Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 11

NOVEMBER 2015

ELECTRICAL TECHNOLOGY MEMORANDUM

MARKS: 200

This memorandum consists of 10 pages.

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 formula(e).

   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 same answer is obtained.

   2.5 Where an erroneous 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 learner should receive the full marks for subsequent calculations.

3. The 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.

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY, TOOLS AND MEASURING INSTRUMENTS

1.1
- No horseplay in the workshop. √
- No eating and drinking in the workshop. √
- Wear protective clothing and equipment when using dangerous tools and machines. √
- Never operate machines without supervision and permission. √
- Never use any tools or machines unless properly trained. √ (Any 3 x 1) (3)

1.2 Set the time per division control. √
Read of the number of divisions between the two waveforms. √
One cycle equals 360 degrees. √
Calculate the phase angle (e.g. if one cycle uses 10 divisions then one division equals 36 degrees). √√ (5)

1.3 An insulation tester uses +/- 500 V when testing and insulation is more likely to break down at the higher voltage. √√ (2)

[10]

QUESTION 2: SINGLE-PHASE AC GENERATION SINGLE-PHASE TRANSFORMERS

2.1 Instantaneous current is the current measured at an instant in time. √√ (2)

2.2 2.2.1 The RMS value of a sine wave is the value that will deliver the same power as an equivalent Direct Current Value. √√ (2)

2.2.2 There are 2π radians in 360º. √ (1)

2.2.3 Magnetic flux through a surface refers to the number of magnetic field lines which pass through a given cross-sectional area. It can be calculated using the formula $\varphi = BA$, where φ is the number of flux lines measured in webers (Wb), B is the magnetic field strength measured in telsa (T), and A is the cross-sectional area measured in meters squared (m^2). √√√ (3)

2.3.1 EMF $= 2\pi BAnN\sin\theta$ √
$= 2\pi \times 0,6 \times 0,03 \times 40 \times 200 \times \sin 90^\circ$ √
$= 904,78$ V √ (3)

2.3.2 $E_{RMS} = E_{max} \times 0,707$ √
$= 904,78 \times 0,707$ √
$= 639,68$ V √ (3)

2.3.3 $e = E_{max}\sin(90^\circ + 60^\circ)$ √
$= 639,68 \times \sin 150^\circ$ √
$= 319,84$ V √ (3)

2.4 2.4.1 The generated EMF is directly proportional to the number of windings. √√ (2)

2.4.2 If more pole pairs are added then for each revolution √ more cycles will be generated increasing the frequency. √ (2)

2.4.3 Laminated cores reduce Eddy currents induced in the core √ thereby making the coil more efficient. √ (2)

2.5 Transformers are rated according to their apparent power (VA). √ (1)

2.6 When an alternating emf is applied to the primary winding, √ an alternating magnetic field is set up around the primary winding. √
This alternating magnetic field induces an alternating emf in the secondary winding. √
The magnitude of this induced emf depends upon the transformation ratio of the transformer. √ (4)

2.7 50 Hz √ Transformers cannot change frequency. √ (2)

2.8 If too much current is drawn from the secondary. (1)

2.9 2.9.1 $N_P/N_S = V_P/V_S = 220 / 24 = 9{,}17 : 1$ √√√ (3)

2.9.2 $R = V / I = 24 / 2 = 12\ \Omega$ √√√ (3)

2.9.3 $V_P / V_S = I_S / I_P$ √
$I_P = (I_S \times V_S) / V_P$
$= (2 \times 24) / 220$ √
$= 218$ mA √ (3)

2.10 An autotransformer is a transformer that does not have separate primary and secondary windings. (The secondary side is tapped off the primary side.) √√ (2)

2.11
- Copper losses (I^2R losses) √√
- Eddy Current losses (Heat losses) √√
- Dielectric losses √√
- Iron losses (Hysteresis losses) √√ (Any 2 x 1) (2)

2.12 Instrument transformers are used to drive panel meters on distribution boards. √√ (2)

2.13 Voltage Transformers (PT's) are used where high voltages need to be measured by low voltage movements in volt meters. √√ Current Transformers (CT's) are used where high currents need to be measured by low current movements in amp. metres. √√ (4)

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QUESTION 3: SINGLE-PHASE MOTORS AND PROTECTION DEVICES

3.1.1 True (1)
3.1.2 False (1)
3.1.3 True (1)
3.1.4 True (1)

3.2
- A single phase induction motor consists of a stator with two windings, namely a start winding and a run winding. √√
- The two windings have different impedances. √
- When an AC supply is applied to the stator, a rotating magnetic field is set up because of the different impedances. √
- This rotating magnetic field induces an EMF in the conductors of the rotor. √
- This EMF sets up magnetic fields that work in conjunction with the rotating magnetic fields of the stator resulting in torque applied to the rotor. √√
- The rotation of the rotor is in the same direction as the rotation of the stator field. √ (8)

3.3
- The centrifugal switch is placed in series with the start winding. √
- When the rotor has run up to speed, the centrifugal switch opens, disconnecting the start winding. √√
- The motor therefore begins to slow down until the centrifugal switch closes again. √
- So the centrifugal switch is used to control the speed of the motor. √ (5)

3.4 When the main contactor is energised, the hold-in circuit (Normally Open) closes, and remains closed when the start button is released. When power is removed, the hold-in circuit opens, there by removing power from the main contactor. The starter controlled circuit therefore has to be manually restarted. √√√ (3)

3.5 3.5.1 The purpose of the continuity test is to measure the resistance of the windings. √ (1)

3.5.2 Insulation test between conductors √
Insulation test between conductors and earth. √ (Any 2 x 1) (2)

3.5.3 Insulation tester (or megger) √ (1)

3.5.4 1 MΩ or greater √ (1)

3.6 Vacuum cleaners, √ portable drills, √ drink mixers, √ sewing machines, √ etc.
(Any 2 x 1) (2)

3.7 Change the polarity of the start winding or run winding but not both. √√√ (3)
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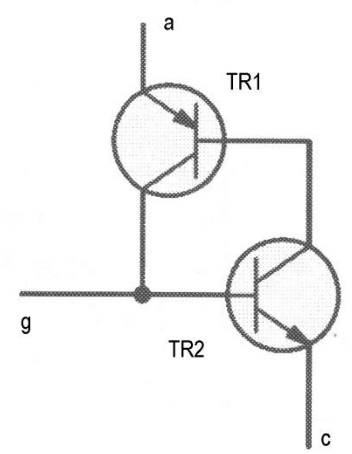
QUESTION 4: SEMI-CONDUCTOR DEVICES, POWER SUPPLIES, AND AMPLIFIERS

4.1 When P-type and N-type materials are joined, holes of the P-type and electrons of the N-type combine to form covalent bonds. √ The electrons diffuse and occupy the holes in the P-type material. A small region of the N-type near the junction loses electrons and behaves like intrinsic semiconductor material. √ In the P-type, a small region get filled up by holes and behaves like an intrinsic semiconductor material. √ This thin intrinsic region is called the depletion region, since it is depleted of charge and offers high resistance. √ (4)

4.2 In simple voltage regulators. √ (1)

4.3 '+' on anode, '-' on cathode √



√√

'+' pulse on g switches TR2 on causing collector of TR2 to become more negative. √
This switches TR1 on, its collector going positive which keeps TR2 on even though the '+' pulse on gate has been removed.√
Current will continue to flow until either the supply is removed between the anode and cathode, or the current falls below the holding current. √

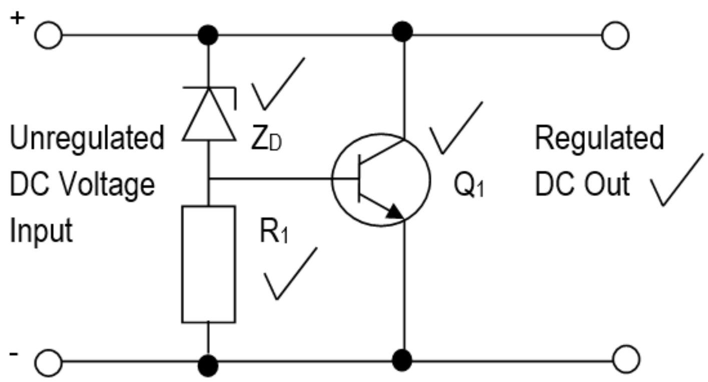
(6)

4.4 Remove supply from anode and cathode. √
Reduce the current to below the holding current. √ (2)

4.5 The series resistor prevents the applied voltage from appearing across the capacitor when the variable resistor is set to 0 Ω. √√ (2)

4.6 AC INPUT → TRANSFORMER √ → RECTIFIER √ → FILTER √ → REGULATOR √ OUTPUT (4)

4.7



(4)

4.8 The output from a bridge rectifier is almost twice that of a circuit using two diodes and a centre-tap transformer. √√ (2)

4.9 4.9.1 The Q-point on the load line is the point at which DC bias is provided to the transistor √ to ensure that it operates, √ depending upon the class of the transistor amplifier. √ (3)

4.9.2 The complete input signal is amplified √ without distortion. √ (2)

4.9.3 Push-pull amplifiers (audio power amplifiers), RF power amplifiers. √√ (2)

4.10 Common-base, common-collector, common-emitter √√√ (3)

4.11
1&2 •R1 and R2 form a voltage divider to set the base voltage. √√
3 •R3 limits the current drawn by the transistor. √
4 •R4 provides a 'load' for the transistor so that $V_{OUT} = V_{CC} - V_{RC}$ √
5 •The transistor amplifies the input signal. √
8 •C1 acts as a coupling capacitor. √
6 •C2 acts as a coupling capacitor to the next stage. √
7 •CE stabilises the bias of the amplifier. √ (8)

4.12
- Reduces noise and distortion at the output. √
- Enables one to design for a specific gain. √
- Stabilises voltage gain. √
- Increases bandwidth. √ (Any 3 x 1) (3)

4.13 4.13.1 When current flows through a transistor it heats up and can overheat if too much current is allowed to flow. √√ (2)

4.13.2 A resistor is placed in series with the emitter, √ to limit the flow of current through the transistor. √ (2)

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QUESTION 5: RLC SERIES CIRCUITS

5.1 5.1.1 Reactance decreases √ (1)

5.1.2 Reactance increases √ (1)

5.1.3 Power factor is the cosine of the phase angle between the applied voltage and the total current. √√ (2)

5.1.4 $X_L = X_C$
Z = Minimum
Power factor = 1
Phase angle = 0
I = maximum (Any 2 x 1) √√ (2)

5.2 5.2.1
$X_L = 2\pi fL$ √
$= 2\pi \times 60 \times 0{,}01$ √
$= 3{,}77\ \Omega$ √

$X_C = \frac{1}{2\pi fC}$ √

$= \frac{1}{2\pi \times 60 \times 470 \times 10^{-6}}$ √

$= 5{,}64\ \Omega$ √

$Z = \sqrt{R^2 + (X_C - X_L)^2}$ √

$= \sqrt{24^2 + (5{,}64 - 3{,}77)^2}$ √

$= 24{,}07\ \Omega$ √ (9)

5.2.2 Leading √ (1)

5.2.3
$f_r = \frac{1}{2\pi\sqrt{LC}}$ √

$= \frac{1}{2\pi\sqrt{0{,}01 \times 470 \times 10^{-6}}}$ √√

$= 73{,}41\ \text{Hz}$ √ (4)

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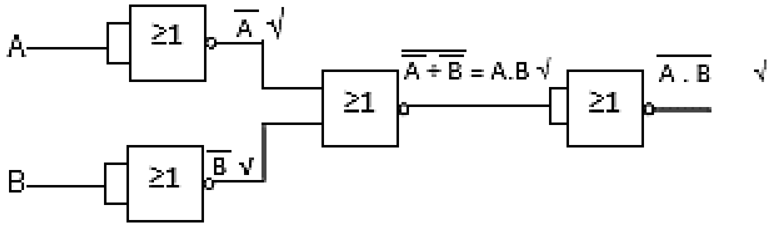
QUESTION 6: LOGIC

6.1 $\overline{A.B} = X$

$\overline{A} + \overline{B} = X$ √



(5)

6.2 6.2.1

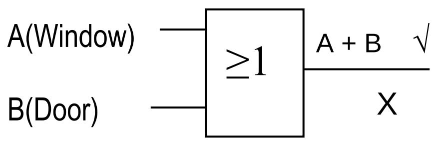
A	B	X	
0	0	0	
0	1	1	√
1	0	1	√
1	1	1	√

(3)

6.2.2 SOP = $\overline{A}.B + A.\overline{B} + A.B$ √√√ (3)

6.2.3 $\overline{A}.B + A.\overline{B} + A.B = B(A + \overline{A}) + A.\overline{B}$
$= B + A.\overline{B}$
$= A + B$ (2)

6.2.4 √



6.3 LHS $= \overline{A}.B.\overline{C} + \overline{A}.B.C + \overline{A}.\overline{B}.C$
$= \overline{A}.B(\overline{C} + C) + \overline{A}.\ \overline{B}.C$ √
$= \overline{A}.B(1) + \overline{A}.\overline{B}.C$ √
$= \overline{A}(B + \overline{B}.C)$ √
$= \overline{A}(B + C)$ √
$= \overline{A}.B + \overline{A}.C$ √
LHS = RHS (5)

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QUESTION 7: COMMUNICATIONS

7.1 7.1.1 FALSE √ (1)

7.1.2 TRUE √ (1)

7.1.3 TRUE √ (1)

7.1.4 FALSE √ (1)

7.1.5 TRUE √ (1)

7.1.6 TRUE √ (1)

7.2 Forestry, ambulance, utilities, police, etc. √√√ (Any 3 x 1) (3)

7.3 7.3.1 With AM the amplitude of the carrier is modulated according to the information signal whereas with FM the frequency of the carrier is modulated according to the information signal. √√√√ (4)

7.3.2 FM is not susceptible to interference. √ (1)

7.3.3
- Increased capacity. √
- Reduced power use. √
- Larger coverage area. √
- Reduced interference from other signals. √ (Any 2 x 1) (2)

7.4 A detector is simply a circuit where half of the AM signal is rectified and the RF is removed, √ leaving the audio signal. √
The discriminator compares the FM signal with a reference signal √ and the difference between the two signals is the original audio signal. √ (4)

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TOTAL: 200