higher education & training

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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING PHYSICS N6

(15070126)

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This question paper consists of 6 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 section on a new page.
5. Use only a black or blue pen.
6. Write neatly and legibly.

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QUESTION 1: SOUND

1.1 Make a neat labelled sketch and explain how standing waves are formed in a fixed string. (4)

1.2 Explain what an adiabatic process is and explain how, in practice, a process can be made as close as possible to a true adiabatic process by referring to the following terms:

1.2.1 Thermal insulation

1.2.2 Sufficient rapidity

(2 × 2) (4)

1.3 A certain groove on an old gramophone record passes the needle at a speed of 3,5 m/s. If the wiggles in the groove are 0,25 mm apart, what will the frequency of the produced sound be? (3)

1.4 A metal guitar string has a mass of $5,8 \times 10^{-3}$ kg/m. The tension in the string is 94,5 N.

1.4.1 Determine the velocity of a transverse wave in the guitar string. (2)

1.4.2 If the tension in a string is four times that in a second identical string, determine the ratio of the wave velocities in the two strings. (3)

1.5 A Kundt tube is filled with air and the distance between the dusts heaps is 10 cm. The tube is filled with hydrogen gas and the dust heaps are then 38,5 cm apart. Regard the velocity of sound in air as 340 m/s.

Calculate the following:

1.5.1 The velocity of sound in hydrogen (4)

1.5.2 The frequency of the vibration produced in the rod. (3)

1.6 Explain what the meaning of the *Doppler effect.* (2)

[25]

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QUESTION 2: THERMODYNAMICS

2.1 Explain he first law of thermodynamics. (2)

2.2 State the difference between *an adiabatic* and *an isothermal* process. (2)

2.3 2,8 litres of gas in the cylinder of a steam engine is under pressure of 735 kPa at a temperature of 1 200 °C. The gas expands to a final pressure of 250 kPa, according to the law $PV^{1,3} = C$.

R for the gas = 289 J/kg°C and Cv = 710 J/kg°C.

Calculate the following:

2.3.1 The final volume in m^3. (3)

2.3.2 The final temperature. (3)

2.3.3 The work done during the expansion. (2)

2.3.4 The maximum change of internal energy during the expansion. (3)

2.4 A test was carried out on an internal steam combustion engine. Calculate the work done during the adiabatic compression of 0,001 Mg of gas with an initial temperature of 17 ºC and a pressure of 180 kPa to a pressure of 0.960 MPa. Use the following information for your calculation:

Cp = 861 J/kg.°C and Cv = 615 J/kg.°C. (5)

2.5 The cooling water enters the condenser of a steam plant at a temperature of 10 °C and leaves it at 40 °C. The steam enters the condenser at 100 °C and leaves it as water at 70 °C. Steam condenses at the pressure concerned at 100 °C and 19 litres of water is required to condense one and a half kilogram of steam. The specific heat capacity of water is $4,187 \times 10^3$ J/kg°C.

Determine the specific latent heat of the vaporization of water. (3)

2.6 Explain why an adiabatic compression can only partially be reached. (2)

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QUESTION 3: ELECTROSTATICS

3.1 Explain what the potential in an electric flied is. (3)

3.2 Explain what is meant by *the law of forces.* (3)

3.3 Explain what is meant by *the unit of electrical charge.* (3)

3.4 Students carried out a test with two identical metal spheres on insulted stands with charges of +2,5 q and –2,5 q respectively, and separated by a distance of *x* metres. The spheres are brought into contact with each other and then returned to their original positions.

3.4.1 What is the charge on each sphere after separation? (2)

3.4.2 Calculate the ratio of the new coulombic force (that is the force after touching and separating) to the original coulombic force. (4)

3.5 An electron is accelerated by 240 V and attains a certain speed.

How many times greater would its final speed be if it were accelerated by 380 V? (3)

3.6 Explain what this means when with the oil-drop experiment Millikan proved that electric charge is quantised. (2)

3.7 A learner pitches a ball which has a charge of +8,8 $^{-12}$ coulombs.

3.7.1 Does the ball contain an excess, or a deficiency of electrons compared with its normal state of electrical neutrality? (2)

3.7.2 How many electrons does the ball have? (1)

3.8 A capacitor is tested and has a charge of 6 × 10-^{4} coulombs when the potential difference across the plates is 380 volts.

Calculate the capacitance of the capacitor. (2)

[25]

QUESTION 4: ATOMIC PHYSICS

4.1 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (4.1.1–4.1.5) in the ANSWER BOOK.

4.1.1 When metal is heated, electrons are ejected through thermionic emission.

4.1.2 For each electron leaving the metal, a net negative charge of +1,6 × 10^{-19} C is formed in the metal.

4.1.3 Plank's constant is 6,6 × 10^{-38}.

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4.1.4 A positive ray is caused by electrons from the cathodes that collide with the gas atoms and strip some electrons from the atom. Positive gas ions are then produced, which move to the positive side of the tube and moves through the holes in the cathode.

4.1.5 X-rays is also called Röntgen rays.

(5 × 1) (5)

4.2 Complete the following paragraphs by choosing a word or words from the list below. Write only the answer next to the question number (4.2.1–4.2.6) in the ANSWER BOOK. Each word can only be used ONCE.

Gamma; Beta; neutrons; protons; Alpha; nucleus

In which a helium that consists of two (… 4.2.1) and two (…4.2.2) are emitted. (…4.2.3) decay occurs in nuclei too large to be stable.

In which an electron is emitted when one of the neutrons in a (…4.2.4) spontaneously turns into a proton. (…4.2.5) decay occurs in nuclei in which the neutron-proton ratio is too large for stability.

In which a (…4.2.6) ray is an electromagnetic wave of shorter wavelength and hence higher quantum energy than those of X-rays emitted by a nucleus with excess energy. As is often the case after one of the other types of decay occurs, gamma decay does not change the nature of a nucleus.

(6)

4.3 Definition is a key element of engineering physics, especially with atomic physics. Define *capacitance*. (2)

4.4 Explain what happens to an atomic number and the mass number of a nucleus in the following cases:

4.4.1 Emits an electron

4.4.2 When an electron undergoes capture

4.4.3 When it emits an alpha particle

(3 × 2) (6)

4.5 Complete the following notations or equations.

4.5.1 $^{24}_{12}\text{Mg}$ (d, ...)^{22}Na

4.5.2 $^{26}_{12}\text{Mg}$ (d, ...)$^{27}_{12}\text{Mg}$

4.5.3 $^{2}_{6}\text{C}$ (d, ...)$^{13}_{7}\text{N}$

4.5.4 $^{55}_{25}\text{Mn}$ (n, ...)$^{56}_{25}\text{Mn}$

4.5.5 $^{30}_{52}\text{Te}$ (d, ...)$^{130}_{53}I$

4.5.6 $^{64}_{29}\text{Cu} \longrightarrow {}^{64}_{28}\text{Ni} + ?$

(6 × 1) (6)

[25]

TOTAL: 100

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ENGINEERING PHYSICS N6

FORMULA SHEET

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