Province of the
EASTERN CAPE
EDUCATION

NATIONAL
SENIOR CERTIFICATE

GRADE 11

NOVEMBER 2017

ELECTRICAL TECHNOLOGY
MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 19 pages.

QUESTION 1: (ELECTRICAL, ELECTRONICS AND DIGITAL) OCCUPATIONAL HEALTH AND SAFETY

1.1 By installing machine guards, √ barrier guards √ and shields. √ (3)

1.2 Lifting of heavy weights √ (Any relevant answer) (1)

1.3 Floor markings around all machinery to be clear √ to show that space is intended only the purpose of performing a particular task. √ (2)

[6]

QUESTION 2: (ELECTRICAL, ELECTRONICS AND DIGITAL) TOOLS AND MEASURING INSTRUMENTS

2.1 Always wear eye protection. √ (Any relevant answer) (1)

2.2 Before plugging in any power tool make sure that the power is switched off. √ (1)

2.3 Provides the knowledge of types of loads √ and helps in calculations of losses during the systems operation. √ (2)

2.4 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)

[6]

QUESTION 3: (ELECTRICAL) DC MACHINES

3.1 3.1.1 Armature losses = $I_A{}^2 \times R_A$
= $30^2 \times 0{,}5$
= 450 W √

Field loss = $I_F{}^2 \times R_F$
= $2{,}5^2 \times 50$
= 312,5 W √

Copper losses = Armature loss + Field loss √
= 450 + 312,5 √
= 762,5 W √ (5)

3.1.2 Total losses = Copper losses + Rotational losses
= 762,5 + 345
= 1107,5 W√

Efficiency = $\frac{output}{output + losses} \times 100\%$
$= \frac{3500}{3500 + 1107{,}5}$ √
= 75,96% √ (3)

3.2
- Armature current establishes a magnetic field which is called the armature flux. The effect of armature flux on the main field is called the armature reaction. √
- The armature reaction demagnetises the main field and cross magnetises the main field. √ (2)

3.3 A DC machine is a device that deals in the conversion of electrical √ and mechanical energy. √ (2)

3.4 To ensure that the motor will continue to run correctly when needed. √√ (2)

3.5
- Increase brush contact resistance √
- Axis of the brushes needs to be carefully adjusted depending on the type of load. (brush shifting) √
- Increased reluctance between the pole tips and the segment surface √
- Interpoles
- Compensating windings (Any 3) (3)

3.6
- An Electric motor is a machine that converts electrical energy into mechanical energy. √
- A generator is a machine that converts mechanical energy into electrical energy. √ (2)

3.7 Voltage drop test are used to find out shorted winding. In the test 240 V AC is applied to the field leads. √ The voltage drop across each field pole is measured with a voltmeter, √ motor is correct all voltage drops should be equal. √ (3)

3.8 Lap winding: Number of parallel paths = 2p √
= 2 × 3
= 6√
Number of conductors per path = $\frac{480}{6}$ √
= 80 conductors √ (4)

[26]

QUESTION 4: (ELECTRICAL) SINGLE-PHASE AC GENERATION

4.1 $V_{MAX} = 2\beta lv$ √
$= 2 \times 120 \times 10^{-3} \times 6 \times 10^{-2} \times 80$ √
= 1,15 V √ (3)

4.2 $V_{AVE} = 0{,}637 \times V_{PK}$
$V_{PK} = \frac{V_{AVE}}{0{,}637}$ √
$= \frac{9{,}54}{0{,}637}$ √
$=$ 14,98 V√ (3)

4.3 $f = \frac{1}{T}$√
$= \frac{1}{40 \times 10^{-3}}$ √
= 25 Hz √ (3)

4.4 $E = \frac{\Delta\emptyset}{\Delta T}$ √

$= \frac{1500 \times 10^{-3}}{0{,}3}$ √

$= 5\,V$ √ (3)

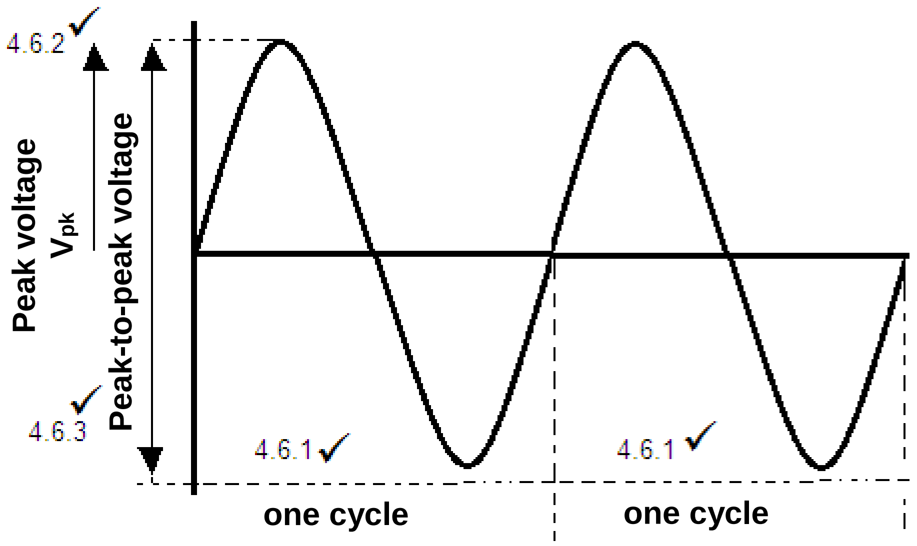
4.5 $E = \frac{\Delta\emptyset}{\Delta T}$

$\Delta\emptyset = E \times \Delta T$ √

$= 1{,}5 \times 0{,}2$ √

= 0,3 Wb √ (3)

4.6 4.6.1



(2)
(1)
(1)

4.7 $\beta = \frac{\emptyset}{A}$

$\emptyset = \beta \times A$ √

$= 600 \times 1{,}5 \times 10^{-4}$ √

= 90 mWb √ (3)

4.8 $f = n \times p$

$= \frac{2400}{60} \times 2$ √

$= 80\,Hz$ √ (2)

4.9 $V_{MAX} = 2\beta l v$

$= 2 \times 12 \times 10^{-3} \times 2 \times 20$ √

= 0,96 V√ (2)

[26]

QUESTION 5: (ELECTRICAL) SINGLE-PHASE TRANSFORMERS

5.1 5.1.1 $\frac{V_S}{V_P} = \frac{N_S}{N_P}$

$V_S = \frac{N_S \times V_P}{N_P}$ √

$= \frac{75 \times 160}{200}$ √

= 60 V √ (3)

5.1.2 $\frac{I_S}{I_P} = \frac{N_P}{N_S}$

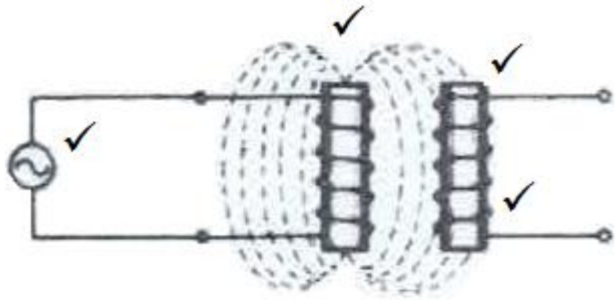
$I_S = \frac{N_P \times I_P}{N_S}$ √

$= \frac{200 \times 0{,}3}{75}$ √

$= 0{,}8A$ or 800 mA √ (3)

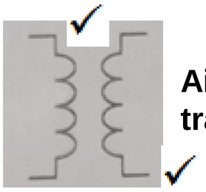
5.2

AC Generator



(4)

5.3



Air cored transformer

(2)

5.4 5.4.1 Voltage instrument transformer √ (1)

5.4.2
1. Load √
2. Potential transformer √
3. AC voltmeter √
4. Grounded for safety √
5. High voltage AC √

(5)

5.5 5.5.1 $F_m = H \times l$ √ where l = 2πr

$= 4000 \times 2 \times \pi \times 0{,}008$ √

= 201,06 A-turns √ (3)

5.5.2 $I = \frac{F_m}{N}$ √

$= \frac{201{,}06}{600}$ √

$= 0{,}34\ A$ √ (3)

5.6 When the current flows in a wire it creates a surrounding magnetic field which does not want to change its condition. √ This built-up in feature is called back-emf. √ (2)

[26]

QUESTION 6: (ELECTRICAL, ELECTRONICS AND DIGITAL) RLC-CIRCUITS

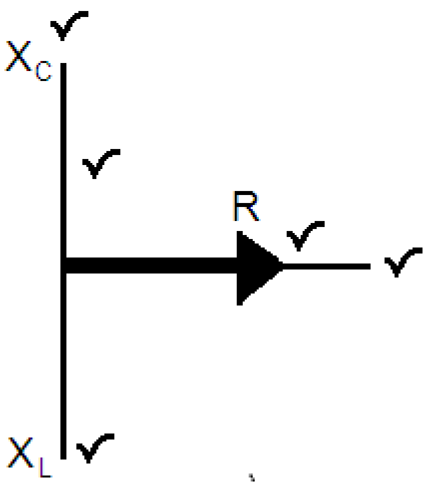
6.1 $X_L = 2\pi f L$ √
$= 2.\pi.50.0,5$ √
$= 157,08\ \Omega$ √ (3)

6.2 $X_C = \frac{1}{2\pi f C}$
$C = \frac{1}{2\pi f X_C}$√
$= \frac{1}{2.\pi.300.3180}$√
$= 166,83\ nF$ √ (3)

6.3 6.3.1 $Z = \sqrt{R^2 + (X_C - X_L)^2}$ √
$= \sqrt{600^2 + (665 - 37,7)^2}$ √
$= 868,05\ \Omega$√ (3)

6.3.2 At resonant frequency point the two reactance are identical in size√ but exactly opposite to each other in direction making $X_L = -X_C$. √ At this point they cancel each other's effect and the only resistance left in the circuit is the resistance of the resistor R √ where the component impedance will be equal to resistance. √ (4)

6.3.3



(5)

6.4 When the frequency increases the inductive reactance also increases √ because inductive reactance is directly proportional to frequency √ (2)

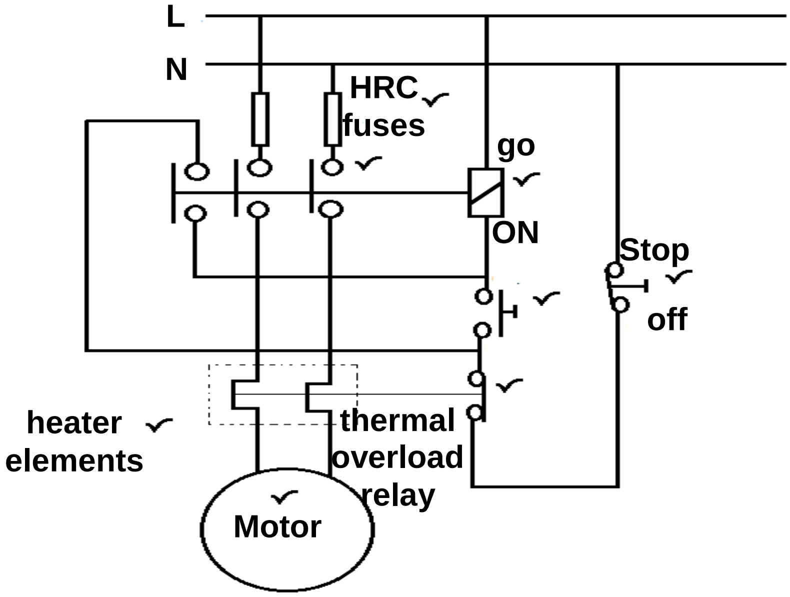
6.5 $f_r = \frac{1}{2\pi\sqrt{LC}}$ √
$= \frac{1}{2.\pi\sqrt{5\times10^{-3}\times50\times10^{-9}}}$ √
$= 10,07$ Hz √ (3)

6.6 Number of cycles completed by a waveform in one second √ (1)

[24]

QUESTION 7: (ELECTRICAL) CONTROL DEVICES

7.1



(8)

7.2
- DOL acts as a switch that turn the motor on and off. √
- Offers over current protection. √ (Any 2 relevant answers) (2)

7.3 Polyfuse or PTC or resettable fuse √ (1)

7.4 It is very useful in protecting against damage caused by over current surges√ as well as over temperature faults. √ (2)

7.5
- Overload √
- Short circuit √
- Ground-earth fault √ (3)

7.6 The size √ and shape of the bi-metallic strip √ and the material it is made from determine the current capacity of the circuit breaker. √ (3)

7.7 As the voltage falls the load on motor will affect its torque, increasing its strain and its overload state. √ If the motor's torque falls below that required by the load this could lead to the motor stalling √ and the only thing it can produce is heat as it overstrains to try to continue to turn. √ (3)

7.8
- A drop in supply could cause an increase in motor torque as it tries to maintain its operation under load. √
- A sudden restart of the motor could cause an excessive in rush of current, exceeding the motor's rated value. √ (2)

7.9 Electronic overload relays use electronic sensing making their greatest benefit the fact that their heater-less design reduces the need for heating coils in bimetallic sensing devices √ and so reduces installation cost. √ The heater-less design also makes the electronic relay insensitive to any surrounding temperature rises that could cause unnecessary, nuisance tripping. √ (3)

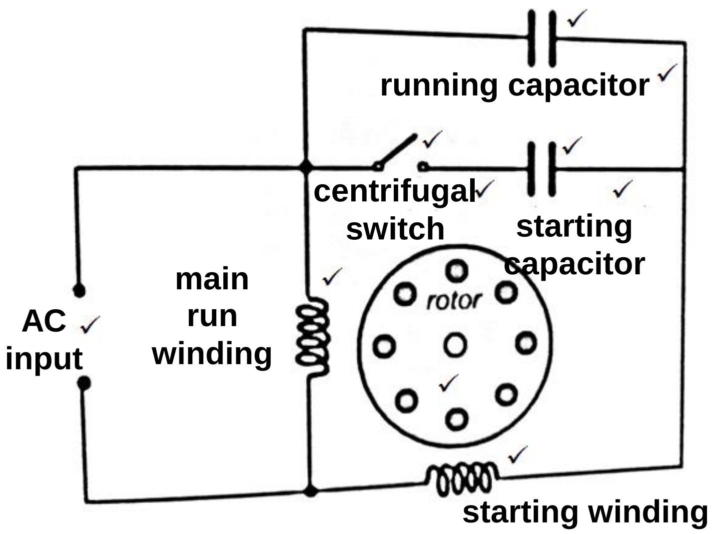
7.10
- Thermal √
- Magnetic √
- Electronic √ (3)

7.11
- Overload condition √
- Short circuit condition √ (2)

[32]

QUESTION 8: (ELECTRICAL)
SINGLE-PHASE MOTORS

8.1



(10)

8.2 Once the start circuit had done its job the high-current winding needs to be removed from the circuit. √ The centrifugal switch does this by disconnecting it from the circuit leaving the running winding to carry the load. √
OR Disconnects the start winding and starting capacitor from the supply √ once the motor reaches 75% of full speed. √ (2)

8.3
- Low cost √
- Quiet √
- Long lasting √
- Trouble free √
- Cheaper
- Robust (Any 4) (4)

8.4 A synchronous motor is one that's speed is synchronous with the frequency of the main supply, √ that is, it spins at exactly the same rate as the incoming frequency. √ (2)

8.5 Reversing the motor's direction requires the changing of direction of the rotating magnetic field created by the two stator windings. √ This can be done by reversing the direction of either the starting or running windings. √ (2)

8.6 To make a single-phase induction motor into a split phase motor requires a second pair of coils to be added. √√ (2)

8.7 A universal motor is able to operate on an AC supply because of the way it is wired, with its two stator field coils connected in series √ with the rotor windings through its commutator √ (2)

8.8
- Have high starting torque √
- Quiet in operation √ (2)

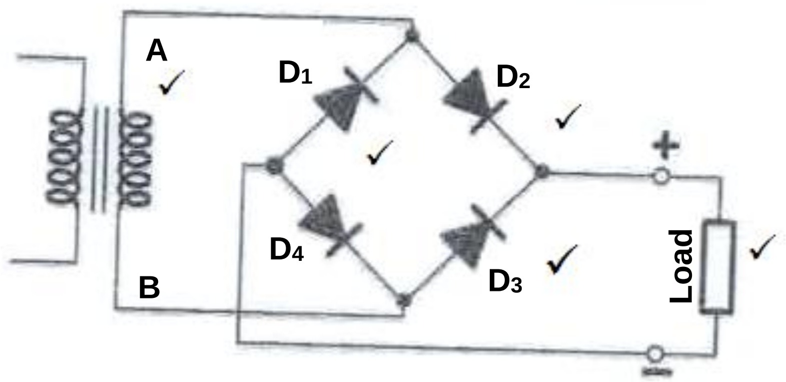
8.9
- Vacuum cleaner √
- Electric hand drills √ (2)

8.10 The second pair of coils is positioned at right angle to the first pair. √√ (2)

[30]

QUESTION 9: (ELECTRICAL)
POWER SUPPLIES

9.1



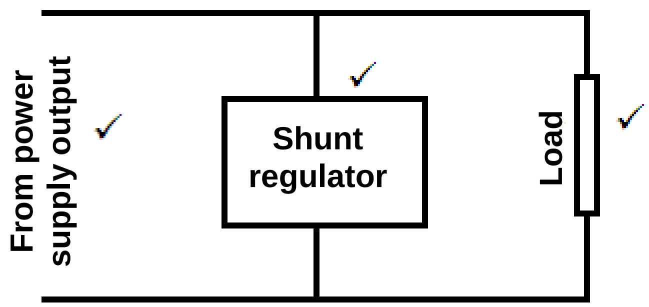
(5)

9.2 The capacitor passes AC voltage while at the same time blocking DC voltage. √ The inductor passes DC voltage while at the same time blocking AC voltage. √ (2)

9.3 The electronic power supply converts an AC mains supply to a DC supply of a lower voltage. √√ (2)

9.4 On each cycle of input the diode allows pulses of charge to enter the capacitor. √ During the period in each cycle that the diodes are off, the capacitor discharges its energy into the load, keeping the supply constant for the full cycle. √ (2)

9.5



(3)

9.6 π filter √ (1)

9.7 9.7.1 $E_{PK} = \frac{E_{RMS}}{0,707}$ √
$= \frac{57,5}{0,707}$ √
$= 81,33\ V$ √ (3)

9.7.2 $V_{PK} = E_{PK} - V_D$ √
$= 81,33 - 0,65$ √
$= 80,68\ V$ √ (3)

9.7.3 $V_{AVE} = 0,637 \times V_{PK}$ √
$= 0,637 \times 80,68$ √
$= 51,39\ V$ √ (3)

[24]

QUESTION 10: (ELECTRONIC AND DIGITAL) WAVE FORMS

10.1 10.1.1 This is the time between the 50% √ amplitude points on both the rising √ and the falling edges of the pulse. √ (3)

10.1.2 Fall time, this is the time a falling pulse takes to make a change from the higher state 'on'√ to the lower state 'off'. √ It is measured between the 10% and 90% points of the completed pulse. √ (3)

10.2 10.2.1 $f = \frac{1}{T}$
$= \frac{300}{60}$ √
$= 5\ Hz$ √ (2)

10.2.2 $T = \frac{1}{f}$ √
$= \frac{1}{5}$ √
$= 0,2\ Hz$ √ (3)

10.3 The clamping circuit actually binds the upper or lower √ extremes of a waveform to a fixed DC voltage level. √ When unbiased, clamping circuits will fix √ the voltage lower limit √ (or upper limit, in the case of negative clampers) to 0 volt. (4)

10.4 10.4.1

Sine wave (2)

10.4.2

Ramp wave (2)

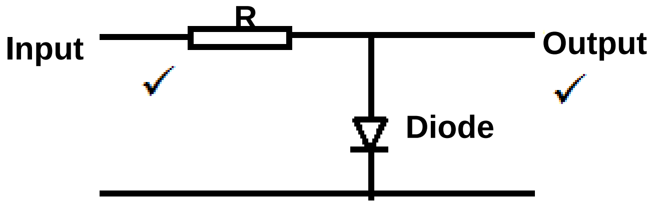
10.4.3

Saw tooth wave (2)

10.5
- Communication √
- Broadcasting √
- Computer network √

(3)

10.6



(2)

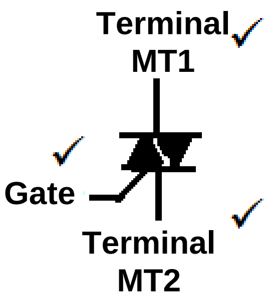
[26]

QUESTION 11: (ELECTRONICS AND DIGITAL) SEMICONDUCTOR DEVICES

11.1 11.1.1 During the forward bias the positive terminal of the battery pumps holes into the P-region of the diode. √ The negative terminal pumps electrons into the N-region. √ As the voltage increases, the depletion region will become thinner and thinner and the diode will offer less and less resistance and start to conduct. √ (3)

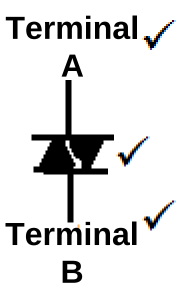
11.1.2 In reverse bias the P-type material is connected to the negative terminal and the N-type material is connected to the positive terminal of the battery. √ In this condition, the holes in the P-type are filled by electrons from the battery. √ The electrons in the N-type material are sucked out of the diode by the positive of terminal of the battery, so the diode is depleted of charge and it will not conduct. √ (3)

11.2 11.2.1



(3)

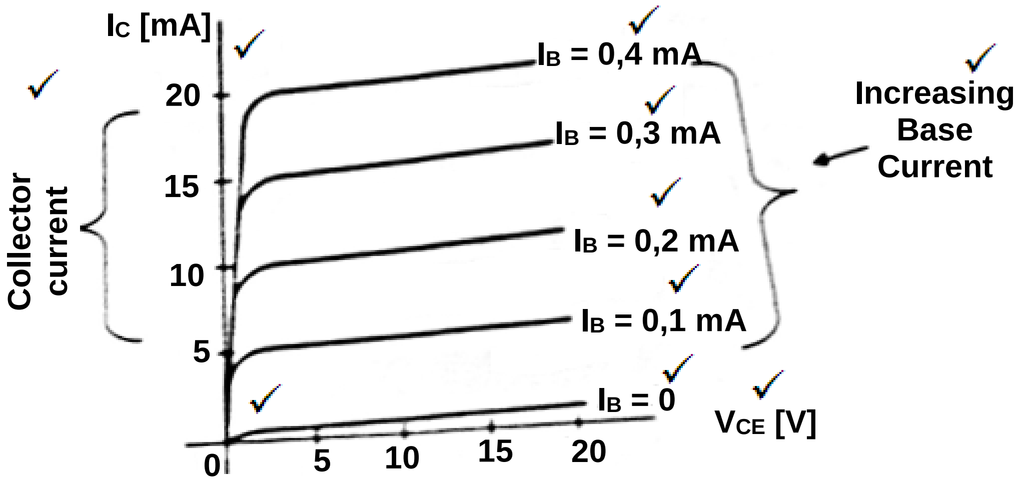
11.2.2



(3)

11.3 A DIAC is commonly used to trigger a TRIAC √ as it breaks down at a precise voltage √ so giving the TRAIC a precise triggering voltage in both half-cycles. √ (3)

11.4



NPN Transistor Output Characteristic curve

(10)

11.5 A zener diode has a unique reverse biased operating characteristic √ in that it blocks any flow of current when under low reverse voltage √ but as soon as the voltage rises to reach its zener breakdown it breaks down √ and allow s current to flow in the reverse direction without any damage to itself. √ (4)

11.6 Voltage regulator √ (1)

11.7 TRIAC is able to conduct in both direction √ (1)

11.8
- SCR cannot switch by itself √
- It can conduct in one direction √ (2)

11.9 Solid-state devices are devices that are built entirely from solid materials √ and in which the electrons or other charge carriers are confined entirely within the solid material. √ (2)

11.10 Holding current is the minimum current √ that must flow to prevent the SCR from switching off. √ (2)

11.11 Apply a voltage across the TRIAC in either polarity, √ and then apply a pulse to the gate of either polarity. √ (2)

11.12
1. Forward conduction √
2. Gate pulse √
3. Reverse conduction √
4. V_{BO} √
5. I_F √
6. I_H √
7. +V √ (7)

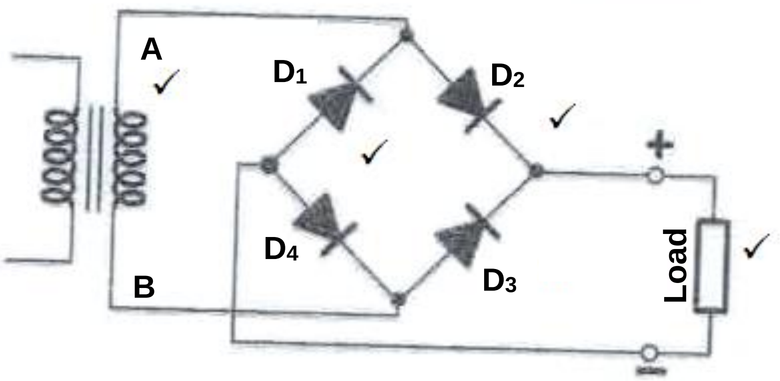
11.13 Silicon Control Rectifier √ (1)

11.14 Phosphorous, arsenic or antimony √ (Any 1) (1)

[48]

QUESTION 12: (ELECTRONICS)
POWER SUPPLIES

12.1

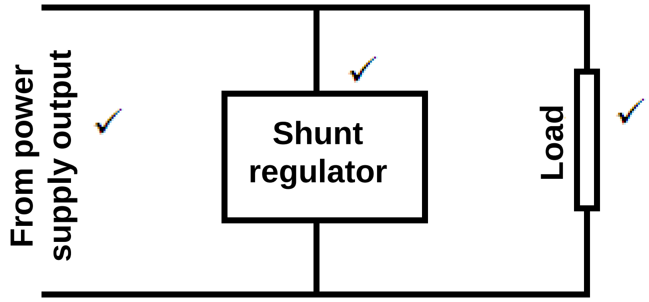


(4)

12.2 The capacitor passes AC voltage while at the same time blocking DC voltage. √ The inductor passes DC voltage while at the same time blocking AC voltage. √ (2)

12.3 The electronic power supply converts an AC mains supply to a DC supply of a lower voltage. √√ (2)

12.4



(3)

12.5 12.5.1 $E_{PK} = \frac{E_{RMS}}{0,707}$ √

$= \frac{57,5}{0,707}$ √

$= 81,33\ V$ √ (3)

12.5.2 $V_{PK} = E_{PK} - V_D$ √

$= 81,33 - 0,65$ √

$= 80,68\ V$ √ (3)

12.5.3 $V_{AVE} = 0,637 \times V_{PK}$ √

$= 0,637 \times 80,68$ √

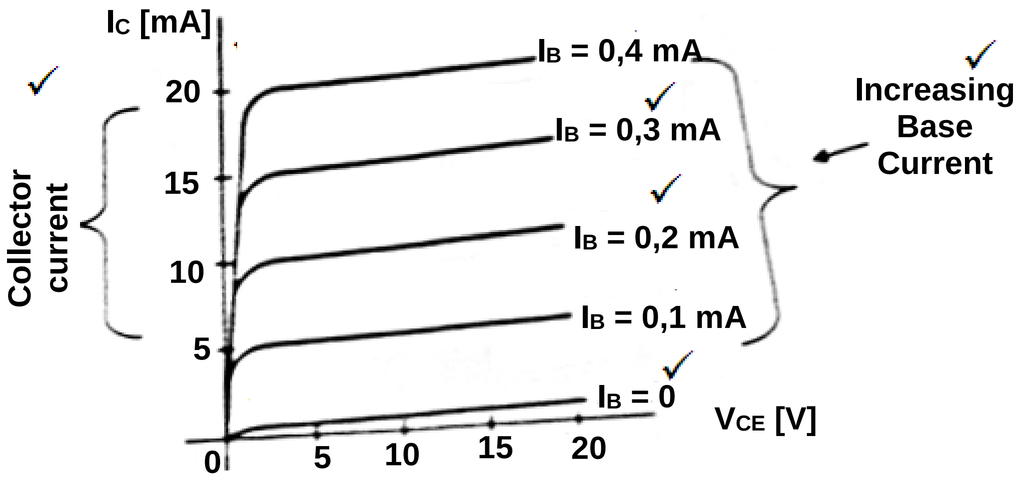
$= 51,39\ V$ √ (3)

[20]

QUESTION 13 (ELECTRONICS)
AMPLIFIERS

13.1
- Common Emitter √
- Common Collector √
- Common Base √ (3)

13.2



NPN Transistor Output Characteristic curve (5)

13.3 It suffers from thermal instability √ as it relies solely on the gain value of the single transistor for which it is designed. √ (2)

13.4
- Improved stability against changes of temperature. √
- More reliable and constant voltage gain. √
- Decrease distortion of the amplifier. √ (3)

13.5 Biasing is used in amplifier design because it establishes the correct operating point √ of the transistor amplifier ready to receive signals, √ thereby reducing any distortion √ to the output signal. √ DC biasing refers to the application of the correct external voltages √ to establish an operating point on the characteristic output curve. √ (6)

13.6 An amplifier is an electronic device that increases √ the power of a smaller input signal. √ (2)

13.7 13.7.1

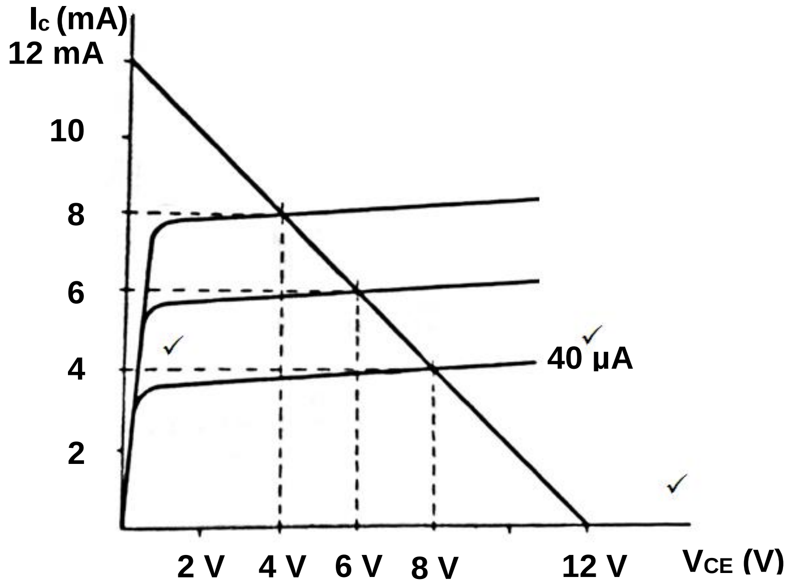
$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$
$$= \frac{12 - 0{,}6}{285\ k\Omega} \ \surd$$
$$= 40\ \mu A \ \surd$$
(2)

13.7.2

$$\beta = \frac{I_C}{I_B}$$
$$I_C = \beta \times I_B \ \surd$$
$$= 100 \times 40 \times 10^{-6} \ \surd$$
$$= 4\ mA \ \surd$$
(3)

13.8 The purpose of a variable resistor is to act as a potential divider √ that is able to hold the voltage on the base terminal √ at a fixed value which will not vary under any conditions. √ (3)

13.9



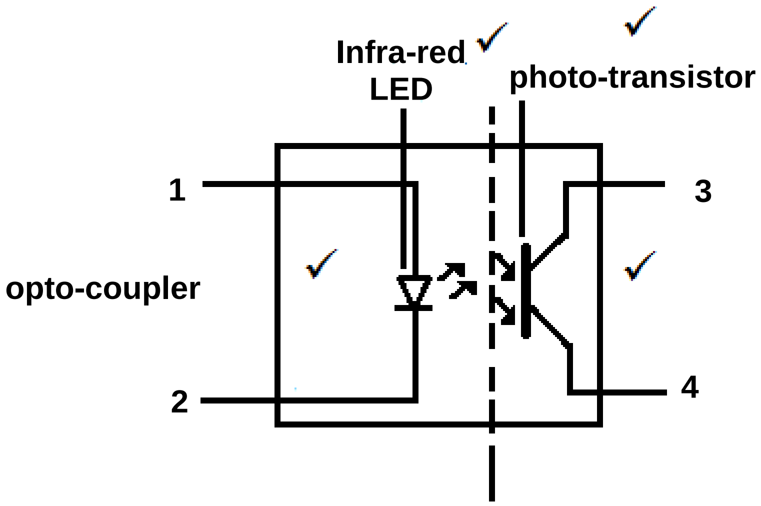
(3)

[32]

QUESTION 14: (ELECTRONICS AND DIGITAL) SENSORS AND TRANSDUCERS

14.1 This detector relies on the oxidation of a thin film of heated metal oxide; √ deposited on a silicon slice when it comes into contact with a gas. √ This oxidation changes the metal resistance. √ (3)

14.2



(4)

14.3 It is a device that changes energy from one form into another. √ (1)

14.4 Piezo Electric Effect √ (1)

14.5 When the load is applied to the body of a resistor load cell the member deforms creating a strain at those locations due to the stress applied. √ As a result two of the strain gauges are in compression √ and the other two are in tension. These four strain sensors are used as the four arms of a Wheatstone Bridge. √ (3)

[12]

QUESTION 15: (ELECTRONICS AND DIGITAL) COMMUNICATION SYSTEMS

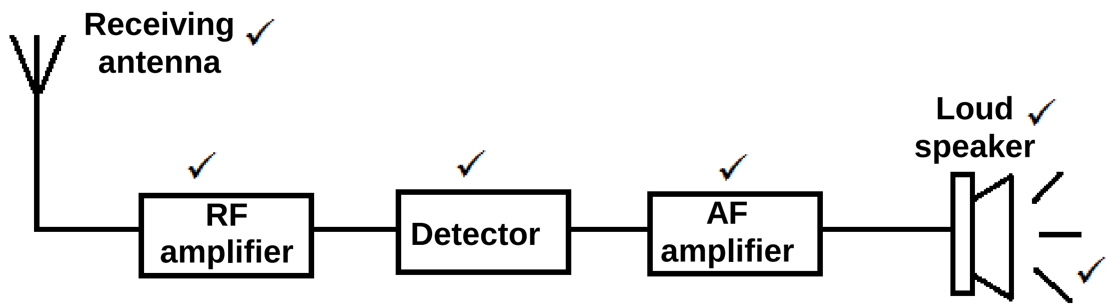
15.1 The increase in amplitude of an oscillation in a mechanical or electrical system, √ under the influence of an external periodic impulse of similar frequency to the original vibration. √ (2)

15.2
- Capacitor √
- Inductor √ (2)

15.3 It constantly adjust its output frequency √ to match the frequency of the input signal. √ (2)

15.4 A regenerative receiver is one that that feeds the output from an amplifier back onto it over and over again. √ If this is done in such a way as to promote positive feedback, √ the circuit has the effect of turning into a high gain amplifier √ as well as giving the circuit added properties. √ This is used in the RF amplifier stage of receivers giving them name of regenerative receivers. √ (5)

15.5



(6)

15.6 FSK is a method that enables the transmission digital pulse signal √ using traditional radio transmitting and receiving method. √ (2)

15.7
1. FM Oscillator √
2. Frequency multiplier √
3. RF amplifier √ (3)

15.8
- Narrower bandwidth: √ Making way for more channels to be accommodated. √
- Noise reduction: √ As the transmission uses only one half the bandwidth of a normal system the thermal noise power is also reduced to one half of a double side band system. √ (4)

[26]

QUESTION 16: (DIGITAL) LOGIC

16.1 16.1.1 AND Function √ (1)

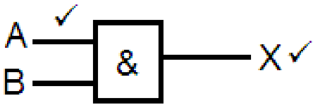
16.1.2

A	B	X	
0	0	0	✓
0	1	0	✓
1	0	0	✓
1	1	1	✓

(4)

16.1.3 **X √ = A.B √** (2)

16.1.4



(2)

16.2 16.2.1 Q_1 √ = A.B √ (2)

16.2.2 $Q ✓ = \overline{A} . \overline{B}$ ✓ (2)

16.2.3 $Q ✓ = \overline{A} . \overline{B}$ ✓ + A . B ✓ (3)

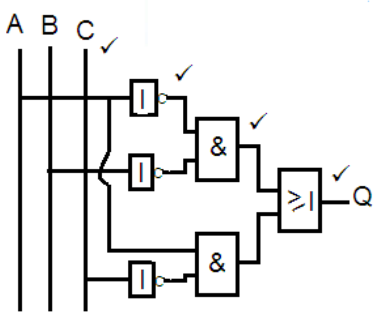
16.3 16.3.1

✓	$\overline{A}\overline{B}$ ✓	$A\overline{B}$	AB	$A\overline{B}$
$\overline{C}$	1		1	1
C	1			

+ 1 mark for each 1 correctly placed
+ 1 mark for each grouping (8)

16.3.2 $Q = \overline{A}\overline{B}$ ✓ + $A\overline{C}$ ✓ (2)

16.3.3



(4)

16.4 16.4.1

Inputs		Output		
A	B	S	Co	✓
0	0	0	0	
0	1	1	0	
1	0	1	0	✓
1	1	0	1	

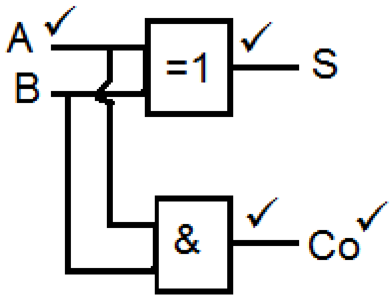
(2)

16.4.2 $S = A \oplus B$ ✓

$Co = A.B$ ✓

(2)

16.4.3



(4)

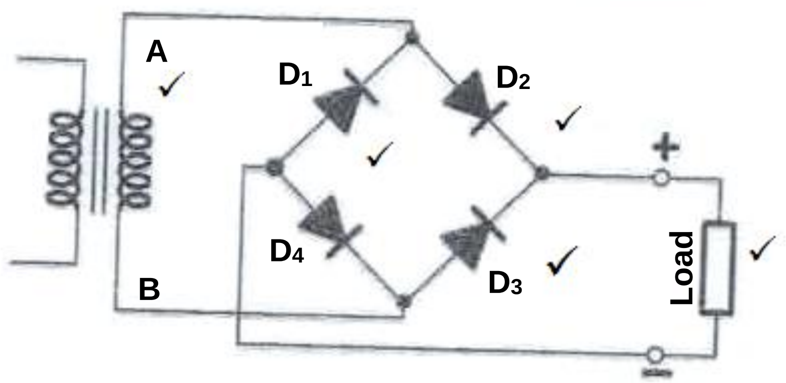
16.5
- Low cost √
- Ease of use √

(2)

[40]

QUESTION 17: (DIGITAL)
POWER SUPPLIES

17.1

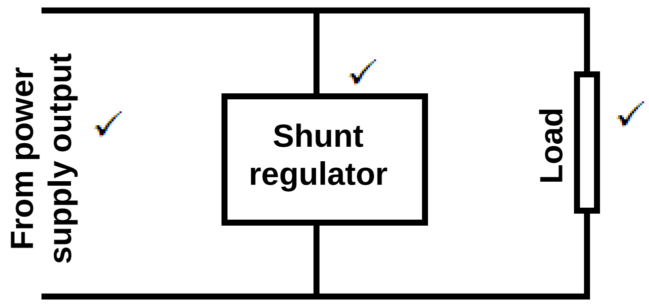


(4)

17.2 The capacitor passes AC voltage while at the same time blocking DC voltage. √ The inductor passes DC voltage while at the same time blocking AC voltage. √ (2)

17.3 The electronic power supply converts an AC mains supply to a DC supply of a lower voltage. √√ (2)

17.4



(3)

17.5 π filter circuit √ (1)

[12]

TOTAL: 200