RAFFLES INSTITUTION
2022 YEAR 5 PROMOTION EXAMINATION

30 September 2022 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, 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 **5** structured questions. You are to write your answers in the spaces provided.

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

Attempt **all** questions in Sections A, B and C.

There are **9** printed pages, inclusive of the cover page and data & formulae page, in this booklet.

 [Turn over

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	=	$T/°C + 273.15$
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	=	$\ln 2 / t_{1/2}$

1 The period T of a simple pendulum of length L is given by the following equation

$$T = 2\pi\sqrt{\frac{L}{g}}$$

where g is the acceleration of free fall.

The fractional uncertainty of the period T is 0.020 and that in the measurement of the length L is 0.030.

What is the fractional uncertainty of the calculated value of g?

A 0.010 **B** 0.050 **C** 0.070 **D** 2.8

2 An equation of the theory of gas flow through small diameter tubes at low pressures is

$$Q = \frac{kr^3(p_1 - p_2)}{Lc}$$

where k is a dimensionless constant,
r is the radius of the tube,
p_1 and p_2 are the pressures at each end of the tube of length L,
c is the speed of the gas molecules

What are the base units of Q?

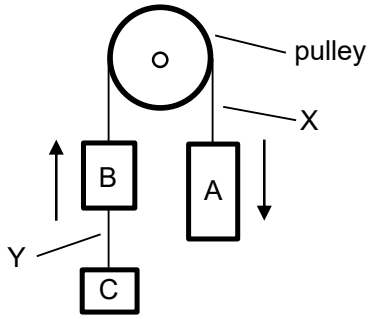
A 1 **B** kg s^{-1} **C** m^3 s^{-1} **D** m s

3 A baseball at a height of 0.80 m above a flat horizontal ground is projected with a velocity of 12 m s^{-1} at an angle 25° to the horizontal. Air resistance is negligible.

What is the horizontal displacement of the ball when it reaches the ground?

A 1.5 m **B** 9.1 m **C** 11.6 m **D** 12.8 m

4 Two blocks A and B, hang from a light inextensible cord X that passes over a frictionless pulley. A third block C is suspended from block B with a light inextensible cord Y. The masses of blocks B and C are 2.0 kg and 1.0 kg respectively. When the masses are released from rest, they move in the direction of the arrows and the tension in cord Y is 12 N.

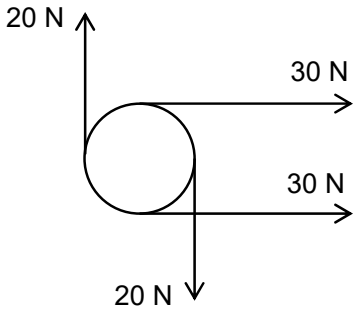


What is the mass of block A?

A 3.2 kg **B** 3.7 kg **C** 4.0 kg **D** 4.7 kg

5 Four forces are applied to a circular object. In which scenario would the object have a non-zero net force but no net torque?

A



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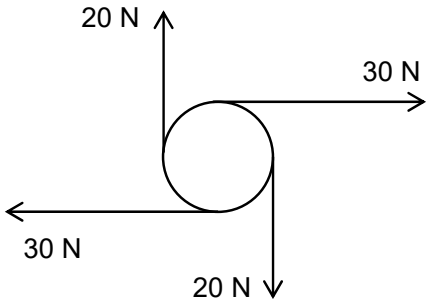

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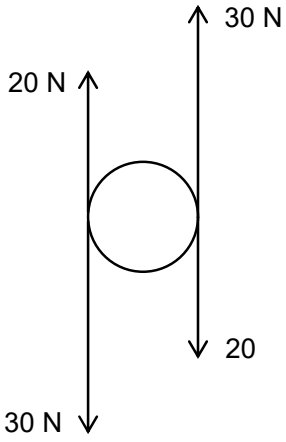

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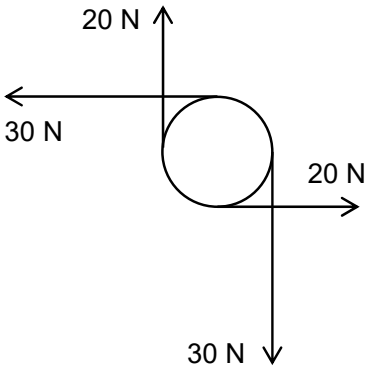


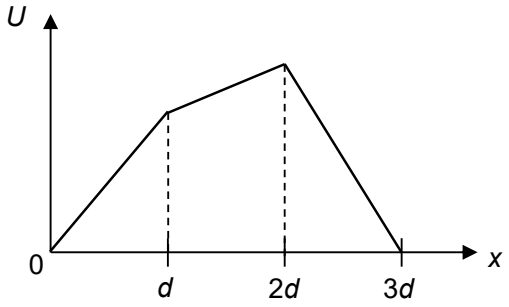
6 An electric vehicle of mass 1800 kg, travelling along a horizontal road at a constant speed of 14 m s^{-1}, requires a power of 5.0 kW.

What is the required power when the vehicle is moving up a slope of 5.0° at the same constant speed of 14 m s^{-1}?

A 5.1 kW **B** 16.5 kW **C** 26.5 kW **D** 251 kW

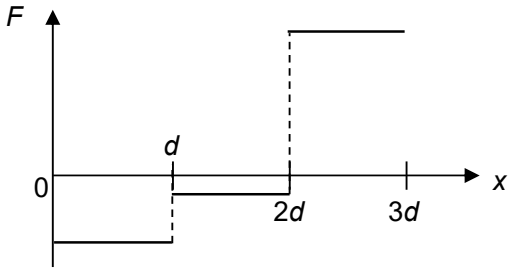
7 A particle moves in a straight line from a point O.

The graph shows how its potential energy *U* varies with its displacement *x* from point O.



Which graph shows how the force *F* acting on the particle varies with displacement *x*?

A



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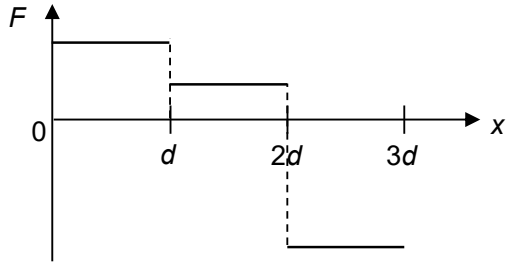

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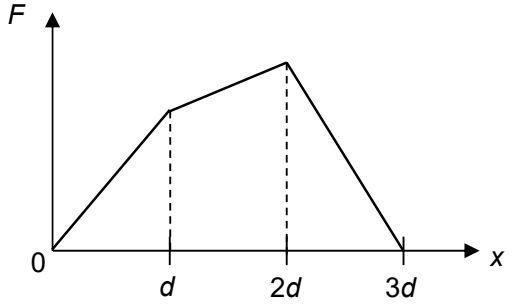

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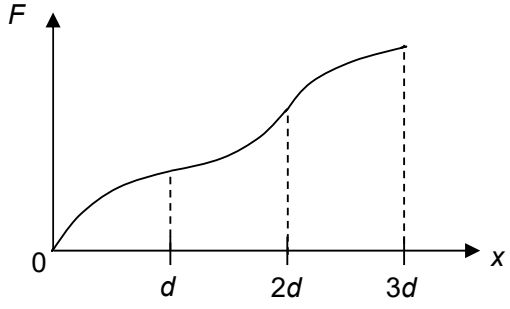
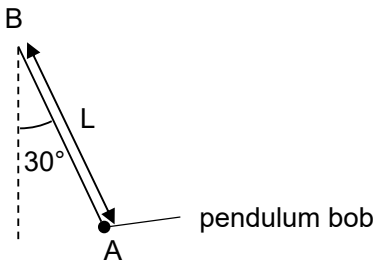


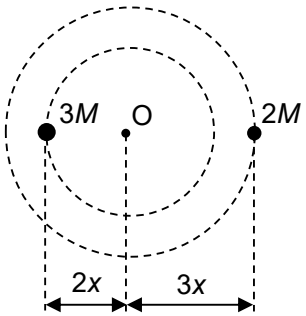
8 A pendulum bob of mass m is attached to a light inextensible string of length L that is fixed to point B. The pendulum bob is released from rest at point A.



What is the tension in the string when the pendulum bob is vertically below B?

A mg **B** 1.3 mg **C** 1.5 mg **D** 2.0 mg

9 Two stars of masses $3M$ and $2M$, orbit in circles about their common centre of mass O, with radii of $2x$ and $3x$ respectively.



What is the angular speed ω of rotation of the stars?

A $0.20\sqrt{\frac{GM}{x^3}}$ **B** $0.33\sqrt{\frac{GM}{x^3}}$ **C** $0.45\sqrt{\frac{GM}{x^3}}$ **D** $0.50\sqrt{\frac{GM}{x^3}}$

10 A satellite orbits a planet at a distance r from its centre. Its gravitational potential energy is –5.6 MJ.

Another identical satellite orbits the planet at a distance $2r$ from its centre.

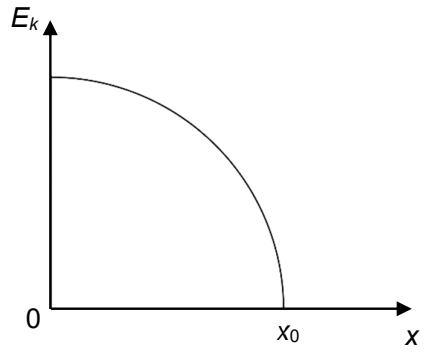
What is the sum of the kinetic energy and the gravitational potential energy of this second satellite?

A – 0.70 MJ **B** – 1.4 MJ **C** – 2.8 MJ **D** – 11.2 MJ

11 A mass undergoes simple harmonic motion with amplitude x_0.

Which graph shows the variation of the kinetic energy E_k of the mass with its displacement x?

A



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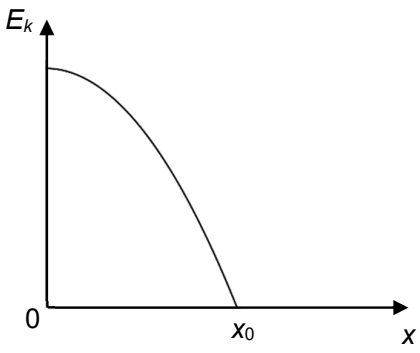

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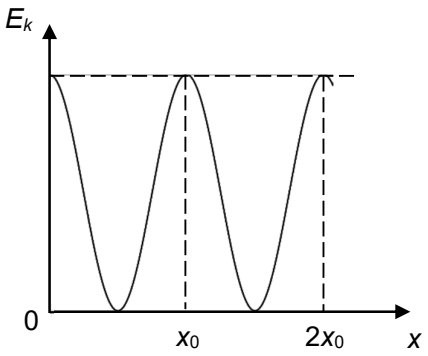

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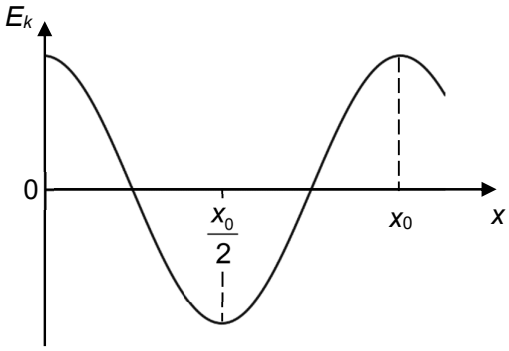
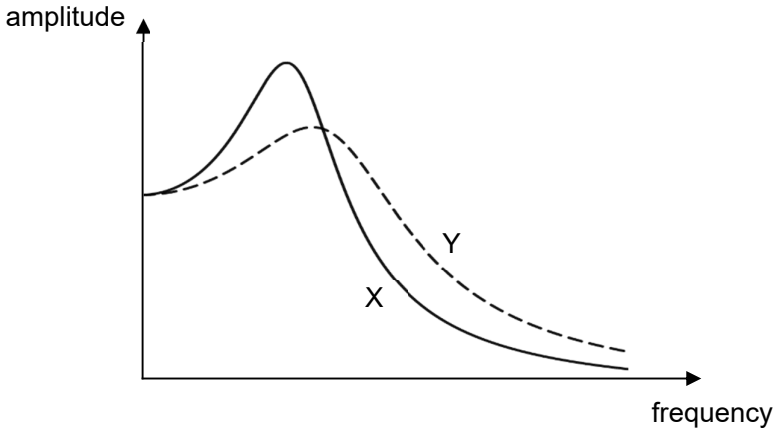


12 A spring-mass system is connected to a driving oscillator. The solid curve X on the graph shows how the amplitude of the spring-mass system varies with the frequency of the driving oscillator. A certain change in condition causes the response of the system to shift to the dashed curve Y.



What is the change in condition?

A The mass decreases.

B There is less damping.

C The amplitude of the driving oscillator increases.

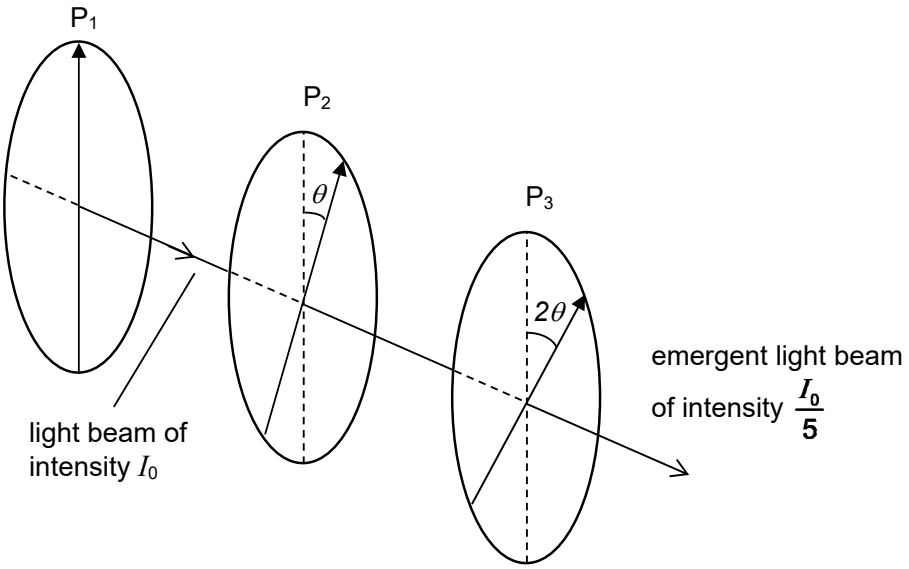
D The frequency of the driving oscillator decreases.

13 A point source of sound emits energy uniformly in all directions at a power P. At a distance r from the source, the air molecules oscillate with an amplitude of A.

If P is halved, what is the amplitude of oscillation of the air molecules at a distance $3r$ from the source?

A $0.056A$ **B** $0.17A$ **C** $0.24A$ **D** $4.2A$

14 A beam of light passes through three polaroids P_1, P_2 and P_3. The intensity of light is I_0 after passing through P_1.

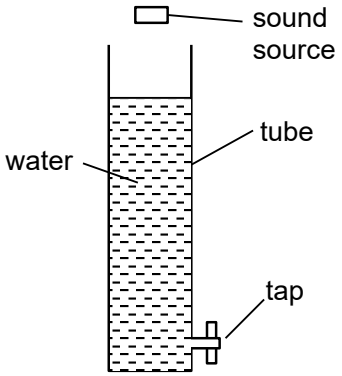


The polarising axes of P_1 and P_2 are at an angle θ to one another and the polarising axes of P_1 and P_3 are at an angle 2θ to one another. The emergent light beam has an intensity of $\frac{I_0}{5}$.

What is the value of θ?

A 30° **B** 32° **C** 48° **D** 63°

15 A vertical tube is completely filled with water. A small sound source of constant frequency is held directly above the top opening of the tube and water is run out from a tap at the bottom.



A number of resonance positions are detected. The third of these occurs when the water surface is 1.3 m below the top of the tube.

At which of the following distances will resonance **not** be detected?

A 0.26 m **B** 0.78 m **C** 0.87 m **D** 1.82 m