higher education & training

Department:
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NATIONAL CERTIFICATE

ENGINEERING PHYSICS N6

(15070126)

23 November 2023 (X-paper)
09:00–12:00

Nonprogrammable calculators may be used.

This question paper consists of 7 pages and a formula sheet of 2 pages.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ENGINEERING PHYSICS N6
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. Use g = 9,81 m/s^2.
5. The values for STP are 0 °C and 101,3 kPa.
6. Use only a black or blue pen.
7. Write neatly and legibly.

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QUESTION 1: SOUND

1.1 Choose the correct term from those in brackets and write it next to the question number (1.1.1–1.1.5) in the ANSWER BOOK.

1.1.1 (Pure tone/Pitch) is free of overtones.

1.1.2 The (power/work done) transmitted per unit area is perpendicular to the direction of propagation.

1.1.3 (Potential/Kinetic) energy is the ability of a body to do work due to its motion.

1.1.4 The (Doppler/frequency) effect occurs as soon as a source moves while it transmits sound because the waves in front will be compressed and more drawn out at the back.

1.1.5 (Sound/Voices) is/are a result of vibrations.

(5 × 1) (5)

1.2 Complete the following paragraph by choosing a word or words from the list below. Write only the answer next to the question number (1.2.1–1.2.6) in the ANSWER BOOK.

closed tube; vibrations; stationary waves; amplitude; resonate; directions

Sound will (1.2.1) … in a/an (1.2.2) … if the wavelength is four times the length of the tube. If two waves travelling in opposite (1.2.3) … through the medium have the same (1.2.4) … their effect is to set up steady (1.2.5) … in the medium. These are called (1.2.6) … (6 × 1) (6)

1.3 The horn of an electric train is sounded at a frequency of 2 800 Hz. The speed of sound in air is 330 m/s.

Calculate:

1.3.1 The frequency heard by a student standing on the platform of the train station while the train approaches him at a speed of 65 km/h

1.3.2 The frequency heard by the student when the train is just passing him

1.3.3 The frequency heard by the student if he runs after the train at a speed of 12 km/h

(3 × 2) (6)

1.4 A steam power plant must generate 540 MW to fulfil the needs of a city. The efficiency of the supply is 74%. The exhaust heat is exposed to the river at an average outlet flow of 8,1 × 10^4 kg/s. Use the specific heat capacity as 4,187 kJ/kg.K.

Calculate the temperature increase of the water. (6)

1.5 A Kundt dust tube, with a rod 0,75 m long and clamped at its midpoint, is set into longitudinal oscillation. The distance between the dust heaps in the tube is 65 mm. The velocity of sound in air is 330 m/s.

Determine:

1.5.1 The velocity of sound in the rod

1.5.2 The frequency of the note emitted by the rod

(2 × 2) (4)

[27]

QUESTION 2: THERMODYNAMICS

2.1 Complete the following sentences by writing only the missing word or words next to the question number (2.1.1–2.1.5) in the ANSWER BOOK.

During a/an (2.1.1) … process the temperature remains constant during compression.

The (2.1.2) … of heat required to raise the (2.1.3) … of 1 kg of substance by 1 °C.

If a gas is heated to rise by 1 °C, the (2.1.4) … is either kept constant and then the external (2.1.5) … on the vessel increases or the volume is kept constant and then the internal pressure of the vessel increases. (5 × 1) (5)

2.2 A gas with a volume of 1,42 × 10^{-2} m^3 is at a pressure of 222 kPa and a temperature of 122 °C. It is then compressed to a pressure of 1,5 MPa according to the law $PV^{1,3} = C$. Use Cp = 1,025 kJ/kg.K and Cv = 0,755 kJ/kg.K.

Calculate:

2.2.1 The mass of the this gas

2.2.2 The volume of the gas at the new P_2

2.2.3 The change in entropy of the gas

2.2.4 The work done on the gas

(4 × 2) (8)

2.3 Define the *specific heat capacity* of a gas or substance. (2)

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2.4 When an ideal engine completes a Carnot cycle, it takes in steam at a temperature of 285 °C and lets out steam at a temperature of 87 °C.

Calculate the efficiency of the machine. (3)

2.5 Calculate the change in entropy if 82 g steam at a temperature of 88 °C is brought to water at 88 °C and the latent heat of steam is equal to 2 558 J/g. (2)

2.6 A 260 ℓ water tank is heated from an initial temperature of 15 °C to 94 °C by using coal as burning fuel. The coal has a heat value of 31,5 MJ/kg.

If the installation is 68% effective, how much coal is used? (5)
[25]

QUESTION 3: ELECTROSTATICS

3.1 What is the *dielectric constant* of a capacitor? (2)

3.2 Define the unit of *electrical charge*. (2)

3.3 A capacitor of 59 µF is charged from a 220 V supply. After the capacitor obtains its maximum charge it is then disconnected from the supply and immediately connected in parallel to a 35 µF capacitor.

Determine:

3.3.1 The potential difference across the combination

3.3.2 The electrostatic energies before and after the capacitors are connected in parallel

(2 × 3) (6)

3.4 Determine the capacitance of a parallel-plate capacitor in microfarads if it is made with five metal plates separated by sheets of mica having a thickness of 0,54 ram and a relative permittivity of 6. The area of one side of the plate is 460 cm^2. Use the permittivity of free space as $8,80 \times 10^{-12}$ F/m. (4)

3.5 Calculate the number of excess electrons on the drop if in a Millikan experiment a negatively charged oil drop of mass $2,44 \times 10^{-15}$ kg is held stationary in a vertical electric field of intensity of $5,5 \times 10^4$ V/m. (3)

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3.6 Complete the following sentences by choosing a word or words from the list below. Write only the answer next to the question number (3.6.1–3.6.6) in the ANSWER BOOK.

current; dielectric; one second; ratio; electrical charge; relative permittivity

A coulomb is the amount of (3.6.1) … through the cross-section of a conductor in (3.6.2) … if a constant (3.6.3) … of 1 ampere flows through the conductor.

The (3.6.4) … of the capacitance with and without the (3.6.5) … between the plates is called the dielectric constant or the (3.6.6) … of the material used.

(6 × 1) (6)

[23]

QUESTION 4: ATOMIC PHYSICS

4.1 Give THREE characteristics of an electron. (3)

4.2 Give THREE characteristics of Röntgen rays. (3)

4.3 An engineering physics student is testing a 1,85 µF television set capacitor that is subjected to a 2 600 V potential difference across its terminals.

Determine the energy stored in the capacitor. (2)

4.4 In a battery with four cells, each cell has an emf of 2,5 V. It is tested at a rate of 16 coulombs per second.

Determine:

4.4.1 The amount of power needed to charge the battery (3)

4.4.2 The amount of energy that is stored in the battery if it is charged for two hours (2)

4.5 Give TWO characteristics of a radioactive substance. (2)

4.6 In a cathode-ray tube test, the number of electrons striking the screen per second is $5,75 \times 10^{14}$. The average kinetic energy as they reach the screen is $4,6 \times 10^{-16}$ J per electron.

Calculate:

4.6.1 The current in the electron beam (3)

4.6.2 The potential difference through which the electrons have been accelerated (2)

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4.7 Engineering physics students are testing different lights that shine onto a particular metal. They use the following information to calculate different energies. A red light with a wave length of $9,45 \times 10^{-7}$ is shone onto a particular metal. The minimum amount of energy required to release an electron from this metal is $1,88 \times 10^{-19}$ J. Use h as $6,5 \times 10^{-34}$ J.s. and C = $2,85 \times 10^{8}$ m/s.

Determine:

4.7.1 The energy of a photon of this red light (3)

4.7.2 The maximum kinetic energy of each ejected electron (2)

[25]

TOTAL: 100

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FORMULA SHEET

The list is not necessarily complete. Any other applicable formula may also be used.

$$E = \frac{T_1 - T_2}{T_1} = 100\%$$

$$\frac{\gamma P}{\rho} = \frac{\gamma RT}{m} = v^2$$

$$\eta = \frac{W}{Q_1} = 1 - \frac{T_2}{T_1} \times 100\%$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$W = m.C_v(T_2 - T_1)$$

$$Q = W = P_1V_1 \ln \frac{V_2}{V_1}$$

$$S_f = 4{,}187 \ln \frac{T_f}{273}$$

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

$$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

$$PV = mRT$$

$$Q_1 = m_1 c \Delta T$$

$$Q = mL_v$$

$$U = mC_v(T_2 - T_1)$$

$$\left(\frac{V_2}{V_1}\right)^{\gamma-1} = \frac{T_1}{T_2}$$

$$\gamma = \frac{C_p}{C_v}$$

$$R = C_p - C_v$$

$$W = mRT_1 \ln\left(\frac{P_1}{P_2}\right)$$

$$P_1V_1^{\gamma} = P_2V_2^{\gamma}$$

$$W = mR \ln \frac{V_1}{V_2}(T_1 - T_2)$$

$$f' = \frac{fV}{V - v}$$

$$f' = \frac{F(V + v)}{V}$$

$$v = \lambda f$$

$$f = \frac{C}{2l}$$

$$V = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma RT}{m}}$$

$$v = \sqrt{\frac{F}{\mu}}$$

$$\frac{V_1}{\lambda_1} = \frac{V_2}{\lambda_2}$$

$$f' = f\left(\frac{v \pm v_o}{v \pm v_z}\right)$$

$$f = \frac{1}{2L}\sqrt{\frac{P}{m}}$$

$$E = \frac{F}{Q_1} = \frac{Q}{4\,\pi\, e_o r^2}$$

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$W = QV$

$E = \frac{mg}{q}$

$E_k = W = Vq$

$Q = CV$

$E = hf$

$F = qE$

$E = \frac{1}{2}CV^2$

$V = \frac{mgr}{Q}$

$t = RC$

$S = \frac{W}{F}$

$E_k = hf - W$

$r = \frac{Q}{4\pi \in_o r}$

$v = \frac{kQ}{r}$

$C = \in_r . \in_o . \frac{A}{d}$

$F = \frac{kq_1q_2}{r^2}$

$E_k = QV$

$e = \frac{v}{d}$

$\frac{1}{c} = \frac{1}{c_1} + \frac{1}{c_2}$

$I = \frac{Q}{t}$

$v = \lambda f$

$\mathrm{W} = \frac{1}{2}\mathrm{QV}$

$m = EQ = \left(\frac{V}{r}\right)Q$

$C = k \in_o \frac{A}{d}$

$a = \frac{F}{m} = \frac{Eq}{m} = \frac{Vq}{S_m}$

$W = Vq = \frac{1}{2}mv^2$

$r = \sqrt{\frac{kq_1q_2}{F}}$

$\sigma = \frac{Q}{4\pi r^2}$

$W = \frac{1}{2}cv^2$

$T = \frac{1}{\lambda} . \ln 2$

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