RAFFLES INSTITUTION

2023 YEAR 5 PROMOTIONAL EXAMINATION

2 October 2023 Time: 2 hr 30 min

H2 PHYSICS

Section A

INSTRUCTIONS TO CANDIDATES

There are 3 sections in this paper.

Section A consists of **15** multiple-choice questions. For each question, four suggested answers are given. You are to choose the most appropriate one and shade your answer on the OMR form, using a soft pencil.

You are advised to attempt Section A first. The **OMR form will be collected at the end of the first 30 minutes**.

Section B consists of **5** structured questions. You are to write your answers in the spaces provided.

Section C consists of **2** longer structured questions. You are to write your answers in the spaces provided.

Attempt ALL the questions in Sections A, B and C.

This document consists of **10** printed pages.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

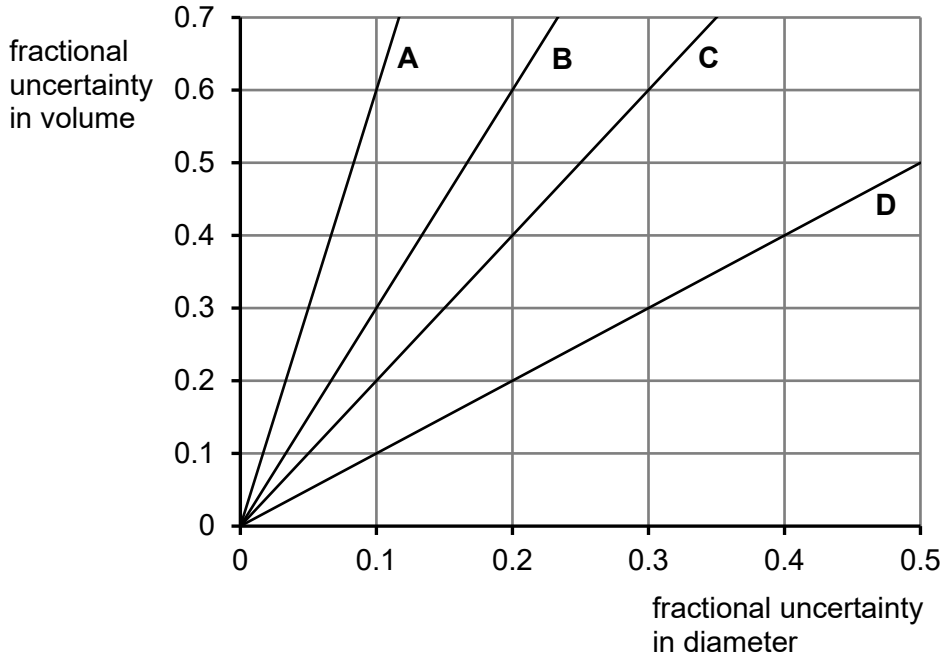
Formulae

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	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	$T / ^\circ\mathrm{C} + 273.15$
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
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	λ	=	$\ln 2 / t_{1/2}$

Section A (15 marks)

1 A spherical balloon is gradually inflated. Its diameter is measured at regular intervals and the uncertainty in the diameter is estimated. The volume of the balloon is then calculated at each interval using the diameter measured.

Which graph shows how the fractional uncertainty in the volume of the balloon varies with the fractional uncertainty in the diameter of the balloon?



2 Which sequence shows the unit prefixes in order of decreasing magnitude?

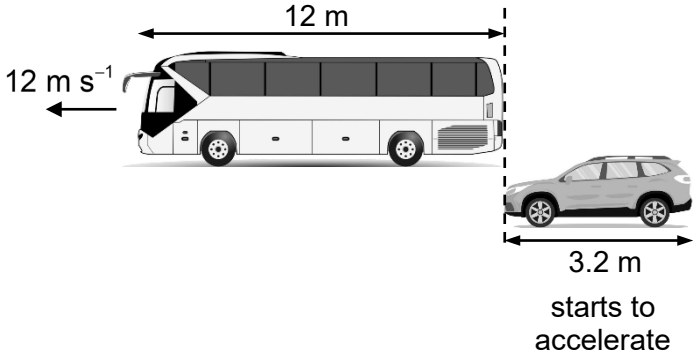
A kilo, giga, tera

B deci, mega, kilo

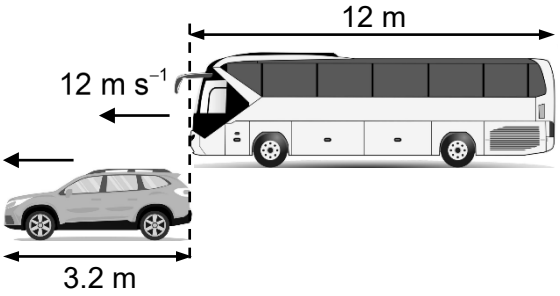
C centi, pico, nano

D milli, micro, nano

3 A car of length 3.2 m accelerates uniformly from rest as a bus of length 12 m passes its front at a constant speed of 12 m s^{-1} as shown.



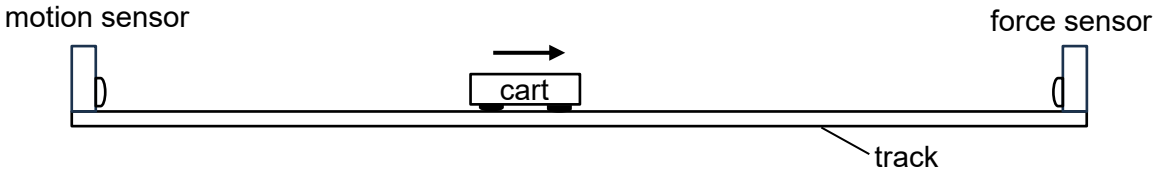
After 30 s, the car passes the front of the bus as shown.



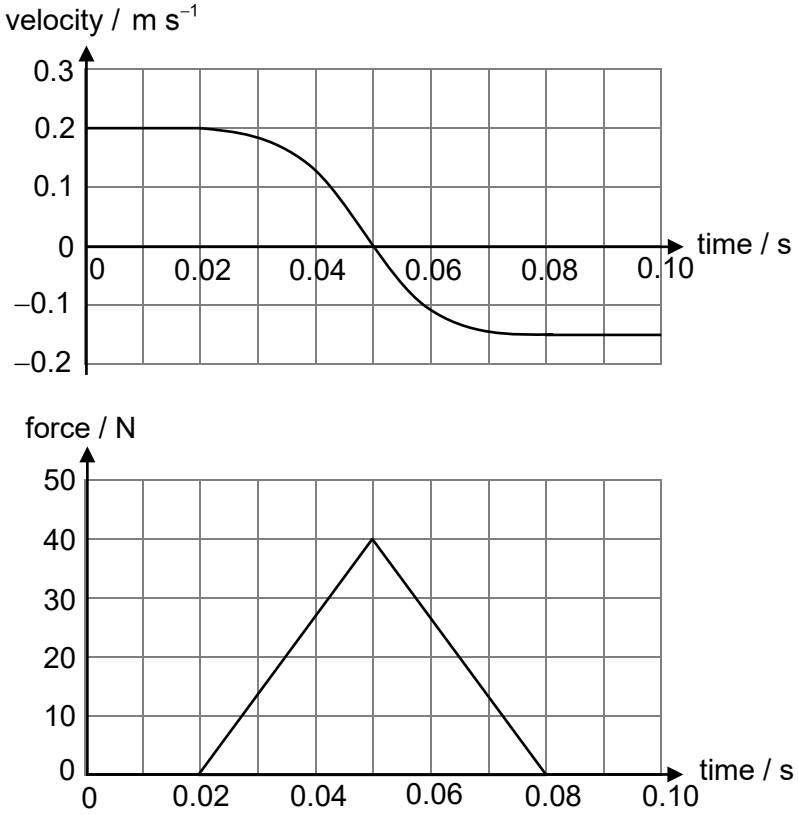
What is the acceleration of the car?

A 0.80 m s^{-2} **B** 0.81 m s^{-2} **C** 0.83 m s^{-2} **D** 0.86 m s^{-2}

4 A cart is placed on a horizontal track between a motion sensor and a force sensor. It is given a push such that it moves towards the force sensor and collides with it.



The variation with time of the velocity of the cart and the force on the sensor during the collision as measured by the motion sensor and force sensor respectively, are shown in the graphs.



What is the mass of the cart?

A 3.4 kg **B** 4.6 kg **C** 6.9 kg **D** 24 kg

5 Which statement about upthrust is always correct?

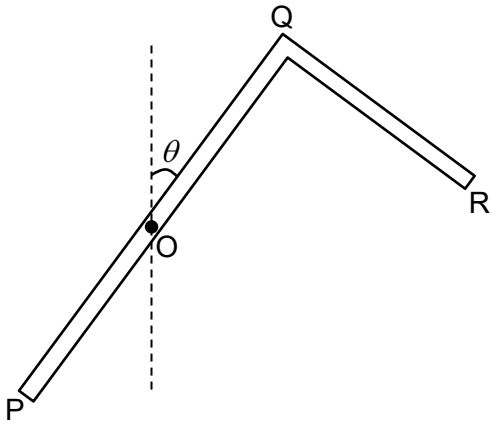
A The upthrust on an object is equal to the weight of the object.

B Two objects of the same mass will experience the same upthrust when fully submerged in the same type of liquid.

C The upthrust experienced by an object submerged in a liquid, is due to the fluid pressure at the bottom surface of the object.

D A solid metal sphere and a hollow plastic sphere with the same dimensions will experience the same upthrust when fully submerged in the same type of liquid.

6 The diagram shows a light, right-angle L-shaped rod PQR. Side PQ is twice the length of side QR. The rod is pivoted at point O, the midpoint of side PQ, such that it rotates freely in the vertical plane.

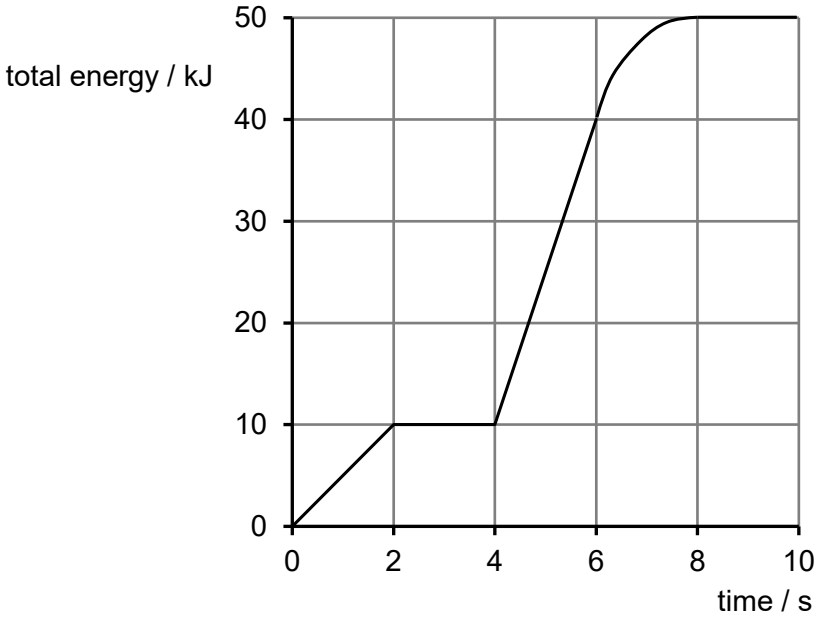


A small piece of clay of mass *m* is attached at R and another small piece of clay of mass 4*m* is attached at P. When the rod rests in equilibrium, PQ is at an angle θ to the vertical.

What is the value of θ?

A 7.1° **B** 14.0° **C** 18.4° **D** 26.6°

7 An electric crane is used to lift a container from the ground. The graph shows the variation with time of the total energy of the container.



If the efficiency of the electric crane is 65 %, what is the maximum electrical power supplied to the crane during the 10 seconds?

A 9.8 kW **B** 15 kW **C** 23 kW **D** 31 kW

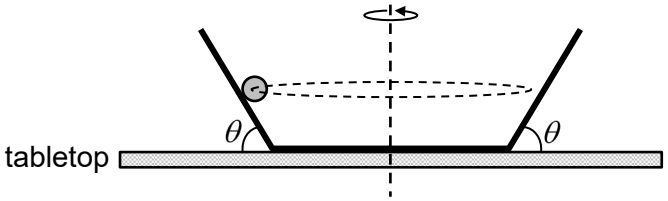
8 The mean radius of the Earth's orbit around the Sun is 1.50×10^{11} m.

What is the mean speed of the Earth in its orbit around the Sun?

A 1.09×10^{7} m s^{-1} **B** 2.99×10^{4} m s^{-1}

C 5.95×10^{-3} m s^{-1} **D** 1.99×10^{-7} m s^{-1}

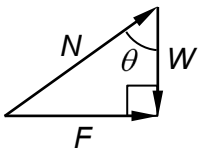
9 A small ball is made to move in a horizontal circle by rotating the bowl at a constant angular velocity about the vertical axis through its centre. The diagram shows the cross-section of the bowl.



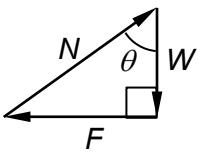
The sides of the bowl make an angle θ with the tabletop. Assume all resistive forces are negligible.

Which diagram shows the vector triangle of the weight of the ball *W*, contact force *N* and the centripetal force *F* on the ball at the instant shown above?

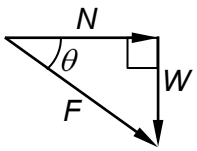
A



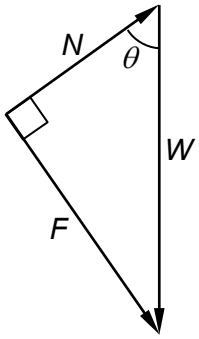
B



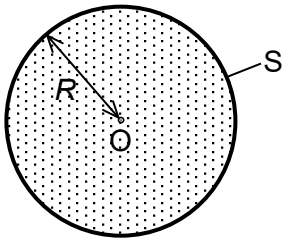
C



D



10 An astronomical spherical gas cloud has mass *M* and radius *R*. The gravitational potential on its surface S is $-\frac{GM}{R}$ and at its centre O is $-\frac{3GM}{2R}$.



A unit mass is moved at constant speed by an external force from S to O.

What is the work done on the mass by the gravitational force?

A $-\frac{5GM}{2R}$ **B** $-\frac{GM}{2R}$ **C** $\frac{GM}{2R}$ **D** $\frac{5GM}{2R}$

11 The escape speed of an object projected from the surface of the Earth is 11.2 km s^{-1}.

The radius of the Earth is 4 times that of the Moon and the ratio of the average density of the Earth to that of the Moon is $\frac{5}{4}$.

What is the escape speed of an object projected from the surface of the Moon?

A 2.50 km s^{-1} **B** 3.13 km s^{-1} **C** 5.01 km s^{-1} **D** 20.0 km s^{-1}

12 Which of the following is an effect of a decrease in damping in a forced oscillation?

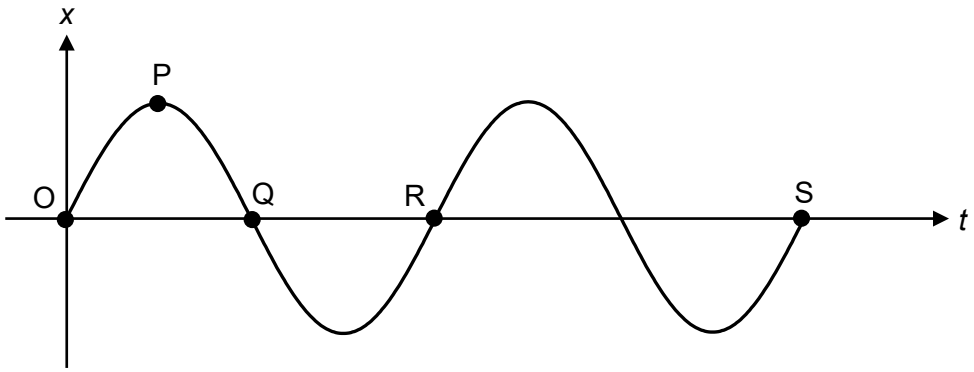
A All the energy from the driving system is transferred to the oscillating system.

B The total energy of the oscillating system decreases.

C The amplitude of the oscillation at resonance decreases.

D The period of the driving force at which resonance occurs decreases.

13 The graph shows the variation with time *t* of the displacement *x* of a particle on a progressive wave.



O, P, Q, R and S are points on the graph.

Which statement is correct?

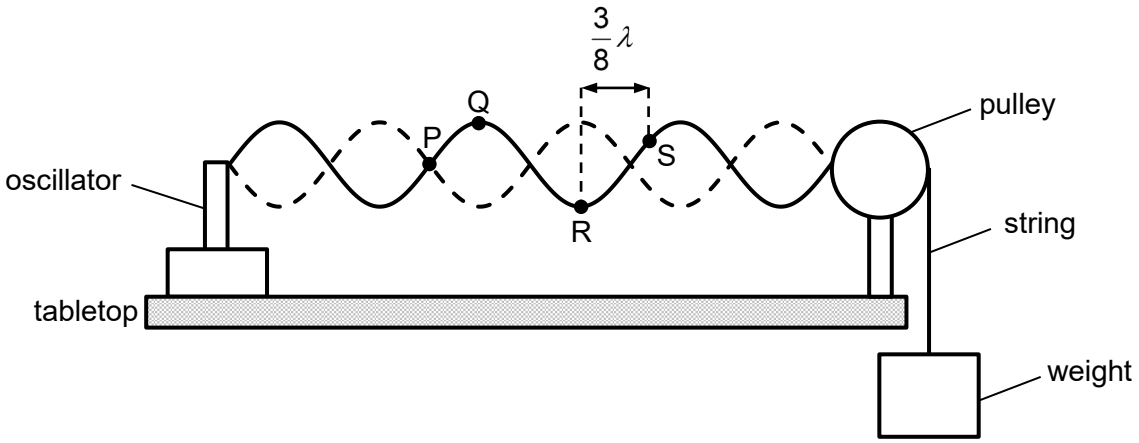
A At P, the acceleration of the particle is zero.

B The phase difference between P and Q is 90°.

C OS represents two wavelengths.

D The kinetic energy of the particle is higher when it is at P than when it is at R.

14 A string is attached at one end to an oscillator and stretched by a weight over a pulley at the other end. When the oscillator is switched on, a stationary wave is formed on the string.



P, Q, R and S are points along the string. The wavelength of the incident wave is λ and the distance between points R and S is $\frac{3}{8}\lambda$.

Which statement is correct?

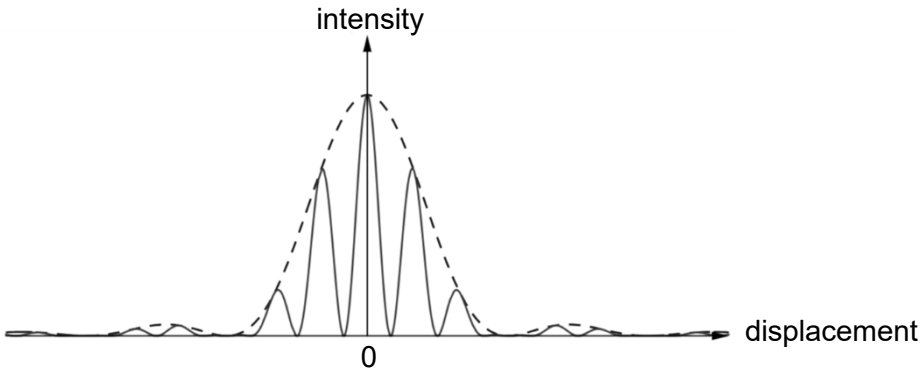
A The phase difference between R and S is $\frac{3}{4}\pi$ rad.

B Q and S are oscillating in phase with each other but have different amplitudes of oscillation.

C At P, the incident and reflected waves on the string always meet $\frac{\pi}{2}$ rad out of phase with each other.

D The distance between Q and R is $\frac{1}{2}\lambda$ and the amplitude of the incident wave is the same as the amplitude of Q.

15 Monochromatic laser light is incident on two narrow slits. The variation with displacement from the centre of the interference pattern of the intensity of the light captured on a screen at a large distance away is shown.



If the slit separation between the two slits is 0.60 mm, what is the width of each slit?

A 0.10 mm **B** 0.12 mm **C** 0.15 mm **D** 0.20 mm

END OF SECTION A