9478 H2 PHYSICS

JC 1 PROMO EXAM
PAST YEAR PAPERS 1

MEASUREMENTS

KINEMATICS

DYNAMICS

FORCES

WORK, ENERGY POWER

CIRCULAR MOTION

GRAVITATIONAL FIELD

OSCILLATIONS

TEMPERATURE & IDEAL GASES

FIRST LAW OF THERMODYNAMICS

WAVE MOTION

NANYANG JUNIOR COLLEGE
JC1 PHYSICS TEAM
SCIENCE DEPARTMENT
2025

H

NANYANG JUNIOR COLLEGE
JC 1 END-OF-YEAR EXAMINATION
Higher 2

CANDIDATE NAME	

CLASS		TUTOR'S NAME	

PHYSICS 9749/01

Paper 1 Multiple Choice **1 October 2024**

40 minutes

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class, Centre number and index number in the spaces at the top of this page.

There are **twenty** questions on this paper. Answer **all** 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 Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ 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	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\phi = -Gm / r$
temperature	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal 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	$R = R_1 + R_2 + \ ...$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ ...$
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	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 Which of the following is the best estimate of the weight of a basketball?

A 5000 mg

B 0.500 kg

C 5.0×10^{-6} MN

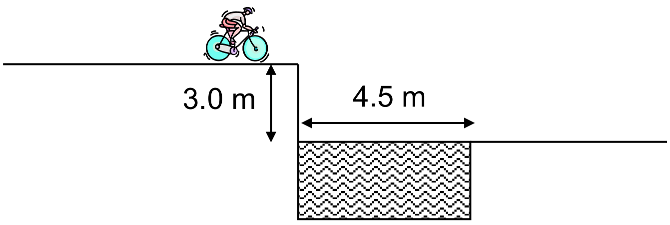
D 5.0×10^{11} nN

2 In an experiment, the external diameter d_1 and internal diameter d_2 of a glass tube are found to be 82 ± 2 mm and 53 ± 1 mm respectively.

What is the percentage uncertainty of the term $(d_1 - d_2)$?

A 0.7% **B** 3% **C** 4% **D** 10%

3 A cyclist moving horizontally takes off from a point 3.0 m above the river surface, landing 4.5 m away as shown.



cross-section of river channel

What was the speed at take-off?

A 3.1 m s^{-1} **B** 3.2 m s^{-1} **C** 5.8 m s^{-1} **D** 7.4 m s^{-1}

4 A trolley moves down a slope with a constant acceleration *a*. The mass of the trolley is now doubled and the trolley is allowed to move down the same slope. In both cases, effects of friction and air resistance are negligible.

Which statement is correct for the second experiment?

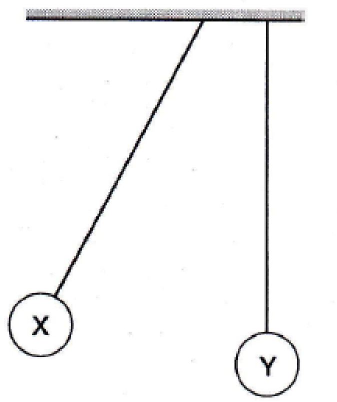
A The acceleration is $\frac{1}{2}a$.

B The acceleration is a.

C The acceleration is $2a$.

D The resultant force is the same.

5 Two steel balls X and Y are suspended on strings. Ball X is pulled to one side as shown.



After ball X is released, the balls collide.

Which quantities must be conserved in the collision?

A kinetic energy, total energy and momentum

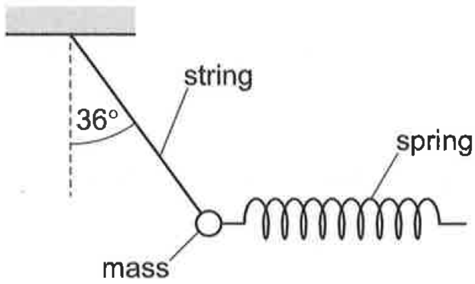
B kinetic energy and momentum only

C kinetic energy and total energy only

D total energy and momentum only

6 A mass is tied to the end of a string. The mass is pulled horizontally to one side by a spring of spring constant 25 N m^{-1}.

The mass is in equilibrium and the extension of the spring is 0.060 m. The string is at an angle of 36° to the vertical, as shown.



What is the weight of the mass?

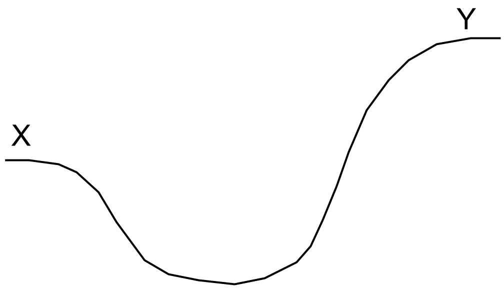
A 1.1 N **B** 1.5 N **C** 1.9 N **D** 2.1 N

7 As a gun fires a shot horizontally, a constant force F is exerted on the bullet of mass m over a time interval t. During this period, the bullet accelerates from rest to a speed v in the gun's barrel with an acceleration a. The length of the gun's barrel is L.

Which of the following gives the expression for the average power of the bullet in the described motion?

A Fv **B** $\frac{2maL}{t}$ **C** $\frac{mv^2}{2t}$ **D** $\frac{mv^2}{t}$

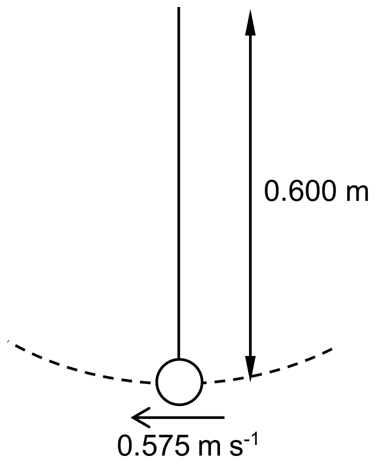
8 A body moves from X to Y along a track. At point Y, its kinetic energy is 25 kJ and its potential energy is 30 kJ more than that at point X.



If the work done against friction along XY is 10 kJ, what is the kinetic energy of the body at X?

A 35 kJ **B** 45 kJ **C** 55 kJ **D** 65 KJ

9 A pendulum bob of mass 1.27 kg is supported by a string so that the radius of its path is 0.600 m. It is moving with velocity 0.575 m s^{-1} horizontally at the lowest point of its motion when the string is vertical.



What is the tension in the string at this instant?

A 11.8 N **B** 12.5 N **C** 13.2 N **D** 13.7 N

10 An Earth satellite is moved from one stable circular orbit to another stable circular orbit at a greater distance from the Earth.

Which one of the following quantities increases for the satellite as a result of the change?

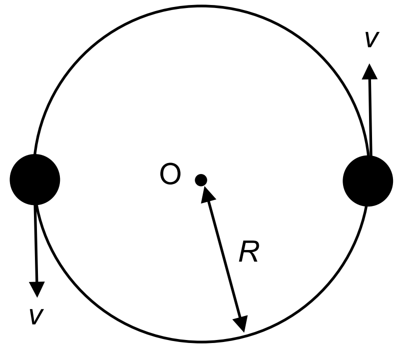
A Gravitational force

B Gravitational potential energy

C Angular velocity

D Tangential velocity

11 Two stars of equal mass M move with constant speed v in a circular orbit of radius R about their common centre of mass O as shown.



What is the magnitude of the centripetal force on each star?

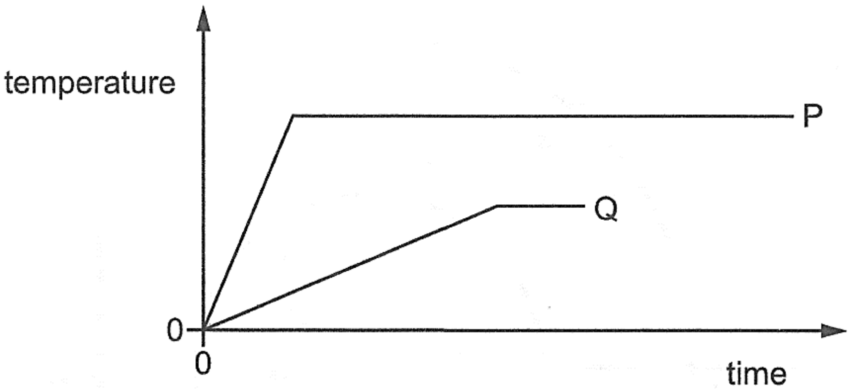
A $\dfrac{GM^2}{4R^2}$ **B** $\dfrac{GM^2}{R^2}$ **C** $\dfrac{2Mv^2}{R}$ **D** $\dfrac{Mv^2}{2R}$

12 A fixed mass of an ideal gas is at a pressure of 1.0×10^5 Pa. It has a temperature of 300 K and a volume of 0.010 m^3.

What is the total kinetic energy of the gas molecules after the volume is changed to 0.0050 m^3 at constant temperature?

A 500 J **B** 1000 J **C** 1500 J **D** 2000 J

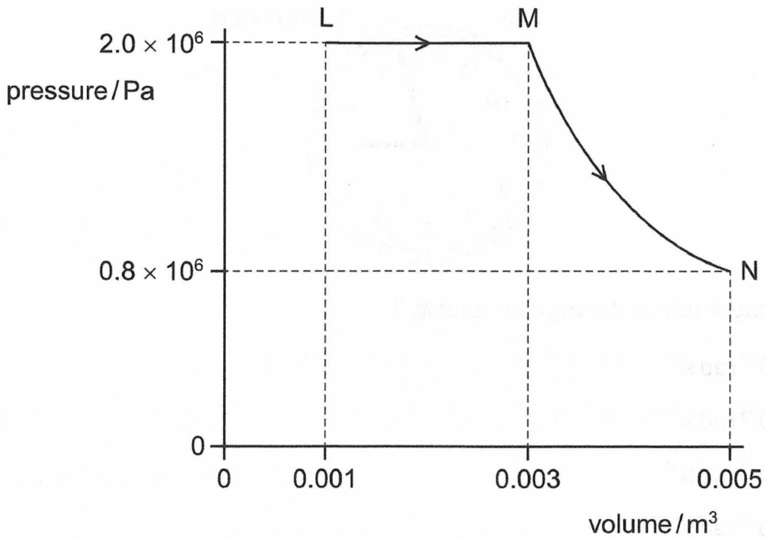
13 Thermal energy is supplied at the same rate to equal masses of two different solids, P and Q. The graphs show how the temperatures of the solids change with time. Each line finishes when the solid it represents has completely changed to liquid.



How do the values for the specific heat capacities and specific latent heat of fusion compare with each other?

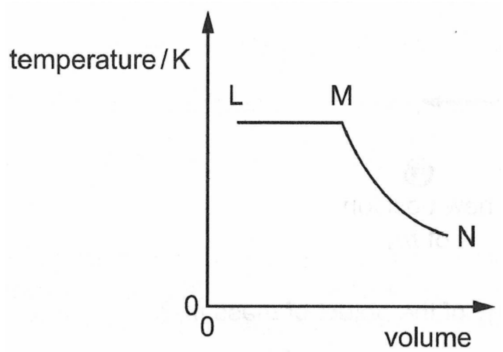
	specific heat capacity of P	specific latent heat of fusion of P
A	smaller than Q	larger than Q
B	smaller than Q	smaller than Q
C	larger than Q	larger than Q
D	larger than Q	smaller than Q

14 A fixed mass of ideal gas undergoes changes of pressure and volume starting at L, as shown.

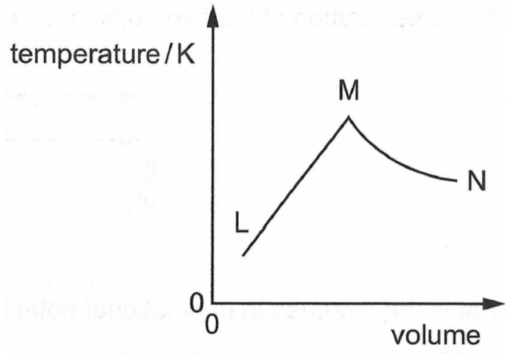


Which graph shows how temperature (measured in kelvin) changes with volume?

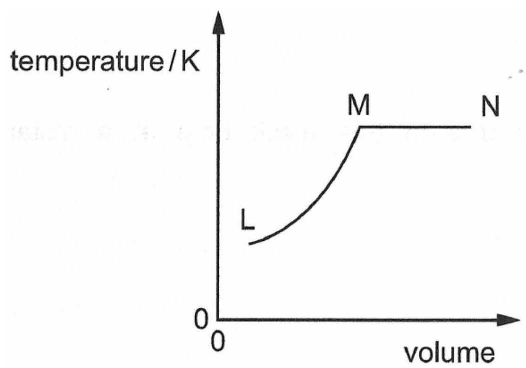
A



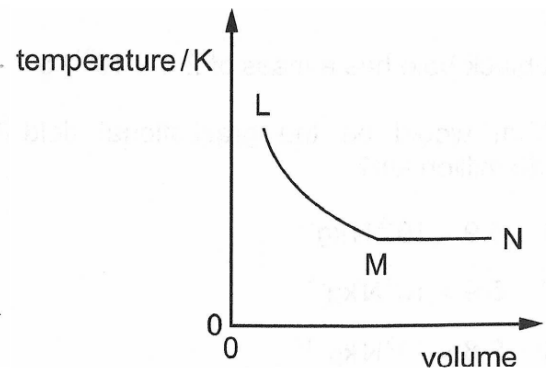
B



C



D



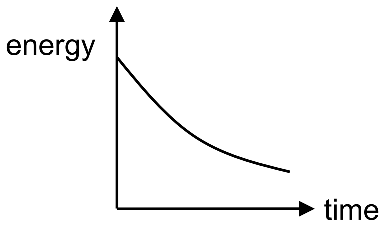
15 An object placed on a horizontal platform is vibrating vertically in simple harmonic motion with a frequency of 1.9 Hz.

What is the amplitude of oscillation which will allow the object to just lose contact with the platform throughout the motion?

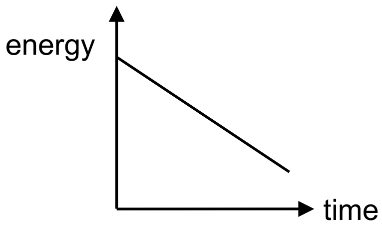
A 2.5 cm **B** 5.1 cm **C** 6.9 cm **D** 8.2 cm

16 Which of the following graphs shows the variation with time of the total energy of an object subjected to light damping?

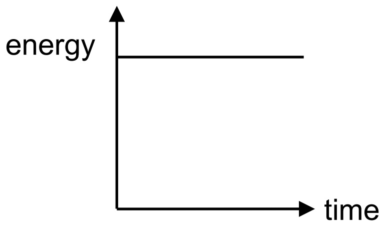
A



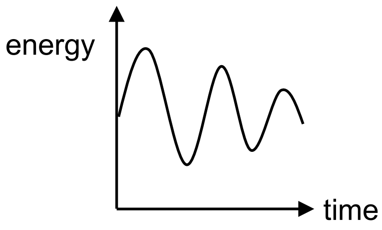
B



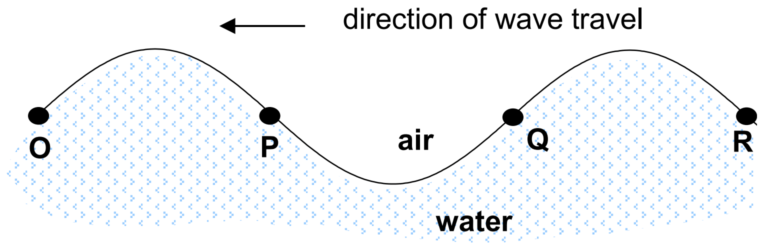
C



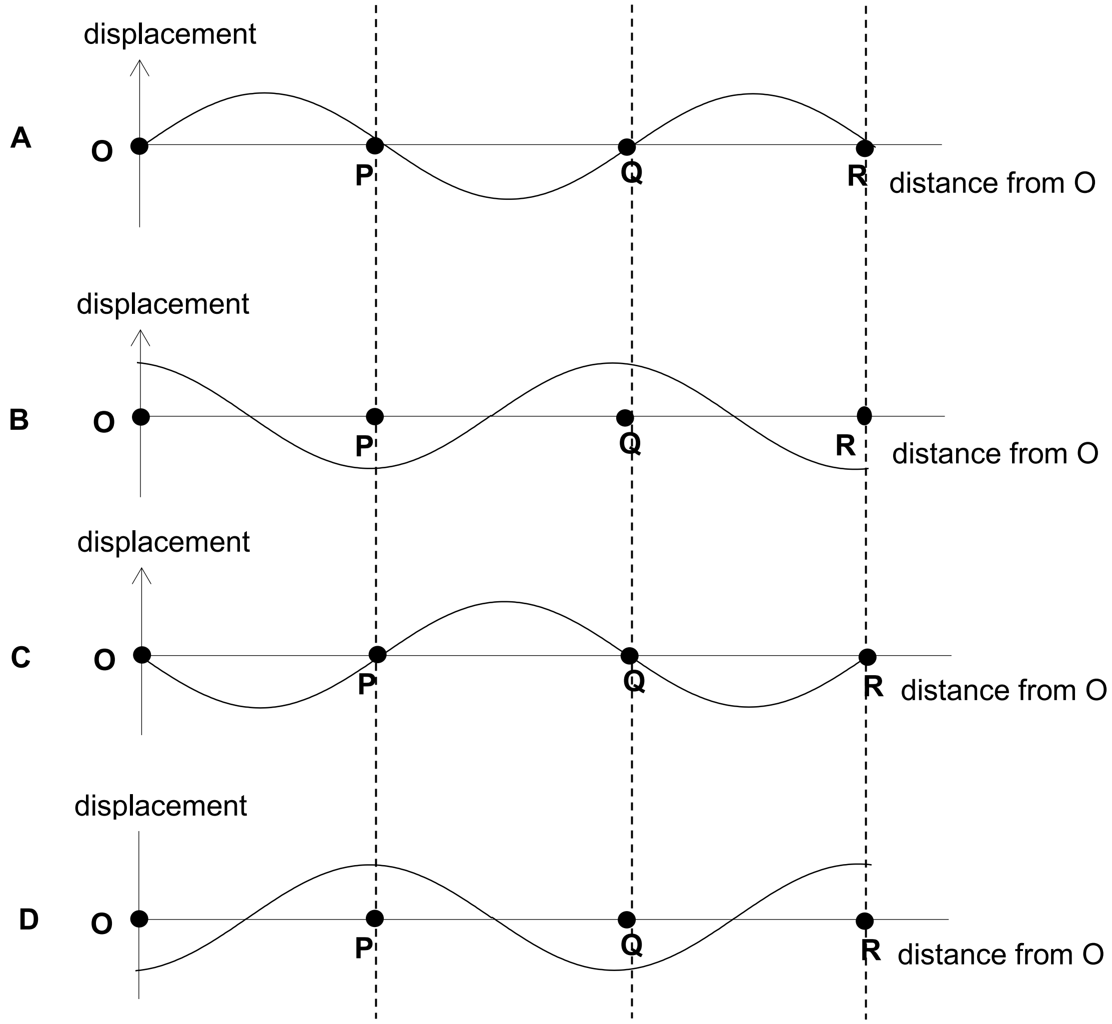
D



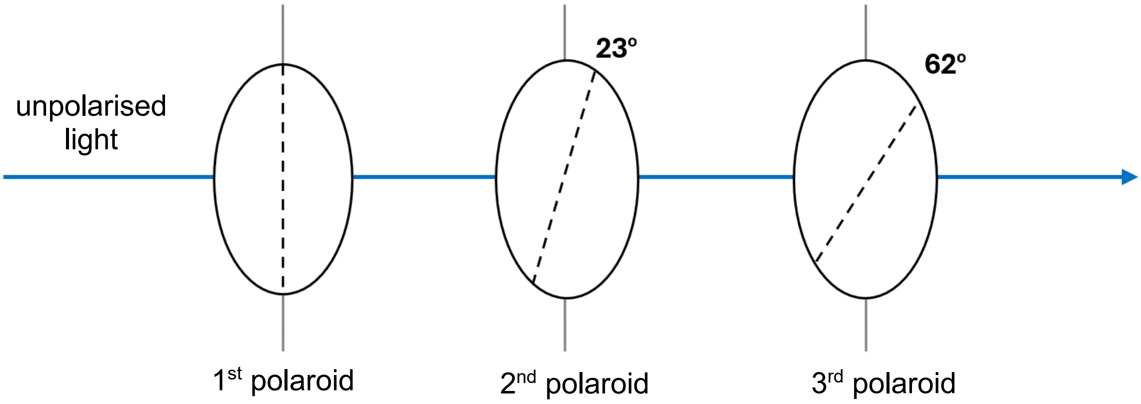
17 The wave profile of a surface wave on water at a particular instant is shown in the diagram below.



Which one of the graphs below best represents the wave profile a quarter period later, taking upward displacement as positive?



18 Light is polarised when it passes through a sheet material known as a polaroid. Three polaroids are stacked, with the polarising axis of the second and third polaroids at 23° and 62° respectively to that of the first polaroid, as shown in the diagram below.

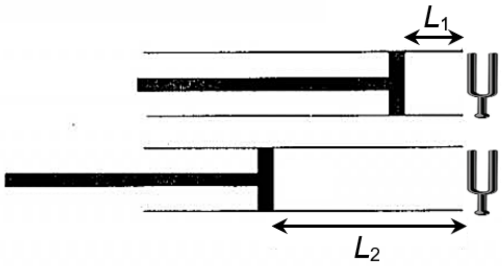


When an unpolarised light is incident on the stack of polaroids, its amplitude after passing through the first polaroid is A_1, and becomes A_2 after it passes through the second polaroid, and subsequently A_3 after it passes through the third polaroid.

What is the value of $\frac{A_3}{A_1}$?

A 0.25 **B** 0.31 **C** 0.43 **D** 0.72

19 A tuning fork of frequency f is held near the open end of a tube which is closed at the other end.



The length of the tube is adjusted until resonance occurs. The two shortest lengths of the tube that produce resonance are L_1 and L_2, where $L_1 < L_2$.

Which of the following expressions represents the speed of the sound?

A $\frac{1}{2}f(L_2 - L_1)$ **B** $f(L_2 - L_1)$ **C** $2f(L_2 - L_1)$ **D** $2f(L_2 + L_1)$

20 A space shuttle orbits at a height of 330 km above the surface of the Earth. It carries two light sources separated by a distance of 24 m. The light sources emit light of wavelength 500 nm towards an observer on the Earth's surface.

The observer views the light sources with a telescope that has an aperture diameter of 85 mm. Assuming that the light sources can be treated as point sources of light for the observer.

Which of the following is correct?

	Will the two light sources seen by the observer be resolved?	Angular separation of two light sources as measured from aperture / rad
A	Yes	5.9×10^{-6}
B	Yes	7.3×10^{-5}
C	No	5.9×10^{-6}
D	No	7.3×10^{-5}

End of Paper

NANYANG JUNIOR COLLEGE
JC 1 END-OF-YEAR EXAMINATION
Higher 2

CANDIDATE NAME

CLASS

TUTOR'S NAME

PHYSICS 9749/02

Paper 2 Structured Questions

1 October 2024

1 hour 50 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class, Centre number and index number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 7
2	/ 6
3	/ 6
4	/ 11
5	/ 9
6	/ 7
7	/ 6
8	/ 10
9	/ 12
Total	/ 74

This document consists of **20** printed pages.

Data

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radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{\ln 2}{t_{\frac{1}{2}}}$

Question 1 continues on the next page

1 Fig. 1.1 shows the cross section of a smooth long ramp inclined at 20° to the horizontal. P and Q are 50.0 cm apart. A ball at point P moves up the ramp with a speed of 30.0 cm s^{-1}.

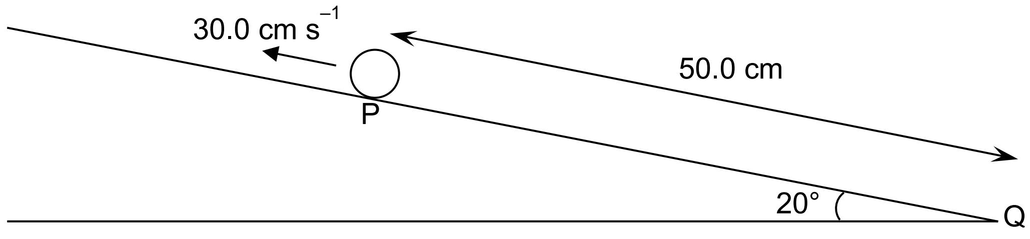


Fig. 1.1

(a) (i) Using Newton's second law of motion, show that the deceleration of the ball is 3.4 m s^{-2}.

[1]

(ii) Calculate the time taken for the ball to reach point Q at the bottom of the ramp.

time taken = ... s [2]

(b) The ball at point P is now given an initial velocity of 60.0 cm s^{-1} *in the plane of the slope*. The initial velocity is in a direction 30° to PS as shown in Fig. 1.2a. This causes the ball to travel upslope and then downslope without leaving the ramp, as shown in the side view in Fig. 1.2b.

PS is parallel to QR and perpendicular to PQ. The ball reaches the bottom of the ramp at point R.

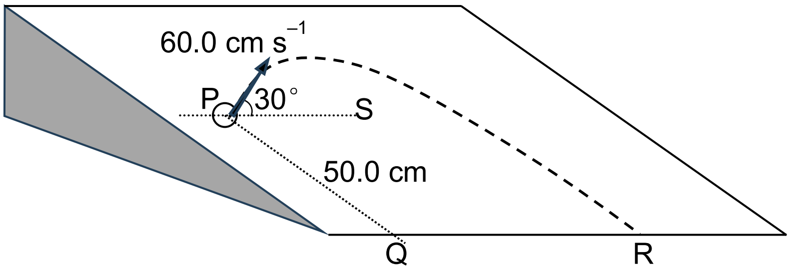


Fig. 1.2a (3-D view)

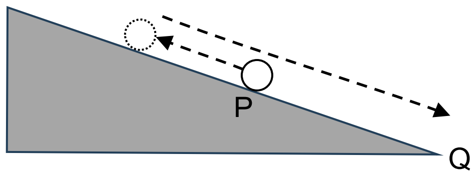


Fig. 1.2b (2-D side view)

(i) Explain why the path of the ball is parabolic.

....

....

....

....[2]

(ii) Calculate the distance QR.

distance QR = ... m [2]

[Total: 7]

2 **(a)** Explain what is meant by *upthrust*.

....

....

....[1]

(b) Before a small balloon is inflated, its mass recorded on an electronic mass balance is 1.30 g. The balloon is inflated with air and becomes spherical in shape with a diameter of 22.0 cm.

(i) The density of air is 1.21 kg m^{-3}. Determine the mass of air displaced by the balloon.

mass of air displaced = ... g [2]

(ii) The inflated balloon gives reading of 1.55 g when placed on the balance. Calculate the mass of air in the balloon.

mass of air in balloon = ... g [2]

(iii) Explain why the value in **(b)(ii)** is larger than the value in **(b)(i).**

....

....

....[1]

[Total: 6]

3 Fig. 3.1 shows a horizontal table where surface TU is smooth and UV is rough. Block A, with a mass of 1.5 kg, is at rest. An inextensible string attached to block A passes over a smooth pulley and supports block B of mass 0.50 kg at its other end.

Block B is released from rest and block A just reaches point U as block B hits the floor.

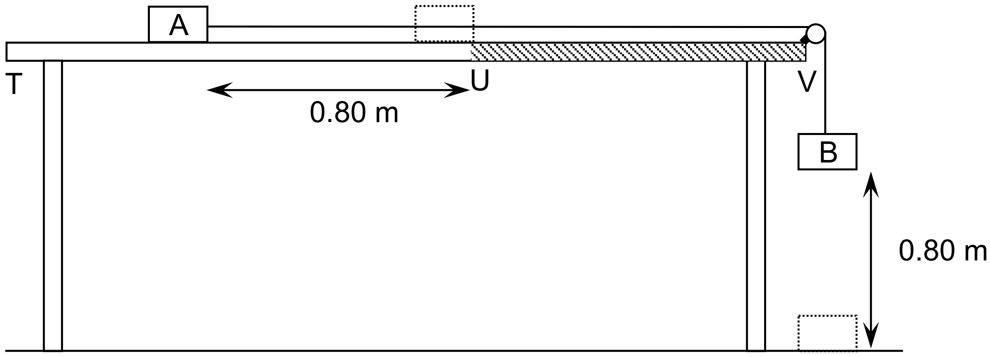


Fig. 3.1

(a) Using energy considerations, show the maximum kinetic energy of block A is 2.9 J.

[2]

(b) Block A continues to slide along the rough surface from U to V until it comes to rest in 0.60 s. Assuming that the frictional force on block A by the rough table is constant, determine the distance moved by block A in the 0.60 s.

distance moved = ... m [3]

(c) State and explain how your answer to **(b)(i)** will change if the mass of the pulley is not negligible.

....

....

....[2]

[Total: 6]

4 The Earth and the Moon may be considered to be spheres that are isolated in space with their masses concentrated at their centres.

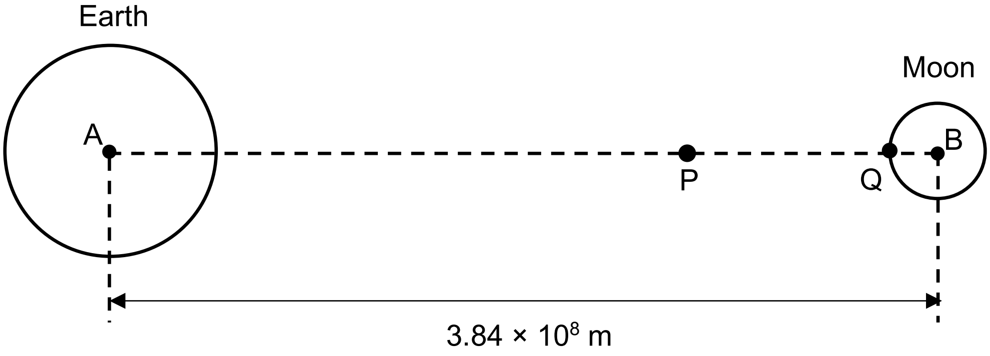


Fig. 4.1

Fig. 4.2 provides some astronomical data for the Earth and the Moon.

Mass of the Earth	5.98×10^{24} kg
Mass of the Moon	7.35×10^{22} kg
Radius of the Earth	6.38×10^{6} m
Radius of the Moon	1.74×10^{6} m
Distance from the centre of Earth to the centre of Moon	3.84×10^{8} m

Fig. 4.2

(a) Define *gravitational potential* at a point.

....

....

....[2]

(b) Show that the resultant gravitational potential at point Q on the surface of the Moon due to both the Earth and the Moon is -3.86×10^{6} J kg^{-1}.

[2]

(c) The table in Fig. 4.3 shows the values of the gravitational potential along the line AB. The distances are measured from the surface of the Earth.

Distance from surface of Earth / 10^8 m	Gravitational potential / 10^6 J kg^{-1}	Remarks
0.00	-62.5	At the surface of the Earth
1.99	-1.97	[redacted]
2.00	-1.96	Point P
2.01	-1.95	[redacted]
3.40	-1.28	Neutral point (zero resultant gravitational force)
3.76	-3.86	Point Q on the surface of the Moon

Fig. 4.3

(i) Using data from Fig. 4.3, estimate the magnitude of the gravitational field strength at point P, at a distance of 2.00×10^8 m from the surface of the Earth.

magnitude of gravitational field strength = ... N kg^{-1} [2]

(ii) Using your answer in **(c)(i)**, calculate the linear speed of an object which is in circular orbit around the Earth at point P.

speed = ... m s^{-1} [2]

(d) An object is projected from the Earth to the Moon.

Using the data in Fig. 4.3 and ignoring any energy losses due to air resistance, estimate the minimum kinetic energy with which this object of mass 10.0 kg would need to be projected in order to reach the surface of the Moon. Explain your working.

minimum kinetic energy = ... J [3]

[Total: 11]

5 **(a)** State what is meant by the internal energy of a system.

....

....

....[2]

(b) A balloon contains a fixed mass of air that expands on heating, as illustrated in Fig. 5.1.

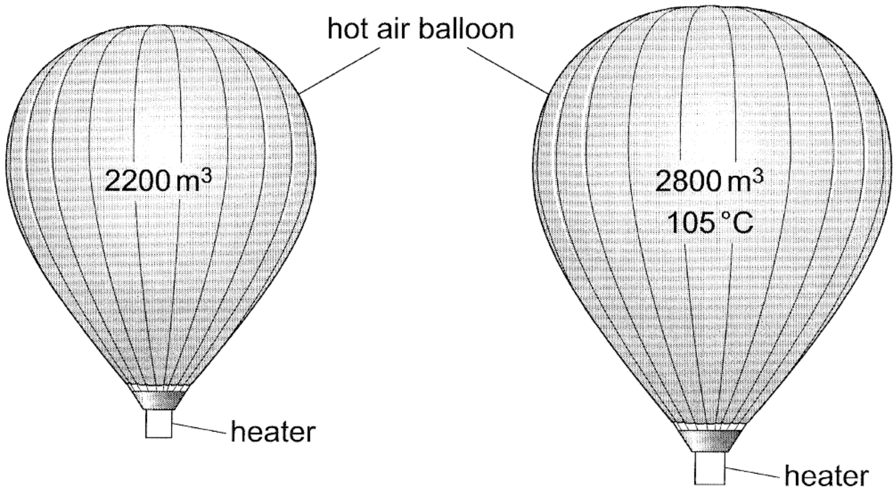


Fig. 5.1

The air is heated to a final temperature of 105 °C and the balloon expands at atmospheric pressure from 2200 m^3 to 2800 m^3, when it is fully inflated.

The air inside the balloon may be assumed to be an ideal gas.

Atmospheric pressure is 1.01×10^5 Pa.

(i) Calculate the work done by the expanding balloon on the atmosphere.

work done = ... J [1]

(ii) Explain, using simple kinetic model, why the internal energy of the air in the balloon increases as the balloon expands.

....

....

....

....[2]

(iii) The propane used in the heater produces 50 MJ of thermal energy for each kilogram of fuel that is burned. The air inside the balloon gains 116 MJ of internal energy during the expansion.

Calculate the minimum mass of propane which must be burned to fully inflate the balloon.

mass = ... kg [2]

(iv) Calculate the initial temperature, in °C, of the air.

temperature = ... °C [2]

[Total: 9]

6 A spring stretches when a mass is attached to its lower end. The spring is then stretched a further distance of 4.0 cm from the equilibrium position, and the mass is released, performing a simple harmonic motion of period 0.44 s.

The variation with time of the vertical displacement of the mass is shown in Fig. 6.1.

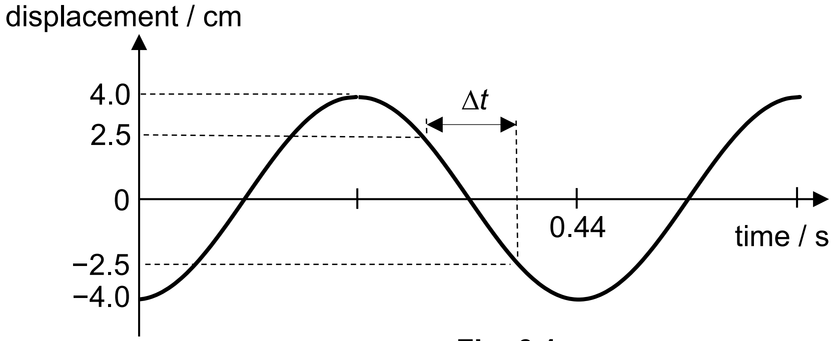


Fig. 6.1

(a) State what is meant by *simple harmonic motion*.

....

....

....[2]

(b) Determine the shortest time taken for the mass to move from x = +2.5 cm to x = −2.5 cm, labelled Δt on Fig. 6.1.

time = ... s [3]

(c) On the axes of Fig. 6.2, sketch the variation with time of kinetic energy of the mass for the first period T.

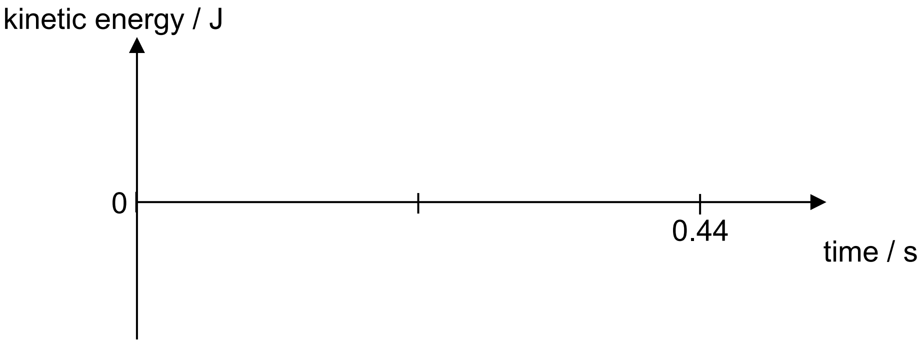


Fig. 6.2 [2]

[Total: 7]

7 **(a)** The figure below shows the variation with time t of p, the excess pressure at a point in a progressive sound wave in air. The speed of the wave is 340 m s^{-1}.

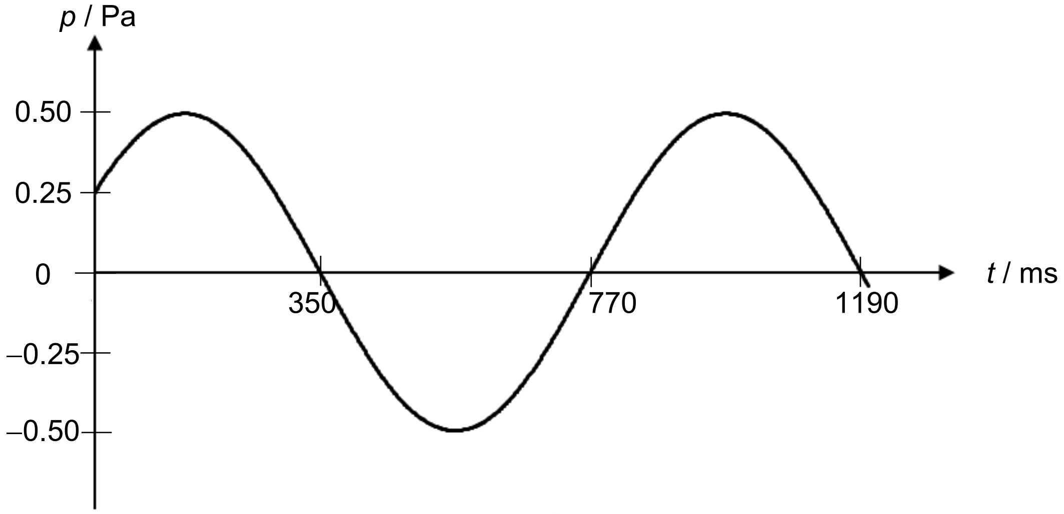


Fig. 7.1

(i) On Fig. 7.1, mark with a letter C a time at which a compression occurs. [1]

(ii) Explain your answer to **(a)(i)** in molecular terms**.**

....

....[1]

(iii) Using Fig. 7.1 to determine the wavelength of the wave.

wavelength = ... m [2]

(b) The intensity of a wave is defined as the rate of transfer of energy per unit area normal to the direction of propagation of the wave. At a distance of 10 m from a point source of waves, the amplitude of a wave is 1.6 mm and its intensity is 4.4×10^{-3} W m^{-2}. At a distance 5.0 m from the source, determine the amplitude of the wave.

amplitude = ... m [2]

[Total: 6]

8 A laser light of wavelength 633 nm is incident on a single slit of width *b*. A diffraction pattern is formed on a vertical screen 4.2 m away from the single slit.

A photograph of the single slit diffraction pattern is shown in Fig. 8.1.

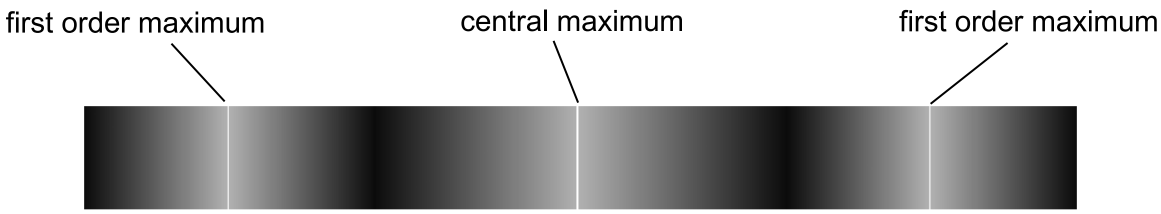


Fig. 8.1 (drawn to scale)

(a) (i) With reference to the positions of the maxima in Fig. 8.1, show that the separation between the central maximum and the *first order minimum* is 3.1 cm.

[1]

(ii) Determine *b*.

b = ... m [2]

(b) A second identical single slit is then placed beside the first slit such that the slit separation between the two slits is 0.320 mm as shown in Fig. 8.2. An interference pattern is then observed.

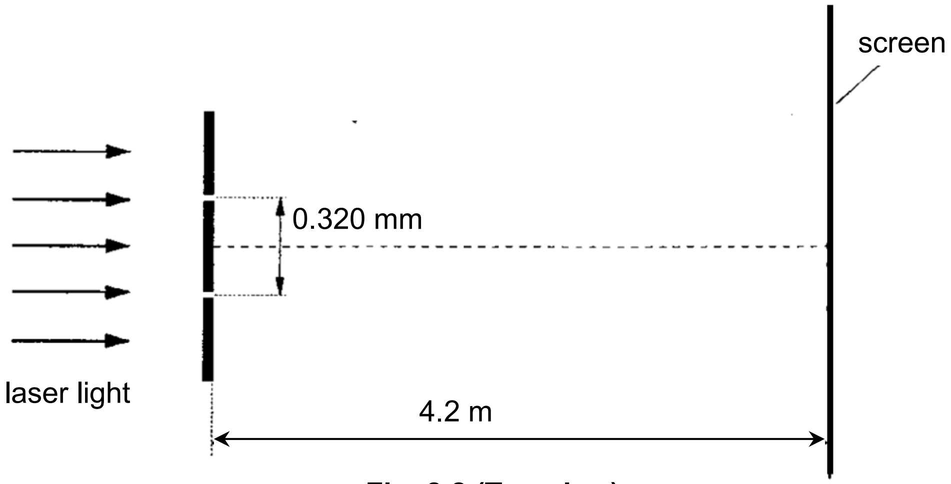


Fig. 8.2 (Top view)

(i) Explain why an interference pattern is observed on the screen.

....

....

....

....

....

....[3]

(ii) Calculate the fringe separation of the interference pattern.

fringe separation = ... m [2]

(iii) In an attempt to produce brighter fringes, the width of both slits is widened, keeping their separation constant. Fringes are no longer observed. Suggest why the fringes are no longer observed.

....

....

....

....[2]

[Total: 10]

9 When a structural engineer is designing a building there will be occasion when a beam must be used to bridge a gap. The width of the gap is called the span. The engineer makes calculations to ensure that there is not too much sag in the beam. Generally, a beam should not be allowed to sag beyond 1/360 of the gap it is spanning.

Sometimes, when the loading is small, a plain wooden beam is sufficient, as shown in Fig. 9.1.

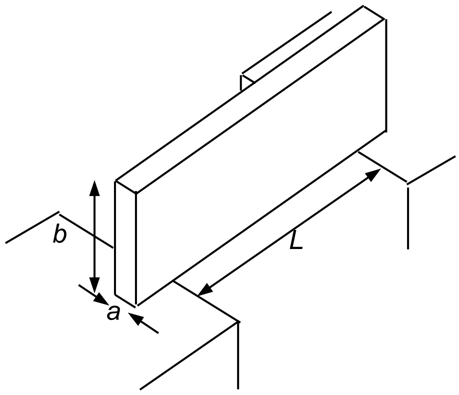


Fig. 9.1

A wooden beam, loaded at its centre, will undergo a depression x given by the expression

$$x = \frac{WL^3}{kab^3},$$

where W is the total load,
L is the span,
a is the width of the wooden beam,
b is the depth of the wooden beam and
k is a constant.

However, when greater loads or greater spans are required, a steel beam may be used. To minimize the amount of steel required, the shape of the beam used is as shown in Fig. 9.2.

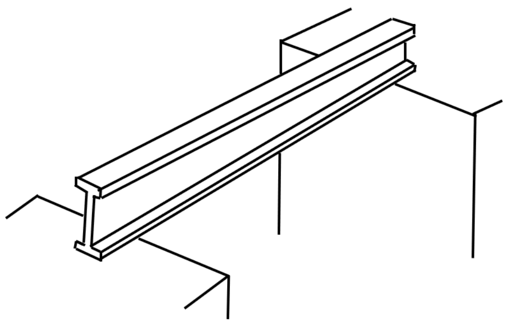


Fig. 9.2

The distribution of the load on a steel beam can be uneven, as shown in Fig. 9.3, where the moments of the forces must be calculated to ensure the sag does not exceed the acceptable allowance.

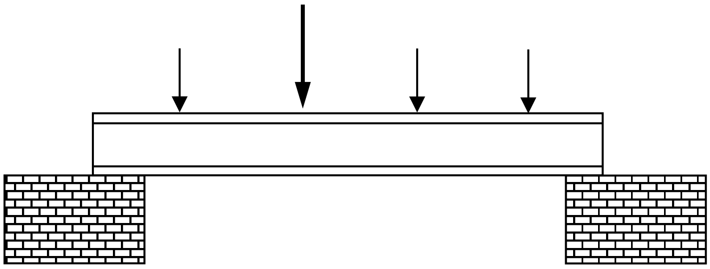


Fig. 9.3

The loading of the steel beam can also be uniform along its length, as shown in Fig. 9.4.

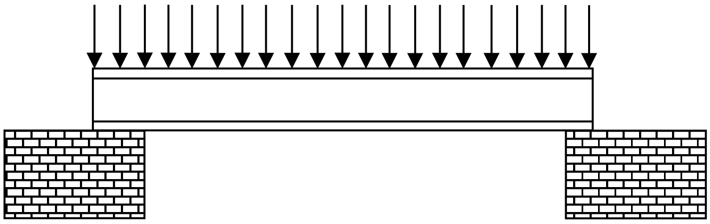


Fig. 9.4

The bending moment B for this uniform loading pattern on a steel beam is given by the expression

$$B = \frac{WL}{8},$$

and the depression x at the centre of the steel beam is given by the expression

$$x = \frac{BL^3}{c},$$

where c is a constant with a value of 3.35×10^8 N m^3.

One measure of the strength of a steel beam is its allowable bending stress. Two dimensionless constants P and Q are determined from the dimensions of the beam and the gap it is spanning. The allowable bending stress is then determined using a table of values shown in Fig. 9.5. For example, when P = 15 and Q = 160, the allowable bending stress is 111 MPa.

allowable bending stress / MPa					
		P			
		15	20	25	30
Q	160	111	96	88	82
	170	106	93	83	77
	180	102	89	80	73

Fig. 9.5

The final check on the suitability of the steel beam is to calculate the ratio between the bending moment *B* it is subjected to and its allowable bending stress. The beam is safe to use if the ratio is less than 2.0×10^{-4} m^3.

(a) (i) An engineer is given a choice of two wooden beams, D and E, to span across a gap. Their cross sections are being shown in Fig. 9.6. The cross-sectional area of the wooden beams are equal.

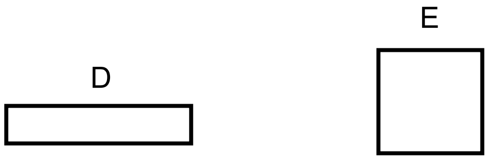


Fig. 9.6

Given that the beams are used in the orientation shown in Fig. 9.6, with reference to the equation given for depression *x*, suggest and explain which beam would sag more.

....

....

....

....

....

....[3]

(ii) Wooden beam D has width 0.50 m, depth 0.10 m and spans 3.0 m.

Calculate the maximum load it can support at its centre for a maximum depression x = 0.010 m. Take k to be 3.6×10^{10} Pa for this wood.

maximum load = ... N [1]

(b) A steel beam across a gap is shown in Fig. 9.7, together with values of the forces acting and their distances from point X.

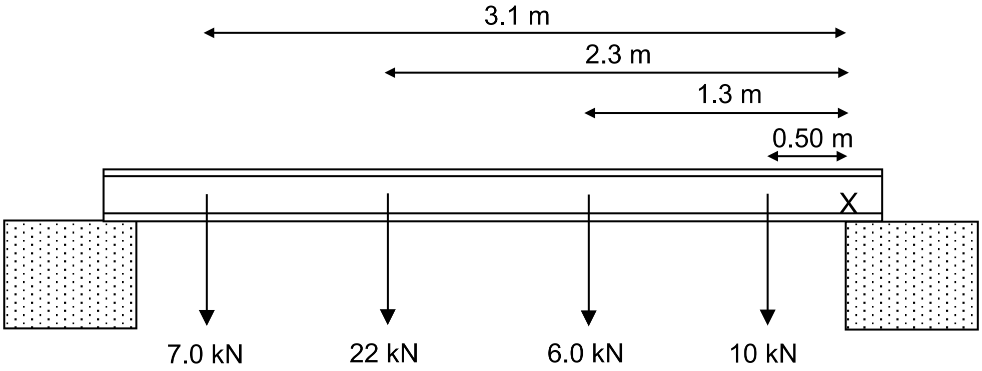


Fig. 9.7

Determine the net moment about point X.

moment = ... N m [2]

(c) A uniformly loaded steel beam is used to carry a total load of 33 000 N and span a gap of 4.20 m.

(i) Calculate the bending moment B of the steel beam.

B = ... N m [1]

(ii) Calculate the depression x at the centre of the steel beam.

x = ... m [1]

(iii) Given that P = 21 and Q = 170 for the dimensions of this steel beam and span of the gap, estimate the allowable bending stress.

allowable bending stress = ... MPa [2]

(iv) Determine whether this steel beam is safe under these conditions.

....

....[2]

[Total: 12]

End of Paper

NANYANG JUNIOR COLLEGE
JC 1 END-OF-YEAR EXAMINATION
Higher 2

CANDIDATE NAME			
CLASS		TUTOR'S NAME	

PHYSICS **9749/01**

Paper 1 Multiple Choice **27 September 2023**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class, Centre number and index number in the spaces at the top of this page.

There are **thirty** questions on this paper. Answer **all** 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 Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **14** printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ 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	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -Gm / r$
temperature	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal 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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 What could **not** be a measurement of a physical quantity?

A 10 K **B** 11 J $N^{-1}m^{-1}$ **C** 17 Pa m^3 N^{-1} **D** 25 Tm

2 A cyclist has a speed of 5 m s^{-1} and a small car has a speed of 12 m s^{-1}.

Which statement does **not** give a reasonable estimate?

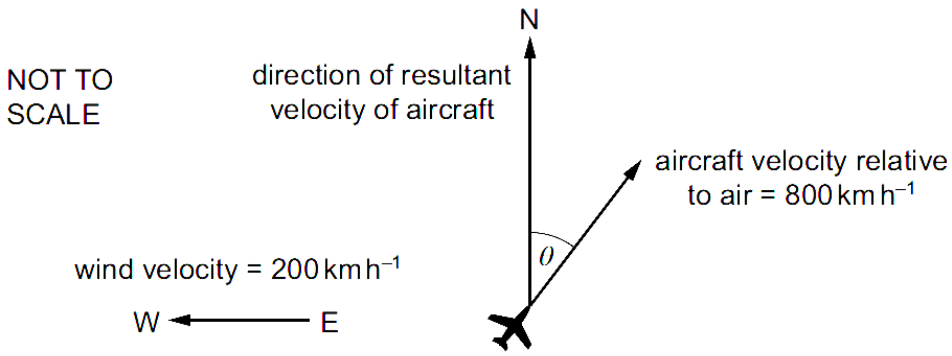
A The kinetic energy of the cyclist is 1×10^3 J.

B The kinetic energy of the car is 7×10^4 J.

C The momentum of the cyclist is 4×10^2 kg m s^{-1}.

D The momentum of the car is 2×10^5 kg m s^{-1}.

3 An aircraft heads in a direction at an angle θ east of north with a horizontal velocity relative to the air of 800 km h^{-1}. The wind blows with a horizontal velocity of 200 km h^{-1} from east to west, as shown.

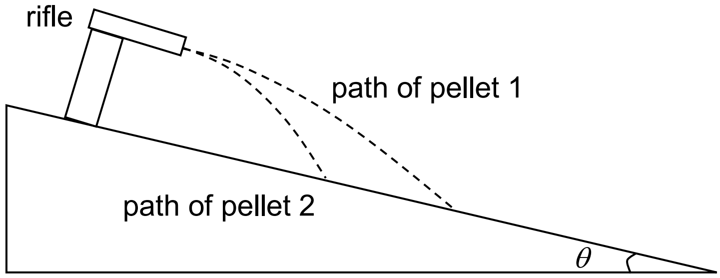


The resultant velocity of the aircraft is in a direction due north.

What is angle θ and what is the magnitude of the resultant velocity?

	θ / °	resultant velocity / km h^{-1}
A	14	770
B	14	820
C	76	770
D	76	820

4 Two identical pellets are projected simultaneously from a rifle, parallel to an inclined plane. Pellet 1 is projected at a higher initial speed that pellet 2.



Which of the following statements is correct if air resistance is neglected?

A Pellet 1 will hit the inclined plane first.

B Pellet 2 will hit the inclined plane first.

C Both pellets will hit the inclined plane at the same time.

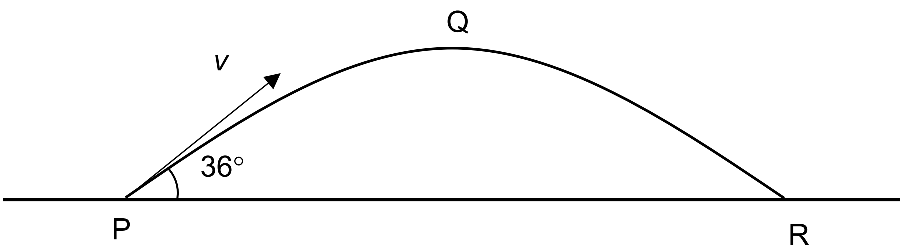
D There is insufficient information to determine which pellet will hit the inclined plane first.

5 A hot air balloon ascends at a constant speed of 4.0 m s^{-1} at an angle 70° to the horizontal. At a height of 100 m above the ground, a ball is released from the hot air balloon.

What is the time taken for the ball to hit the ground?

A 3.4 s **B** 4.1 s **C** 4.7 s **D** 4.9 s

6 A projectile is fired with velocity v from the point P as shown below. The projectile passes point Q at the top of its trajectory and lands at point R. Air resistance is negligible.

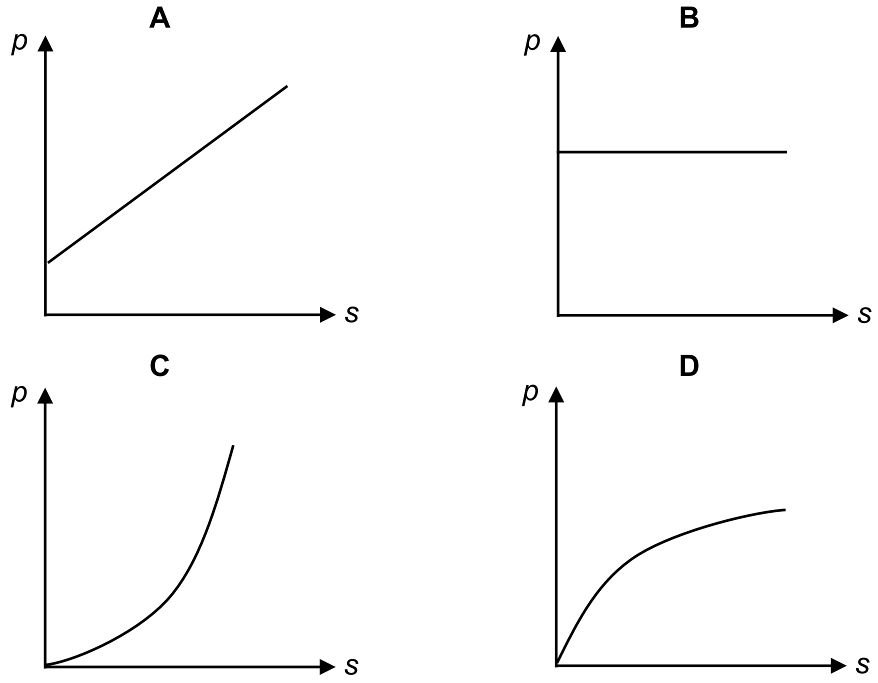


What is the magnitude of the change in velocity between Q and just before landing at R?

A 0.35v **B** 0.59v **C** 1.2v **D** 1.9v

7 A railway trolley starts from rest and is driven along a straight horizontal track by a motor which exerts a constant force. The effects due to resistive forces are negligible.

Which of the graphs below best represents the variation of the momentum *p* with distance travelled *s*?



8 A soccer ball hits the window, smashing a window pane into pieces. Which one of the following statements is true?

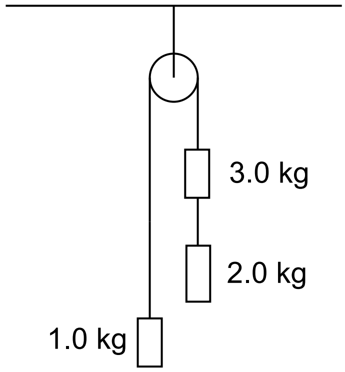
A The force of the ball on the window pane is greater than the force of the window pane on the ball.

B The force of the ball on the window pane is the same as the force of the window pane on the ball.

C The force of the ball on the window pane is less than the force of the window pane on the ball.

D The net force on the window pane is zero.

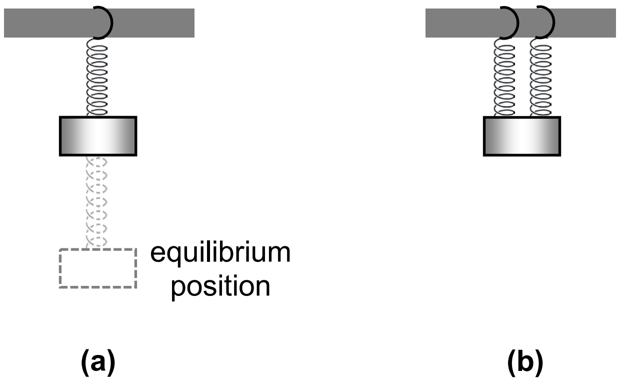
9 A light inextensible string is wound, as shown, over a frictionless, light pulley.



What is the tension in the string between the 2.0 kg and the 3.0 kg masses when the system is released from rest?

A 6.5 N **B** 16 N **C** 20 N **D** 39 N

10 A mass of weight W is attached to a vertical light spring as shown.

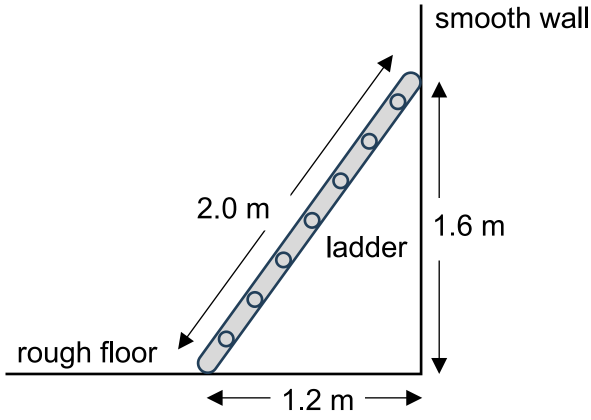


In the equilibrium position of the mass-spring system as shown in **(a)**, the force in the spring is F and the energy stored in the spring is U.

Another spring identical to the first is attached to the mass in parallel to the first as shown in **(b)**. What is the total force and the energy stored in the springs in the equilibrium position of this mass-spring system?

	total force	total energy
A	$F/2$	U
B	F	$U/2$
C	F	$U/4$
D	$2F$	U

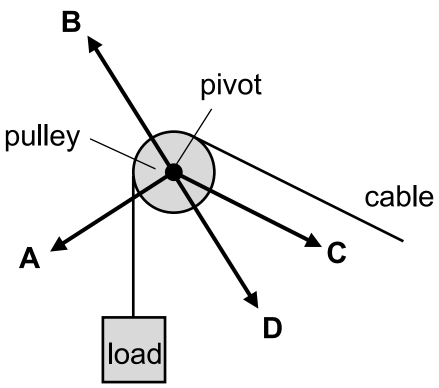
11 A 2.0 m ladder of weight 56 N rests on a rough floor against a smooth wall, as shown below.



What is the magnitude of the force exerted by the wall on the ladder?

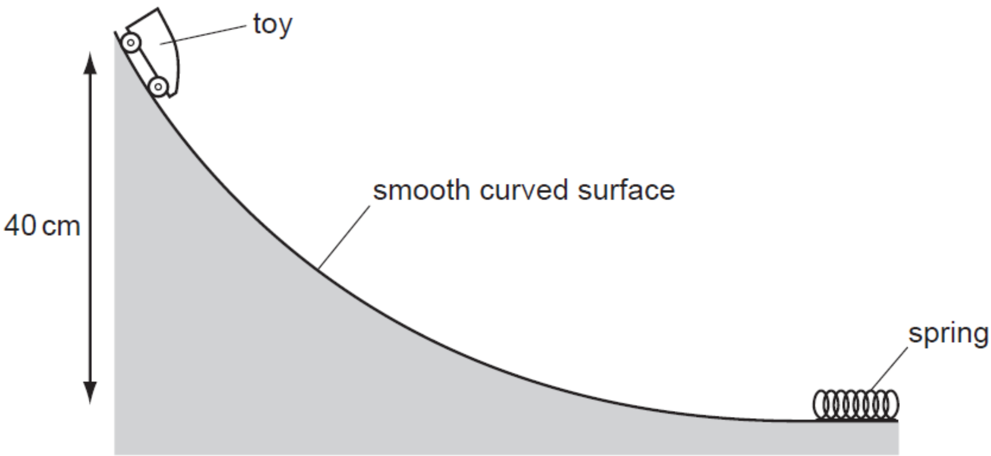
A 21 N **B** 28 N **C** 42 N **D** 60 N

12 A fixed smooth light pulley and light cable are used to slowly lift a load, as shown below.



Which of the arrows best shows the direction of the force on the pivot of the pulley?

13 A toy is released from rest on a smooth curved surface.



The toy, of mass 0.22 kg, runs down the curved surface through a vertical distance of 0.40 m. It strikes a spring of force constant 350 N m^{-1} and compresses it a distance x before coming to rest.

Assuming no energy losses, what is the value of x?

A 4.9×10^{-3} m **B** 7.2×10^{-3} m **C** 2.2×10^{-2} m **D** 7.0×10^{-2} m

14 A car of mass 1000 kg is moving at 25 m s^{-1}. The brakes are applied, causing the car to stop.

The car has four brakes, each consisting of a 3.0 kg metal disc that rubs against a wheel. The specific heat capacity of the metal from which the discs are made is 400 J kg^{-1} K^{-1}.

What is the maximum rise in the temperature of the brakes?

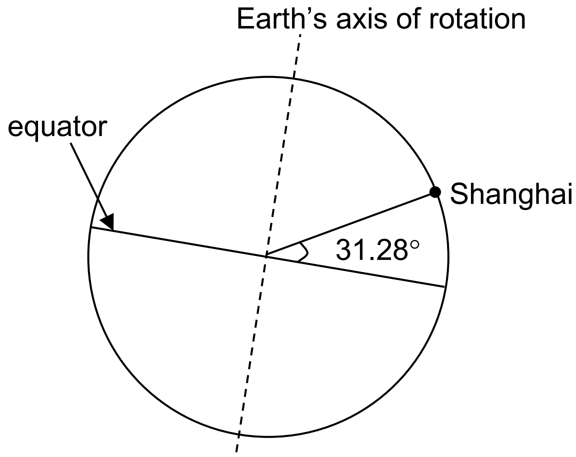
A 2.6 °C **B** 5.2 °C **C** 65 °C **D** 260 °C

15 Sky City in Tokyo is 1.0 km tall. The lifts take 2.0 minutes to reach the top. A lift of mass 450 kg carries two passengers who have a combined mass of 140 kg.

What is the average power supplied to the ascending lift?

A 4.9 kW **B** 37 kW **C** 48 kW **D** 2900 kW

16 A man is located in Shanghai which has a latitude of 31.28° N as shown.



Assuming Earth to be a sphere of radius 6380 km, what is the man's linear velocity due to the rotation of the Earth about its axis?

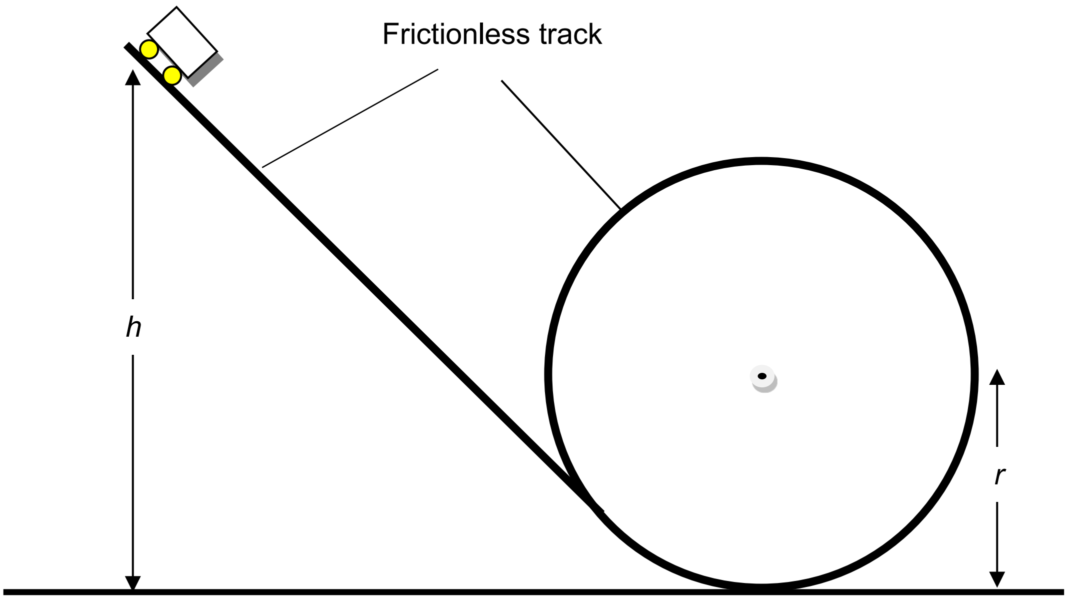
A 241 m s^{-1} **B** 337 m s^{-1} **C** 397 m s^{-1} **D** 464 m s^{-1}

17 A block is attached to an elastic spring of unstretched length *a* and travels in a horizontal circle of radius 2*a* on a smooth horizontal table. The elastic spring is horizontal throughout the circular motion. The period of rotation of the block is *T*.

The block is spun at a higher speed such that it now moves in a circle of radius 3*a*. Assuming that the spring obeys Hooke's law, the period of rotation is now

A $\frac{9}{16}T$ **B** $\frac{3}{4}T$ **C** $\sqrt{\frac{3}{4}}T$ **D** $\sqrt{\frac{4}{3}}T$

18 A small car of mass m is released from rest at the top of a frictionless track of height h. It then enters a vertical circular loop of radius r. The car can loop the loop without losing contact with the track.



Which of the following expressions correctly represents the centripetal force of the car at the top of the loop?

A $\dfrac{2mg(h-r)}{r}$ **B** $\dfrac{2mg(h-r)}{h}$ **C** $\dfrac{mg(h-2r)}{r}$ **D** $\dfrac{2mg(h-2r)}{r}$

19 A piece of rock, which weighs 15 N on the Earth, weighs 2.5 N on the Moon.

What is the mass of the rock and the gravitational field strength on the Moon?

	mass / kg	gravitational field strength / N kg^{-1}
A	1.5	1.6
B	1.5	6.1
C	150	0.016
D	150	6.1

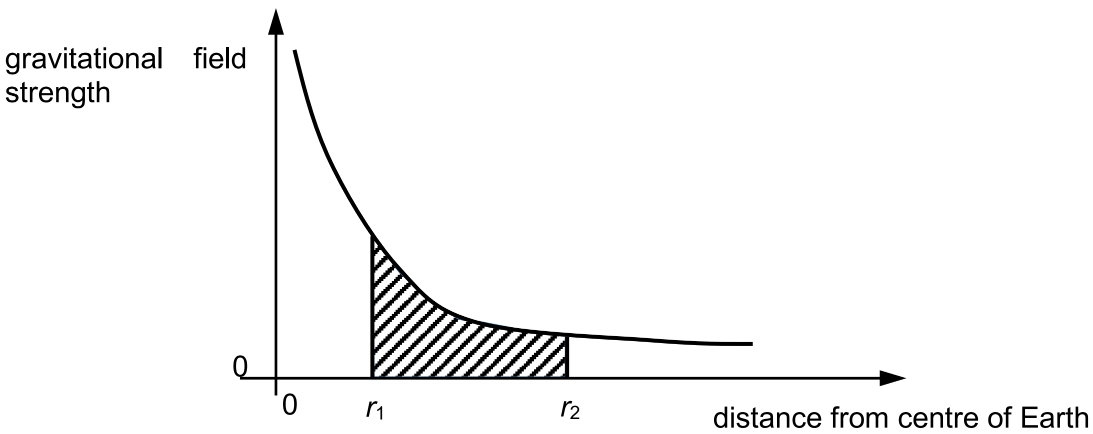
20 The planet Jupiter has satellites called Io and Europa which have different orbital radii and different orbital time periods. The table shows the orbital radii for Io and Europa and the orbital time period of Io.

	orbital radius / km	orbital time period / days
Io	4.2×10^5	1.8
Europa	6.7×10^5	T_E

What is the orbital time period T_E of Europa?

A 0.88 days **B** 2.4 days **C** 2.8 days **D** 3.6 days

21 A satellite of mass m above the Earth in a circular orbit of radius r_1 is moved to a higher circular orbit of radius r_2.



The graph shows the variation of the gravitational field strength with distance.

Which of the following represents the change in gravitational potential energy of the satellite?

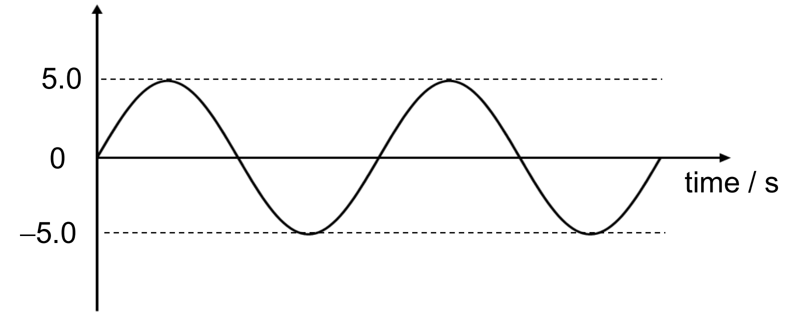
A Shaded area

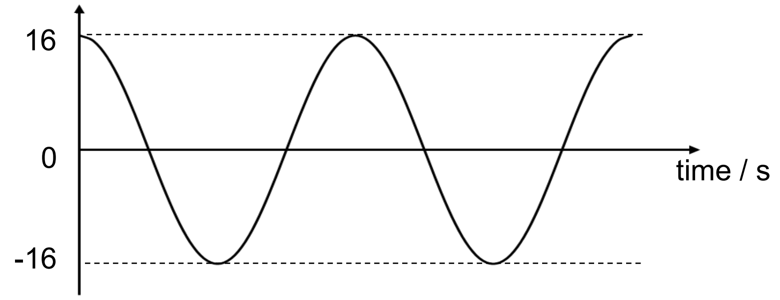
B Shaded area $\times$ m

C Gradient of the graph at r_1

D Gradient of the graph at r_2

22 The graphs below show the variation of displacement and velocity with time of a body oscillating in simple harmonic motion.

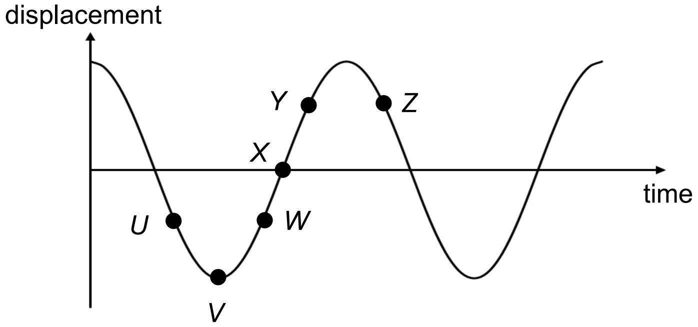




Given that T is the period of the oscillation, what is the magnitude of the acceleration of the body at $\dfrac{T}{8}$ s?

A 0.70 cm s^{-2} **B** 12 cm s^{-2} **C** 36 cm s^{-2} **D** 51 cm s^{-2}

23 The diagram below shows the variation with time the displacement of a body undergoing simple harmonic motion.



At which points U, V, X, Y, Z are the velocity and acceleration in the opposite directions?

A V and X **B** U and Y **C** W and Z **D** X and Z

24 An ideal gas is initially at a temperature of 30 °C and its molecules are moving with a root-mean-square speed of c.

The gas is then heated to reach a temperature of 90 °C. What is the root-mean-square speed of the molecules at this temperature?

A 1.1 c **B** 1.2 c **C** 1.7 c **D** 3.0 c

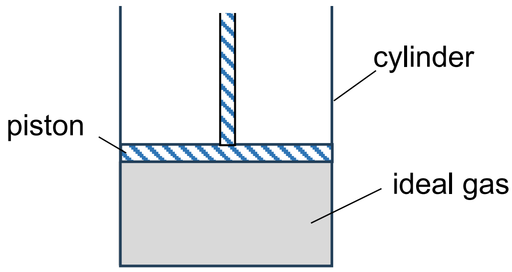
25 An insulating foam cup with lid contains 250 g of hot water at 95 °C.

Assuming that the cup exchanges negligible heat with its contents and surrounding, what is the minimum amount of ice at 0 °C that must be added to the cup to bring the temperature of the water down to 70 °C?

Specific heat capacity of water = 4.2×10^3 J kg^{-1} K^{-1}
Specific heat capacity of ice = 2.1×10^3 J kg^{-1} K^{-1}
Specific latent heat of fusion of water = 3.3×10^5 J kg^{-1}

A 42 g **B** 55 g **C** 69 g **D** 80 g

26 A cylinder enclosed with a smooth piston contains a monoatomic ideal gas of internal energy U with an initial volume of V at a pressure of P. The gas is then heated so that it expands under constant pressure until its volume is 1.5V.



Which of the following gives the expression for the heat supplied to the gas?

A $\dfrac{PV}{2}$ **B** $\dfrac{3U - PV}{2}$ **C** $\dfrac{U - PV}{2}$ **D** $\dfrac{U + PV}{2}$

27 An antenna broadcasts a signal uniformly in all directions with a power of 240 W. What is the power received by a circular receiver dish of diameter 3.0 m positioned 750 m away?

A 9.6×10^{-7} W **B** 2.4×10^{-4} W **C** 9.6×10^{-4} W **D** 3.8×10^{-3} W

28 Plane polarised light of intensity I is incident on a polarising filter aligned so that no light is transmitted. The polarising filter is now rotated through an angle of 30°.

What is the intensity of the transmitted light?

A 0.25 I **B** 0.50 I **C** 0.75 I **D** 0.87 I

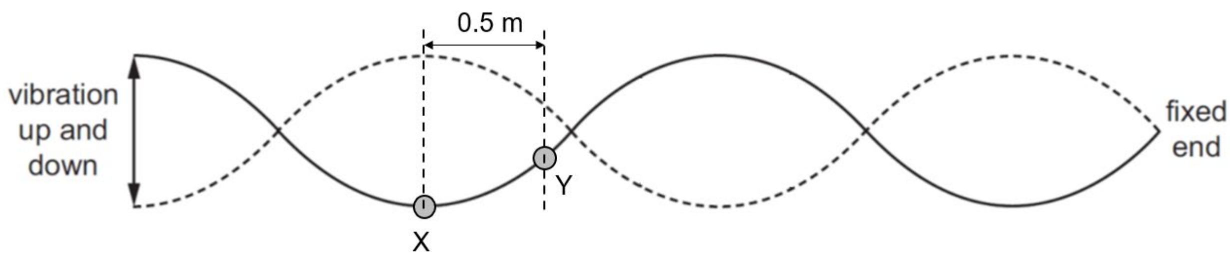
29 A stationary wave is set up on a string that is stretched between two fixed points that are 48 cm apart.

At one instant, the appearance of the string is as shown.

What is the wavelength of the stationary wave?

A 16 cm **B** 32 cm **C** 48 cm **D** 72 cm

30 The diagram shows a long rope fixed at one end. The other end is moved up and down, setting up a stationary wave of wavelength 2 m. The horizontal distance between point X and Y on the rope is 0.5 m.



What is the phase difference between the oscillations at X and Y?

A 0° **B** 90° **C** 180° **D** 135°

End of Paper

NANYANG JUNIOR COLLEGE
JC 1 END-OF-YEAR EXAMINATION
Higher 2

CANDIDATE NAME

CLASS

TUTOR'S NAME

PHYSICS 9749/02

Paper 2 Structured Questions **27 September 2023**

1 hour

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class, Centre number and index number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 8
2	/ 8
3	/ 8
4	/ 16
Total	/ 40

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

Data

speed of light in free space	$c = 3.00 \times 10^{8}\ \mathrm{m\ s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\ m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\ m^{-1}}$
	$(1 / (36\pi)) \times 10^{-9}\ \mathrm{F\ m^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\ s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant	$R = 8.31\ \mathrm{J\ K^{-1}\ mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\ \mathrm{J\ K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\ m^2\ kg^{-2}}$
acceleration of free fall	$g = 9.81\ \mathrm{m\ s^{-2}}$

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	$p = \rho g h$
gravitational potential	$\phi = -Gm / r$
temperature	$T / \mathrm{K} = T / {}^\circ\mathrm{C} + 273.15$
pressure of an ideal gas	$p = \dfrac{1}{3}\dfrac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal molecule	$E = \dfrac{3}{2}kT$
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	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \dfrac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \dfrac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{\ln 2}{t_{\frac{1}{2}}}$

1 **(a)** Explain what is meant by *displacement*.

....

....[1]

(b) Fig. 1.1 shows the variation with time the velocity v of the car travelling on a horizontal straight road. The car starts moving at time t = 0 s when displacement x = 0 m.

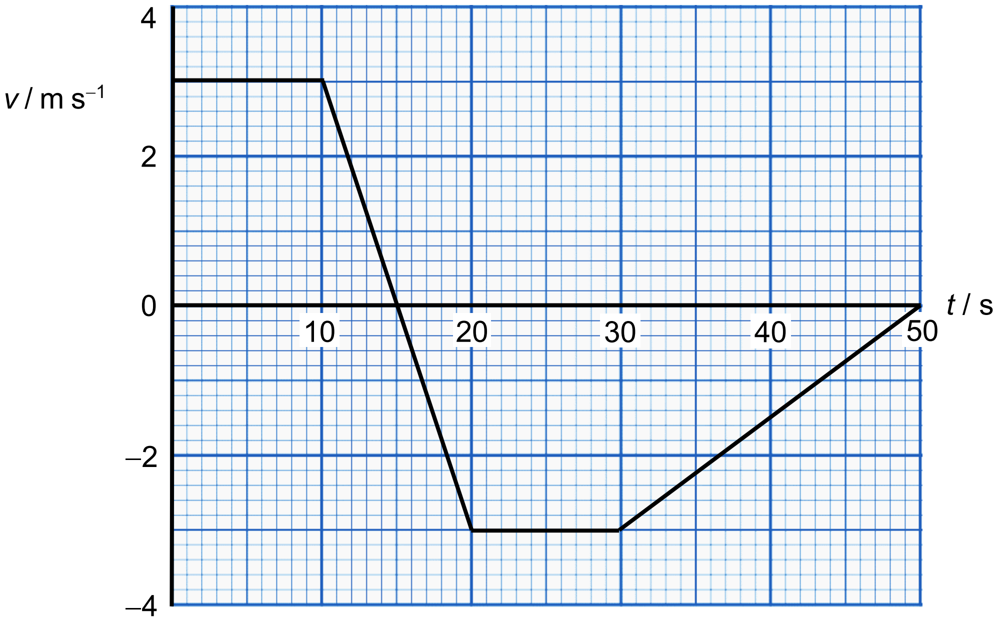


Fig. 1.1

(i) State and explain the time t at which the car returns to displacement x = 0 m.

....

....

....[2]

(ii) Using Fig. 1.1, determine the acceleration of the car at t = 15 s.

acceleration = ... m s^{-2} [2]

(iii) Hence on Fig. 1.2, sketch the variation with time t the acceleration a of the car. No further calculations are required.

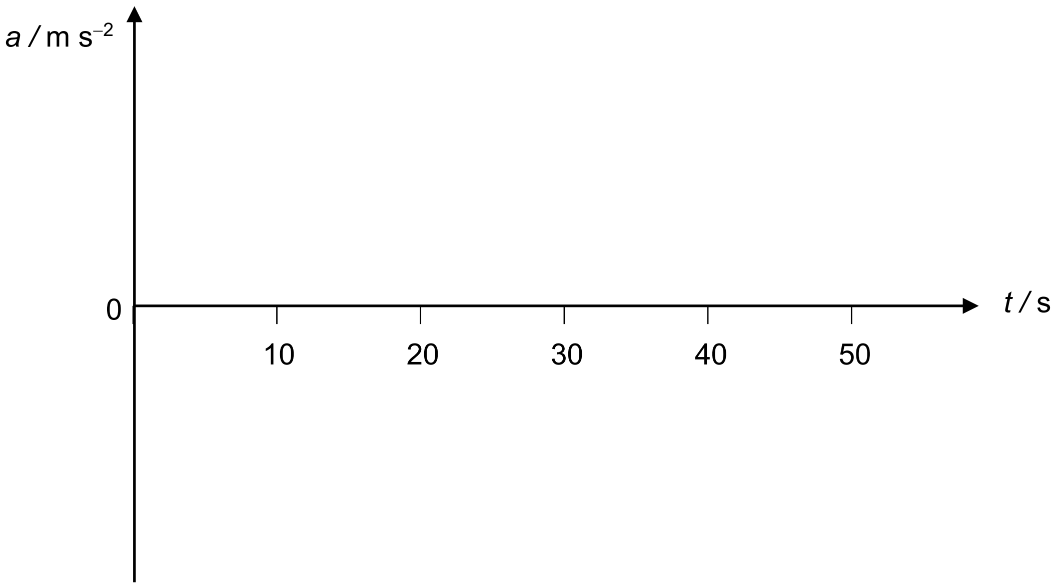


Fig. 1.2

[3]

[Total: 8]

2 A non-uniform block of length 0.800 m, height 0.200 m, width 0.200 m and mass 25.5 kg is fully submerged in water of density 1.02×10^3 kg m^{-3}. It is held in a fixed position by two identical vertical cables X and Y, at each end of the block as shown in Fig. 2.1.

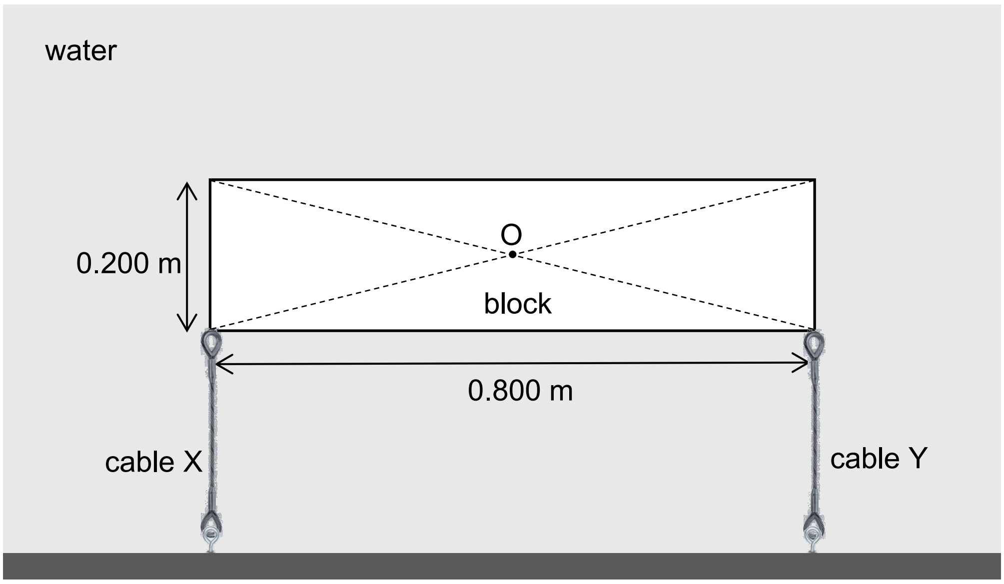


Fig. 2.1

(a) Explain the origin of *upthrust*.

....

....

....[2]

(b) Calculate the magnitude of the upthrust on the block.

upthrust = ... N [2]

(c) Hence show that the total force exerted by cables X and Y on the block is 70 N.

[1]

(d) The force exerted by cables X and Y on the block are 45 N and 25 N respectively. Deduce why cable X exerts a larger force on the block than cable Y.

....

....[1]

(e) Upthrust on the block acts from the geometric centre O of the block as shown in Fig. 2.1. Calculate the horizontal distance of the centre of gravity of the block from O.

distance = ... m [2]

[Total: 8]

3 A 4.00 kg mass is attached to a vertical rod using two inextensible cords of length 1.25 m. The mass rotates about the axis of the rod such that both cords are taut as shown in Fig. 3.1.

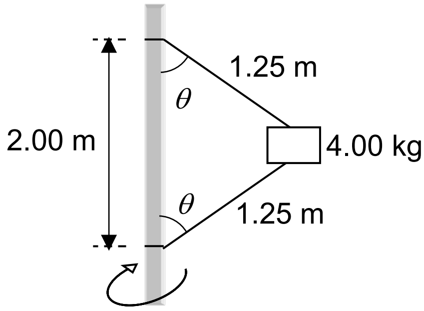


Fig. 3.1

(a) Calculate the angle θ between each of the cords and the vertical rod.

angle θ = ... ° [1]

(b) On Fig. 3.1, draw all the forces acting on the mass. [2]

(c) Hence, show that the magnitude of the tension in the upper cord is 49.1 N more than that in the lower cord.

[2]

(d) The rotation is gradually slowed down until the lower cord just loses its tautness. Determine the frequency of rotation of the mass when this happens.

frequency of rotation = ... s^{-1} [3]

[Total: 8]

4 A bridge is constructed across a river as shown in Fig. 4.1. On each side of the bridge, two towers were sunk into the riverbed and each tower supports 5 cables. Each cable forms an inverted-V where one end of the cable is attached to the roadway, passes over a tower and the other end is also attached to the roadway.

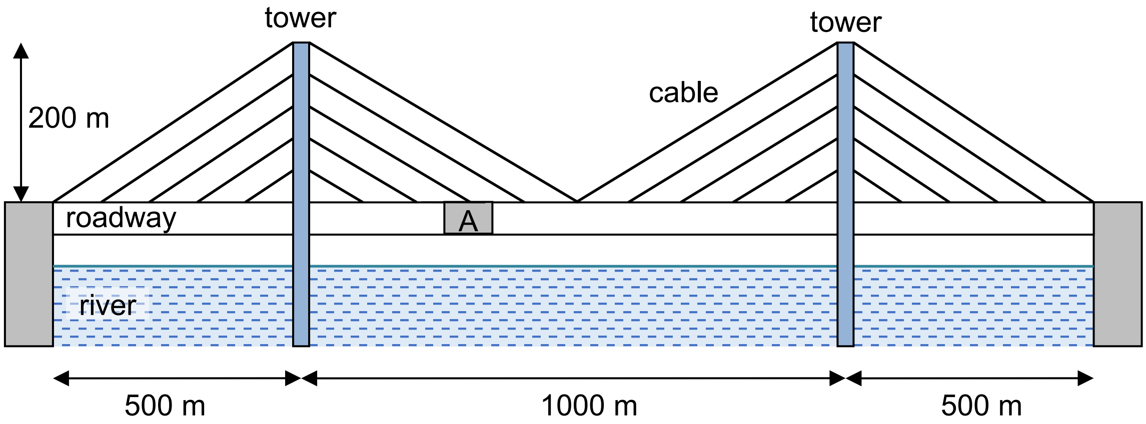


Fig. 4.1 (side view)

As a car enters the bridge, it will drive past a total of 4 towers and 20 cables on both the left and right side of the car. The arrangement and number of cables are identical on both sides of the car. Having multiple cables is a much better system than having a traditional suspension bridge which relies on the immense tensile strength of a single pair of cables taking the entire load. Simplified data concerning the bridge are given below.

Length of bridge supported by the towers	= 2000 m
Height of tower above roadway	= 200 m
Total mass of all the cables	= 1.4×10^6 kg
Mass of roadway	= 8.5×10^6 kg
Maximum mass of load of traffic	= 12.5×10^6 kg
Horizontal distance between cables	= 100 m
Vertical distance between cables	= 40 m
Total number of inverted V cables (both sides of road)	= 20

(a) Determine the maximum total mass that each of the four towers will need to support.

mass = ... kg [2]

(b) Assuming that car traffic is uniformly distributed on the bridge, determine the total mass of a 100 m section of the roadway and the traffic it supports.

mass = ... kg [2]

(c) Given that all adjacent cables are parallel to each other, calculate the angle between each cable and the horizontal.

angle to horizontal = ... ° [1]

(d) On Fig. 4.1, section A is a 100 m section of the roadway which is fully laden and supported by a pair of cables. Fig 4.2 shows a close-up view of section A which is under compression.

Draw and label, on Fig. 4.2, the forces acting on section A.

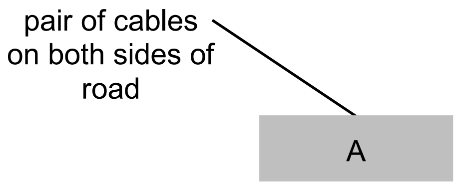


Fig. 4.2 [3]

(e) Using Fig. 4.2, determine the tension in each cable supporting section A when it is fully laden.

tension = ... N [3]

(f) The force constant of each cable is 7.0×10^{7} N m^{-1}.

Determine the increase in the length of each cable when an initially empty roadway becomes fully laden.

increase in length = ... m [3]

(g) Using your answer to **(d)**, suggest and explain which section of the roadway is under the greatest compression.

....

....

....

....[2]

[Total: 16]

End of Paper

NANYANG JUNIOR COLLEGE
JC 1 END-OF-YEAR EXAMINATION
Higher 2

CANDIDATE NAME

CLASS

TUTOR'S NAME

PHYSICS

9749/03

Paper 3 Longer Structured Questions

2 October 2023

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class, Centre number and index number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

You are advised to spend one and a half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	**/ 10**
2	**/ 10**
3	**/ 8**
4	**/ 8**
5	**/ 12**
6	**/ 12**
Section B	
7	**/ 20**
8	**/ 20**
Total	**/ 80**

This document consists of **21** printed pages and **2** blank pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$(1 / (36\pi)) \times 10^{-9}$ F m^{-1}
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the Planck constant	$h = 6.63 \times 10^{-34}$ J s
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gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

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	$v^2 = u^2 + 2as$
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gravitational potential	$\phi = -Gm / r$
temperature	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \dfrac{1}{3}\dfrac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal molecule	$E = \dfrac{3}{2}kT$
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	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \dfrac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \dfrac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{\ln 2}{t_{\frac{1}{2}}}$

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Section A

Answer **all** the questions in the spaces provided.

1 **(a)** Give a **reasoned** estimate of the area of the island of Singapore in SI unit.

area = ...unit.................. [2]

(b) A coin is made in the shape of a circular disc, as shown in Fig. 1.1.

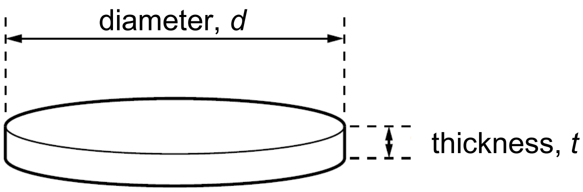


Fig. 1.1

Fig. 1.2 shows the measurements made in order to determine the density ρ of the material used to make the coin.

quantity	measurement	uncertainty
mass, m	8.2 g	± 0.5 g
thickness, t	2.00 mm	± 0.01 mm
diameter, d	22.1 mm	± 0.1 mm

Fig. 1.2

(i) State the name of the measuring instrument suitable for making the measurement of thickness t.

....[1]

(ii) Calculate the density ρ of the coin in kg m^{-3}.

ρ = ...kg m^{-3} [2]

(iii) Calculate uncertainty of the density ρ of the coin and give the value of ρ with its actual uncertainty.

ρ = ... ± .... kg m^{-3} [3]

(iv) The densities of three metals are given in Fig. 1.3.

metal	density
iron	7870 kg m^{-3}
copper	8960 kg m^{-3}
silver	10500 kg m^{-3}

Fig. 1.3

State and explain which metal the coin is made of.

....

....

....[2]

[Total: 10]

2 An object P of mass 1.5 kg with an initial velocity u collides elastically with another object Q of mass 2.4 kg that is initially at rest. The variation of the force that P exerts on Q with time is shown in Fig. 2.1.

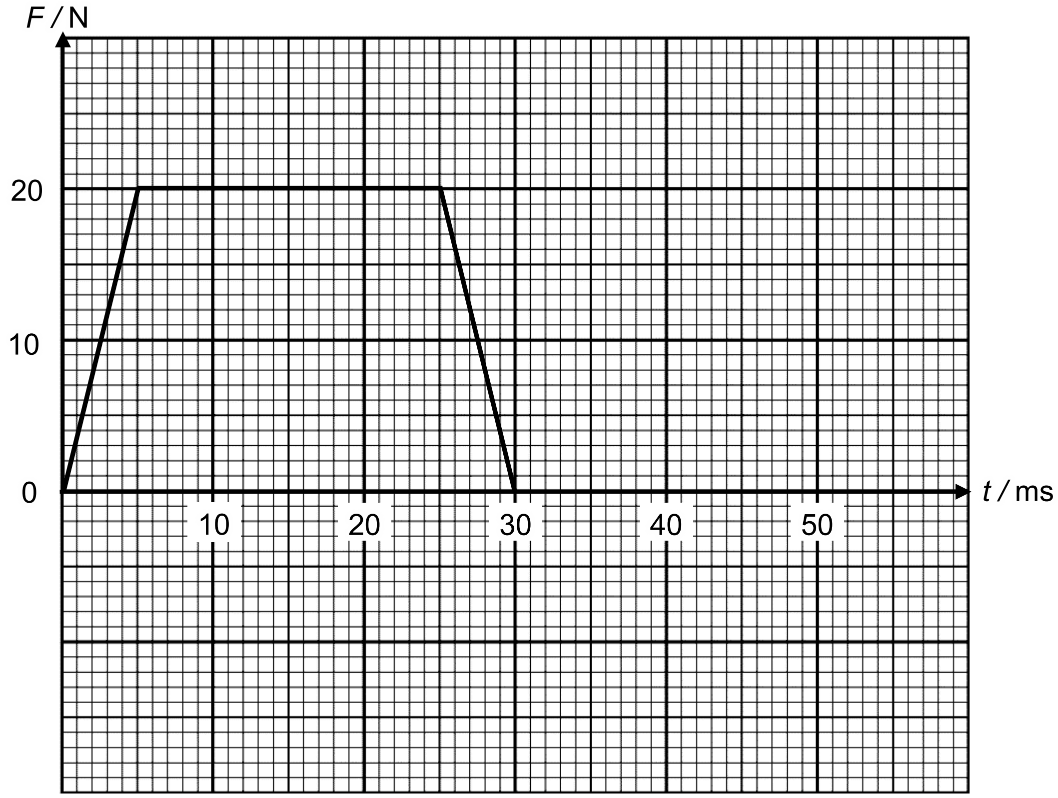


Fig. 2.1

(a) Explain what is meant by an *elastic* collision.

....

....[1]

(b) Sketch, on Fig. 2.1, a graph that shows the variation of the force that Q exerts on P with time. Explain your answer.

....

....[2]

(c) State what the area under the graph drawn in **(b)** represents.

....[1]

(d) Calculate the velocity of Q after the collision.

velocity of Q = ... m s^{-1} [2]

(e) Calculate the velocity of P before and after the collision.

velocity of P before collision = ... m s^{-1}

velocity of P after collision = ... m s^{-1} [4]

[Total: 10]

3 **(a)** Fig. 3.1 shows two graphs. Graph A shows the displacement at time t = 0 s of different points on a progressive wave. Graph B shows the displacement of the same wave at t = 0.10 s.

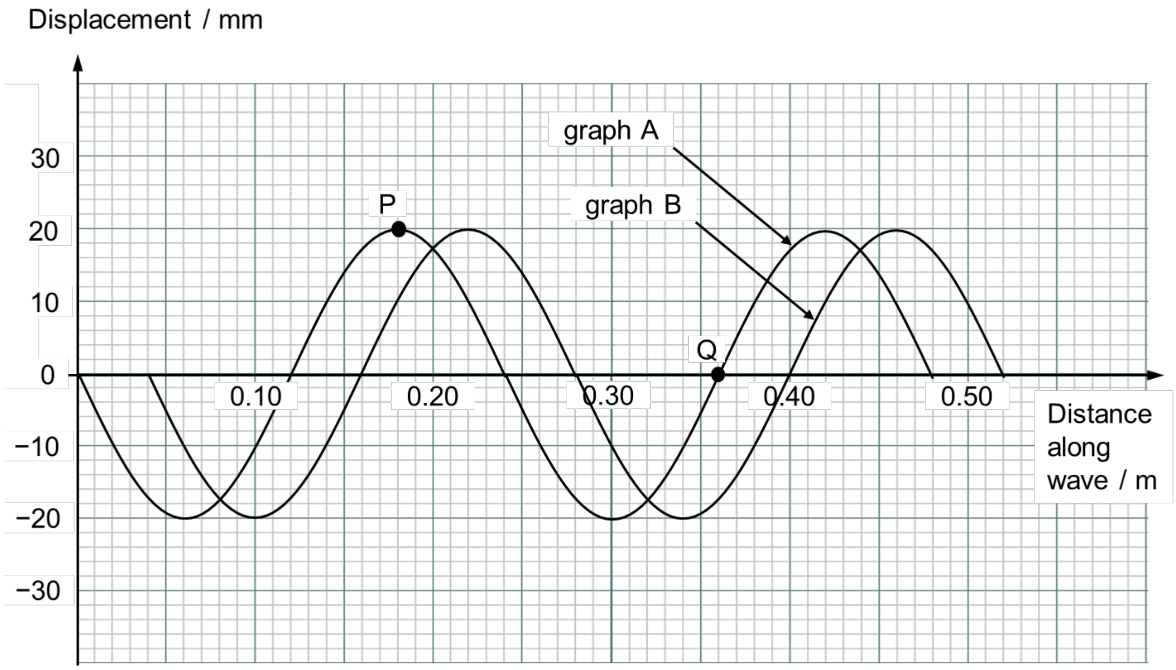


Fig. 3.1

(i) Determine the phase difference between points **P** and **Q** marked on graph **A** in terms of π.

phase difference = ... rad [1]

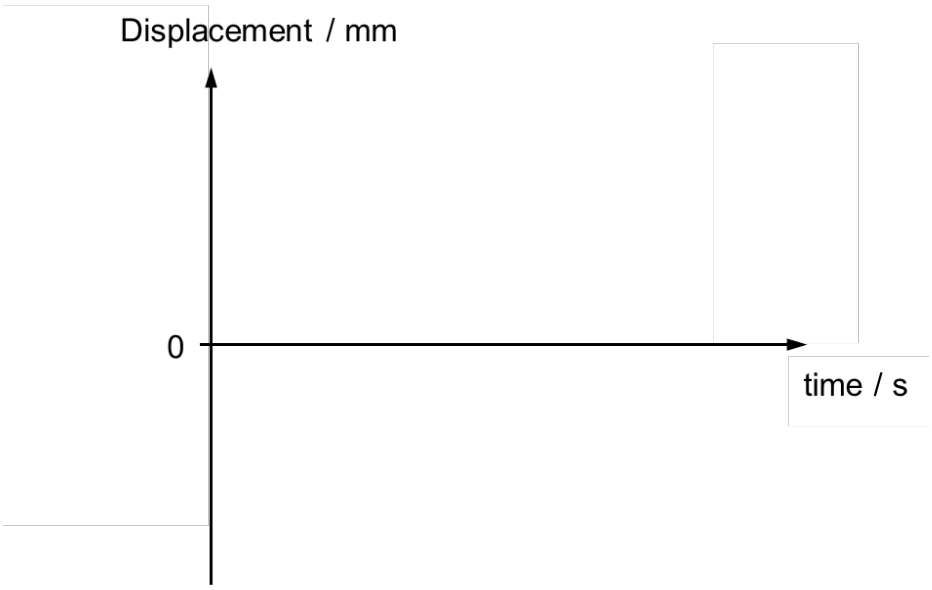
(ii) Determine the wave speed.

wave speed = ... m s^{-1} [2]

(iii) Determine the period of the wave.

period = ... s [1]

(iv) Using the grid below, sketch a graph to show the variation with time of the displacement of point **Q**, showing numerical scales on both axes.



[2]

(b) (i) Explain what is meant by a *transverse wave*.

....

....[1]

(ii) State a phenomenon that only applies to transverse waves but not longitudinal waves.

....[1]

[Total: 8]

4 A speaker emitting sound of frequency 512 Hz is placed near the open end of a narrow tube which has a moveable piston, as shown in Fig. 4.1.

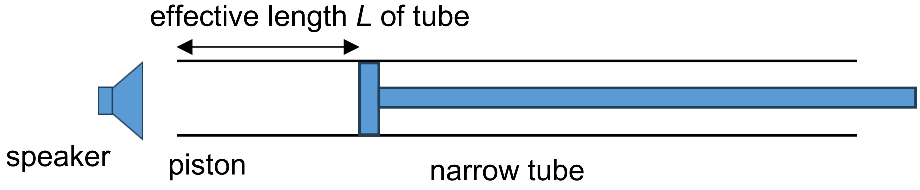


Fig. 4.1

With the piston initially positioned near the open end, the effective length L of the tube is increased by moving the piston to the right. When L reaches a certain length, a stationary wave forms in the tube and a loud sound is first observed.

(a) Explain how the stationary wave is formed inside the tube.

....

....

....

....[2]

(b) Sketch, on Fig. 4.1, the stationary wave formed in the tube when the loud sound is first observed. [1]

(c) L is further increased by 33.4 cm, during which the sound diminishes and becomes loud again. Show that the speed of sound in air is 342 m s^{-1}.

[2]

(d) The frequency of the sound wave is now varied. Given that the maximum value of L is 64.8 cm, determine the lowest frequency of sound that can resonate in this tube.

frequency = ... Hz [3]

[Total: 8]

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5 A fixed amount of an ideal gas undergoes a cycle of processes A → B → C → A.

The pressure and volume of the gas at each state is shown in Fig. 5.1.

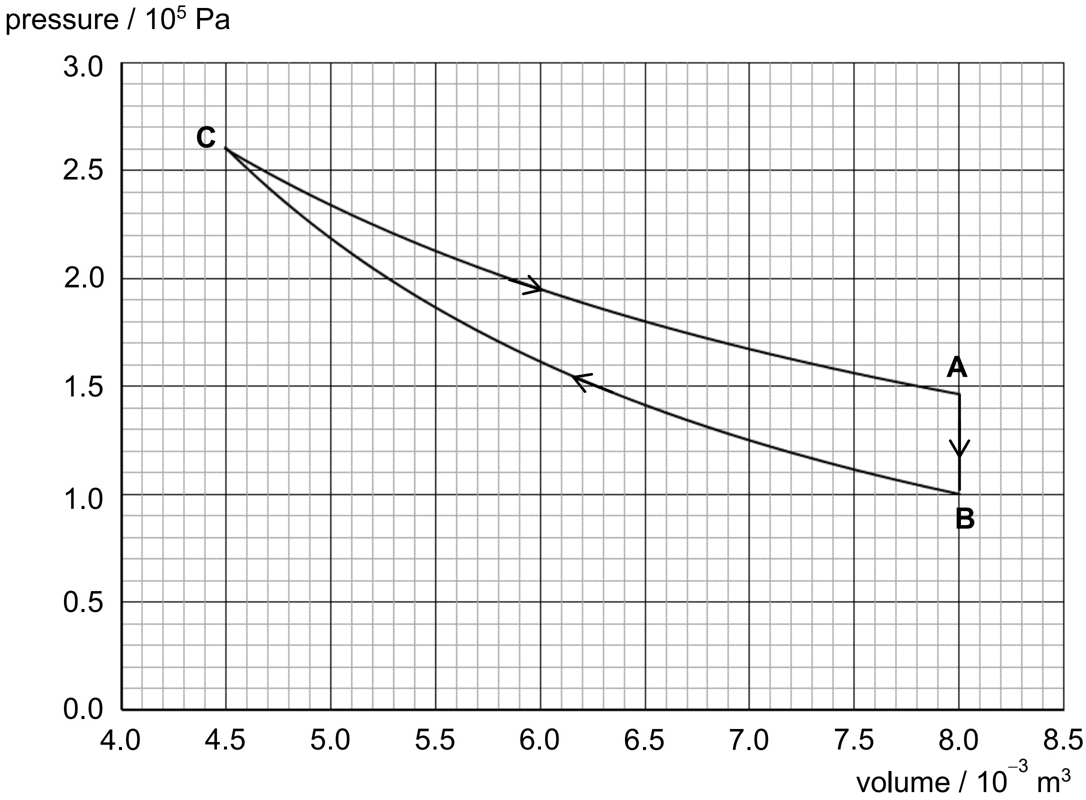


Fig. 5.1

(a) In process A → B, the gas cools at a constant volume. By considering the motion of the gas atoms, explain why the pressure exerted by the gas decreases when the gas cools.

....

....

....

....[2]

(b) The temperature of the gas at C is 434 K. Determine the temperature of the gas at B.

temperature at B = ... K [3]

(c) Since the temperature at A is also 434 K, it is deduced that C → A is an isothermal process. Provide an additional piece of evidence from Fig. 5.1 that supports this deduction.

[2]

(d) In the process C → A, 675 J of heat was supplied to the gas.

Using the First Law of Thermodynamics, explain why the temperature of the gas did not increase even though heat was supplied to it.

....

....

....[2]

(e) The area enclosed in the loop ABCA is 115 Pa m^3.

Calculate the work done on the gas in process B → C. Explain your working.

work done on gas = ... J [3]

[Total: 12]

6 A student is investigating the angle at which a glass cylinder containing oil topples, as shown in Fig. 6.1.

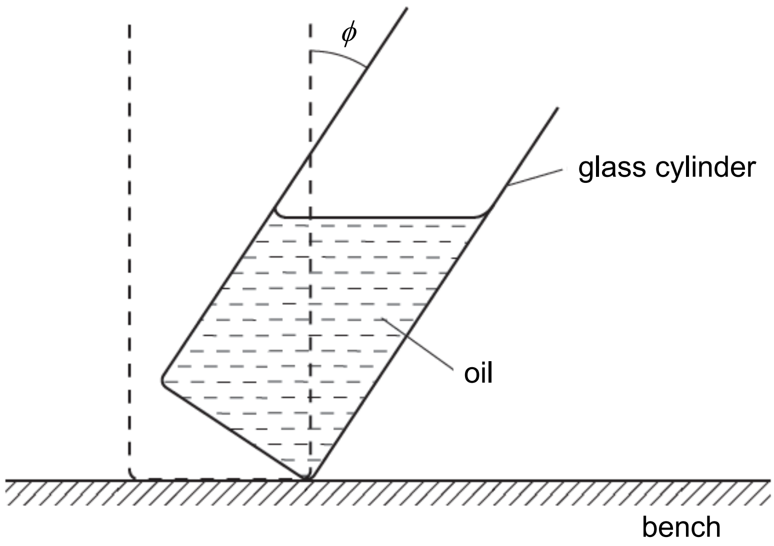


Fig. 6.1

A cylinder containing a mass m of oil can be tilted through a maximum angle ϕ from the vertical before it topples.

It is suggested that the relationship between m and ϕ is

$$\frac{1}{\tan\phi} = \frac{am}{\rho d^3} + b$$

where d is the diameter of the cylinder, ρ is the density of the oil and a and b are constants.

Design a laboratory experiment to determine the values for a and b.

Draw a diagram showing the arrangement of your equipment. You should pay particular attention to

- the procedure to be followed,
- the measurements to be taken,
- the control of variables,
- the analysis of the data,
- any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

[12]

[Total: 12]

Section B

Answer **one** question from this Section in the spaces provided.

7 (a) (i) State *Newton's law of gravitation*.

....

....

....[2]

(ii) Define *gravitational field strength*.

....

....[1]

(iii) Explain why the gravitational field strength near surface of Earth is constant and numerically equal to acceleration of free fall.

....

....

....

....[2]

(b) The International Space Station is travelling in a circular orbit at a distance r from the centre of the Earth. The radius of Earth is R.

(i) Show that the linear speed of the International Space Station is given by the expression

$$v = \sqrt{\frac{gR^2}{r}}$$

where g is the acceleration of free fall at the surface of Earth.

[2]

(ii) The radius R of Earth is 6400 km and orbital radius r of the Space Station is 6.8×10^6 m.

Use the expression in **(b)(i)** to determine the orbital period of the International Space Station.

period = ... min [3]

(iii) Explain why the apparent weight of an astronaut inside the International Space Station is zero.

....

....

....

....[2]

(c) (i) Using the expression in **(b)(i)**, show that the total energy E_T of the International Space Station is given by the expression

$$E_T = -\frac{gR^2 m}{2r}$$

where m is the mass of the International Space Station.

[2]

(ii) The mass m of the International Space Station is 4.2×10^5 kg.

Determine the total energy of the International Space Station.

energy = ... J [1]

(iii) Due to air resistance, the total energy of the Space Station will gradually decrease.

Explain the energy changes as the Space Station orbits around Earth.

....

....

....

....[3]

(iv) Thrusters are used to re-boost the Space Station every few months.

Suggest how the Space Station should fire its thrusters to restore its total energy and orbital radius to their original values.

....

....

....

....[2]

[Total: 20]

8 **(a)** State what is meant by *simple harmonic motion*.

....

....

....[2]

(b) A smooth cylindrical tube, containing some sand, floats upright in a liquid of density ρ as shown in Fig. 8.1.

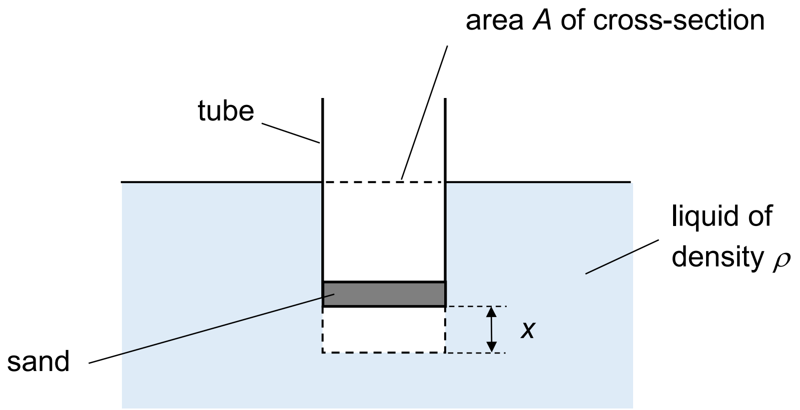


Fig. 8.1

The tube has cross-sectional area A. The total mass of the tube and sand is M.

The tube is displaced vertically downwards and then released. The tube oscillates vertically.

(i) Derive an expression, in terms of ρ A, x and the acceleration of free fall g, for the resultant force F acting vertically on the tube when the displacement of the tube from its equilibrium position is x. Explain your working.

[3]

(ii) Using the expression derived in **(b)(i)**, show that the acceleration *a* of the tube at displacement *x* is given by

$$a = -\left(\frac{\rho A g}{M}\right)x.$$

[2]

(iii) The mass *M* of the tube and sand is 120 g. The area *A* of the cross-section of the tube is 5.8 cm^3.

Calculate the frequency of the oscillation of the tube when floating in water of density 1.0×10^3 kg m^{-3}.

frequency = ... Hz [4]

(iv) State and explain the changes to your answer in **(b)(iii)** if the tube is now floating in cooking oil.

....

....

....[2]

(c) The smooth cylindrical tube in **(b)** is now incident with water waves. The water waves cause resonance in the up-and-down motion of the tube.

(i) Explain what is meant by the term *resonance*.

....

....

....

....[2]

(ii) Water waves of variable frequency and constant amplitude *y* are now incident on the tube and causes forced oscillation.

1. On Fig. 8.2, sketch a labelled graph to show the variation with frequency of the water waves of the amplitude of oscillation of the tube. Include the natural frequency of the block and the amplitude *y* of the water waves on the axes.

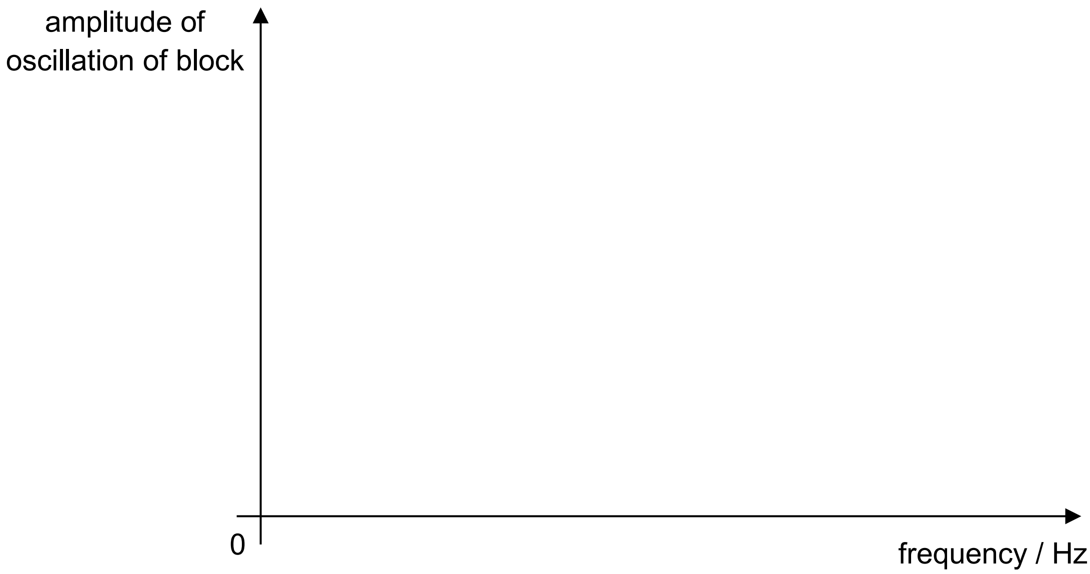


Fig. 8.2

[2]

2. On Fig. 8.2, sketch a graph to show the variation with frequency of the water waves of the amplitude of oscillation of the tube, if the tube is rough. [3]

[Total: 20]

End of Paper

H

NANYANG JUNIOR COLLEGE
JC 1 END OF YEAR EXAMINATION
Higher 2

CANDIDATE NAME	

CLASS		TUTOR'S NAME	

PHYSICS 9749/01

Paper 1 Multiple Choice **30 September 2022**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class, Centre number and index number in the spaces at the top of this page.

There are **thirty** questions on this paper. Answer **all** 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 Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

Data

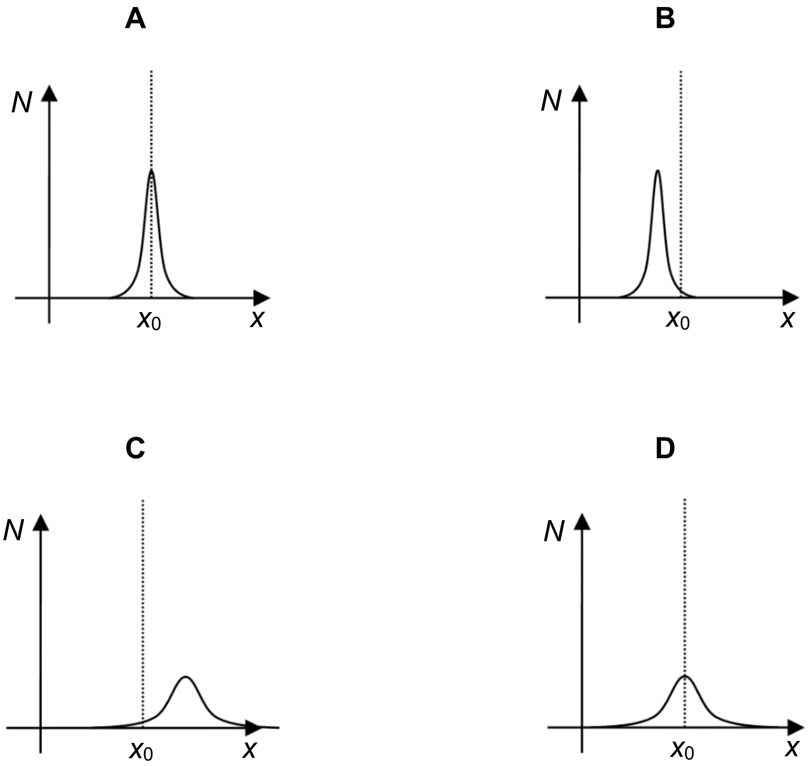
speed of light in free space	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$
	$(1 / (36\pi)) \times 10^{-9}\ \text{F m}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\ \text{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\ \text{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\ \text{kg}$
molar gas constant	$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^{2}\ \text{kg}^{-2}$
acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$

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	$p = \rho gh$
gravitational potential	$\phi = -Gm / r$
temperature	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} \langle c^2 \rangle$
mean translational kinetic energy of an ideal 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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 The true value of a quantity x is x_0. In an experiment, the quantity is measured many times and the number of readings, N, giving a value x, is plotted against x.

Which of the following graphs best shows measurements that are precise but inaccurate?



2 In an experiment to determine the acceleration of free fall, g, a student presented his calculated value as 9.7846 m s^{-2} which has a percentage uncertainty of 5%.

Which of the following gives his result reduced to the appropriate number of significant figures?

A 10 m s^{-2} **B** 9.8 m s^{-2} **C** 9.78 m s^{-2} **D** 9.785 m s^{-2}

3 In still air, a bird can fly at a speed of 10 m s^{-1}. The wind is blowing from the east at 8.0 m s^{-1}.

In which direction must the bird fly in order to travel to a destination that is due north of the bird's current location?

A 37° east of north **B** 37° west of north

C 53° east of north **D** 53° west of north

4 A golfer hits a golf ball on a flat golf course. The golf ball travels a horizontal distance of 500 m before reaching the ground. It reaches a maximum height of 210 m.

What is the approximate angle to the horizontal at which the golf ball leaves the golf club?
Air resistance may be assumed to be negligible.

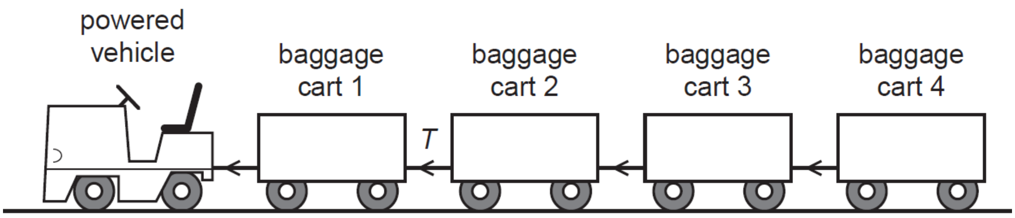
A 30° **B** 40° **C** 50° **D** 60°

5 Water is pumped through a hose-pipe at a rate of 90 kg per minute. Water emerges horizontally from the hose-pipe with a speed of 20 m s^{-1}.

What is the minimum force required by a person holding the hose-pipe to prevent it from moving backwards?

A 30 N **B** 270 N **C** 1800 N **D** 108 000 N

6 A transport system, used to move luggage from the airport terminal to the aircraft, consists of a powered vehicle connected to four baggage carts by a series of connecting bars.

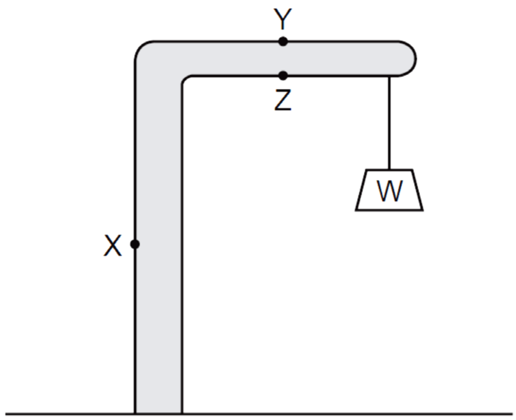


The mass of the powered vehicle is 200 kg and each of the baggage carts has a mass of 400 kg. The system starts with an acceleration of 2.0 m s^{-2}.

What is the tension T in the connecting bar between baggage carts 1 and 2? (Ignore any friction forces on the carts.)

A 800 N **B** 1200 N **C** 2400 N **D** 3600 N

7 A simple light crane consists of a rigid vertical pillar supporting a horizontal beam.

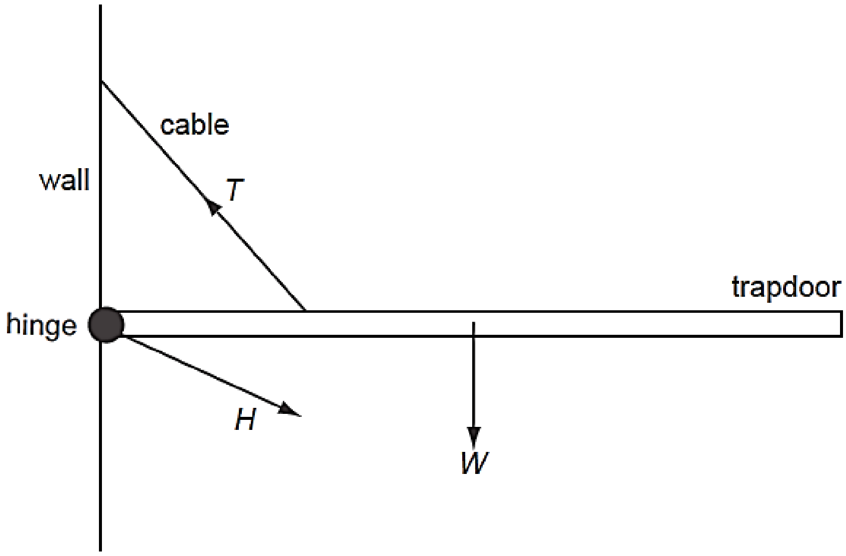


A weight W is lifted by a rope at the end of the beam.

What are the forces at points X, Y and Z?

	force at X	force at Y	force at Z
A	tension	tension	compression
B	tension	compression	tension
C	compression	tension	tension
D	compression	compression	compression

8 A hinged trapdoor is held closed in the horizontal position by a cable that is connected midway between the hinge and the centre of gravity of the trapdoor.



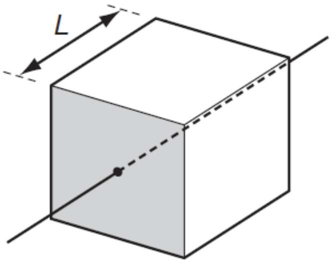
(forces are not drawn to scale)

Three forces act on the trapdoor: the weight W of the trapdoor, the tension T in the cable and the force H at the hinge.

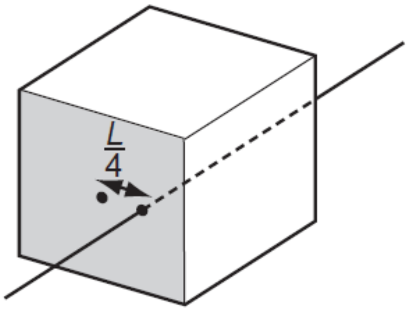
Which list gives the three forces in increasing order of magnitude?

A H, W, T **B** H, T, W **C** W, H, T **D** W, T, H

9 The diagram shows a solid cube with weight W and sides of length L. It is supported by a frictionless spindle that passes through the centers of two opposite vertical faces. One of these faces is shaded.



The spindle is now removed and replaced at a distance $\frac{L}{4}$ to the right of its original position.



When viewed from the direction of the shaded face, what is the torque of the couple that will now be needed to stop the cube from toppling?

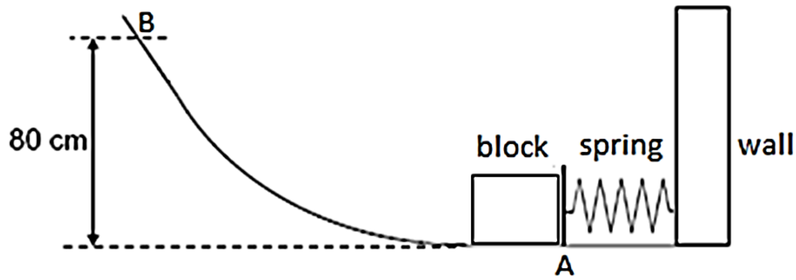
A $\dfrac{WL}{2}$ anticlockwise

B $\dfrac{WL}{2}$ clockwise

C $\dfrac{WL}{4}$ anticlockwise

D $\dfrac{WL}{4}$ clockwise

10 A 1.5 kg block rests against a spring that has a compression of 30 cm as shown in the diagram. Upon release, the spring pushes the block up a curved frictionless track.



If the force constant of the spring is 350 N m^{-1}, what is the speed of the block at position B at a height 80 cm above position A?

A 0 m s^{-1} **B** 2.30 m s^{-1} **C** 4.58 m s^{-1} **D** 7.37 m s^{-1}

11 Two iceboats hold a race on a frictionless and horizontal frozen lake. The two iceboats have masses *m* and 2*m*, respectively. Each iceboat has an identical sail, so the wind exerts the same constant force on each iceboat. The two iceboats start from rest and cross the finishing line a distance *s* away.

Which of the following statements is correct?

A The two iceboats have the same kinetic energy at the finishing line.

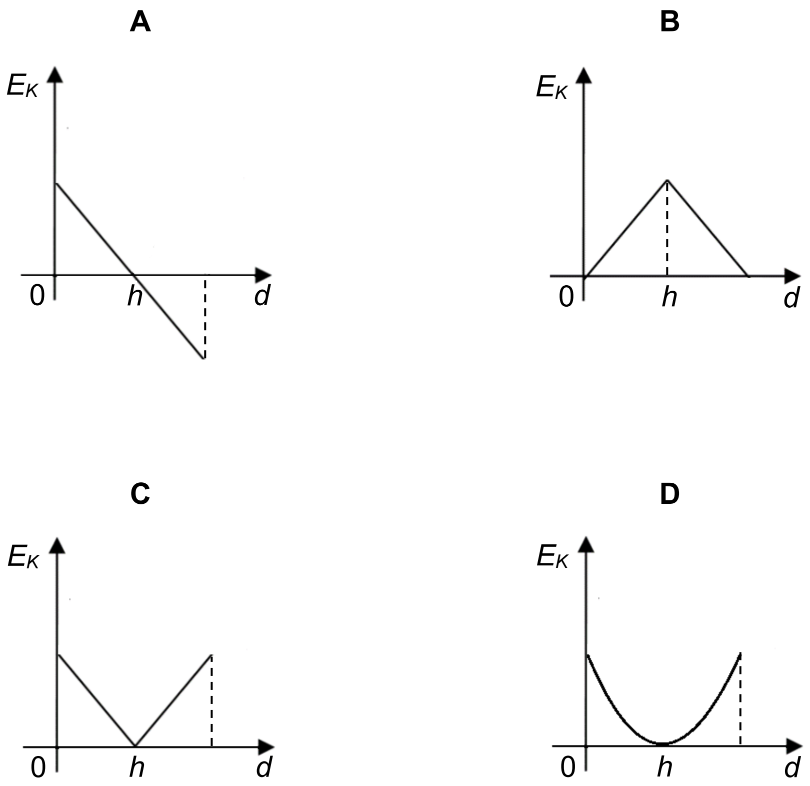
B The heavier iceboat attains a greater kinetic energy at the finishing line.

C The lighter iceboat attains a greater kinetic energy at the finishing line.

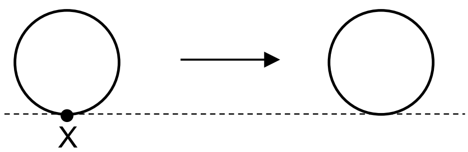
D The kinetic energy of the two iceboats is the same initially. However, the kinetic energy differs when the two iceboats reach the finishing line.

12 A ball, thrown vertically upwards, rises to a height *h* and then falls to its starting point. Air resistance may be taken as negligible.

Which graph best shows the variation with distance *d* travelled of the kinetic energy E_k of the ball?



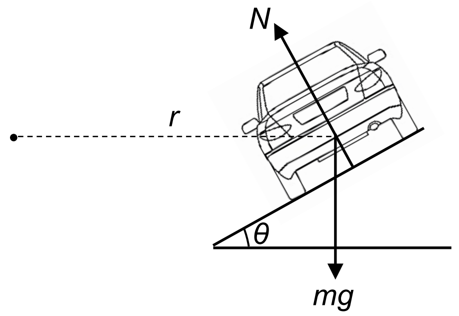
13 A cylinder of radius 0.100 m is rolling at a constant angular velocity of $\frac{3}{4}\pi$ rad s^{-1} along a horizontal surface from left to right. The side view of the cylinder is as shown. The point X is initially at the bottom of the cylinder.



After 4.00 s, what is the displacement of X?

A 0.020 m **B** 0.150 m **C** 0.942 m **D** 0.963 m

14 A car of mass m is moving with speed v in a horizontal circle of radius r on a banked road inclined at an angle θ to the horizontal, as shown. The normal contact force on the car is N.

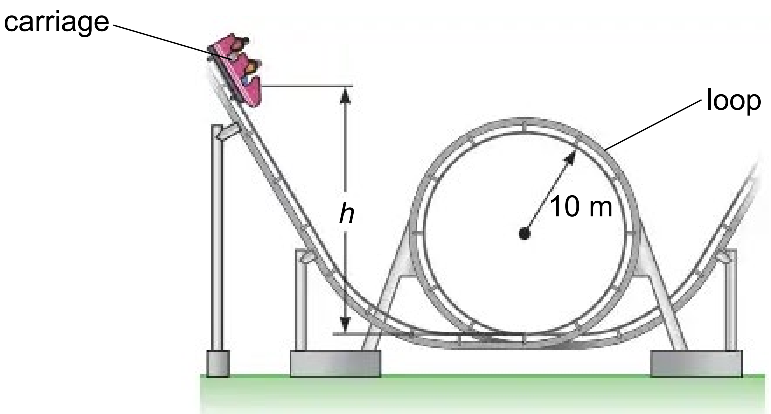


Which of the following expressions is correct?

A $N\cos\theta = mg$ **B** $N = mg\cos\theta$

C $v^2 = \dfrac{rg}{\sin\theta}$ **D** $v^2 = \dfrac{rg}{\tan\theta}$

15 In a segment of a rollercoaster track, a carriage descends from rest at a vertical height h measured from the lowest point of the track, as shown. Friction between the carriage and the track may be taken as negligible.



If the carriage is to complete the loop without leaving the track, what is the minimum value of the height h?

A 15 m **B** 20 m **C** 25 m **D** 30 m

16 Why does the Moon stay in its orbit at a constant distance from the Earth?

A The gravitational pull of the Earth on the Moon balances the gravitational pull of the Moon on the Earth.

B The gravitational pull of the Earth on the Moon is just sufficient to cause the centripetal acceleration of the Moon.

C The gravitational pull of the Moon on the Earth is negligible at this distance.

D The centripetal force the Earth exerts on the Moon balances the centripetal force the Moon exerts on the Earth.

17 Two moons were discovered to be orbiting around Jupiter with the same period.

Which one of the following quantity for the moons must be the same?

A mass

B momentum

C kinetic energy

D radii of orbit

18 The escape speed (i.e. the speed which a body must have in order to escape to an infinite distance from the Earth) of an oxygen molecule at the Earth's surface is 1.1×10^4 m s^{-1}.

What is the escape speed of the oxygen molecule at a height $0.2R_E$ above the Earth's surface, where R_E is the radius of the Earth?

A 0.9×10^4 m s^{-1} **B** 1.0×10^4 m s^{-1}

C 1.2×10^4 m s^{-1} **D** 1.3×10^4 m s^{-1}

19 Which of the following statements regarding simple harmonic motion of an oscillating body is false?

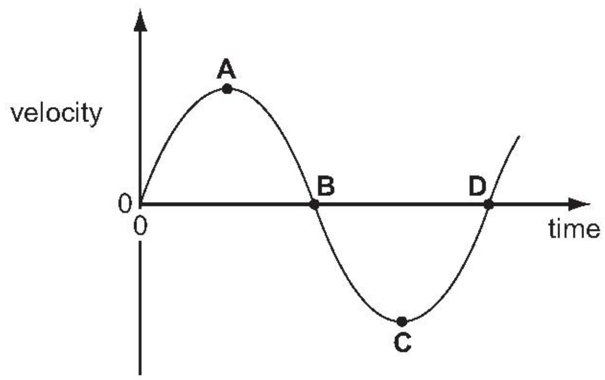
A An oscillating body with larger amplitude will have a longer period.

B An oscillating body with larger amplitude will have a greater maximum velocity.

C The maximum kinetic energy of the body is dependent on the frequency of the oscillation.

D The shortest time taken for the body to change from maximum kinetic energy to maximum potential energy is a quarter of the period of the oscillation.

20 The diagram shows a velocty-time graph for a mass moving up and down on the end of a spring.



Taking upward as positive, which point represents the velocity of the mass when it is at the equilibrium position and moving towards the highest point?

21 A simple pendulum is 1.0 m long and oscillates with simple harmonic motion of angular amplitude 0.050 rad and period 2.0 s.

What is the angular speed of the pendulum bob when the angular displacement is 0.030 rad?

A 0.0010 rad s^{-1} **B** 0.020 rad s^{-1} **C** 0.050 rad s^{-1} **D** 0.13 rad s^{-1}

22 Which of the following gives three regions of the electromagnetic spectrum in order of increasing frequency?

A gamma rays, microwaves, visible light

B radio waves, ultraviolet, X-rays

C ultraviolet, infrared, microwaves

D visible light, gamma rays, radio waves

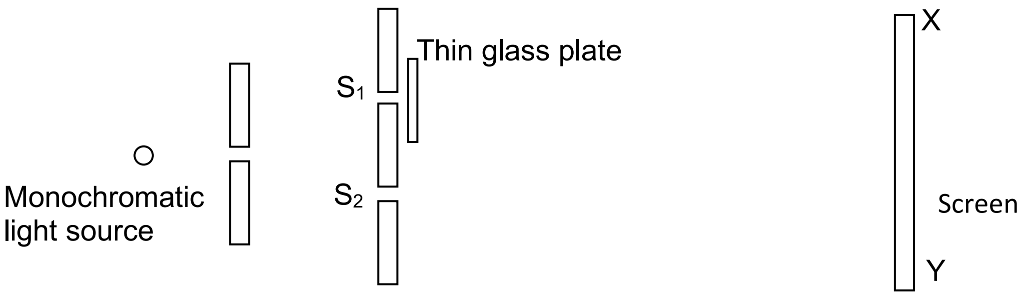
23 The least distance between two points of a progressive transverse wave which have a phase difference of $\frac{\pi}{3}$ rad is 0.050 m. If the frequency of the wave is 500 Hz, what is the speed of the wave?

A 75 m s^{-1} **B** 150 m s^{-1} **C** 250 m s^{-1} **D** 1670 m s^{-1}

24 A person is initially 10.0 m from a point source which emits energy uniformly in all directions at a constant rate. If the power of the source is to be doubled but the sound is to be as loud as before, at what distance should the person be from the source?

A 5.0 m **B** 7.1 m **C** 14 m **D** 20 m

25 The diagram below illustrates an experimental arrangement that produces interference fringes with a double slit.



When slit S_1 is covered with a very thin plate of glass as shown, the speed of light decreases when light passes through it. Which of the following is observed?

A The separation of the fringe increases

B The separation of the fringe decreases

C The fringe pattern moves towards X

D The fringe pattern moves towards Y

26 The angular resolution of a vertical slit for horizontally separated objects is 0.50×10^{-3} rad.

What is the angular resolution if the width of the slit is halved?

A 0.25×10^{-3} rad

B 0.50×10^{-3} rad

C 1.0×10^{-3} rad

D 2.0×10^{-3} rad

27 A diffraction grating has N lines per unit length and is placed at 90° to monochromatic light of wavelength λ.

What is the expression for θ, the angle to the normal to the grating at which the second order diffraction peak is observed?

A $\sin\theta = \dfrac{1}{2N\lambda}$

B $\sin\theta = \dfrac{2\lambda}{N}$

C $\sin\theta = \dfrac{N\lambda}{2}$

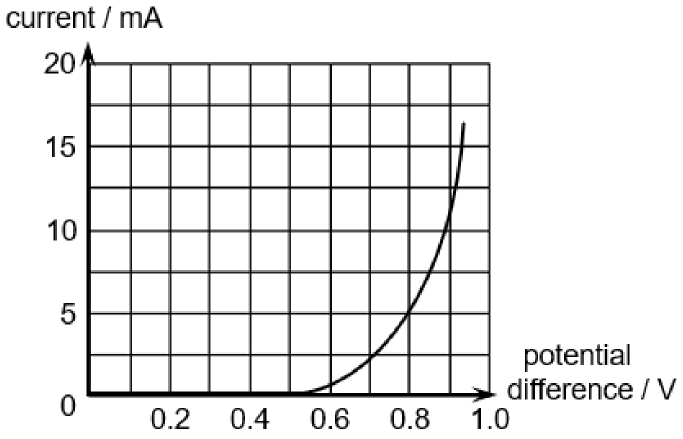
D $\sin\theta = 2N\lambda$

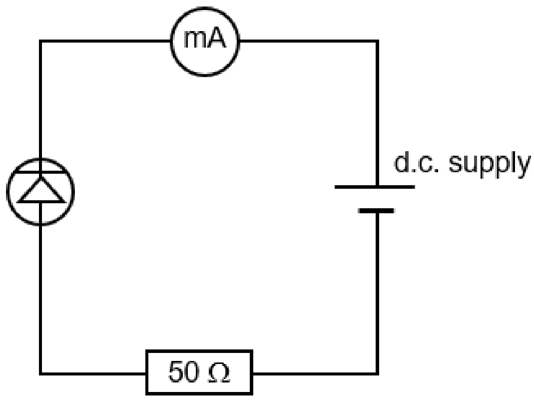
28 The resistance of a thermistor depends on its temperature and the resistance of a light-dependent resistor depends on the illumination.

Under what conditions will the effective resistance of a thermistor and a light-dependent resistor connected in series be the maximum?

	thermistor	light-dependent resistor
A	high temperature	high illumination
B	high temperature	low illumination
C	low temperature	high illumination
D	low temperature	low illumination

29 A diode with forward I-V charecteristics shown below is connected in series with a low-voltage variable d.c. power supply, a milli-ammeter of negligible internal resistance and a 50 Ω resistor as shown below.

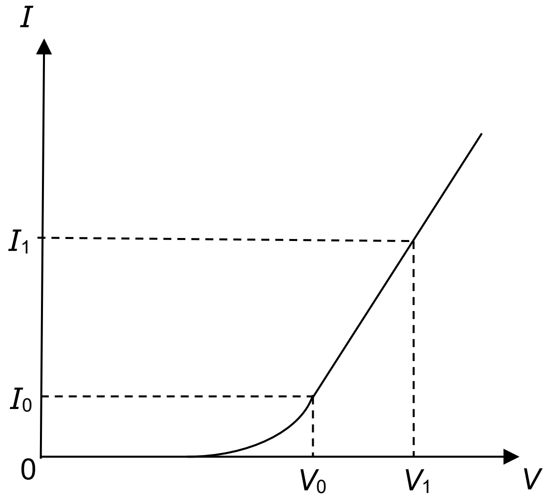




When the milliammeter shows 5.0 mA, the potential difference across the d.c. power supply is

A 0.25 V **B** 0.55 V **C** 0.80 V **D** 1.05 V

30 The graph below shows the I-V charecteristics of an electrical component.



What is the resistance of the component at potential difference V_1 and how does the resistance change, if at all, when the potential difference increases from V_0 to V_1?

	resistance at V_1	change between V_0 and V_1
A	$\frac{V_1 - V_0}{I_1 - I_0}$	no change
B	$\frac{V_1 - V_0}{I_1 - I_0}$	decreases
C	$\frac{V_1}{I_1}$	no change
D	$\frac{V_1}{I_1}$	decreases

End of Paper

H

NANYANG JUNIOR COLLEGE
JC 1 END OF YEAR EXAMINATION
Higher 2

CANDIDATE NAME	

CLASS		TUTOR'S NAME	

PHYSICS 9749/02

Paper 2 Structured Questions **30 September 2022**

1 hour

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class, Centre number and index number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 6
2	/ 7
3	/ 7
4	/ 20
Total	/ 40

This document consists of **14** printed pages.

Data

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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}

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pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal 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	$1/R = 1/R_1 + 1/R_2 + \ldots$
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radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Question 1 continues on the following page.

Answer **all** the questions in the spaces provided.

1 A speed-time graph for an MRT train travelling between two stations is shown in Fig. 1.1.

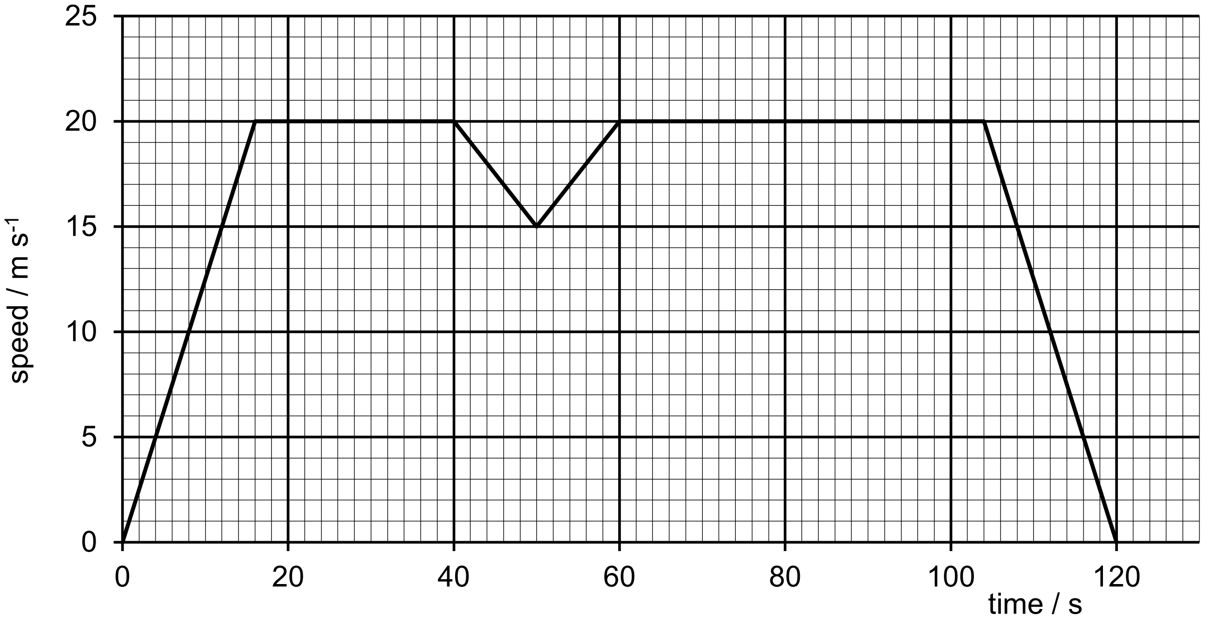

Fig. 1.1

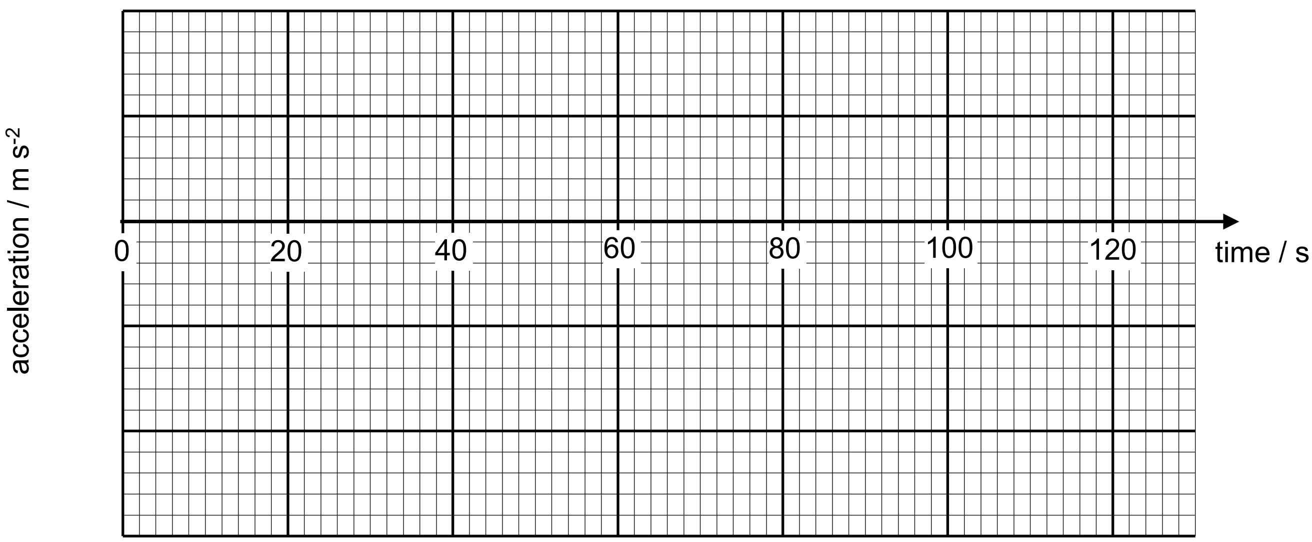

Fig. 1.2

(a) On Fig. 1.2, draw the corresponding acceleration-time graph. Label numerical values on the acceleration axis. [2]

(b) Calculate the distance travelled between the two stations.

distance = ... m [2]

(c) On Fig.1.3, sketch a distance-time graph of the train between the two stations from time t = 0 to t = 60 s. Numerical values on the distance axis are not required.

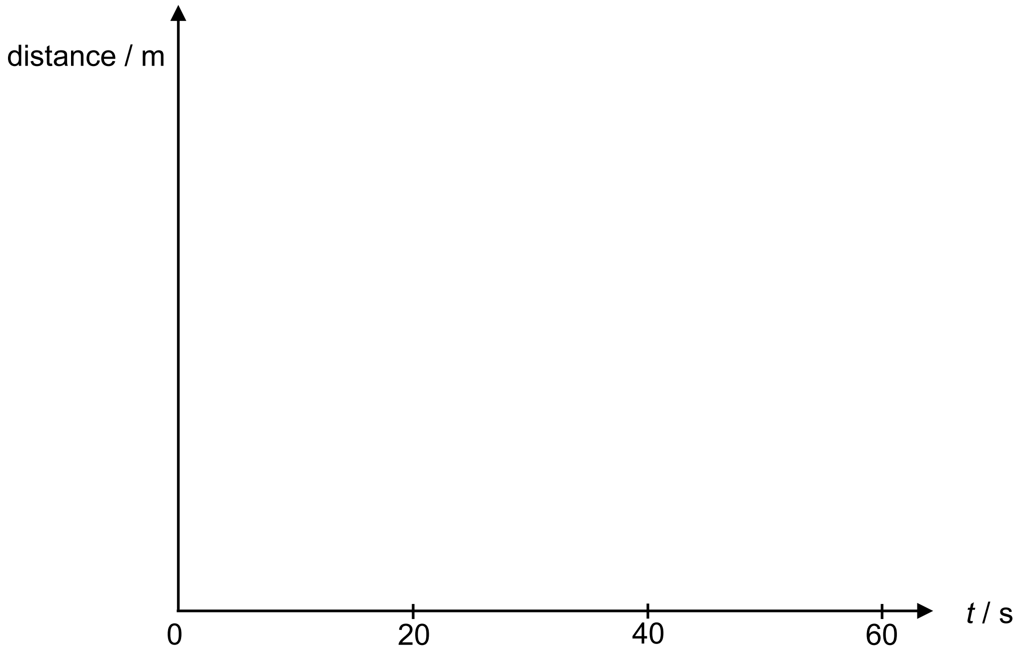

Fig. 1.3

[2]

[Total: 6]

2 Fig. 2.1 shows a ride in an amusement park. A cabin is mounted on one end of an arm, and a counterweight is attached to the opposite end. A man of mass 80 kg sits in the cabin, which moves at constant speed in a vertical circle of radius 8.0 m. In one minute, the man completes 14 revolutions. When the cabin is at the top of the circle, the man in it is upside down, as shown.

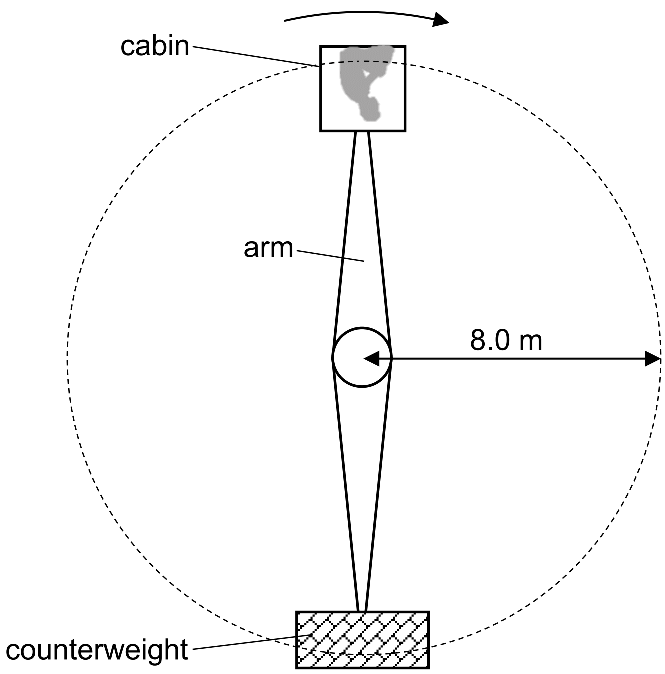

Fig. 2.1

(a) (i) Explain, for the man to remain on the floor of the cabin, why his centripetal acceleration at the top of the circle must be greater than the acceleration of free fall.

....

....

....

.... [2]

(ii) Calculate the centripetal acceleration of the man.

centripetal acceleration = ... m s^{-2} [2]

(b) Determine the minimum speed at the top of the circle for the man to remain on the floor of the cabin.

minimum speed = ... m s^{-1} [2]

(c) Fig. 2.2 shows the arm in a horizontal position.

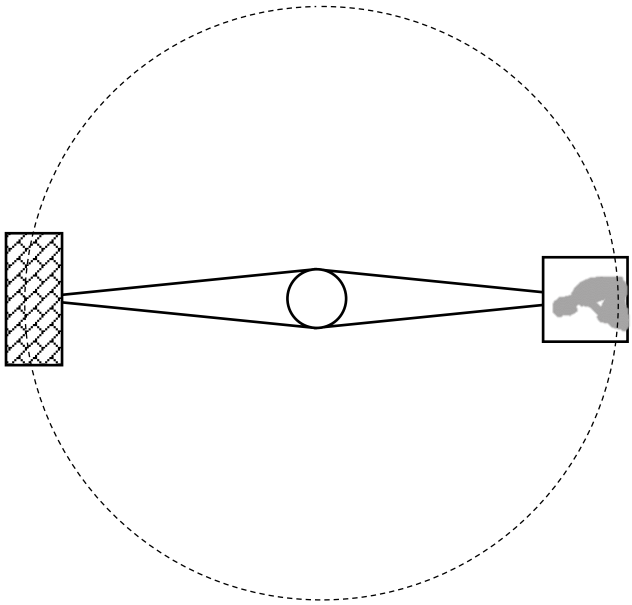

Fig. 2.2

On Fig. 2.2, draw an arrow to show the direction of the force *F* exerted by the floor of the cabin on the man. [1]

[Total: 7]

3 Fig. 3.1 shows a circuit consisting of a battery of electromotive force (e.m.f.) E, internal resistance r, an ammeter of negligible resistance and a variable resistor R.

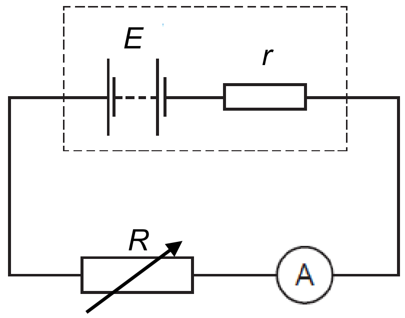

Fig. 3.1

Fig. 3.2 shows how current I in the circuit varies as the potential difference (p.d.) V across the variable resistor changes.

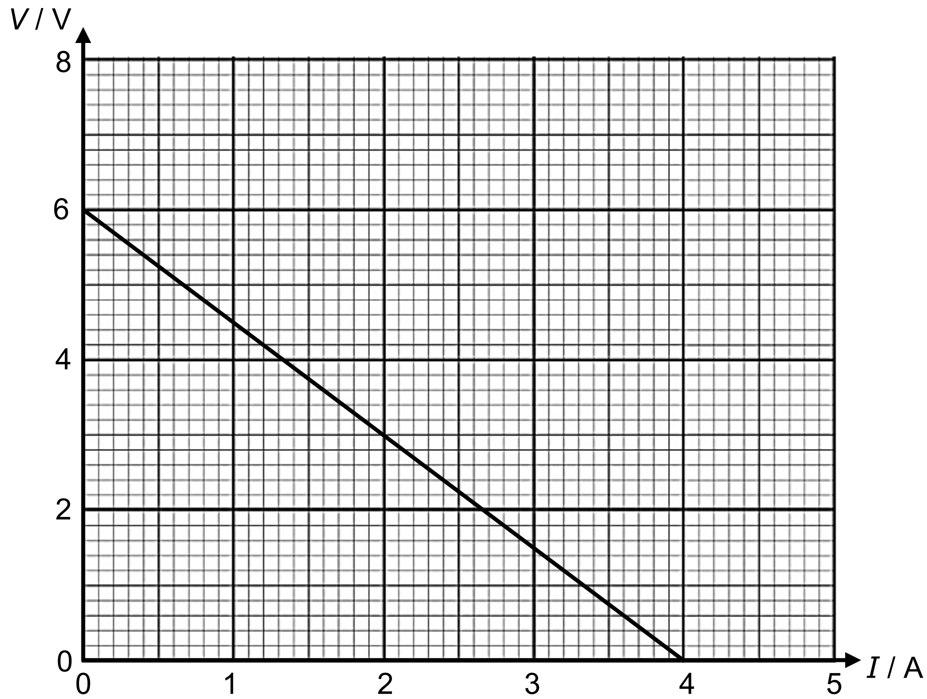

Fig. 3.2

(a) Explain the difference between p.d. and e.m.f. using energy considerations.

....

....

....

....[2]

(b) (i) State the value of E.

E = ... V [1]

(ii) Determine the power dissipated in the variable resister R when the current in the circuit is 1.2 A.

power dissipated = ... W [2]

(iii) Calculate the internal resistance r of the battery.

internal resistance r = ... Ω [2]

4 In the design of structures such as buildings, towers or bridges, an engineer may use a cantilever beam to allow for overhanging structure without external bracing. A cantilever is a beam supported only at one end.

The engineer will make calculations to ensure that the cantilever beam is strong enough to withstand any forces applied on it and ensure that there is not too much vertical deflection. An appropriate beam can then be chosen based on the maximum allowable load to be applied.

Fig. 4.1 illustrates a cantilever of length *L* loaded with a point load *P* at its end. A vertical deflection *y* of the free end of the cantilever will result from the loading.

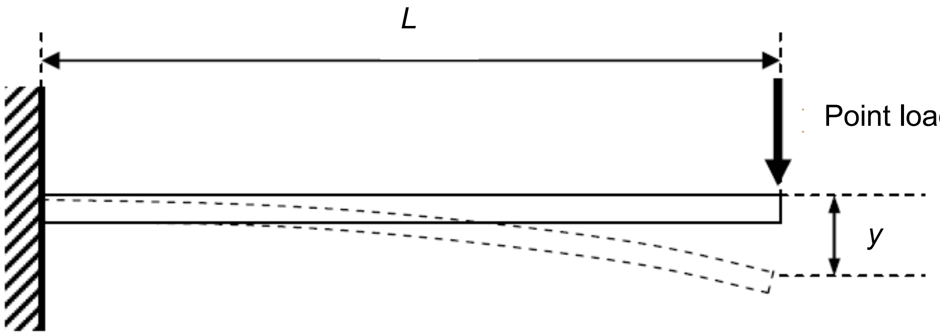

Fig. 4.1

A student was asked to investigate the behaviour of such an arrangement and found an expression for the vertical deflection of a loaded cantilever which was given by Equation 1:

$$y = \frac{4PL^3}{kbh^3} \quad \textbf{(Equation 1)}$$

where k is a constant

b is the breadth of cantilever

h is the height of cantilever

(a) The student first used two steel cantilevers to investigate the relationship between y, P and L. He first kept L constant and varied P to obtain the results as shown in Table 4.1.

Table. 4.1

P (N)	10	20	40	50		90
y (mm) for Cantilever A	1.9	3.9	7.8	9.9	13.8	17.7
y (mm) for Cantilever B	10.8	16.8	28.6	34.4		57.9

The graph showing the relationship between y and P for Cantilever A has been sketched on Fig. 4.2. Some of the data points of Cantilever B have also been plotted in Fig. 4.2.

(i) Complete Table. 4.1. [1]

(ii) On Fig. 4.2, complete the plot and sketch the graph to show the relationship between y and P for Cantilever B. [2]

Graph of Deflection *y* (mm) against Point Load *P* (N)

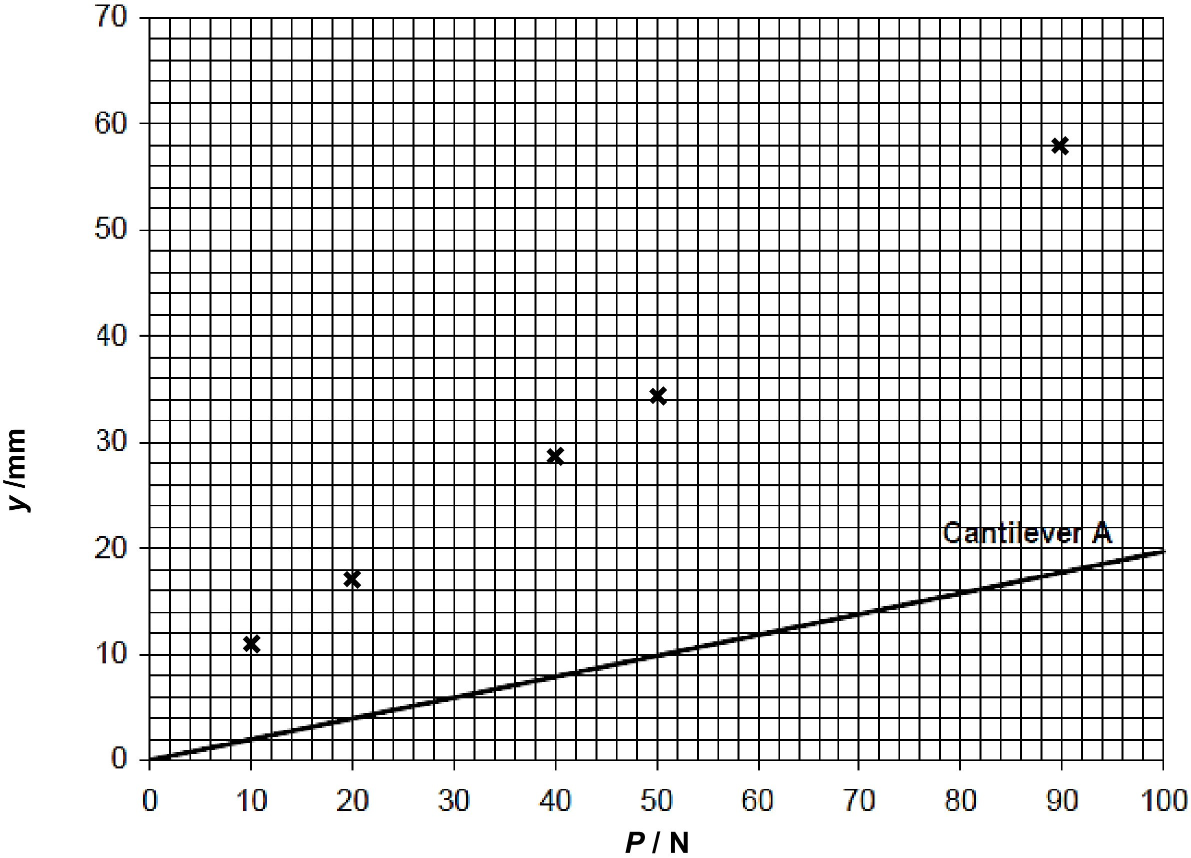

Fig 4.2

(iii) Explain how the graph of Cantilever A supports Equation 1.

....

....

.... [2]

(iv) Explain how the graph suggests that the measurements for Cantilever B were subjected to systematic error.

....

....

.... [2]

(v) Hence, estimate the amount of systematic error.

.... [1]

(vi) Suggest a reason how this error may have arisen.

....

.... [1]

(b) The student continued his investigation by keeping *P* constant and varying *L*, obtaining the results for Cantilever A as shown in Table 4.2.

Table. 4.2

L / m	1.0	1.5	2.0	2.5	3.0	3.5	4.0
y / mm	1.6	5.3	12.5	24.6	42.4	67.2	99.9

These results did not suggest direct proportionality between *y* and *L*. The student proceeded to sketch a graph showing the variation of lg *y* against lg *L* as shown in Fig. 4.3.

Graph of lg (*y*/mm) against lg (*L*/m)

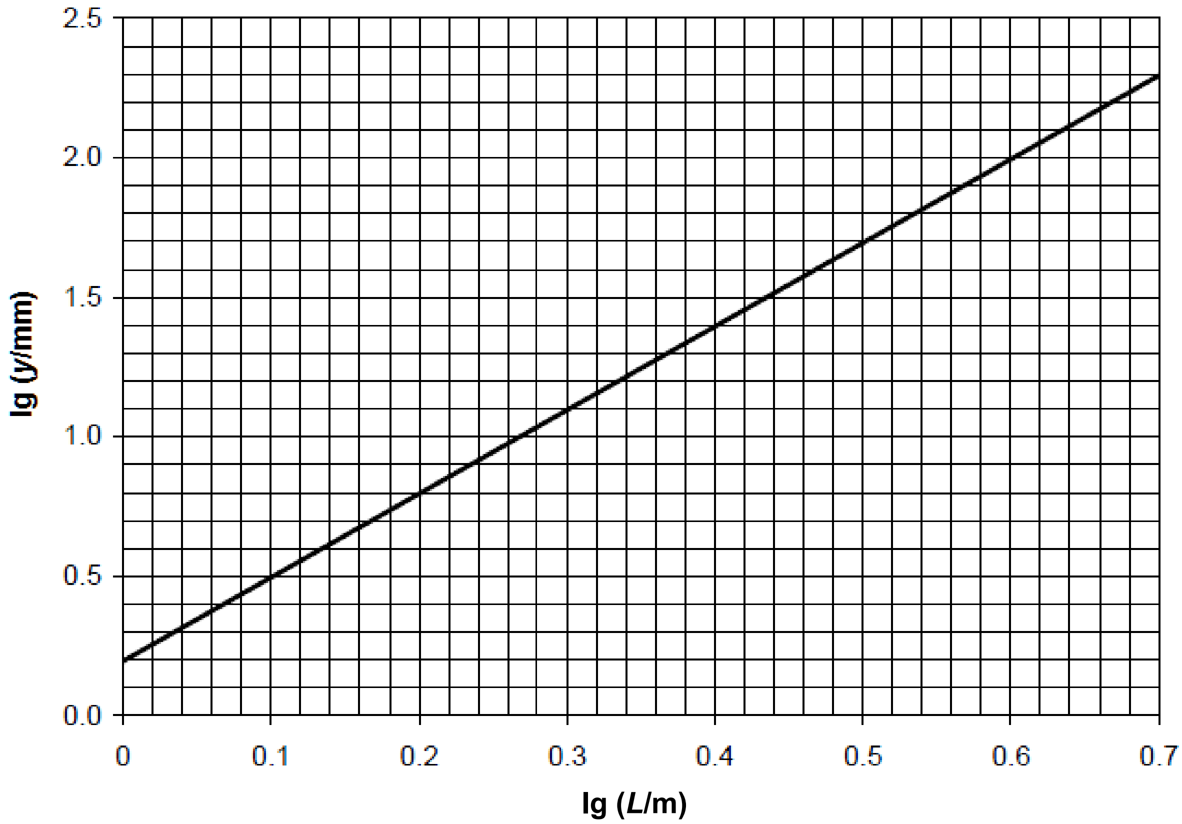

Fig. 4.3

(i) Determine the gradient of the graph. Show your working.

gradient = ... [2]

(ii) Hence discuss whether the data in Table 4.2 support Equation 1.

....

....

.... [2]

(c) After researching further into the subject, the student found out that the constant *k* in Equation 1 is known as the Young's Modulus which is a property of the material of the cantilever.

(i) Use Equation 1 to show that the S.I. unit of *k* is Pa.

[2]

(ii) A steel cantilever has breadth 0.12 m, height of 0.040 m and length of 2.0 m as shown in Fig. 4.4. If a point load of 1.0 kN is applied at the end, a vertical deflection of 2.0 cm was measured at the end.

Calculate the Young's Modulus of steel.

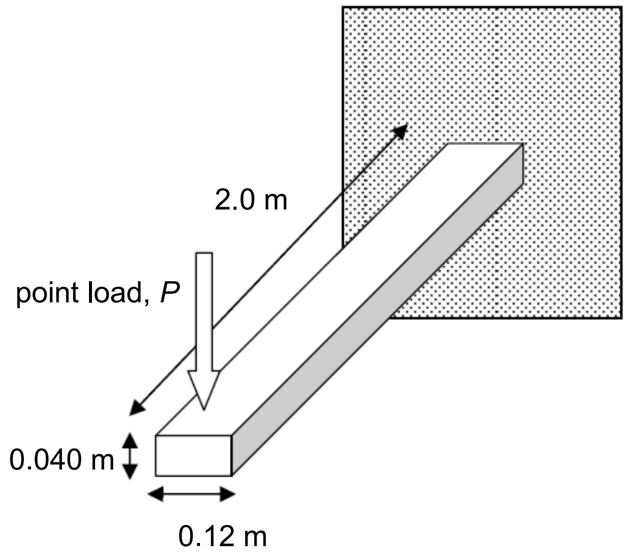

Fig. 4.4

Young's Modulus = ... Pa [2]

(iii) To increase the maximum allowable load for a given vertical deflection, the student proposed to orientate the direction of the steel cantilever in **(c)(ii)** differently to the new orientation as shown in Fig. 4.5.

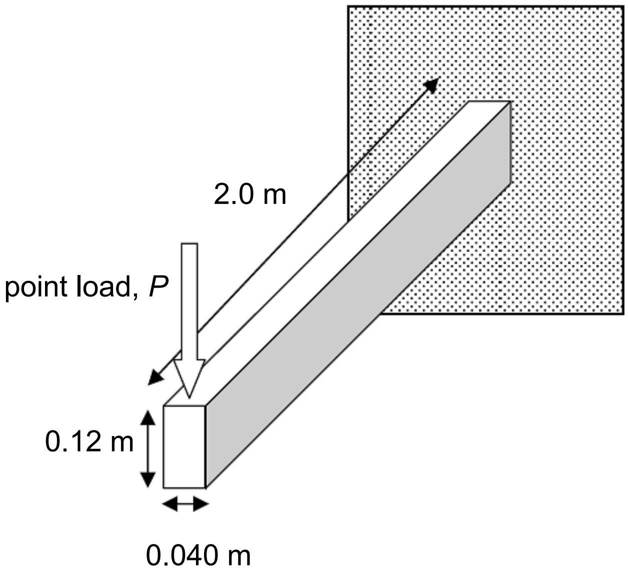

Fig. 4.5

Suggest, with reason, whether the student's proposal should be adopted.

....

....

....

.... [2]

(iv) In the construction industry, steel beams normally come in an "I" shape with a cross section as shown in Fig. 4.6.

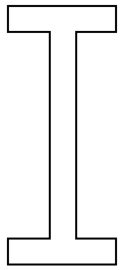

Fig. 4.6

Suggest a reason why they are designed this way instead of the rectangular cross section shown in **(c)(iii)**.

....

....

.... [1]

End of Paper

NANYANG JUNIOR COLLEGE
JC 1 END OF YEAR EXAMINATION
Higher 2

CANDIDATE NAME

CLASS

TUTOR'S NAME

PHYSICS 9749/03

Paper 3 Longer Structured Questions

27 September 2022

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class, Centre number and index number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 8
2	/ 4
3	/ 9
4	/ 9
5	/ 12
6	/ 9
7	/ 12
8	/ 12
Total	/ 75

This document consists of **19** printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ 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	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -Gm / r$
temperature	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal 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	$R = R_1 + R_2 + \ ...$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ ...$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** the questions in the spaces provided.

1 **(a)** There are two possible methods of measuring the volume of a cylindrical container. The first method is by measuring the inner diameter and the height of the container and calculating the volume. The readings are as follows:

Inner diameter = (1.98 ± 0.01) cm

Height = (4.5 ± 0.1) cm

(i) Calculate the volume with its associated uncertainty.

volume = ... ± .... cm^3 [3]

(ii) The second method is by filling the container with water, and then pouring the water out into a measuring cylinder. The measuring cylinder can read to the nearest cm^3. With reference to your answer in **(a)(i)**, state and explain which method would give a more precise value.

....

....

....[1]

(b) Three forces act on a stationary object with magnitude and direction as shown in the table.

Force	**Magnitude / N**	**Direction (anticlockwise from positive *x*-axis)**	***x*-component of force / N**	***y*-component of force / N**
F_1	10.0	53.1°		
F_2	15.6	140.2°	-12	10
F_3	14.6	344.1°		
$F_1 + F_2 + F_3$				

By resolving vectors into its *x*-component and *y*-component, complete the table. [4]

[Total: 8]

Question 2 continues on the following page.

2 An astronaut of mass *m* is at a distance of several metres from the entrance of his space shuttle. The astronaut is stationary relative to the space shuttle. He wishes to return to the space shuttle by means of his jetpack. The jetpack is attached to his body and it ejects a stream of exhaust gas when it is turned on.

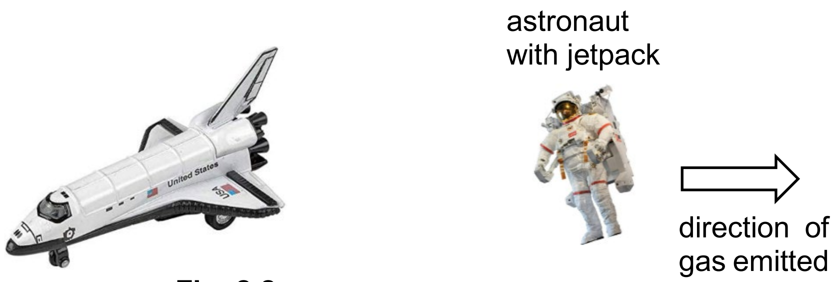

Fig. 2.2

(a) The jetpack emits gas in a rightward direction as shown in Fig. 2.2.

Use momentum considerations to explain why the jetpack produces a leftward force on the astronaut.

....

....

....

....[3]

(b) State and explain how the time taken for the astronaut to return to his space shuttle will change, if any, if his mass is greater than *m*.

....

....[1]

[Total: 4]

3 **(a)** **(i)** Explain the origins of *upthrust*.

....

....

....[1]

(ii) State the point which upthrust acts through.

....[1]

(b) A student conducted an experiment to study the buoyancy of a rock. He established that the rock has a mass of 500 g and a volume of 47.6 cm^3.

He put the rock into a rectangular transparent glass tank with a base of dimensions 15.0 cm by 15.0 cm, and poured in water till it reached a depth of 2.0 cm and the rock is completely submerged as shown in Fig. 3.1.

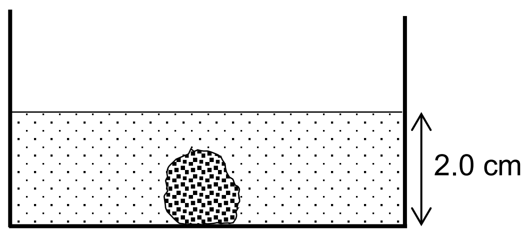

Fig. 3.1

(i) On Fig. 3.1, draw and label all forces acting on the rock. [2]

(ii) Determine the magnitude of the force exerted by the base of the tank on the rock. The density of water is 1.0 g cm^{-3}.

magnitude of force = ... N [2]

(c) A second liquid of density 13.5 g cm^{-3} is slowly poured in the tank until the rock just lifts off the bottom of the tank as shown in Fig. 3.2.

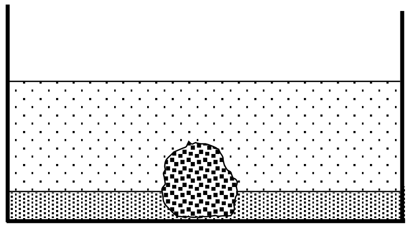

Fig. 3.2

Determine the volume of the second liquid displaced by the rock at this instant.

volume of second liquid displaced = ... cm^3 [3]

[Total: 9]

4 A particular type of slide for children in a theme park is called a 'drop slide'. This is a slide in which the first part of the fall is vertical. Fig. 4.1 shows a child of mass 28 kg on a drop slide.

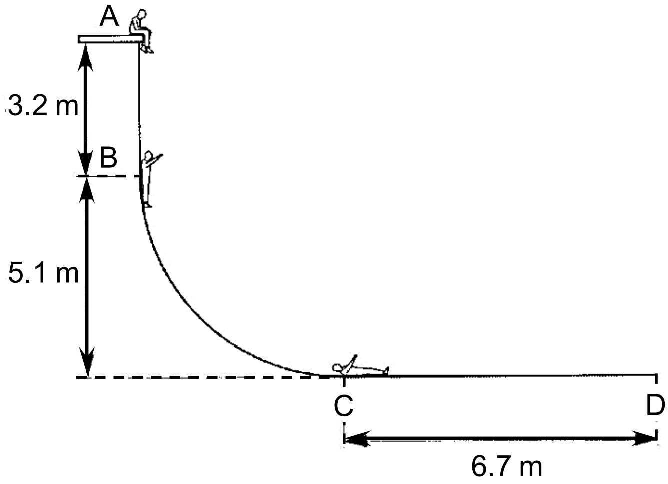

Fig. 4.1

The child drops from A to B, a distance of 3.2 m, before reaching the surface of the slide and then travels around a bend from B to C, while falling a further vertical distance of 5.1 m. At C the child's speed is the same as it was at B. After this the child travels 6.7 m horizontally before stopping at D.

(a) (i) Calculate the child's speed at B.

speed = ... m s^{-1} [2]

(ii) State one assumption made in this calculation.

....

....[1]

(b) Determine the loss of gravitational potential energy of the child between B and C.

loss of gravitational potential energy = ... J [2]

(c) Explain how it is possible for the child's speed to be the same at B and at C.

....

....

....[2]

(d) Calculate the average frictional force slowing the child between C and D.

force = ... N [2]

[Total: 9]

5 Fig. 5.1, which is not to scale, shows how the gravitational potential between the surface of the Moon, A, and the surface of the Earth, B, varies along the line joining their centres. At point P, the gravitational potential is a maximum.

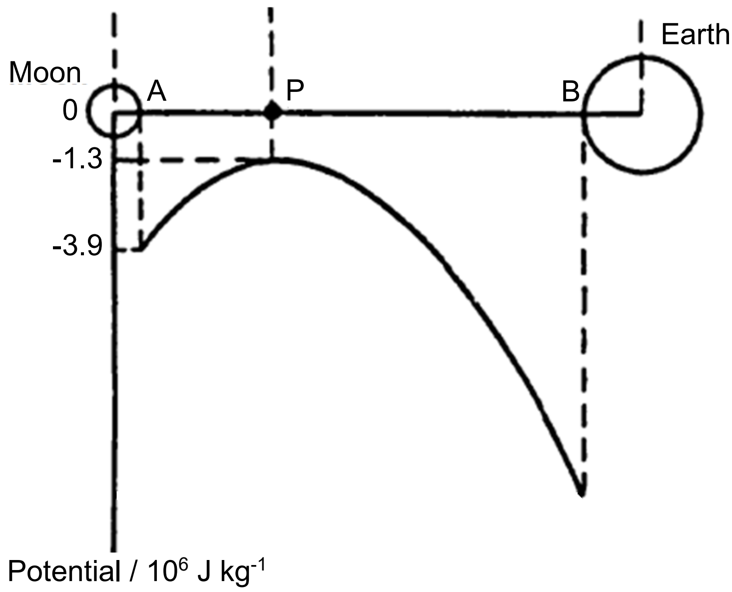

Fig. 5.1

The distance between the centres of the Moon and the Earth is about 470 000 km.

The table below gives approximate values of the radius *R* and mass *M* of the Earth and Moon.

Table 5.1

	R / 10^6 m	M / 10^{24} kg
Earth	6.4	6.0
Moon	1.7	0.074

(a) Define *gravitational potential* at a point.

....

....[1]

(b) Explain why the values of gravitational potential in Fig. 5.1 are negative.

....

....

....[2]

(c) Calculate the gravitational potential at point B.

gravitational potential = ... J kg^{-1} [2]

(d) **(i)** State, in words, how the magnitude of the resultant gravitational force on a mass at any point between the Moon and the Earth could be deduced from Fig. 5.1.

....

....

....[1]

(ii) Describe how the resultant gravitational force on a mass changes as it travels from the Moon to the Earth along line AP.

....

....

....[2]

(e) **(i)** Determine the minimum speed required for a meteorite leaving the Moon's surface to reach point P.

minimum speed = ... m s^{-1} [2]

(ii) Explain why the minimum speed required for the meteorite leaving the moon's surface to reach the Earth is the same as that required to reach P.

....

....

....

....

....[2]

[Total: 12]

6 A cylindrical tube, containing some sand, floats upright in a liquid of density ρ as shown in Fig. 6.1.

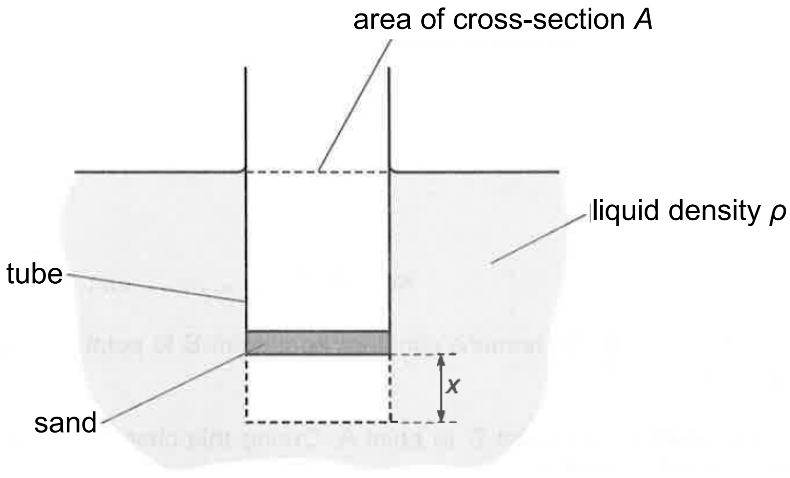

Fig. 6.1

The tube has a cross-sectional area A. The total mass of the tube and sand is M. The tube is displaced vertically downwards and then released. The tube oscillates vertically.

(a) The displacement of the tube from its equilibrium position is x. Show that acceleration of the tube at displacement x is given by

$$a = -\left(\frac{\rho A g}{M}\right)x$$

Explain your working.

[3]

(b) Fig.6.2 shows the variation with time t of the vertical displacement x of the tube.

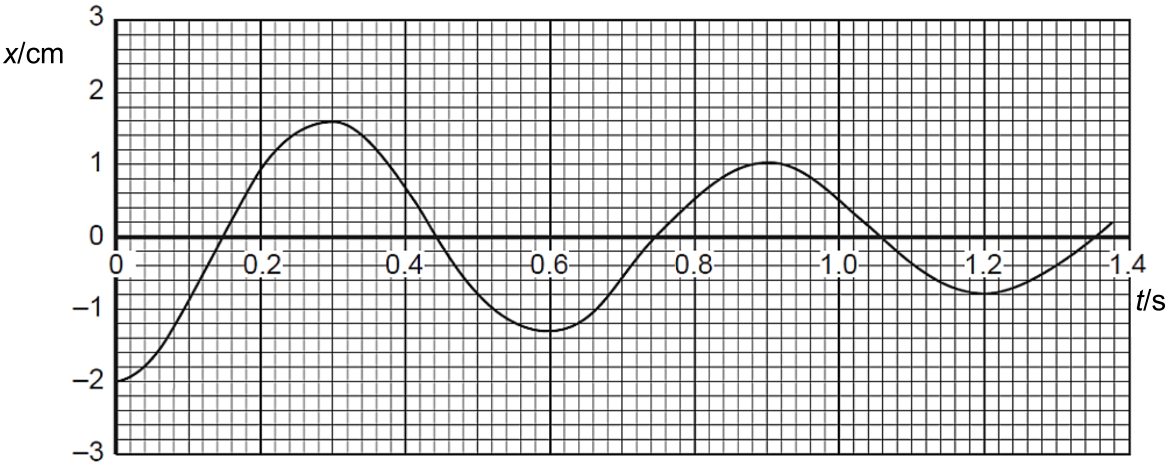

Fig. 6.2

(i) The tube has an external diameter of 2.5 cm and is floating in a liquid of density 1050 kg m^{-3}. By using equation in **(a)** and Fig. 6.2, calculate the mass of the tube and its contents.

mass = ... kg [3]

(ii) Explain how Fig. 6.2 indicate that the oscillations are damped.

....

....[1]

(c) State and explain how the displacement - time relationship of the tube in Fig. 6.2 will change when it is submerged into a new liquid of higher density.

....

....

....

....[2]

[Total: 9]

7 **(a)** The apparatus illustrated in Fig. 7.1 is used to demonstrate two-source interference using light.

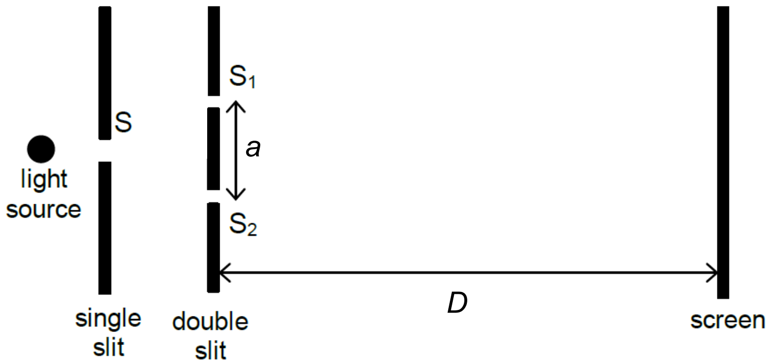

Fig. 7.1 (not to scale)

The separation of the two slits in the double slit arrangement is a and the interference fringes are viewed on a screen at a distance D from the double slit. When light of wavelength λ is incident on the double slit, the separation of the bright fringes on the screen is x.

(i) For a typical laboratory setting, suggest a suitable value for the separation, a, of the slits in the double slit.

....[1]

(ii) Describe the effect, if any, on the separation and on the maximum brightness of the fringes when the following changes are made independently of each other.

1. The distance D is increased to $3D$, while keeping a and λ constant.

....

....

....[2]

2. The wavelength λ is increased to 2λ, while keeping a and D constant.

....

....

....[2]

3. The intensity of the light incident on the double slit is increased, while keeping λ, a and D constant.

....

....

....[2]

(b) A glass tube, closed at one end, has fine dust sprinkled along its length. A sound source is placed near the open end of the tube, as shown in Fig. 7.2.

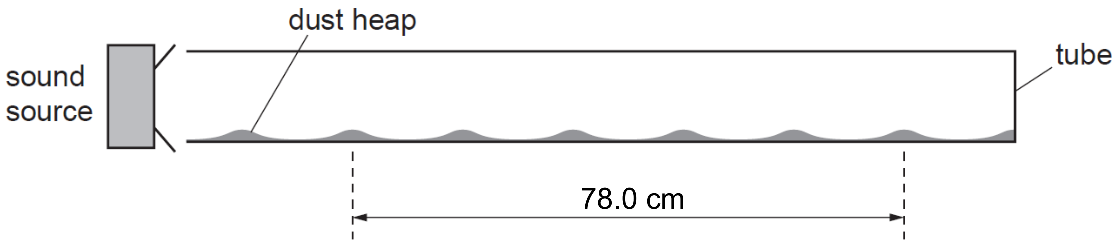

Fig. 7.2

The frequency of the sound emitted by the source is varied and, at one frequency, the dust forms small heaps in the tube.

(i) One frequency at which heaps are formed is 1.07 kHz. The distance between six heaps, as shown in Fig. 7.2, is 78.0 cm.

Calculate the speed of sound in the tube.

speed = ... m s^{-1} [2]

(ii) The wave in the tube is a stationary wave. Explain, by reference to the formation of a stationary wave, what is meant by the speed calculated in **(b)(i)**

....

....

....

....

....[3]

[Total: 12]

8 A student investigates the vertical oscillations of a solid cylinder which floats in cooking oil. Fig. 8.1 shows a cylinder of radius r.

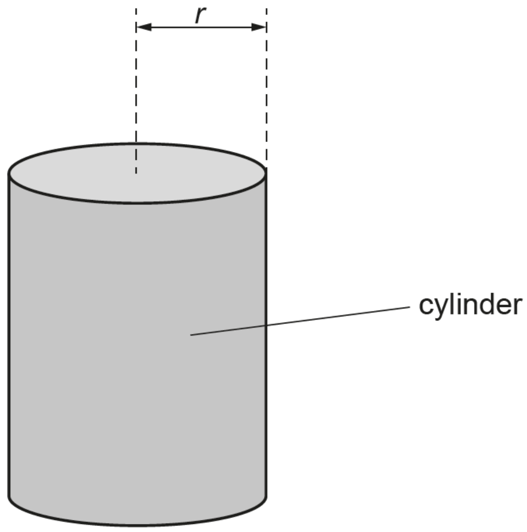

Fig. 8.1

The student places the cylinder of mass m in the oil. The cylinder is displaced vertically from its equilibrium position and released so that it oscillates. The period T of the oscillations is determined.

A number of cylinders of different mass are available.

It is suggested that the relationship between T and m is

$$T = 2\sqrt{\frac{\pi m}{\sigma K r^2}}$$

where σ is the density of the oil and K is a constant.

Design a laboratory experiment to test the relationship between T and m.
Explain how your results could be used to determine a value for K.

You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to:

- the procedure to be followed
- the measurements to be taken
- the control of variables
- the analysis of the data
- any safety precautions to be taken.

Diagram

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[Total: 12]

End of Paper

NANYANG JUNIOR COLLEGE
JC 1 END-OF-YEAR EXAMINATION
Higher 2

CANDIDATE NAME			
CLASS		TUTOR'S NAME	

PHYSICS 9749/01

Paper 1 Multiple Choice **4 October 2021**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class and tutor's name in the spaces at the top of this page.

There are **thirty** questions on this paper. Answer **all** 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 Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **14** printed pages.

1 Which list of quantities contains only one vector?

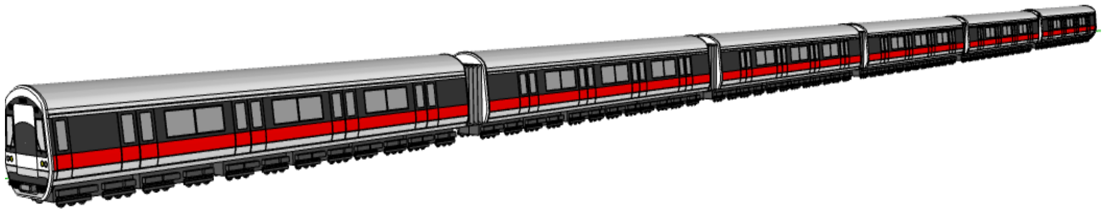
A density, electric charge, power

B speed, impulse, upthrust

C current, torque, pressure

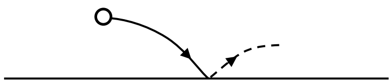
D gravitational potential, moment of force, displacement

2 What is the order of magnitude of the volume of an SMRT train along the North−South line?

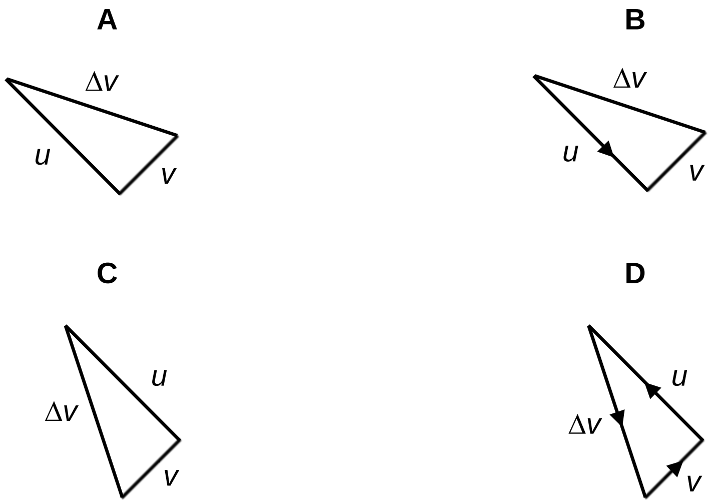


A 10^1 m^3 B 10^3 m^3 C 10^5 m^3 D 10^7 m^3

3 A ball hits the floor with velocity u. It rebounds with velocity v which is half its initial speed.



Which diagram correctly indicates the change in velocity Δv of the ball?

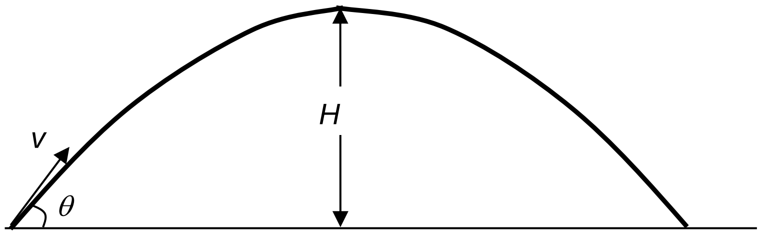


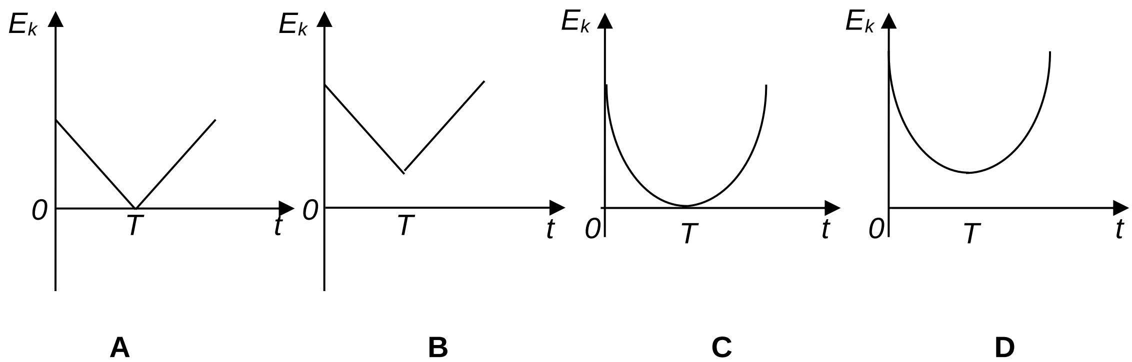
4 A stone is thrown vertically downwards from the edge of a cliff with an initial speed of 15 m s^{-1}. Just before hitting the ground, it has a final speed of 45 m s^{-1}.

If the stone were thrown horizontally outwards from the top of the cliff with the same initial speed, what is its final speed just before hitting the ground?

A 34 m s^{-1} B 37 m s^{-1} C 45 m s^{-1} D 48 m s^{-1}

5 A ball was projected from the ground with a velocity v at an angle θ to the horizontal. It traces a parabolic path as shown below, reaching a maximum height H after a time T and then falls back down to the ground. Air resistance may be assumed to be negligible. Which graph best shows the variation of kinetic energy E_k of the ball with time t?



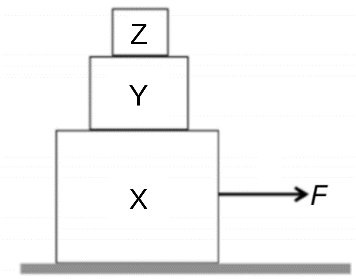


6 A boy holding a ball is standing on the floor of a lift. The lift then starts accelerating from rest at 4.9 m s^{-2} upwards. After 2.0 s, he releases the ball at 1.2 m with respect to the floor of the lift. At the moment the ball is released, the lift comes to a sudden complete stop.

What is the time taken for the ball to reach the floor of the lift?

A 0.49 s **B** 1.1 s **C** 2.1 s **D** 3.0 s

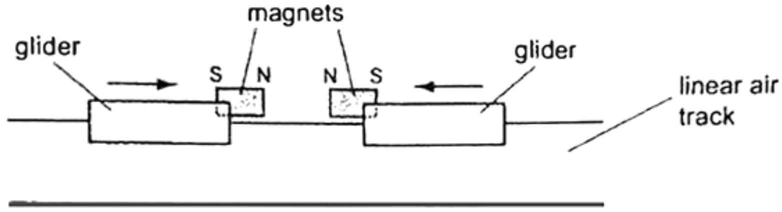
7 Three boxes X, Y and Z with masses 3M, 2M and M respectively are stacked on top of each other on a smooth floor. A horizontal force F is applied to box X as shown, causing the boxes to accelerate rightwards together.



If the friction between boxes X and Y is f_1, and the friction between boxes Y and Z is f_2, which of the following gives the correct ratio $F : f_1 : f_2$?

A 3 : 2 : 1 **B** 3 : 1 : 1 **C** 6 : 5 : 3 **D** 6 : 3 : 1

8 Two gliders of equal mass, each fitted with a magnet, move along a linear air track without friction.



They move towards each other with equal initial speeds. As they approach, the magnets repel each other. Each glider decelerates to rest, then accelerates and moves off in the opposite direction.

Which statement is true throughout the whole motion?

A Kinetic energy is conserved because none is converted to heat.

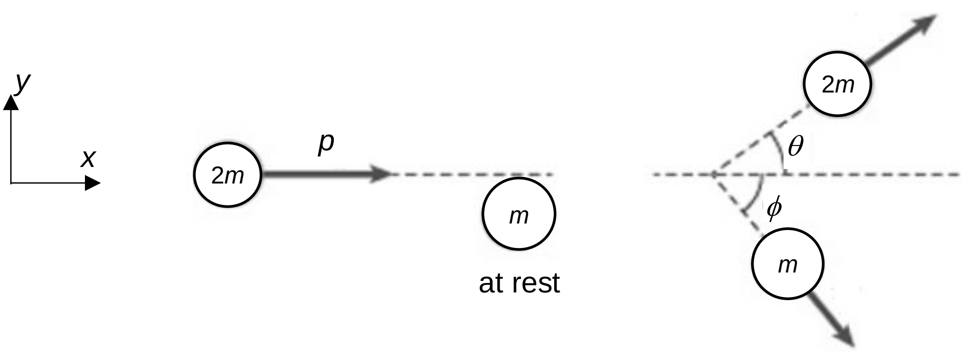
B Kinetic energy is not conserved because neither moves at constant speed.

C Momentum is conserved because no external force acts on the gliders.

D Momentum is not conserved because at the instant of closest approach, both gliders are at rest.

9 A puck of mass $2m$ with momentum p in the x-direction is travelling along a frictionless surface of an air hockey table. It strikes the edge of another puck of mass m which is initially at rest, resulting in an elastic collision. The diagrams below show the top view of the motion of the pucks before and after the collision.

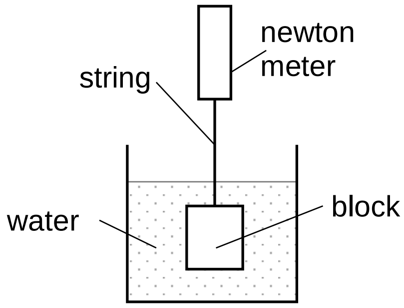
Before collision After collision



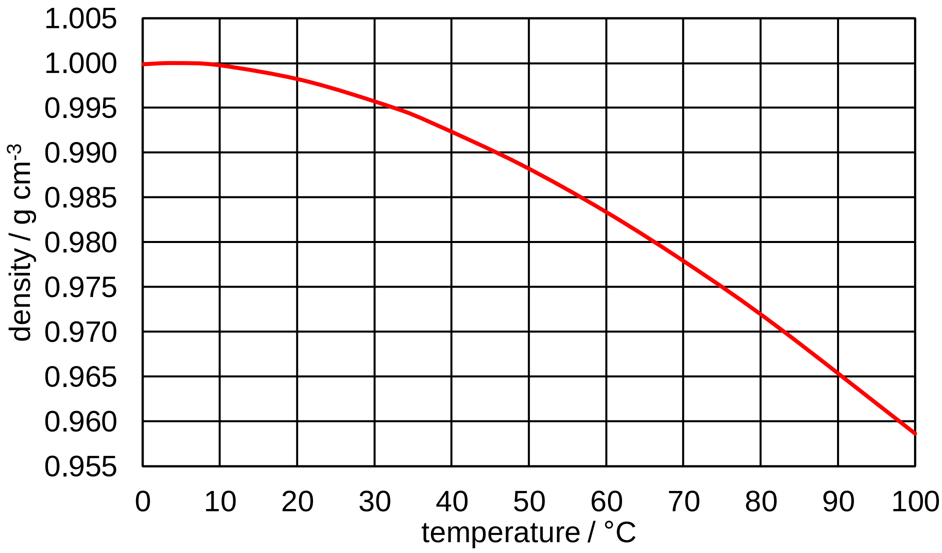
Which of the following gives the correct expressions for the magnitude of the total momentum in the x-direction and kinetic energy of the pucks after the collision?

	Total momentum in the x-direction	Total kinetic energy
A	$p\,(\cos\theta + \cos\phi)$	$\dfrac{p^2}{4m}$
B	$p\,(\sin\theta + p\sin\phi)$	$\dfrac{p^2}{2m}$
C	p	$\dfrac{p^2}{4m}$
D	p	$\dfrac{p^2}{2m}$

10 A block of volume 1000 cm^3 is attached to a newton meter by an inextensible string and is fully submerged in water of temperature 40 °C. The newton meter reads 0.149 N.



The graph below shows the relationship between the density and the temperature of water.

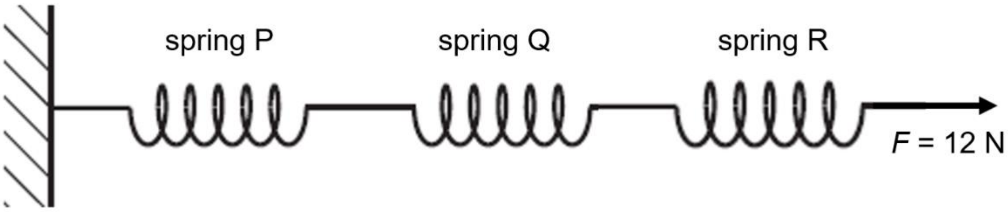


The temperature of the water is then changed.

What is the new temperature of the water if the reading on the newton meter changes to read 0.321 N?

A 15 °C **B** 50 °C **C** 75 °C **D** 90 °C

11 Three light springs P, Q and R with spring constants k_P = 2.0 N m^{-1}, k_Q = 3.0 N m^{-1} and k_R = 6.0 N m^{-1} respectively are connected in series as shown below.



When a force F = 12 N is applied as shown in the diagram above, the springs extend by x_P, x_Q and x_R respectively.

What is the ratio of the extensions $x_P : x_Q : x_R$?

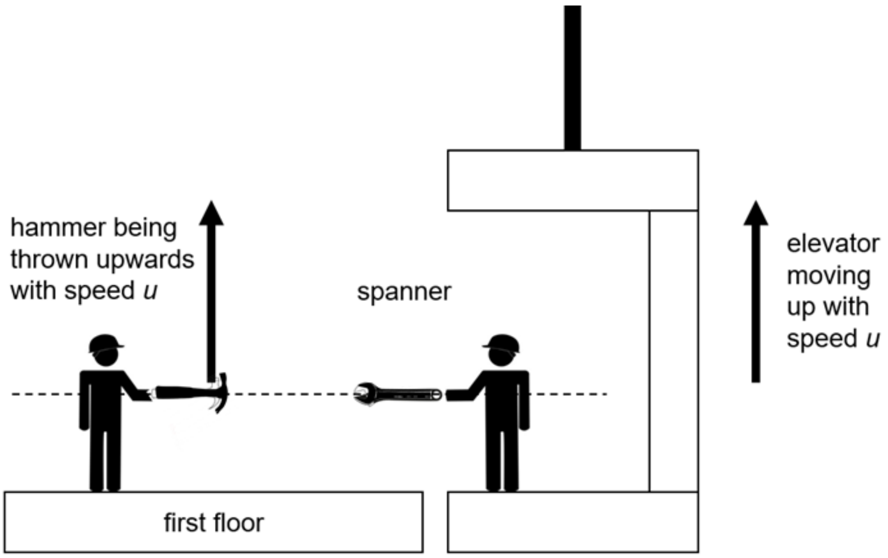
A 1 : 2 : 3

B 2 : 3 : 6

C 3 : 2 : 1

D 6 : 3 : 2

12 At a construction site, a workman is in an elevator moving upwards at a constant speed u. When the elevator is level with the first floor, he lets go of a spanner. At the same instant, a second workman standing on the first floor throws a hammer upwards with initial speed u. Assume that both the spanner and the hammer are being released from the same height above the first floor.



Which of the following statements correctly describes the motion of the hammer and the spanner?

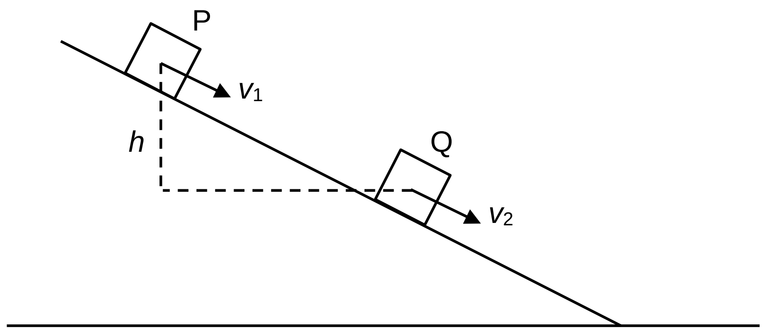
A The spanner lands on the first floor before the hammer does.

B Both the spanner and hammer lands on the first floor at the same time.

C The spanner travels a longer distance than the hammer before landing on the first floor.

D The spanner and the hammer both move upwards, but the spanner rises more slowly than the hammer.

13 A box of mass m slides down a rough incline. At position P, its velocity is v_1 while at position Q, a vertical distance h down the incline, its velocity is v_2.



What is the expression for the energy lost due to friction in going from position P to Q?

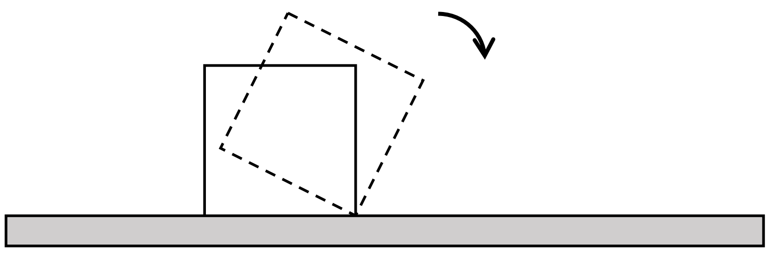
A $\frac{1}{2}m(v_2 - v_1)^2 - mgh$

B $mgh - \frac{1}{2}m(v_2 - v_1)^2$

C $mgh + \frac{1}{2}m(v_2^{\,2} - v_1^{\,2})$

D $mgh - \frac{1}{2}m(v_2^{\,2} - v_1^{\,2})$

14 A uniform cube of mass m and side d rests on a horizontal surface with one of its six faces as the base. A force acts on it such that it flips over and rests on an adjacent face as the new base.



The minimum amount of work required to perform this is

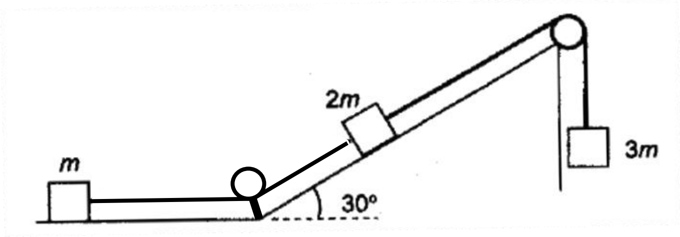
A 0.21 mgd

B 0.41 mgd

C 0.71 mgd

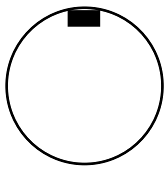
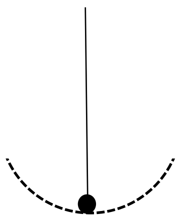
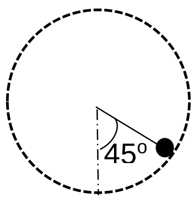
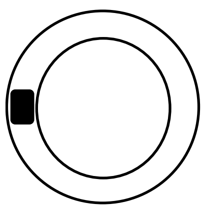
D 0.91 mgd

15 The diagram shows three masses of mass m, $2m$ and $3m$ connected by a light string over two light, frictionless pulleys. The objects are released from rest where mass $3m$ moves down by a distance x. What will be the total kinetic energy of the three masses?



A mgx **B** $2mgx$ **C** $3mgx$ **D** $4mgx$

16 Which of the following is correct?

	Scenario	Centripetal Force provided by
A	Cart at the top when going around a vertical roller coaster loop 	Normal contact force of track on cart
B	Stone attached to a rope is at the bottom when swung in a vertical plane 	Tension in rope
C	Pendulum bob at an angle of 45° to the vertical and swinging in vertical plane 	Weight of pendulum
D	Car moving along a roundabout Top view 	Frictional force at the wheels directed towards centre of circular path

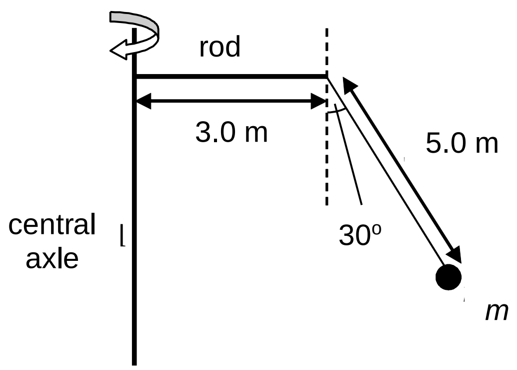
17 A car of mass m moving at a constant speed v passes over a humpback bridge of radius curvature r.

Given that the car remains in contact with the road, what is the net force exerted by the car on the road when it is at the top of the bridge?

A mg **B** $\frac{mv^2}{r} - mg$ **C** $mg - \frac{mv^2}{r}$ **D** $\frac{mv^2}{r} + mg$

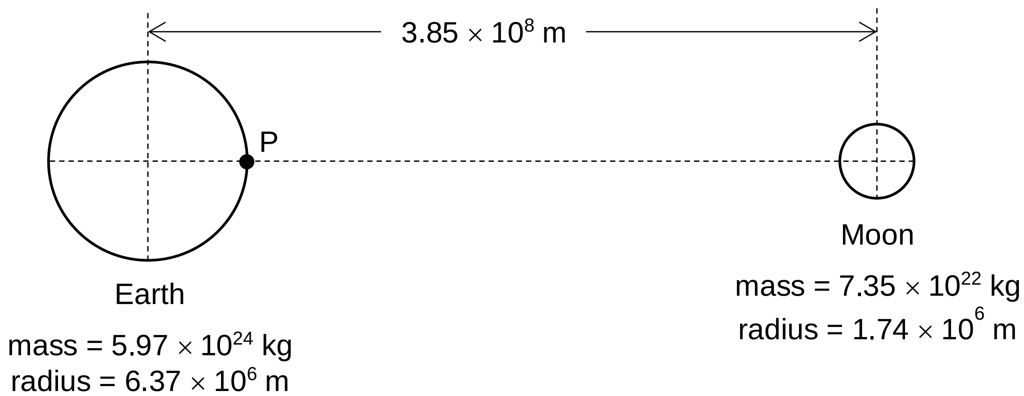
18 A mass m, attached to one end of an inextensible string of length 5.0 m, is made to move in a horizontal circle as the central axle and horizontal rod is rotated. In a particular circular motion, the string makes an angle of 30° with the vertical as shown below.

What is the period of the mass's motion about the central axle?



A 1.0 s **B** 3.5 s **C** 4.8 s **D** 6.2 s

19 The figure below shows a point P on the surface of the Earth that lies on the line joining the centres of mass of the Earth and the Moon which are 3.85×10^8 m apart. The masses of the Earth and the Moon are 5.97×10^{24} kg and 7.35×10^{22} kg respectively, and the radii of the Earth and the Moon are 6.37×10^6 m and 1.74×10^6 m respectively.



The resultant gravitational field strength at P is 9.81 N kg^{-1}. What percentage of this is due to the gravitational field of the Moon?

A – 20% **B** – 0.00035% **C** + 0.021% **D** + 14%

20 A polar satellite orbits around the Earth such that it is able to scan the surface of the Earth from the North pole to the South pole in 55 minutes. Given that the mass of Earth is 6.0×10^{24} kg, what is the radius of the orbit of the satellite?

A 5.0×10^{5} m **B** 4.8×10^{6} m **C** 7.6×10^{6} m **D** 2.1×10^{10} m

21 An object is projected from the surface of the Earth towards the surface of the Moon. The table below shows the potential at five points along its path.

Points	P	Q	R	S	T
Distance from surface of Earth / 10^{8} m	3.20	3.30	3.40	3.50	3.60
Potential / MJ kg^{-1}	–1.303	–1.284	–1.276	–1.289	–1.352

Which of the following statements is true?

A The gravitational field strength is weakest at R.

B The gravitational potential energy of the object is lowest at R.

C The gravitational force on the object is greatest at R.

D The gravitational potential gradient is greatest at R.

22 The displacement in metres s of an oscillator can be expressed in terms of time in seconds t as

$$s = 5.0 \cos (4.0\pi\, t) + 2.5.$$

Which of the following correctly gives the amplitude and period of the oscillations?

	Period / s	Amplitude / m
A	0.25	2.5
B	0.50	5.0
C	2.0	7.5
D	4.0	10.0

23 Which of the following statements about oscillations is correct?

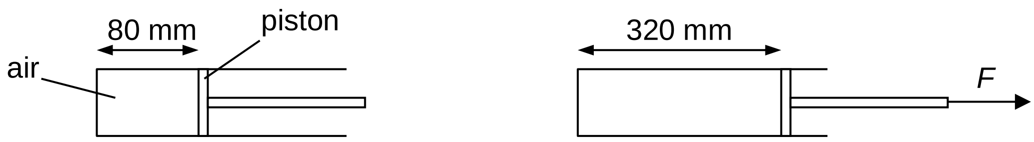
A In the absence of a driver, a damped oscillator oscillates at its natural frequency.

B A freely oscillating object does not experience any external forces.

C When an oscillator is critically damped, there is resonance when the frequency of the driver is equal to its natural frequency.

D The driver of a forced oscillation is itself an oscillator.

24 Air is enclosed in a cylinder by a gas-tight, frictionless piston of cross-sectional area 3.0×10^{-3} m^2. When atmospheric pressure is 100 kPa, the piston settles 80 mm from the end of the cylinder. The piston is then pulled out until it is 320 mm from the end of the cylinder and is held there. The temperature of the air in the cylinder returns to its original value.



What is the force F required to hold the piston in its new position?

A 75 N **B** 100 N **C** 225 N **D** 300 N

25 A piece of metal P, of mass m, at 0°C, is placed into a cavity in a block of metal Q, of mass $5m$, at 100°C. The thermal equilibrium temperature is 75°C.

Assuming that there is no heat loss to the surroundings, the ratio of the specific heat capacity of P to the specific heat capacity Q is

A 0.200 **B** 0.250 **C** 0.600 **D** 1.67

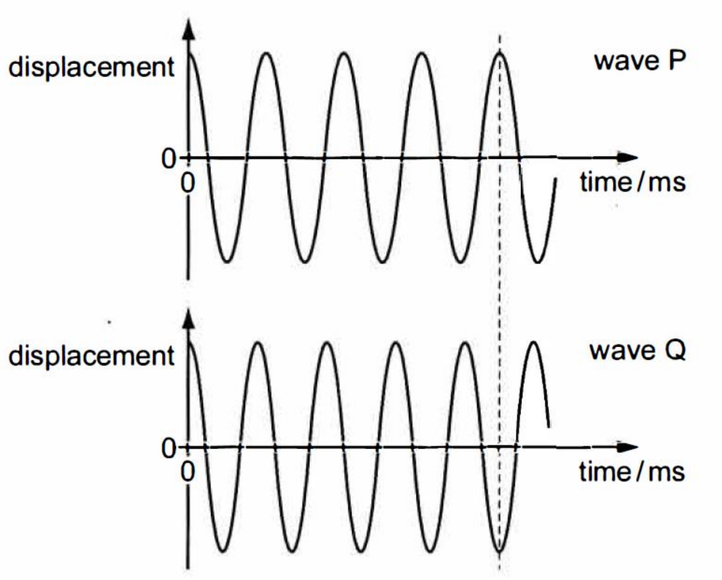
26 When an ideal monatomic gas absorbs 1000 J of heat and does 500 J of work, its temperature changes by T_1.

When the same gas absorbs 2000 J of heat and 500 J of work is done on it, its temperature changes by T_2.

Assuming that there is no heat loss to the surroundings, the ratio of T_1 to T_2 is

A 0.200 **B** 0.333 **C** 0.600 **D** 1.00

27 The diagram shows the displacement-time graphs of two pure sound waves P and Q at a point in space. The graphs have the same scales for the time axes.



The frequency of Q is 125 Hz. The waves are in phase at time t = 0.

At what time are the waves next in phase?

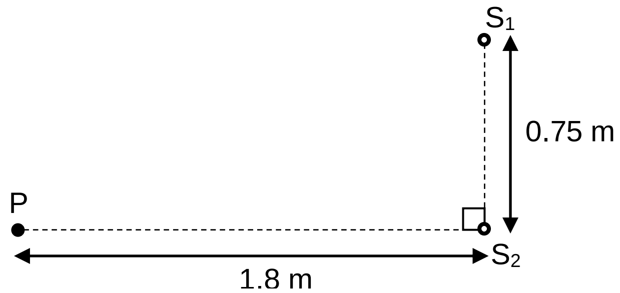
A 32 ms **B** 36 ms **C** 64 ms **D** 72 ms

28 The loudness of a constant-frequency sound wave with initial amplitude a and intensity I increases such that its intensity is doubled.

What is the increase in amplitude in terms of a?

A a **B** $\sqrt{2}\,a$ **C** $\left(\sqrt{2}-1\right)a$ **D** $3\,a$

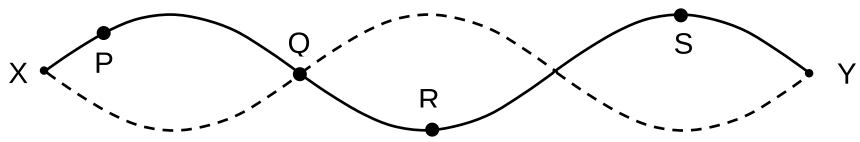
29 Two wave generators S_1 and S_2 produce water waves of wavelength 0.30 m. They are placed 0.75 m apart in a water tank and a detector P is placed on the water surface 1.8 m from S_2 as shown.



When operated alone, each generator produces a wave at P with an amplitude A. When both generators are operating together and in phase, what is the resultant amplitude at P?

A 0 **B** 0.72A **C** A **D** 2A

30 A stationary wave is set up on a stretched string XY as shown. P, Q, R, S are points on the string.



Which of the following statements is incorrect?

A Points P and S are in phase.

B The distance between points Q and R is equal to one quarter wavelength.

C The amplitude of point P on the string is the same as the amplitude of point R on the string.

D The energy of point S on the string changes from kinetic energy to potential energy and back to kinetic energy twice for every period.

End of Paper

H

NANYANG JUNIOR COLLEGE
JC 1 END-OF-YEAR EXAMINATION
Higher 2

CANDIDATE NAME	

CLASS		TUTOR'S NAME	

PHYSICS 9749/02

Paper 2 Structured Questions **4 October 2021**

1 hour

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and tutor's name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 8
2	/ 8
3	/ 8
4	/ 16
Total	/ 40

This document consists of **12** printed pages.

1 Car A is stationary at a red light. As the traffic light turns green, it accelerates forward at 2.4 m s^{-2} along a straight road. At the exact same instant, car B passes by travelling at a constant velocity. The two cars meet again after 14.0 s.

(a) Determine the velocity of car B.

velocity of car B = ... m s^{-1} [3]

(b) Calculate the distance from the traffic light where the two cars meet again.

distance = ... m [2]

(c) Sketch the displacement-time graph for car A and B on Fig. 1.1 and label them as “A” and “B” respectively.

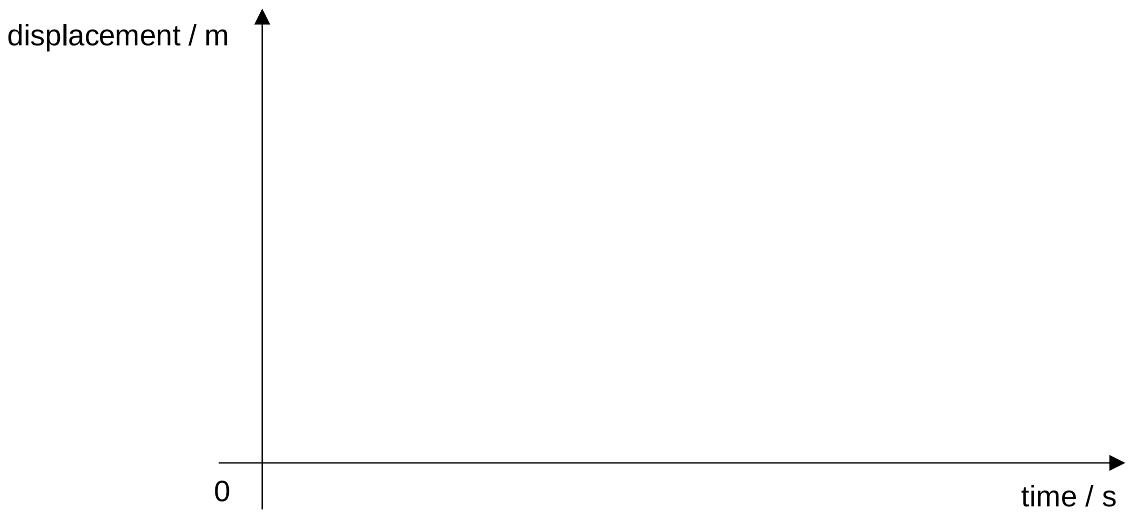


Fig. 1.1

[2]

(d) Without any further calculations, state and explain whether the average speed of car B during the 14.0 s is larger, smaller or equal to that of car A.

....

....

....[1]

[Total: 8]

2 **(a)** An athlete of mass 75 kg who is standing on one foot, attempts to tiptoe. The forces on the skeletal part of the foot are shown in Fig. 2.1. In this stationary position, the normal force *N* can be considered to be acting at point X. The tendon muscle exerts a tensional force *T* at point Z on the heel and makes an angle of 75° with the horizontal. The tibia exerts a contact force *C* at the ankle joint Y. The vertical and horizontal distances between the various points are given on the diagram. The weight of the foot is negligible.

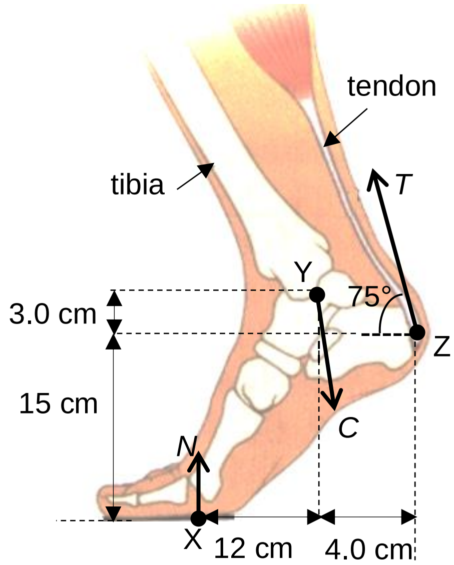


Fig. 2.1

(i) Using Newton's laws of motion, explain why the normal force *N* is equal in magnitude to the weight of the man.

....

....

....[1]

(ii) By taking moments about point Y, determine the tensional force *T*.

T = ... N [2]

(b) Fig. 2.2 shows a man trying to remove a closed barrel of mass 200 kg and volume 0.160 m^3 from a lake. He is pulling it with an elastic cord at a constant speed up the sloped bank of a lake. A total resistive force *f* of 25 N acts on the barrel when it is in the lake, as it slides up the rough slope.

The slope and cord are inclined 40° to the horizontal, and the density of water in the lake is 1000 kg m^{-3}.

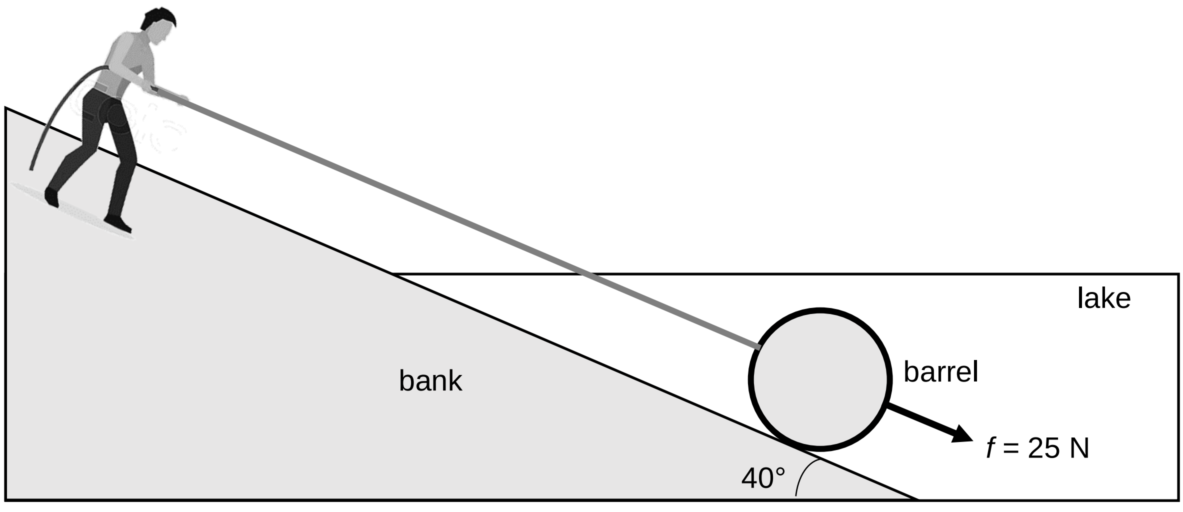


Fig. 2.2

(i) Draw, on Fig. 2.2, all the other forces acting on the barrel. Label the forces clearly. [2]

(ii) Hence, calculate the tension in the cord when the barrel is in the lake.

tension = ... N [2]

(iii) Suggest why the extension of the cord increases when the barrel is completely removed from the lake.

....

....

....[1]

[Total: 8]

3 A small disc of mass 30.0 g is placed on a turntable at a distance 15.0 cm from the axis of rotation as shown in Fig. 3.1. The maximum frictional force between the disc and the turntable is 0.18 N.

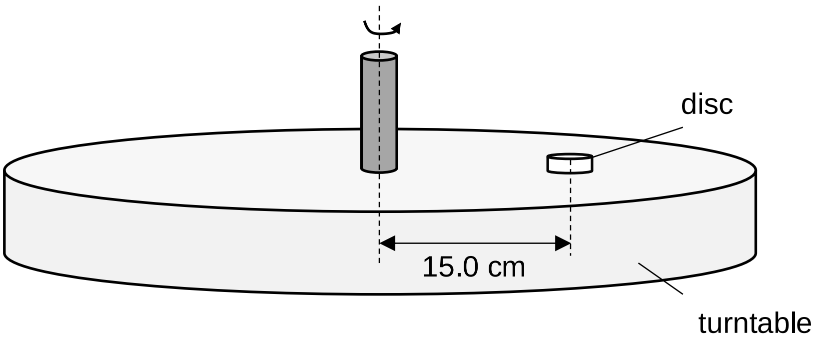


Fig. 3.1

(a) Use Newton's laws of motion to explain why a body moving with uniform speed in a circle must have a resultant force acting towards the centre of the circle.

....

....

....

....[2]

(b) Calculate the maximum angular velocity ω of the turntable for the disc to remain in a circular path of radius 15.0 cm.

ω = ... rad s^{-1} [2]

(c) Hence calculate the frequency of rotation of the turntable.

frequency = ... Hz [1]

(d) State and explain what happens to the disc if the frequency of the rotation of the turntable is increased.

....

....

....

....

....

....[3]

[Total: 8]

4 Radiation is a significant component of thermal energy transfer in buildings, especially for sun-exposed surfaces and regions of large temperature differences. Most countries have building regulations that contain instructions about limiting heat transfer in order to reduce the amount of air-conditioning required.

In order to calculate energy transfer, a thermal transmittance coefficient or U-value, U, is measured for each type of building component and is given by the equation:

$$U = \frac{P}{A\Delta T}$$

where P is the rate of energy transfer through the component in W,
A is the surface area of the component through which energy transfer occurs in m^2, and
ΔT is the air temperature difference between each side of the structure in K.

The values of U of three building components are given below in Fig. 4.1:

Component	**U / W m^{-2} K^{-1}**
Single-glazed window	5.6
Double-glazed window	3.2
Uninsulated roof	1.9
Thermal insulation (50 mm)	1.4

Fig. 4.1

A house has windows of total area 24 m^2 and a roof of area 60 m^2. During the winter period, the owner heats the house for 250 hours per month on average to a temperature that is 14 K above that of the air outside.

(a) **(i)** Show that 1 kWh is equivalent to 3.60×10^6 J.

[1]

(ii) Calculate the amount of energy lost in a month through single-glazed windows.

energy loss = ... J [2]

(iii) By replacing single-glazed windows with double-glazed windows, calculate the monthly savings given that electricity costs 0.25 dollars per kWh.

savings = ... dollars [3]

(b) The roof is insulated with two 50 mm thick layers of thermal insulation on each side to reduce heat transfer as shown in Fig. 4.2 below.

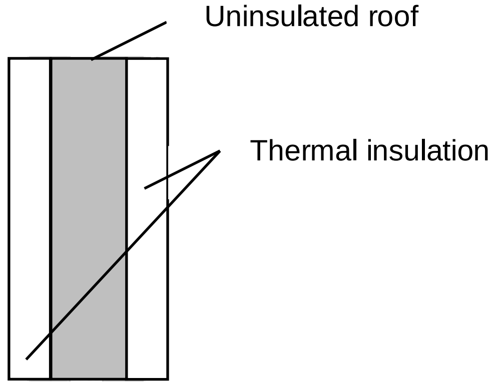


Fig. 4.2

To calculate the rate of heat transfer P through such a roof, a composite U-value, U_c, has to be used. U_c can be expressed in terms of the U-values of the individual materials by the equation:

$$\frac{1}{U_C} = \frac{1}{U_1} + \frac{1}{U_2} + ...$$

(i) Using the above equation, show that the rate of heat transfer P through the roof with thickness of thermal insulation of 50 mm on each side is 430 W.

[2]

(ii) Complete Fig. 4.3 below for the different values of thickness *t.*

***t* / mm**	***U* / W m^{-2} K^{-1}**	***P* / W**
25	0.806	
50	0.512	430
75	0.375	315
100		248
125	0.244	205
150	0.208	175
175	0.181	152
200	0.160	135

Fig. 4.3

[2]

(iii) Some corresponding values of *P* and *t* for the data in Fig. 4.3 are plotted on the graph of Fig. 4.4.

`

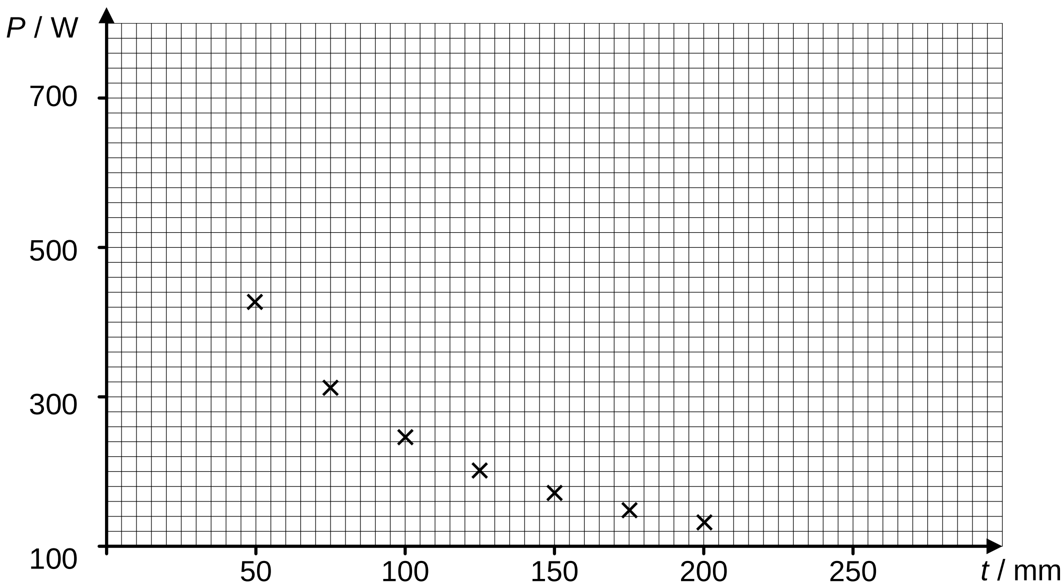


Fig. 4.4

On Fig. 4.4,

1. plot the point corresponding to thickness t = 25 mm,

2. draw the best-fit line for all the plotted points. [2]

(iv) Explain why the rate of heat transfer for a thickness of 250 mm thermal insulation on each side cannot be accurately determined from Fig. 4.4.

....

....

....[1]

(c) External work is required to get energy to flow from a cold reservoir to a hot reservoir. A heat pump is such a device, which applies external work W to extract an amount of heat Q_C from a cold reservoir, and delivers heat Q_H to a hot reservoir, as shown in Fig. 4.5 below.

Thermal efficiency e of a heat pump is defined as the ratio of W to Q_H during one cycle of the process. W, which is equivalent to (Q_H–Q_C), maintains a particular temperature difference between the hot and cold reservoirs.

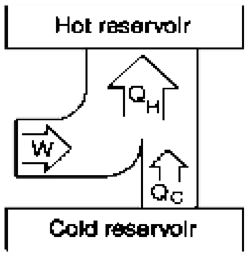


Fig. 4.5

The coefficient of performance (COP) of a heat pump is given by the equation:

$$\text{COP} = \frac{1}{e}$$

Fig. 4.6 shows the relationship between thermal efficiency, e, of an ideal heat pump and the temperature of the hot reservoir, T_h, for a temperature difference of 27 K.

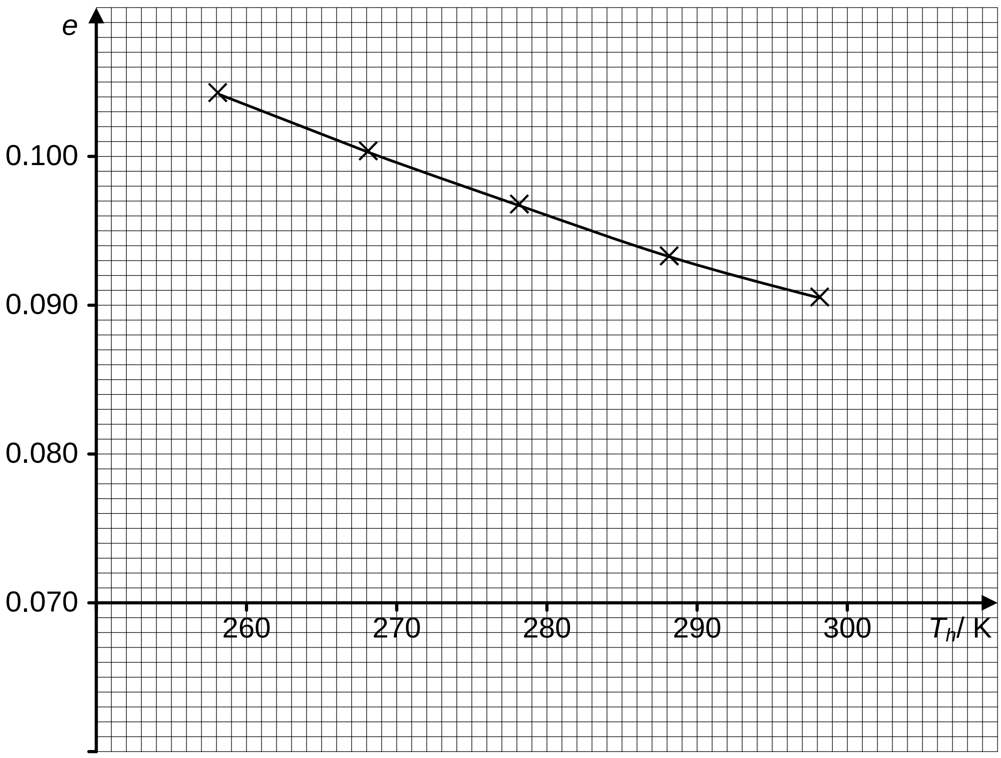


Fig. 4.6

The house loses energy at a rate of 5.00 kW when the interior temperature is 287 K and the outside temperature is 260 K.

(i) Using Fig. 4.6, calculate the COP for an ideal heat pump.

COP = ... [1]

(ii) Assuming that a heat pump operates with a coefficient of performance that is 60% of the ideal value, calculate the electric power needed by the heat pump to maintain the interior temperature at 287 K.

power = ... W [2]

[Total: 16]

End of Paper

H

NANYANG JUNIOR COLLEGE
JC 1 END-OF-YEAR EXAMINATION
Higher 2

CANDIDATE NAME	
CLASS	
TUTOR'S NAME	

PHYSICS 9749/03

Paper 3 Longer Structured Questions

28 September 2021

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and tutor's name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

You are advised to spend one and a half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	**/ 10**
2	**/ 10**
3	**/ 6**
4	**/ 10**
5	**/ 12**
6	**/ 12**
Section B	
7	**/ 20**
8	**/ 20**
Total	**/ 80**

This document consists of **24** printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ 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	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\phi = -Gm / r$
temperature	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} \langle c^2 \rangle$
mean translational kinetic energy of an ideal 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	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \dfrac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \dfrac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in the spaces provided.

1 In the study of materials, tensile stress, σ, in a wire is defined as the normal force applied per unit cross-sectional area. Tensile strain, ε, is the ratio of extension to the natural length.

The property of the material, Young's modulus E, is the ratio of stress over strain.

$$E = \frac{\sigma}{\varepsilon}$$

(a) Determine the base units of E.

base units = ... [2]

(b) An experiment is performed to determine the Young's modulus E of a thin wire of steel. The following measurements were obtained:

Force applied	(200 ± 5) N
Diameter	(4.0 ± 0.2) mm
Strain	(1.5 ± 0.5) x 10^{-5}

Calculate

(i) the uncertainty of stress $\Delta\sigma$ in the wire,

$\Delta\sigma$ = ... unit .... [2]

(ii) the Young's modulus E of the material and its associated uncertainty.

E = ... ± .... unit .... [3]

(c) (i) State and explain which measurement may be improved to most effectively reduce the uncertainty of Young's modulus ΔE.

....

....

....[2]

(ii) Suggest the instrument that may be used.

....[1]

[Total: 10]

2 The driving force F_D (in N) required for a car of mass 1000 kg to move at a constant speed v (in m s^{-1}) on a flat road is given by

$$F_D = 100\,v^2 + 150.$$

(a) Suggest why, even though a driving force is applied, the car moves with a constant speed.

....

....[1]

(b) Show that the driving force required for the car to move at a constant speed of 60 km h^{-1} is 28 kN.

[1]

(c) Calculate the acceleration required for the car to increase its speed from 60 km h^{-1} to 78 km h^{-1} in 5.0 s.

acceleration = ... m s^{-2} [1]

(d) Calculate the driving force required for the car moving at 60 km h^{-1} to produce the acceleration calculated in **(c)**.

driving force = ... N [2]

(e) Explain why the car may never reach its target speed of 78 km h^{-1} with the driving force calculated in **(d)**.

....

....

....[2]

(f) The driving force on the car, initially moving at 60 km h^{-1}, is increased to 30 kN as it begins to climb up a slope inclined at 18° to the horizontal. Calculate the initial acceleration of the car as it begins to climb up the slope.

acceleration = ... m s^{-2} [3]

[Total: 10]

3 A 50 W transmitter emits microwaves of frequency 10 GHz uniformly in all directions, as shown in Fig. 3.1. A receiver is initially at point O which is 500 m from the transmitter, and detects microwaves of an amplitude of 15 cm. The receiver is then moved 300 m to point P.

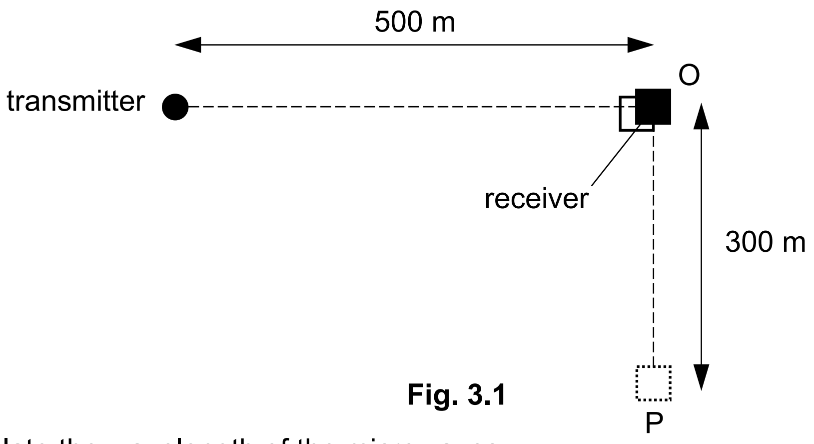


Fig. 3.1

(a) Calculate the wavelength of the microwaves.

wavelength = ... m [1]

(b) Determine the intensity of the microwaves at P.

intensity at P = ... W m^{-2} [2]

(c) Show that the amplitude A of the microwaves at a point is inversely proportional to the distance r between the transmitter and that point.

[2]

(d) Hence, determine the amplitude of the microwaves detected by the receiver at P.

amplitude = ... cm [1]

[Total: 6]

4 **(a)** State the *principle of superposition*.

....

....

....[1]

(b) Two sources of waves with amplitude A and period T meet $\frac{\pi}{2}$ rad out of phase at point P as shown in Fig. 4.1.

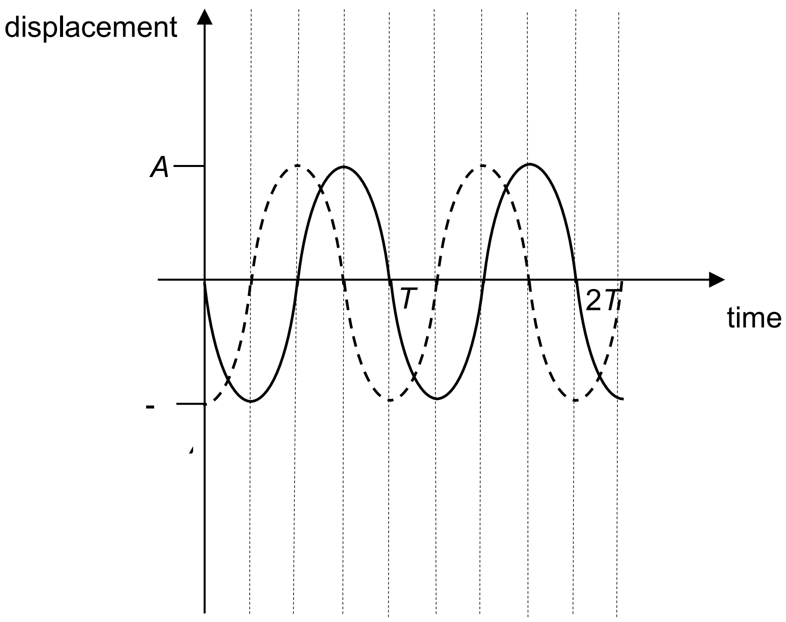


Fig. 4.1

(i) State the time, in terms of T, at which the two waves first have the same displacement.

time = ... T [1]

(ii) Determine the displacement of the resultant waveform, in terms of A, at the time stated in **(b)(i)**.

resultant displacement = ... A [2]

(iii) By applying the principle of superposition, sketch and label, on Fig. 4.1, the variation of resultant displacement at P with time. [3]

(c) Stationary waves can be produced by the superposition of progressive waves when a guitar string is plucked. The side view of the guitar is shown in Fig. 4.2. The guitar string can produce different musical notes by pressing the string at different distances L from the far end.

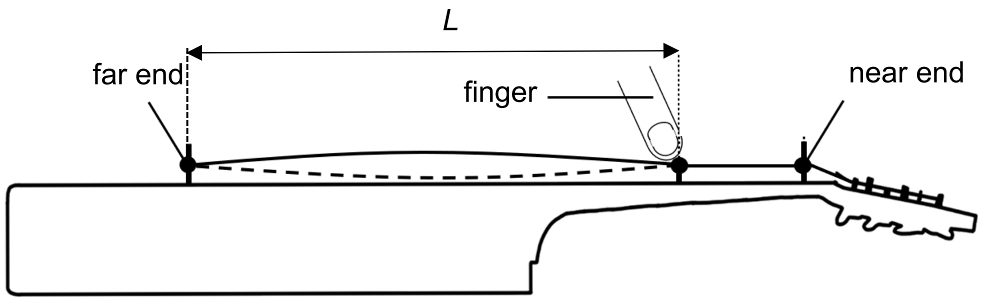


Fig. 4.2

Assuming that the speed of the wave remains constant at 425 m s^{-1}, calculate the change in L when a guitarist changes from playing a note with a fundamental frequency of 247 Hz to a note with a fundamental frequency of 262 Hz.

change in L = ... m [3]

[Total: 10]

5 **(a)** State the *First Law of Thermodynamics*.

....

....

....[1]

(b) A monoatomic ideal gas is enclosed in an air-tight cylinder with a movable piston, as shown in Fig. 5.1.

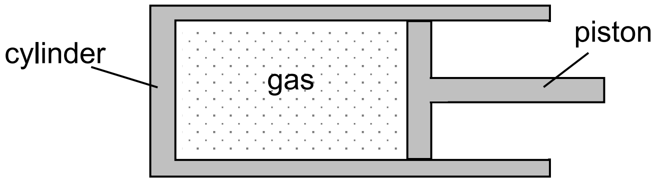


Fig. 5.1

The gas is compressed as it transits from state A to B very quickly as shown in Fig. 5.2.

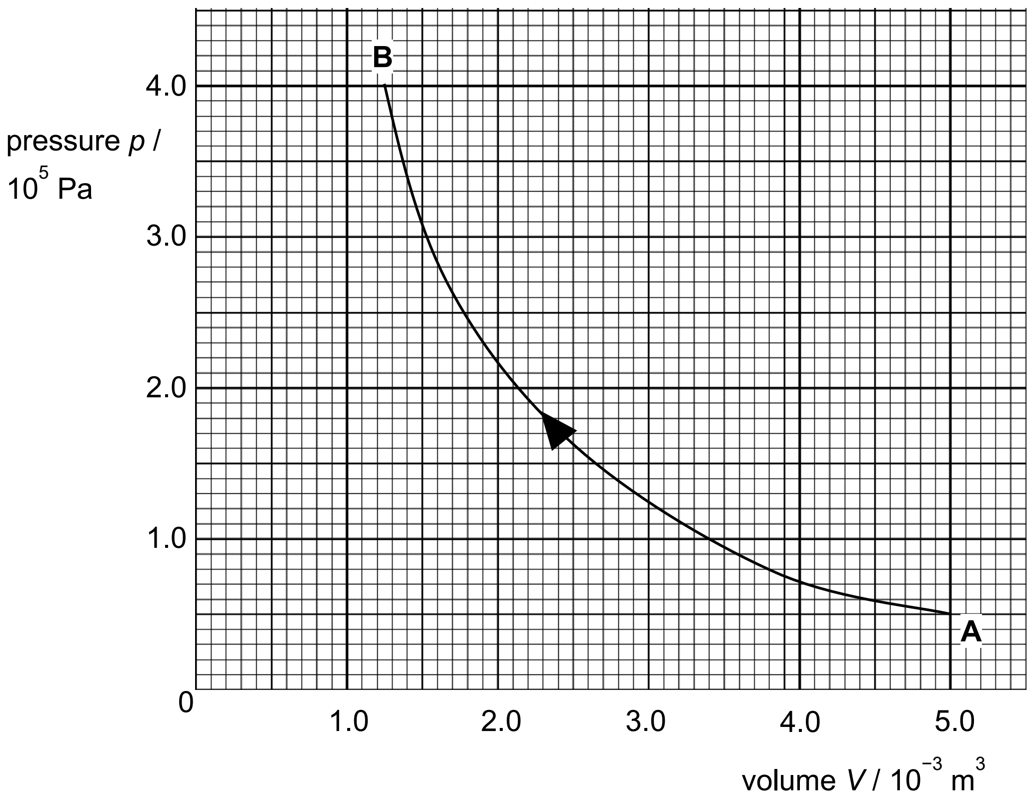


Fig. 5.2

(i) Determine the internal energy of the gas at state A.

internal energy = ... J [2]

(ii) The gas then goes through two more processes:
State B → C: The gas is cooled while the piston is kept at the same position.
State C → A: The gas expands at constant temperature slowly.

Determine the pressure of the gas at state C.

pressure = ... Pa [2]

(iii) With reference to the processes in **(b)(ii)**, complete the *p*-*V* diagram in Fig. 5.2. Label state C. [2]

(iv) Explain why the change in internal energy of the gas from state A to state B is equal to the area under the *p*−*V* graph as shown in Fig. 5.2.

....

....

....

....[3]

(v) Without further calculations, sketch, on Fig. 5.3, the variation of pressure *p* with temperature *T* as the gas undergoes energy changes from state B to C to A. Label the values of pressure of gas at states A, B and C.

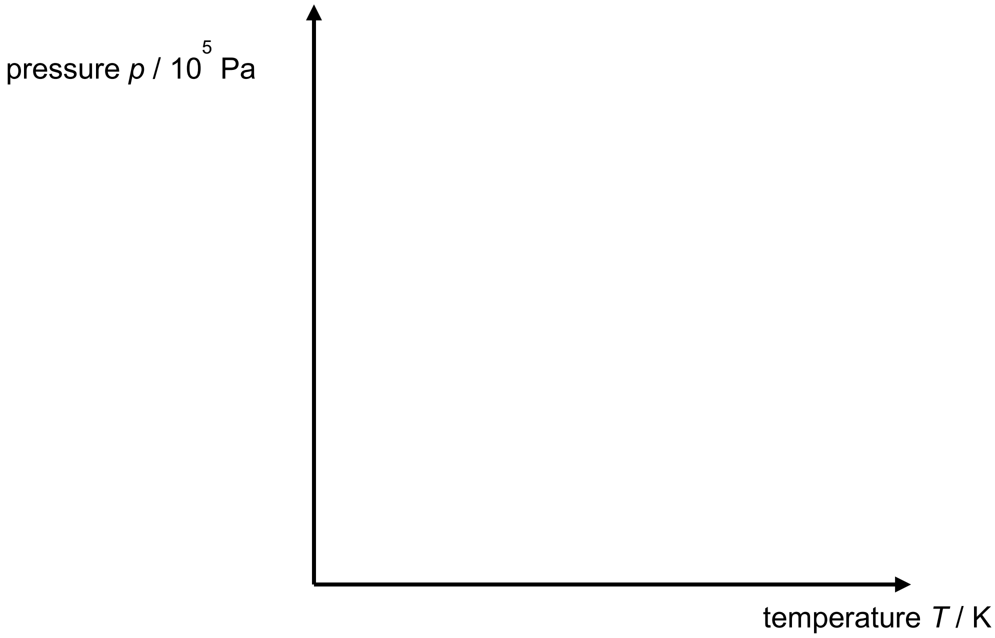


Fig. 5.3

[2]

[Total: 12]

6 Static friction can be defined as the frictional force which exist between a stationary object and the surface it is in contact. The magnitude of static friction that an object experiences can vary over a range of values. It can be affected by factors such as the mass of the object, the magnitude of the external force that is exerted on the object and the texture of the surface that it is in contact with. The maximum static friction can be defined as the magnitude of the force the surface exerts on the stationary object just before the object starts to move.

When an object is placed on a circular disc and the disc starts to spin about its centre, the static friction provides the centripetal force to keep the mass on the same location on the disc. The mass can be observed to start slipping when the angular velocity of the disc exceeds a certain value, ω_{min}.

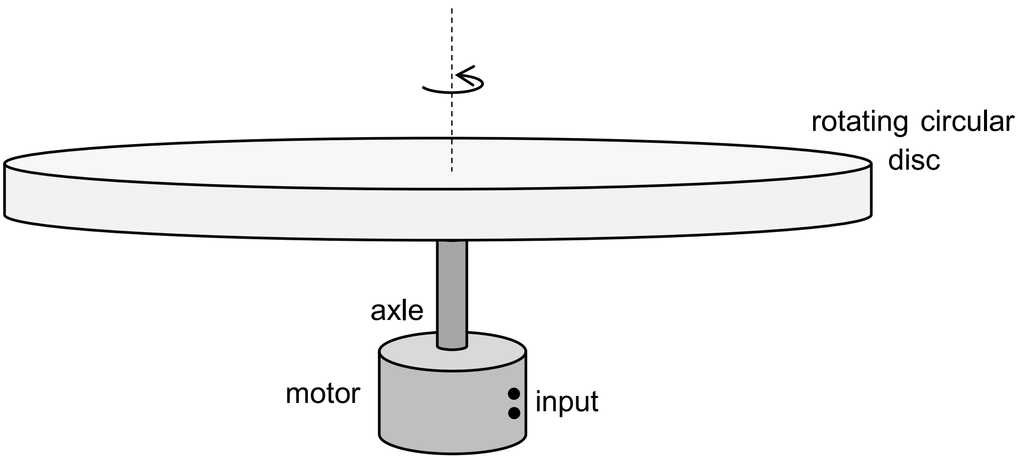
The relationship between the minimum angular velocity of the disc, ω_{min}, and the mass of the object, m, may be written in the form

$$\omega_{min} = k\, m^n$$

where k and n are constants.

Design an experiment to investigate the relationship between the minimum angular velocity ω_{min} and the mass of the object m and determine the value of k.

You are provided with a motor which has an axle that is attached to the centre of a circular disc. The motor has a variable power supply to vary angular velocity. You may also use any of the other equipment usually found in a physics laboratory.



You should draw a labelled diagram to show the arrangement of your apparatus. In your account you should pay particular attention to

(a) the equipment you would use
(b) the procedure to be followed
(c) how the minimum angular velocity is measured
(d) the control of variables
(e) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram

....

....

[12]

Section B

Answer **one** question from this Section in the spaces provided.

7 **(a)** **(i)** Define *gravitational potential* at a point.

....

....[1]

(ii) The gravitational potential ϕ at a distance r from an isolated point mass m is given by the expression

$$\phi = -\frac{Gm}{r}$$

where G is the gravitational constant.

Explain why gravitational potential is negative.

....

....

....

....

....[3]

(b) The Earth and Moon can both be assumed to be isolated uniform spheres of masses 6.0×10^{24} kg and 7.3×10^{22} kg respectively. The radius of Earth is 6.4×10^{6} m and the radius of the Moon is 1.7×10^{6} m.

The variation with displacement x of the gravitational potential ϕ between the surface of the Moon and the surface of Earth along the line joining their centres is shown in Fig. 7.1. Q is the point at which the gravitational potential is maximum.

(i) The gravitational potential on the surface of the moon at point P is -3.9×10^{6} J kg^{-1}. Show that the distance D between the centres of the Earth and Moon is 3.9×10^{8} m.

[2]

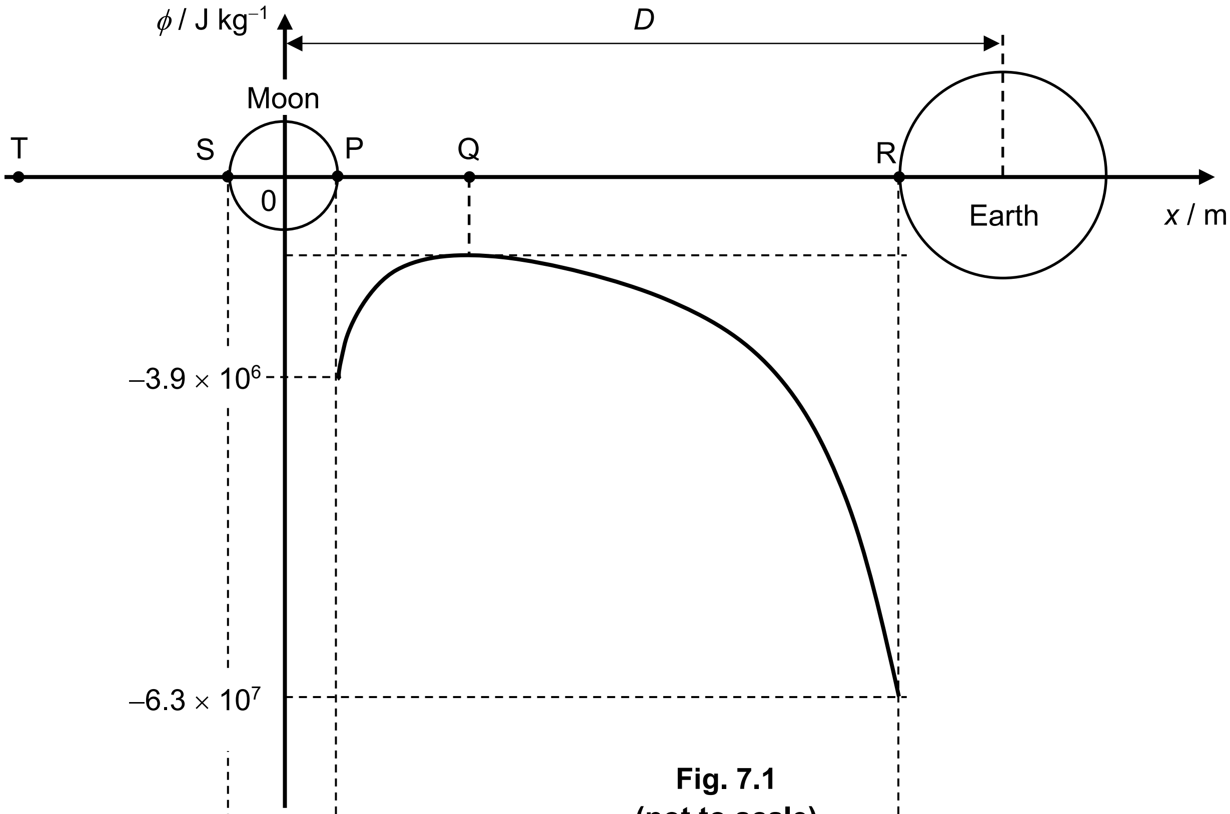


Fig. 7.1
(not to scale)

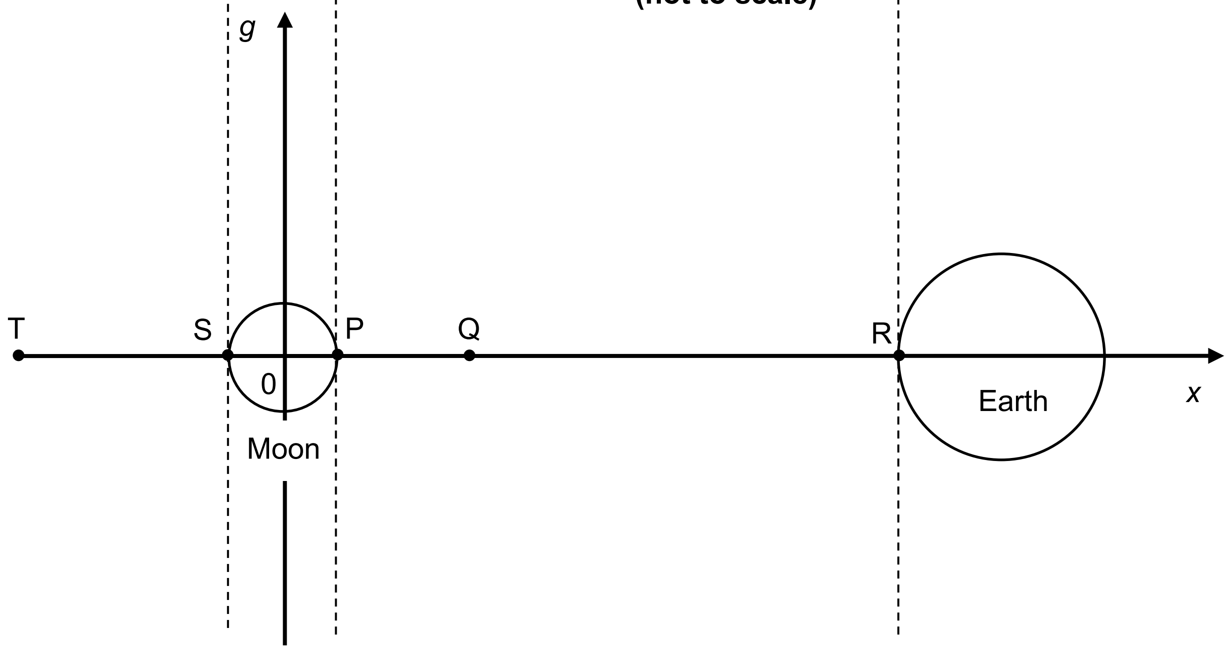


Fig. 7.2
(not to scale)

(ii) Using Fig. 7.1, state and explain the motion, if any, of an object when it is released from rest at point Q.

....

....

....

....[2]

(iii) Show that the distance between Q and the centre of the Earth is 3.5×10^8 m.

[2]

(iv) A scientific instrument of mass 100 kg was projected at a velocity v from point R on the surface of the Earth towards point P on the surface of the Moon, along the line joining their centres. The instrument reached the surface of the Moon with kinetic energy 1.5×10^8 J.

1. State the energy changes that take place from the instant the instrument is projected from R to the instant just before it hits P.

....

....

....

....[2]

2. The gravitational potential at R is -6.3×10^7 J kg^{-1}.

Calculate the velocity v at which the instrument is projected.

v = ... m s^{-1} [3]

(c) (i) On Fig. 7.1, sketch, without further calculations, a graph to show the variation of gravitational potential ϕ with displacement x along the line ST, paying attention to the potential at point S. [1]

(ii) On Fig. 7.2, sketch, without further calculations, a graph to show the variation of the resultant gravitational field strength g with displacement x along the line TR

1. between PR, [3]

2. between ST. [1]

[Total: 20]

8 Fig. 8.1 shows a setup consisting of a light inextensible string attached to a spring at one end, and is wound around a frictionless moveable pulley. The top ends of the string and spring are fixed to the ceiling. The pulley is supporting a block which is resting in equilibrium.

The spring has spring constant k and the block has mass M. The mass of the pulley and spring are negligible.

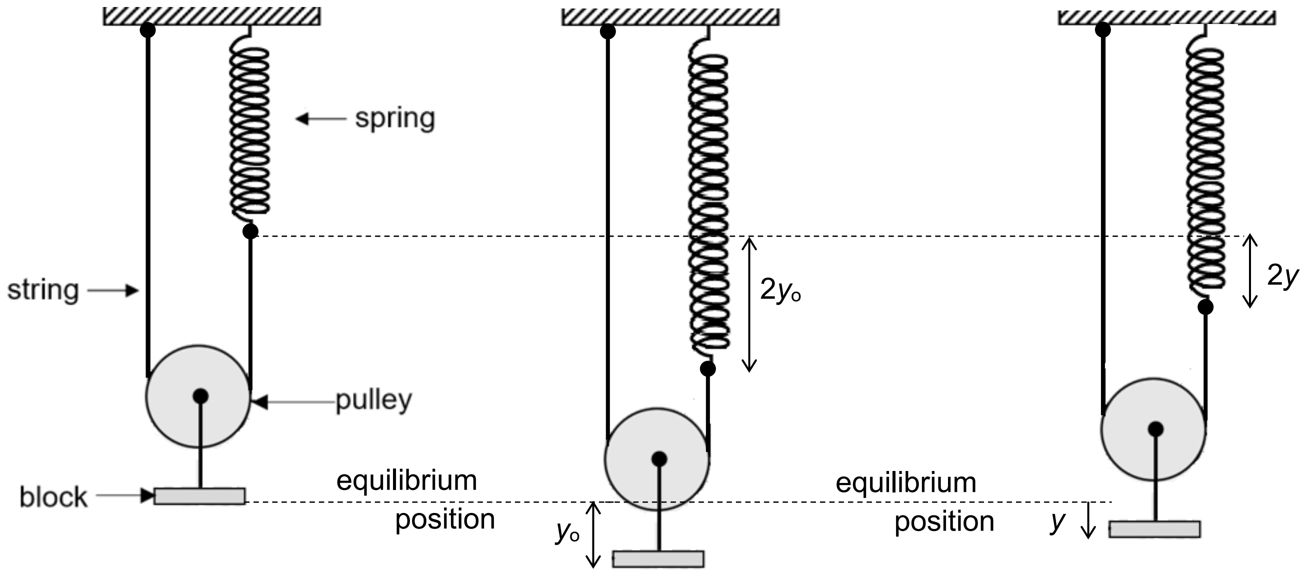


Fig. 8.1 **Fig. 8.2** **Fig. 8.3**

As shown in Fig. 8.2, the block is displaced vertically downwards from the equilibrium position by a distance y_o, resulting in a further extension of the spring by $2y_o$. It is then released from rest and subsequently oscillates with simple harmonic motion.

At an instant, the displacement from the equilibrium position is y as shown in Fig. 8.3.

(a) **(i)** Derive an expression for the extension of the spring when the block is in equilibrium, in terms of k, M and g.

[1]

(ii) By considering the net force on the block and using the expression in **(a)(i)**, show that the acceleration a of the block at displacement y from its equilibrium position is given by

$$a=-\frac{4k}{M}y\ .$$

[2]

(b) For the oscillations to remain simple harmonic when the block reaches the top position, the distance y_o by which it is initially lowered cannot exceed half of the extension of the spring in **(a)(i)**. Explain why.

....

....

....

....[3]

(c) The spring constant k is 50 N m^{-1}, the mass M of the block is 500 g and the distance y_o is 1.0 cm.

(i) Determine

1. the period of oscillation of the block,

period = ... s [2]

2. the time taken for the block to reach a displacement of 0.50 cm above its equilibrium position from the moment of release,

time = ... s [2]

3. the maximum kinetic energy of the block.

maximum kinetic energy = ... J [2]

(ii) 1. Using the values obtained in **(c)(i)**, sketch a labelled graph, on Fig. 8.4, to show the variation with time t of kinetic energy of the block from the moment of release for one period. Label this graph P. [2]

Fig. 8.4

2. The block is replaced with another of mass $4M$ and the experiment is repeated. Sketch, on Fig. 8.4, the graph obtained for this second block. Label this graph Q. [3]

(d) A small motor is now introduced to the same setup in **(c)** as shown in Fig. 8.5. The motor is attached to the bottom of the block and switched on to drive the oscillations.

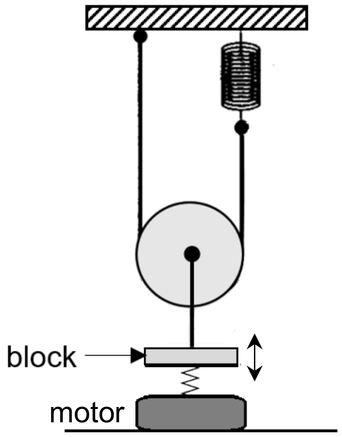


Fig. 8.5

The frequency of the motor is slowly increased until maximum amplitude is achieved.

(i) Determine the frequency at which this occurs.

frequency = ... Hz [2]

(ii) Suggest a reasonable way to reduce the amplitude achieved at the frequency obtained in **(d)(i)**.

....

....[1]

[Total: 20]

End of Paper

NANYANG JUNIOR COLLEGE
JC 1 END-OF-YEAR EXAMINATION
Higher 2

CANDIDATE NAME	

CLASS		TUTOR'S NAME	

PHYSICS **9749/01**

Paper 1 Multiple Choice **30 September 2019**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class, Centre number and index number in the spaces at the top of this page.

There are **thirty** questions on this paper. Answer **all** 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 Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **14** printed pages.

1 Express the gravitational potential, ϕ, in S.I. base units.

A kg m^2 s^{-2} **B** kg m^2 s^{-3} **C** kg m^3 s^{-2} **D** m^2 s^{-2}

2 The acceleration due to gravity near the surface of Earth, g, was determined by measuring the time taken t for a ball to travel a distance h vertically when released from rest. In one experiment, the following measurements for t and h were obtained:

h = (41.30 ± 0.01) m
t = (2.9 ± 0.2) s

Which of the following would result in the greatest improvement in precision of the value of g?

A Measuring the height, h, to a precision of 0.1 cm.

B Measuring the time, t, to a precision of 0.01 s

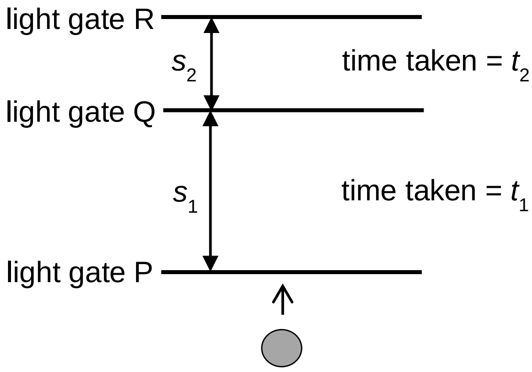
C Taking the average of multiple measurements of h.

D Taking the average of multiple measurements of t.

3 A stopwatch is used to measure the time a sprinter takes to run a distance of 100 m. The recorded time for the run is 10.0 s. Assuming that the uncertainty due to human reaction time in pressing the stopwatch each time is 0.2 s, what is the lowest possible average speed of the runner?

A 9.6 m s^{-1} **B** 9.8 m s^{-1} **C** 10.0 m s^{-1} **D** 10.2 m s^{-1}

4 An object is thrown vertically upwards and passes through three light gates P, Q and R as shown.

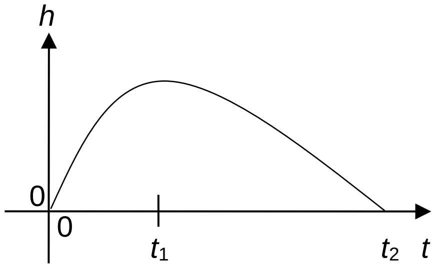


The object has a speed u when it passes P. It takes a time of t_1 to move up a distance s_1 between P and Q, and then takes a time t_2 to travel a distance s_2 between Q and R. The object reaches its highest point exactly at R.

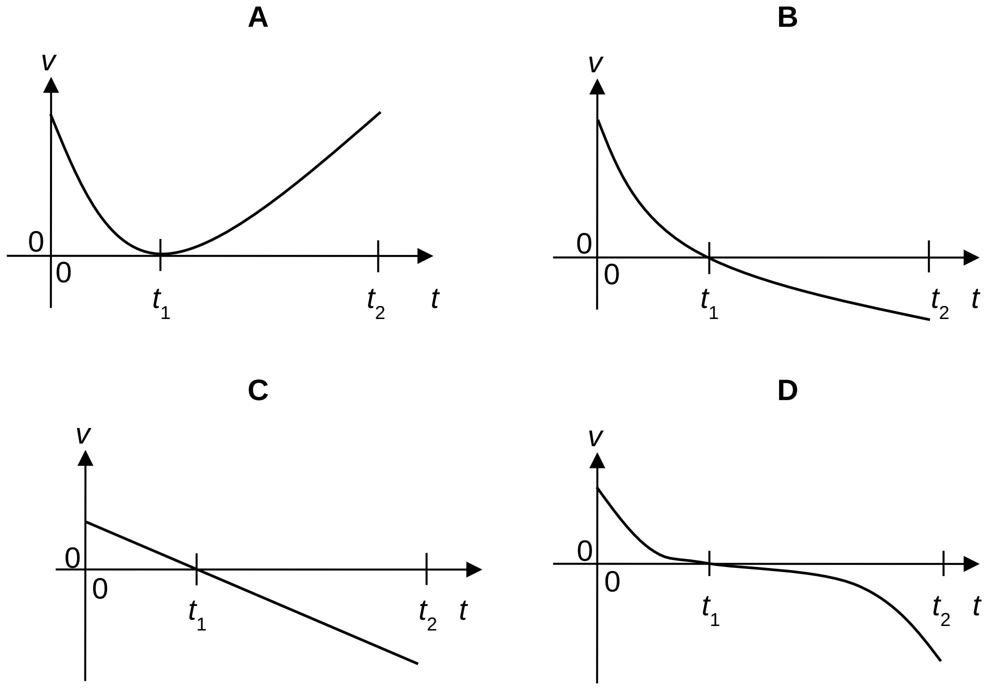
If the acceleration due to gravity is g, what is the distance (s_1 + s_2) in terms of g, t_1 and t_2?

A $g\left(t_1+t_2\right)$ **B** $g\left(t_1+t_2\right)^2$ **C** $\dfrac{g\left(t_1+t_2\right)^2}{2}$ **D** $\dfrac{\left(t_1+t_2\right)^2}{2g}$

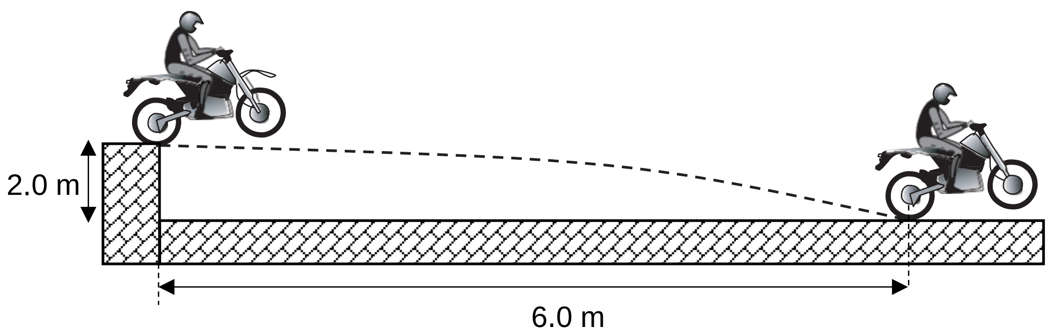
5 A ball is thrown vertically upwards and returns along the same path. The graph shows how its height h above the ground varies with time t.



Which graph shows the variation with time t of the velocity v of the ball?



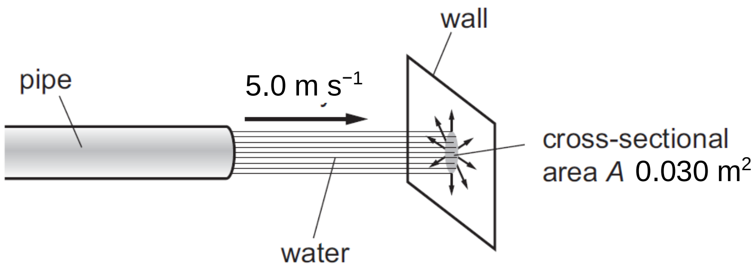
6 A stunt-rider takes off horizontally from a point 2.0 m above the ground, landing 6.0 m away as shown. Air resistance is negligible.



What was the speed of the stunt-rider at take-off?

A $6.3\ \text{m s}^{-1}$ **B** $9.4\ \text{m s}^{-1}$ **C** $9.9\ \text{m s}^{-1}$ **D** $15\ \text{m s}^{-1}$

7 Water flows out of a pipe with a speed of 5.0 m s^{-1} and hits a wall, forming a cross-sectional area of 0.030 m^2 before it falls vertically downwards. The density of water is 1030 kg m^{-3}.

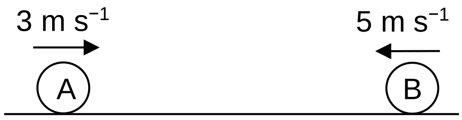


An engineer adjusts the flow valve, causing the water to flow at speed v, and the force exerted on the wall by the water was halved.

What is the value of v?

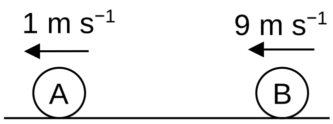
A 1.3 m s^{-1} **B** 2.5 m s^{-1} **C** 3.5 m s^{-1} **D** 7.1 m s^{-1}

8 Two objects A and B of mass 1.0 kg and 3.0 kg respectively collide head-on elastically on a horizontal, frictionless surface as shown. The initial velocities of both objects before the collision are shown in the diagram below.

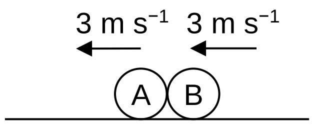


Which of the following diagrams showing the final velocities of both objects after the collision is correct?

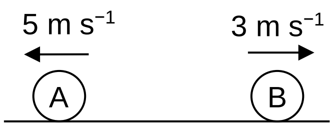
A



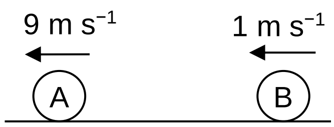
B



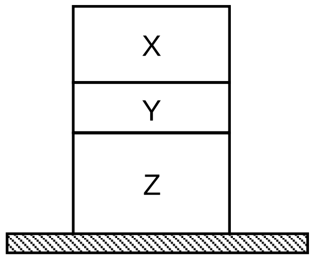
C



D



9 Three crates X, Y and Z of masses *3m, m* and *5m* respectively, are stacked on top of one another on the floor of a lift which is moving upwards but decelerating, and their common acceleration is *a*.



What is the magnitude of the force exerted by crate Y on crate Z during this acceleration?

A $4mg + 4ma$

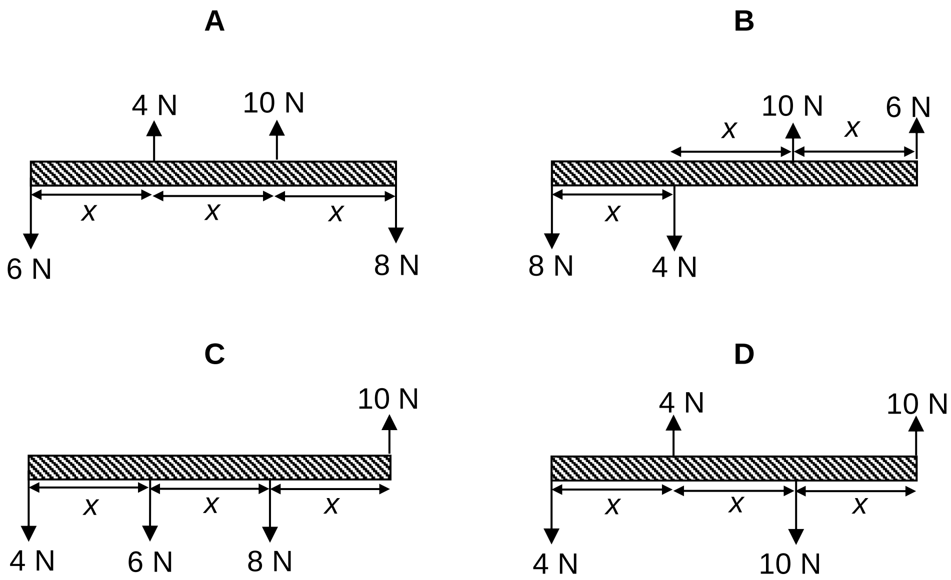
B $4mg + 5ma$

C $4mg - 4ma$

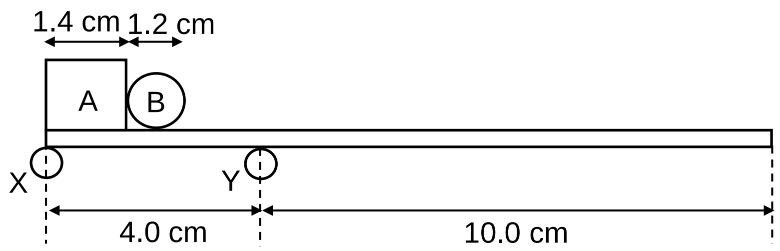
D $4mg - 5ma$

10 The force diagrams below show all the forces acting on a beam of length $3x$, which is at rest initially.

Which force system experiences only rotational motion of the beam, without any linear acceleration?



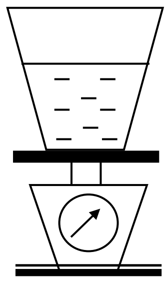
11 A beam of negligible mass is supported by two rods X and Y. A block A of mass 200 g and a ball B of mass 100 g rest on the beam as shown. Both A and B have uniform density.



If ball B starts to roll to the right, what is the distance it has moved when the beam just loses contact with rod X?

A 6.6 cm **B** 8.0 cm **C** 8.6 cm **D** 9.4 cm

12 A cup half-filled with water resting on a weighing scale registers a reading W. When a boy dips his finger into the water without touching the base, the reading of the weighing scale is W'.



Which of the following statements is correct?

A $W' = W$ because the water has not overflowed from the beaker.

B $W' < W$ because the water exerts an upthrust on the boy's finger.

C $W' > W$ because the water exerts an upthrust on the boy's finger and the boy's finger exerts a force on the water equal to the upthrust by the water on his finger.

D $W' > W$ because the weight of the boy's finger is added to that of the water.

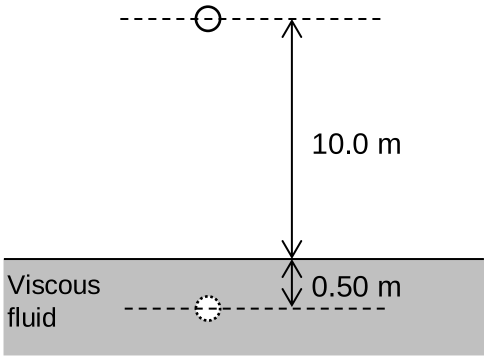
13 A 1.0 kg ball is released from a certain height. When it is 0.70 m above the floor, its potential energy is exactly equal to its kinetic energy. What is the speed of the ball just before it hits the floor?

A 3.7 m s^{-1} **B** 5.2 m s^{-1} **C** 14 m s^{-1} **D** 27 m s^{-1}

14 A car of mass m is accelerated horizontally from rest to a speed v by a constant force F. How much work is done on the car during this acceleration?

A ½ Fv **B** Fv **C** mv **D** ½ mv^2

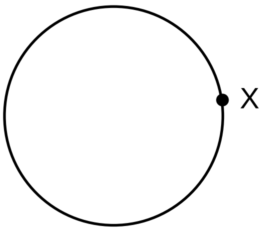
15 A small object is dropped from a height of 10.0 m above the surface of a viscous fluid as shown in the diagram below. The mass of the object is 1.0 kg and the viscous fluid offers a constant retarding force of 160 N.



What is the speed of the object after it has moved 0.50 m into the viscous fluid?

A 6.0 m s^{-1} **B** 6.8 m s^{-1} **C** 13 m s^{-1} **D** 14 m s^{-1}

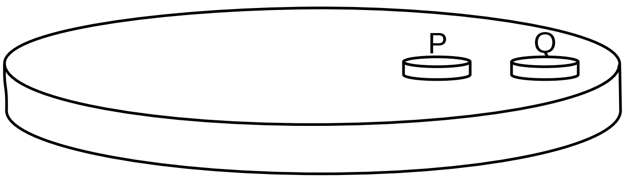
16 An object moves in a circular path of radius 0.80 m at an angular speed of $\frac{2\pi}{3}$ rad s^{-1}.



What is its distance travelled from a point X, 6.0 s after passing X?

A 0.80π m **B** 1.6π m **C** 3.2π m **D** 4.0π m

17 Two identical coins P and Q rest on a flat, rough turntable.



The turntable starts from rest and spins about its vertical axis through its centre at an increasing rate. When the turntable reaches a certain rate of rotation, one of the coins begins to slide.

Which of the following statements best explains why this happens?

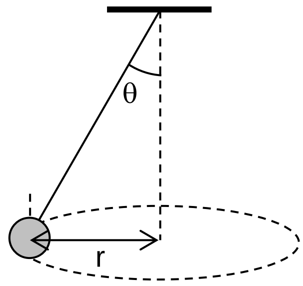
A P begins to slide because it has less friction.

B Q begins to slide because it has less friction.

C Q begins to slide because it has a larger angular velocity.

D Q begins to slide because it is moving with a larger radius.

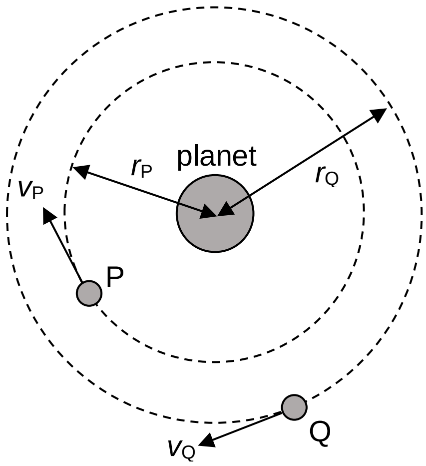
18 A pendulum bob is suspended from the ceiling by a light inextensible string. It is set to whirl in a horizontal circle of radius r such that the cord is inclined at an angle θ to the vertical.



What is the period of rotation of the pendulum?

A $\sqrt{\dfrac{4\pi^2 r}{g}}$ **B** $\sqrt{\dfrac{4\pi^2 r}{g\tan\theta}}$ **C** $\sqrt{\dfrac{4\pi^2 r}{g\sin\theta}}$ **D** $\sqrt{\dfrac{4\pi^2}{rg\tan\theta}}$

19 Two moons P and Q move in circular orbits about a planet as shown below.



Moon P has an orbital radius r_P of 1.4×10^8 m and linear speed v_P. Moon Q has an orbital radius r_Q of 2.3×10^{10} m and linear speed v_Q.

What is the ratio $\dfrac{v_P}{v_Q}$?

A 6.1×10^{-3}

B 7.8×10^{-2}

C 13

D 160

20 Star X of mass 2M and Star Y of mass M perform circular motion about their common centre of mass under their gravitational attraction. Ignoring the effects of any other bodies, what is the ratio $\dfrac{\text{centripetal force acting on X}}{\text{centripetal force acting on Y}}$?

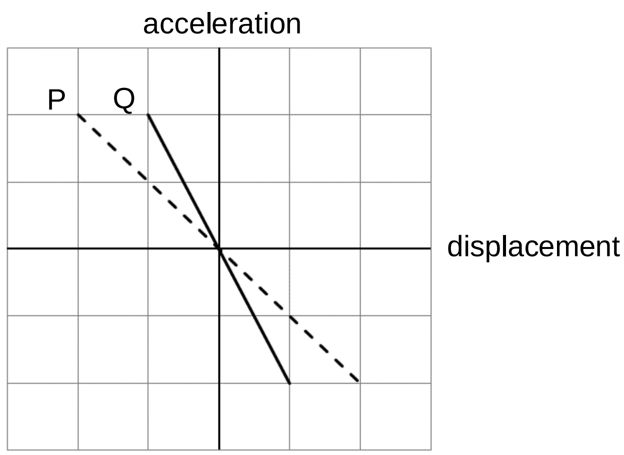
A 0.5 **B** 1 **C** 2 **D** 4

21 A stationary object is released from a distance 6*R* from the centre of the Earth which has radius *R* and mass *M*.

Which one of the following expressions gives the speed of the object upon hitting the Earth?

A $\sqrt{\dfrac{GM}{R}}$ **B** $\sqrt{\dfrac{GM}{5R}}$ **C** $\sqrt{\dfrac{5GM}{2R}}$ **D** $\sqrt{\dfrac{5GM}{3R}}$

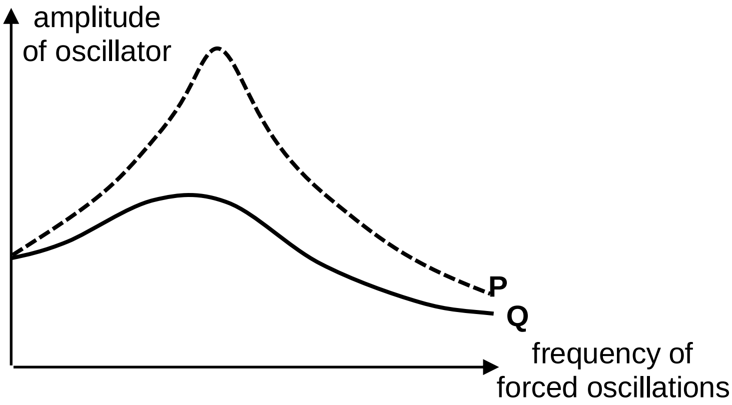
22 The figure below shows the acceleration-displacement graphs of two oscillators P and Q. The amplitude and period of P are x_0 and *T* respectively.



Which of the following correctly gives the amplitude and period of Q?

	amplitude	period
A	x_0	$2\,T$
B	x_0	T / 4
C	x_0 / 2	$T / \sqrt{2}$
D	x_0 / 2	T / 2

23 The graphs below show the frequency responses of two identical oscillators P and Q when subjected to forced oscillations by the same driver but two different levels of damping.



Which of the following statements is correct?

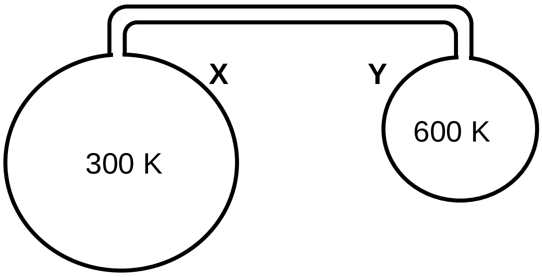
A The natural frequency of P is higher than that of Q.

B The damping on P is heavier than that on Q.

C P and Q oscillate at different frequencies when the driver is disengaged.

D P exhibits resonance and Q does not.

24 The volume of bulb X is twice that of bulb Y. They are filled with the same ideal gas and are connected by a narrow tube, as shown. A steady state is established with bulb X held at 300 K and bulb Y at 600 K. If there are *n* moles of gas in bulb X, how many moles of gas are there in bulb Y?



A ¼ *n* **B** ½ *n* **C** *n* **D** 2*n*

25 An ideal gas with a mass of 1.60 kg exerts a pressure of 1.00×10^5 Pa in a container of volume 0.500 m^3.

What is the root-mean-square speed of the gas molecules?

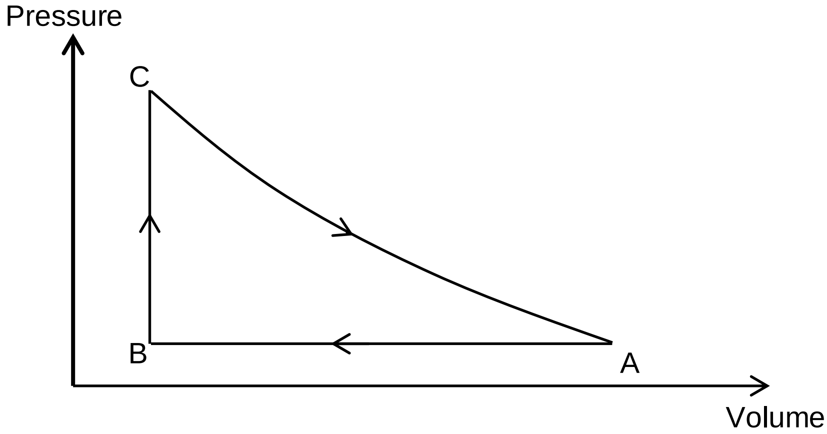
A 250 m s^{-1}

B 286 m s^{-1}

C 300 m s^{-1}

D 306 m s^{-1}

26 An ideal gas undergoes a cycle of changes A → B → C → A, as shown below.



During the process, heat is supplied to the gas as shown in the table.

Process	Heat supplied / kJ
A → B	− 15.0
B → C	+ 20.0
C → A	0

The efficiency of the gas engine is defined as follows:

$$\text{efficiency} = \frac{\text{net work done in a cycle}}{\text{heat supplied to gas from process B} \rightarrow \text{C}}$$

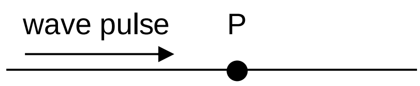
The efficiency of the gas engine is

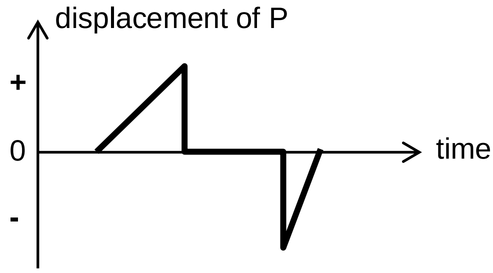
A 0.25 **B** 0.30 **C** 0.50 **D** 0.75

27 The least distance between two points of a progressive transverse wave which have a phase difference of $\pi/3$ rad is 0.050 m. If the frequency of the wave is 500 Hz, what is the speed of the wave?

A 75 m s^{-1} **B** 150 m s^{-1} **C** 250 m s^{-1} **D** 1670 m s^{-1}

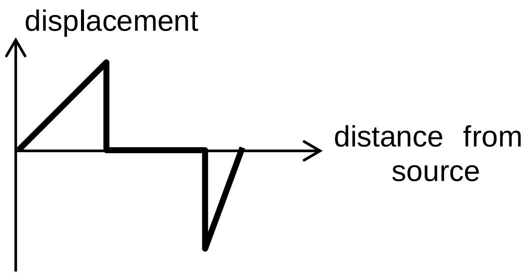
28 A wave pulse is travelling to the right as shown in the diagram below. The graph on the right shows the variation with time of the displacement of a particle P as the pulse passes it.



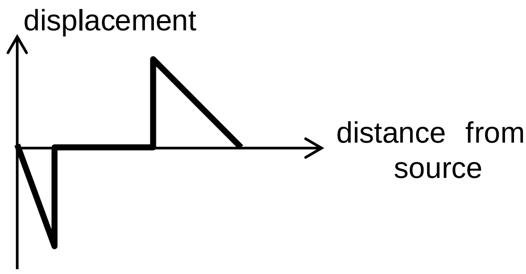


Which one of the following graphs represents the variation of the displacement with positions of the particles along the path of the wave pulse at a certain instant?

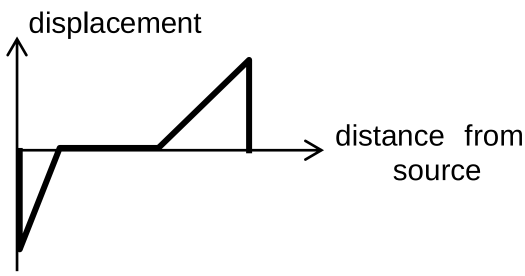
A



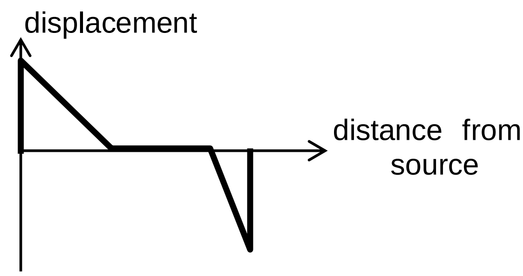
B



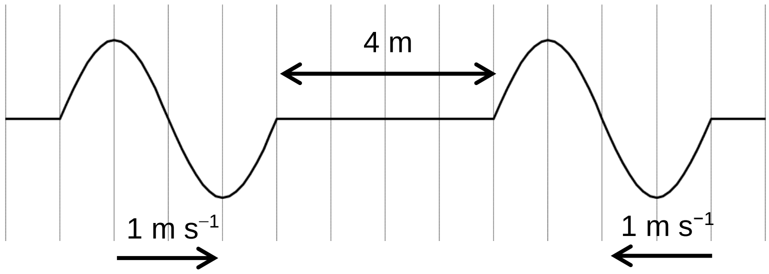
C



D

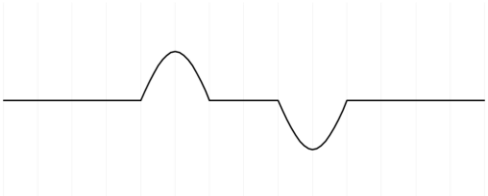


29 The figure below shows two waves, each of wavelength 4 m, moving towards each other on a string with speeds of 1 m s^{-1}.

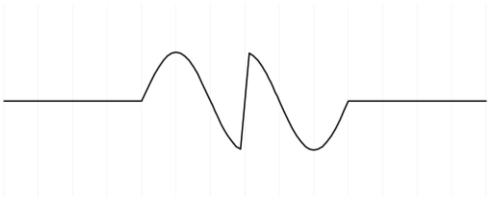


Which of the following shows the string after 3 s?

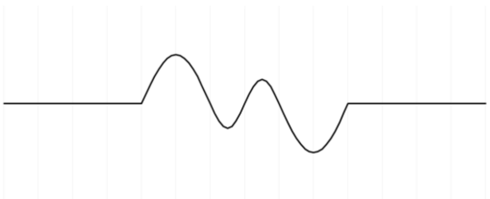
A



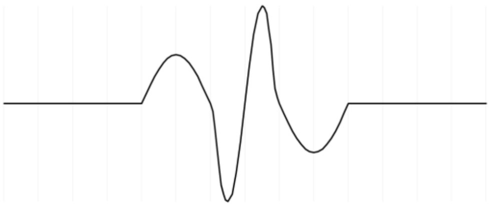
B



C



D



30 When a continuous tone of frequency 130 Hz is played close to a taut string of 60 cm, the string vibrates as shown below.

What is the speed of the wave in the string?

A zero **B** 26 m s^{-1} **C** 52 m s^{-1} **D** 78 m s^{-1}

End of Paper

H

NANYANG JUNIOR COLLEGE
JC 1 END-OF-YEAR EXAMINATION
Higher 2

CANDIDATE NAME

CLASS

TUTOR'S NAME

PHYSICS

9749/02

Paper 2 Structured Questions

30 September 2019

1 hour

Candidates answer on the Question Paper.

No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

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

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 7
2	/ 8
3	/ 9
4	/ 16
Total	/ 40

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

1 **(a)** State two differences between *random* and *systematic* errors.

....

....

....[2]

(b) **(i)** When determining period T directly using a stopwatch, it is good practice to measure the time taken for a large number of oscillations rather than for one oscillation.

Explain why this should be done.

....

....

....[1]

(ii) Fig. 1.1 shows a simple pendulum consisting of a mass m attached to a light inextensible string of length L. The pendulum is secured to a fixed point, and undergoes oscillations when displaced sideways by a small angle θ.

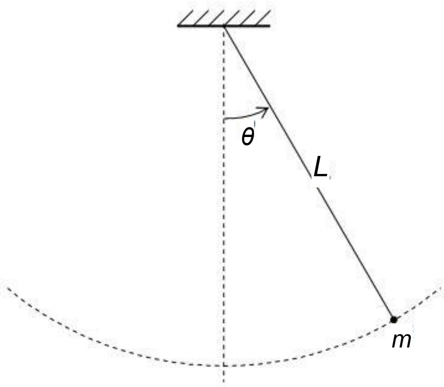


Fig. 1.1

The acceleration of free fall g and the period of oscillation T are related according to the following equation:

$$T^2 = 4\pi^2 \frac{L}{g}$$

Given that L = (50.0 ± 0.2) cm, and the time for 20 oscillations t_{20} = (28.2 ± 0.2) s, determine g with its associated uncertainty.

(g ± Δg) = ... m s^{-2} [4]

2 A water wheel, which is used to generate electricity for a village, has eight buckets equally spaced around its circumference as shown in Fig. 2.1.

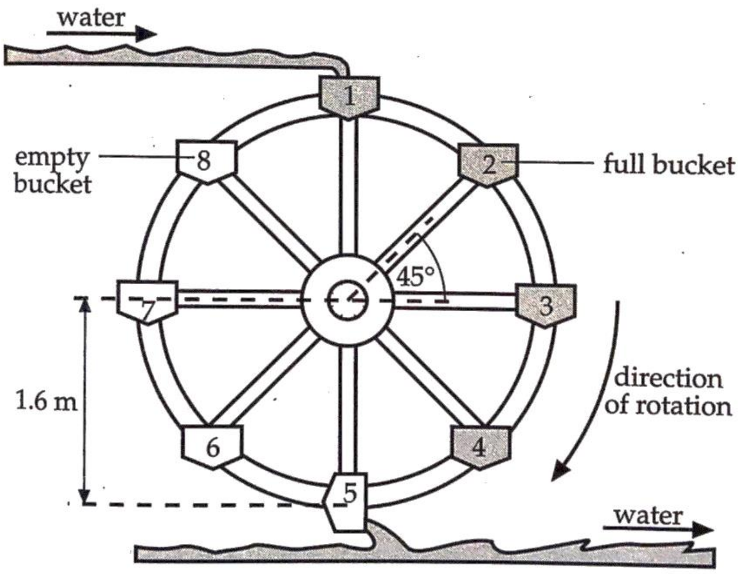


Fig. 2.1

The distance between the centre of each bucket and the centre of the wheel is 1.6 m. When a bucket is at the highest point, the bucket is filled with a mass of 40 kg of water. The wheel rotates at a constant speed and the bucket is emptied at its lowest point.

(a) Define the *moment* of a force.

....

....[1]

(b) State the bucket number that provides the largest moment about the axle of the wheel.

number = ... [1]

(c) Calculate, for the wheel in the position shown in Fig. 2.1, the total moment due to the weight of the water in the buckets about the centre of the axle of the wheel.

moment = ... N m [3]

(d) Calculate the loss in gravitational potential energy of water in bucket number 1 as it moves from the top to the bottom.

loss = ... J [1]

(e) Hence, determine the total loss in gravitational potential energy of water in the buckets for one complete revolution.

loss = ... J [1]

(f) State how the principle of conservation of energy is applied as the water wheel rotates.

....

....[1]

3 Bobsledding is an Olympic winter sport in which teams of two or four crews make timed runs down an ice track in a bobsled. The team with the fastest timed run wins. In one part of the journey, the bobsled moves in a circular path along a banked curve, as shown in Fig. 3.1. Friction is assumed to be negligible.

Fig. 3.1

(a) When the bobsled travels at constant speed in a circular path along the track in Fig. 3.1, it experiences a resultant force. Explain how a resultant force acts on the bobsled even though it is travelling at constant speed.

....

....

....

....[2]

(b) Explain why it is necessary for the track to be banked.

....

....[1]

(c) Fig. 3.2 shows the top view of two horizontal curves of radius r and $2r$, which form part of the track. The tracks are banked at the same angle θ as shown in Fig. 3.3. The safe speed for the bobsled to turn around the curve of smaller radius is v.

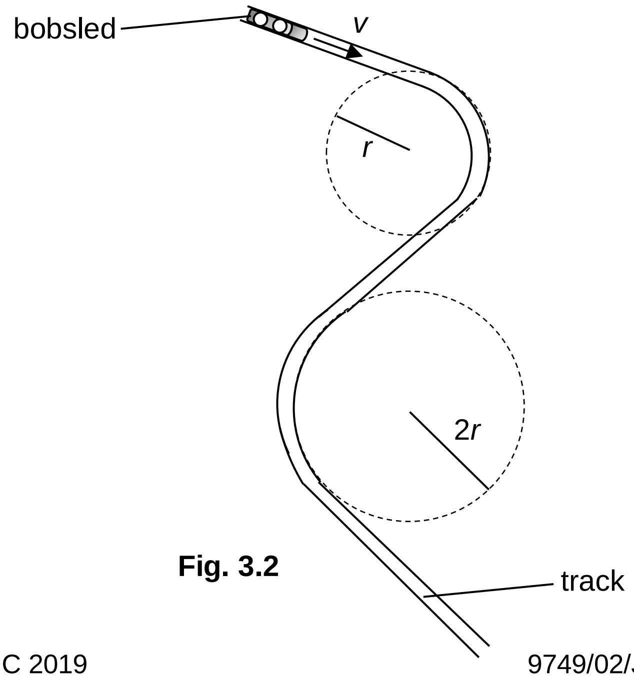


Fig. 3.2

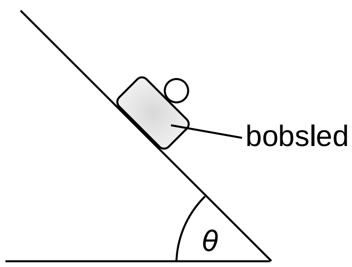


Fig. 3.3

(i) Derive an expression for the safe speed, v, for the curve of smaller radius, in terms of θ, r and g, where g is the acceleration due to gravity.

v = ... [3]

(ii) Hence express, in terms of v, the safe speed v' for the bobsled to turn about the curve of larger radius.

v' = ... [1]

(iii) In the actual Olympics bobsled track, the banking angle θ, defined as the angle the tangent to the curve makes with the horizontal, is not constant but varies as shown in Fig. 3.4. When coming around a turn, the bobsled crew will intentionally "climb the track", which is to go higher up the track. State and explain the reason for doing this.

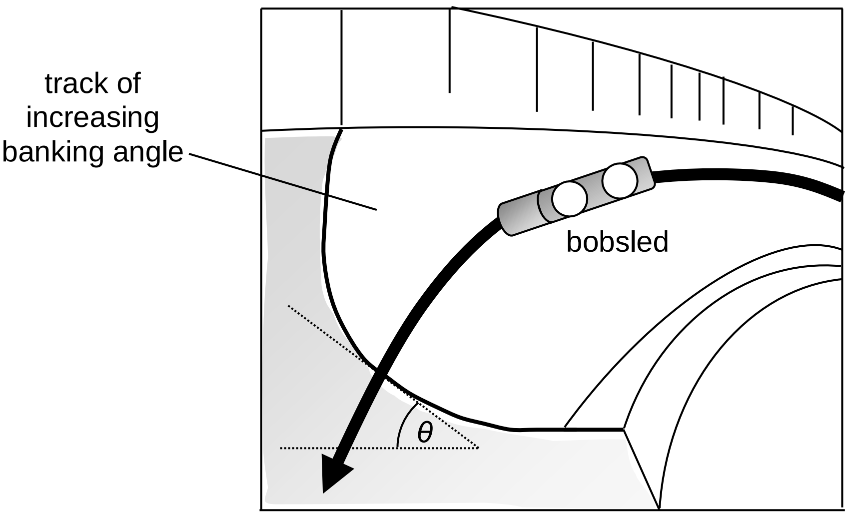


Fig. 3.4

....

....

.... [2]

For Examiner's Use

4 This question is about a space shuttle used to take tourists to the "edge of space".

(a) Fig. 4.1 shows the variation with height *h* above the Earth's surface of pressure *p*.

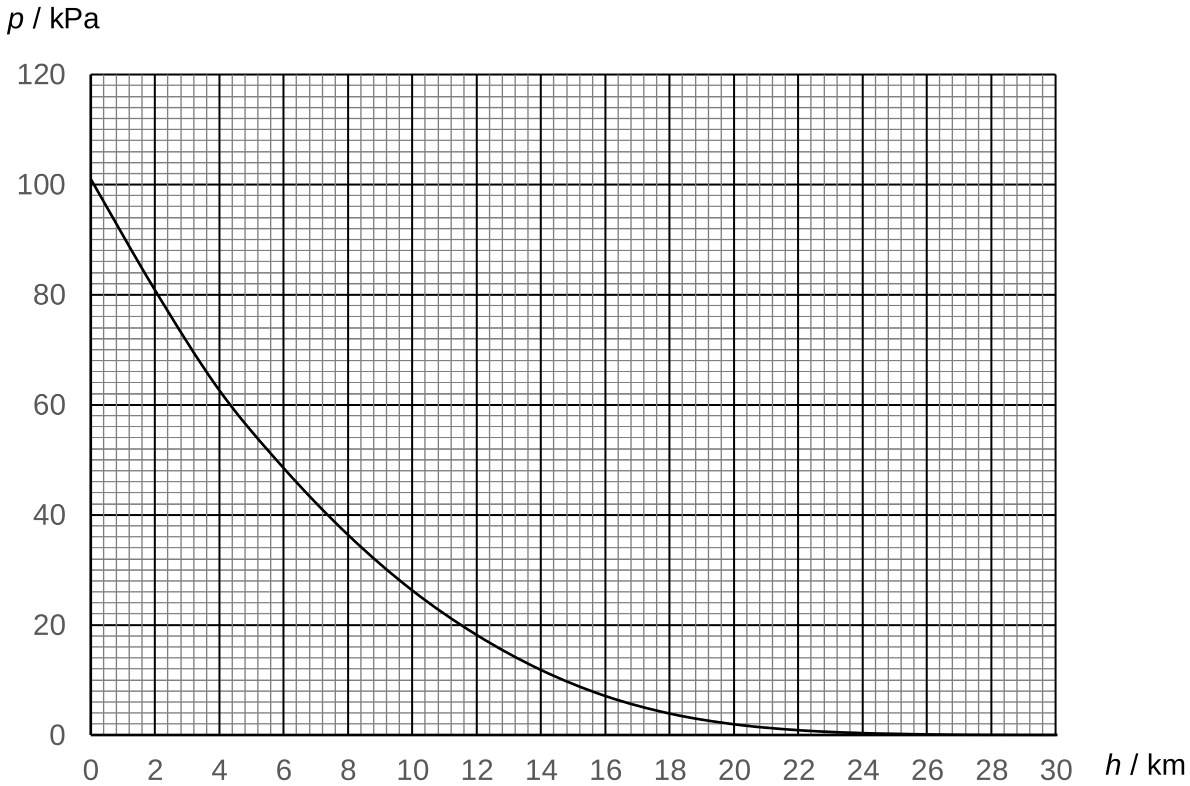


Fig. 4.1

(i) Using Fig. 4.1, suggest how the density of air varies with height *h*.

....

....[2]

(ii) The space shuttle, carrying passengers, is taken to a suitable height above the Earth's surface on the back of a carrier craft. At this height where the air pressure is only 25% of that at the surface of the Earth, the space shuttle is released from the carrier craft

Using Fig. 4.1, determine the height *h* above the Earth's surface where pressure is 25% of that at the surface.

h = ... km [2]

(iii) Suggest and explain an advantage of releasing the space shuttle at the height in **(ii)** instead of at the Earth's surface.

....

....[1]

(b) Fig. 4.2 shows the variation with the height h near the Earth's surface of the gravitational potential ϕ.

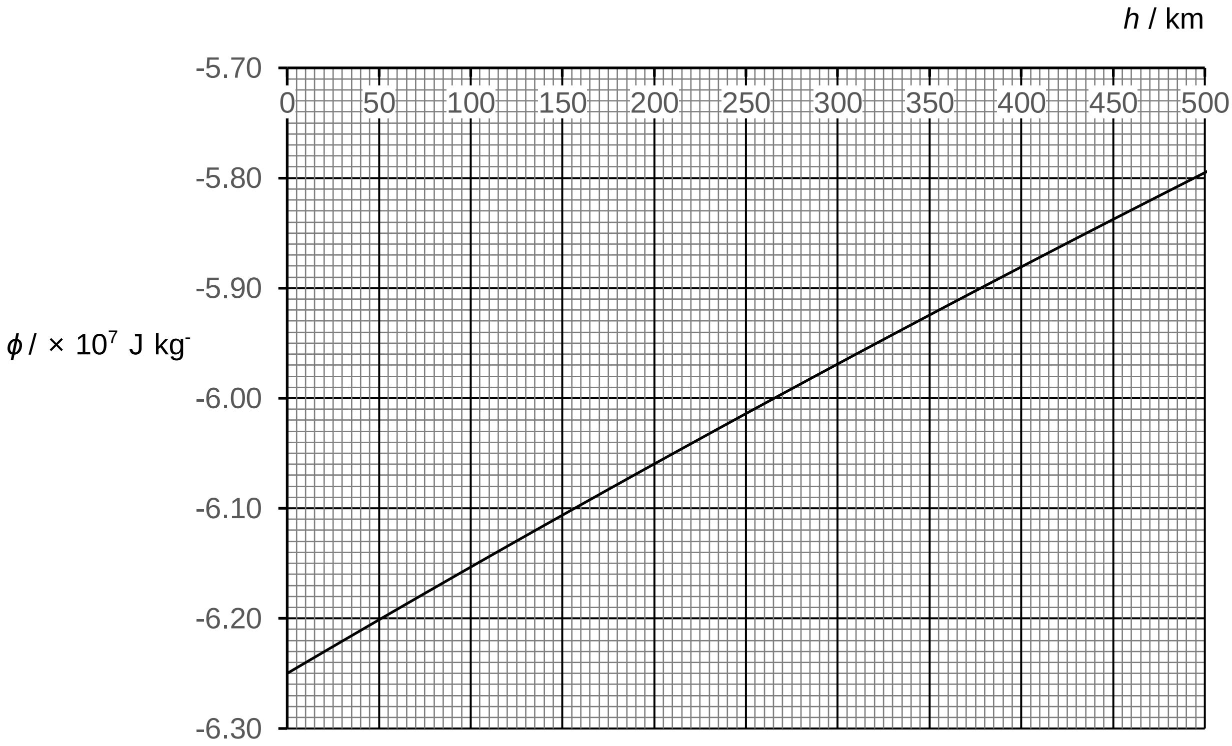


Fig. 4.2

(i) State the feature of the graph in Fig. 4.2 which shows that the gravitational field strength is non-uniform over the range of the flight from h = 0 to 500 km.

....

....[1]

(ii) Calculate the energy required by the space shuttle of mass 3800 kg to rise from the Earth's surface to 500 km above the surface.

energy required = ... J [2]

(iii) Estimate the gravitational field strength at a height of 300 km above the Earth's surface.

gravitational field strength = ... N kg^{-1} [2]

(c) When the shuttle is 300 km above the Earth's surface, the engines of the space shuttle exert a vertical thrust of 74 kN, radially away from the Earth. Calculate the acceleration on the shuttle at this instant.

acceleration = ... m s^{-2} [2]

(d) With the engines turned off, the space shuttle continues to travel radially away from the Earth in very thin atmosphere. Explain any change in the speed of the space shuttle.

....

....

....

....[2]

(e) Towards the end of the journey when the shuttle returns to Earth, the space shuttle descends near the Earth's surface where atmospheric pressure is high. State and explain whether the passmgers in the cabin of the shuttle experience weightlessness.

....

....

....

....[2]

End of Paper

H

NANYANG JUNIOR COLLEGE
JC 1 END-OF-YEAR EXAMINATION
Higher 2

CANDIDATE NAME	

CLASS		TUTOR'S NAME	

PHYSICS

9749/03

Paper 3 Structured Questions

3 October 2019

2 hour

Candidates answer on the Question Paper.

No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

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

Answer **all** questions in Sections A and C.
Answer **1 out of 2** questions in Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 12
2	/ 12
3	/ 12
4	/ 12
5	/ 20
6	/ 20
7	/ 12
Total	/ 80

This document consists of **22** printed pages.

Section A

Answer **all** the questions in the spaces provided.

1 **(a)** An aerial drone is used to take videos of an amusement park for an advertising company. Determine the magnitude and direction of the increase in velocity when the drone, which has been moving due south at 6.00 m s^{-1}, changes direction and moves north-west at 8.00 m s^{-1}.

magnitude = ... m s^{-1}

direction = ...

[3]

(b) At the shooting range in the amusement park, players win a prize if they manage to hit a moving target with a bow and arrow. The player stands at O which is 10.0 m away from T, where the target is initially. The player shoots the arrow 2.00 s after the target starts to move at a constant velocity of 12.0 m s^{-1} away from T. Assume that air resistance is negligible.

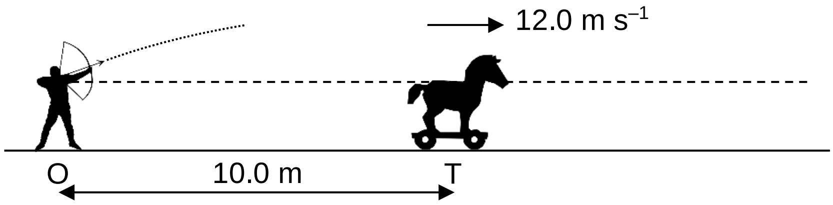


Fig. 1.1

(i) Explain why, in order for the arrow to hit the target, the player has to aim the arrow at an angle above the target, and not directly at the target.

....

....

....

....[2]

(ii) Calculate the distance between the player and target when the arrow leaves the bow.

distance = ... m [1]

(iii) The arrow leaves the bow at an angle of 30.0° above the horizontal with an initial velocity of 32.0 m s^{-1}. Show that the time of flight for the arrow to return to the same horizontal level as it left the bow is 3.26 s.

[1]

(iv) Hence determine whether the player is able to win a prize.

[3]

(v) In reality, air resistance is not negligible. State how air resistance affects the change in acceleration in the vertical direction, if any, as the arrow

1. rises, and

....[1]

2. falls.

....[1]

2 **(a)** State the *principle of conservation of linear momentum.*

....

....

....[1]

(b) A pellet of mass 40 g is launched towards a stationary trolley of mass 1.0 kg. It has a velocity of 12.0 m s^{-1} at an angle of 60.0° below the horizontal just before it lands on the trolley, as shown in Fig. 2.1. The pellet sticks to the trolley and moves off horizontally after impact.

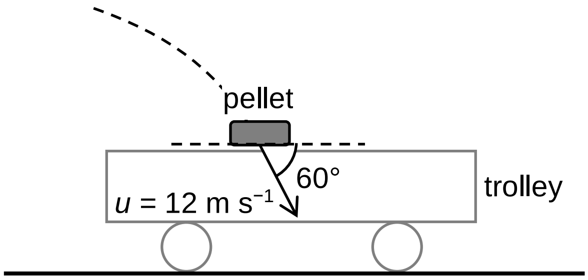


Fig. 2.1

(i) Explain why the momentum of the pellet and trolley is not conserved in the vertical direction.

....

....

....[1]

(ii) Show that the final horizontal velocity of the pellet and trolley is 0.23 m s^{-1}.

[1]

(iii) If the time of collision with the trolley is 0.15 s, calculate the average horizontal force exerted on the pellet upon collision with the trolley.

horizontal force = ... N [3]

(iv) Show that the change in momentum of the pellet in the vertical direction is 0.416 kg m s^{-1}.

[1]

(v) Determine the average vertical force exerted by the trolley on the pellet.

average vertical resultant force = ... N [2]

(vi) Hence, determine the magnitude of average force exerted by the trolley on the pellet.

magnitude of average force = ... N [1]

(c) If the trolley in **(b)** is now given a small initial velocity to the right, and the same pellet is launched such that it hits the trolley with the same speed and angle of impact, explain why the increase in velocity of the trolley will be smaller than 0.23 m s^{-1}.

....

....

....

....[2]

For Examiner's Use

3 T is a point source of microwaves which transmits waves of frequency 0.60 MHz uniformly in all directions. A and B are identical microwave receivers placed equidistant on either side of T, as shown in Fig. 3.1.

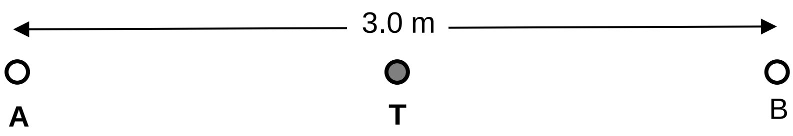


Fig 3.1

The distance between A and B is 3.0 m, and the intensity of the wave received by each of them is 74 mW m^{-2}.

(a) Explain what is meant by the *intensity* of a wave.

....

....

....[1]

(b) Calculate the power of source T.

power = ... W [2]

(c) T is moved 0.50 m towards B. Calculate the ratio of

$$\frac{\text{amplitude of wave at A}}{\text{amplitude of wave at B}}.$$

ratio = ... [3]

(d) The waves emitted by T are polarised in a vertical plane.

(i) Explain why microwaves can be polarized.

....

....

....[1]

(ii) Calculate the percentage loss in intensity if a receiver is orientated with its axis off the vertical by an angle of 10°.

percentage loss = ... [3]

(e) A second source U identical to T is located on the opposite side of B at an equal distance. When U begins transmitting together with T, the amplitude at B drops to zero. Deduce why this is so.

....

....

....[2]

4 An oscillator comprising a mass and two light springs shown in Fig. 4.1 has a mass of 0.50 kg. It is displaced from its equilibrium state and released. As a result, it performs simple harmonic motion about its equilibrium position.

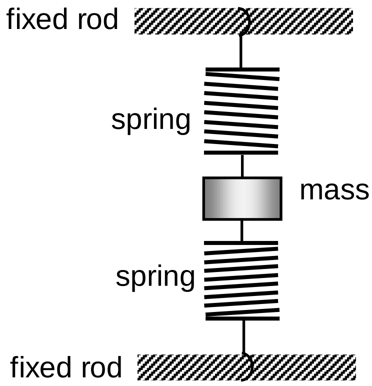


Fig. 4.1

The kinetic energy of the oscillator varies with its displacement from its equilibrium position as shown in Fig. 4.2.

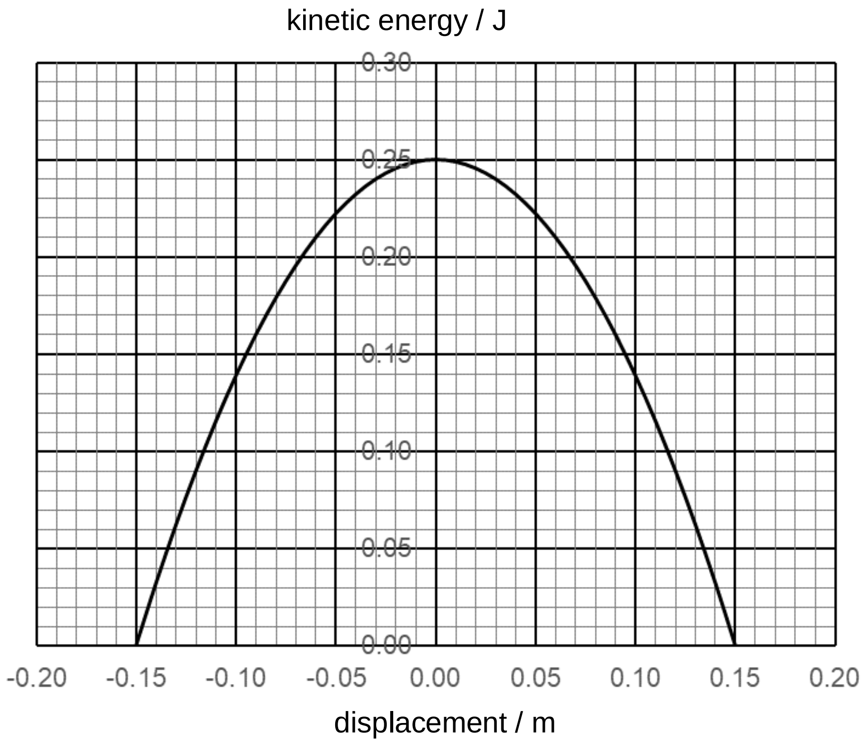


Fig. 4.2

(a) Explain what is meant by *simple harmonic motion*.

....

....

....[2]

(b) Determine the speed of the oscillator when it is **(i)** at its equilibrium point, and **(ii)** furthest from its equilibrium point.

speed at equilibrium point = ... m s^{-1}

speed at furthest point = ... m s^{-1}
[3]

(c) Determine the natural frequency of the oscillator.

natural frequency = ... Hz [3]

(d) A student explains that the shape of the graph in Fig. 4.2 is as shown because elastic potential energy is converted to kinetic energy and back as the oscillator oscillates. Comment on the validity of his explanation.

....

....

....[2]

(e) Using the axes in Fig. 4.2, sketch a graph of kinetic energy against displacement for the oscillator if its amplitude is halved. Indicate the values of the intercepts on both axes. [2]

For Examiner's Use

Section B

Answer **ONE** question from this section.

5 The table shows how the gravitational potential varies at three points above the surface of an unknown planet of radius 1.25×10^5 m.

Height above surface of planet / 10^5 m	Gravitational potential / 10^3 J kg^{-1}
0	- 15.0
1.75	- 6.25
6.25	- 2.50

(a) State what is meant by *gravitational potential* at a point.

....

....[1]

(b) Show, using the data above, that the potential is inversely proportional to the distance from the centre of the planet.

[2]

(c) Determine the mass of the planet.

mass = ... kg [1]

(d) Hence determine the gravitational field strength at the surface of the planet.

gravitational field strength at surface = ... N kg^{-1} [2]

(e) It is suggested that a space vehicle could land on the planet to search for valuable minerals. The planet is spinning and the time for one rotation is 5.0 hours.

The space vehicle of mass 3.0×10^4 kg is located on the equator of the planet at a distance of 1.25×10^5 m from the centre, as shown in Fig. 5.1.

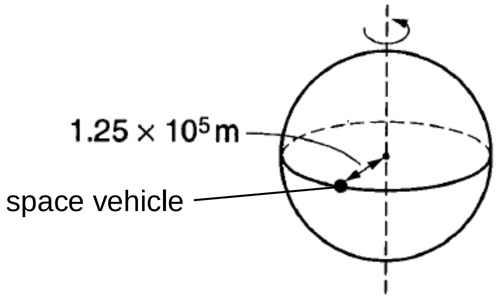


Fig. 5.1

(i) Calculate the centripetal force needed to keep the vehicle on the surface of the planet.

centripetal force = ... N [2]

(ii) Hence deduce quantitatively whether the vehicle will stay on the surface of the rotating planet.

....

....

....[3]

For Examiner's Use

(f) A space probe is launched from the North pole of the planet. During the launch, the energy E given to the space probe of mass m is

$$E = \frac{3GMm}{4R}$$

where G is the gravitational constant and M and R are the mass and radius of the planet respectively. Work done in overcoming resistive forces can be neglected.

(i) State and explain whether the space probe will be able to escape from the gravitational field of the planet.

....

....

....[2]

(ii) The space probe enters a circular orbit of radius r around the planet. Derive expressions, in terms of G, M, R , m and r for

1. the change in gravitational potential energy of the space probe as it travels from the planet's surface to its orbit,

change in gravitational potential energy = ... J [2]

2. the kinetic energy of the space probe when it is in its orbit.

kinetic energy = ... J [2]

(iii) Use your answers in **(f)(ii)** and the total energy supplied to the space probe as given in **(f),** to determine the height of the orbit above the planet's surface in terms of R.

height = ... m [3]

For Examiner's Use

6 (a) (i) State the *First Law of Thermodynamics*.

....

....

....[1]

(ii) The densities of water and steam at 100 ^{o}C and 1.01 × 10^{5} Pa are 1000 kg m^{-3} and 0.590 kg m^{-3} respectively. Calculate the change in volume which occurs when 1.00 kg of water changes to steam at 100 ^{o}C and atmospheric pressure of 1.01 × 10^{5} Pa.

change in volume = ... m^{3} [2]

(iii) Calculate the work done against the atmosphere when water changes to steam.

work done = ... J [2]

(iv) The specific latent heat of vaporisation of water at 100 ^{o}C is 2.26 × 10^{6} J kg^{-1}. Calculate the increase in internal energy of the molecules when 1.00 kg of water changes to steam.

increase in internal energy = ... J [2]

(v) State the increase in potential energy of the molecules. Explain your answer.

....

....

....[2]

For Examiner's Use

(b) Fig. 6.1 shows the below shows a p-V diagram for a fixed mass of gas.

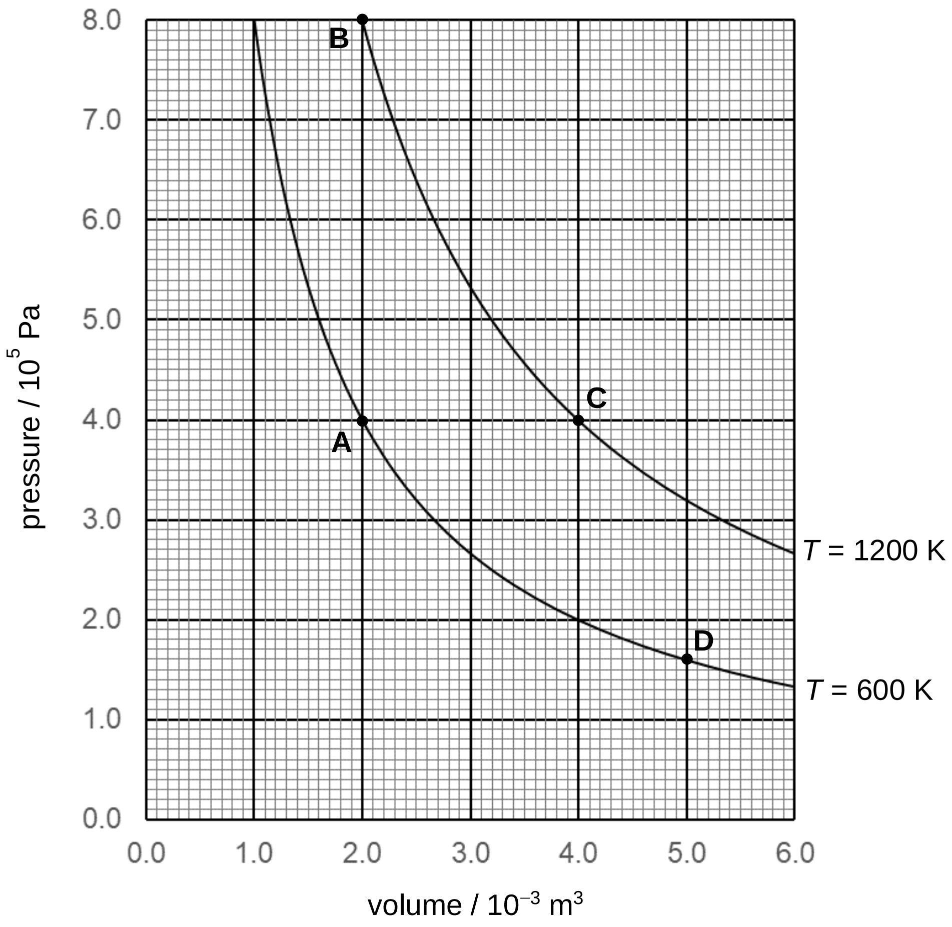


Fig. 6.1

(i) Write down the ideal gas equation.

....[1]

(ii) Show that the data of the graph are consistent with the gas behaving as an ideal gas over the range of temperature from 600 K to 1200 K.

[3]

(iii) Calculate the number of moles of the gas.

number of moles = ... [1]

(iv) The gas has a heat capacity of 3.33 J K^{-1} at constant volume and 4.66 J K^{-1}at constant pressure. Calculate the amount of heat supplied when the gas undergoes a process:

1. from A to B along line AB,

heat supplied = ... J [1]

2. from A to C along line AC.

heat supplied = ... J [1]

(v) If the internal energy at A is given to be 2000 J, determine the internal energy at C.

internal energy = ... J [3]

(vi) Explain why the internal energy of the gas at D is also 2000 J.

....

....[1]

Section C

Answer the question from this section.
It is recommended that you spend about 30 minutes on this section.

7 A student is investigating the bending of a loaded wooden strip. Fig. 7.1 shows a rectangular strip of width *b* and thickness *t* overhanging the edge of a bench. A length *L* of the strip is unsupported.

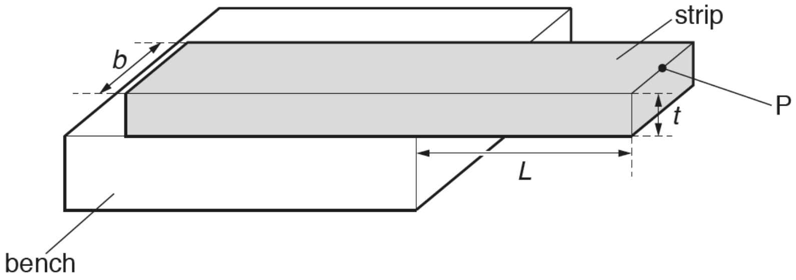


Fig. 7.1

A load of mass *M* is positioned at point P. This causes the unsupported part of the strip to bend with a deflection *s*, as shown in Fig. 7.2

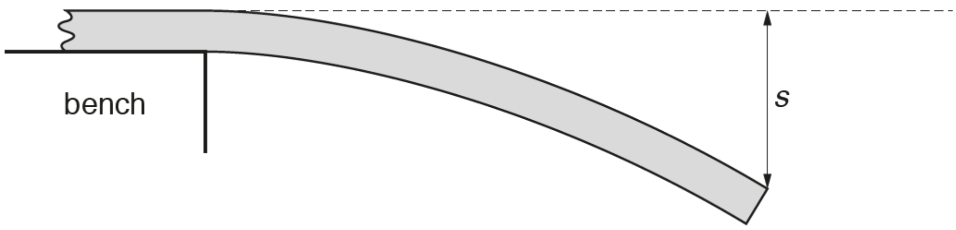


Fig. 7.2 (not to scale)

It is suggested that the relationship between *s* and *L* is

$$E = \frac{4MgL^3}{bst^3}$$

where *g* is the acceleration of free fall and *E* is the Young modulus of the wood.

Design a laboratory experiment to test the relationship between *s* and *L*.
Explain how your results could be used to determine a value for *E*.

In your account you should pay particular attention to:

- the procedure to be followed
- the measurements to be taken
- the control of variables
- the analysis of the data
- any safety precautions to be taken.

[12]

For Examiner's Use

Diagram

For Examiner's Use

[12]

End of Paper

NANYANG JUNIOR COLLEGE
JC 1 END-OF-YEAR EXAMINATION
Higher 2

PHYSICS 9749/01

Paper 1 Multiple Choice

2 October 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and tutor's name on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** 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 Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

This document consists of **12** printed pages.

[Turn over

1 A student uses a digital ammeter to measure a current. The reading of the ammeter is found to fluctuate between 1.98 A and 2.02 A.

The manufacturer of the ammeter states that any reading has a systematic uncertainty of ±1 %. Which of the following values of current should be quoted by the student?

A (2.00 ± 0.01) A
B (2.00 ± 0.02) A
C (2.00 ± 0.03) A
D (2.00 ± 0.04) A

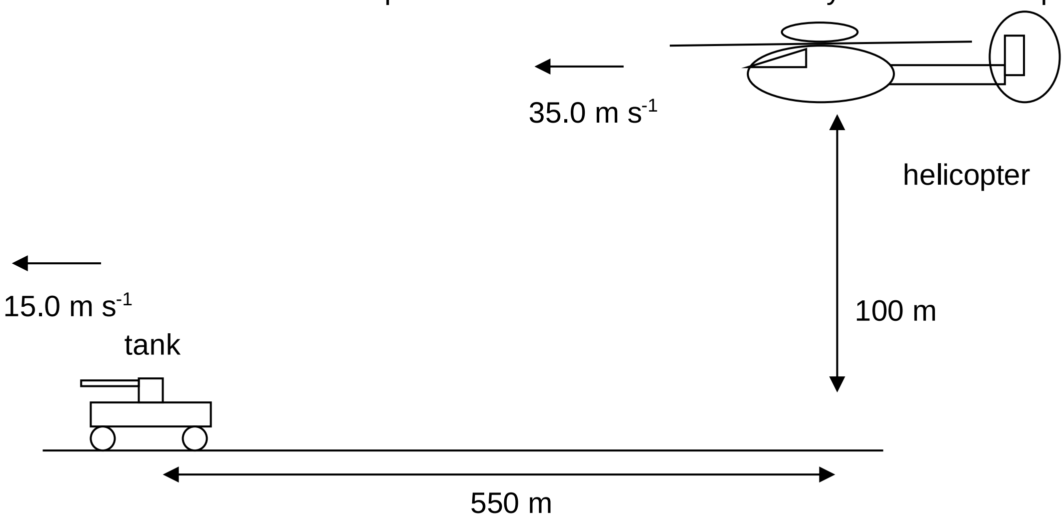
2 The following four possible sources of error in a series of measurements are listed as follows.

1) An analogue meter whose scale is read from different angles.
2) A meter whose measurements are always 5% too high.
3) A meter with a needle that is not frictionless, so the needle sometimes do not turn properly.
4) A meter with a zero error.

Which of the above sources of errors are random and which are systematic?

	random error	systematic error
A	1 and 2	3 and 4
B	1 and 3	2 and 4
C	2 and 4	1 and 3
D	3 and 4	1 and 2

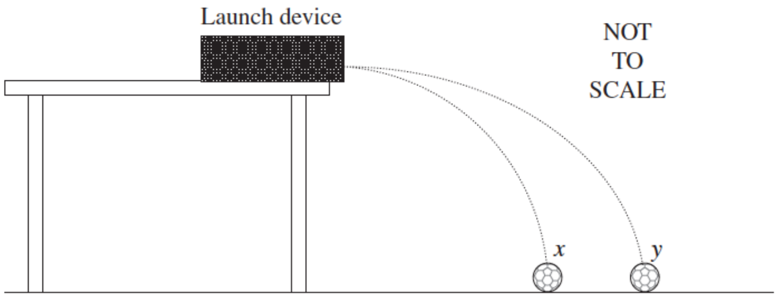
3 A helicopter flies at 100 m above a tank with a constant horizontal speed 35.0 m s^{-1} while the tank travels with a constant speed 15.0 m s^{-1} and is 550 m away from the helicopter.



At t = 0 s, the helicopter and the tank are at the above position, with the tank located 550 m horizontally away from the helicopter. How many seconds later, after this initial position at t = 0 s, should the helicopter release a bomb so that it will eventually hit the tank?

A 2.57 s **B** 4.52 s **C** 23.0 s **D** 27.5 s

4 A device launches two identical balls x and y horizontally from the same height at the same time. The balls eventually land on the ground. The landing positions of the balls are as indicated in the below diagram.



Which of the following statements is correct?

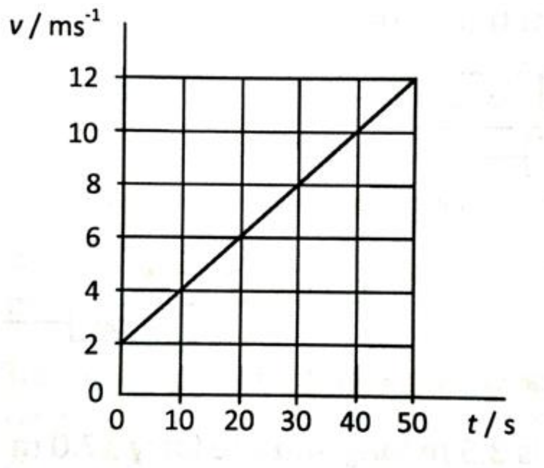
A x hits the ground before y as it is closer to the launch site.

B y hits the ground before x as it has a higher launch velocity.

C x and y hit the ground simultaneously with the same velocity.

D x and y hit the ground simultaneously with different velocities.

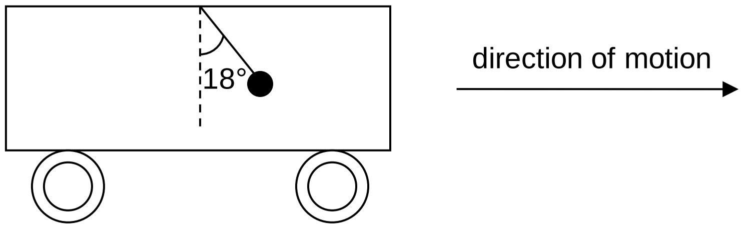
5 A train travelling at 2.0 m s^{-1} passes through a station. The graph below shows the variation with time t of the speed v of the train after leaving the station.



What is the speed of the train when it is 150 m from the station?

A 6.0 m s^{-1} **B** 8.0 m s^{-1} **C** 10 m s^{-1} **D** 12 m s^{-1}

6 A pendulum bob is suspended in a bus of mass 3000 kg that is undergoing constant deceleration. The pendulum makes an angle of 18° with the vertical. What is the deceleration of the bus?



A 0.32 m s^{-2} **B** 3.0 m s^{-2} **C** 3.2 m s^{-2} **D** 9.3 m s^{-2}

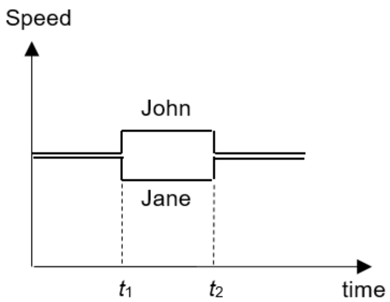
7 A movable noticeboard of mass 4.0 kg is placed on a smooth horizontal floor. A horizontal stream of water with speed 10 m s^{-1} strikes the noticeboard at a rate of 1.0 kg s^{-1} for a duration of 60 s. Assuming that the water does not rebound upon hitting the noticeboard and the mass of the noticeboard remains constant, what is the acceleration of the noticeboard?

A 2.5 m s^{-2} **B** 5.0 m s^{-2} **C** 10 m s^{-2} **D** 40 m s^{-2}

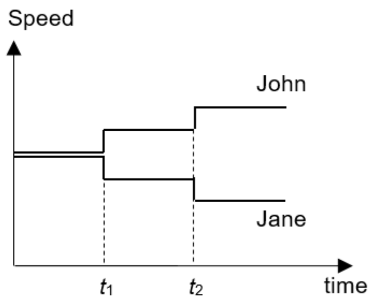
8 John and Jane are skating on smooth ice such that they are moving with equal speeds in the same straight line. John skates backwards facing Jane in front of her. At time t_1 John throws a ball to Jane and at time t_2 receives it back.

Assuming that the time of flight of the ball and air resistance are both negligible, which of the following gives the correct speed-time graph for the two skaters?

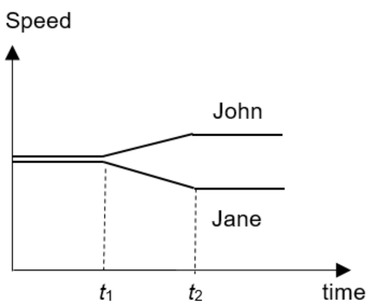
A



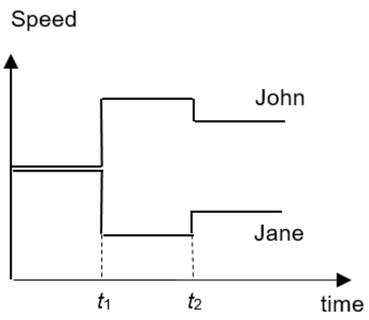
B



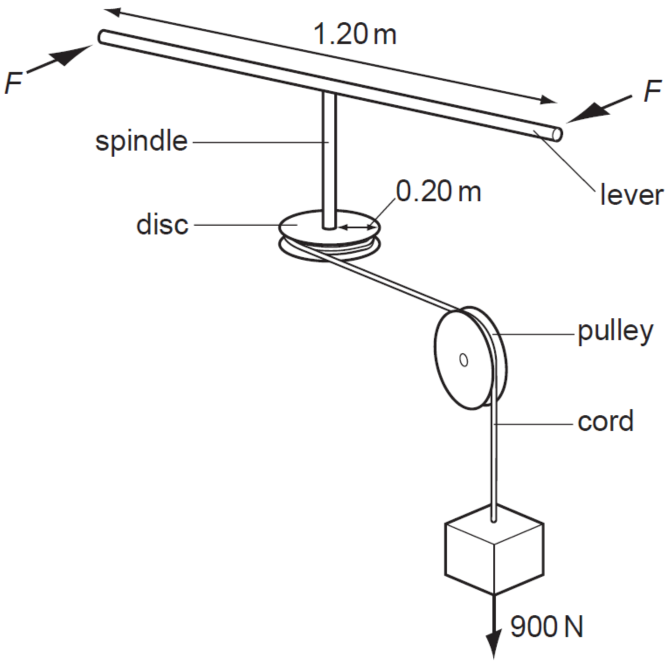
C



D



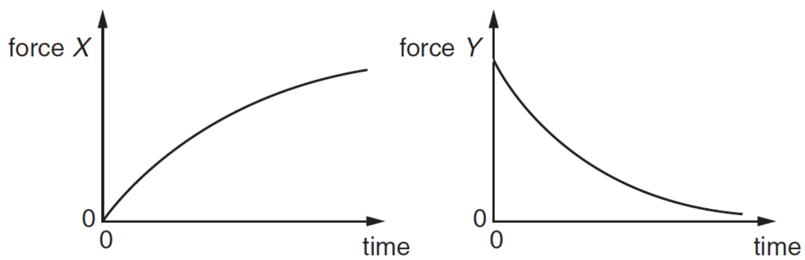
9 A spindle is attached at one end to the centre of a lever 1.20 m long and at its other end to the centre of a disc of radius 0.20 m. A cord is wrapped round the disc, passes over a pulley and is attached to a 900 N weight.



What is the minimum force *F*, applied to each end of the lever, that could lift the weight?

A 75 N **B** 150 N **C** 300 N **D** 950 N

10 A ball falls from rest through air and eventually reaches a constant velocity. For this fall, forces *X* and *Y* vary with time as shown. Which of the following could be forces *X* and *Y*?

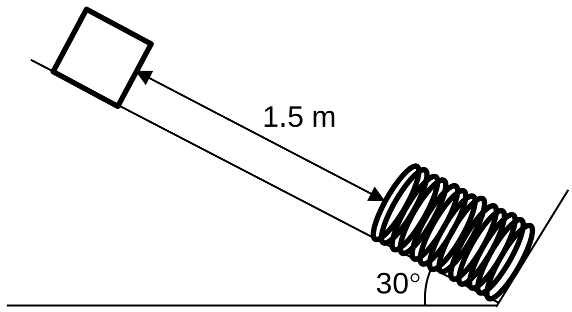


	force X	force Y
A	air resistance	resultant force
B	air resistance	weight
C	upthrust	resultant force
D	upthrust	weight

11 A thin horizontal plate of area 0.036 m^2 lies beneath the surface of a liquid of density 930 kg m^{-3}. The force on one side of the plate due to the pressure of the liquid is 290 N. What is the depth of the plate beneath the surface of the liquid?

A 0.88 m **B** 1.1 m **C** 1.8 m **D** 8.7 m

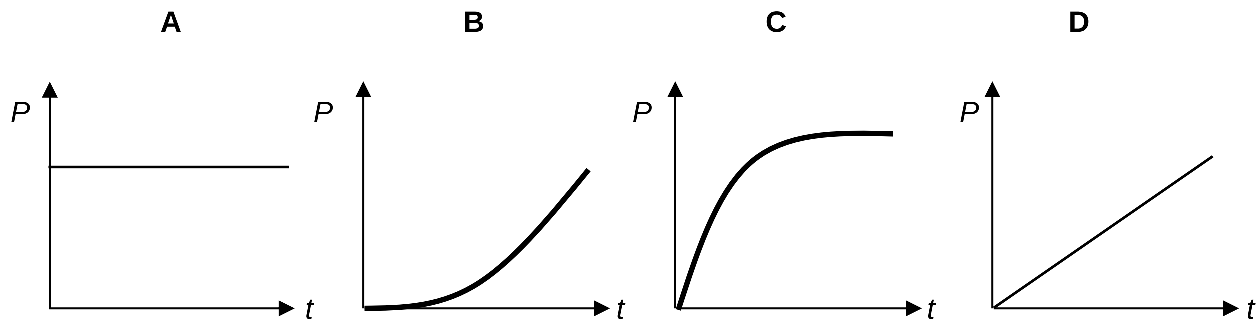
12 A block of mass 250 g is placed on a rough, inclined plane which makes an angle 30° with the horizontal. The spring at the end of the inclined plane has spring constant 5.0 N cm^{-1}. The distance between the mass and spring is 1.5 m as shown.



The block is then released from rest and it slides down the inclined plane before hitting the spring. Given that the frictional force acting on the mass is $\frac{1}{5}$ of its weight, what is the maximum compression of the spring?

A 6.5 cm **B** 6.8 cm **C** 10 cm **D** 83 cm

13 A constant force is applied to a body which is initially stationary. Assuming that the effects of friction are negligible, which of the following graphs best represents the variation of the power supplied P with time t?

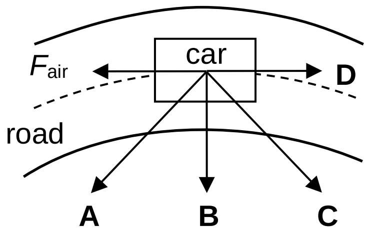


14 A light inextensible string can bear up to 3.7 kg of mass. A stone of mass 500 g is tied to one end of the string and revolved in a vertical circular path of radius 4.00 m. Taking g = 10 m s^{-2}, what is the maximum angular velocity of the stone?

A 3.0 rad s^{-1} **B** 4.0 rad s^{-1} **C** 5.0 rad s^{-1} **D** 6.0 rad s^{-1}

15 A car travels at constant speed on a horizontal circular road as shown. F_{air} is the air resistance acting on the car.

Which of the following best represents the horizontal force exerted by the road on the car?



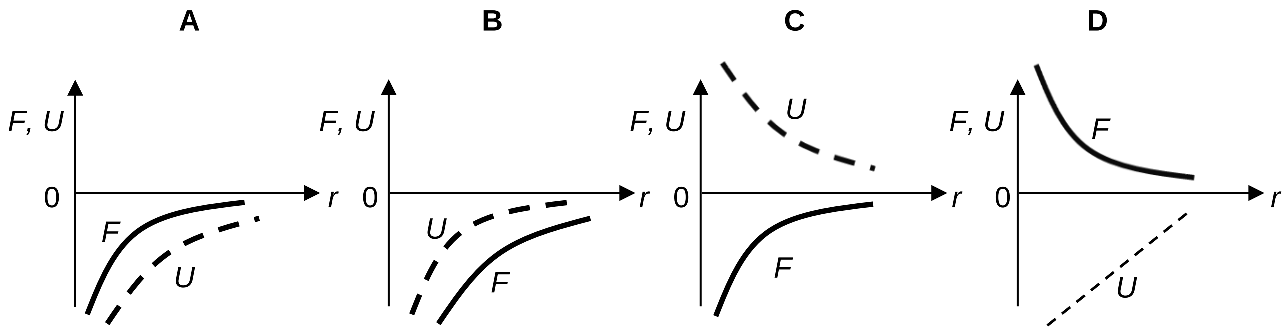
16 A racing car moving round a circular track of radius 300 m travels at a constant speed of 95 m s^{-1}. Given that the mass of the car is 700 kg, what is the angle at which the track should be banked, so that frictional force is not required for the car to make the turn?

A 18 ° **B** 36 ° **C** 57 ° **D** 72 °

17 The surface area of Earth is A and its density is ρ. What of the following is a correct expression for the gravitational field strength at the surface of Earth?

A $\frac{2}{3}G\rho\sqrt{A\pi}$ **B** $\frac{2}{3}(6A)^{\frac{1}{3}}G\pi^{\frac{2}{3}}\rho$ **C** $\frac{2}{3}G\pi\rho$ **D** $4G\pi\rho$

18 Which of the following correctly shows the variation of gravitational force F acting on a mass, and the variation of its gravitational potential energy U, with its distance r from another mass?



19 In a binary star system, two stars of mass M and $2M$ are at a distance d apart. The stars orbit each other (i.e. they orbit about their common centre of mass), with the same angular speed. Where is the common centre of mass of this binary star system located?

A $\left(\sqrt{2}-1\right)d$ from M **B** $\frac{2}{3}d$ from M

C $\left(2-\sqrt{2}\right)d$ from $2M$ **D** $\frac{2}{3}d$ from $2M$

20 A spring is suspended from a fixed point. A mass attached to the spring is set into vertical undamped simple harmonic motion. When the mass is at its lowest position, which one of the following has its minimum value?

A The potential energy of the system.

B The kinetic energy of the mass.

C The acceleration of the mass.

D The tension in the spring.

21 A mass is attached to the end of a vertical spring. It is given a downward displacement of 3.0 cm from its equilibrium position and then released. The mass is found to oscillate with a period of 0.50 s. What is the maximum speed of the oscillating mass?

A 0.21 m s^{-1} **B** 0.38 m s^{-1} **C** 0.53 m s^{-1} **D** 0.88 m s^{-1}

22 Which of the following is *false* for a system in resonance?

A The driving frequency coincides with the natural frequency of the system.

B The amplitude of oscillation of the system is maximum.

C When damping is increased, the peak of the frequency response graph shifts to the right.

D When damping is increased, the amplitude of oscillation of the system decreases.

23 Gas leaks out slowly of a cylinder of constant volume. The temperature of the gas in the cylinder does not change. Which of the following is constant for the gas molecules in the cylinder?

A The number of molecules striking a unit area of the cylinder surface per unit time.

B The number of collisions between molecules per unit time.

C The number of molecules per unit volume.

D The average speed of the molecules.

24 Two containers of volume 4.0 m^3 and 6.0 m^3 contain ideal gases at pressures of 100 Pa and 50 Pa respectively. They have the same temperature. A tube of negligible volume then joins the containers so that the molecules can move from one container to the other with no change in temperature. The final pressure in the containers is

A 70 Pa **B** 75 Pa **C** 80 Pa **D** 150 Pa

25 To determine the specific latent heat of vaporisation of water, a student uses a heater to boil water. When the water is boiling, the mass of water vapour produced per minute is measured at two different powers of the heater.

The reason the student repeats the experiment using a different power of the heater is to

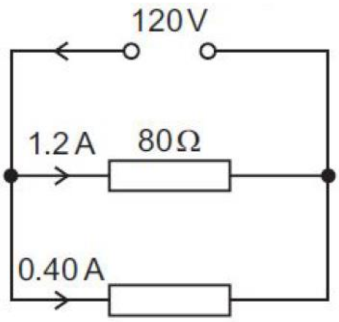
A reduce random errors in the measurements of the mass of water vapour produced per minute.

B allow the rate of heat loss from the apparatus to be eliminated from the calculations.

C determine an average value of the specific latent heat of vaporisation.

D check for reproducibility of the measurements.

26 The electromotive force of a power supply is 120 V. It delivers a current of 1.2 A to a resistor of resistance 80 Ω and a current of 0.40 A to another resistor, as shown.



What is the internal resistance of the power supply?

A 15 Ω **B** 20 Ω **C** 60 Ω **D** 75 Ω

27 There is a current in a resistor for an unknown period of time.

Which two quantities can be used to calculate the energy dissipated by the resistor?

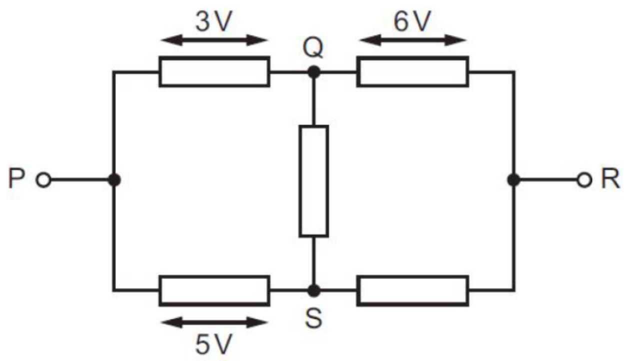
A The current in the resistor and the potential difference across the resistor.

B The resistance of the resistor and the current in the resistor.

C The total charge passing through the resistor and the potential difference across the resistor.

D The total charge passing through the resistor and the resistance of the resistor.

28 There is a current from P to R in the resistor network shown.



The potential difference (p.d.) between P and Q is 3 V.

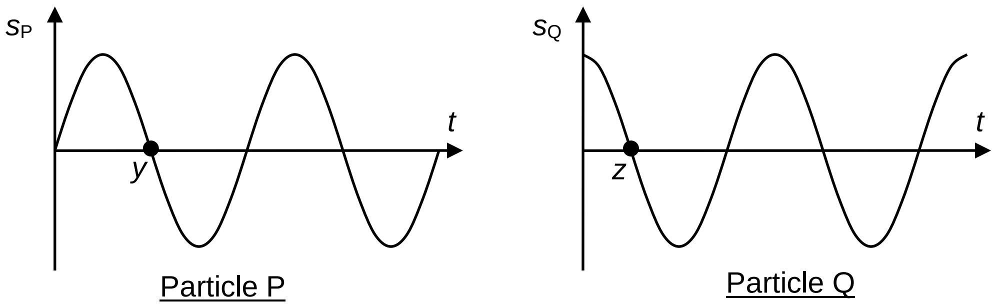
The p.d. between Q and R is 6 V.

The p.d. between P and S is 5 V.

Which of the following is correct?

	p.d. between Q and S	p.d. between S and R
A	2 V	4 V
B	2 V	10 V
C	3 V	4 V
D	3 V	10 V

29 The diagrams below show the displacement-time graphs of two particles P and Q separated by a fixed distance *x* along the path of a wave.

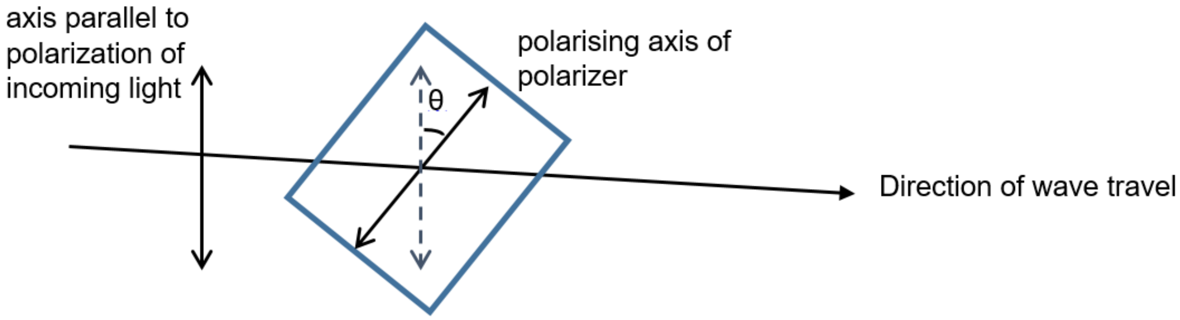


Which of the following correctly gives the wavelength and speed of the wave?

	wavelength	speed
A	$4x$	$4x / y$
B	$4x$	x / z
C	$2y$	$y / 2z$
D	$4z$	$2z / y$

30 An incoming beam of plane-polarised light of intensity I falls normally onto a thin sheet of polarizer. The polarising axis of the polarizer is at an angle θ to the axis of polarization of the incoming beam of light.

If the intensity of the beam after passing through the polarizer is $\frac{1}{4}I$, what is the angle θ?



A 22.5° **B** 30° **C** 45° **D** 60°

NANYANG JUNIOR COLLEGE
JC 1 END-OF-YEAR EXAMINATION
Higher 2

CANDIDATE NAME	

CLASS		TUTOR'S NAME	

PHYSICS **9749/02**

Paper 2 Structured Questions

2 October 2018

1 hour

Candidates answer on the Question Paper.

No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

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

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
5	
Total	

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

[Turn over

For Examiner's Use

1 One end of a wire is connected to a fixed point. A load is attached to the other end so that the wire hangs vertically.

The diameter d of the wire and the load F are measured as

$$d = 0.40 \pm 0.02 \text{ mm}$$
$$F = 25.0 \pm 0.5 \text{ N}$$

(a) For the measurement of the diameter of the wire, state

(i) the name of a suitable measuring instrument,

.... [1]

(ii) how random errors may be reduced when using the instrument named in **(i)**.

....

.... [1]

(b) The stress σ in the wire is calculated by using the expression

$$\sigma = \frac{4F}{\pi d^2}$$

(i) Determine the percentage uncertainty in σ.

percentage uncertainty = ... % [1]

(ii) Hence determine the value of σ with its associated uncertainty.

σ = (.................................. ± ....) N m^{-2} [2]

For Examiner's Use

2 **(a)** A steady stream of air hits a vertical wall horizontally and is brought to rest immediately.

(i) Using Newton's laws of motion, explain why the air exerts a force on the vertical wall.

....

....

....

.... [3]

(ii) Explain why the vertical wall does not experience a change in momentum when it is hit by the stream of air.

....

.... [1]

(b) A steady stream of air with speed 10.0 m s^{-1} hits block A of mass 0.50 kg (block A is not stationary initially). It is given that the density of air is 1.25 kg m^{-3} and the effective cross-sectional area of block A is 0.50 m^2. Assuming that the stream of air is immediately brought to rest after hitting block A,

(i) calculate the change in momentum of the air in one second,

change in momentum = ... kg m s^{-1} [2]

(ii) determine the force exerted by the air on the block.

force = ... N [1]

(iii) After being hit by the stream of air, block A slides on the ground and collides at a speed of 3.0 m s^{-1} with a stationary block B of mass 0.80 kg. Given that block A rebounds at a speed of 1.0 m s^{-1} after the collision,

1. determine the speed of block B after the collision.

speed = ... m s^{-1} [2]

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2. State and explain whether the collision between blocks A and B is elastic.

....

....

.... [2]

3 A pulley system is used to lift a mass *m* of 100 kg which is initially at rest, as shown in Fig. 3.1.

Fig. 3.1

A constant force *F* of 2000 N is exerted on the light cable, pulling the cable down by a distance of 1.2 m. Determine

(a) the work done by force *F*,

work done = ... J [2]

(b) the gain in gravitational potential energy of the mass *m*,

gain in gravitational potential energy = ... J [2]

(c) the speed of the mass *m* after the cable has been pulled down by 1.2 m.

speed = ... m s^{-1} [2]

4 **(a)** Explain why a body moving with uniform speed in a circle must experience a force towards the centre of the circle.

....

....

....

....

....

.... [2]

(b) A massless spring with force constant k = 78.4 N m^{-1} is fixed to the left side of a level track. A block of mass m = 0.50 kg is pressed against the spring and compresses it by a distance d as shown in Fig. 4.1. The block is then released from rest and travels toward a circular loop-the-loop of radius R = 1.5 m.

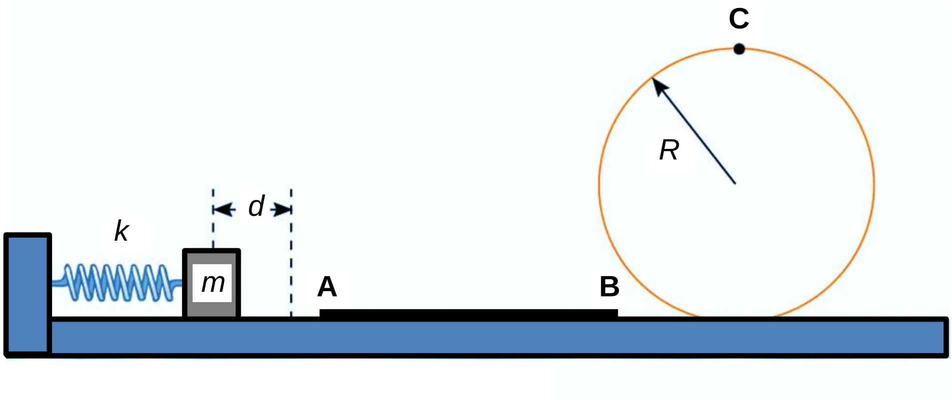

Fig. 4.1

The entire track and the loop-the-loop are frictionless except for the section of track between points **A** and **B**.

Given that the friction between the block and the track along **AB** is 1.47 N and the length of **AB** is 2.5 m, determine the minimum compression *d* of the spring that enables the block to just make it through the loop-the-loop at point **C**.

d = ... m [3]

(c) An elastic cord has a natural length of 13.0 cm. One end of the cord is attached to a fixed point **D**. A small mass of weight 5.0 N is hung from the free end of the cord. The cord extends to a length of 14.8 cm, as shown in Fig. 4.2.

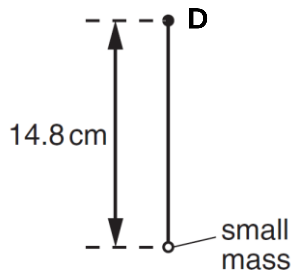

Fig. 4.2

The cord and mass are now made to rotate at *constant* angular speed ω in a vertical plane about point **D**. When the cord is vertical and above **D**, its length is its natural length of 13.0 cm, as shown in Fig. 4.3.

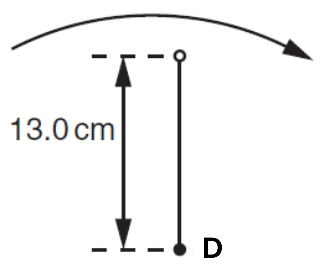

Fig. 4.3

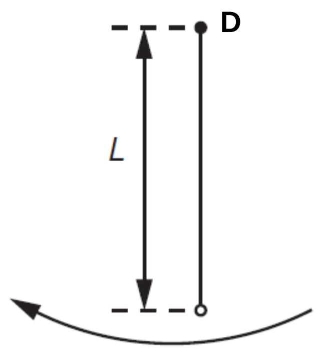

Fig. 4.4

The cord and mass rotate so that the cord is vertically below **D**, as shown in Fig. 4.4. Calculate the length L of the cord in Fig. 4.4, assuming that it obeys Hooke's law.

L = ... m [3]

5 **(a)** A block M_1 of mass 3.0 kg is connected to a spring with spring constant k. M_1 rests on a smooth surface. Another block M_2 of mass 2.0 kg is placed on top of M_1, as shown in Fig. 5.1.

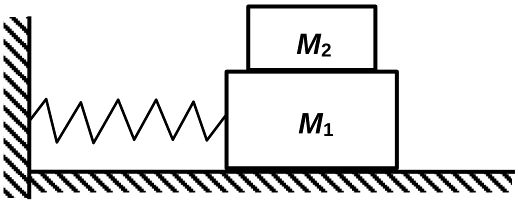

Fig 5.1

M_1 is then given a horizontal displacement and released. The above system oscillates with simple harmonic motion and its acceleration is given by the expression

$$a = -\frac{k}{M_1 + M_2}x$$

where x is the displacement of the system from its equilibrium position.

(i) Given that the spring constant of the spring is 50 N m^{-1}, calculate the frequency of oscillation of the system.

frequency = ... Hz [2]

(ii) The maximum potential energy of the system is 8.0 J. Determine the speed of the system when its displacement is equal to half the amplitude of its oscillation.

speed = ... m s^{-1} [2]

(b) **(i)** One possible consequence of the oscillations is that block M_2 may slide along M_1 if the amplitude of the oscillating system exceeds a certain value. Explain why this can happen.

....

....

.... [2]

(ii) The positions of the two blocks are now swapped, such that block M_2 is now connected to the spring instead. This system of blocks M_1 and M_2 is then set into oscillation by giving it an initial horizontal displacement. State and explain whether the frequency and amplitude of this oscillating system will remain the same as those in **(a)**.

Frequency:

....

....

Amplitude:

....

.... [2]

(c) The spring-mass system consisting of only the mass M_1 is now connected to a vibrator, as shown in Fig. 5.2. The frequency of the vibrator is slowly increased.

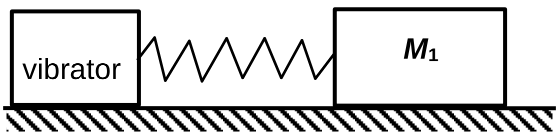

Fig 5.2

The amplitude of M_1 is observed to increase to a maximum before it decreases again.

Determine the frequency of the vibrator at the instant when maximum amplitude is observed. Explain your working clearly.

frequency = ... Hz [2]

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JC 1 END-OF-YEAR EXAMINATION
Higher 2

CANDIDATE NAME

CLASS

TUTOR'S NAME

PHYSICS

9749/03

Paper 3 Structured Questions

4 October 2018

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

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

Answer **all** questions in Section A and Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	
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5	
Section B	
6	
Total	

This document consists of **19** printed pages.

[Turn over

For Examiner's Use

Section A

1 A performer juggles 3 balls A, B and C in a repeated pattern as shown in Fig. 1.1. The performer starts with balls A & C in his left hand and ball B in his right hand, and begins juggling by tossing ball A into the air while still holding balls B and C. As ball A reaches its peak, the performer begins to toss ball B into the air. As ball B reaches its peak, the performer catches ball A with his right hand and begins to toss ball C with his left hand, and the cycle continues.

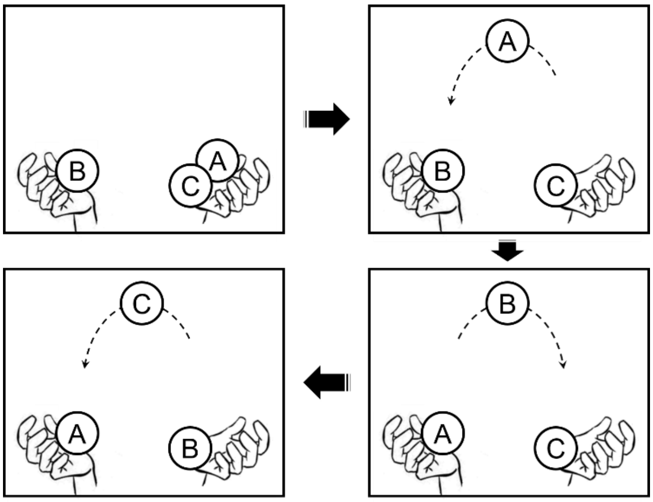

Fig. 1.1

(a) Show that the vertical component of the speed of projection of the ball has to be 4.43 m s^{-1} if the performer wants to throw a ball to a maximum height of 1.0 m from the point of release.

[1]

(b) Show that ball C stays in the performer's hand for 0.90 s while ball A is in the air.

[1]

(c) Hence determine the angle of projection of the ball if the performer keeps his hands 30 cm apart.

angle of projection = ... º [2]

(d) With reference to the juggling sequence described above, sketch, on Fig. 1.2, the velocity-time graphs for the vertical component v_y of the velocity of **balls A and B**.
On your graphs, **label** appropriate values of v_y and time t.
Your graphs should begin at t = 0 s when **ball A first leaves** the perfomer's hand, and end when **ball B first returns** to the performer's hand.

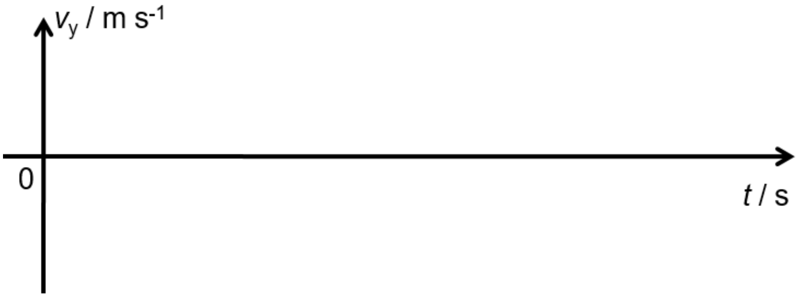

Fig. 1.2

[3]

2 (a) A cylinder of weight 0.60 N is hung from the end A of a non-uniform bar AB, as shown in Fig. 2.1.

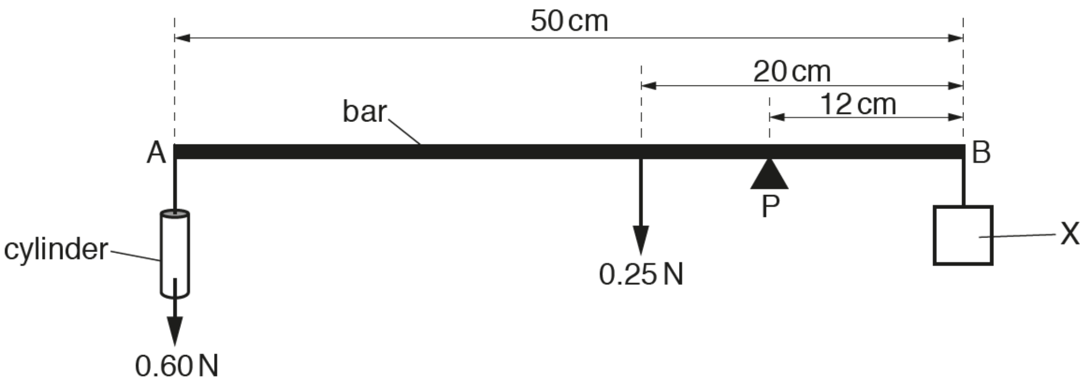

Fig. 2.1

The bar has length 50 cm and has weight 0.25 N. The centre of gravity of the bar is 20 cm from B. The bar is pivoted at P. The pivot is 12 cm from B.

An object X is hung from end B. The weight of X is adjusted until the bar is horizontal and in equilibrium.

(i) Explain what is meant by *centre of gravity*.

....

....

.... [1]

(ii) State the two conditions necessary for a body to be in *equilibrium*.

1. ....

....

2. ....

.... [2]

(iii) Calculate the weight of X.

weight = ... N [2]

(b) The cylinder is now immersed in water, as illustrated in Fig.2.2.

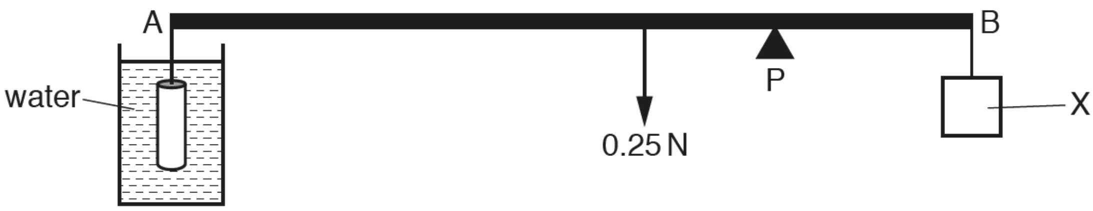

Fig. 2.2

An upthrust acts on the cylinder and the bar is not in equilibrium.

(i) Explain the origin of the upthrust.

....

....

.... [1]

(ii) Explain why the weight of X must be reduced in order to obtain equilibrium for AB.

....

....

....

.... [2]

3 Fig. 3.1 shows a simple heat engine. When gas inside the metal cylinder is heated by the heat reservoir, a load on the platform is raised and thereby gains gravitational potential energy. In this way, thermal energy is converted into mechanical energy.

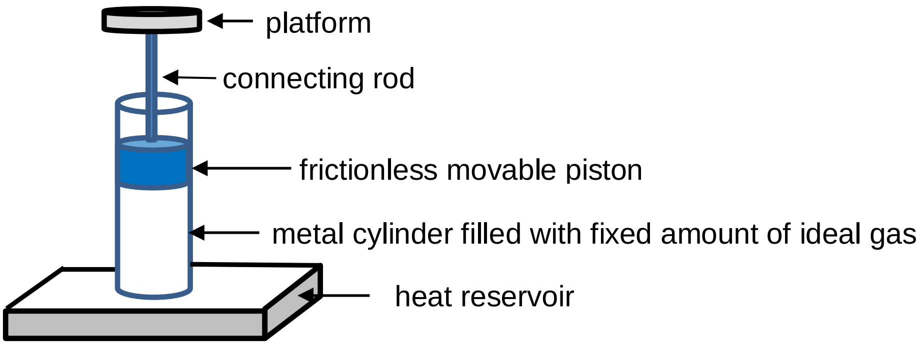

Fig. 3.1

In one cycle, the heat engine goes through the states $A \rightarrow B \rightarrow C \rightarrow D \rightarrow A$ as shown in Fig. 3.2.

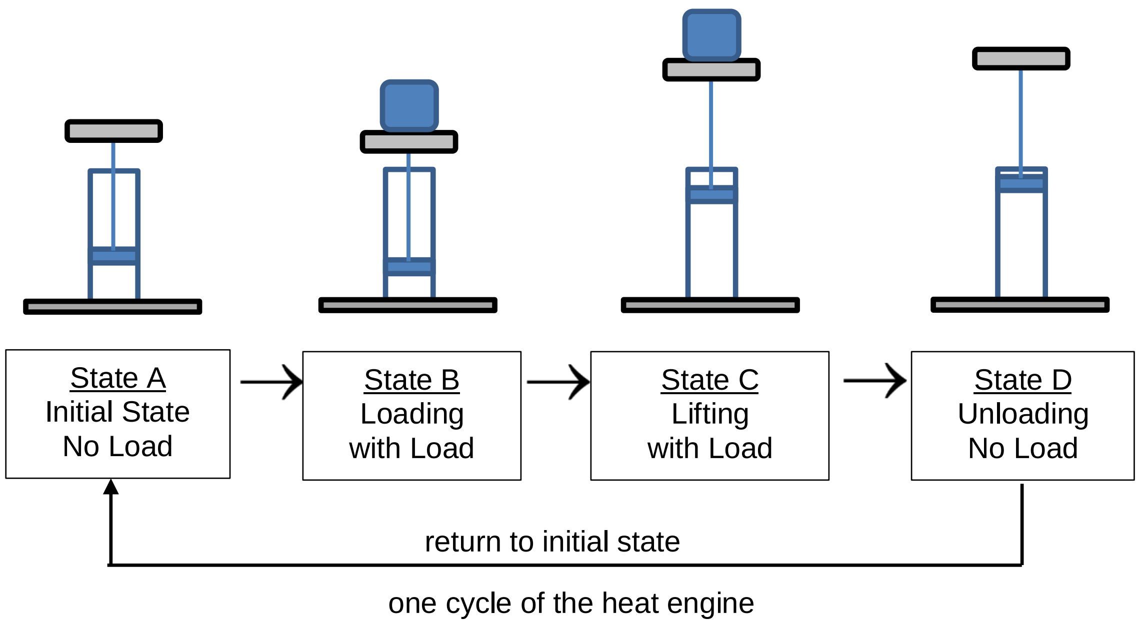

Fig. 3.2

For Examiner's Use

(a) Fig. 3.3 shows the pressure, volume and temperature of the ideal gas inside the metal cylinder for states A, B, C and D.

State	Pressure / kPa	Volume / m^3	Temperature / K
A	100	1.000	292
B	110	0.909	292
C	112	1.150	376
D	100		353

Fig. 3.3

(i) Complete Fig. 3.3 by filling in the volume for state D. [1]

(ii) With reference to Fig. 3.2, explain why the pressure for states A and D are the same.

....

....

.... [1]

(b) Fig. 3.4 illustrates the cycle of changes of pressure, volume and temperature undergone by the fixed mass of ideal gas inside the metal cylinder from state A to state B to state C.

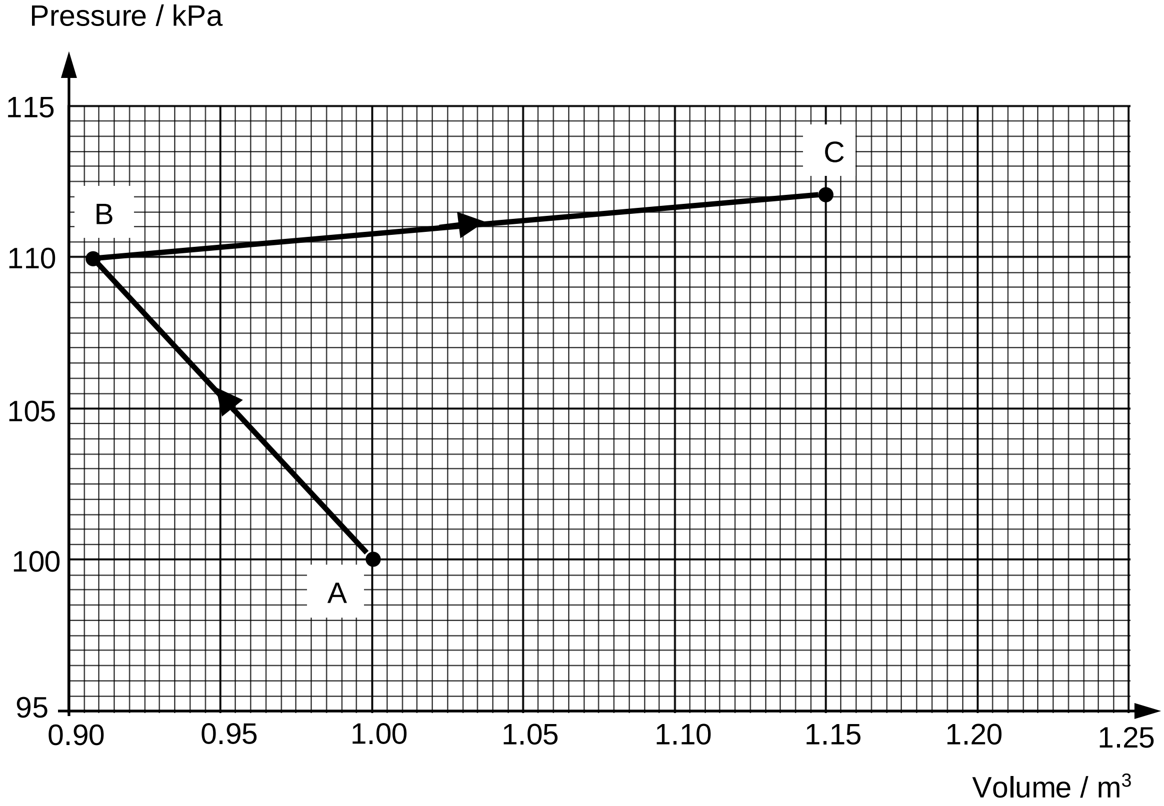

Fig. 3.4

(i) **1.** On Fig. 3.4, mark and label state D. [1]

2. On Fig. 3.4, draw the process lines joining state C to state D to state A, with arrows to indicate the direction. [1]

(ii) Using Fig. 3.4, estimate the work done by the ideal gas in one cycle.

work done = ... J [2]

(c) **(i)** State the *first law of thermodynamics*.

....

....

.... [1]

(ii) **1.** State what is meant by the *internal energy* of a system.

....

....

.... [1]

2. Explain why the internal energy of an *ideal gas* is proportional to the temperature of the gas.

....

....

....

.... [1]

(iii) Calculate the change in internal energy of the ideal gas in the metal cylinder when it goes from state B to state C in **(b)**.

change in internal energy = ... J [2]

(iv) Hence determine the amount of thermal energy *Q* absorbed by the gas from the heat reservoir as it goes from state B to state C.

Q = ... J [2]

4 The *I*-*V* characteristic of an electrical component X is investigated using the circuit shown in Fig. 4.1.

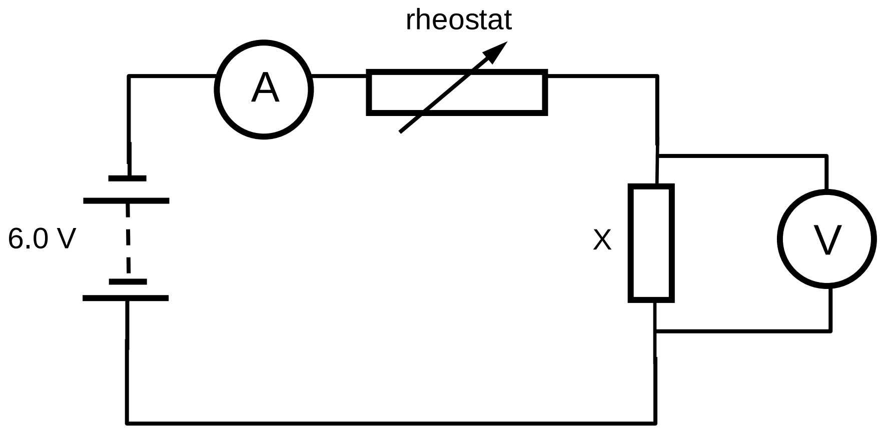

Fig 4.1

The *I*-*V* graph obtained from the results is shown in Fig 4.2.

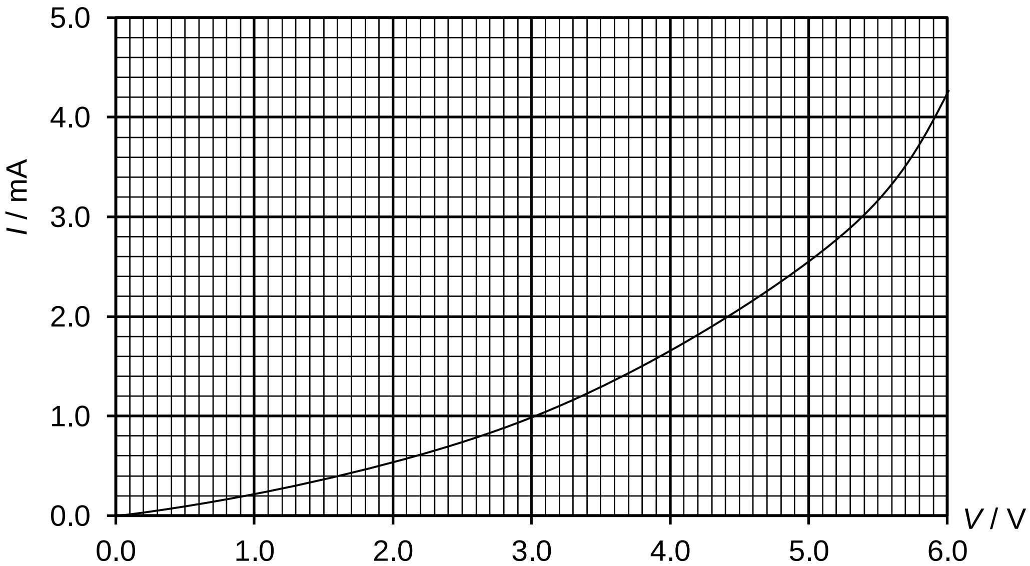

Fig. 4.2

(a) Determine the minimum and maximum resistance of component X over the range 0 – 6.0 V.

minimum resistance = ... Ω

maximum resistance = ... Ω [3]

(b) State and explain whether the voltmeter reading is equal to the terminal p.d. of the cell.

....

....

.... [2]

(c) The rheostat used in Fig. 4.1 has a resistance that ranges from 0 – 10 kΩ.

(i) Explain how the rheostat should be adjusted in order to measure a p.d. of 6.0 V across the component X.

....

....

.... [1]

(ii) State an assumption made in your answer to **(c)(i)**.

....

....

.... [1]

(iii) Suggest whether it is possible to obtain a value for the p.d. across the component X that is close to 0 V.

....

....

.... [1]

(d) Three identical pieces of component X are arranged as shown in Fig 4.3.

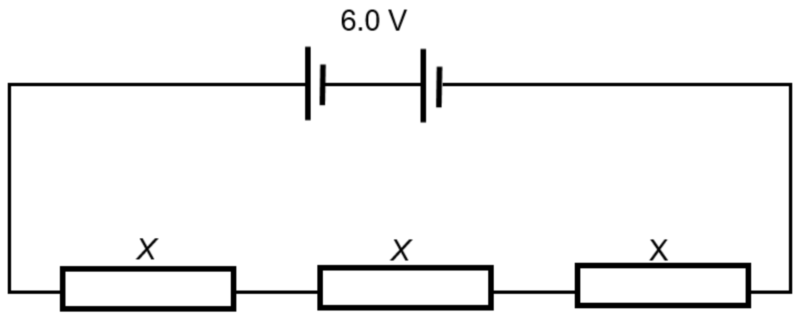

Fig. 4.3

(i) Determine the total resistance of the circuit.

total resistance = ... Ω [2]

(ii) Explain why your answer in **(d)(i)** is not equal to the minimum resistance of component X.

....

....

.... [1]

(iii) The circuit is then re-arranged as shown in Fig. 4.4. The total current in the circuit is 1.65 mA. Using Fig 4.2, deduce the new total resistance of the circuit in Fig. 4.4.

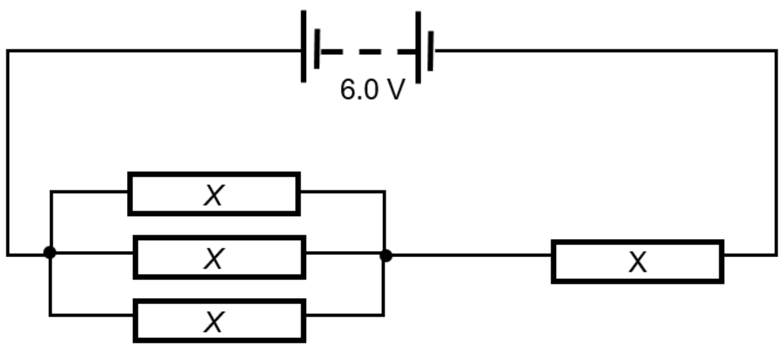

Fig. 4.4

new total resistance = ... Ω [1]

5 The article below is based on an article on the Internet.

Read the article and then answer the questions that follow.

Photovoltaic (PV) Efficiency: The Temperature Effect

A photovoltaic (PV) cell absorbs light energy and converts this into electrical energy. A PV panel consists of a large number of photovoltaic cells. A PV system consists of a PV panel and the rest of the circuit to which it is connected.

Temperature generally affects current in an electrical circuit by changing the speed at which the electrons travel. In metals, this is due to an increase in resistance of the circuit that results from an increase in temperature. The opposite effect is seen in semiconductor materials where an increased temperature results in a decrease in resistance due to a change in the number density of charge carriers.

It is important that the equipment associated with a PV panel is appropriate for the context in which it will be used. The current and voltage output of a PV cell is affected by changing weather conditions. A PV system at a higher temperature will have a lower maximum voltage, lower efficiency and lower power output than the same system at a lower temperature.

Engineers must carefully choose the PV system for different temperature environments to ensure that the output voltage is not too high, which could damage the equipment. It is also important to consider the average operating voltage and current of a PV system for safety concerns, equipment capabilities and choices, and to minimize the amount of wire required for construction.

Since PV panels are more efficient at lower temperatures, engineers design systems with active and passive cooling. An example of active cooling is to pump water behind the panels to remove the heat. An example of passive cooling is to let the system be cooled by convection currents in the air.

While it is important to know the temperature of a solar PV panel to predict its power output, it is also important to know the PV panel materials because the efficiencies of different materials have varied levels of dependence on temperature. Therefore a PV system must be engineered not only according to the maximum, minimum and average environmental temperatures at each location, but also with an understanding of the materials used.

The temperature dependence of a material is described with a temperature coefficient. For monocrystalline PV panels, if the temperature decreases by 1 ^{o}C, the voltage increases by 0.48 V, so the temperature coefficient is 0.48 V $^{o}C^{-1}$. The general equation for estimating the open circuit voltage V of a material at the temperature T of the panel is

$$V = \mu\ (T_R - T) + V_R$$

where μ is the temperature coefficient, T_R is a reference temperature and V_R is the open circuit voltage at the reference temperature. The temperatures are in degrees Celsius.

The variation with voltage of current at two different temperatures for one cell of the panel is shown in Fig. 5.1.

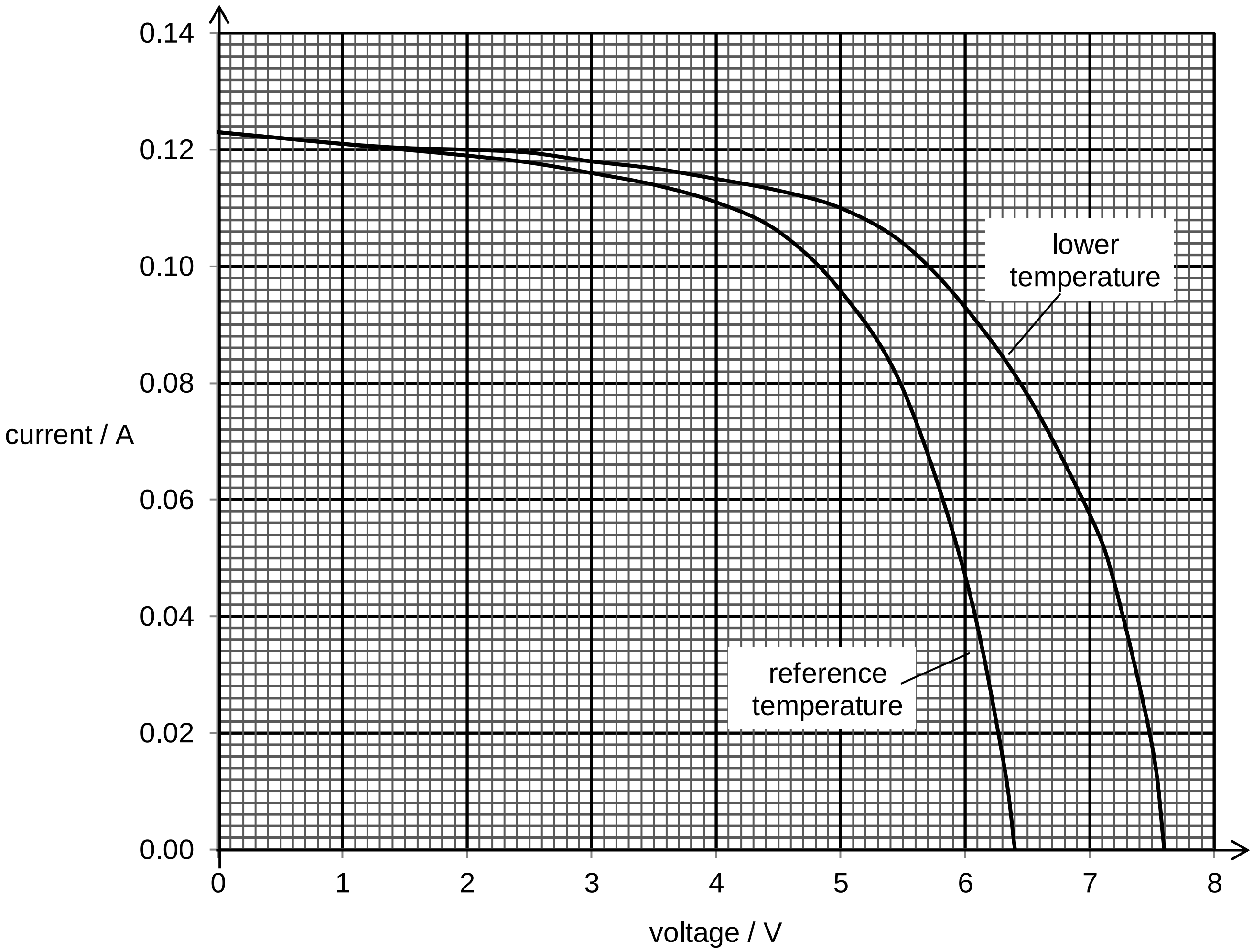

Fig. 5.1

(a) State and explain why the resistance of metals increases with temperature.

....

....

.... [2]

(b) The panel produces a much larger voltage or current than an individual cell. State how the cells are connected in a panel so that

(i) the voltage is increased,

.... [1]

(ii) the current is increased.

.... [1]

For Examiner's Use

(c) **(i)** Suggest what is meant by *passive cooling*.

....

....

.... [1]

(ii) Suggest why engineers do not design systems with active cooling alone.

....

....

.... [1]

(d) Give one suggestion on how passive air cooling may be enhanced for a PV panel.

....

....

.... [2]

(e) **(i)** Use Fig. 5.1 to state the open circuit voltage (e.m.f.) of the PV cell at both the reference temperature and the lower temperature.

V_R = ... V

V = ... V [2]

(ii) Use Fig. 5.1 to describe qualitatively the variation with temperature of the current in the cell.

....

....

....

.... [2]

(iii) Fig. 5.2 shows the variation with temperature T of the open circuit voltage V.

For Examiner's Use

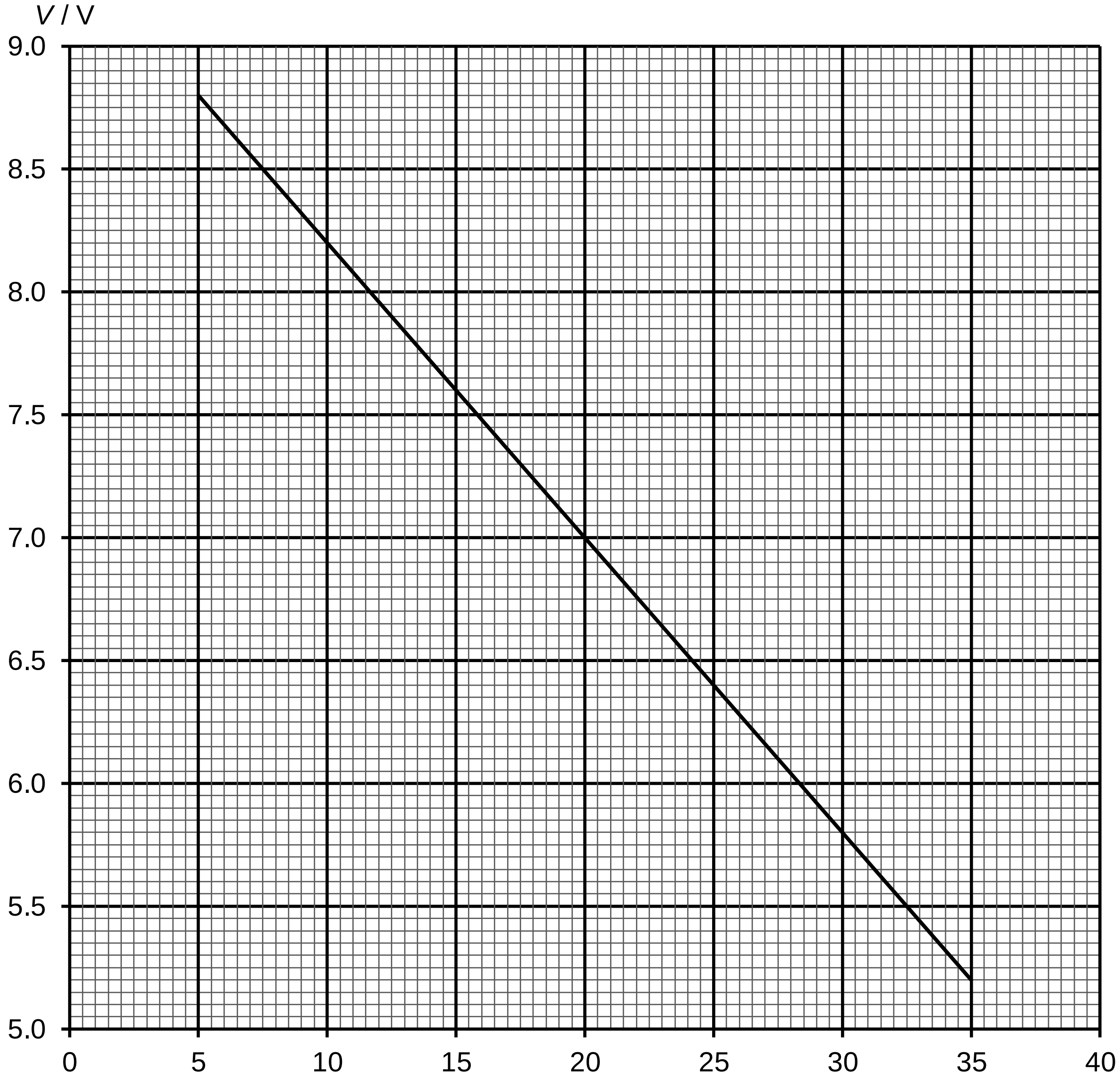

Fig. 5.2

Use Fig. 5.2 to determine the constants μ and T_R.

For Examiner's Use

μ = ... V $^oC^{-1}$

T_R = ... ^oC [2]

(iv) Use your answers to **(e)(i)** and **(e)(iii)** to determine the lower temperature used to obtain the data for Fig. 5.1.

lower temperature = ... ^oC [1]

(v) The PV cell is producing 6.0 V at the reference temperature. On Fig. 5.1, **shade clearly** the area which represents the output power of the cell. [1]

(vi) Use Fig. 5.1 to estimate the maximum power output of the PV cell at the reference temperature.

maximum power output = ... W [2]

(f) **(i)** A PV cell may have multiple layers of different semi-conducting materials. As the number of layers increases, the efficiency of conversion of light energy to electrical energy increases.

Suggest a reason why the efficiency increases.

....

....

.... [1]

(ii) Suggest how the angle between the PV panel and the incident sunlight affects the power output of the PV panel.

....

....

.... [1]

For Examiner's Use

Section B

6 **(a)** State what is meant by a *gravitational field*.

....

.... [1]

(b) Distinguish between the mass of a body and its weight.

....

....

.... [2]

(c) Two bodies A and B, of mass 1.0×10^{30} kg and 4.0×10^{30} kg respectively, are placed at an initial distance 1.5×10^{8} km apart in space and are far away from other massive bodies, as shown in Fig. 6.1.

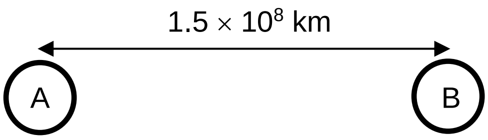

Fig. 6.1

(i) Sketch the graph of gravitational field strength g against distance x from A, and the corresponding graph of gravitational potential ϕ against distance x from A, for the region of space between bodies A and B only, on Fig. 6.2 and Fig. 6.3 respectively.

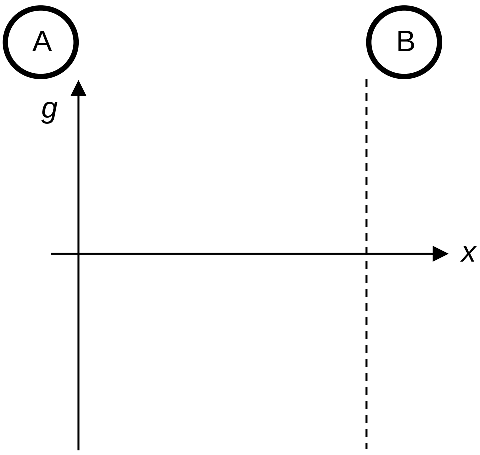

Fig. 6.2

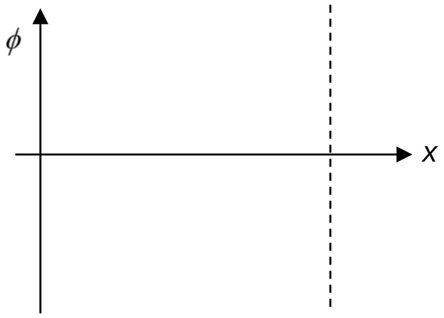

Fig. 6.3

[4]

(ii) Bodies A and B are now released at the same time from their initial positions as shown in Fig. 6.1.

1. Determine the speeds of bodies A and B when the distance between them is half their initial distance apart.

speed of body A = ... m s^{-1}

speed of body B = ... m s^{-1} [4]

2. Calculate the ratio of the initial acceleration of A to that of B.

ratio = ... [2]

(iii) Both A and B are now fixed in position and a third mass m is placed at a distance r from A as shown in Fig. 6.4.

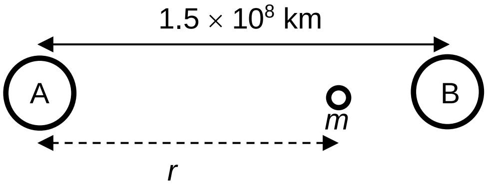

Fig. 6.4

1. Determine the range of possible values which *r* can take, such that *m* will accelerate towards A when it is released from rest at this distance *r* from A.

range: .... [2]

2. Using $r = 6.0 \times 10^{10}$ m and $m = 2.5 \times 10^{28}$ kg , calculate the gravitational potential energy of *m* in Fig. 6.4.

gravitational potential energy = ... J [2]

3. Using the same values of *r* and *m* as in **(c)(iii)2.**, determine the speed of mass *m* when it is midway between A and B, after being released from rest at its initial position in Fig. 6.4.

speed = ... m s^{-1} [2]

(iv) State an assumption made in the calculations in **(c)(ii)** and **(c)(iii)**.

....

.... [1]