



basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

ELECTRICAL TECHNOLOGY: ELECTRONICS

2022

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 16 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.
3. This memorandum is only a guide with model answers. Alternative interpretations must be considered and marked on merit. However, this principle should be applied consistently throughout the marking session at ALL marking centres.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

- | | | |
|------|-----|-------------|
| 1.1 | C ✓ | (1) |
| 1.2 | A ✓ | (1) |
| 1.3 | C ✓ | (1) |
| 1.4 | B ✓ | (1) |
| 1.5 | C ✓ | (1) |
| 1.6 | B ✓ | (1) |
| 1.7 | C ✓ | (1) |
| 1.8 | B ✓ | (1) |
| 1.9 | D ✓ | (1) |
| 1.10 | A ✓ | (1) |
| 1.11 | C ✓ | (1) |
| 1.12 | D ✓ | (1) |
| 1.13 | A ✓ | (1) |
| 1.14 | A ✓ | (1) |
| 1.15 | D ✓ | (1) |
| | | [15] |

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

- 2.1 Machinery means any article or combination of articles assembled, arranged or connected ✓ and which is used or intended to be used for converting any form of energy to performing work. ✓ (2)
- 2.2 Critical incident is an event that causes a grave or severe physical injury ✓ to a person ✓, threatening their safety. (2)
- 2.3
- Sound the alarm system immediately. ✓
 - Use the correct fire extinguisher if you were trained to ✓
 - If there is a telephone nearby in a safe location, call your school secretary or principal to let them know of the situation. (2)
- 2.4 Due to the pandemic the mask protects oneself and others from viral infections ✓. Not using a mask will be an unsafe act because you are creating a life threatening unsafe act. ✓

OR

- Respirators and masks assist in preventing damage to the lungs when working in a contaminated area. (2)
- 2.5
- Make use of a chemical waste company to remove or to dispose of chemicals. ✓
 - Waste chemicals should NEVER be poured into toilets or down the drain as they can be harmful to the environment and the local sewerage system. ✓
 - Only neutralised chemicals can be disposed of safely.
- NOTE: If the candidate mentions safety considerations with reference to the working environment, 1 mark will be awarded, but not personal protective equipment. (2)

[10]

QUESTION 3: RLC CIRCUITS

3.1 A phasor diagram is a graphical representation ✓ of a sinusoidal alternating current or voltage in an RLC circuit. ✓ (2)

3.2 3.2.1
$$V_T = \sqrt{V_R^2 + (V_L - V_C)^2}$$
 ✓

$$= \sqrt{150^2 + (180 - 90)^2}$$
 ✓

$$= 174,93 \text{ V}$$
 ✓ (3)

3.2.2 Lagging. ✓ The circuit is inductive because the inductive voltage (V_L) is greater than the capacitive voltage (V_C) ✓ and the voltage leads ✓ the current. (3)

3.3 3.3.1
$$I_T = \sqrt{I_R^2 + (I_L - I_C)^2}$$
 ✓

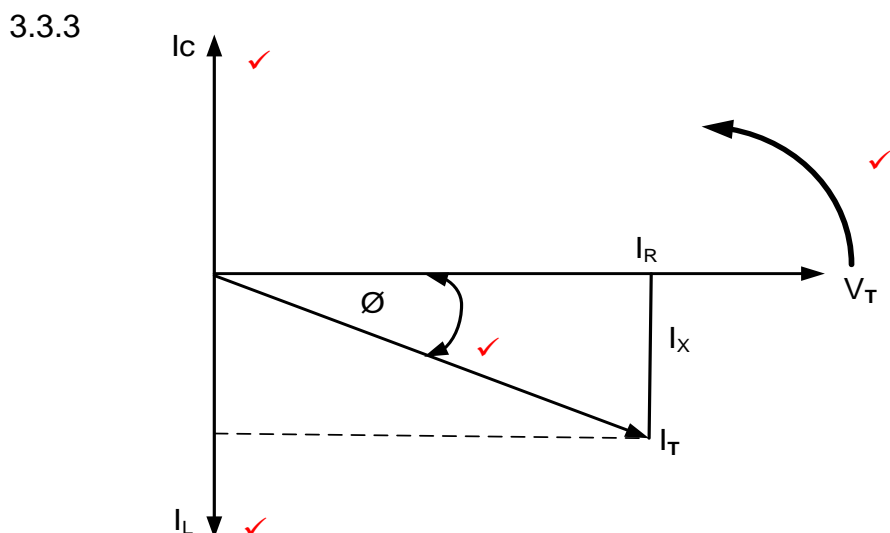
$$= \sqrt{4^2 + (6 - 4)^2}$$
 ✓

$$= 4,47 \text{ A}$$
 ✓ (3)

3.3.2
$$\theta = \text{Cos}^{-1} \frac{I_R}{I_T}$$
 ✓

$$= \text{Cos}^{-1} \frac{4}{4,47}$$
 ✓

$$= 26,49^\circ$$
 ✓ (3)



NOTE: I_C , I_L and the angle is considered the primary marks. If the rotation is omitted a mark will be allocated to V_T being the reference. (4)

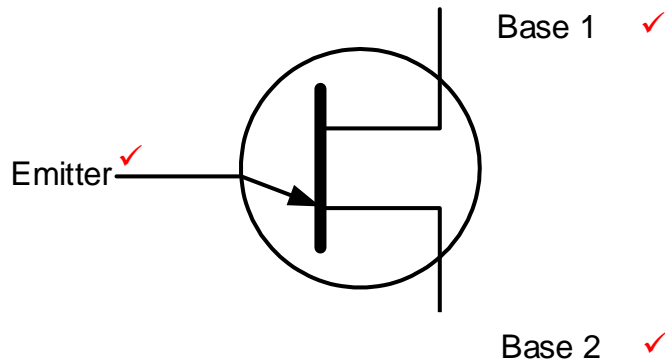
3.3.4 The circuit is inductive ✓ because the inductive current is greater than the capacitive current. ✓ (2)

- 3.4 3.4.1 At resonance $X_L = X_C = 150 \Omega$
- $$Q = \frac{R}{X_L} \quad \checkmark$$
- $$= \frac{2200}{150} \quad \checkmark$$
- $$= 14,67 \quad \checkmark \quad (3)$$
- 3.4.2 $BW = \frac{f_r}{Q}$ \checkmark
- $$= \frac{2,387 \times 10^3}{14,66} \quad \checkmark$$
- $$= 162,82 \text{ Hz} \quad \checkmark \quad (3)$$
- 3.4.3 $X_C = \frac{1}{2 \times \pi \times f \times C}$ \checkmark
- $$C = \frac{1}{2 \times \pi \times f \times X_C} \quad \checkmark$$
- $$= \frac{1}{2 \times \pi \times 2,387 \times 10^3 \times 150}$$
- $$= 4,445 \times 10^{-7} \text{ F}$$
- $$= 444,51 \text{ nF} \quad \checkmark \quad (3)$$
- 3.4.4 Selectivity is a measure \checkmark of how well a resonant circuit responds to a range of frequencies \checkmark and excludes others. (2)
- 3.5 3.5.1 Capacitor- \checkmark the current leads the voltage by 90° . \checkmark (2)
- 3.5.2 Pure resistor \checkmark
The voltage and current are in phase. \checkmark (2)

[35]

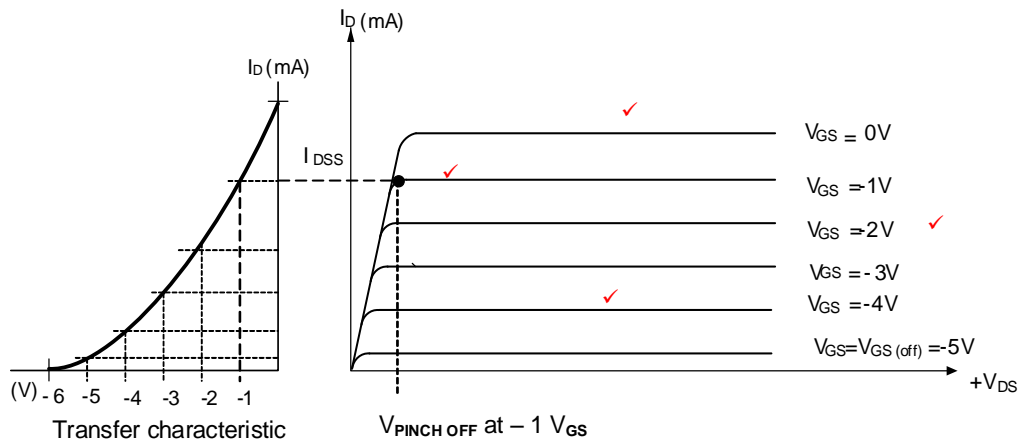
QUESTION 4: SEMICONDUCTOR DEVICES

4.1



(3)

4.2 4.2.1



NOTE: 2 marks for the family of curves
1 mark for the range of V_{GS}

(3)

4.2.2 Refer to the answer in 4.2.1 for pinch- off voltage at $V_{GS} = -1\text{ V}$ ✓

(1)

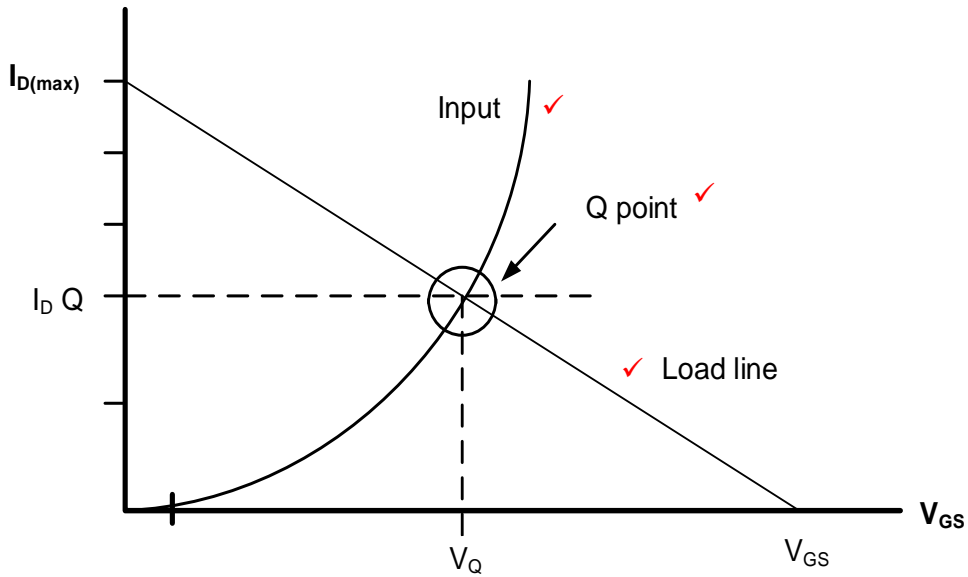
4.3 4.3.1 Enhancement – mode ✓ common source MOSFET ✓ amplifier.

(2)

4.3.2 The circuit will be able to amplify the input signal once the correct bias resistor values are selected. ✓
Set the operating point on the centre ✓ of the transfer characteristic curve. ✓

(3)

4.3.3



(3)

4.4 4.4.1 Darlington pair transistor as a switch ✓ (1)

4.4.2 When switch (S_1) is closed, a voltage of 1,4 V is applied to the base ✓ of the darlington pair. This voltage causes the Darlington pair to be forward biased, ✓ causing current to flow through the transistor, ✓ resulting in the LED glowing. (3)

4.5 4.5.1 The input is connected to the inverting terminal of the Op-amp. ✓ (1)

4.5.2 The gain of the op-amp is controlled using negative feedback ✓ through the feedback resistor (R_F) ✓ which is connected between the op-amp output terminal and its inverting input terminal. (2)

4.5.3

$$A_V = -\frac{R_F}{R_{IN}} \quad \checkmark$$

$$= -\frac{3000}{100} \quad \checkmark$$

$$= -30 \quad \checkmark$$

(3)

4.6 4.6.1

- Pin 6 sets the voltage at which the 555 IC will trigger. ✓
- It is used to maintain the voltage across the timing capacitor ✓ which is then discharged through Pin 7. ✓

(3)

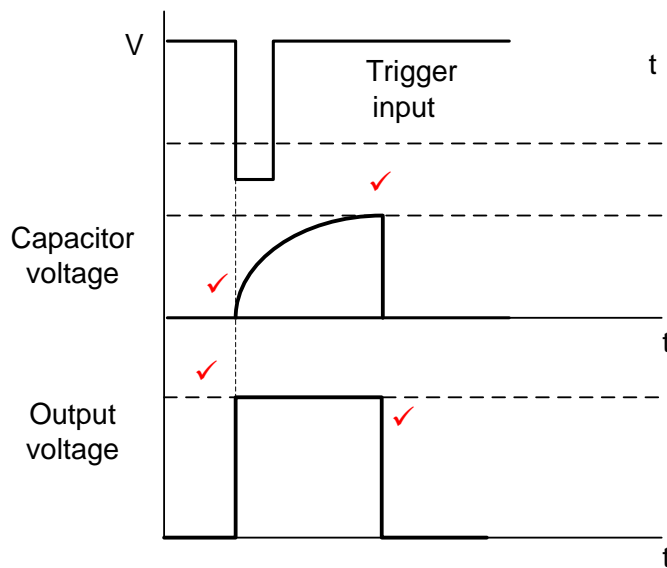
4.6.2 The 555 IC can only operate at power supply voltages between +5 V ✓ to +18 V ✓. (2)

4.6.3 The RS flip-flop stores the incoming information temporarily, ✓ until new information is received. ✓ (2)

4.7 4.7.1 Monostable multivibrator. ✓ (1)

- 4.7.2
- As soon as the push-to-make switch is activated, it pulls Pin 2 to ground, activating the 555 circuit. ✓
 - The circuit is immediately reset, setting both the output Pin 3 and discharge Pin 7 high ✓ which allows the timing capacitor to begin charging through resistor R_2 . ✓
 - When the threshold voltage on Pin 6 is reached, the 555 circuit will reset to zero and output Pin 3 will go low. ✓ (4)

4.7.3



(4)

4.8 4.8.1 The LED will be flashing ON and OFF ✓ as the multivibrator changes its state at 1 Hz. ✓ (2)

4.8.2 (a) The rate of the LED flashing ON and OFF would increase. ✓ (1)

(b) The rate of the LED flashing ON and OFF would decrease. ✓ (1)

[45]

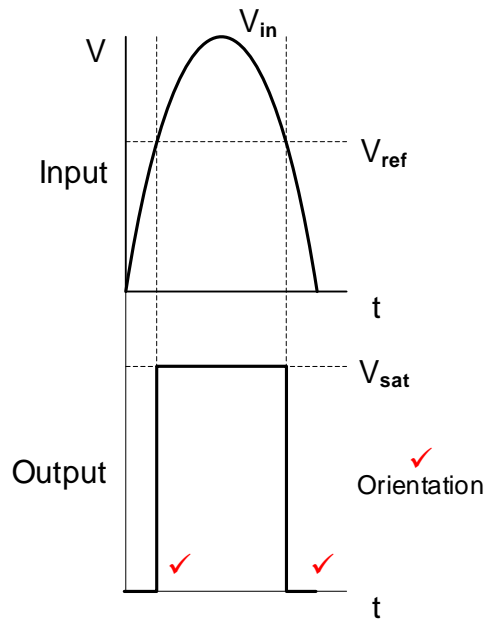
QUESTION 5: SWITCHING CIRCUITS

- 5.1 5.1.1 Monostable multivibrator ✓ (1)
- 5.1.2 Bistable multivibrator ✓ (1)
- 5.2 5.2.1 (a) Pull-up resistor. ✓
R₁ keeps the voltage on pin 4 high. (1)
- (b) To limit the current flowing to the LED. ✓ (1)
- 5.2.2 LED OFF ✓ (1)
- 5.2.3 When set is pressed, it pulls pin 2 'low' ✓ (0 V) and cause the output to go 'high'. ✓ (LED ON) (2)
- 5.2.4 Threshold pin 6 is connected to ground (0 V) so that the IC cannot reset ✓ itself keeping the output high ✓ when the set switch is pressed. (2)
- 5.3 5.3.1 R₂ sets the reference voltage ✓ on the inverting input. (1)
- 5.3.2 As the level of light increases the resistance of the LDR decreases, ✓ decreasing the voltage on the non-inverting input. ✓ (2)
- 5.3.3 The op amp compares the voltages on its two input terminals. ✓ When the voltage on the non-inverting input is higher than the voltage on the inverting input it drives the output of the op amp output into positive saturation. ✓ When the output is high LED 2 illuminates. ✓

OR

- The op amp compares the voltages on its two input terminals. When the voltage on the non-inverting input is lower than the voltage on the inverting input, it drives the output of the op amp output into negative saturation. When the output is low, LED 1 will illuminate. (3)
- 5.3.4 LED₁ on (forward biased) ✓
LED₂ off (reverse biased) ✓ (2)

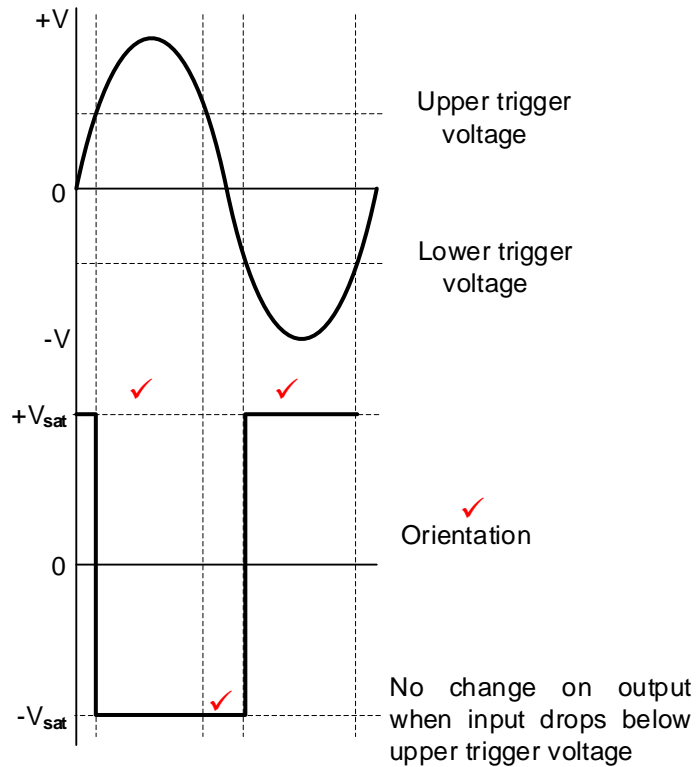
5.3.5



(3)

- 5.4 5.4.1 Inverting ✓ Schmitt trigger (1)
- 5.4.2 -10 V ✓ (1)
- 5.4.3 Positive feedback ✓ (1)
- 5.4.4 The moment the input voltage rises above 1 V ✓ the Op-amp output is driven into negative saturation. ✓ The output remains in this state until the input voltage falls below -1 V. ✓ The moment the input voltage falls below -1 V the output is driven into positive saturation. ✓ (4)
- 5.4.5 An increase in the value of R_1 will cause the trigger voltage level to increase. ✓ (1)

5.4.6



(4)

5.5 5.5.1 Negative feedback ✓

Controlling the gain of the amplifier. ✓

(2)

5.5.2

$$V_{OUT} = - \left(V_1 \frac{R_F}{R_1} + V_2 \frac{R_F}{R_2} + V_3 \frac{R_F}{R_3} \right) \quad \checkmark$$

$$= - \left(0,4 \frac{78\,260}{10\,000} + 0,5 \frac{78\,260}{10\,000} + 0,25 \frac{78\,260}{10\,000} \right) \quad \checkmark$$

$$= -9\,V \quad \checkmark$$

(3)

5.5.3 When R_F increases the gain of the amplifier increase. ✓

(1)

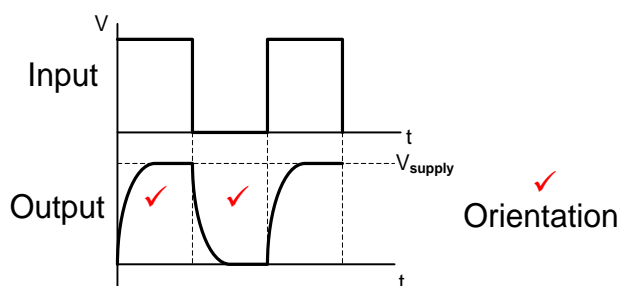
5.5.4 This amplifier is connected to a 9 V dual supply limiting the output to a maximum of +/- 9 V. ✓ The output of the amplifier is already at -9 V with R_F set to 78,26 kΩ. ✓ By increasing the value of R_F beyond 78,26 kΩ, the gain increases further ✓ and the Op-amp is driven to saturation causing the output to be distorted. ✓

(4)

5.5.5 This limitation can be overcome by setting the supply voltage to be higher ✓ than the maximum possible output voltage. ✓ This limitation can be overcome by decreasing the V_{in} of each resistor respectively. This will bring the V_{out} within the maximum of +/- 9V.

(2)

5.6 5.6.1

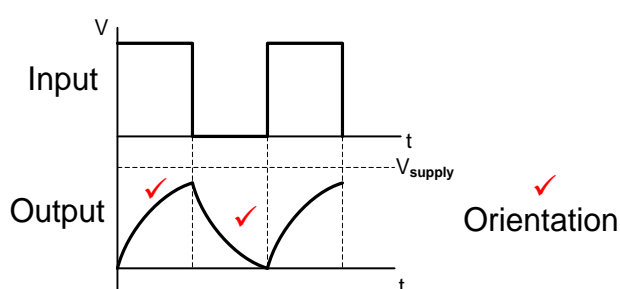


NOTE: square wave is accepted

If the output resembles the shape of a charging capacitor, but is not clipped at the top and bottom, 1 mark will be awarded for orientation.

(3)

5.6.2



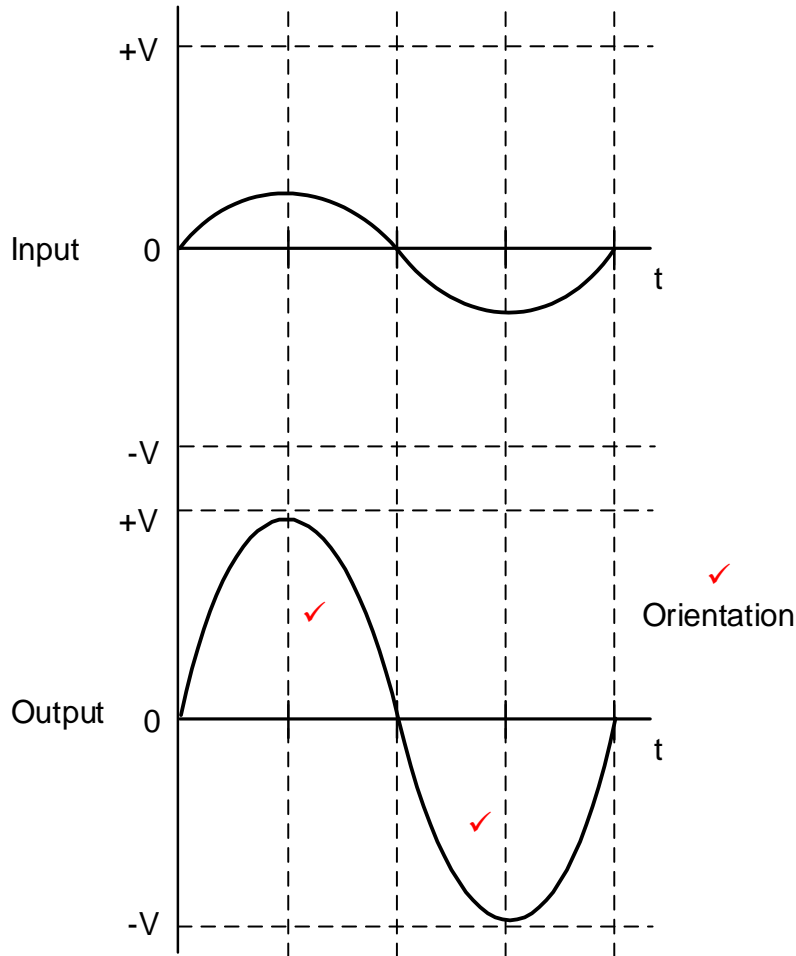
NOTE: triangular wave is accepted.

(3)
[50]

QUESTION 6: AMPLIFIERS

- 6.1 Linear amplifier provides amplification of a signal without any distortion ✓
so that the output signal is an exact amplified replica ✓ of the input signal. (2)
- 6.2
- By the operating frequency range ✓
(frequency range over which it operates)
 - By the coupling method between stages
 - By the purpose of the circuit
 - By the q-point or dc bias point. (How output transistors are biased). (1)
- 6.3
- 6.3.1 Region A. ✓ (1)
- 6.3.2 Set between Q_2 and Q_3 ✓
 Q_3 (1)
- 6.3.3
- Changing temperatures ✓
 - Power supply variations
 - Changing of the transistor biasing. (1)
- 6.4 The transistor is biased at the bottom of the load line on the cut-off point ✓
causing the amplifier to amplify 180° of the input signal. ✓ (2)
- 6.5
- 6.5.1 The purpose of using multi-stages in amplifier circuits is to
increase the overall voltage gain. ✓ (1)
- 6.5.2 $A_{VT} = A_{V1} \times A_{V2}$ ✓
 $= 10 \times 15$ ✓
 $= 150$
to change into decibel
 $A_V = 20 \log \times A_{VT}$ ✓
 $= 20 \log \times 150$ ✓
 $= 43,52 \text{ dB}$ ✓ (5)
- OR**
- $A_{V1} = 20 \log 10 = 20,0 \text{ dB}$
 $A_{V2} = 20 \log 15 = 23,52 \text{ dB}$
 $A_V = 20,0 \text{ dB} + 23,52 \text{ dB}$
 $= 43,52 \text{ dB}$

6.5.3



NOTE: 1 mark for the cycle
 1 mark for the orientation
 1 mark for gain (3)

6.6 6.6.1 C_2 - maintain a fixed DC operating point on the base ✓ which will be unaffected by the applied ac input signal. ✓ (2)

- 6.6.2
- Good impedance matching, resulting in maximum voltage and current gain. ✓
 - Improved amplification efficiency or higher efficiency.
 - The DC resistance of the transformer is fairly low, resulting in low voltage loss and power losses in the circuit (1)

- 6.6.3
- It is taken through transformer coupling to reduce the loading effects on the circuit. ✓
 - Also the turns ratio can compensate for impedance matching. ✓ (2)

6.7 6.7.1 Radio frequency amplifier. ✓ (1)

6.7.2 Radio frequency amplifiers are constructed in such a way that they are able to amplify a single frequency ✓ whilst suppressing other frequencies. ✓ (2)

- 6.7.3 To improve the selectivity of the circuit by being able to resonate at the required frequency ✓ and suppress the unwanted frequencies. ✓ (2)
- 6.8 $A_p = 10 \log \frac{P_2}{P_1}$ ✓
 $= 10 \log \frac{100 \times 10^{-3}}{200 \times 10^{-3}}$ ✓
 $= -3,01 \text{ dB}$ ✓ (3)
- 6.9 6.9.1 Colpitts oscillator. ✓ (1)
- 6.9.2 (a) The function of the amplifier circuit is to overcome the losses ✓ and establish a gain of 1 (unity gain). ✓
 Positive feedback to the tank circuit ensures that oscillation is maintained. (2)
- (b) The tank circuit determines the oscillation frequency of the oscillator ✓ and creates a 180° phase shift that is fed to the input of the transistor. ✓ (2)
- 6.9.3 The RF choke suppresses all harmonic frequencies ✓ and C₃ passes the oscillatory frequency signal back to the tank circuit ✓ in phase, causing positive feedback of only the resonant frequency, thus acting as a filter. (2)
- 6.10 6.10.1 • It serves as the potential divider with R_B. ✓
 • It forms RC phase-shift network with C₃ to provide a 60° phase-shift. (1)
- 6.10.2 • The RC-phase-shift oscillator uses three sets of RC combinations ✓ to create a phase-shift of 180° of the output waveform from the amplifier ✓ and attenuates it.
 • Together with the 180° phase-shift between the base voltage and collector voltage of the amplifier, ✓ the output signal with a phase-shift of 360° is achieved and amplified before supplying it to the RC-network. ✓
 • The cycle repeats itself. (4)
- 6.10.3 $f_o = \frac{1}{2\pi \times \sqrt{6}RC}$ ✓
 $= \frac{1}{2\pi \times \sqrt{6} \times 10000 \times 0,001 \times 10^{-6}}$ ✓
 $= 6,50 \text{ kHz}$ ✓ (3)
[45]

TOTAL: 200