H

NATIONAL JUNIOR COLLEGE

SENIOR HIGH 2 PRELIMINARY EXAMINATION

Higher 2

CANDIDATE NAME

SUBJECT CLASS

REGISTRATION NUMBER

PHYSICS **9749/03**

Paper 3 Longer Structured Questions **(Section B)**

19 Sep 2025
2 hours

Candidate answers on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your subject class, registration number and name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section B
Answer **one** questions only.

You are advised to spend one and a half hours on Section A and half an hour on Section B.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section B	
7	/ 20
8	/ 20

This document contains **11** printed pages and **1** blank pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/°\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin\omega t$
velocity of particle in s.h.m.	$v = v_0 \cos\omega t$ $= \pm\,\omega\sqrt{x_0^{\,2} - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	$x = x_0 \sin\omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **one** question from this Section in the spaces provided.

7 **(a)** A cylindrical tube, containing some sand, floats upright in a liquid of density ρ, as shown in Fig. 7.1.

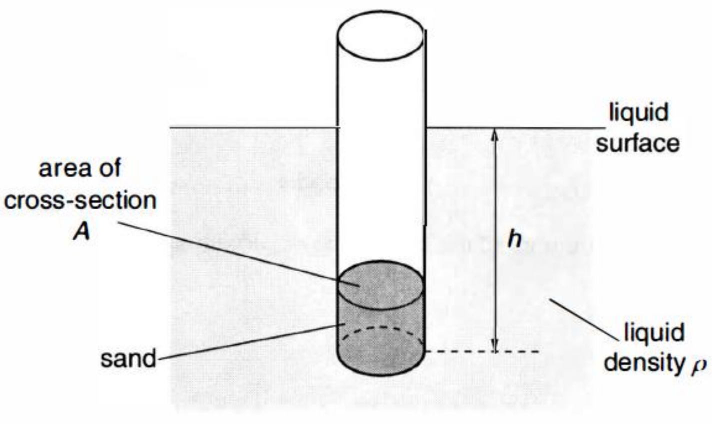

Fig. 7.1

The tube has cross-sectional area *A*. The total mass of the tube and sand is *M*.
The tube floats in equilibrium with its base a distance *h* below the surface of the liquid.

(i) By considering the pressure due to a fluid, show that $M = \rho h A$.
Explain your working.

[2]

(ii) The tube is now held stationary below the equilibrium floating position of the tube.

Show that, when released, the acceleration *a* of the tube is related to its displacement *x* from the equilibrium position by the equation:

$$a = -\left(\frac{\rho A g}{M}\right)x$$

where *g* is the acceleration of free fall.
Explain your working.

[3]

(iii) Explain whether the tube is performing simple harmonic motion.

……………………………………………………………………………………………………

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……………………………………………………………………………………………… [2]

(iv) The mass *M* of the tube and sand is 130 g. The area of cross-section *A* of the tube is 5.3 cm^2. The tube, floating in a liquid of density 1.2×10^3 kg m^{-3}, is held stationary 1.3 cm below its equilibrium position and then released.

Calculate

1. the frequency of oscillation of the tube,

frequency = ……………………………… Hz [3]

2. the total energy of oscillation of the tube.

energy = ……………………………… J [2]

(b) A dipper oscillates at a frequency of 2.0 Hz in a ripple tank. Surface water waves ripple circularly out from the dipper with wavelength 1.0 cm as shown in Fig. 7.3.

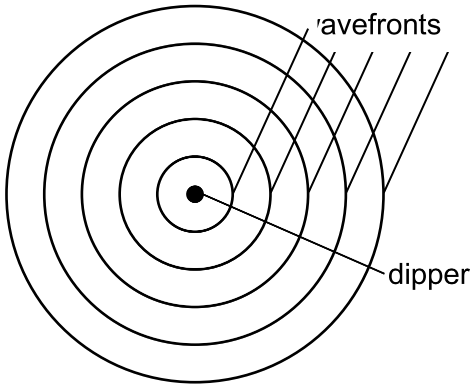

Fig. 7.3

(i) Explain why the amplitude of the wave decreases with distance from the dipper.

....

....

....

.... [2]

(ii) Show that the dipper and the water at a point 2.0 cm away from the dipper oscillate in phase.

[2]

(iii) At a particular instance in time, the dipper is at its maximum negative displacement. X on Fig. 7.4 shows the variation with distance of the amplitude of the water wave.

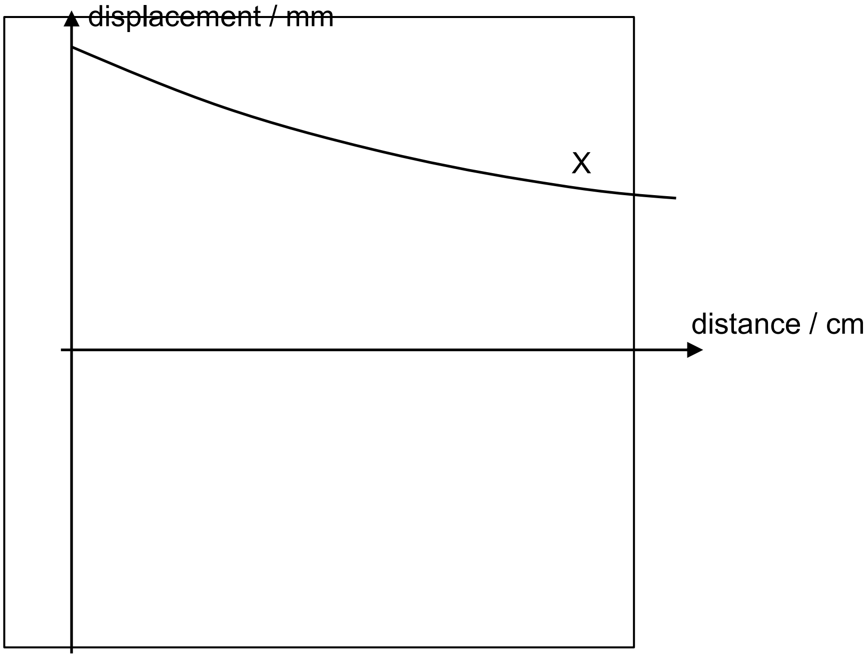

Fig. 7.4

On Fig. 7.4, sketch the displacement-distance graph of the water wave at this instance. [2]

(iv) The dipper is at its maximum negative displacement when time = 0 s. On Fig. 7.5, sketch the displacement-time graph of the water at a point 3.0 cm away from the dipper.

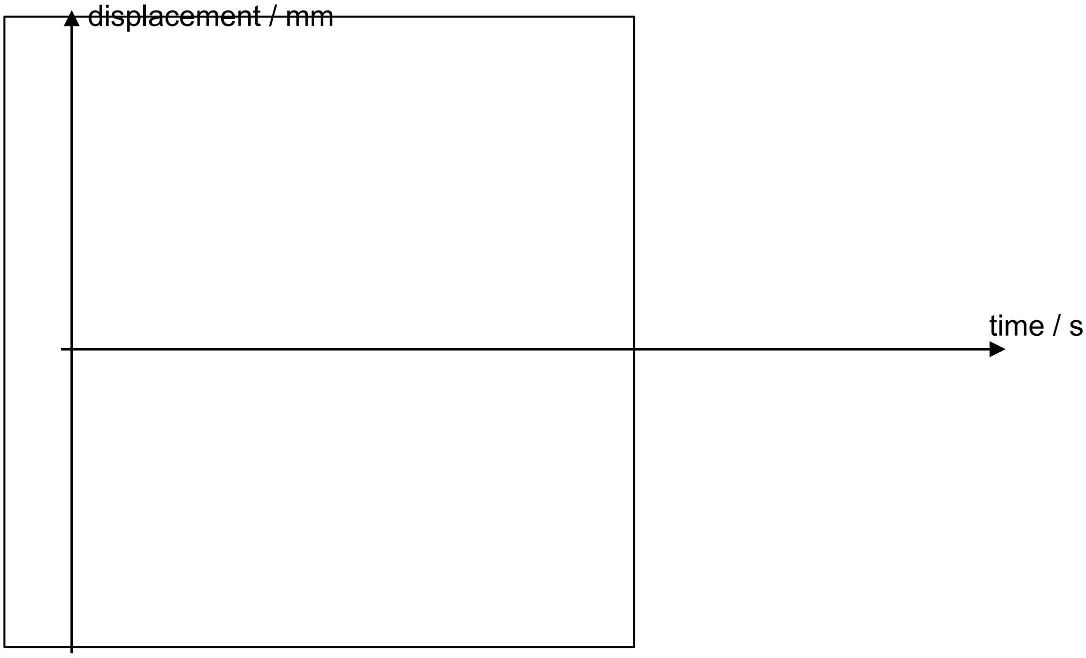

Fig. 7.5

[2]

[Total: 20]

8 **(a)** The masses of various nuclides and of various sub-atomic particles, are shown in Fig. 8.1.

nuclide or sub-atomic particles	proton number	mass / u
electron	n/a	0.000549
proton	n/a	1.007276
neutron	n/a	1.008664
helium-4	2	4.002603
thallium-205	81	204.974428
bismuth-209	83	208.980399
polonium-209	84	208.982430

Fig. 8.1

(i) Bismuth-209 is radioactive.

Use the data in Fig. 8.1 to determine which type(s) of radiation (α or β) it is possible for bismuth-209 to emit. Explain your reasoning.

radiation emitted: .... [4]

(ii) Determine the binding energy per nucleon of bismuth-209.

binding energy per nucleon = ... MeV [4]

(b) A radiation detector is placed close to a radioactive source. The variation with time *t* of the measured count rate is shown in Fig. 8.2.

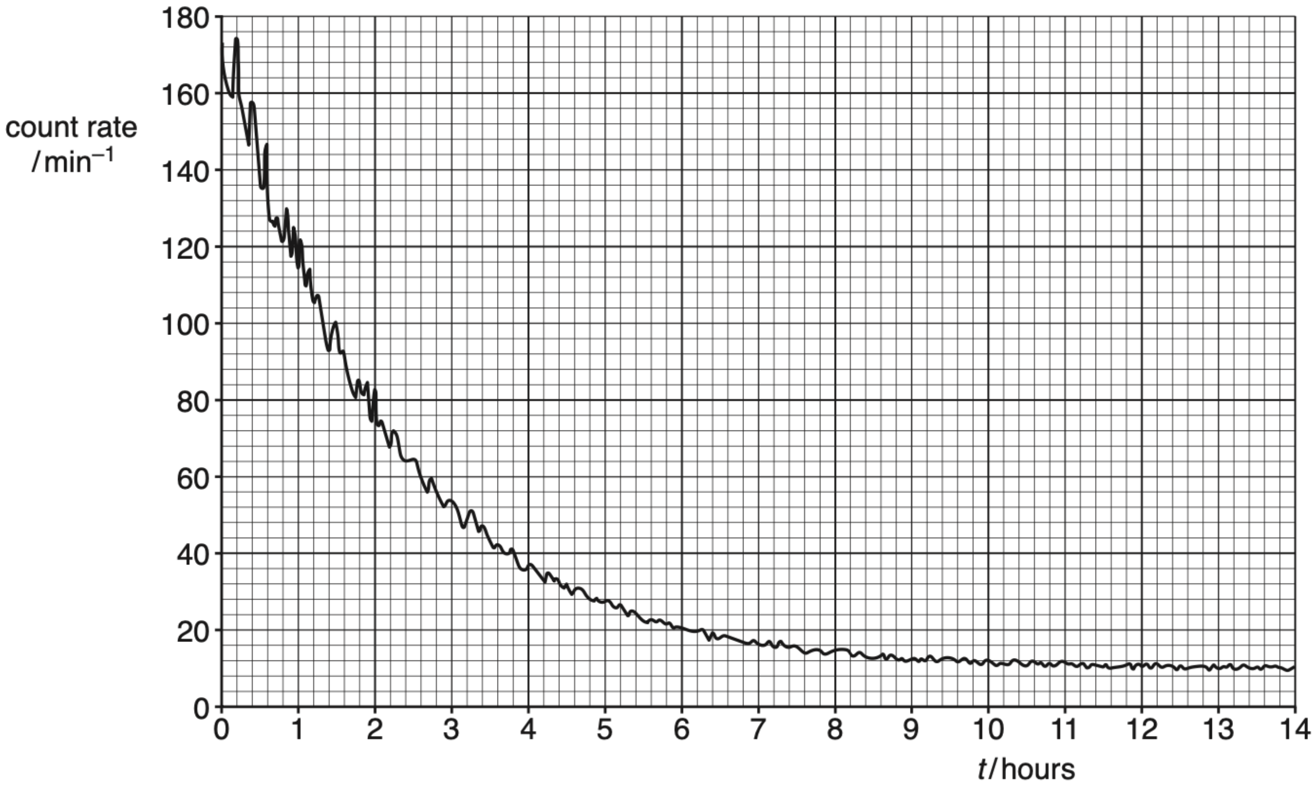

Fig. 8.2

(i) State the feature of Fig. 8.2 that indicates the random nature of radioactive decay.

....
......

.... [1]

(ii) State the background count rate recorded by the radiation detector.

background count rate = ... min^{-1} [1]

(iii) Use Fig. 8.2 to determine the half-life of the radioactive isotope in the source.

half-life = ... hours [3]

(c) Samples of Moon rock were collected by Apollo astronauts.

Scientists measure the relative abundance of strontium isotopes in samples of Moon rock to determine the age of the rocks.

The isotope rubidium-87, found in Moon rock, is radioactive. It decays by beta emission. The nuclide decay equation is

$$3787Rb \rightarrow 3887Sr + -10e + \text{neutrino}$$

(i) The decay constant of rubidium-87 is 1.44×10^{-11} yr^{-1}.
Calculate, in years, the half-life of rubidium-87.

half-life = ... yr [1]

(ii) When Moon rocks were formed about 4.0×10^9 years ago they contained rubidium-87, strontium-87 and strontium-86. The two strontium isotopes are stable. The rate at which strontium-87 atoms are created is equal to the rate of decay of the rubidium-87 atoms.

Use the half-life your answer in **(c)(i)**, show that this rate has remained almost constant over the age of the rock.

[2]

(iii) The ratio *R* of the strontium isotopes found in Moon rock is given by

$$R = \frac{number\ of\ atoms\ 3887Sr}{number\ of\ atoms\ 3886Sr}$$

On Fig. 8.3, sketch a graph to show how the ratio *R* has varied with time since the rock samples formed.

Fig. 8.3

[2]

(iv) Explain how a measure of the ratio *R* in **(c)(iii)** could be used to estimate the age of the Moon rock. State any additional information that would be required.

………

………

………

………

…………………………………………………………………………………………………… [2]

[Total: 20]

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