**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

ELECTRICAL TECHNOLOGY

FEBRUARY/MARCH 2013

MEMORANDUM

MARKS: 200

This memorandum consists of 13 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, substitution, answer and unit.

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

   2.3   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 recalculate 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 the marking session at ALL marking centres.

QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1   Wind energy is a renewable energy source.✓
The generation of wind energy has a very small pollution effect on the
environment. ✓   (2)

1.2   Solar energy reduces CO_2 emissions into the atmosphere reducing pollution✓
therefore reducing health hazards to society. ✓
(Any acceptable answers)   (2)

1.3   Ramps must be in place to allow physical access for a person in a wheelchair
to have easy access to the workshop. ✓
Work benches and equipment must be so designed to allow easy wheelchair
movement and access for the pupil to work. ✓
Correct toilet facilities must be made available.
(Any two)   (2)

1.4   He must be able to find a need and fulfil it.✓ You need to investigate what the
market requires and then try to meet that requirement. ✓
Focus on your on your customers. ✓ It is important to recognise the needs
desires and the differences of your customers. ✓
Identify a problem and solve it.
Invest sweat equity in your business.   (4)
                                                                     [10]

QUESTION 2: THE TECHNOLOGICAL PROCESS

2.1   2.1.1   It is a very clear and logical plan✓ detailing the sequence of steps to
follow in the manufacturing of a product. ✓   (2)

2.1.2   The specification in the design brief was converted to well-
formulated criteria✓ to establish whether the solution meets the
need. ✓
(Any relevant answer)   (2)

2.2   Compare similar products. ✓
Get experts to evaluate the product and give feedback. ✓
Set public questioners to get feedback on the product. ✓
Conduct interviews on your product.
Do research on the product.
(Any relevant answers)   (3)

2.3   It is a unique product. ✓
It is relatively affordable. ✓
There is a demand for the product✓
It will be readily available.
(Any relevant answers)   (3)
                                                                     [10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 Suitable eye protection must be worn. ✓
Wear correct protective clothes. (1)

3.2 No horseplay in the workshop. ✓
No working on a machine which does not have correct safety guards. ✓
(Any other relevant answers) (2)

3.3 No CO_2 fire extinguisher in the workshop✓
No earth leakage protection installed in the workshop
Live exposed electrical connection are present in the workshop
Workshop floors full of grease or oil
Sharp objects stored carelessly in the workshop
(Any correct answer) (1)

3.4 To prevent the spreading of infections and disease✓ from one person to another person ✓
(Any other relevant answers HIV/AIDS) (2)

3.5 Switch off the supply/main switch immediately✓
If you are unable to switch off the supply, pull or push the victim away from the point of shock using an insulated item.✓
Do not use your bare hands✓
Apply FIRST AID or get a trained person to do it✓
Call for help (4)
[10]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 For alternators of similar frame sizes, three-phase machines produce more power than single-phase machines. ✓
In the case alternators, machinery of the same size may be used to drive single-phase and three-phase machines with the three-phase machine developing more power. ✓
Three-phase alternators can be connected in parallel to obtain a combined supply.
Three-phase power is cheaper to generate than single-phase power.
The rotor of a three-phase alternator is usually connected in star to create a neutral point with which the system can be earthed to prevent floating voltages. As a result of the star connection, losses are also limited because of the lower voltages (57,7% of the line voltage) across the rotor coils.
(Any two) (2)

4.2 $V_L = V_{Ph}$
$V_L = 30$ A
$V_{Ph} = 30$ A ✓ (1)

4.3

(4)

4.4
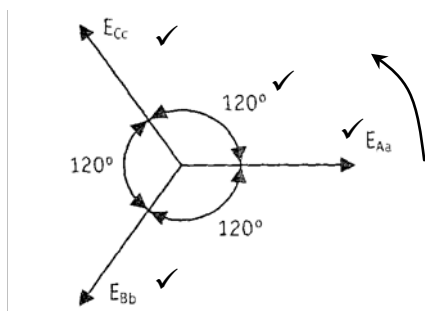
$$P = 3V_{ph}I_{ph}\cos\theta \quad \checkmark$$
$$= 3 \times 240 \times 20 \times \cos 30 \checkmark$$
$$= 12.47 \ kW \checkmark$$

(3)
[10]

QUESTION 5: RLC CIRCUITS

5.1   5.1.1   The inductive reactance will increase ✓   (1)

         5.1.2   The capacitive reactance will decrease✓   (1)

5.2   No ✓   (1)

5.3   5.3.1

$$V_R = IR \quad \checkmark$$
$$= 3 \times 70 \checkmark$$
$$= 210 V \checkmark$$

(3)

         5.3.2

$$X_L = 2\pi FL \checkmark$$
$$= 2 \times \pi \times 50 \times 0.17 \checkmark$$
$$= 53.4 \Omega \checkmark$$

(3)

         5.3.3

$$V_L = IX_L \checkmark$$
$$= 3 \times 53.4 \checkmark$$
$$= 160.23 V \checkmark$$

(3)

         5.3.4

$$X_C = \frac{1}{2\pi fC} \quad \checkmark$$
$$= \frac{1}{2 \times \pi \times 50 \times 160 \times 10^{-6}} \quad \checkmark$$
$$= 19.89 \Omega \quad \checkmark$$

(3)

5.3.5

$$V_C = IX_C \checkmark$$
$$= 3 \, x \, 19.89 \checkmark$$
$$= \underline{59.67\,V} \checkmark$$

(3)

5.4   5.4.1

$$I_R = \frac{V}{R} \checkmark$$
$$= \frac{240}{20} \checkmark$$
$$= \underline{12\,A} \checkmark$$

(3)

5.4.2

$$I_C = \frac{V}{X_C} \checkmark$$
$$= \frac{240}{32} \checkmark$$
$$= \underline{7.5\,A} \checkmark$$

(3)

5.4.3

$$I_L = \frac{V}{X_L} \checkmark$$
$$= \frac{240}{24} \checkmark$$
$$= \underline{10\,A} \checkmark$$
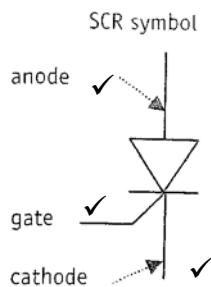
(3)

5.4.4   Inductive reactance = capacitive reactance ✓
Supply current   = Current in the resistor ✓
Current in coil   = Current in capacitor ✓
Phase angle   = zero
(any relevant answer)

(3)
[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1

(If symbol is correct with no or incorrect labelling = 1 Mark) (3)

6.2 To switch on the SCR the anode must be positive in relation to the cathode voltage. ✓ Under this condition when a positive pulse is applied to the gate, the SCR will switch on. ✓
If the forward voltage applied to the SCR rises above V_{BO} it will switch on. ✓ (3)

6.3 Speed control of electric motors. ✓
Lamp dimming. ✓
Temperature control.
SCR's are used in switching circuits (2)

6.4 1 – V_{BO}✓
2 - I✓
3 – I_H✓
4 – Forward conduction✓
5 – Reverse breakdown✓ (5)

6.5 The DIAC is switched on when a voltage is applied across the two terminals✓ in either direction✓ and raised above V_{BO}✓ of between 30 V and 50V which is the break over voltage of the DIAC. (3)

6.6 6.6.1 1 – MT1 ✓ or anode1
2 – MT2 ✓ or anode 2
3 - Gate✓ (3)

6.6.2 R_1 acts as a current limiter. ✓
R_1 protect the components from over current
R_1 controls the maximum brightness of the lamp (1)

6.6.3 A DIAC conducts in both directions✓ it can therefore trigger the TRIAC in both Halves of the ac waveform. ✓ A Diode can only conduct in one direction. ✓ The TRIAC therefore will only conduct for a half of the ac input waveform. ✓ (4)

6.6.4 R2 is a variable resistor/preset/potentiometer. ✓ (1)

[25]

QUESTION 7: AMPLIFIERS

7.1   Open-loop voltage gain A_v = infinite ✓
        Input impedance Z_{in} = infinite ✓
        Output impedance Z_{out} = zero✓
        Bandwidth = infinite✓
        Uncondititional stability
        Differential inputs, i.e. two inputs
        Infinite common-mode rejection
        (any four)   (4)

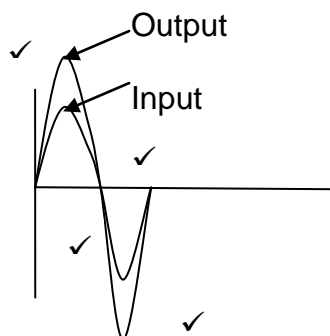7.2   The gain can be controlled more accurately ✓
        Acts more closely to an ideal amplifier ✓
        (any relevant answer)   (2)

7.3
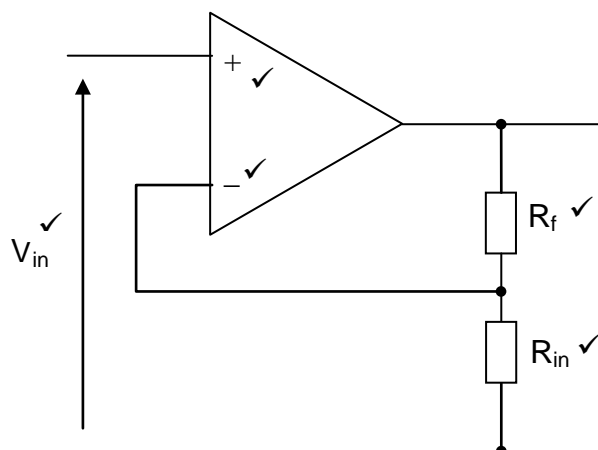
(5)

7.4

        Must show increased amplitude in phase.   (4)

7.5   The input signal of the one input terminal ✓ is compared to the input signal (or
        reference voltage V_{ref}) of the other terminal and the different is amplified. ✓   (2)

7.6   value of the input resistor✓
        value of the feedback resistor ✓   (2)
        the type of feedback used
        internal characteristics of the op-amp

7.7   7.7.1   In the inverting input, the output will be a maximum✓ , but out of
                  phase ✓ with the input.✓   (3)

        7.7.2   In the non-inverting input, the output will be a maximum✓ and in
                  phase ✓ with the input.✓   (3)

                                                                                     [25]

QUESTION 8: THREE-PHASE TRANSFORMERS

8.1   Copper losses ✓
Iron losses ✓
Stray losses✓
Dielectric losses ✓   (4)

8.2   Secondary winding✓   (1)

8.3   To step up or step down an ac. voltage✓
To isolate electrical circuits.
Impedance matching between circuits (Any correct answer)   (1)

8.4   8.4.1

$$V_{L(S)} = \sqrt{3}V_{ph(S)} \quad ✓$$
$$= \sqrt{3} \, x \, 240 \quad ✓$$
$$= 415.69V \quad ✓$$

                                                            (3)

         8.4.2

$I_{ph} = I_L \quad (Star\ connection)$ $S = 3V_{ph(s)}I_{ph(S)}$

$S = \sqrt{3}V_L I_L$ $and\ I_{ph(S)} = \dfrac{S}{3V_{ph(S)}}$

$and\ I_L = \dfrac{S}{\sqrt{3}V_L} \quad ✓$ **OR**

$= \dfrac{300000}{\sqrt{3} \, x \, 415.69} \quad ✓$ $= \dfrac{300000}{3 \, x \, 240}$

$= 416.67 \ A$ $I_{ph} = \underline{416.67\,A}$

$\therefore I_{ph} = \underline{416.67\,A} \quad ✓$

                                                            (3)

         8.4.3

$$P = \sqrt{3}V_L I_L \cos\theta \quad ✓$$
$$= \sqrt{3} \, x \, 415.69 \, x \, 416.67 \, x \, 0.8✓$$
$$= \underline{240\,kW}✓$$

                                                          (3)
                                                           [15]

QUESTION 9: LOGIC CONCEPTS AND PLCs

9.1
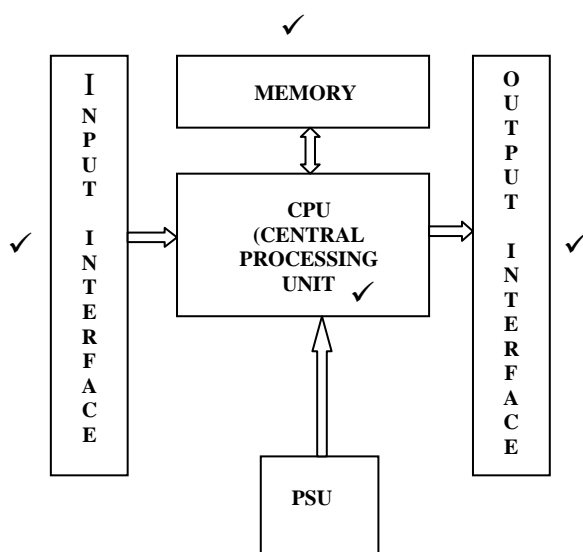
(4)

9.2   More economical✓
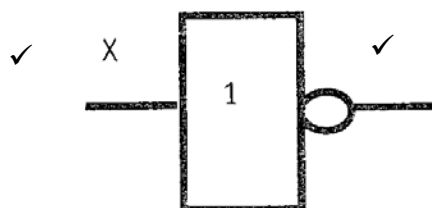   A simpler design✓
        A quicker delivery✓
        More compact and standardised
        Improve reliability
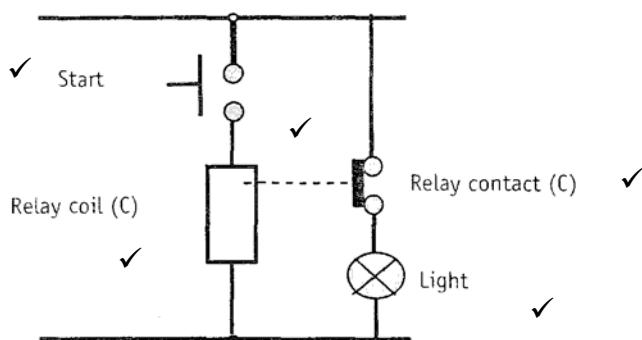   Reduced maintenance
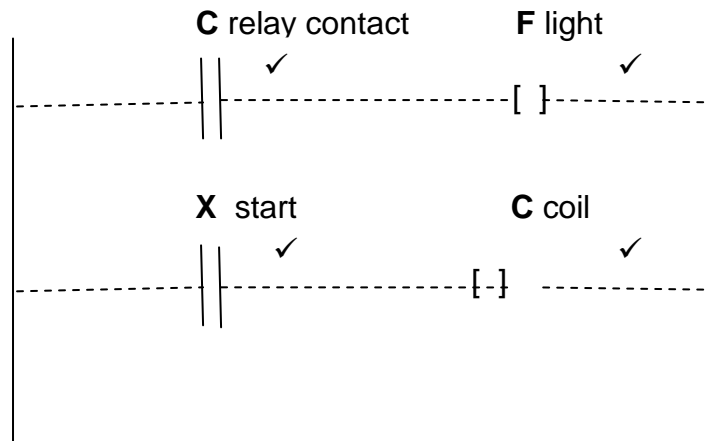   (any three)   (3)

9.3   9.3.1

(2)

        9.3.2

(5)

9.3.3

(4)

9.4

SET	RESET	Q	$\bar{Q}$	
0	0	0	1	✓
0	1	0	1	✓
1	0	1	0	✓
0	1	0	1	✓
1	0	1	0	✓
1	1	Not allowed		✓

(6)

9.5   9.5.1   Push buttons✓
Limit switches✓
Overload
Relay contacts
(any relevant answer) (2)

       9.5.2   Indicator lamps✓
Solenoid valves✓
Relay coils
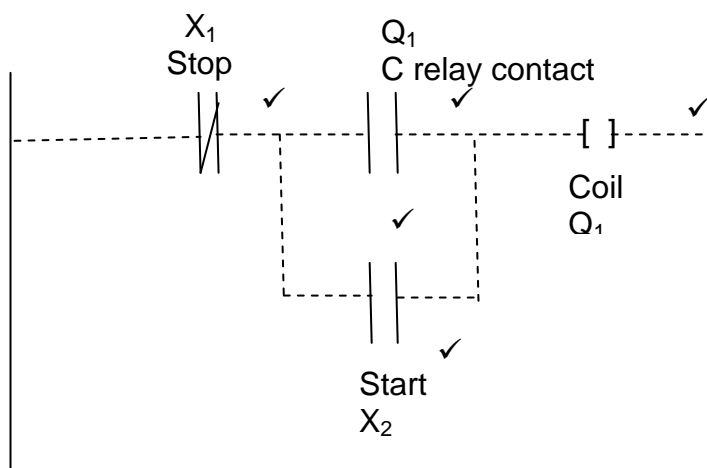Contactor coils
(any relevant answer) (2)

9.6   A program is a series of instructions written ✓in a language that a PLC can understand. ✓ (2)

9.7

(5)

[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1   Earth leakage unit✓
        Circuit breakers
        Fuses
        Overload Unit
        (Any one)   (1)

10.2   Check frame✓
        Check rotor✓
        Check fan
        Check bearings
        Check end plates
        Check stator
        (Any two)   (2)

10.3   Direct-on-line starter✓
        Star/delta starter✓
        Autotransformer starter✓
        Forward/Reverse starter
        Sequence starter
        (Any three)   (3)

10.4   Lagging power factor✓
        Resistive inductive power factor   (1)

10.5   No-volt protection prevents a motor from restarting after a power failure. ✓
        The operator needs to re-engage the start switch in order to restart the motor. ✓
        This protects both the operator and the equipment.✓   (3)

10.6   10.6.1 $P_i = \sqrt{3} V_L I_L \cos\theta$ ✓

                  $P_i = \sqrt{3} \times 415 \times 14 \times 0,8$ ✓

                  $\underline{P_i = 8.05 kW}$ ✓   (3)

        10.6.2 $I_L = \sqrt{3} I_P$

                  $I_P = \dfrac{I_L}{\sqrt{3}}$ ✓

                  $I_P = \dfrac{14}{\sqrt{3}}$ ✓   (3)

                  $\underline{I_P = 8,08 A}$ ✓

10.7   10.7.1   1- overload✓
                  2- delta contactor✓
                  3- star contactor✓
                  4- terminal box or stator connection✓   (4)

10.7.2 Normally open contacts are contacts open✓ in the de-energised state✓ closed in the energised state. ✓ (3)

10.7.3 When the N/O start is depressed the main contactor, the timer contactor and the star contactor are all energised✓ supplying the motor which is now connected in the star mode with power. ✓
The timer contactor now begins to time through. ✓
Once timed through to a preset time the N/C timer contacts open de-energising the star contactor. ✓
The N/O timer contacts close energising the delta contactor. This now connects the motor to delta. ✓
The N/C star and delta contacts provide interlocking✓ to prevent both contactors been energised at the same time. ✓ (7)
[30]

TOTAL: 200