Civic Group	Index Number	Name
25S		

ST. ANDREW'S JUNIOR COLLEGE
JC 1 2025
Final Examination Time Trial

PHYSICS, Higher 2 **9478**

19 September 2025 **1 hours 20 minutes**

Candidates answer on the question paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

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

For Examiner's Use	
1	/ 7
2	/ 11
3	/ 10
4	/ 13
5	/ 13
Total	/ 54
Percentage	/ 100
Grade	

This question paper consists of **14** printed pages including this page.

Data

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

Formulae

uniformly accelerated motion	$s = u t + ½ a t^2$
	$v^2 = u^2 + 2 a s$
work done on/by a gas	$W = p \Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\phi = -\dfrac{Gm}{r}$
displacement of particle in s.h.m.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$v = \pm \omega \sqrt{x_0^2 - x^2}$

Answer all the questions in the spaces provided.

1 A car starts from rest and travels upwards along a rough straight road inclined at 5.0° to the horizontal, as shown in Fig. 1.1 below. The length of the road is 458 m and the car has a mass of 800 kg. The speed of the car increases to 28 m s^{-1} at the top of the cliff. The car then veers off the cliff and lands on flat ground below.

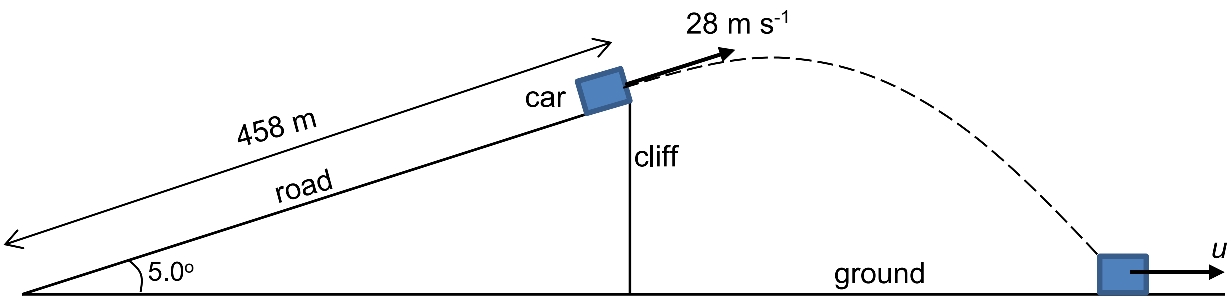

Fig. 1.1

(a) Determine the height of the top of cliff from the ground.

height = ……………………. m [1]

(b) Calculate the time of flight for the car to leave the cliff to the point when it lands onto the ground.

time = ……………………… s [2]

(c) When the car lands, it loses 90% of its mechanical energy after its impact with the ground. It continues to move forward with a speed u. Determine this speed u.

u = …………………… m s^{-1} [2]

(d) The car then experiences a constant deceleration of 2.5 m s^{-2} while travelling on the ground. There is a wall that is at a distance of 100 m from the foot of the cliff as shown in Fig. 1.2 below. Given that the car lands 86 m from the foot of the cliff, determine if the car will collide with the wall.

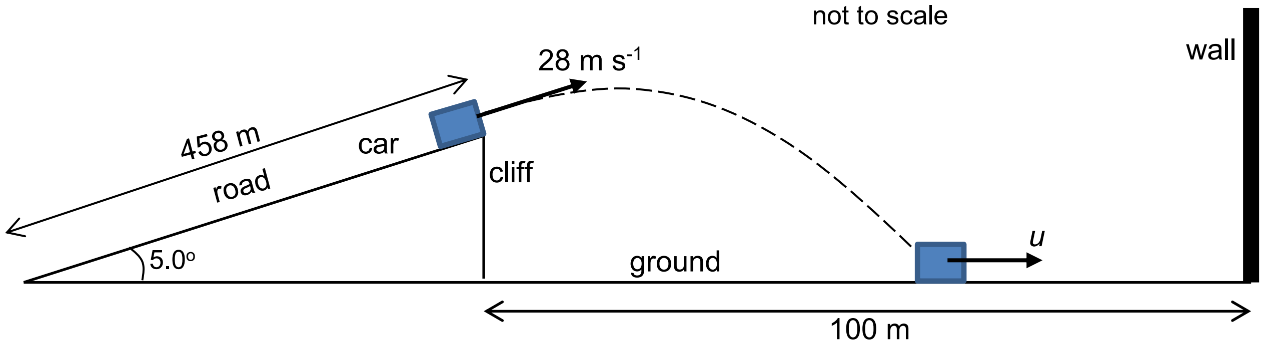

Fig. 1.2

…………………………………………………………………………………………………

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

2 **(a)** Trolley A of mass 6.0 kg travelling at a speed of 5.0 m s^{-1} collides head-on with trolley B of mass 10 kg travelling at a speed of 3.0 m s^{-1} as shown in Fig. 2.1. Trolley B then travels backwards after the collision with a speed of 2.0 m s^{-1}.

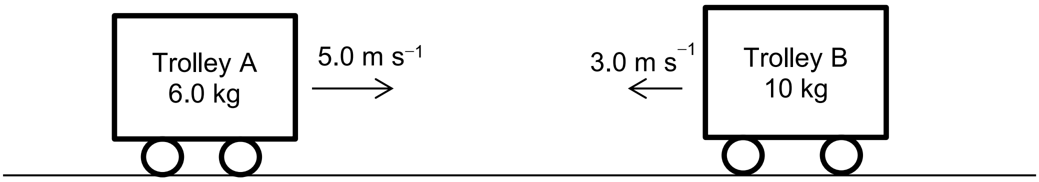

Fig. 2.1

(i) **1.** Determine the speed of trolley A after the collision.

speed = ……………………… m s^{-1} [2]

2. Explain whether the collision is an elastic or inelastic collision. Substantiate your conclusion with clear working.

………………………………………………………………………………………………

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

(ii) Fig. 2.2 shows how the velocity of trolley B vary with time.

1. Sketch the corresponding velocity-time graph for trolley A. [2]

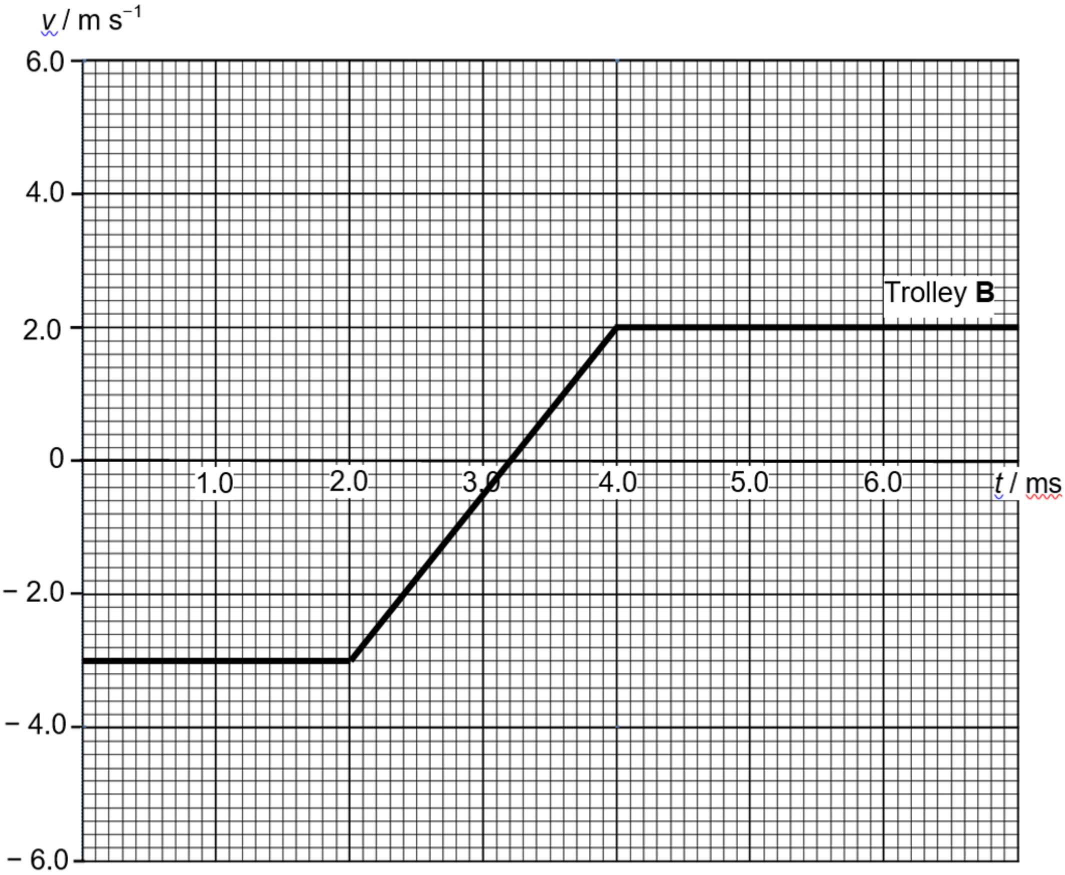

Fig. 2.2

2. Determine the force acting on trolley B.

force = ……………………… N [2]

(b) Fig. 2.3 shows a simplified cross-section diagram of a submarine, an aquatic vehicle whose buoyancy can be adjusted such that it can be allowed to sink underwater and float on the surface. This is achieved by flooding the rigid metal ballast tanks with seawater to an adjustable extent, thereby varying the volume of air inside the ballast tanks.

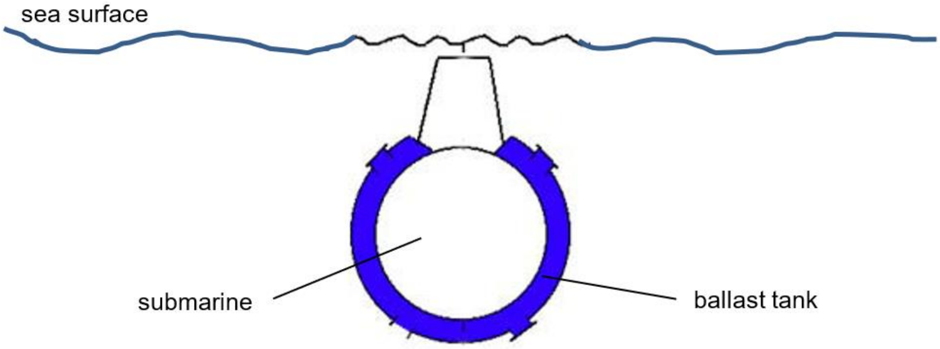

Fig. 2.3

(i) Explain how the variation of the volume of air and seawater in the ballast tanks can result in the submarine sinking or floating given the upthrust is constant when the submarine is fully submerged.

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………[1]

(ii) The submarine is cruising horizontally at 2.0 m s^{-1} when an underwater explosive mine is spotted. A 500-kg torpedo is launched by the submarine horizontally to destroy the mine. The launching force on the torpedo over 500 ms launching period is shown in Fig. 2.4.

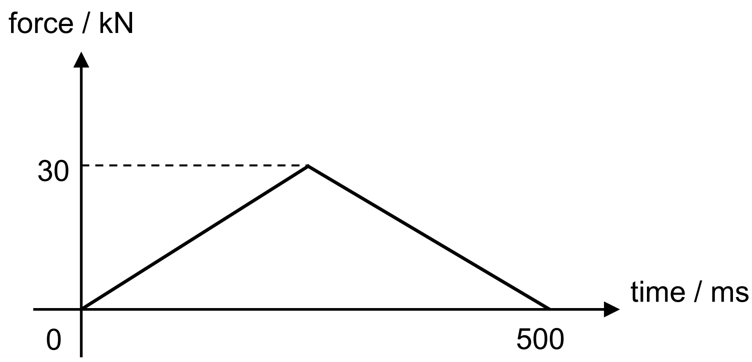

Fig. 2.4

Determine the velocity of the torpedo after launch.

velocity = ………………… m s^{-1} [2]

3 **(a)** State the conditions for a rigid body to be in equilibrium.

....

....

.... [2]

(b) A uniform rigid rod of mass 30 kg is attached to a vertical wall by a hinge as shown in Fig. 3.1. The other end of the rod is held to the ceiling by a cable.

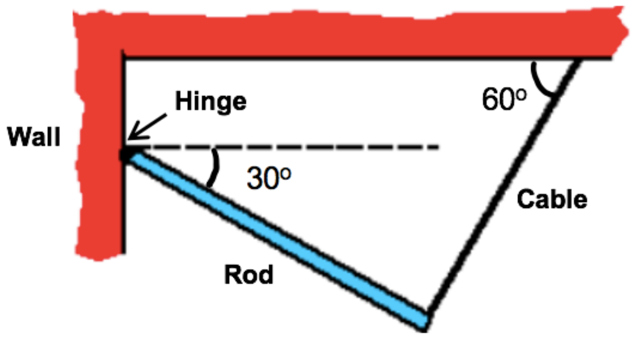

Fig. 3.1

(i) Draw the free body diagram of the forces acting on the rod in Fig. 3.1. Label all the forces clearly. [2]

(ii) Show that the tension *T* in the cable is 127 N.

[2]

(iii) Determine the force acting on the rod by the hinge.

force = ………………………… N

direction = ………………………………… [4]

4 **(a)** Define *gravitational potential* at a point in a gravitational field.

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

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

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

(b) Fig. 4.1 shows lines of equal gravitational potential near to the surface of a small spherical asteroid of mass *M* and radius *R*.

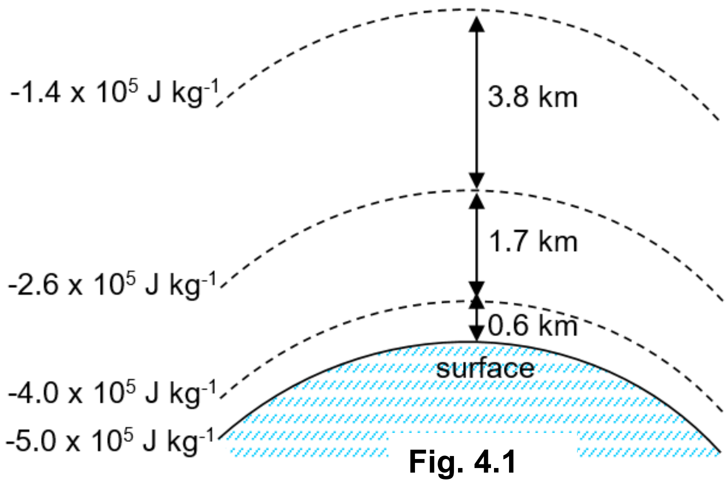

Fig. 4.1

(i) Explain why all the values of potential are negative.

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

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

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

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

(ii) Write down the equation relating field strength *g* and gravitational potential ϕ at a point in the gravitational field. Hence, estimate the value of *g* at the surface of the asteroid.

g = ………………………….N kg^{-1} [3]

(iii) Deduce the value of radius R and mass M of the asteroid.

R = ……………..………………….m

M = ……………….….………..kg [4]

(iv) Calculate the escape speed from the surface of the asteroid.

speed = ………………..……….m s^{-1} [2]

5 **(a)** Define simple harmonic motion.

....

....

.... [2]

(b) A metal tube of uniform cross-sectional area is sealed at one end. It floats upright and stationary in water, as shown in Fig. 5.1.

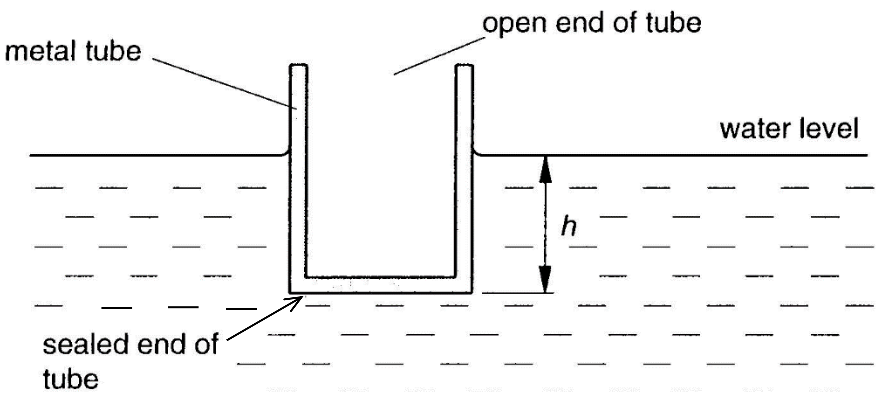

Fig. 5.1

The tube is then given a vertical displacement and released. Fig. 5.2 shows the variation with time *t* of the depth *h* of the base of the tube below the surface.

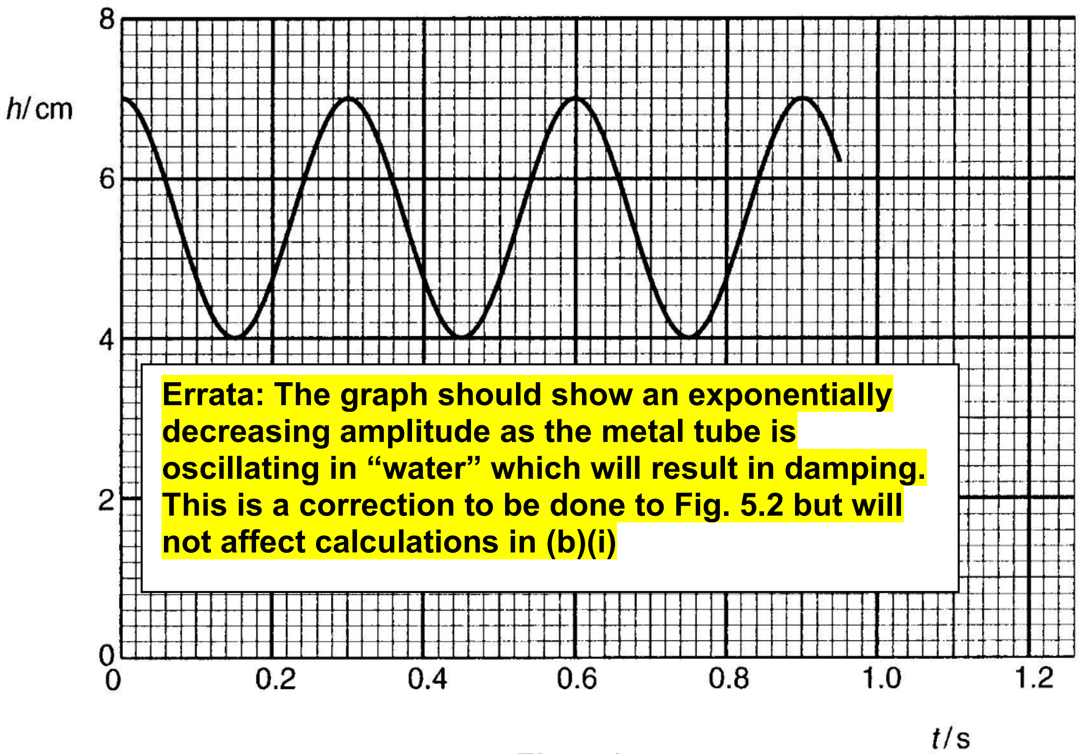

Fig. 5.2

(i) **1.** Use Fig. 5.2 to determine the amplitude of the oscillations of the tube.

amplitude = ……………… cm [1]

2. Determine the frequency of the oscillations.

frequency = ……………… Hz [1]

(ii) Surface water waves are now produced by a nearby wave generator of frequency *f*. The water waves cause forced oscillations of the tube. The amplitude *y* of the tube's oscillations depends on *f*.

1. Sketch a graph to show how *y* varies with *f* over a wide range of frequencies which *includes* the natural frequency of the tube. [2]

2. Add to your graph a second line which shows the effects of increased damping. Label this line **D**. [1]

Errata: "increased damping" NOT "light damping"

(c) Some parents rock their babies to sleep by using a cradle attached to the end of a fixed spring as shown in Fig. 5.3 below.

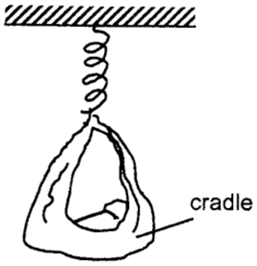

Fig. 5.3

A 5.0 kg baby is placed in a cradle of negligible mass and given a downward displacement of 20.0 cm such that it undergoes vertical simple harmonic motion. The spring has a force constant of 60 N m^{-1}.

(i) 1. Calculate the maximum kinetic energy given the angular frequency, ω of a spring-mass system is given by $\omega^2 = k/m$ where k is the spring constant and m is the load.

maximum kinetic energy = …………………… J [2]

2. Sketch a labelled graph of the kinetic energy of the system against displacement. Include appropriate numerical values. [1]

(ii) Taking the gravitational potential energy of the system to be zero at the highest point of oscillation, determine the total energy of the system.

total energy = ………………… J [3]

[End of Paper]