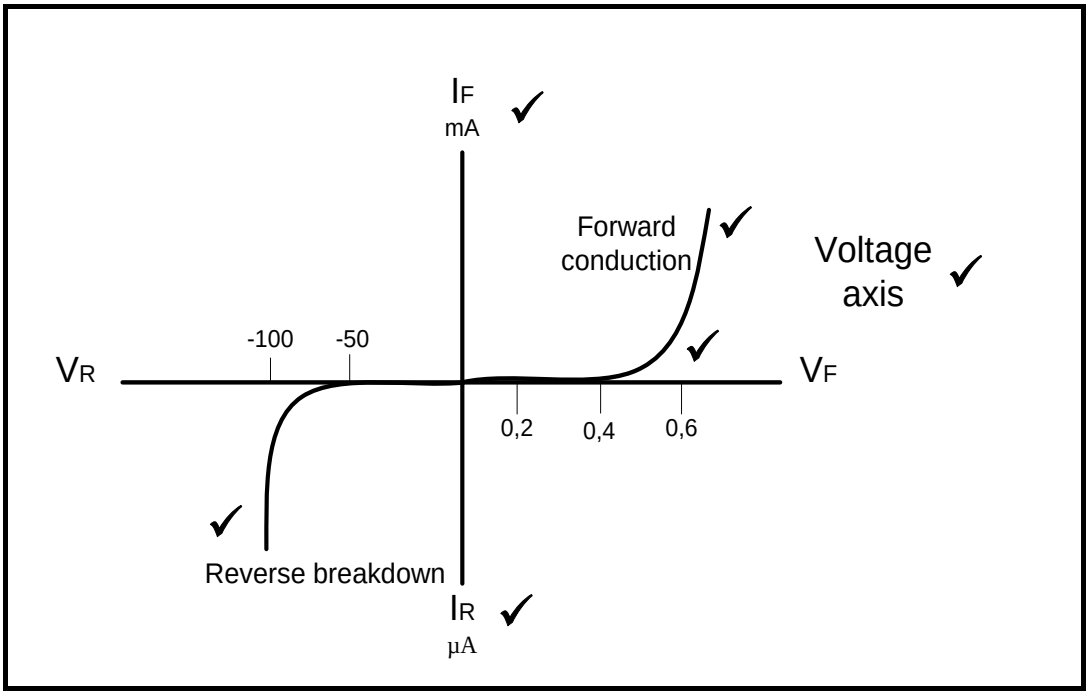
9.1 9.1.1



Symbol correct ✓
Labels correct ✓ (2)

9.1.2 Doping is when an impurity is added to silicon or germanium ✓to manufacture N- or P-type materials. ✓ (2)

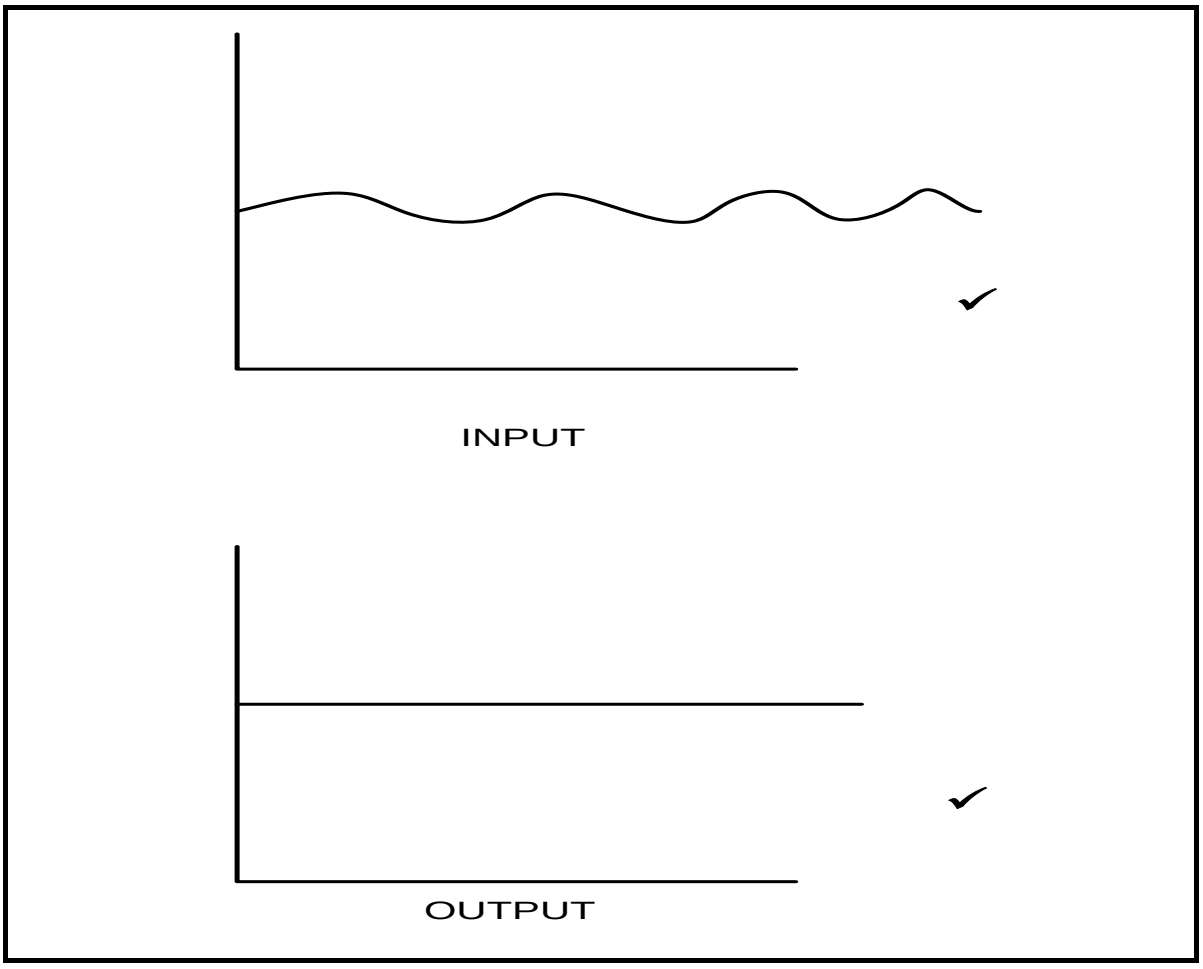
9.1.3



(6)

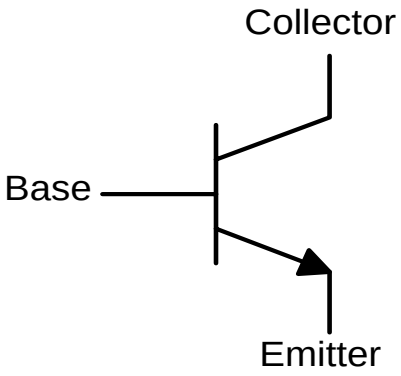
9.2 Unlike normal diodes that are damaged by reverse current flow, ✓ Zener diodes breakdown at a certain reverse voltage and allows current to flow. ✓ (2)

9.3



(2)

9.4



Symbol ✓
Labels ✓ (2)

9.5 $\gamma = \frac{1}{2\sqrt{3}CfR_L}$ ✓

$C = \frac{1}{2\sqrt{3}fR_L\gamma}$

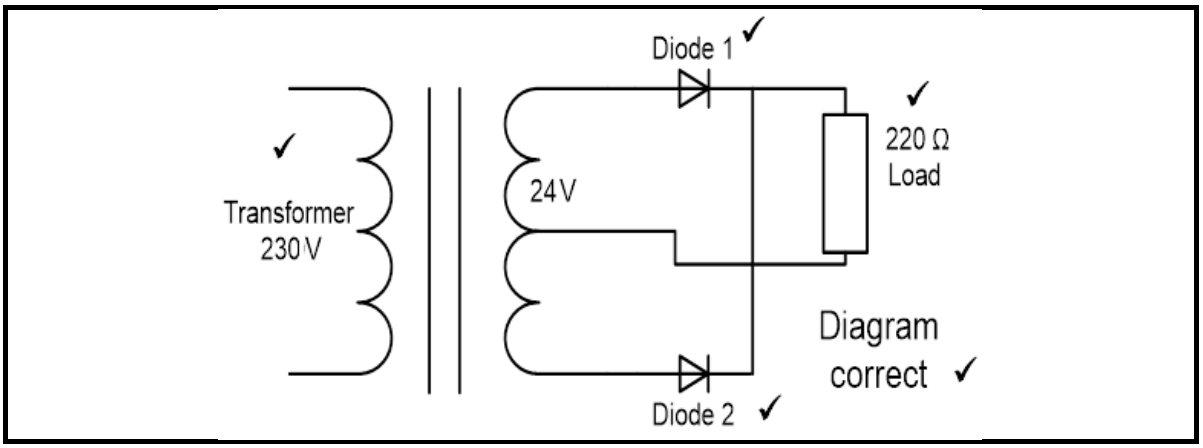
$= \frac{1}{2\times\sqrt{3}\times50\times50\times1,1547}$ ✓

$= 1 \times 10^{-4}F$ ✓

$= 100\ \mu F$ ✓

(4)

9.6



(5)

9.6.1 0,6 V ✓ (1)

[26]

TOTAL: 200