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This question paper consists of 6 pages and 1 formula sheet.
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. Questions may be answered in any order, but subsections of questions must be kept together.
5. Use only blue or black ink.
6. Write neatly and legibly.
QUESTION 1: ALTERNATING CURRENT AND VOLTAGE

1.1

FIGURE 1 shows an RLC circuit connected in series. Refer to the above diagram and calculate the following:

1.1.1 The value of the capacitor (2)
1.1.2 The value of the inductor (2)
1.1.3 The line current (2)
1.1.4 The voltage drop across each component (6)

1.2 Sketch the graph in the answer book for the alternating voltage represented by \( e = 538.2 \sin(250t) \).

Label the axes and important points on the graph. (4)

1.3 Determine the following for the voltage in QUESTION 1.1 above:

1.3.1 The frequency
1.3.2 The RMS value
1.3.3 The instantaneous value 0.02 seconds after the wave passes through zero in a positive direction.

(3 x 2) (6)

QUESTION 2: D.C. GENERATOR

2.1 Explain how the terminal EMF of a shunt-wound generator is built up. (4)
2.2 What is meant by armature reaction? (2)
2.3 A six-pole armature has 65 slots with 6 conductors per slot and is driven at 1 000 rpm. The useful flux per pole is 10 mWb.

Calculate the EMF generated in the following:

2.3.1 A wave-wound armature

2.3.2 A lap-wound armature

(2 x 3) (6)

QUESTION 3: D.C. MOTOR

3.1 Explain in detail the mechanical losses of a D.C. motor. (5)

3.2 A shunt wound motor is connected to a 220 V supply and draws a full load current of 15 A.

Determine the efficiency of the motor when it has the following losses:

Iron loss = 55 watts
Armature copper loss = 80 watts
Shunt winding copper loss = 35 watts
Brush contact loss = 5 watts

(6) (11)

QUESTION 4: ALTERNATOR

4.1 Explain in detail how you would test the rotor of an alternator.

Name all the test instruments used and the readings which should be obtained for a rotor in good condition. (4)

4.2 State TWO advantages of using an alternator rather than a generator in the charging system of a vehicle. (2)

4.3 Briefly explain, with the aid of a diagram, the difference between star and delta connected stators. (4) (10)
QUESTION 5: IGNITION SYSTEM

5.1 Modern vehicles use electronic ignition systems.

Name THREE advantages of electronic ignition systems compared to the conventional ignition system. (3)

5.2 The Hall-effect triggering system is used in the modern electronic ignition system.

Briefly explain how this system operates. (5)

5.3 What are the functions of the following in a capacitor discharge ignition system:

5.3.1 SCR
5.3.2 Coil
5.3.3 Capacitor
5.3.4 Inverter and step-up (4 x 1)

QUESTION 6: MEASURING INSTRUMENTS

6.1 What is a dwell meter used for? (1)

6.2 Name TWO types of moving-coil instruments. (2)

6.3 State FIVE factors that affect the performance of the ignition system that can be observed on the oscilloscope. (5)

6.4 What is the purpose of the following with regard to measuring instruments:

6.4.1 A controlling device.
6.4.2 A damping device.
6.4.3 A deflecting device. (3 x 1)
QUESTION 7: TRANSFORMERS

7.1 Why is the core of a transformer laminated?  

7.2 A single-phase transformer has a supply voltage of 220 volts and a primary current of 16 A. The secondary current is 600 mA and there are 750 turns on the primary coil.

Calculate the following:

7.2.1 The turns ratio.  
7.2.2 The number of turns on the secondary coil.  
7.2.3 The secondary voltage.  
7.2.4 The secondary power.  
7.2.5 The voltage per turn.  

\[ (5 \times 2) \quad (10) \quad [12] \]

QUESTION 8: ELECTRONICS

8.1 Draw a fully labelled characteristic curve for a 9 V Zener diode.  

8.2 Draw a fully labelled circuit diagram of an NPN transistor in a common emitter amplifier circuit.  

\[ TOTAL: \quad 100 \]
MOTOR ELECTRICAL THEORY N3

FORMULA SHEET

1. \[ I = \frac{V}{R} \text{ (A)} \]

2. \[ I = \frac{V}{Z} \text{ (A)} \]

3. \[ e = E_n \cdot \sin(2\pi f t) \text{ (V)} \]

4. \[ i = I_n \cdot \sin(2\pi f t) \text{ (A)} \]

5. \[ X_L = 2\pi f L \text{ (\Omega)} \]

6. \[ X_C = \frac{1}{2\pi f C} \text{ (\Omega)} \]

7. \[ Z = \sqrt{R^2 + (X_L - X_C)^2} \text{ (\Omega)} \]

8. \[ \cos \phi = \frac{R}{Z} \]

9. \[ P = I^2 R \text{ (W)} \]

10. \[ P = V \cdot I \cdot \cos \phi \text{ (W)} \]

11. \[ E = \frac{2ZNP\phi}{60C} \text{ (V)} \]

12. \[ E = V + I_aR_a \text{ (V)} \]

13. \[ E = V - I_aR_a \text{ (V)} \]

14. \[ T = \frac{ZP\phi I_a}{\pi C} \text{ (N.m)} \]

15. \[ P = IV \text{ (W)} \]

16. \[ P = 2\pi nT \text{ (W)} \]

17. \[ n = \frac{P_{out}}{P_{in}} \times 100\% \]

18. \[ P_{out} = P_{in} - P_{loss} \]

19. \[ \frac{E_p}{E_s} = \frac{N_p}{N_s} = \frac{I_s}{I_p} \]

20. \[ R_s = \frac{V_t}{I_m} - R_m \]

21. \[ R_{sh} = \frac{I_m R_m}{I_t - I_m} \]
MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

MOTOR ELECTRICAL THEORY N3

5 APRIL 2016

This marking guideline consists of 8 pages.
QUESTION 1

1.1  1.1.1  \[ X_c = \frac{1}{2\pi f_c} \]
\[ C = \frac{1}{2\pi f X_c} \]
\[ = \frac{1}{2\pi (50)(14)} \]
\[ = 0.000227364 \text{ F} \]
\[ = 227.364 \mu\text{F} \]  \hspace{1cm} (2)

1.1.2  \[ X_L = 2\pi f L \]
\[ L = \frac{X_L}{2\pi f} \]
\[ = \frac{15}{2\pi (50)} \]
\[ = 0.047746 \text{ F} \]
\[ = 47.746 \text{ mH} \]  \hspace{1cm} (2)

1.1.3  \[ I = \frac{V}{Z} \]
\[ Z = \sqrt{R^2 + (X_L - X_c)^2} \]
\[ = \sqrt{10^2 + (15 - 14)^2} \]
\[ = \sqrt{100 + 1} \]
\[ = 10.05 \Omega \]  \hspace{1cm} (2)

1.1.4  \[ V_R = I x R \]
\[ = 21.891 \times 10 \]
\[ = 218.91 \text{ V} \]  \hspace{1cm} (2)

\[ V_L = I \times X_L \]
\[ = 21.891 \times 15 \]
\[ = 328.365 \text{ V} \]  \hspace{1cm} (2)

\[ V_C = I \times X_c \]
\[ = 21.891 \times 14 \]
\[ = 306.474 \text{ V} \]  \hspace{1cm} (2)

1.2

\[ e = E \text{ max Sin} (2\pi ft) \]
\[ e = E \text{ 538.2 Sin 2500 t} \]

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1.3  

1.3.1  

\[ 2\pi f l = 250 \]

\[ f = \frac{250}{2\pi} \]

\[ f = 39.789 \text{ Hz} \]

1.3.2  

\[ V_{RMS} = 0.707 \times V_{MAX} \]

\[ = 0.707 \times 538.2 \]

\[ = 380.507 \text{ V} \]

1.3.3  

\[ e = 538.2 \sin(250 \times 0.02) \]

\[ = 538.2 \sin(5) \]

\[ = 46.907 \text{ V} \]

\[ (3 \times 2) \quad (6) \quad [22] \]

**QUESTION 2**

2.1  

**EMF in a generator**

As the armature conductors rotate they cut the weak magnetic field due to residual magnetism and a low (weak) EMF is thus generated. This generated EMF in turn increases the exciting current and the generated EKF proportionally increases until a maximum generated EMF is obtained.  

\[ (4) \]

2.2  

**Armature reaction** is the distortion of the main magnetic field as a result of the current flowing in the armature conductors or Distortion of the flux in a D.C. machine is due to the interaction between the armature flux and the field flux.  

\[ (2) \]

2.3  

C = 2 (Wave)  

Z = 65 x 6 = 390  

P = 3  

N = 1000 rpm  

C = 2P (Lap)  

\[ \Phi = 10 \text{mWb} = 0.01 \text{ Wb} \]

2.3.1  

\[ \text{EMF} = \frac{2ZNP\Phi}{C \times 60} \]

\[ = \frac{2(390)(1000)(3)(0.01)}{2 \times 60} \]

\[ = 195 \text{ V} \]

2.3.2  

\[ \text{EMF} = \frac{2ZNP\Phi}{C \times 60} \]

\[ = \frac{2(390)(1000)(3)(0.01)}{2 \times 3 \times 60} \]

\[ = 65 \text{ V} \]

\[ (2 \times 3) \quad (6) \quad [12] \]
QUESTION 3

3.1 Mechanical losses are brush friction, bearing friction, windage, etc.

Brush friction is the power wasted in overcoming brush contact on the commutator.
This loss depends on:
The hardness and the type of the brush.
The pressure on the commutator.
The total contact area.
The speed of the commutator.

Bearing losses – depends on the type of the bearing, the diameter and the peripheral shaft speed.

Windage losses – losses set up by the ventilation fan. (5)

3.2 Total losses = 175 Ω

\[\text{Input} = V \times i\]
\[= 220 \times 15\]
\[= 3300 \text{ W}\]

\[\text{Efficiency} = \frac{\text{Input} - \text{losses}}{\text{Input}} \times 100\%\]
\[= \frac{3300 - 175 \times 100\%}{3300}\]
\[= 94.70\%\] (6)

QUESTION 4

4.1 Rotor Test

Continuity test: Test instruments: ohmmeter, Ammeter, test light.

Connect the probes to the slip ring of the rotor. Ohmmeter reading should read 4 to 6 ohms. (12V). Ammeter should read 2 to 3 amps if the rotor is in good condition.

Earth leakage test:
Use ohmmeter set on the highest scale or high voltage test light. Connect one probe to the slip ring, the other probe to the core or shaft. Ohmmeter reading should be greater than 500 kilo ohms or the test light should be off if the rotor is in good condition. (4)

4.2
- Higher output
- More robust
- Less maintenance
- Requires no cut out

(Any 2) (2)
4.3

STAR CONNECTION – is obtained by connecting the ends of the three coils together and the other ends (ABC) are connected to a pair of diodes.
DELTA CONNECTION – is obtained by connecting three coils end to end and connecting the connected ends (ABG) to a pair of diodes. Please check my interpretation.

QUESTION 5

5.1
- Lower maintenance
- Better spark energy
- More precise timing

5.2 Hall effect triggering

The Hall-effect generator consists of a semi-conductor material through which a current flows, enclosed by a permanent magnetic field at right angles to the current flow. In this condition a small voltage is generated across the semiconductor (the Hall voltage). The magnetic field is diverted by means of a soft iron trigger vane attached to the distributor shaft and this has the effect of reducing the Hall voltage to practically zero. As the vane passes the pick-up, the Hall trigger is switched on and off when there is no gap.

The number of vanes corresponds to the number of cylinders and the width of each vane determines the dwell angle when used in conjunction with a constant dwell amplifier.

5.3

5.3.1 SCR – Connects capacitor across primary allowing it to discharge when fired.

5.3.2 COIL – Gives high tension output by transformer action.

5.3.3 CAPACITOR – Charges up – storing energy to discharge through primary when SCR is fired.

5.3.4 INVERTER AND STEPUP – Converts 12 V dc to +/- 500 V ac.

(4 x 1)
QUESTION 6

6.1 A dwell meter is used to measure the point gap in terms of the cam rotation angle through which the points remain closed. (1)

6.2 • Attraction type
• Repulsion type (2)

6.3 • Firing voltage requirements.
• Spark duration.
• Coil and capacitor action.
• Breaker point action.
• Maximum voltage output of the ignition system. (5)

6.4 6.4.1 A controlling device: determines the magnitude of the deflection – indicates the magnitude of the quantity to be measured. (3 x 1)

6.4.2 A damping device: prevents oscillation of the moving system and enables the pointer to reach its final position quickly.

6.4.3 A deflecting device: causes the deflection of the pointer from its zero position – the mechanical force is produced by the electric current. [11]

QUESTION 7

7.1 To reduce the flow of eddy currents. (2)

7.2 \[ V_P = 220 \text{ V} \quad I_P = 16 \text{ A} \quad N_P = 750 \]
\[ I_S = 600 \text{ mA} = 0,6 \text{ A} \]

7.2.1 \[ \frac{N_P}{N_S} = \frac{750}{20000} = 0,0375 \]
\[ 1 : 26,667 \]

7.2.2 \[ \frac{N_P}{N_S} = \frac{I_S}{I_P} \]
\[ N_S = \frac{N_P I_P}{I_S} = \frac{750 \times 16}{0,6} = 20000 \text{ Turns} \]
7.2.3 \[ V_P = \frac{I_S}{I_P} \]
\[ V_S = \frac{V_p I_P}{I_s} \]
\[ = \frac{220 \times 16}{0.6} \]
\[ = 5866.667 \text{ V} \]

7.2.4 \[ P = V_S \times I_S \]
\[ = 5866.667 \times 0.6 \]
\[ = 3520 \text{ W} \]

7.2.5 Voltage per turn = \( \frac{N_p}{V_p} \)
\[ = \frac{220}{750} \]
\[ = 0.293 \text{ volts per turn} \]

QUESTION 8

8.1
8.2

\[ R_B, R_C, C_C, I_a, Q_1, V_B, R_E, C_E, +V_{cc}, -V_{cc} \]

(5)

[10]

TOTAL : 100
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