higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING PHYSICS N6

(15070126)

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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. Start each question on a new page.
5. Only use a black or blue pen.
6. Write neatly and legibly.

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QUESTION 1: SOUND

1.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'True' or 'False' next to the question number (1.1.1–1.1.6) in the ANSWER BOOK.

1.1.1 Sound waves are not both transversely and longitudinal.

1.1.2 A high note is produced by a high frequency.

1.1.3 A high amplitude will not produce a loud sound.

1.1.4 A low note is produced by a hard sound.

1.1.5 Pure tone is free of overtone.

1.1.6 Overtones are always heard together with the fundamental tone.

(6 × 1) (6)

1.2 Name FOUR objects that can resonate with an open tube. (4)

1.3 Differentiate between a *longitudinal wave* and a *transverse wave.* (6)

1.4 An electric train approached a stationary person at a speed of 72 km/h, the whistle of the engine sounding continuously.

Calculate the ratio between the apparent frequency of the whistle as observed by the person as the train passes the person.

The velocity of sound in air is 330 m/s. (4)

1.5 A guitar string with a mass of 0,45 g and a length of 53 cm is under a tension of 90 N.

Determine the following from first principles:

1.5.1 The velocity of a transverse wave in the string (3)

1.5.2 The frequency of its fundamental note (2)

[25]

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QUESTION 2: THERMODYNAMICS

2.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'True' or 'False' next to the question number (2.1.1–2.1.4) in the ANSWER BOOK.

2.1.1 During an isothermic process, the temperature remains constant during compression.

2.1.2 Heat can flow from one body to another at a higher temperature.

2.1.3 Entropy is an indication of the amount of thermodynamic degradation that takes place and has the same unit as heat capacity.

2.1.4 The third law of thermodynamics states that the absolute freezing point can be approached but not reached.

(4 × 1) (4)

2.2 One kilogram of gas is expanded isothermally from a volume of 0,0567 m^3 to a volume of 0,285 m^3.

The initial temperature is 135 °C.
Cp = 1,045 kJ/kg.K
Cv = 0,754 J/kg.K

Calculate the following:

2.2.1 The amount of work done by the gas in kJ when R = 0,297 kJ/kg.K

2.2.2 The change in internal energy

(2 × 3) (6)

2.3 2,5 MJ of heat is added to 2 kg of water at a temperature of 80 °C.

Calculate the amount of steam that is produced.

The specific heat capacity of water is 4 186 J/kg °C.
The heat of vaporization of water is 2, 26 × 10^6 J/kg. (4)

2.4 A steam engine operating between a boiler temperature of 212 °C and a condenser temperature of 48 °C delivers 6,25 kW.

Determine the power absorbed by the boiler if its efficiency is 35% of that of an ideal heat engine operating between these temperature limits.

$$\text{The formula} = \frac{T_1 - T_2}{T_1}$$

$$\eta = \frac{\text{Power output}}{\text{Power input}} \text{ x } 100$$

HINT: T_1 = absolute temperature of the reservoir which supplies the working substance
T_2 = absolute temperature of the reservoir to which working substance is exhausted, can be used to determine the maximum efficiency of a heat engine. (4)

2.5 Differentiate between an *isothermal* and an *adiabatic* change when referring to the following concepts:

2.5.1 Pressure

2.5.2 Volume

2.5.3 Temperature

2.5.4 Heat

2.5.5 Work

(5 × 1) (5)

2.6 Explain the concept *heat of vaporization (Lv)* of a substance. (2)
[25]

QUESTION 3: ELECTROSTATICS

3.1 Explain why the surface charge density of a conductor is the largest where the curvature is the largest. (3)

3.2 A parallel-plate capacitor has a capacitance of 300 picofarad. It has nine plates of 4 cm × 3 cm each, separated by mica with a dielectric constant of 5.

Determine the thickness of the mica. (3)

3.3 Two capacitances of 3 µF and 6 µF respectively are connected.

Calculate the following:

3.3.1 The total capacitance when the capacitances are connected in series

3.3.2 The total capacitance when the capacitances are connected in parallel

3.3.3 The charge on each capacitor if the voltage is 1,2 kV and the capacitors are connected in series

(3 × 2) (6)

3.4 Calculate the electric field strength in air midway between two point charges of + 20 × 10^{-8} C and -5 × 10^{-8} C separated by a distance of 10 cm.

Take (k = 9 × 10^{9} Nm^2/C^2) (3)

3.5 In an oil drop experiment of Millikan, the distance between plates is 0,025 m. A positively charged oil drop with a mass equal to 4,5 × 10^{-15} kg is balanced when the potential difference between the plates is 3 000 V.

Determine the following:

3.5.1 The total charge of the oil drop

3.5.2 The number of electrons removed from the oil drop

3.5.3 The change in electrical potential energy when a charge of 8,5 × 10^{-16} C moves from one plate to the other.

(3 × 2) (6)

3.6 In a Millikan demonstration, a lecturer is using a negative charged oil drop with a mass of 2,5 × 10^{-12} g. The oil drop is held stationary in a vertical electrical field with an intensity of 8 × 10^{4} V/m.

Determine the excess number of electrons. (4)

[25]

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QUESTION 4: ATOMIC PHYSICS

4.1 In a NaCℓ molecule, a Na ion with a charge e is $2,3 \times 10^{-10}$ m from a Cℓ ion with charge -e.

Determine the magnitude of the force between the ions.

Take: $e = 1,6 \times 10^{-19}$ C $k = 9 \times 10^{9}$ Nm² C^{-2}. (3)

4.2 Differentiate between *thermionic emission* and the *photo-electric effect*. (4)

4.3 An electron is accelerated in an X-ray tube through a potential difference of 34 kV. It releases a photon when it hits the anode. It is assumed that all the energy of the electron is transferred to the photon.

Use Planck's constant as $6,6 \times 10^{-34}$ Js. Determine the frequency of the photon. (4)

4.4 In a typical fission reaction, a ${}^{235}_{92}U$ nucleus absorbs a neutron and splits into a ${}^{140}_{54}Xe$ nucleus and a ${}^{94}_{38}Sr$ nucleus.

Determine how many neutrons are liberated in this process. (3)

4.5 Light is reflected on the cathode of a photo cell connected to an ammeter that gives a reading.

Explain what will happen to the reading on the ammeter if the intensity of the light is increased. (3)

4.6 Give the number of protons, neutrons and electrons in ${}^{56}_{26}Fe^{3-}$ (3)

4.7 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'True' or 'False' next to the question number (4.7.1–4.7.5) in the ANSWER BOOK.

4.7.1 ${}^{14}_{7}N + {}^{1}_{1}H \rightarrow {}^{11}_{6}C + {}^{4}_{2}He$

4.7.2 ${}^{27}_{13}Al + {}^{1}_{0}n \rightarrow {}^{27}_{12}Mg + {}^{2}_{2}H$

4.7.3 ${}^{43}_{20}Co(\alpha, [\rho]) {}^{46}_{21}Sc$

4.7.4 ${}^{55}_{26}Mn(d\ , [2n]) {}^{55}_{26}Fe$

4.7.5 $H_2 + Cl_2 \rightarrow 2HCl$.

(5 × 1) (5)

[25]

TOTAL: 100

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ENGINEERING PHYSICS N6

FORMULA SHEET

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

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

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

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

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

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

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

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

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

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

$$PV = mRT$$

$$Q_1 = m_1 c \Delta T$$

$$Q = mL_v$$

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

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

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

$$R = C_p - C_v$$

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

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

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

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

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

$$v = \lambda f$$

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

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

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

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

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

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

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

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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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