higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING PHYSICS N6

(15070126)

17 November 2022 (X-paper)
09:00–12:00

Nonprogrammable calculators may be used.

This question paper consists of 9 pages and a formula sheet.

066Q1E2217

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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 a blue pen.
6. Take gravitational acceleration as 9,81 m/s^2.
7. Write neatly and legibly.

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QUESTION 1: SOUND

1.1 Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (1.1.1–1.1.6) in the ANSWER BOOK.

1.1.1 A student wants to determine the longest and shortest length of an organ pipe, open at both ends, of which the frequency must be between 85 to 2290 Hz. The velocity of sound in air is 340 m/s.

The longest and shortest length of an organ pipe, open at both ends is …

A Longest length = 2 m and shortest length = 0,074 m.
B Longest length = 2,646 m and shortest length = 0,082 m.
C Longest length = 1,556 m and shortest length = 1,2 m.
D Longest length = 1,8 m and shortest length = 0,095 m. (2)

1.1.2 Some students want to calculate the speed of a bat travelling towards a stationary obstacle. The bat emits sound waves at a frequency of 49 500 Hz and detects sound waves of 53 000 Hz.

Take the velocity of sound in air is 340 m/s.

The speed of the bat is …

A 10,193 m/s.
B 21,405 m/s.
C 24,040 m/s.
D 11,608 m/s. (4)

1.1.3 Determine the frequency of the following unknown source if FIGURE 1 was shown on an oscilloscope.

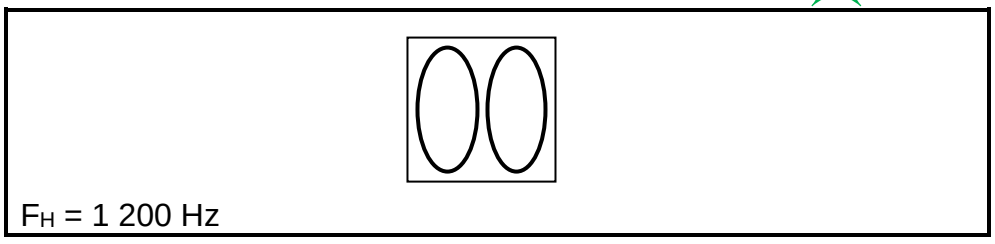


FIGURE 1

A 2 400 Hz
B 1 200 Hz
C 4 800 Hz
D 1 800 Hz (1)

1.1.4 Determine the frequency of the following unknown source if FIGURE 2 was shown on an oscilloscope.

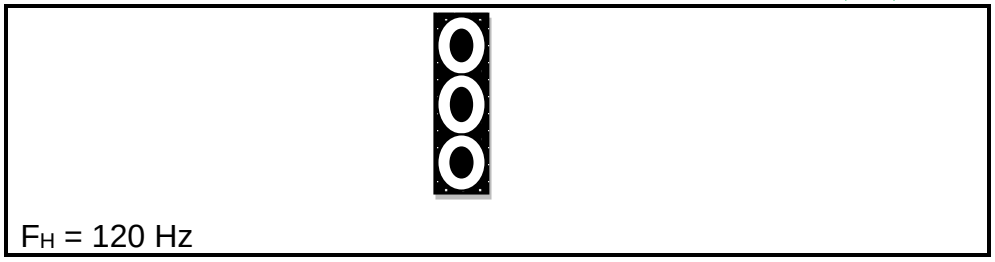


FIGURE 2

A 360 Hz
B 120 Hz
C 40 Hz
D 180 Hz (1)

1.1.5 Determine the frequency of the following unknown source if FIGURE 3 was shown on an oscilloscope.

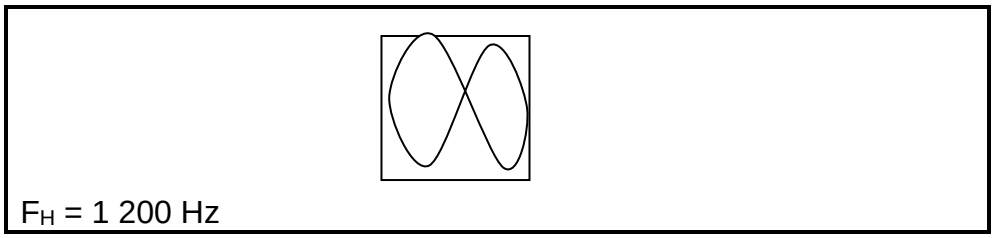


FIGURE 3

A 2 400 Hz
B 1 200 Hz
C 1 800 Hz
D 600 Hz (1)

1.1.6 Determine the frequency of the following unknown source if FIGURE 4 was shown on an oscilloscope.

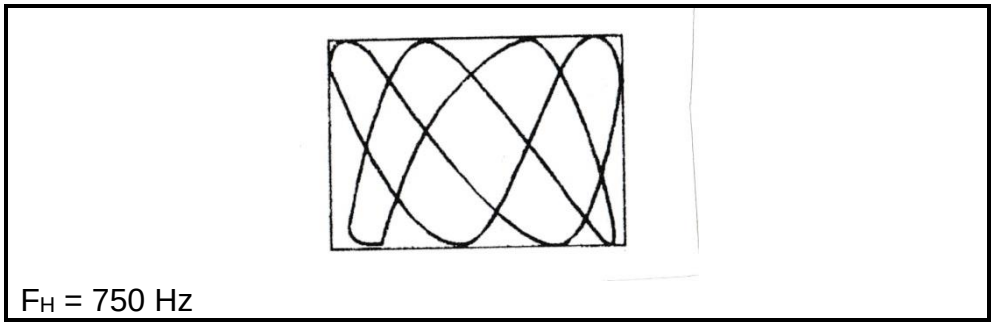


FIGURE 4

A 750 Hz
B 500 Hz
C 375 Hz
D 250 Hz (1)

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1.2 Calculate the velocity of a transverse wave in a metal string with a mass of 4,8 × 10^{-4} kg and 75 cm long. The tension in the string is 75 N.

Also determine the frequency of the *fundamental note* and the *first* and *second overtone*. (6)

1.3 The lecturer gave students an assignment with the following information: A uniform tube 12,5 mm long, which is open at both ends, is placed vertically when one end is immersed in water. If the length above the water is 360 mm, it resonates with a tuning fork of 586 Hz and resonates again when it protrudes 555 mm above the water.

Calculate the lowest frequency at which the tube will resonate if it is taken out of the water. Take end correction into account. (9)

[25]

QUESTION 2: THERMODYNAMICS

Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (2.1.1–2.1.5) in the ANSWER BOOK.

2.1 2.1.1 $P_1V_1 = P_2V_2$ is an isothermal process.

2.1.2 The law of thermodynamics has only 3 laws.

2.1.3 Carnot's principle is when a machine that operates reversible, has the minimum possible efficiency.

2.1.4 The experiment of the porous plug was done by Joule-Kelvin in 1852.

2.1.5 An ideal gas satisfies the gas law of $P_1V_1 = mRT_1$ and does not cool down with expansion.

(5 × 1) (5)

2.2 Explain the following statement:

'In practice, an adiabatic expansion is approached when the operation is carried out very quickly. Alternatively, an adiabatic expansion is approached if a system is sufficiently thermally insulated'. (4)

2.3 In a steam engine operating between a boiler temperature of 218 °C and a condenser temperature of 48,9 °C, delivers 7,2 kW. Its efficiency is 35% of that of an ideal engine operating between these temperature limits. Calculate the following:

2.3.1 The actual efficiency of the engine (3)

2.3.2 The power that is absorbed by the boiler (2)

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2.4 A mass of air has a volume of $2,6 \times 10^{-3}$ m^3 at an initial pressure of 98 kPa and an initial temperature of 25 °C. It expands adiabatically so that the volume is tripled and thereafter compressed isothermally to a volume of $3,8 \times 10^{-3}$ m^3.

Use the following information for your calculation: Cv = 0,715 kJ/kg.K and Cp = 1,00 kJ/kg.K.

Determine:

2.4.1 The final temperature of the process (6)

2.4.2 The final pressure of the process (2)

2.5 The initial temperature of hot water is 96 °C with a mass of 0,87 kg. It is mixed with 222 g of ice at -18 °C. Take the specific heat capacity of ice as 2,108 kJ/kg °C and that of water as 4187 J/kg. °C.

Calculate what the final temperature of the mixture will be. (3)
[25]

QUESTION 3: ELECTROSTATICS

Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (3.1.1–3.1.6) in the ANSWER BOOK.

3.1 3.1.1 The formula to determine the force between two charges is

$$F = k\,x\,\frac{Q_1\,x\,Q_2}{r}$$

3.1.2 The dielectric constant on a capacitor is the ratio of the capacitance with and without the dielectric between the plates.

3.1.3 Coulomb is the quantity of electric charge which moves through a conductor in one second when a variable or erratic current of one ampere is flowing through it.

3.1.4 The potential at any point in a charged sphere is constant throughout and equal to the potential on the outside.

3.1.5 The formula to calculate capacitance in series is:

$C_T = C_1 + C_2 + C_3$

3.1.6 The capacitance of a capacitor is the ratio of the capacitor charge over the capacitor potential and has the ability to store energy.

(6 × 1) (6)

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3.2 Engineering Physics N6 students want to know what the potential difference of a particle will be when placed between two plates. They have the following information to test the potential difference:

A particle having a mass of 25 pico-kg and a charge of $2,8 \times 10^{-18}$ C is kept in equilibrium by a vertical upward electric field between two parallel, horizontal plates. The plates are placed 1,45 cm apart.

Determine what the potential difference between the plates will be. (4)

3.3 The distance between the plates in a Millikan oil-drop experiment is 35 mm. A positively charged oil drop with a mass equal to $0,945 \times 10^{-15}$ kg is balanced (in equilibrium) when the potential difference between the plates is 2 650 V.

Determine:

3.3.1 The charge on the oil drop (3)

3.3.2 The number of electrons that have been removed from the oil drop. (2)

3.3.3 The charge in the electrical potential energy when a charge of $8,45 \times 10^{-16}$ C moves from one plate to the other. (2)

3.4 Students charged a capacitor to 55 µF from a 220 V supply. After obtaining its maximum charge, it is disconnected from the supply and immediately connected in parallel to a capacitor of 38 µF.

Calculate:

3.4.1 The potential difference across the combination (4)

3.4.2 The electrostatic energies before and after the capacitors are connected in parallel (4)

[25]

QUESTION 4: ATOMIC PHYSICS

4.1 Complete the following sentences by filling in the missing word(s). Write only the word(s) next to the question number (4.1.1–4.1.6) in the ANSWER BOOK.

When a metal is heated, electrons are ejected. This phenomenon is called (4.1.1) … .

Field emission takes place when (4.1.2) ... leave a cold metal surface under the influence of a suitably strong field.

An electric field of (4.1.3) … V/m is necessary to let field emission take place.

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The threshold frequency is the (4.1.4) … frequency which light should have in order to liberate an electron from a metal when it is (4.1.5) … with light.

Millikan proved by the oil-drop experiment that an electrical charge is quantised. From this experiment it means that a charge can have a certain value if it is multiplied by (4.1.6) … .

(6 × 1) (6)

4.2 Explain how gas discharge takes place. (3)

4.3 One square centimetre of membrane has a capacitance of $9,68 \times 10^{-7}$ F. If the potential difference across the membrane is 0,125 V, calculate the electric energy stored in 1,6 cm² of membrane. (2)

4.4 A red light with a wave length of 0,91 µm is shone onto a particular metal. The minimum amount of energy required to release an electron from this metal is $2,82 \times 10^{-19}$ J. Take $c = 380 \times 10^{6}$ m/s and $h = 6,9 \times 10^{-34}$ Js.

Determine the following:

4.4.1 The energy of a photon of this red light

4.4.2 The maximum kinetic energy of each ejected electron

(2 × 2) (4)

4.5 A microwave oven emits electromagnetic waves at a frequency of 3 500 MHz. Determine the energy of one of the photons of these waves. Take Planck's constant as $6,6 \times 10^{-34}$ Js. (2)

4.6 A hydrogen atom consists of a proton (charge $^{+}$e) and an electron (charge $^{-}$e) that are an average of $6,53 \times 10^{-11}$ m apart.

Determine the attractive force between them. (3)

4.7 What happens to the atomic number and mass number of a nucleus after it

4.7.1 Emits an electron

4.7.2 Undergoes electron capture

4.7.3 Emits an alpha particle

(3 × 1) (3)

4.8 Why should a neutron be an effective projective for penetrating the nucleus of an atom? (2)

[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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