RAFFLES INSTITUTION

2023 YEAR 5 TERM 3 COMMON TEST

4 July 2023 Time: 2 hr 15 min

H2 PHYSICS

Section A

INSTRUCTIONS TO CANDIDATES

There are 2 sections in this paper.

Section A consists of **14** 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 **7** structured questions. You are to write your answers in the spaces provided.

Attempt ALL questions in Sections A and B.

This document consists of **8** 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 (14 marks)

1 The diagram shows the iOLab device you have used to measure various physical quantities in the school laboratory.

What is a reasonable estimate for the volume of the iOLab device?

A 3.0×10^{-4} m^3 **B** 3.0×10^{-3} m^3 **C** 3.0×10^{-2} m^3 **D** 3.0×10^{-1} m^3

2 An equation in fluid dynamics is given as

$$v^2 = gh\left(1+\frac{1}{3}k^2\phi^2\right)$$

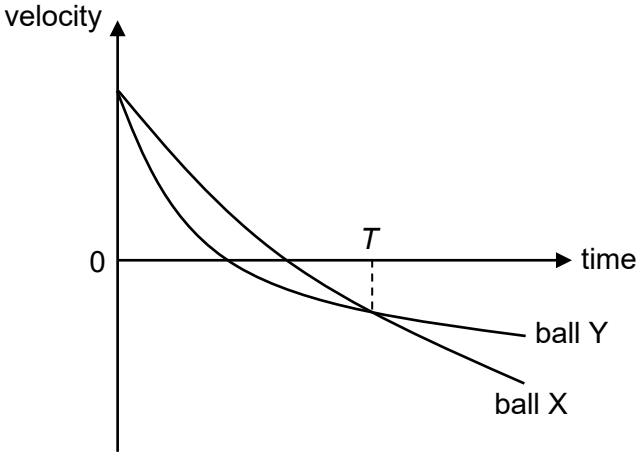
where v is the speed of water waves, g is the acceleration of free fall, h is the depth of the water and k is the wave number with units m^{-1}.

What is a possible physical quantity for ϕ ?

A length **B** time

C area **D** a unitless constant

3 Two balls X and Y are thrown vertically upwards simultaneously from the top of a hill with the same speed. The variation with time of their velocities are shown.



Which statement is correct?

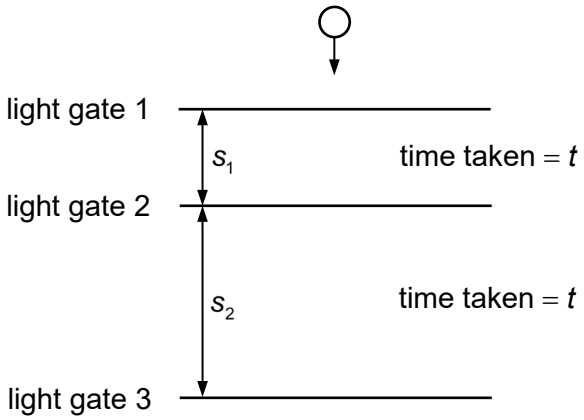
A The average air resistance on ball X is smaller than on ball Y before time *T* but larger on ball X than on ball Y after time *T*.

B The accelerations of both balls are always smaller than the acceleration of free fall.

C The accelerations of both balls are the same when their velocities are zero.

D Both balls are at the same distance from the top of the hill at time *T*.

4 An object falls freely with constant acceleration from above three light gates. It is found that it takes a time *t* to fall between the first two light gates a distance of s_1 apart. It then takes an additional time, also *t*, to fall between the second and third light gates a distance s_2 apart.



What is the acceleration of the object in terms of s_1, s_2 and t ?

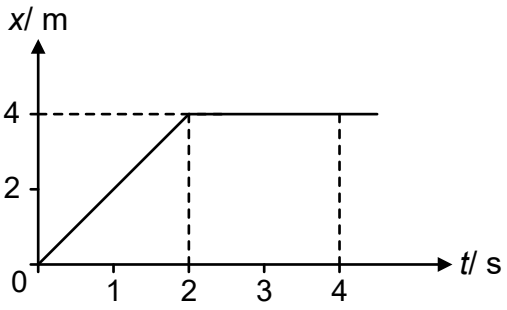
A $\frac{2(s_2 - s_1)}{t^2}$ **B** $\frac{2(s_2 - s_1)}{3t^2}$ **C** $\frac{(s_2 - s_1)}{t^2}$ **D** $\frac{(s_2 - s_1)}{2t^2}$

5 A closed empty plastic box of mass m that was found submerged in water, was seen rising with an acceleration of $\frac{g}{6}$.

What mass of sand should be filled in the box so that it moves downwards with an acceleration of $\frac{g}{6}$? Ignore all resistive forces.

A $\frac{1}{5}m$ **B** $\frac{2}{5}m$ **C** m **D** $\frac{7}{5}m$

6 The graph shows the variation with time t of the displacement x of a particle of mass 0.10 kg.

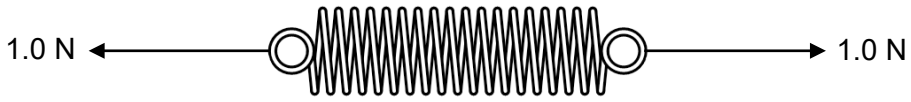


What is the impulse on the particle?

A -2.0 kg m s^{-1} **B** -0.20 kg m s^{-1} **C** 0.20 kg m s^{-1} **D** 4.0 kg m s^{-1}

7 A light spring has a force constant of 50 N m^{-1}.

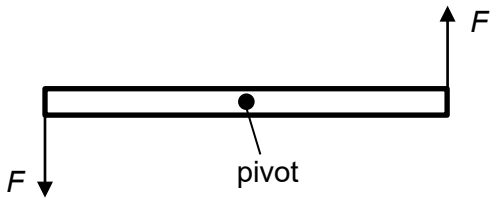
It is being pulled by a 1.0 N force on each end, in opposite directions.



What is the extension of the spring?

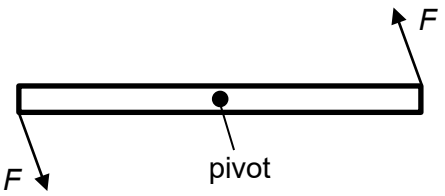
A 0 m **B** 0.010 m **C** 0.020 m **D** 0.040 m

8 A pair of forces with the same magnitude F act on the ends of a rod that is pivoted at its centre. The forces act in opposite directions and are perpendicular to the rod.

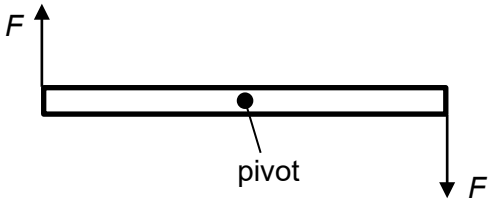


In which other situation will the same rod experience the same torque about the pivot as the situation above?

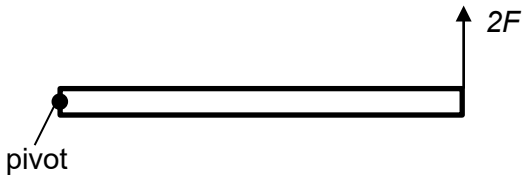
A



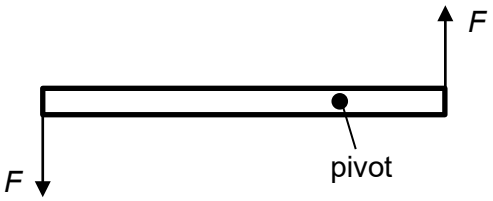
B



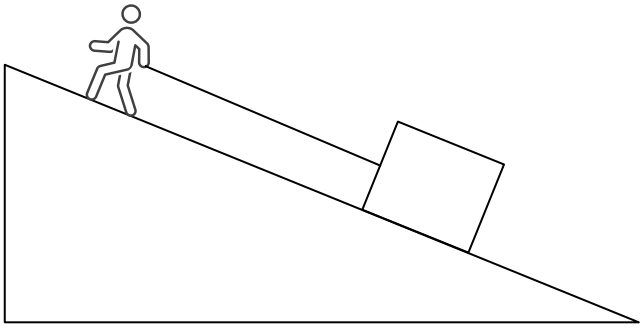
C



D



9 A man pulls a block up a rough inclined plane at constant velocity with a rope.



Which statement is correct?

A The work done against the weight of the block is equal to the gain in gravitational potential energy of the block.

B The work done by the force of the rope is equal to the work done against the frictional force by the plane because there is no gain in kinetic energy.

C The weight of the block does no work because the displacement of the block is not in the direction of its weight.

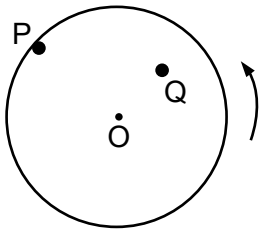
D The normal contact force from the plane does positive work because it has a component up the slope and the block is moving up the slope.

10 A speedboat with two engines, each of equal power output, can achieve maximum speed v when both engines are working. The total drag D on the boat when it is travelling at maximum speed is proportional to v^2.

What is the maximum speed of the boat when only one engine is working?

A $0.25v$ **B** $0.50v$ **C** $0.71v$ **D** $0.79v$

11 P and Q are points on a disc that is rotating with uniform circular motion about its centre O.

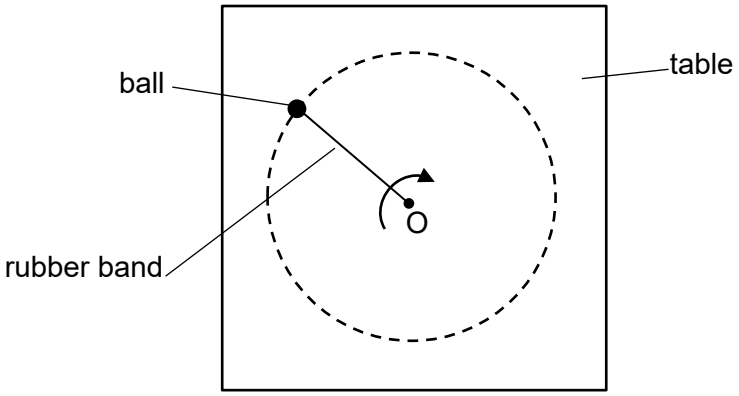


How do the angular velocities and angular displacements of P and Q compare after a quarter of a revolution?

	angular velocities	angular displacements
A	different	different
B	different	the same
C	the same	different
D	the same	the same

12 A ball of mass 0.100 kg is attached to one end of a piece of rubber band of unstretched length 0.20 m. The force constant of the rubber band is $30\ \text{N m}^{-1}$.

The ball is rotated steadily on a table about a fixed point O in a horizontal circle of radius 0.25 m. A constant frictional force of 0.20 N acts radially towards point O on the ball as it rotates. The diagram shows the top view of the set-up.



What is the linear speed of the ball?

A $1.8\ \text{m s}^{-1}$ **B** $2.1\ \text{m s}^{-1}$ **C** $3.2\ \text{m s}^{-1}$ **D** $4.3\ \text{m s}^{-1}$

13 Callisto is the fourth moon of Jupiter. It orbits Jupiter at a radius of 1.88×10^{6} km and with a period of 17 days.

What is the mass of Jupiter?

A 1.82×10^{18} kg **B** 1.82×10^{27} kg

C 4.26×10^{32} kg **D** 1.36×10^{37} kg

14 The acceleration of free fall on the surface of planet X is 4 times that of planet Y. The mean density of planet X is $\frac{7}{3}$ times that of planet Y.

What is the ratio $\frac{\text{radius of planet X}}{\text{radius of planet Y}}$?

A 0.1 **B** 0.7 **C** 1.7 **D** 9.3

END OF SECTION A