higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T610**(E)**(A1)T

NATIONAL CERTIFICATE

ENGINEERING PHYSICS N6

(15070126)

1 April 2019 (X-Paper)
09:00–12:00

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. Keep subsections of questions together.

5. Rule off across the page on completion of each question.

6. ALL calculations should consist of at least THREE steps:

   6.1 The formula used or manipulation thereof
   6.2 Substitution of the given data in the formula
   6.3 The answer with the correct SI unit

7. Use the constant values, as they appear on the attached information sheet, when possible.

8. Round off answers to THREE decimal places.

9. Use g = 9,8 m/s^2.

10. Write neatly and legibly.

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QUESTION 1: SOUND

1.1 List THREE properties of an ordinary wave applied to sound waves. (3)

1.2 What determines the loudness of a sound? (2)

1.3 How would a person produce a sound in an iron rod? (2)

1.4 What are the factors when the frequency is directly proportional to the tension in a string? (3)

1.5 A stone with a mass of 5 kg is dropped vertically into a well. It takes the stone 15 seconds to reach the water at the bottom of the well.

Calculate the depth of the well and the velocity of the stone when it hit the water. Use the velocity of sound in air as 330 m/s (4)

1.6 In a Kundt's dust tube test, a rod of 1,25 m long is clamped at its midpoint and set into longitudinal oscillation. The distance between the dust heaps in the tube is 75 mm. The velocity of sound in air is 330 m/s.

Calculate the following:

1.6.1 The velocity of sound in the rod

1.6.2 The frequency of the note emitted by the rod

(2 × 2) (4)

1.7 A bystander noticed that an anchored boat rise and fall through a total range of 2,5 meters once every 5 seconds as waves pass by. The crests of the waves are 28 meters apart.

Calculate the following:

1.7.1 The frequency of the rise and fall of the waves

1.7.2 The velocity of the rise and fall of the waves

(2 × 2) (4)

1.8 A string, 60 cm long and with a mass of $2,5 \times 10^{-4}$ kg/m per unit length, is connected to one end of a tuning fork vibrating at a frequency of 265 Hz.

Calculate the following:

1.8.1 The wavelength (λ) of the stationary waves

1.8.2 The velocity (V) of the stationary waves

(2 × 2) (4)

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QUESTION 2: THERMODYNAMICS

2.1 The Carnot cycle is a series of changes of pressure, volume and temperature in a specific order.

Name and describe the FOUR changes of the Carnot cycle in sequence. (4)

2.2 A certain gas has a volume of $1,4 \times 10^{-2}$ m^3 at a pressure of 220 kPa and a temperature of 125 °C. It is then compressed to a pressure of 1,55 MPa according to the law $PV^{1.25} = C$.
Use the following values: Cp = 1,005 kJ/kg.K
Cv = 0,748 kJ/kg.K

Calculate the following:

2.2.1 The mass of 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 concept *specific heat capacity* of a gas or substance. (2)

2.4 When an ideal engine completes a Carnot cycle, it takes in steam at a temperature of 235 °C and lets out steam at a temperature of 67 °C.

Calculate the efficiency of the machine. (3)

2.5 Calculate the change in entropy if 80 g steam at a temperature of 85 °C is brought to water at 85 °C. The latent heat of steam is equal to 2 258 J/g. (3)

2.6 A 250-litre water tank is heated from an initial temperature of 18 °C to 96 °C by using coal as burning fuel. The coal has a heat value of 32,5 MJ/kg. The installation is 58% effective.

How much coal is used? (5)
[25]

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QUESTION 3: ELECTROSTATICS

3.1 The sides of an equilateral triangle of are 3,6 m long.
In a test, point charges of -1,8 µC, 3,6 µC and 5,4 µC are placed respectively at angles A, B and C of the triangle.
Y is the centre of BC.
Use E_o = 8,85 x 10^{-12} F/m.

Calculate the following:

3.1.1 The electrical potential at Y due to the three charges (4)

3.1.2 The electrical field strength at Y due to the three charges (4)

3.2 Two negative point charges of 3,25 µC each are 1,25 cm apart in a vacuum holder.

Determine the following:

3.2.1 The force between the two points (3)

3.2.2 How this force is influenced if the magnitude of the charges is tripled (2)

3.2.3 How this force is influenced if the distance between the charges is doubled (2)

3.3 The measurements of two rectangular parallel plates forming a capacitor are 5 cm by 4 cm each. The plates are 0,8 cm apart.
The potential difference between the plates is 2 800 Volts.
When a dielectric is placed between the plates, the potential difference decreases to 950 Volts.
The permittivity of free space is 8,85 × 10^{-12} F/m.

Calculate the following:

3.3.1 The capacitance without the dielectricum

3.3.2 The charge on each plate

3.3.3 The capacitance with the dielectricum

3.3.4 The value of the dielectric constant of the dielectricum

(4 × 2) (8)

3.4 Define the *law of forces.* (2)

[25]

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QUESTION 4: ATOMIC PHYSICS

4.1 Explain how the internal photoelectric effect is used when light intensity is measured with a photographic exposure meter. (3)

4.2 Give TWO properties of Röntgen rays. (2)

4.3 What is a positive ray? (3)

4.4 A hydrogen atom consists of a proton (charge +e) and an electron (charge -e) that are an average of $5,25 \times 10^{-11}$ m apart.

Calculate the attractive force between them. (3)

4.5 A Highveld thundercloud with a horizontal area of 12 km^2 is forming at 2 750 m above the ground.

Use this information as a capacitor and determine the electrical energy stored in the system if the potential difference in the cloud is $1,25\ 10^5$ V.

The permittivity of free space is $8,85 \times 10^{-12}$ F/m. (4)

4.6 Name THREE characteristics of electrons. (3)

4.7 How is radiation detected and measured? (2)

4.8 Determine how many alpha particles are emitted when a thorium isotope $^{228}_{90}\mathrm{Th}$ decays into a lead isotope $^{\mathbf{212}}_{\mathbf{82}}\mathrm{Pb}$. (2)

4.9 A microwave oven emits electromagnetic waves with a frequency of 5×10^9 Hz.
Use Planck's constant = $6,63 \times 10^{-34}$ Js.

Calculate the energy of the photons of these waves. (2)

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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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