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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T510(E)(N14)T
NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

ELECTRO-TECHNOLOGY N3

(11040343)

14 November 2013 (X-Paper)
09:00–12:00

This question paper consists of 6 pages and 3 formula sheets.

ENGINEERING

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ELECTRO-TECHNOLOGY N3
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Keep subsections of questions together.
5. Sketches and diagrams must be done in pencil. The sketches/diagrams must be neat, reasonably large and fully labelled.
6. The answers must be rounded off to THREE decimal places.
7. Use the correct units for answers.
8. Write neatly and legibly.

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QUESTION 1

1.1 Define the term *commutation* as applicable to a DC machine. (2)

1.2 Name ONE method that is used to wind an armature of a DC machine. (1)

1.3 Name TWO components in a DC machine, which can be damaged due to poor commutation. (2)

1.4 Make a neat labeled sketch showing the compensating and armature windings and also the relative directions of the current flowing through them. (5)
[10]

QUESTION 2

2.1 Name TWO generators which are dependent on the excitation process in order to operate. (2)

2.2 Make TWO relevant sketches to distinguish between the two generators named in QUESTION 2.1. (4)

2.3 List FOUR factors that determine the magnitude of the induced EMF in a conductor. (4)
[10]

QUESTION 3

3.1 An eight-pole DC machine has 360 armature conductors and it rotates at 11r/s. The magnetic flux is 0,013 Wb per pole.

Determine the following:

3.1.1 The speed in r/min (2)

3.1.2 EMF generated if it is a lap-wound machine (3)

3.1.3 EMF generated if it is a wave-wound machine (3)

3.2 Name TWO variable factors that the torque of a DC motor is dependent upon. (2)
[10]

QUESTION 4

4.1 Briefly explain the operation of the bimetal-strip type overload as used in motor starters. (4)

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4.2 Label FIGURE 1 below. Write only the answer next to the letter (A–F) in the ANSWER BOOK.

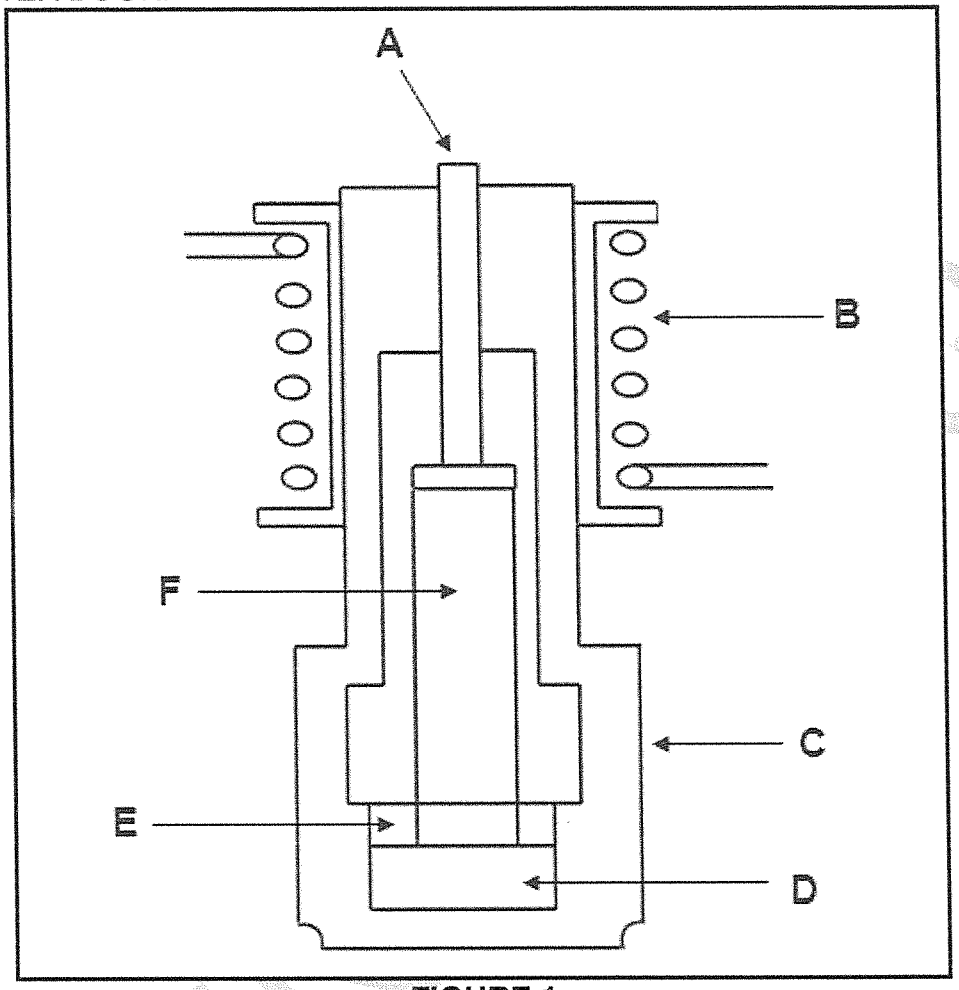

FIGURE 1

(6)
[10]

QUESTION 5

During a brake test performed on a DC motor, the effective load was 0,425 kN at a drum speed of 420 rpm. The effective diameter of the drum is 0,6 m and the input to the motor is 33 000 mA at a supply voltage of 220 V.

Determine the following:

5.1 Output power of the motor in kW (4)

5.2 Input power of the motor in kW (3)

5.3 The motor's efficiency (3)
[10]

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QUESTION 6

The following ordinate points were read from the full cycle of an alternating quantity:

$(i_1) = 22$ A; $(i_2) = 44$ A; $(i_3) = 85$ A; $(i_4) = 122$ A; $(i_5) = 97$ A; $(i_6) = 37$ A; $(i_7) = 20$ A

Determine the following from the data given above:

6.1 The type of alternating quantity stated above (1)

6.2 Actual value (4)

6.3 Average value (3)

6.4 Form factor (1)

6.5 The type of wave form deduced from the value of the crest factor, if the crest factor is 1,414 (1)

[10]

QUESTION 7

7.1 An 80 kW, 400 V, three-phase alternating-current motor has a power factor of 0,86 and an efficiency of 87%.

Determine the line current of the motor in kA. (4)

7.2 A 200 kW, three-phase, AC motor is connected in delta and the supply voltage is 440 V.

Determine the following if the power factor is 0,9:

7.2.1 Phase voltage in kV (2)

7.2.2 Phase current of the motor in mA (4)

[10]

QUESTION 8

8.1 Give FOUR differences between a single-phase transformer and an auto-transformer.

Tabulate your answer. (8)

8.2 A single-phase transformer has 49 turns on the secondary winding and is connected to a 240 V supply. The output voltage is 80 V and the primary current is 0,218 A.

Determine the primary number of turns. (2)

[10]

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QUESTION 9

9.1 A galvanometer has a resistance of 60 Ω and gives a full-scale deflection when 3 mA passes through.

Calculate:

9.1.1 The series resistance required to use it as a voltmeter up to 3 V. (3)

9.1.2 The resistance required to use the instrument as an ammeter for a 2A current flow. (3)

9.2 List FOUR components which are found in a moving-iron dynamo-meter instrument. (4)
[10]

QUESTION 10

10.1 Explain with the aid of a neat sketch the term *forward bias.* (2)

10.2 Change the following decimal numbers to binary and show ALL the necessary steps:

10.2.1 $8,5_{10}$

10.2.2 $4,25_{10}$

10.2.3 Add the answers of QUESTION 10.2.1 and QUESTION 10.2.2 and leave the answer in binary number.

(3 × 2) (6)

10.3 Draw the IEC symbols for the following logic gates:

10.3.1 NAND gate (1)

10.3.2 OR gate (1)
[10]

TOTAL: 100

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FORMULA SHEETS

Any applicable formula may also be used.

1. $E = V - I_a R_a$

2. $E = V + I_a R_a$

3. $E = 2p\Phi \dfrac{ZN}{60C}$

4. $N = \dfrac{V}{K\Phi}$

5. $T = \dfrac{0{,}318\ I_a\ Zp\ \Phi}{C}$

6. $Efficiency/Rendement = \dfrac{VI}{VI + Ia^2 Ra + IsV + C} \times 100$

7. $Efficiency/Rendement = \dfrac{VI - (Ia^2 Ra + IsV + C) \times 100}{VI}$

8. $Efficiency/Rendement = \dfrac{2\pi N(W - S) \times r}{60\ VI} \times 100$

9. $Efficiency/Rendement = \sqrt{\dfrac{I_1}{I_1 + I_2}} \times 100$

10. $E = Blv$

11. $e = E_m Sin2\pi ft$

12. $i = I_m Sin2\pi ft$

13. $e_{ave/gem}$ *of/or* $i_{ave/gem} = 0{,}637\ Em$ *or/of* Im

14. $e_{rms/wgk}$ *or/fr* $i_{rms/wgk} = 0{,}707\ Em$ *or/of* Im

15. $E_{ave/gem} = \dfrac{e_1 + e_2 + e_3 + ... + e_n}{n}$

    or/of $I_{ave/gem} = \dfrac{i_1 + i_2 + i_3 + ... + i_n}{n}$

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16. $E_{rms/wgk} = \sqrt{\frac{e_1^2 + e_2^2 + e_3^2 + ... + e_n^2}{n}}$

or/of $I_{rms/wgk} = \sqrt{\frac{i_1^2 + i_2^2 + i_3^2 + ... + i_n^2}{n}}$

17. $Form\ factor/Vormfaktor = \frac{E_{rms/wgk}}{E_{ave/gem}}\ or/of\ \frac{I_{rms/wgk}}{I_{ave/gem}}$

18. $Crest\ factor/Kruinfaktor = \frac{E_m}{E_{rms/wgk}}\ or/of\ \frac{I_m}{I_{rms/wgk}}$

19. $I = \frac{V}{R}$

20. $X_L = 2\pi fL\ ;\ i = \frac{V}{X_L}$

21. $X_C = \frac{1}{2\pi fC}\ ;\ i = \frac{V}{X_C}$

22. $Z = \sqrt{R^2 + X_L^2}\ ;\ Z = \sqrt{R^2 + X_C^2}\ ;\ I = \frac{V}{Z}$

23. $Tan\ \theta = \frac{X_L}{R}\ ;\ Tan\ \theta = \frac{X_C}{R}$

24. $VR = I \times R\ ;\ V_L = I \times X_L\ ;\ V_C = I \times X_C$

25. $Z = \sqrt{R^2 + (X_L - X_C)^2}\ ;\ Z = \sqrt{R^2 + (X_C - X_L)^2}$

26. $\text{Tan}\ \theta = \frac{X_L - X_C}{R}\ ;\ Tan\ \theta = \frac{X_C - X_L}{R}$

27. $P = V \times I\ ;\ P = I^2R\ ;\ P = \frac{V^2}{R}$

28. $P = VI \text{ Cos } \theta$

29. $\text{Cos } \theta = \frac{R}{Z}\ ;\ Cos\ \theta = \frac{W\ or/of\ KW}{VA\ or/of\ KVA}$

30. $I_{active/aktief} = I\ cos\ \theta$

$I_{reactive/reaktief} = I \sin \theta$

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31. $P = VI \text{ Cos } \theta$

$Q = VI \text{ Sin } \theta$

32. $fr = \frac{1}{2\pi\sqrt{LC}}$

33. $I = \sqrt{I_R^2 + I_L^2}$; $Tan\ \theta = \frac{I_L}{I_R}$

34. $I = \sqrt{I_R^2 + I_C^2}$; $Tan\ \theta = \frac{I_C}{I_R}$

35. $I = \sqrt{I_R^2 + (I_L - I_C)^2}$; $Tan\ \theta = \frac{I_L - I_C}{I_R}$

36. $I = \sqrt{I_R^2 + (I_C - I_L)^2}$; $Tan\ \theta = \frac{I_C - I_L}{I_R}$

37. $Cos\ \theta = \frac{I_R}{I}$

38. $V_L = V_P$; $I_L = \sqrt{3}\, Ip$

39. $V_L = \sqrt{3}\, Vp$; $I_L = I_p$

40. $W = \sqrt{3}\, V_L I_L\ Cos\ \theta \times \eta$

41. $\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$

42. $KVA = \frac{\sqrt{3}\, V_L I_L}{1\,000}$

43. $V_{shunt/sjunt} = V_{meter}$; $I_s R_s = I_m R_m$

44. $I_T = I_m + I_s$

45. $I_T = \frac{V_T}{R_T}$

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MARKING GUIDELINE

NATIONAL CERTIFICATE

NOVEMBER EXAMINATION

ELECTRO-TECHNOLOGY N3

14 NOVEMBER 2013

This marking guideline consists of 7 pages.

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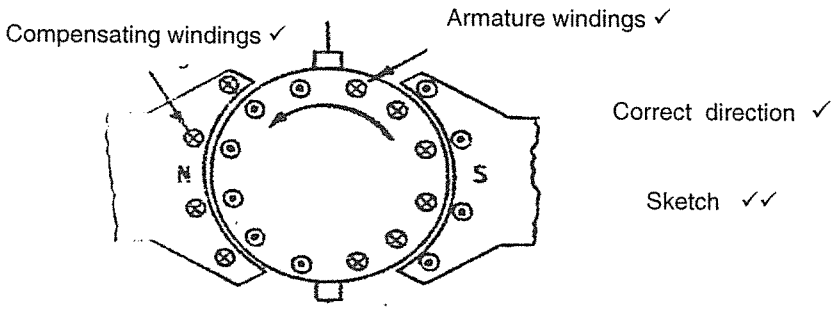
QUESTION 1

1.1 COMMUTATION is the reversal of the EMF and current, ✓
in a short-circuited coil, during its transfer from one commutator segment to the next. ✓ (2)

1.2 Lap winding or wave winding ✓ (1)

1.3
- Brushes ✓
- The commutator surface ✓ (2)

1.4



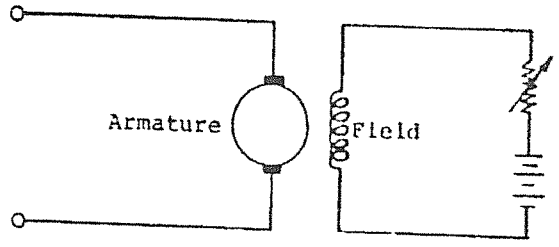
(5)
[10]

QUESTION 2

2.1
- Separately excited generator ✓
- Self-excited generator✓ (2)

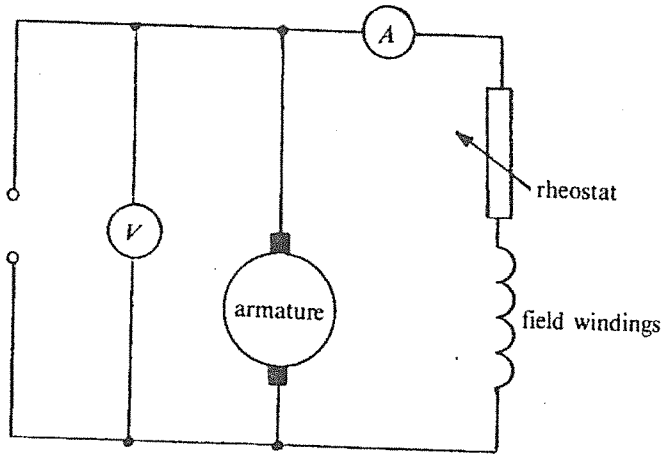
2.2

SEPARATELY EXCITED GENERATOR



Sketch ✓✓ (2)

SELF-EXCITED GENERATOR



Sketch ✓✓ (2)

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2.3 The strength of the magnetic field ✓
The number of pairs of poles used ✓
The number of active conductors connected in series✓
The rate at which the magnetic flux is cut by the moving conductor✓ (4)
[10]

QUESTION 3

3.1 Given:
p = 4 Z = 360 conductors
N = 11 rev/sec Φ = 0,013 Wb

3.1.1 The speed in r/min [N] = speed x 60
= 11 x 60 ✓
= 660 r/min ✓ (2)

3.1.2 EMF generated = $\frac{2ZpN\phi}{C60} = \frac{2\times360\times4\times660\times0,013}{2\times4\times60}$ ✓✓
= 51,48 V ✓ (3)

3.1.3 EMF generated = $\frac{2ZpN\phi}{C60} = \frac{2\times360\times4\times660\times0,013}{2\times60}$ ✓✓
= 205,92 V✓ (3)

3.2
- Armature current [I_a]
- Flux per pole [Φ]

(2)
[10]

QUESTION 4

4.1 When the current reaches overload magnitude ✓ the heating coil will heat the bimetal strip✓ to the extent that it will bend far enough ✓to operate the tripping contacts ✓ (4)

4.2
A Trip-out mechanism✓
B Overload coil✓
C Oil dashpot✓
D Piston✓
E Oil✓
F Plunger✓ (6 × 1) (6)
[10]

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QUESTION 5

Given:
Effective load = 0,425 kN = 425 N
N = 420 r/min
diameter = 0,6 m
radius = 0,3 m
I = 33 000 = 33 A
V = 220 V

5.1 Output power of the motor = $\frac{2\pi N(W-w)r}{60} = \frac{2\times 3{,}142\times 420\times 425\times 0{,}3}{60}$ ✓✓
= 5608,47 W ✓
= 5,609 kW✓ (4)

5.2 Input power of the motor = IV = 33 A x 220 V ✓
= 7260 W ✓
= 7,26 kW ✓ (3)

5.3 Efficiency of the motor [η] = $\frac{Output}{Input}\times 100\% = \frac{5609}{7260}\times 100\%$ ✓
= 0'77259 x 100% ✓
= 77,259% ✓ (3)
[10]

QUESTION 6

6.1 Alternating current ✓ (1)

6.2 Actual Value = $\sqrt{\frac{i_2^{\,2}+i_2^{\,2}+i_3^{\,2}+\ldots+i_n^{\,2}}{n}}$ ✓
$= \sqrt{\frac{22^2+44^2+85^2+122^2+97^2+37^2+20^2}{7}}$ ✓
$= \sqrt{\frac{35707}{7}} = \sqrt{5101}$ ✓
= 71,421 A ✓ (4)

6.3 Average value [I_{ave}] = $\frac{i_1+i_2+i_3+\ldots+i_n}{n}$
$= \frac{22A+44A+85A+122A+97A+37A+20A}{7}$ ✓
$= \frac{427}{7}$ ✓
= 61 A ✓ (3)

6.4 Form factor = $\frac{I_{rms}}{I_{ave}} = \frac{71{,}421A}{61A}$
= 1,171 ✓ (1)

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6.5 Sine wave or peak wave or sinusoidal wave ✓ (1)
[10]

QUESTION 7

7.1 Line current $[I_L] = \frac{P}{\sqrt{3}V_L Cos\theta\eta} = \frac{80000}{\sqrt{3} \times 400V \times 0{,}86 \times 0{,}87}$ ✓✓

$= \frac{80000W}{518{,}368}$

= 154,331 A ✓

= 0,154 kA ✓ (4)

7.2 Given: P = 200 kW; Delta connection; $V_s = 440\,V$; power factor = 0,9

7.2.1 Phase voltage = line voltage (Delta connection)

= 440 V✓

= 0,44 kV ✓ (2)

7.2.2 $I_L = \frac{P}{\sqrt{3}\,V_L \times Cos\theta} = \frac{200\,000}{1{,}732 \times 440\,V \times 0.9}$ ✓

= 291.599 A ✓

But $I_L = \sqrt{3} I_{PH}$

$I_{PH} = \frac{291{,}599A}{\sqrt{3}}$ ✓

= 168,359 A

= 168 359 mA ✓ (4)
[10]

QUESTION 8

8.1

SINGLE-PHASE TRANSORMER	AUTO-TRANSFORMER
• Mutual induction✓ • No electrical connection✓ • Step up or down✓ • Primary and secondary windings are apart✓	• Self induction✓ • Are connected electrically✓ • Step down only✓ • Primary and secondary have the same winding✓

(8)

8.2 Primary number of turns: $\frac{V_1}{V_2} = \frac{N_1}{N_2}$

$N_1 = \frac{240V \times 49}{80V}$ ✓

= 147 turns ✓ (2)
10]

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QUESTION 9

9.1 Given: $R_M = 60\ \Omega; I_M = 3m\ A = 0{,}003\ A$

9.1.1 As a voltmeter:

$$R_t = \frac{V_t}{I_t} = \frac{3\ V}{0{,}003\ A}$$

$= 1\ 000\ \Omega$ ✓

$$R_{series} = R_t - R_m$$

$= 1\ 000\ \Omega - 60\ \Omega$✓

$= 940\ \Omega$ ✓ (3)

9.1.2 As an ammeter:
Voltage across ammeter

$$V_m = I_m R_m = 0{,}003\ A \times 60\ \Omega$$

$= 018\ V$ ✓

Current through shunt:

$$I_s = I_t - I_m = 2\ A - 0{,}003\ A$$

$= 1{,}997\ A$ ✓

$$R_s = \frac{V_s}{I_s} = \frac{0{,}18\ V}{1{,}997 A}$$

$= 0{,}090\ \Omega$ ✓ (3)

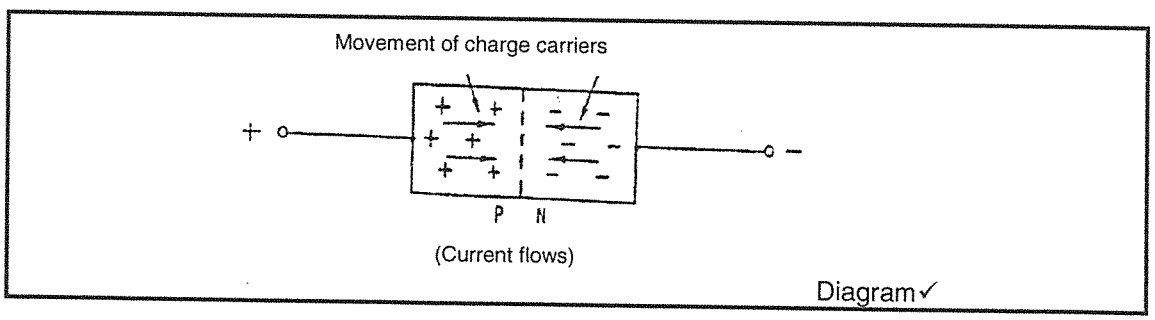
9.2

MOVING-IRON INSTRUMENT	DYNAMO-METER INSTRUMENT
Uneven Scale	Uneven scale✓
Pointer/Needle	Pointer/Needle✓
Balance weight	Balance weight✓
Spring	Spring✓

(4)
[10]

QUESTION 10

10.1



Diagram✓

FORWARD BIAS CONCEPT (2)

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10.2 10.2.1

2	8 remainder 0
2	4 remainder 0
2	2 remainder 0
2	1 remainder 1

0,5 x 2 = 1
0,0 x 2 = 0

Showing steps✓
$8,5_{10} = 1000,1_2$ ✓

10.2.2

2	4 remainder 0
2	2 remainder 0
2	1 remainder 1

0,25 x 2 = 0
0,5 x 2 = 1

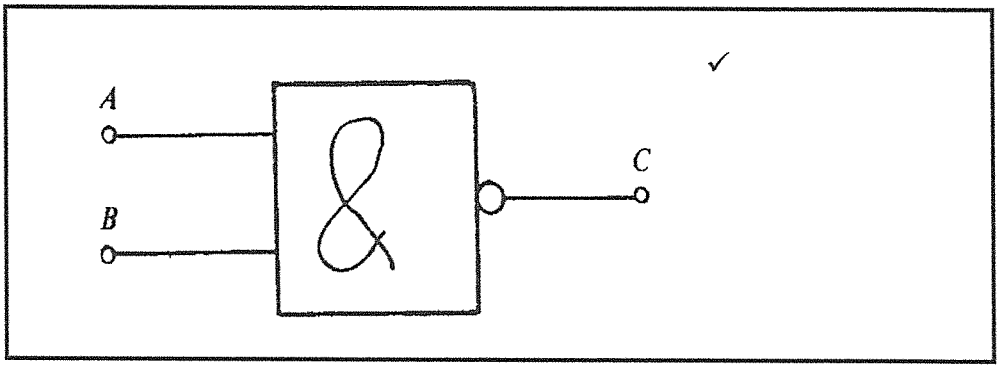
Showing steps✓
$4,25_{10} = 100,01_2$ ✓

10.2.3

$$\begin{array}{r} 1000,1_2 \\ +100,01_2 \\ \hline 1100,11_2 \end{array}$$ ✓

(3 × 2) (6)

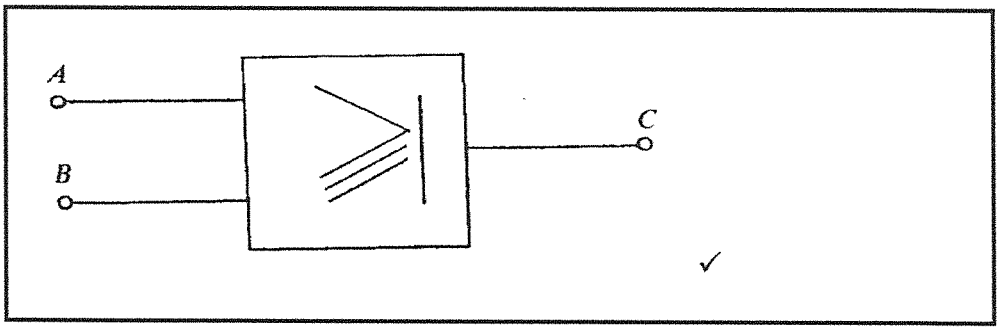
10.3 10.3.1



✓

NAND gate (IEC symbol) (1)

10.3.2



✓

OR gate (IEC Symbol) (1)
[10]

TOTAL: 100

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