RAFFLES INSTITUTION
2022 YEAR 5 JULY COMMON TEST

29 June 2022 Time: 2 hr 30 min

H2 PHYSICS

Section A

INSTRUCTIONS TO CANDIDATES

There are 2 sections in this paper.

Section A consists of 15 multiple-choice questions. For each question, there are four possible answers **A**, **B**, **C** and **D**. Choose the one you consider correct and record your choice in soft pencil on the separate Optical Mark Sheet.

You are advised to attempt Section A first. The Optical Mark Sheets will be collected after the first **30** minutes.

Section B consists of **6** structured questions and **1** data analysis question. You are to write your answers in the spaces provided.

Attempt ALL questions in Sections A and B.

There are 10 printed pages, inclusive of the cover page and data & formulae page, in this booklet.

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

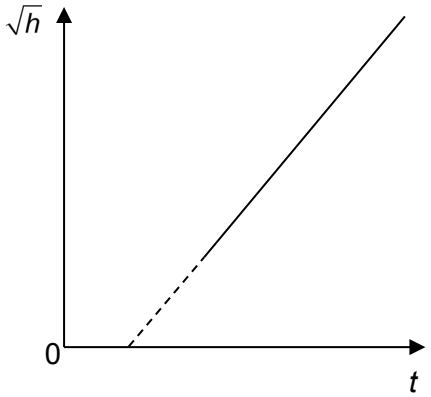
uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	$T / ^\circ\text{C} + 273.15$
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean 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

1 What is a reasonable estimate for the volume of an average sized classroom in Raffles Institution?

A 2.0 m^3 **B** 20 m^3 **C** 200 m^3 **D** 2000 m^3

2 A student measures the time t for a ball to fall from rest through various vertical distances h. The student plots the graph as shown.



Which of the following is an explanation for the non-zero intercept on the t-axis?

A Human reaction time of the student.

B There is an error in the timer that consistently makes it run fast.

C The effect of air resistance is significant for larger values of h.

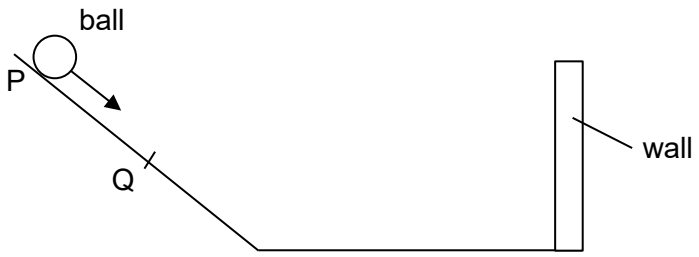
D There is a constant time lag between starting the timer and releasing the ball.

3 A ball moves at a speed of 3.0 m s^{-1} from point A to B and travels at 5.0 m s^{-1} back from B to A.

What is the average speed of the ball?

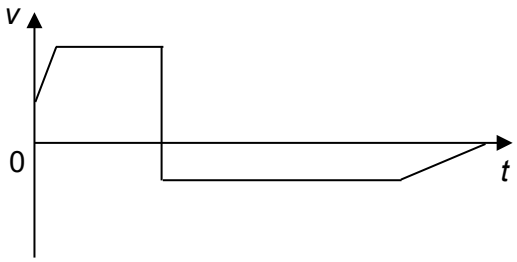
A 0 m s^{-1} **B** 1.9 m s^{-1} **C** 3.8 m s^{-1} **D** 4.0 m s^{-1}

4 A ball is released from rest on a frictionless surface at P. It moves down the slope, rebounds inelastically off the wall, and comes to rest momentarily at Q.

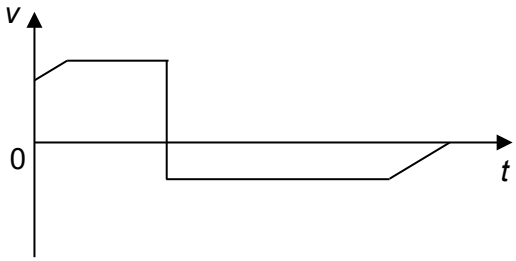


Which graph best represents the variation of ball's horizontal velocity v with time t as it moves from Q to the wall and back to Q?

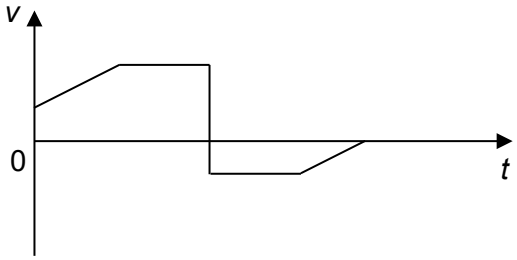
A



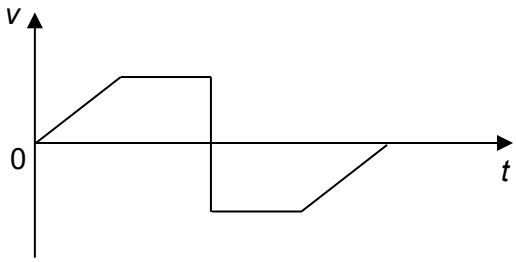
B



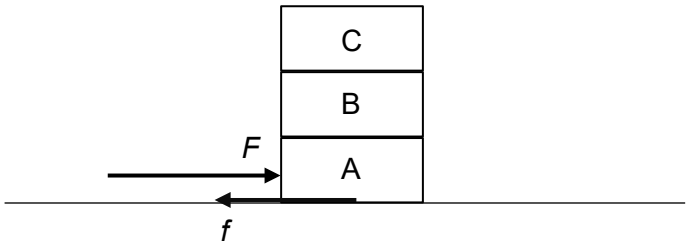
C



D



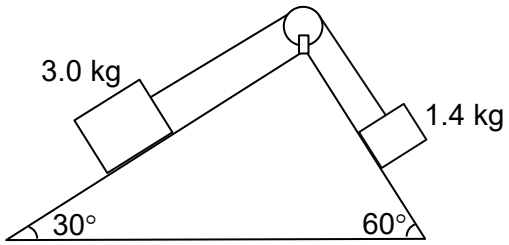
5 Three identical blocks are arranged in a vertical stack and accelerated along a rough surface by a horizontal force F acting on block A.



Block A experiences a resistive force f from the surface during this acceleration. What is the magnitude of the frictional force between blocks A and B?

A 0 **B** $\frac{2f}{3}$ **C** $\frac{2F}{3}$ **D** $\frac{2(F-f)}{3}$

6 Two masses are connected by a light string over a frictionless pulley and allowed to slide on the smooth surfaces of a fixed triangular wedge as shown.



What is the magnitude of the acceleration of the masses?

A 0.64 m s^{-2} **B** 3.3 m s^{-2} **C** 3.6 m s^{-2} **D** 4.2 m s^{-2}

7 Which one of the following pairs of forces is **not** an example of action and reaction to which Newton's Third Law of Motion applies?

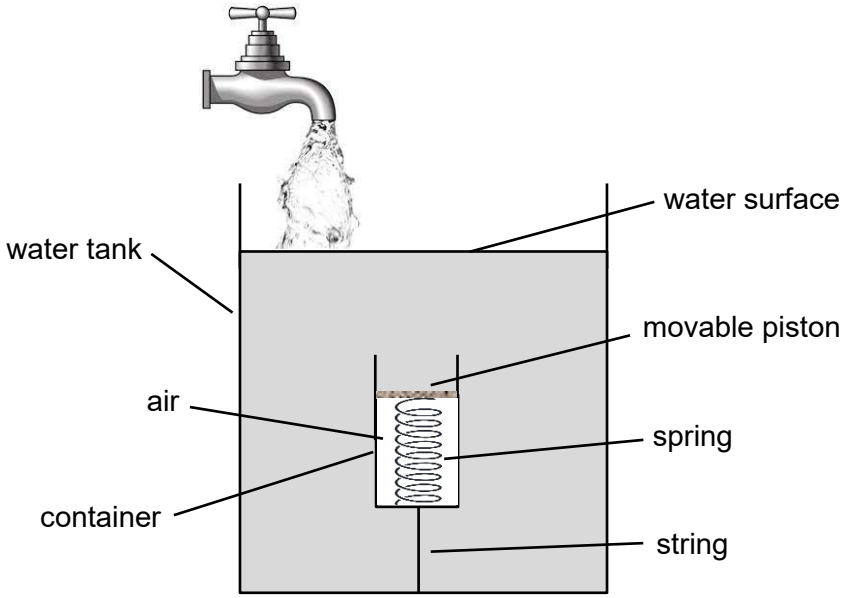
A The forces of attraction between an electron and a proton in a hydrogen atom.

B The centripetal force keeping a satellite in orbit round the Earth and the weight of the satellite.

C The normal contact force experienced by a book resting on a table and the force the book exerts on the table.

D The force accelerating a free-falling object to the Earth and the gravitational force exerted by the object on the Earth.

8 A container filled with air has a spring attached to its base. The top end of the spring is attached to a movable piston. The container is fully submerged in a tank filled with water and secured to the tank by a string as shown.

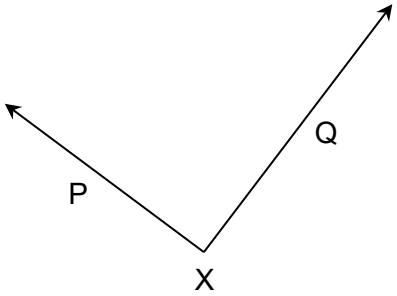


The tap is turned on and the water level in the tank rises, while the string remains taut.

How will the length of the spring and the tension in the string change?

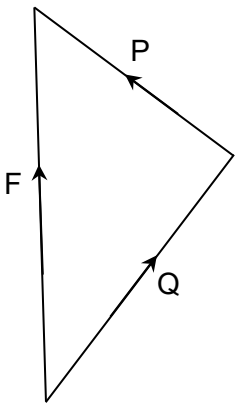
	length of spring	**tension in string**
A	decreases	decreases
B	decreases	increases
C	no change	decreases
D	no change	no change

9 Two forces P and Q act at a point X as shown in the vector diagram below.

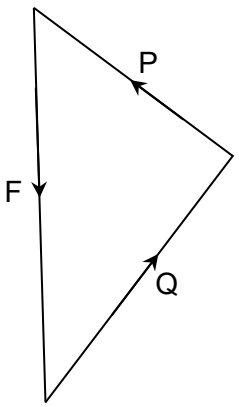


In which of the following diagrams does the vector F represent the force which must be applied at X to maintain equilibrium?

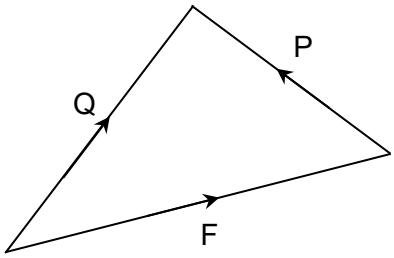
A



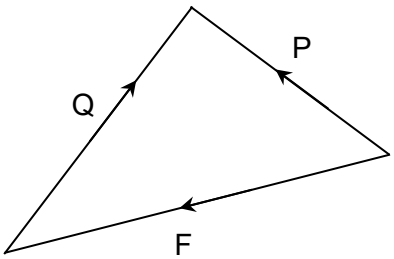
B



C



D



10 A ball of mass 0.50 kg falls from a height and reaches a speed of 2.0 m s^{-1} when it is 50 cm above a vertical spring. It strikes the spring and compresses it by a distance of 6.0 cm before the ball comes to a rest momentarily.

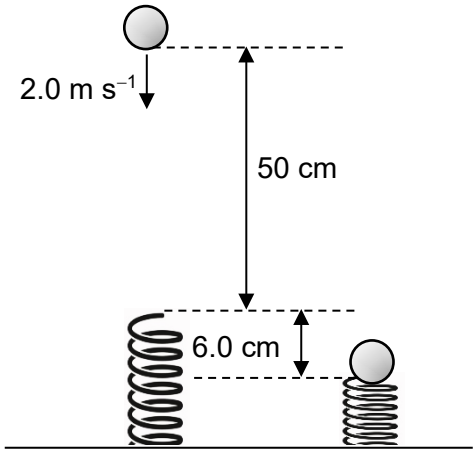


diagram not drawn to scale

Assume that all the energy the ball loses is transformed into elastic potential energy in the spring.

What is the average force exerted by the spring during its compression?

A 46 N **B** 58 N **C** 62 N **D** 125 N

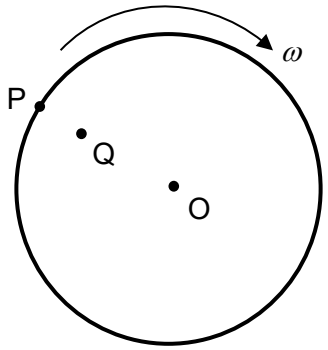
11 A small solar panel fitted on a toy car of total mass 2.0 kg has an efficiency of 30% in converting solar energy to kinetic energy of the car.

The car is able to reach a speed of 14 km h^{-1} from rest in 3.0 seconds.

What is the amount of solar power that is incident on the solar panel?

A 1.5 W **B** 5.0 W **C** 17 W **D** 220 W

12 A disc of radius 6.0 cm rotates about its centre O. P is a point on the circumference and Q is a point 4.0 cm from O.

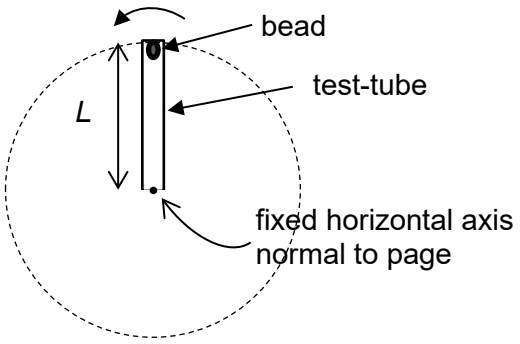


At P, the angular velocity ω is 3.0 rad s^{-1} and the centripetal acceleration a is 54 cm s^{-2}.

Which row shows the correct angular velocity ω and centripetal acceleration a at Q?

	ω / rad s^{-1}	a / cm s^{-2}
A	2.0	16
B	2.0	24
C	3.0	24
D	3.0	36

13 A test-tube of length L containing a small bead of weight W undergoes uniform circular motion in the vertical plane about a fixed horizontal axis passing through its open end. The magnitude of the force exerted by the bead on the base of the tube is $\frac{W}{2}$ at the instant when the tube is vertical but upside down.



In terms of L, what is the frequency of rotation?

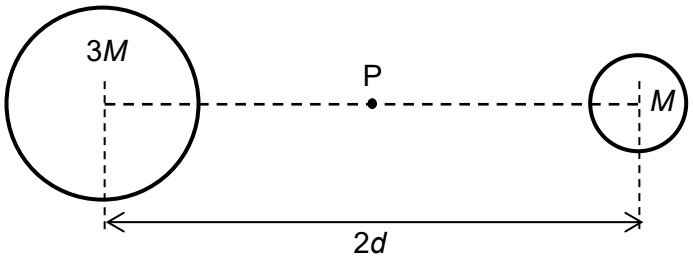
A $0.35\sqrt{\frac{1}{L}}$ **B** $0.43\sqrt{\frac{1}{L}}$ **C** $0.61\sqrt{\frac{1}{L}}$ **D** $2.3\sqrt{\frac{1}{L}}$

14 A spherical planet of uniform density 5240 kg m^{-3} has a diameter of 12100 km.

What is the acceleration due to gravity on the surface of the planet?

A 8.86 m s^{-2} **B** 17.7 m s^{-2} **C** 26.6 m s^{-2} **D** 53.1 m s^{-2}

15 The centres of two uniform spheres of masses $3M$ and M are separated by a distance $2d$. Point P lies mid-way on the line joining the centres of the two spheres.



In terms of M, d and the gravitational constant G, which row gives the correct expressions for the resultant gravitational field strength and potential at P?

	gravitational field strength	gravitational potential
A	$\frac{GM}{2d^2}$	$-\frac{2GM}{d}$
B	0	$-\frac{4GM}{d}$
C	$\frac{2GM}{d^2}$	$-\frac{2GM}{d}$
D	$\frac{2GM}{d^2}$	$-\frac{4GM}{d}$