9749 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
2023

## Data

| | | | |
|---|---|---|---|
| speed of light in free space | $c$ | = | $3.00 \times 10^{8}$ m s$^{-1}$ |
| permeability of free space | $\mu_o$ | = | $4\pi \times 10^{-7}$ H m$^{-1}$ |
| permittivity of free space | $\varepsilon_o$ | = | $8.85 \times 10^{-12}$ F m$^{-1}$<br>$(1 / (36\pi)) \times 10^{-9}$ 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 | $s$ | = | $ut + ½at^2$ |
| | $v^2$ | = | $u^2 + 2as$ |
| work done on/by a gas | $W$ | = | $p\Delta V$ |
| hydrostatic pressure | $p$ | = | $\rho gh$ |
| gravitational potential | $\phi$ | = | $-Gm / r$ |
| temperature | $T$/K | = | $T$/°C + 273.15 |
| pressure of an ideal gas | $p$ | = | $\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$ |
| mean translational kinetic energy of an ideal molecule | $E$ | = | $\frac{3}{2}kT$ |
| displacement of particle in s.h.m. | $x$ | = | $x_o \sin \omega t$ |
| velocity of particle in s.h.m. | $v$ | = | $v_o \cos \omega t$ |
| | | = | $\pm\omega\sqrt{\left(x_o{}^2 - x^2\right)}$ |
| 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 | $V$ | = | $Q / 4\pi\varepsilon_o r$ |
| alternating current/voltage | $x$ | = | $x_o \sin \omega t$ |
| magnetic flux density due to a long straight wire | $B$ | = | $\mu_o I / 2\pi d$ |
| magnetic flux density due to a flat circular coil | $B$ | = | $\mu_o NI / 2r$ |
| magnetic flux density due to a long solenoid | $B$ | = | $\mu_o nI$ |
| radioactive decay | $x$ | = | $x_o \exp(-\lambda t)$ |
| decay constant | $\lambda$ | = | $\ln 2 / t_{1/2}$ |

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.

1 Which list of quantities contains only one vector?

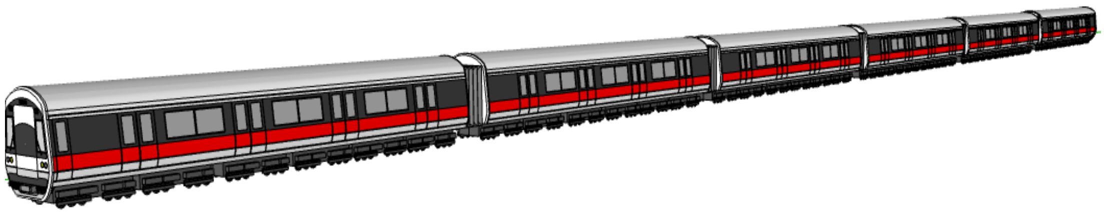
**A** density, electric charge, power

**B** speed, impulse, upthrust

**C** current, torque, pressure

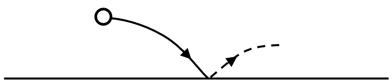
**D** gravitational potential, moment of force, displacement

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



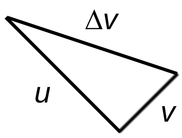
**A** $10^1$ m$^3$ **B** $10^3$ m$^3$ **C** $10^5$ m$^3$ **D** $10^7$ m$^3$

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

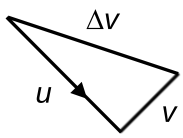


Which diagram correctly indicates the change in velocity $\Delta v$ of the ball?

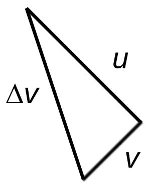
**A**



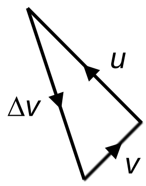

**B**




**C**




**D**

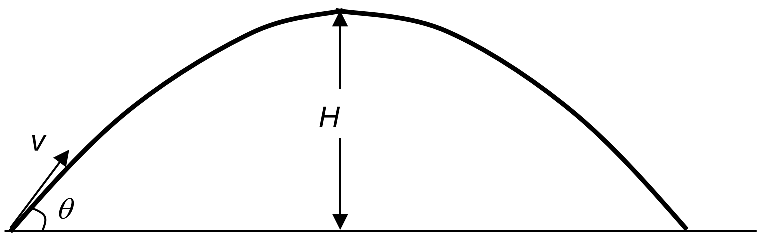


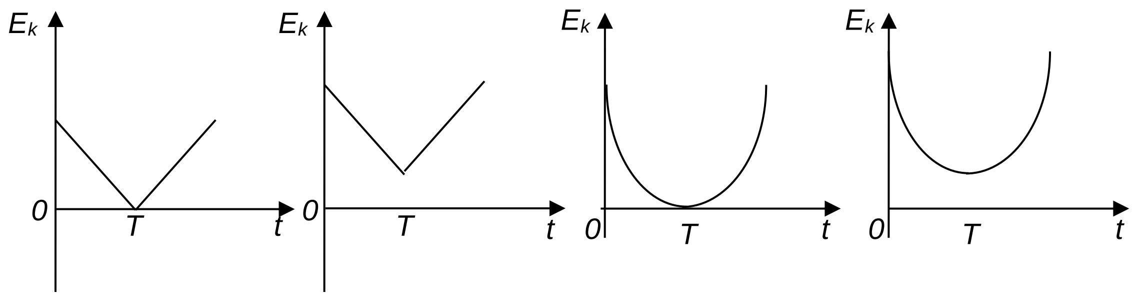

4 A stone is thrown vertically downwards from the edge of a cliff with an initial speed of 15 m s$^{-1}$. Just before hitting the ground, it has a final speed of 45 m s$^{-1}$.

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 $\theta$ 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 $t$?



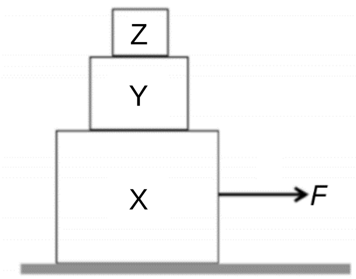

**A** **B** **C** **D**

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

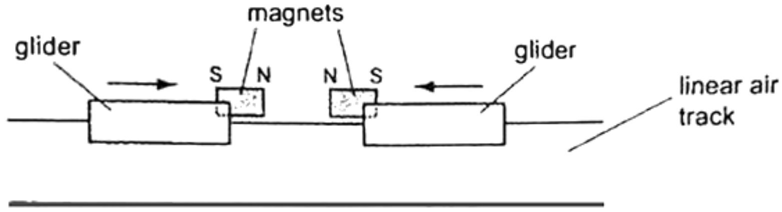
7 Three boxes X, Y and Z with masses 3$M$, 2$M$ and $M$ respectively are stacked on top of each other on a smooth floor. A horizontal force $F$ is applied to box X as shown, causing the boxes to accelerate rightwards together.




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?

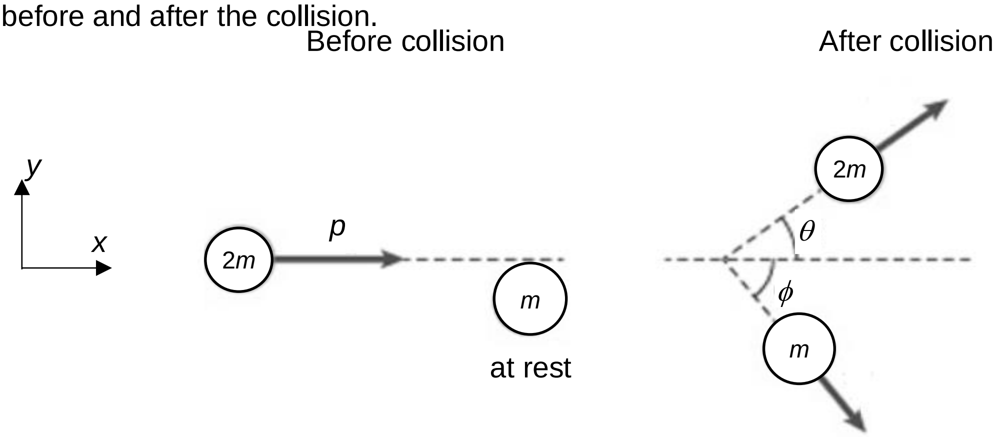
**A** Kinetic energy is conserved because none is converted to heat.

**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.

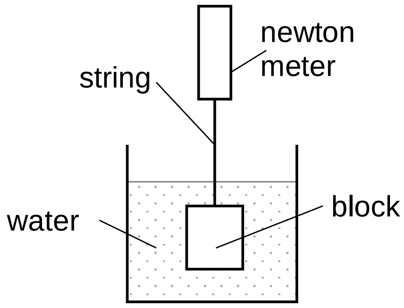
**9** A puck of mass 2$m$ with momentum $p$ in the $x$-direction is travelling along a frictionless surface of an air hockey table. It strikes the edge of another puck of mass $m$ which is initially at rest, resulting in an elastic collision. The diagrams below show the top view of the motion of the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



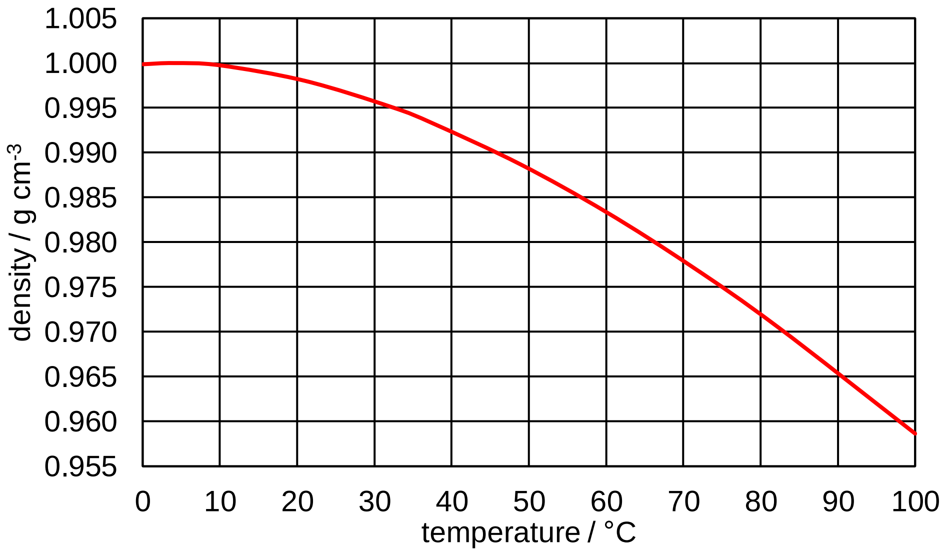

Which of the following gives the correct expressions for the magnitude of the total momentum in the $x$-direction and kinetic energy of the pucks after the collision?

| | 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.

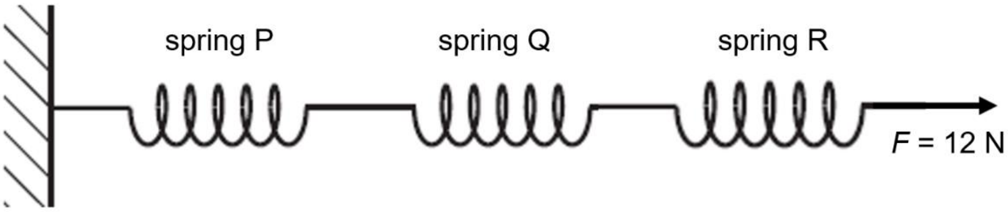



The temperature of the water is then changed.

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 $x_P : x_Q : x_R$?

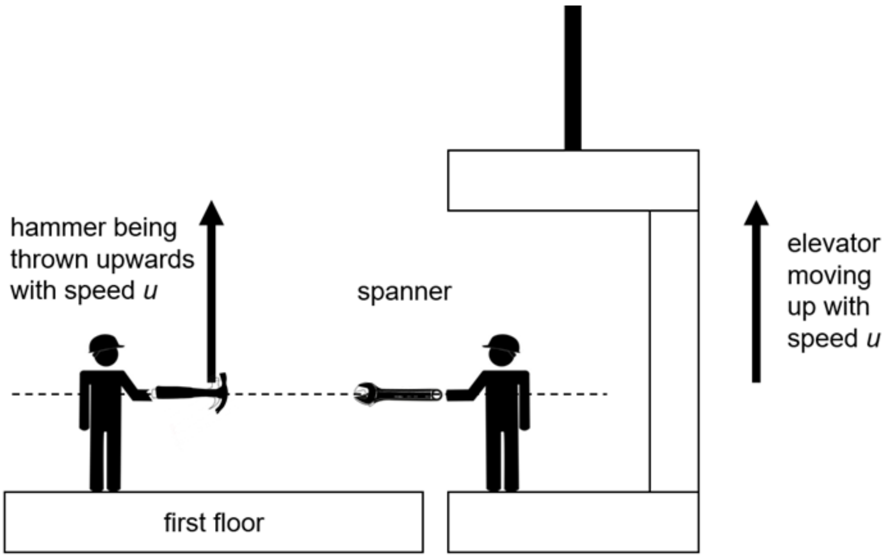
**A** 1 : 2 : 3

**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?

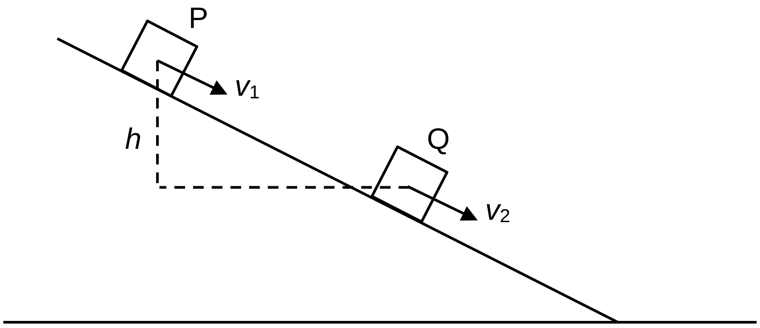
**A** The spanner lands on the first floor before the hammer does.

**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?

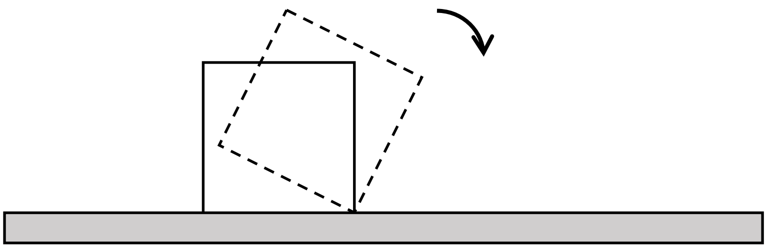
**A** $\frac{1}{2}m(v_2 - v_1)^2 - mgh$

**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

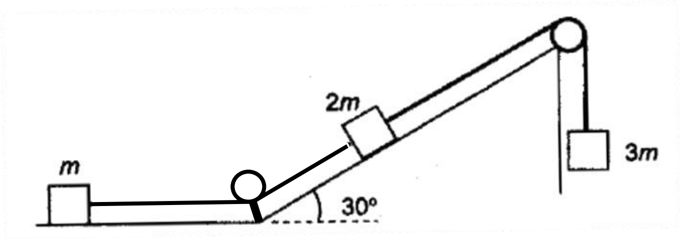
**A** 0.21 *mgd*

**B** 0.41 *mgd*

**C** 0.71 *mgd*

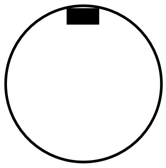
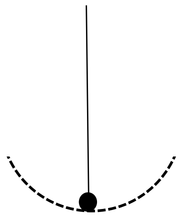
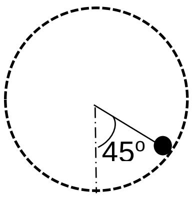
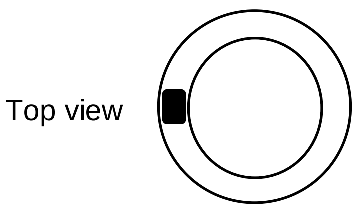
**D** 0.91 *mgd*

**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  | Frictional force at the wheels directed towards centre of circular path |

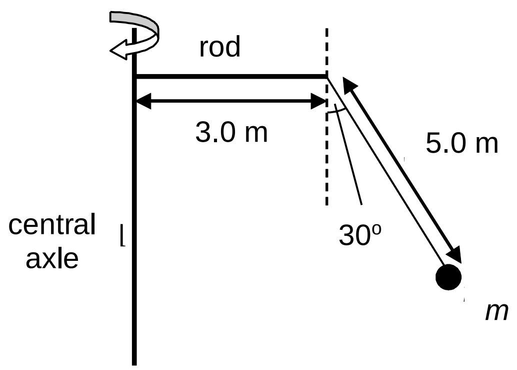
**17** A car of mass *m* moving at a constant speed *v* passes over a humpback bridge of radius curvature *r*.

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** $\frac{mv^2}{r} + mg$

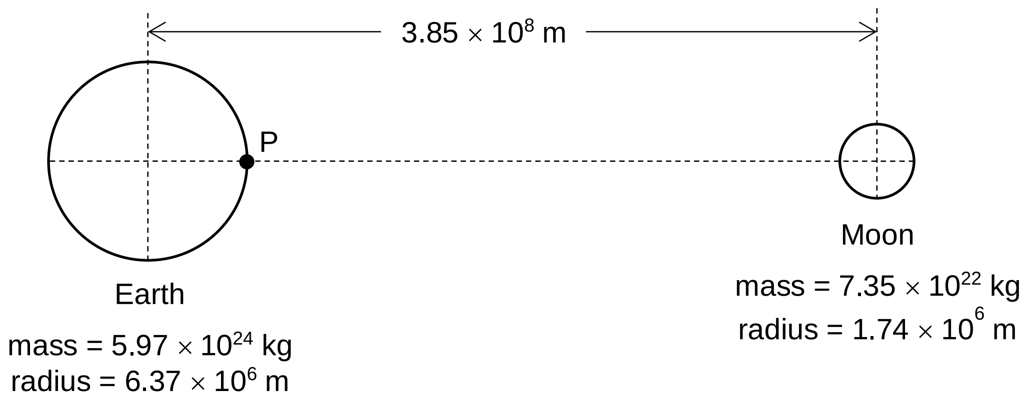
**18** A mass *m*, attached to one end of an inextensible string of length 5.0 m, is made to move in a horizontal circle as the central axle and horizontal rod is rotated. In a particular circular motion, the string makes an angle of 30° with the vertical as shown below.

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 $3.85 \times 10^8$ m apart. The masses of the Earth and the Moon are $5.97 \times 10^{24}$ kg and $7.35 \times 10^{22}$ kg respectively, and the radii of the Earth and the Moon are $6.37 \times 10^6$ m and $1.74 \times 10^6$ 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 $6.0 \times 10^{24}$ kg, what is the radius of the orbit of the satellite?

**A** $5.0 \times 10^{5}$ m **B** $4.8 \times 10^{6}$ m **C** $7.6 \times 10^{6}$ m **D** $2.1 \times 10^{10}$ 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?

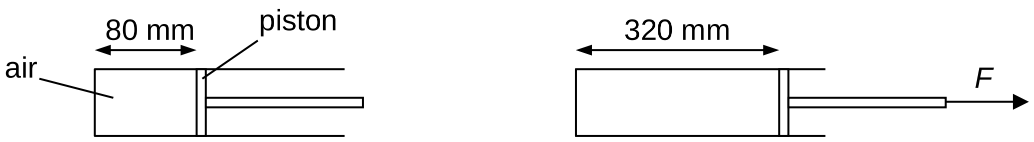
**A** In the absence of a driver, a damped oscillator oscillates at its natural frequency.

**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 $3.0 \times 10^{-3}$ 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 5*m*, 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

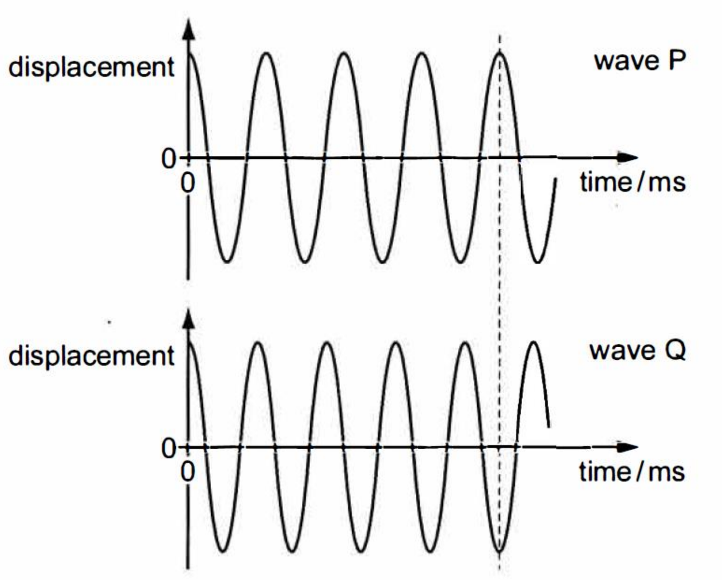
**26** When an ideal monatomic gas absorbs 1000 J of heat and does 500 J of work, its temperature changes by $T_1$.

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?

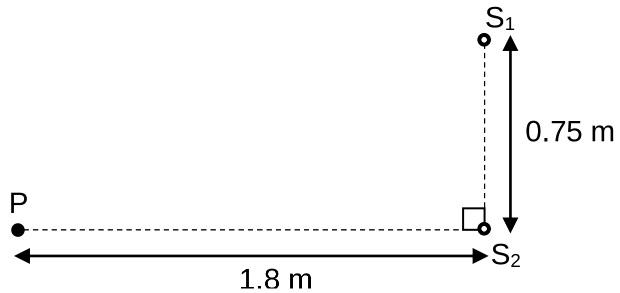
**A** 32 ms **B** 36 ms **C** 64 ms **D** 72 ms

**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** $3\,a$

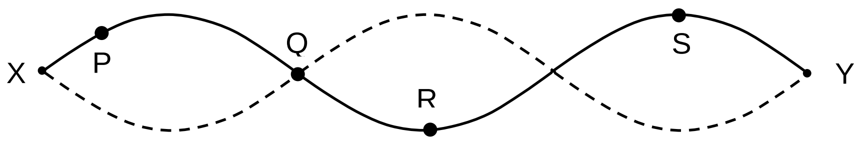
**29** Two wave generators $S_1$ and $S_2$ produce water waves of wavelength 0.30 m. They are placed 0.75 m apart in a water tank and a detector P is placed on the water surface 1.8 m from $S_2$ as shown.




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** 0.72$A$ **C** $A$ **D** 2$A$

**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.

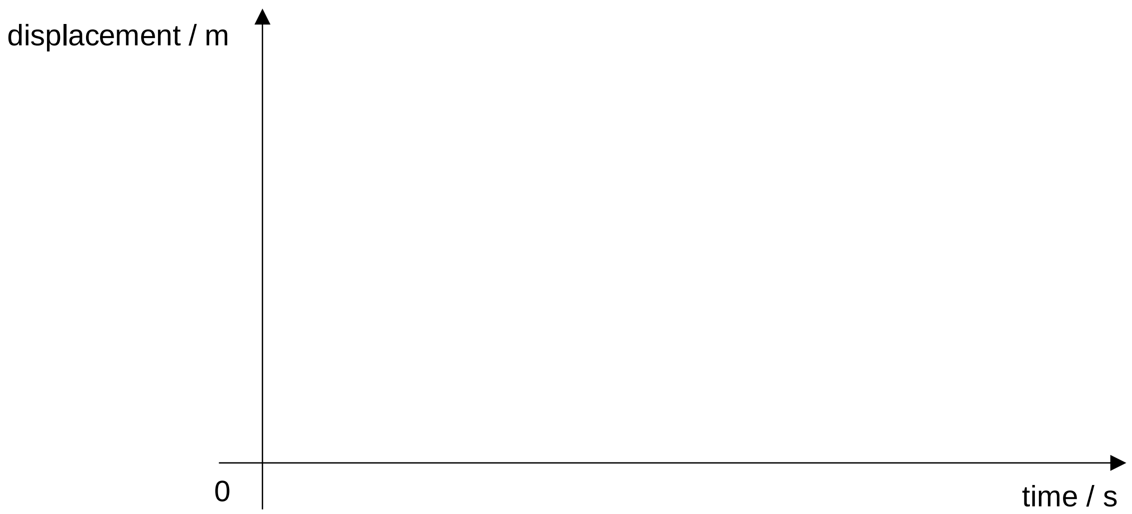



**Fig. 1.1**

[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.

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.......................................................................................................................................[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.

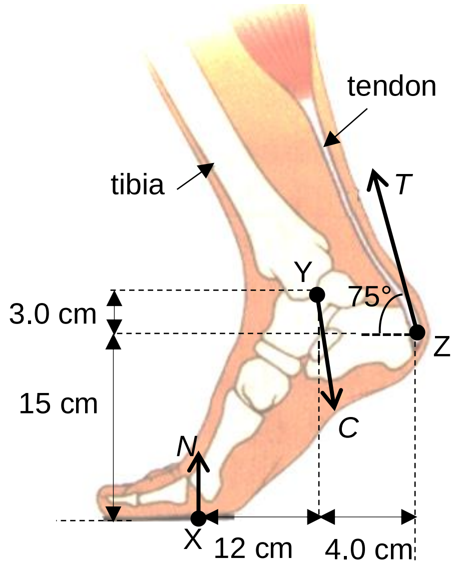


**Fig. 2.1**

**(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 $m^{-3}$.

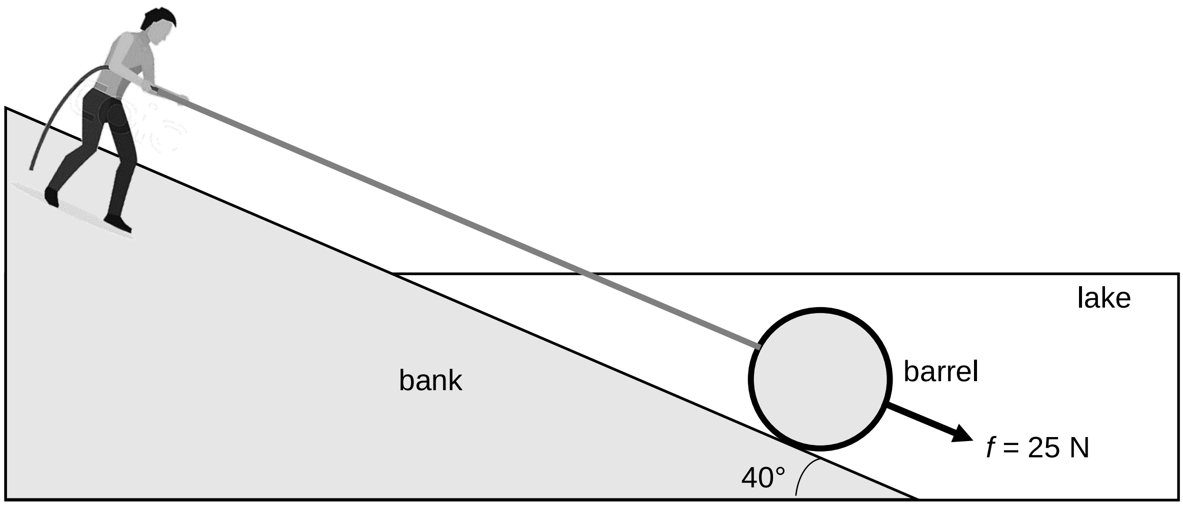


**Fig. 2.2**

**(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.

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[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.

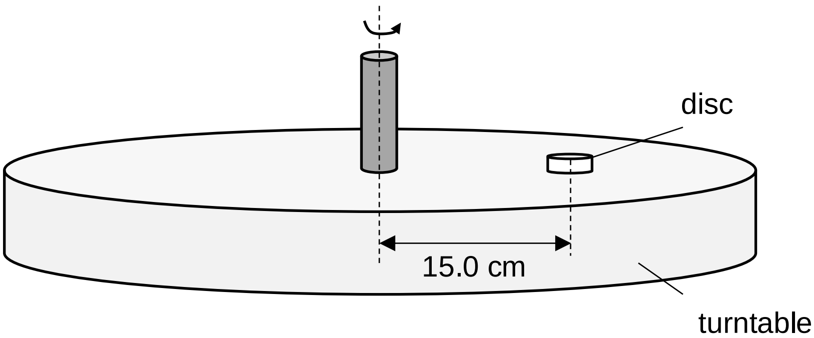


**Fig. 3.1**

**(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.

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.....................................................................................................................................[2]

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

$\omega$ = .......................................... 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.

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..........................................................................................................................................[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
$\Delta T$ 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 $3.60 \times 10^6$ 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.

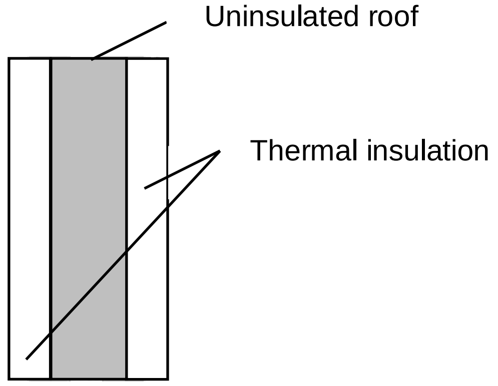


**Fig. 4.2**

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.

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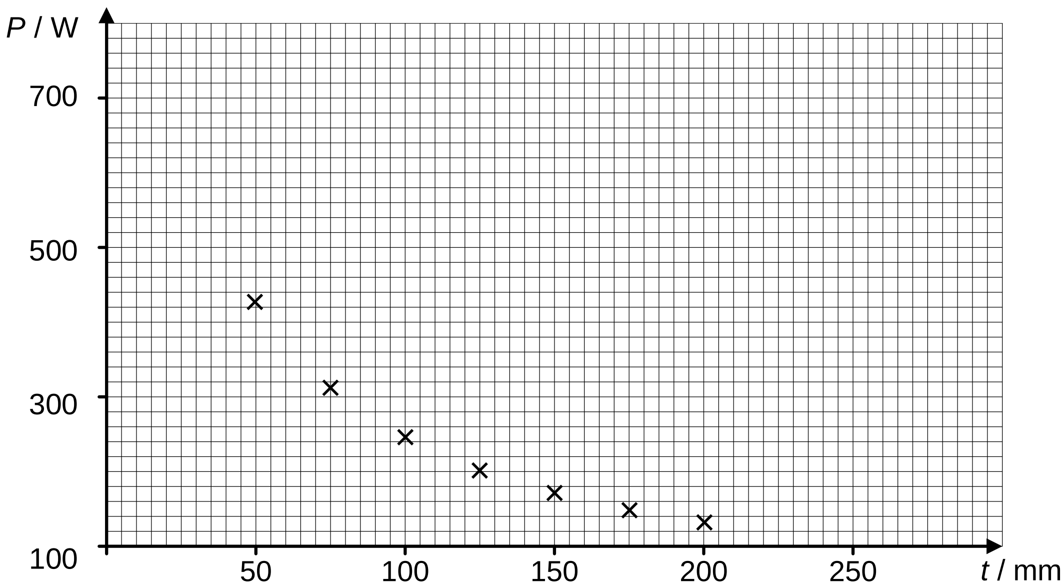


**Fig. 4.4**

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.

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**(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.

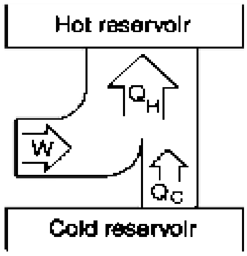


**Fig. 4.5**

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.

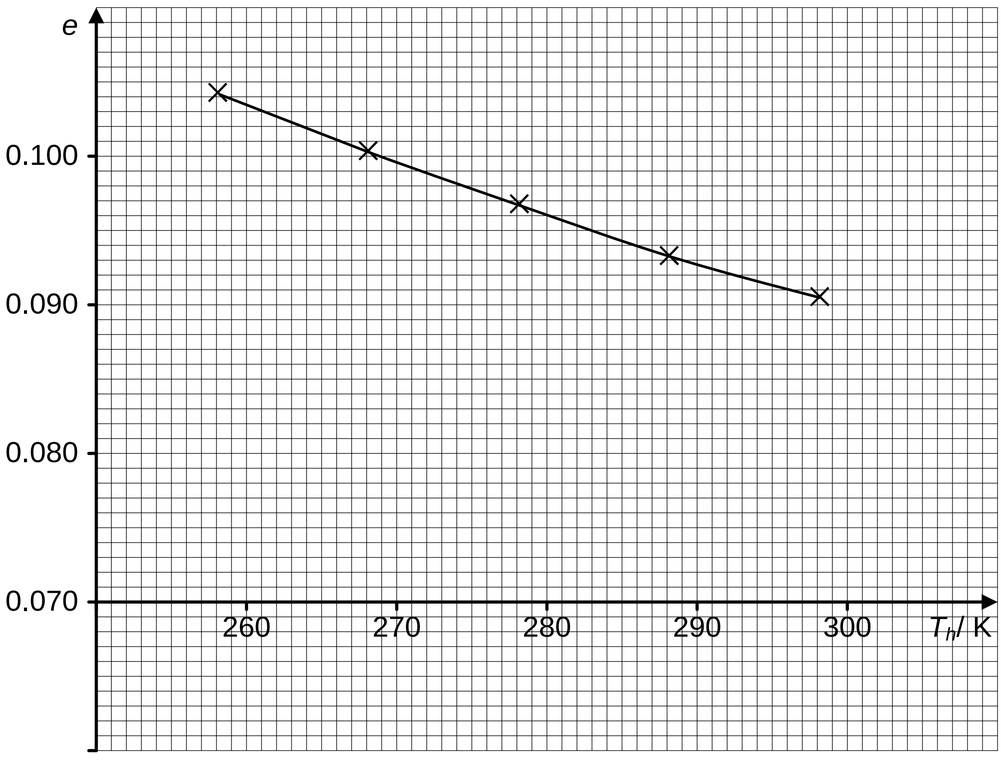


**Fig. 4.6**

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**

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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.

## Section A

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

**1** In the study of materials, tensile stress, $\sigma$, in a wire is defined as the normal force applied per unit cross-sectional area. Tensile strain, $\varepsilon$, 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 $\Delta E$.

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..........................................................................................................................................

..........................................................................................................................................[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)**.

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..........................................................................................................................................[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.

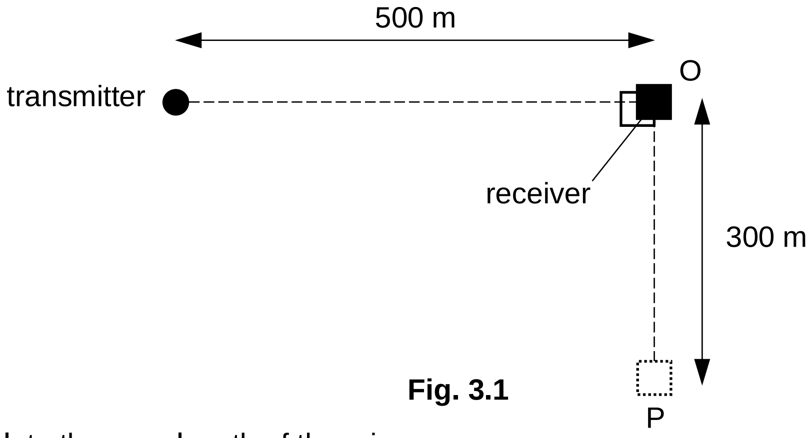


**Fig. 3.1**

**(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*.

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..........................................................................................................................................[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.

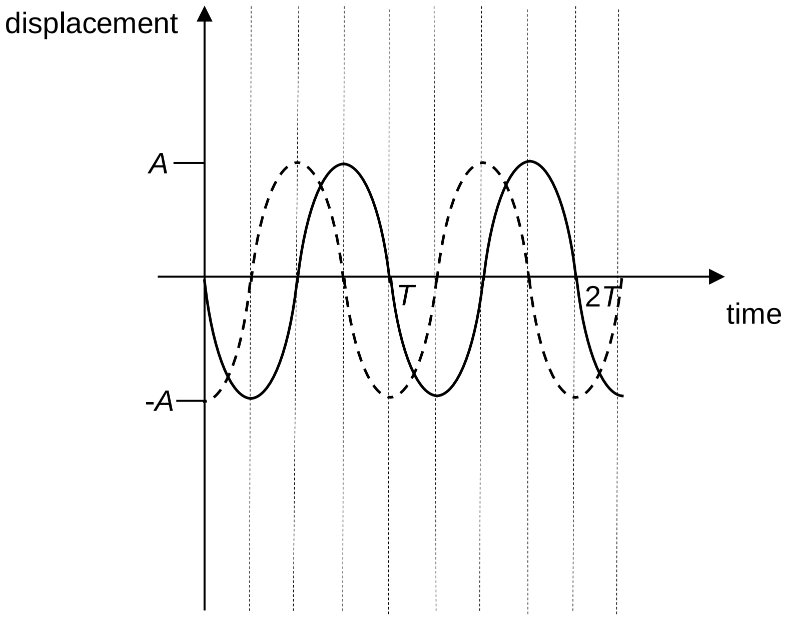


**Fig. 4.1**

**(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.

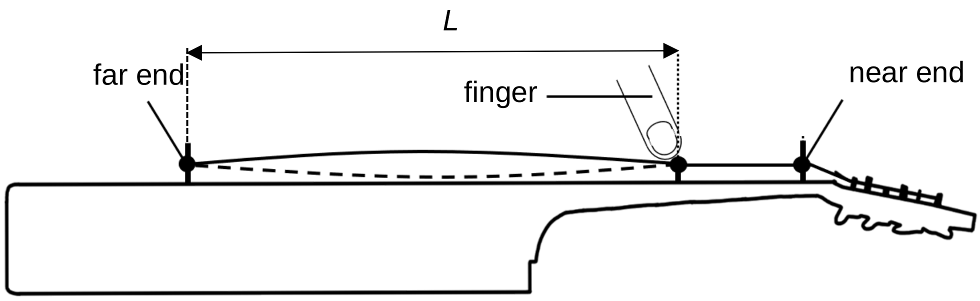


**Fig. 4.2**

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*.

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..........................................................................................................................................[1]

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

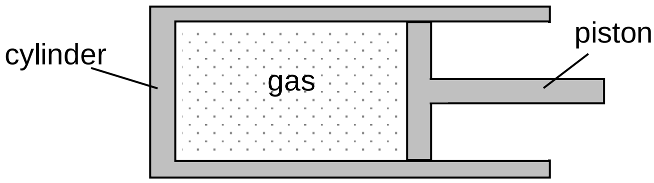


**Fig. 5.1**

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

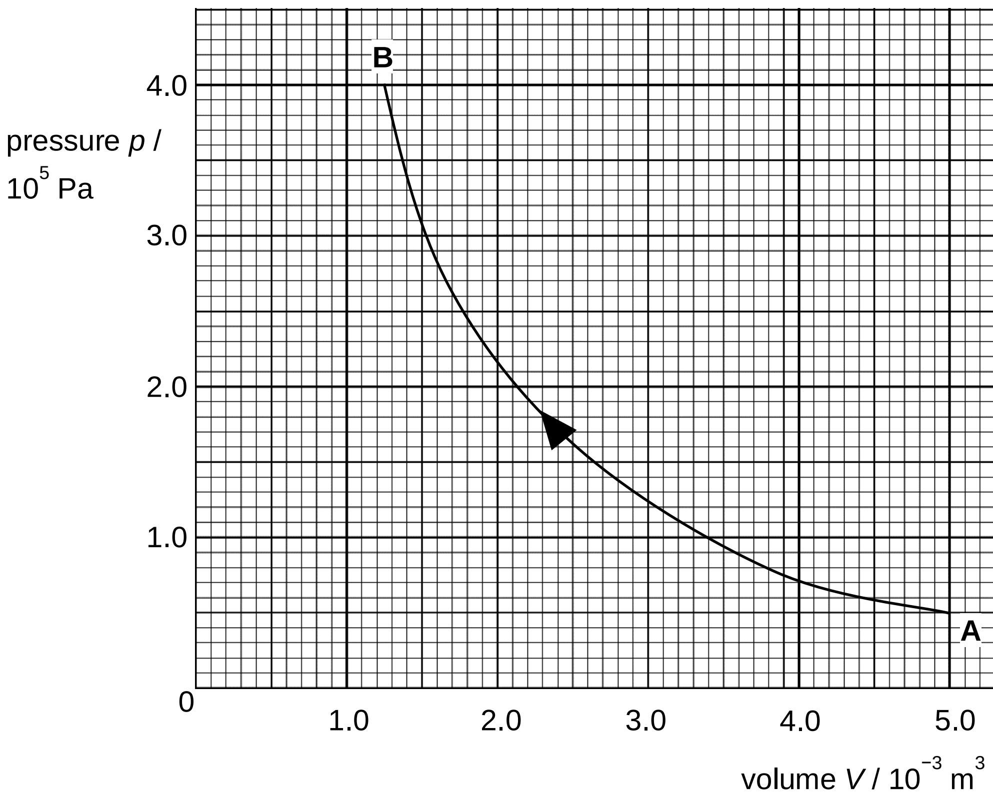


**Fig. 5.2**

**(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.

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..........................................................................................................................................[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.

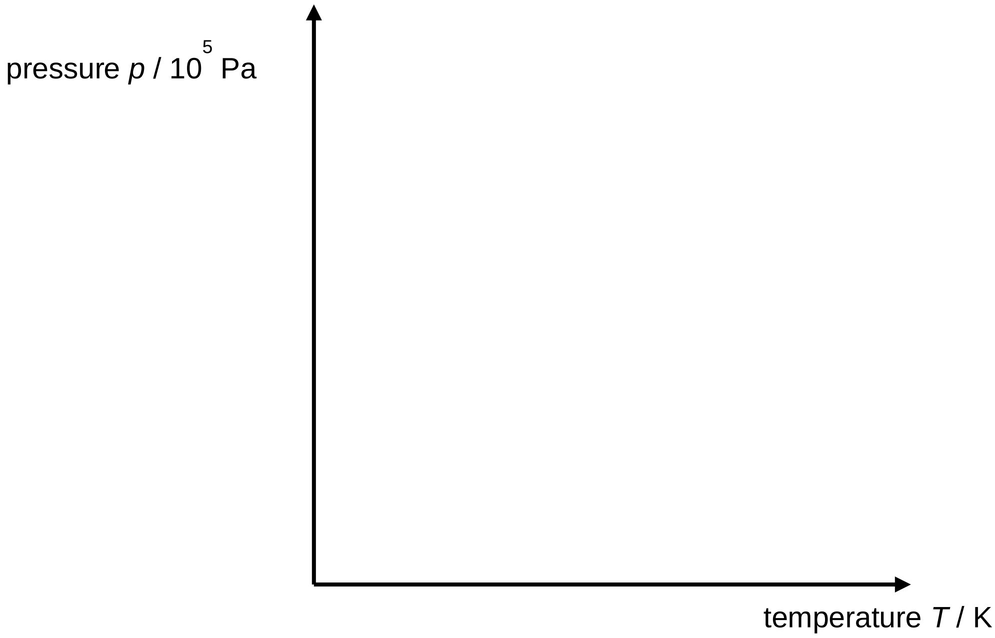



**Fig. 5.3**

[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, $\omega_{min}$.

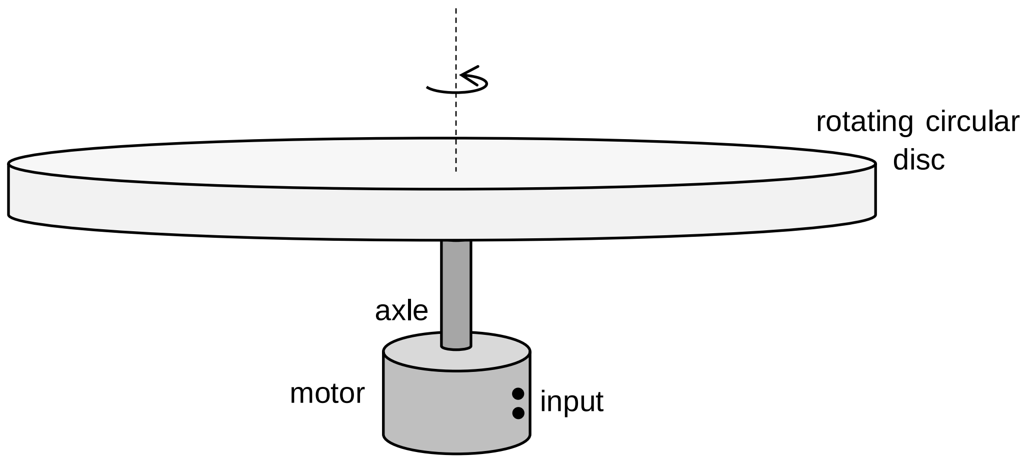
The relationship between the minimum angular velocity of the disc, $\omega_{min}$, and the mass of the object, $m$, may be written in the form

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

where $k$ and $n$ are constants.

Design an experiment to investigate the relationship between the minimum angular velocity $\omega_{min}$ 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**

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## 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 $\phi$ 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.

..........................................................................................................................................

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............................................................................................................................................[3]

**(b)** The Earth and Moon can both be assumed to be isolated uniform spheres of masses $6.0 \times 10^{24}$ kg and $7.3 \times 10^{22}$ kg respectively. The radius of Earth is $6.4 \times 10^{6}$ m and the radius of the Moon is $1.7 \times 10^{6}$ m.

The variation with displacement $x$ of the gravitational potential $\phi$ 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 $-3.9 \times 10^{6}$ J kg$^{-1}$. Show that the distance $D$ between the centres of the Earth and Moon is $3.9 \times 10^{8}$ m.

[2]

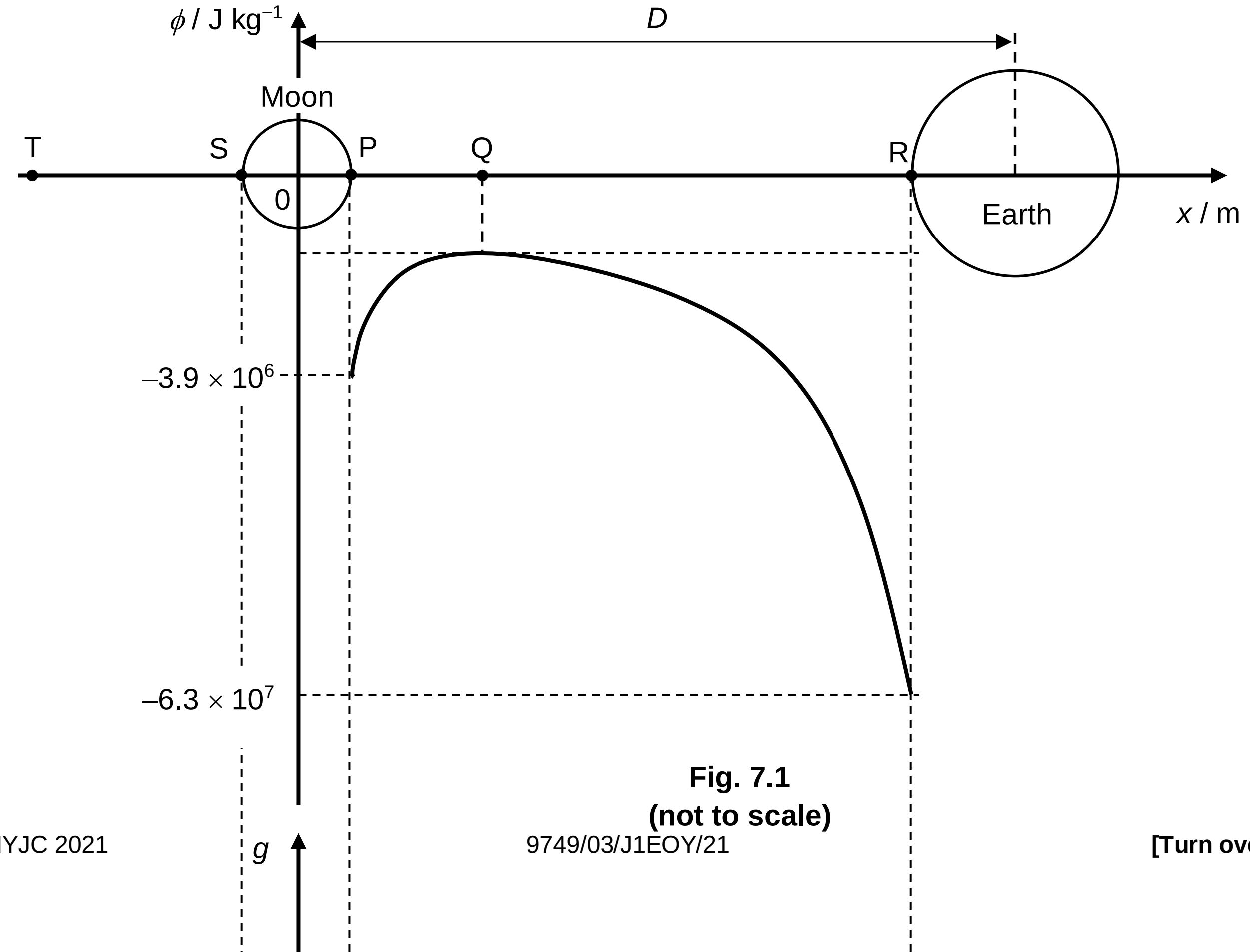


**Fig. 7.1**
**(not to scale)**

**(ii)** Using Fig. 7.1, state and explain the motion, if any, of an object when it is released from rest at point Q.

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.......................................................................................................................................[2]

**(iii)** Show that the distance between Q and the centre of the Earth is $3.5 \times 10^8$ 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 $1.5 \times 10^8$ 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.

..........................................................................................................................

..........................................................................................................................

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..........................................................................................................................[2]

**2.** The gravitational potential at R is $-6.3 \times 10^7$ 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 $\phi$ 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.

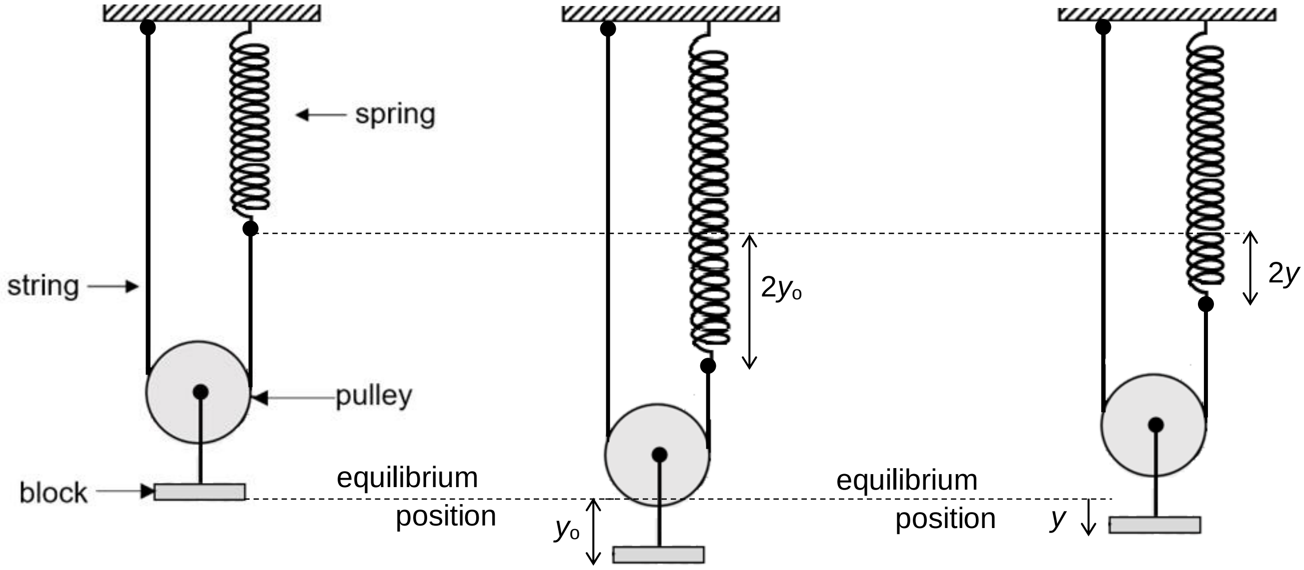


**Fig. 8.1** **Fig. 8.2** **Fig. 8.3**

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 4$M$ 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.

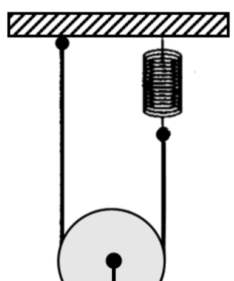

**Fig. 8.5**

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

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| 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, $\phi$, 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

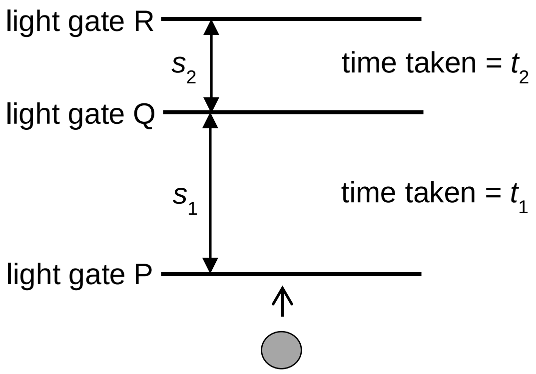
**C** Taking the average of multiple measurements of *h*.

**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.

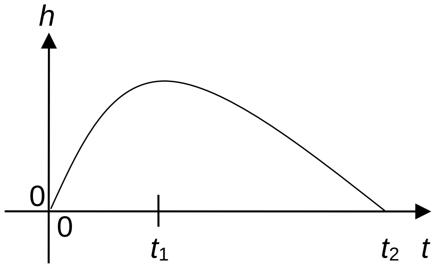



The object has a speed *u* when it passes P. It takes a time of $t_1$ to move up a distance $s_1$ between P and Q, and then takes a time $t_2$ to travel a distance $s_2$ between Q and R. The object reaches its highest point exactly at R.

If the acceleration due to gravity is *g*, what is the distance ($s_1$ + $s_2$) in terms of *g*, $t_1$ and $t_2$?

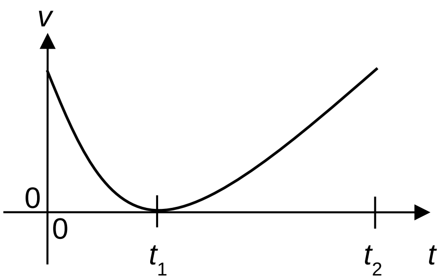
**A** $g(t_1+t_2)$ **B** $g(t_1+t_2)^2$ **C** $\dfrac{g(t_1+t_2)^2}{2}$ **D** $\dfrac{(t_1+t_2)^2}{2g}$

**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 $t$.

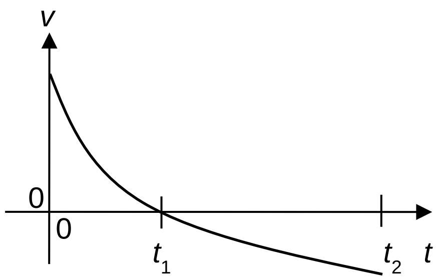



Which graph shows the variation with time $t$ of the velocity $v$ of the ball?

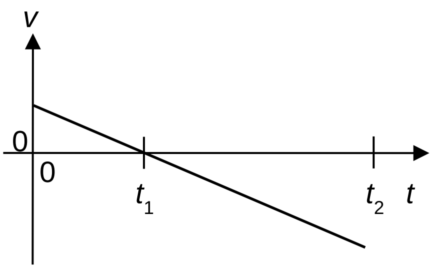
**A**



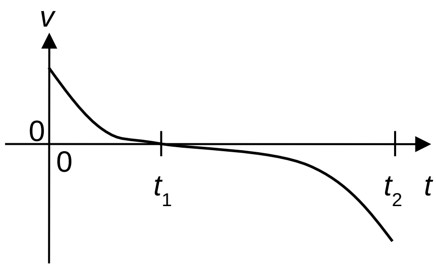

**B**



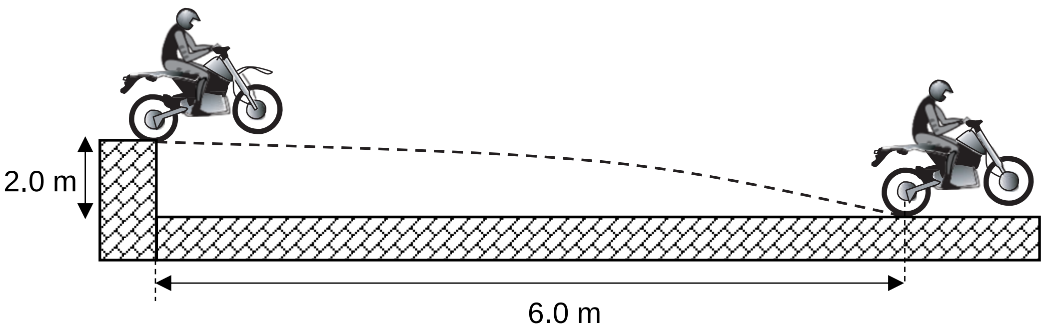

**C**




**D**



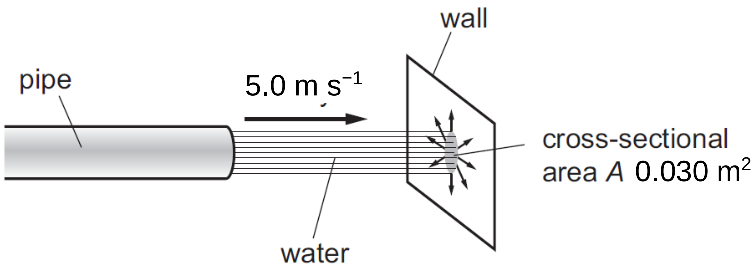

**6** A stunt-rider takes off horizontally from a point 2.0 m above the ground, landing 6.0 m away as shown. Air resistance is negligible.




What was the speed of the stunt-rider at take-off?

**A** 6.3 m s$^{-1}$ **B** 9.4 m s$^{-1}$ **C** 9.9 m s$^{-1}$ **D** 15 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 $m^{-3}$.

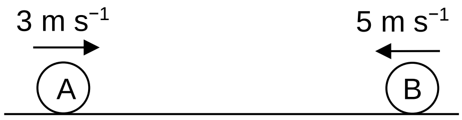



An engineer adjusts the flow valve, causing the water to flow at speed $v$, and the force exerted on the wall by the water was halved.

What is the value of $v$?

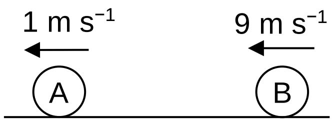
**A** 1.3 m $s^{-1}$ **B** 2.5 m $s^{-1}$ **C** 3.5 m $s^{-1}$ **D** 7.1 m $s^{-1}$

**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.

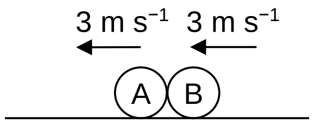



Which of the following diagrams showing the final velocities of both objects after the collision is correct?

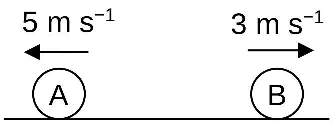
**A**



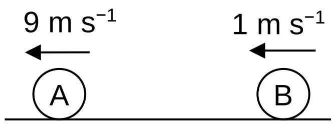

**B**



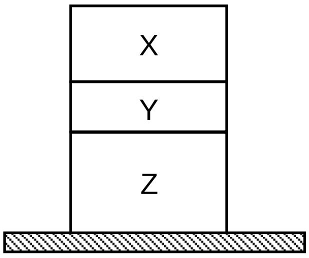

**C**




**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** $4mg + 4ma$

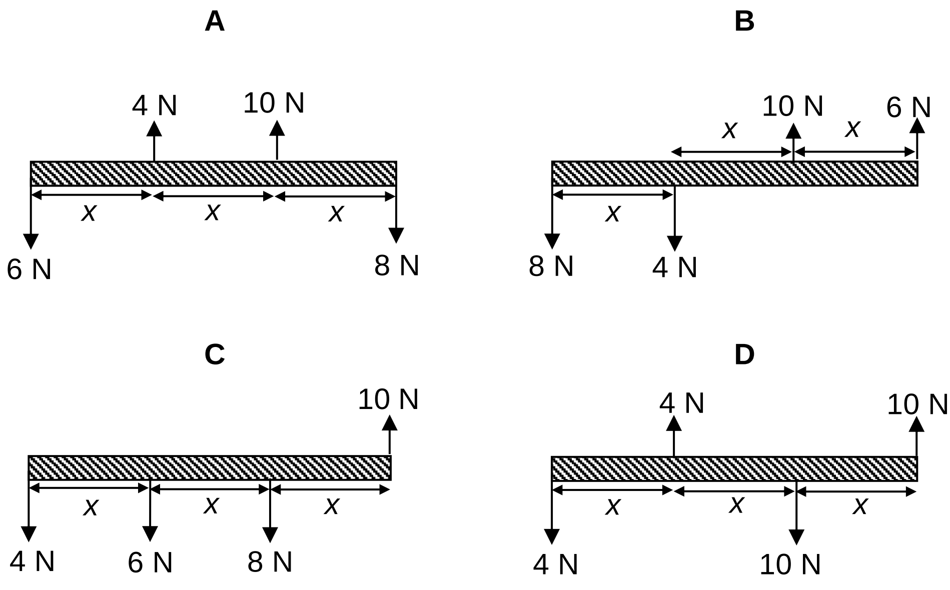
**B** $4mg + 5ma$

**C** $4mg - 4ma$

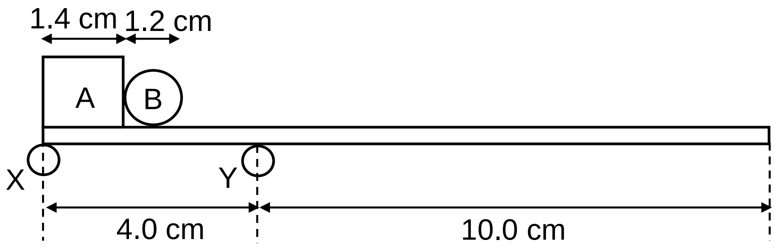
**D** $4mg - 5ma$

**10** The force diagrams below show all the forces acting on a beam of length 3*x*, which is at rest initially.

Which force system experiences only rotational motion of the beam, without any linear acceleration?



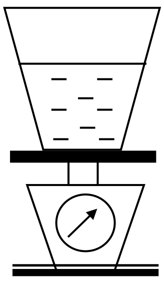
**11** A beam of negligible mass is supported by two rods X and Y. A block A of mass 200 g and a ball B of mass 100 g rest on the beam as shown. Both A and B have uniform density.




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.

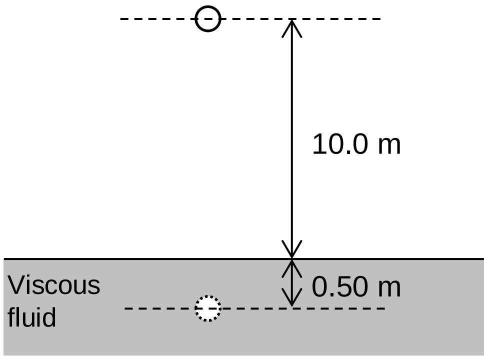
**13** A 1.0 kg ball is released from a certain height. When it is 0.70 m above the floor, its potential energy is exactly equal to its kinetic energy. What is the speed of the ball just before it hits the floor?

**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 $mv^2$

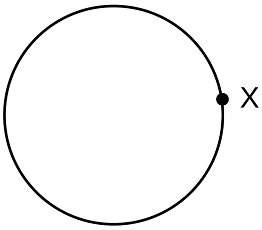
**15** A small object is dropped from a height of 10.0 m above the surface of a viscous fluid as shown in the diagram below. The mass of the object is 1.0 kg and the viscous fluid offers a constant retarding force of 160 N.




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 $s^{-1}$

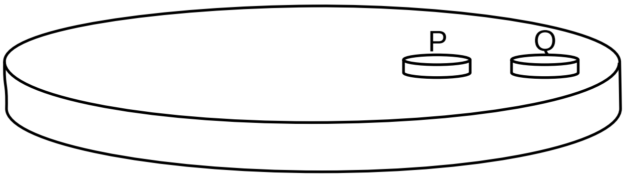
**16** An object moves in a circular path of radius 0.80 m at an angular speed of $\frac{2\pi}{3}$ rad $s^{-1}$.




What is its distance travelled from a point X, 6.0 s after passing X?

**A** $0.80\pi$ m **B** $1.6\pi$ m **C** $3.2\pi$ m **D** $4.0\pi$ 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?

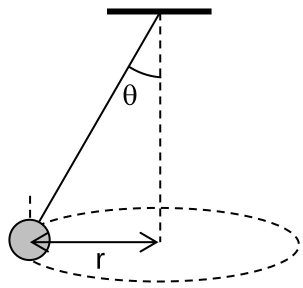
**A** P begins to slide because it has less friction.

**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.

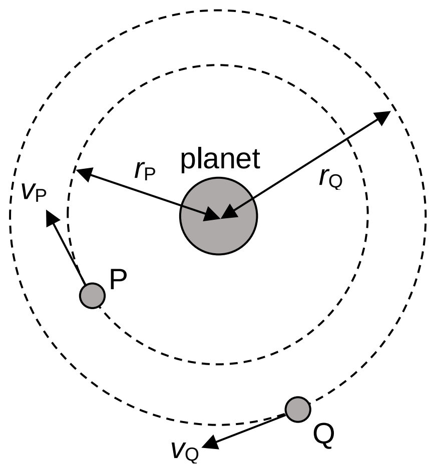
**18** A pendulum bob is suspended from the ceiling by a light inextensible string. It is set to whirl in a horizontal circle of radius $r$ such that the cord is inclined at an angle $\theta$ to the vertical.




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 $1.4 \times 10^8$ m and linear speed $v_P$. Moon Q has an orbital radius $r_Q$ of $2.3 \times 10^{10}$ m and linear speed $v_Q$.

What is the ratio $\dfrac{v_P}{v_Q}$?

**A** $6.1 \times 10^{-3}$

**B** $7.8 \times 10^{-2}$

**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 $\dfrac{\text{centripetal force acting on X}}{\text{centripetal force acting on Y}}$?

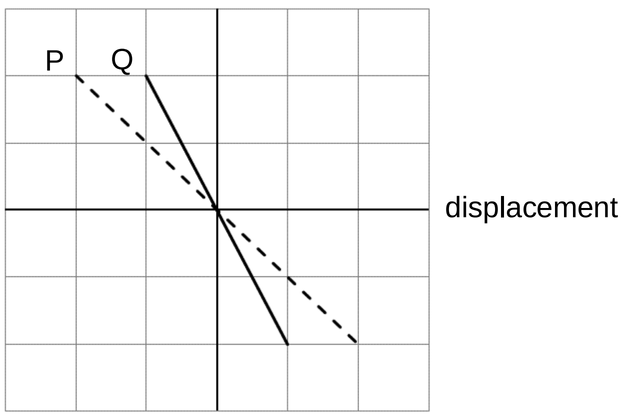
**A** 0.5 **B** 1 **C** 2 **D** 4

**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** $\sqrt{\dfrac{5GM}{3R}}$

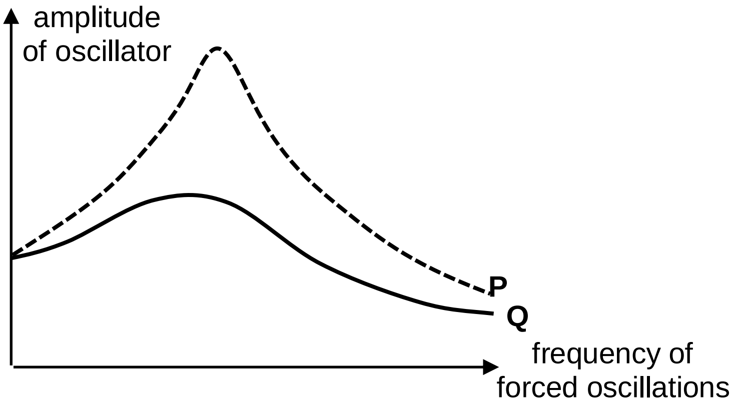
**22** The figure below shows the acceleration-displacement graphs of two oscillators P and Q. The amplitude and period of P are $x_0$ and *T* respectively.




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?

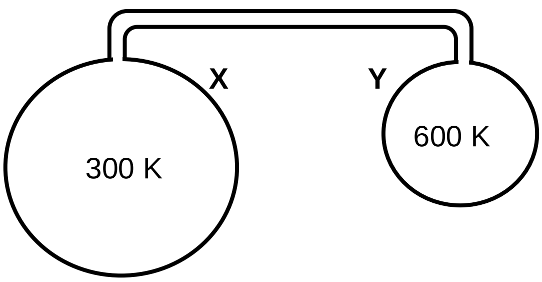
**A** The natural frequency of P is higher than that of Q.

**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 $1.00 \times 10^5$ Pa in a container of volume 0.500 $m^3$.

What is the root-mean-square speed of the gas molecules?

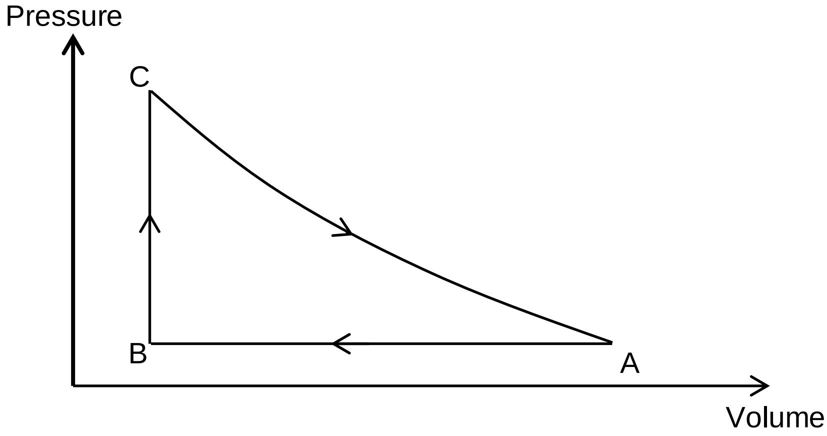
**A** 250 m $s^{-1}$

**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:

$$\text{efficiency} = \frac{\text{net work done in a cycle}}{\text{heat supplied to gas from process B} \rightarrow \text{C}}$$

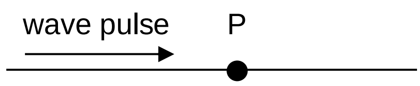
The efficiency of the gas engine is

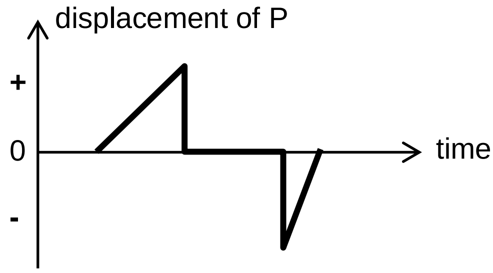
**A** 0.25 **B** 0.30 **C** 0.50 **D** 0.75

**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 $s^{-1}$

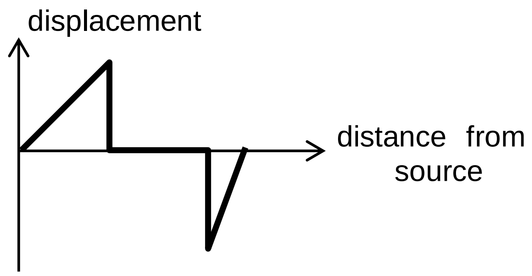
**28** A wave pulse is travelling to the right as shown in the diagram below. The graph on the right shows the variation with time of the displacement of a particle P as the pulse passes it.



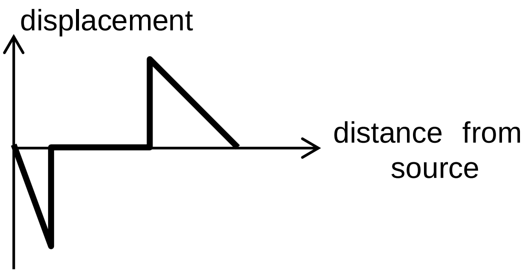




Which one of the following graphs represents the variation of the displacement with positions of the particles along the path of the wave pulse at a certain instant?

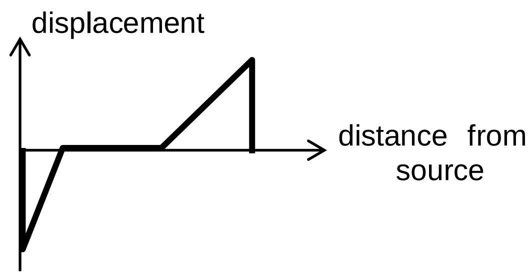
**A**



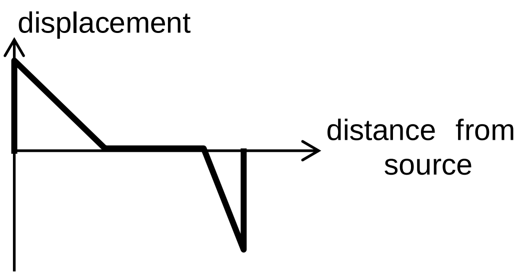

**B**



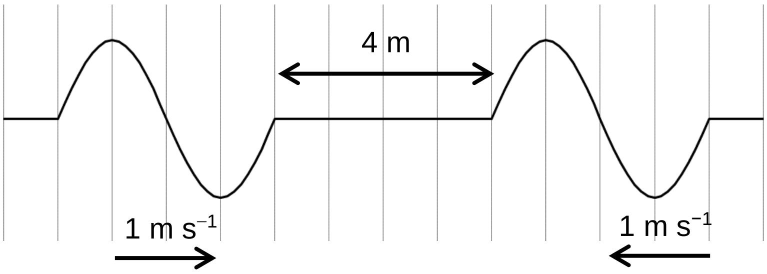

**C**




**D**

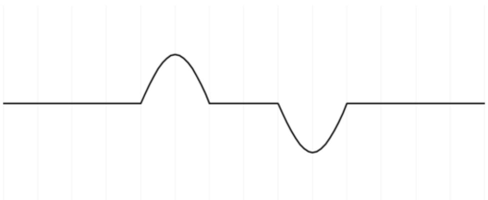


**29** The figure below shows two waves, each of wavelength 4 m, moving towards each other on a string with speeds of 1 m $s^{-1}$.

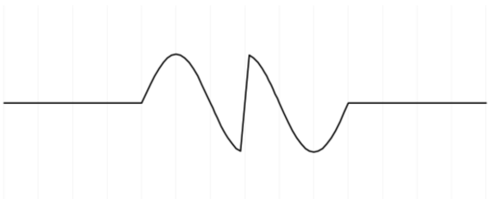



Which of the following shows the string after 3 s?

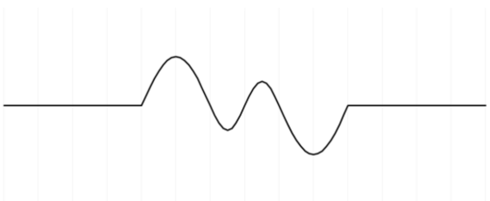
**A**



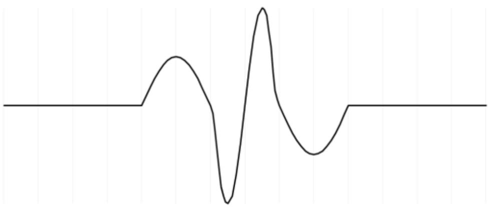
**B**



**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 $\theta$.

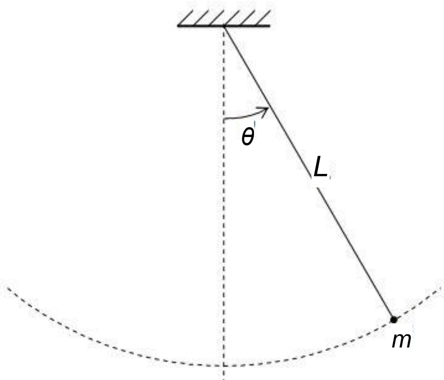



**Fig. 1.1**

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.

($g$ ± Δ$g$) = …………………………… 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.

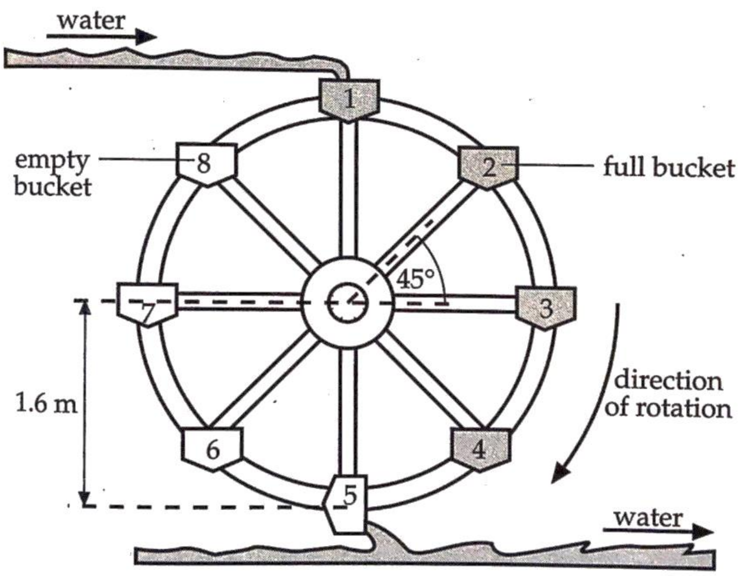



**Fig. 2.1**

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]

For Examiner's Use

**(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.

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.........................................................................................................................................[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 $\theta$ as shown in Fig. 3.3. The safe speed for the bobsled to turn around the curve of smaller radius is $v$.

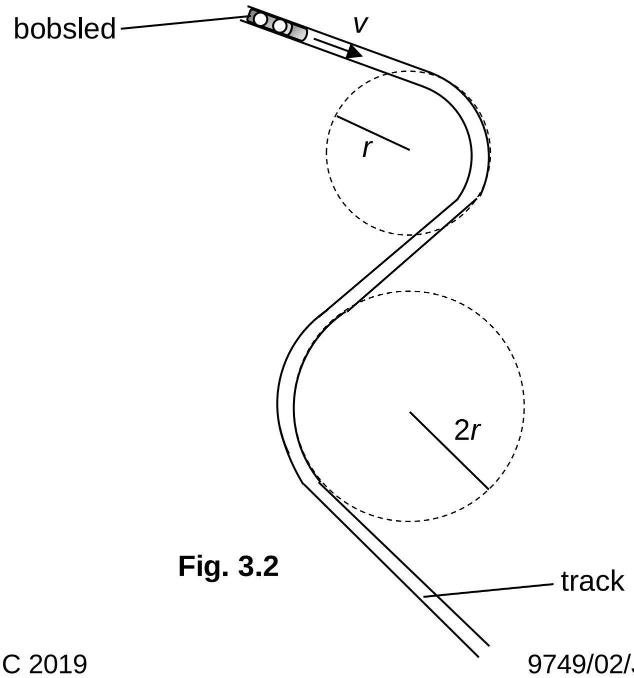


**Fig. 3.2**

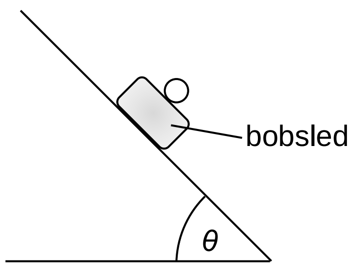


**Fig. 3.3**

**(i)** Derive an expression for the safe speed, $v$, for the curve of smaller radius, in terms of $\theta$, $r$ 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 $\theta$, 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.

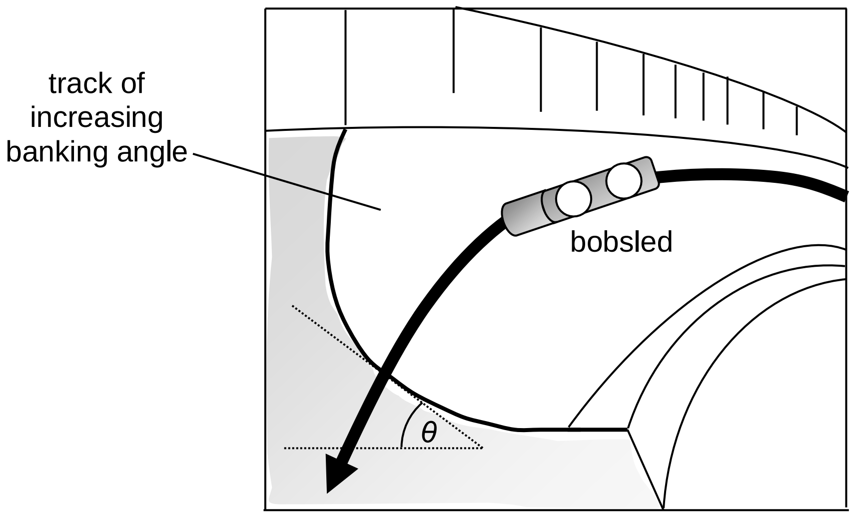


**Fig. 3.4**

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..........................................................................................................................................

.......................................................................................................................................... [2]

**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*.

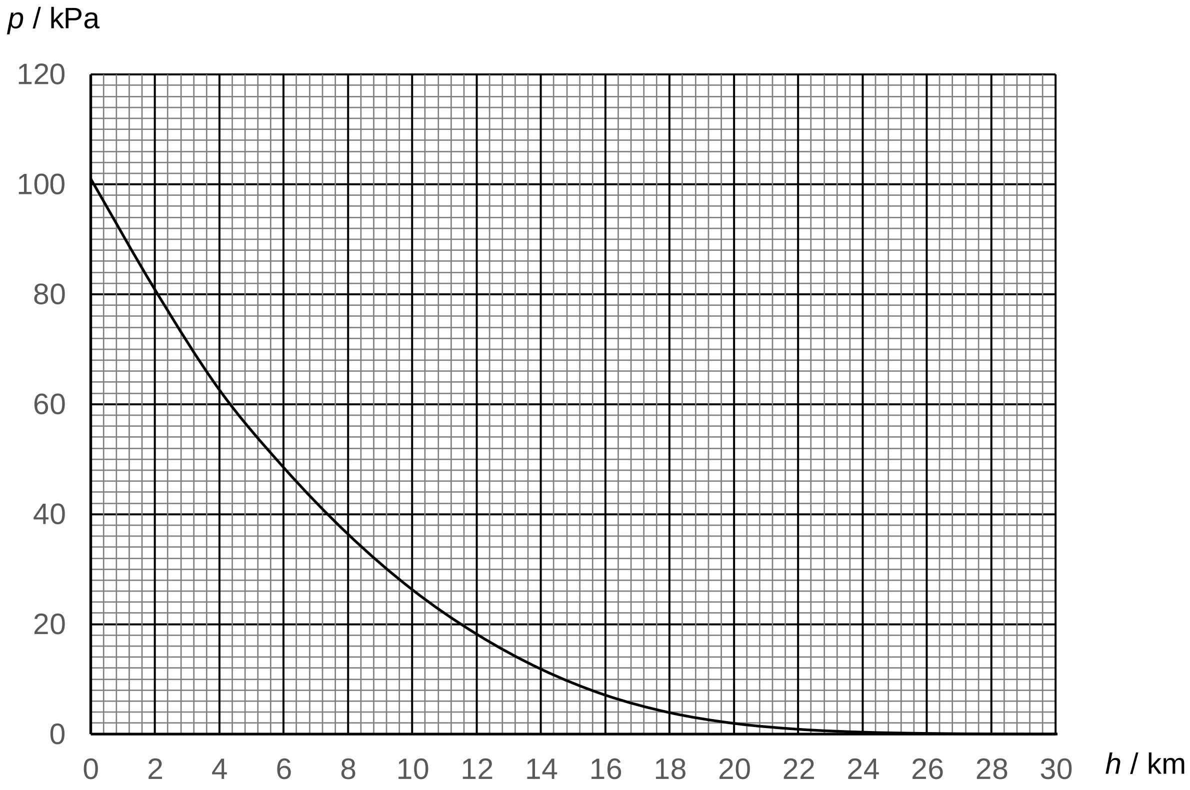


**Fig. 4.1**

**(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 $\phi$.

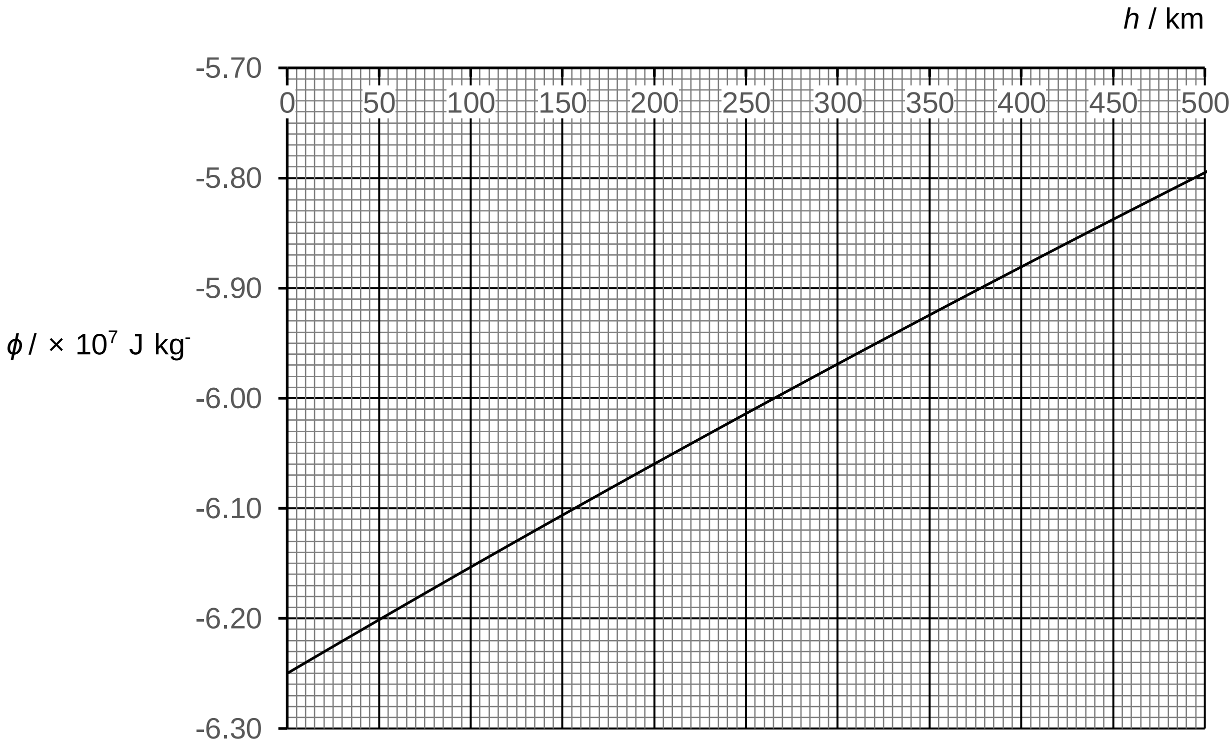


**Fig. 4.2**

**(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]

For Examiner's Use

**(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.

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..........................................................................................................................................[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.

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**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.

For Examiner's Use

## 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.

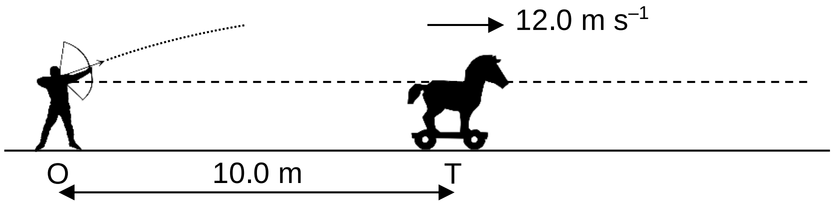


**Fig. 1.1**

**(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.

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..............................................................................................................................

..............................................................................................................................[2]

For Examiner's Use

**(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.

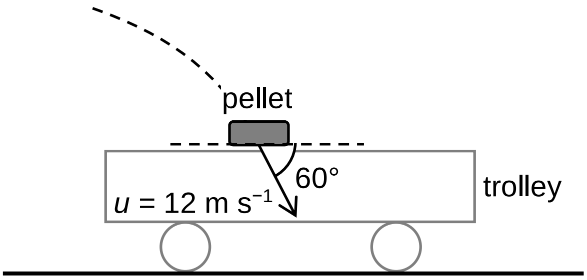


**Fig. 2.1**

**(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$^{-1}$.

..............................................................................................................................................

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..............................................................................................................................................[2]

**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.

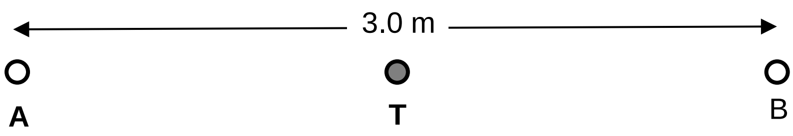


**Fig 3.1**

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.

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..........................................................................................................................................

.......................................................................................................................................[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.

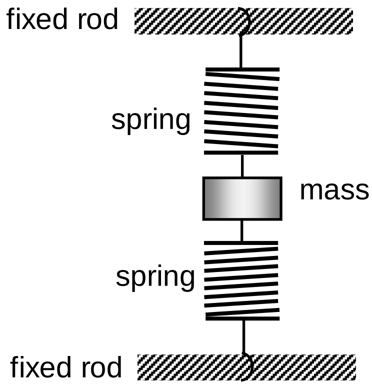



**Fig. 4.1**

The kinetic energy of the oscillator varies with its displacement from its equilibrium position as shown in Fig. 4.2.

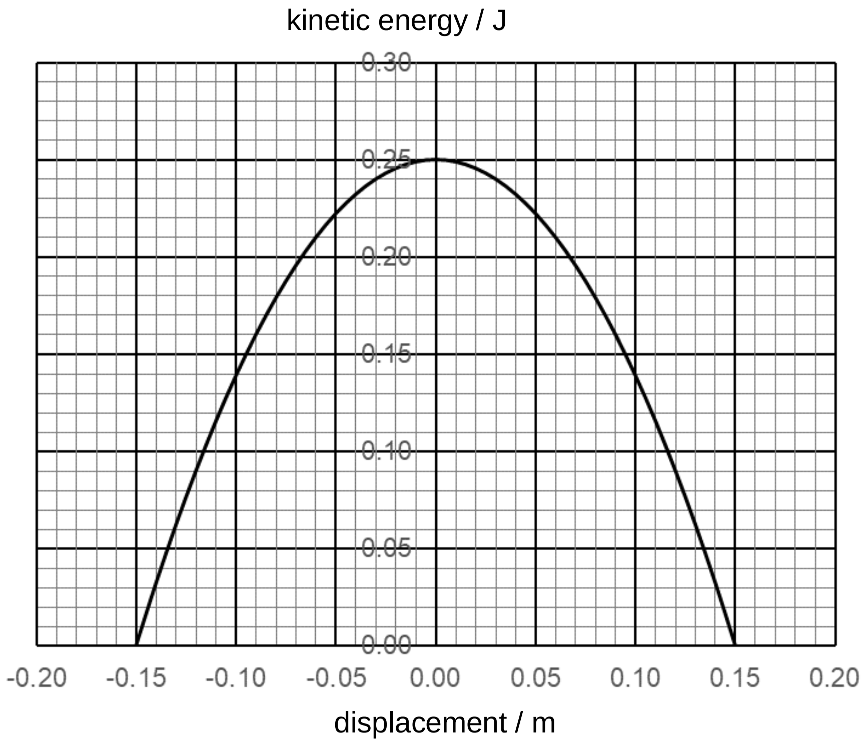



**Fig. 4.2**

**(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 $1.25 \times 10^5$ 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]

For Examiner's Use

**(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 $3.0 \times 10^4$ kg is located on the equator of the planet at a distance of $1.25 \times 10^5$ m from the centre, as shown in Fig. 5.1.

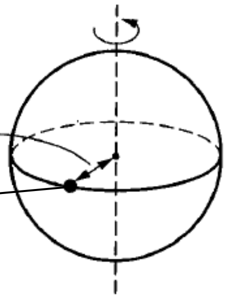



**Fig. 5.1**

**(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]

**(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.

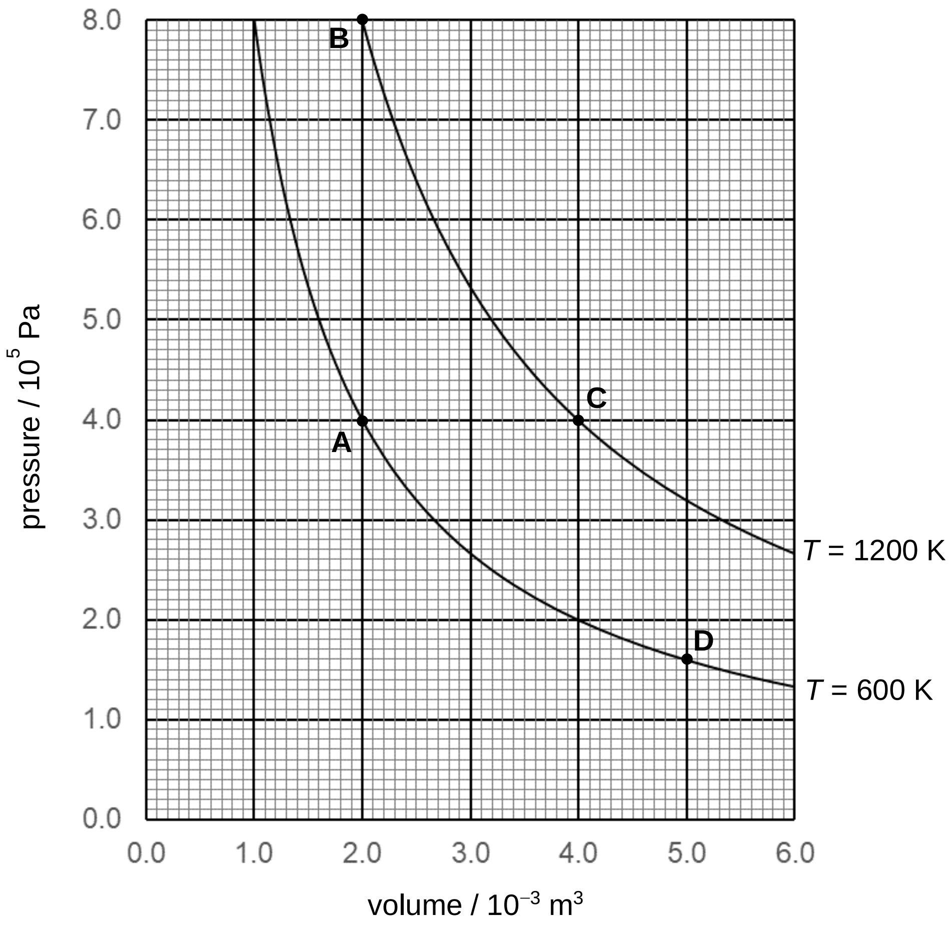



**Fig. 6.1**

**(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]

For Examiner's Use

**(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]

For Examiner's Use

**(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.

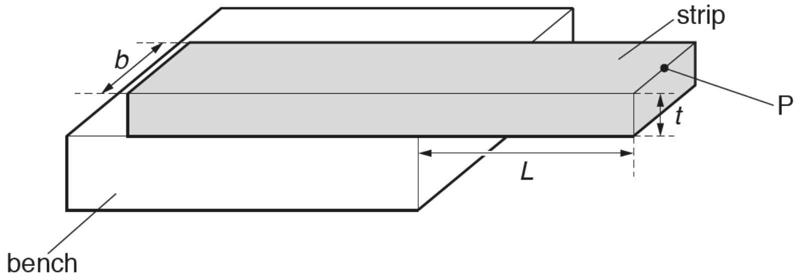



**Fig. 7.1**

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

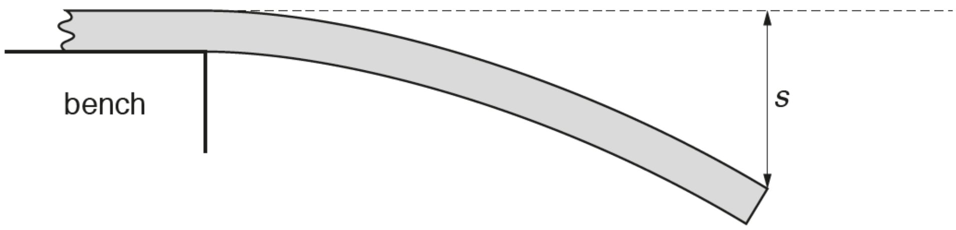



**Fig. 7.2** (not to scale)

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**

H

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

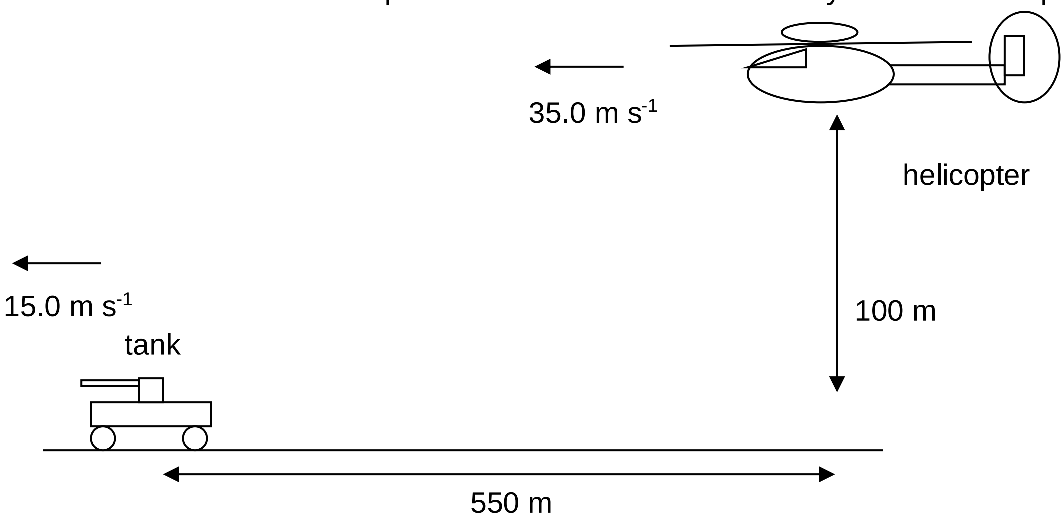
**2** The following four possible sources of error in a series of measurements are listed as follows.

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 |

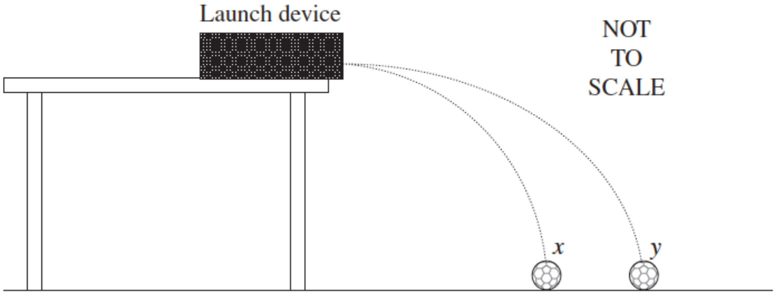
**3** A helicopter flies at 100 m above a tank with a constant horizontal speed 35.0 m $s^{-1}$ while the tank travels with a constant speed 15.0 m $s^{-1}$ and is 550 m away from the helicopter.




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?

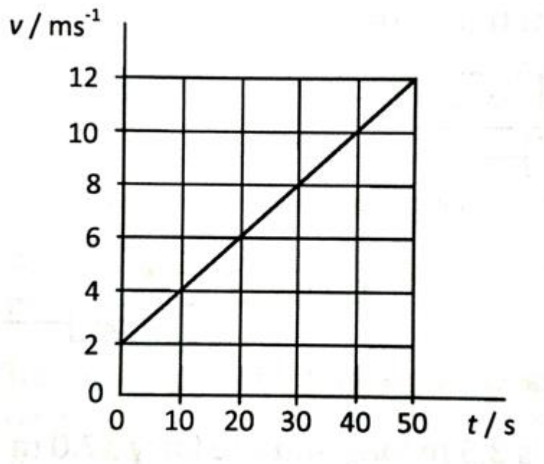
**A** $x$ hits the ground before $y$ as it is closer to the launch site.

**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.

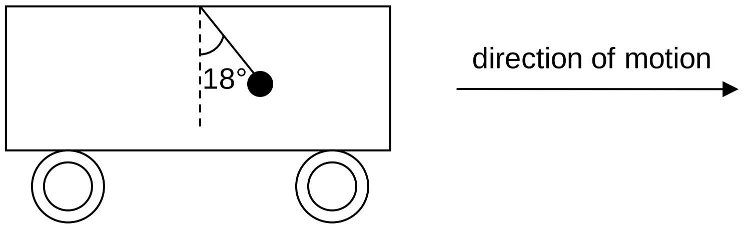
5 A train travelling at 2.0 m s$^{-1}$ passes through a station. The graph below shows the variation with time $t$ of the speed $v$ of the train after leaving the station.




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$^{-2}$

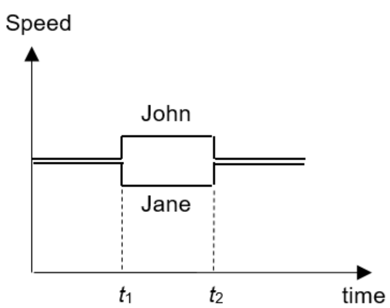
**7** A movable noticeboard of mass 4.0 kg is placed on a smooth horizontal floor. A horizontal stream of water with speed 10 m s$^{-1}$ strikes the noticeboard at a rate of 1.0 kg s$^{-1}$ for a duration of 60 s. Assuming that the water does not rebound upon hitting the noticeboard and the mass of the 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$^{-2}$

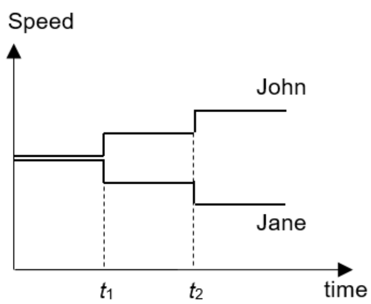
**8** John and Jane are skating on smooth ice such that they are moving with equal speeds in the same straight line. John skates backwards facing Jane in front of her. At time $t_1$ John throws a ball to Jane and at time $t_2$ receives it back.

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?

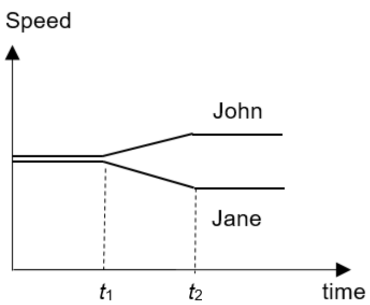
**A**



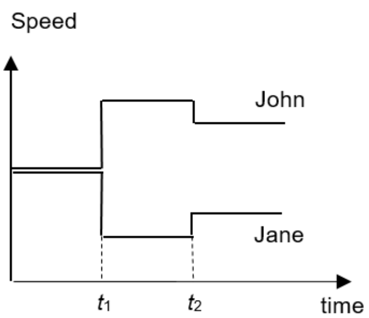

**B**



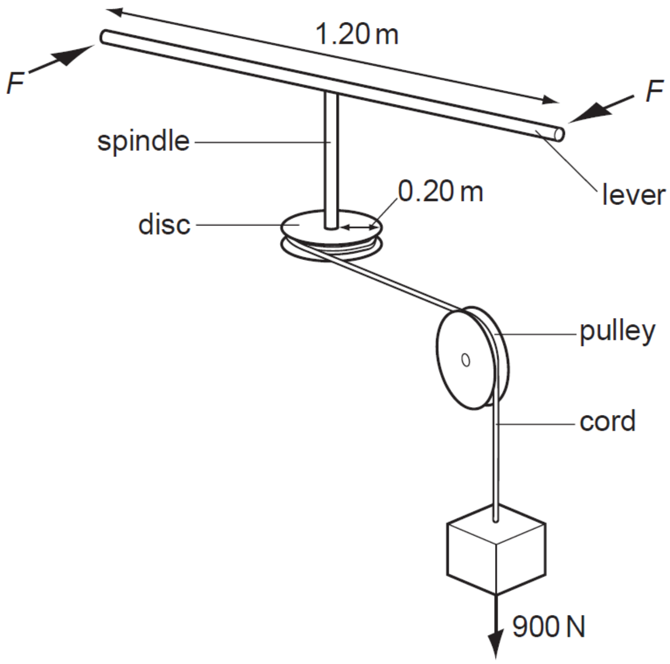

**C**




**D**



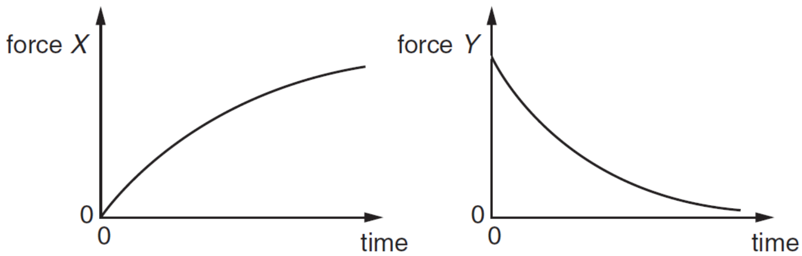
**9** A spindle is attached at one end to the centre of a lever 1.20 m long and at its other end to the centre of a disc of radius 0.20 m. A cord is wrapped round the disc, passes over a pulley and is attached to a 900 N weight.




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*?

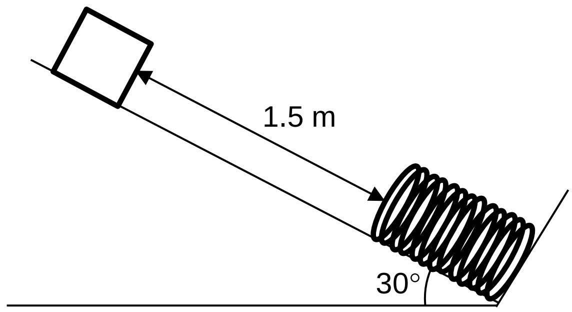



| | force X | force Y |
|---|---|---|
| **A** | air resistance | resultant force |
| **B** | air resistance | weight |
| **C** | upthrust | resultant force |
| **D** | upthrust | weight |

**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

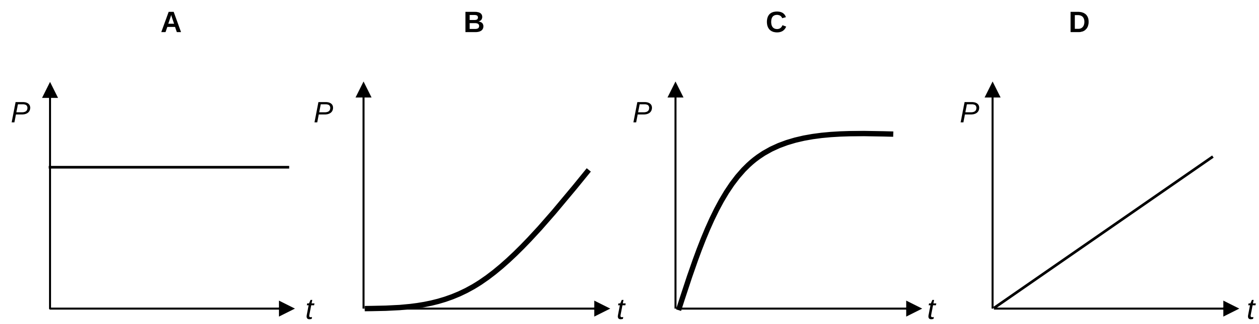
**12** A block of mass 250 g is placed on a rough, inclined plane which makes an angle 30° with the horizontal. The spring at the end of the inclined plane has spring constant 5.0 N $cm^{-1}$. The distance between the mass and spring is 1.5 m as shown.




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*?

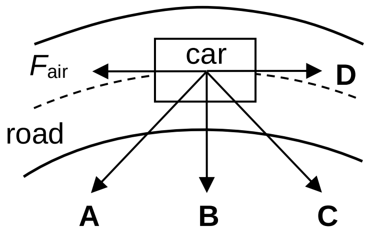



**14** A light inextensible string can bear up to 3.7 kg of mass. A stone of mass 500 g is tied to one end of the string and revolved in a vertical circular path of radius 4.00 m. Taking $g$ = 10 m $s^{-2}$, what is the maximum angular velocity of the stone?

**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?



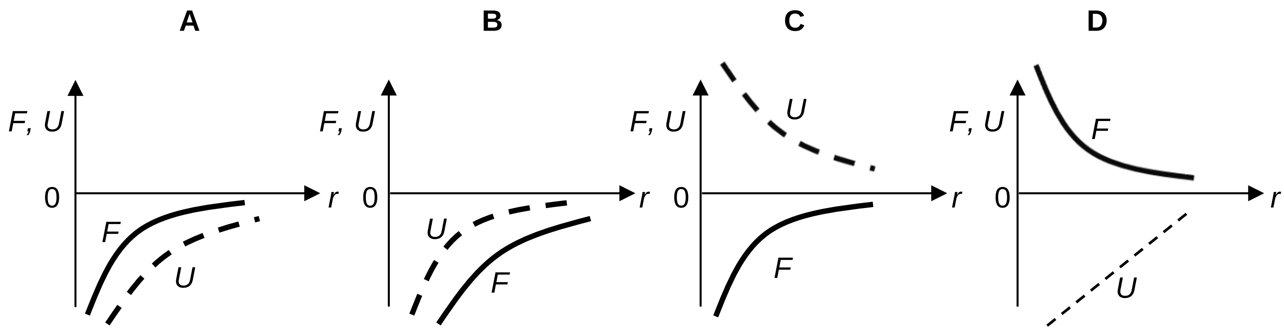

**16** A racing car moving round a circular track of radius 300 m travels at a constant speed of 95 m $s^{-1}$. Given that the mass of the car is 700 kg, what is the angle at which the track should be banked, so that frictional force is not required for the car to make the turn?

**A** 18 ° **B** 36 ° **C** 57 ° **D** 72 °

**17** The surface area of Earth is $A$ and its density is $\rho$. 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** $(\sqrt{2}-1)d$ from $M$ **B** $\frac{2}{3}d$ from $M$

**C** $(2-\sqrt{2})d$ 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

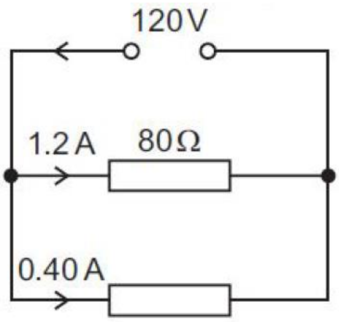
**A** reduce random errors in the measurements of the mass of water vapour produced per minute.

**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?

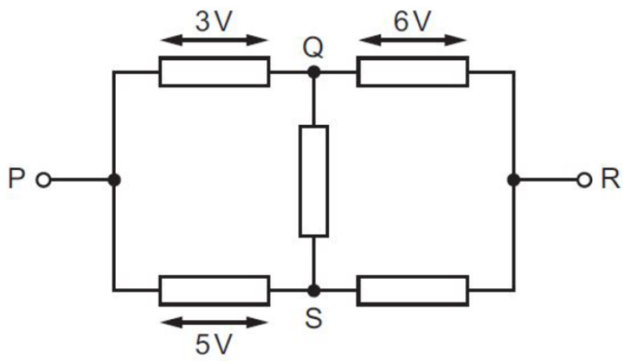
**A** The current in the resistor and the potential difference across the resistor.

**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.

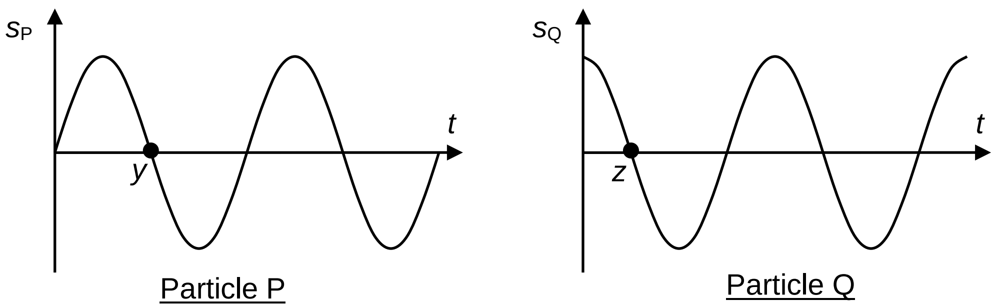
The p.d. between Q and R is 6 V.

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.

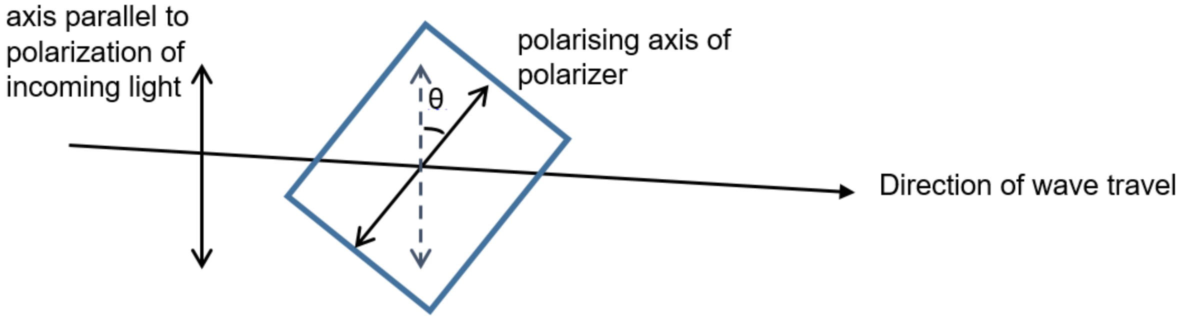



Which of the following correctly gives the wavelength and speed of the wave?

| | 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 $\theta$ 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 $\theta$?




**A** 22.5° **B** 30° **C** 45° **D** 60°

NANYANG JUNIOR COLLEGE
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Higher 2

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| CANDIDATE NAME | |

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| 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**

**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 $\sigma$ in the wire is calculated by using the expression

$$\sigma = \frac{4F}{\pi d^2}$$

**(i)** Determine the percentage uncertainty in $\sigma$.

percentage uncertainty = ................................ % [1]

**(ii)** Hence determine the value of $\sigma$ with its associated uncertainty.

$\sigma$ = (................................ ± ................................) N m$^{-2}$ [2]

**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.

..........................................................................................................................

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...................................................................................................................... [3]

**(ii)** Explain why the vertical wall does not experience a change in momentum when it is hit by the stream of air.

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...................................................................................................................... [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]

For Examiner's Use

**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.

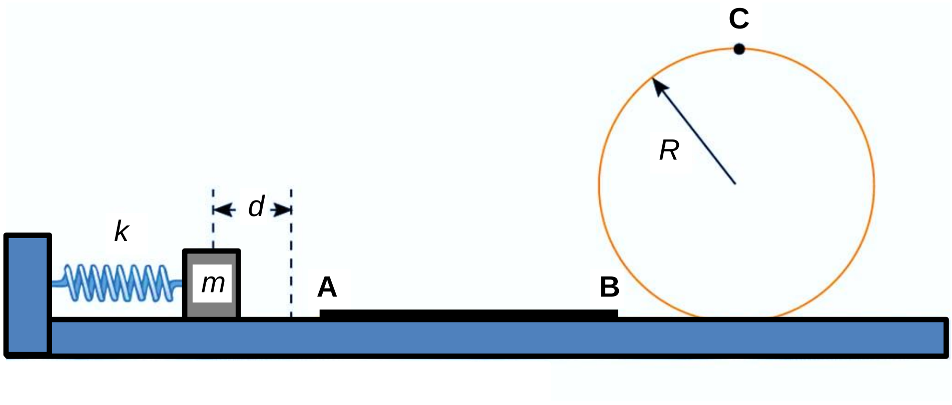


**Fig. 4.1**

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.

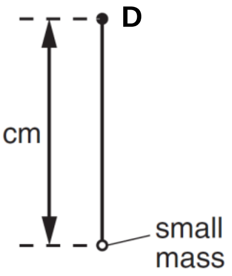


**Fig. 4.2**

The cord and mass are now made to rotate at *constant* angular speed $\omega$ 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.

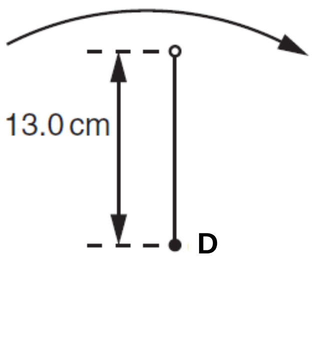


**Fig. 4.3**

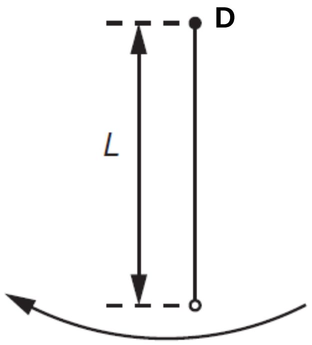


**Fig. 4.4**

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.

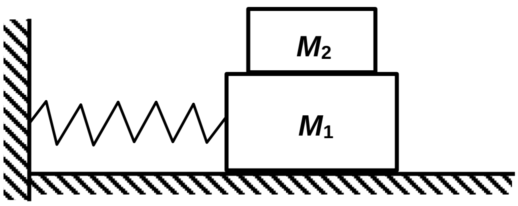


**Fig 5.1**

$M_1$ 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.

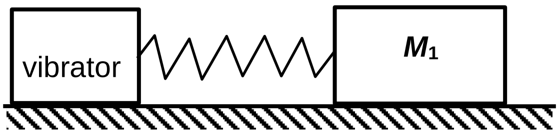


**Fig 5.2**

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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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** | |
| **2** | |
| **3** | |
| **4** | |
| **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.

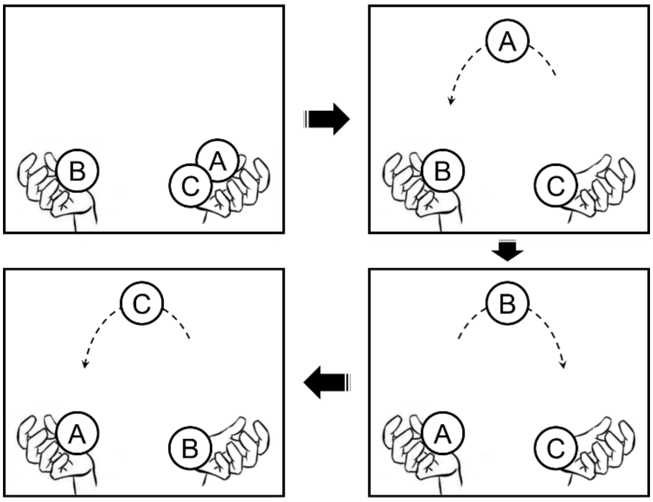


**Fig. 1.1**

**(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 = .............................. ° [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.

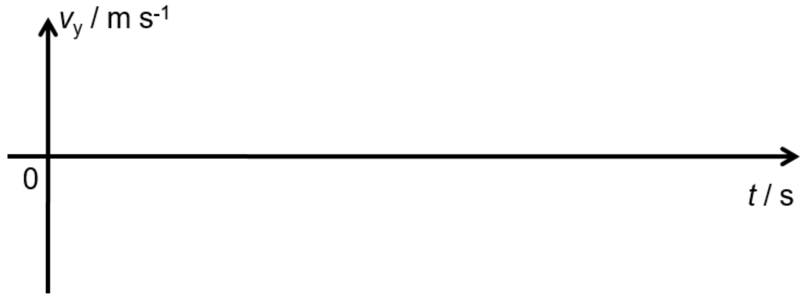


**Fig. 1.2**

[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.

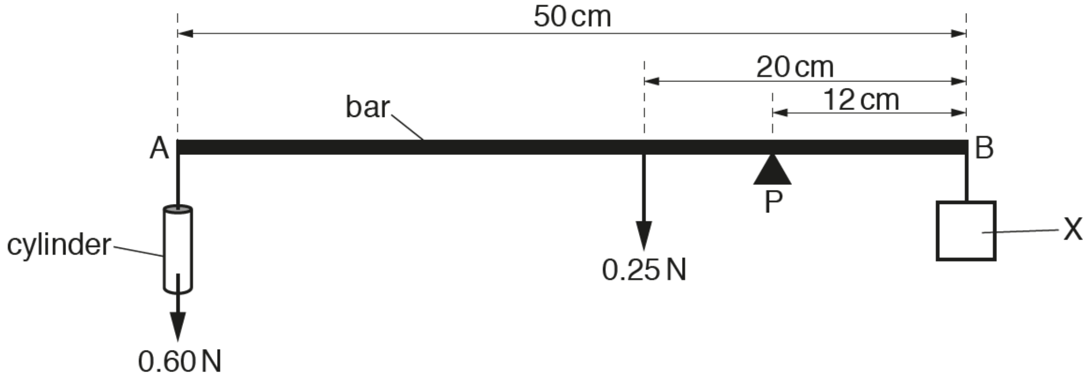


**Fig. 2.1**

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.

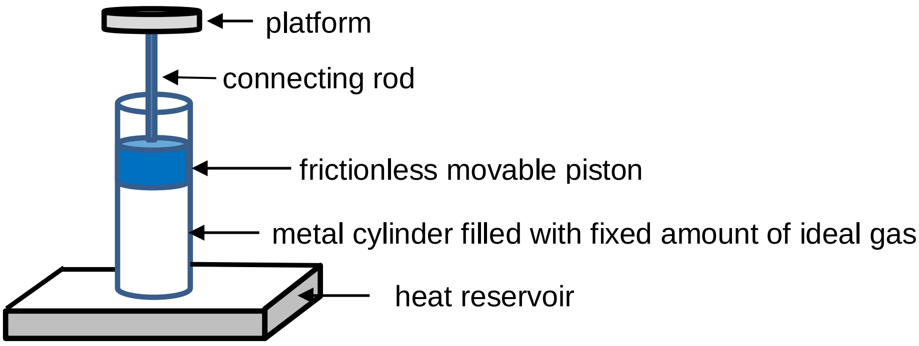


**Fig. 3.1**

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.

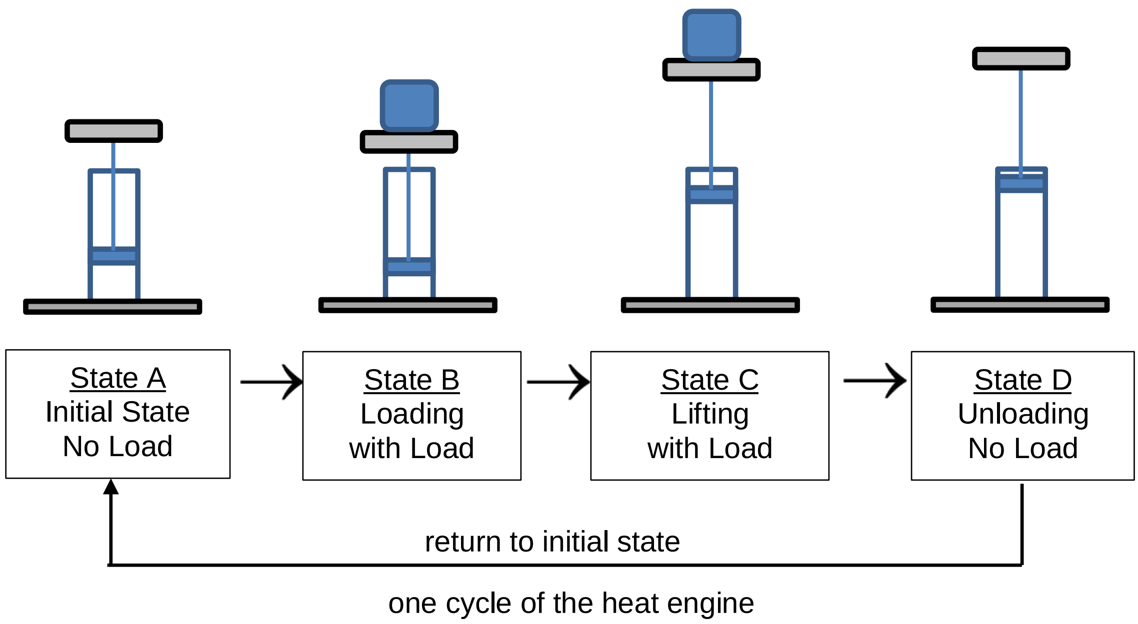


**Fig. 3.2**

**(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.

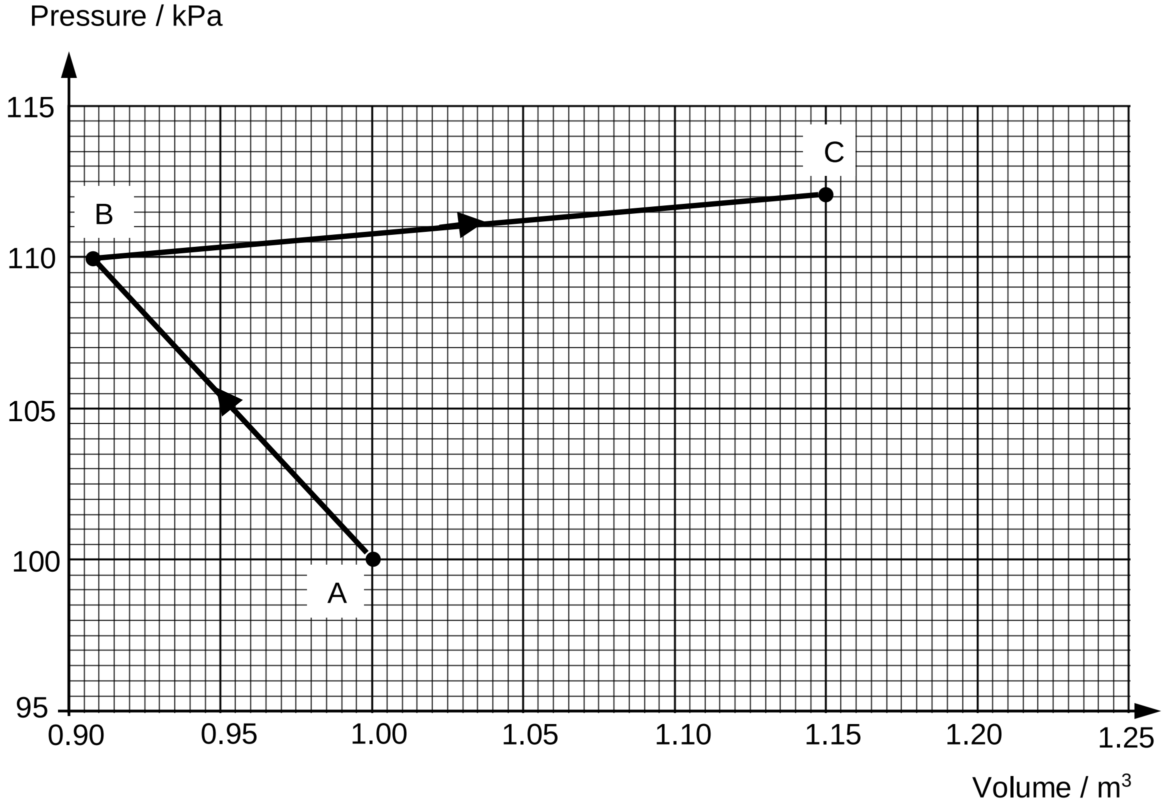


**Fig. 3.4**

**(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.

..........................................................................................................................

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.................................................................................................................... [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.

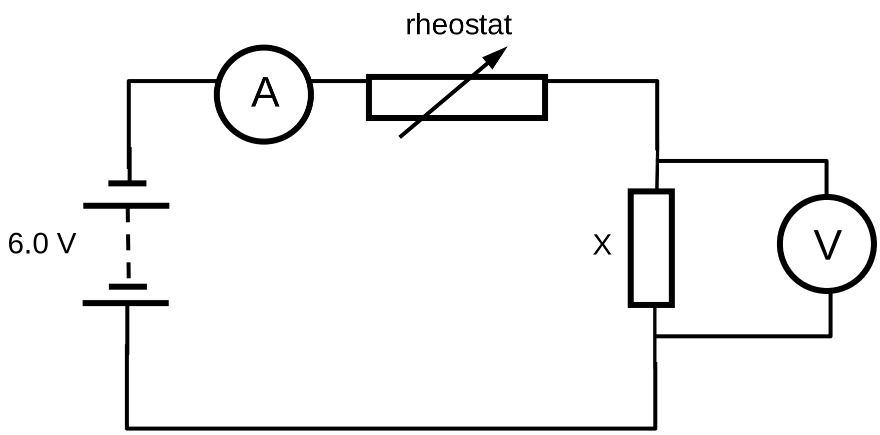


**Fig 4.1**

The *I*-*V* graph obtained from the results is shown in Fig 4.2.

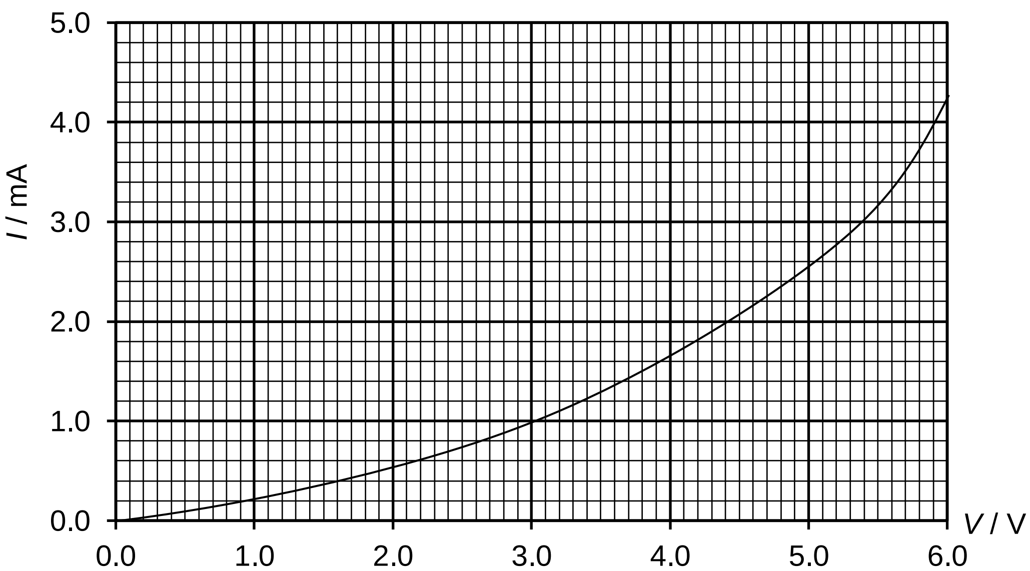


**Fig. 4.2**

**(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.

..........................................................................................................................................

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.................................................................................................................................... [1]

**(d)** Three identical pieces of component X are arranged as shown in Fig 4.3.

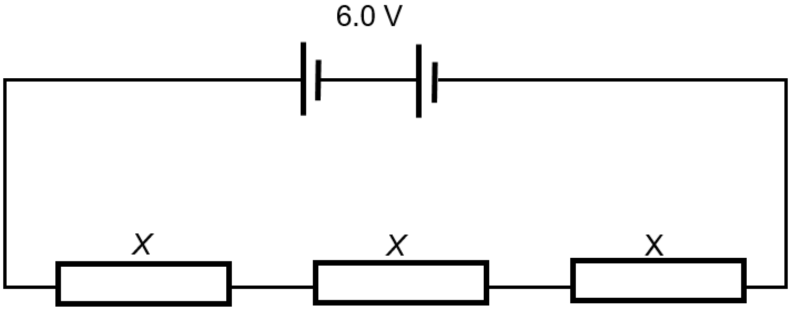


**Fig. 4.3**

**(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.

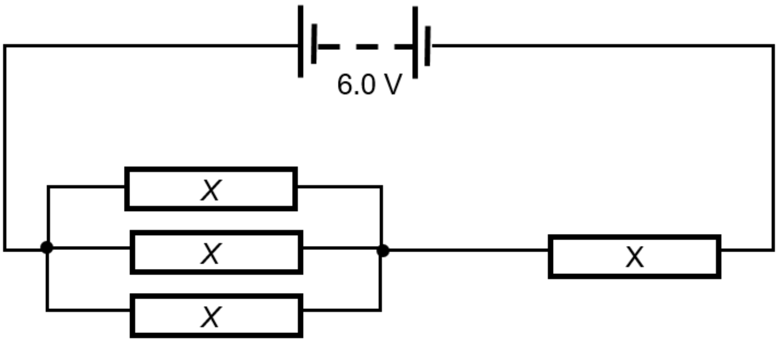


**Fig. 4.4**

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 $\mu$ 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.

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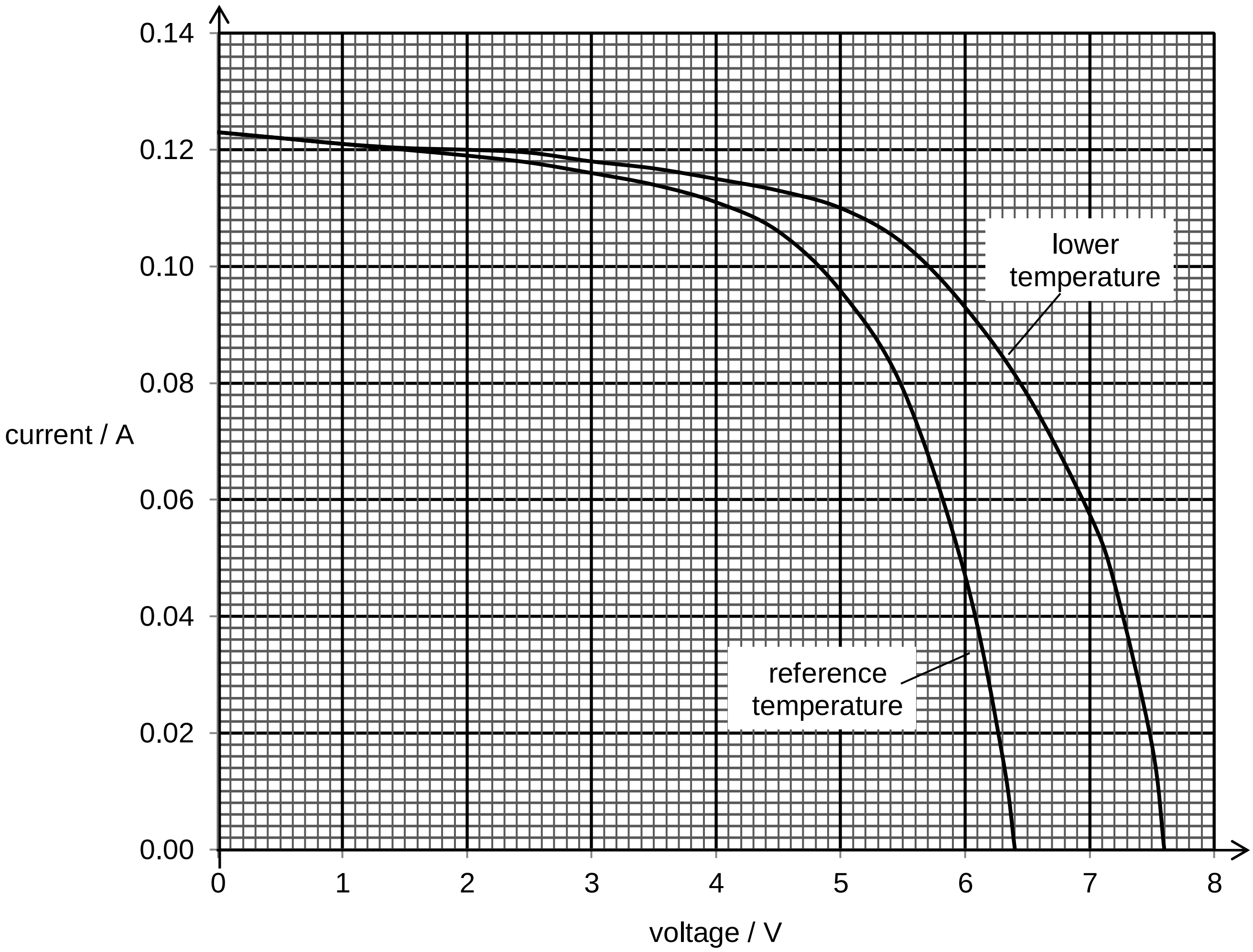


**Fig. 5.1**

**(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]

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**(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 $V$.

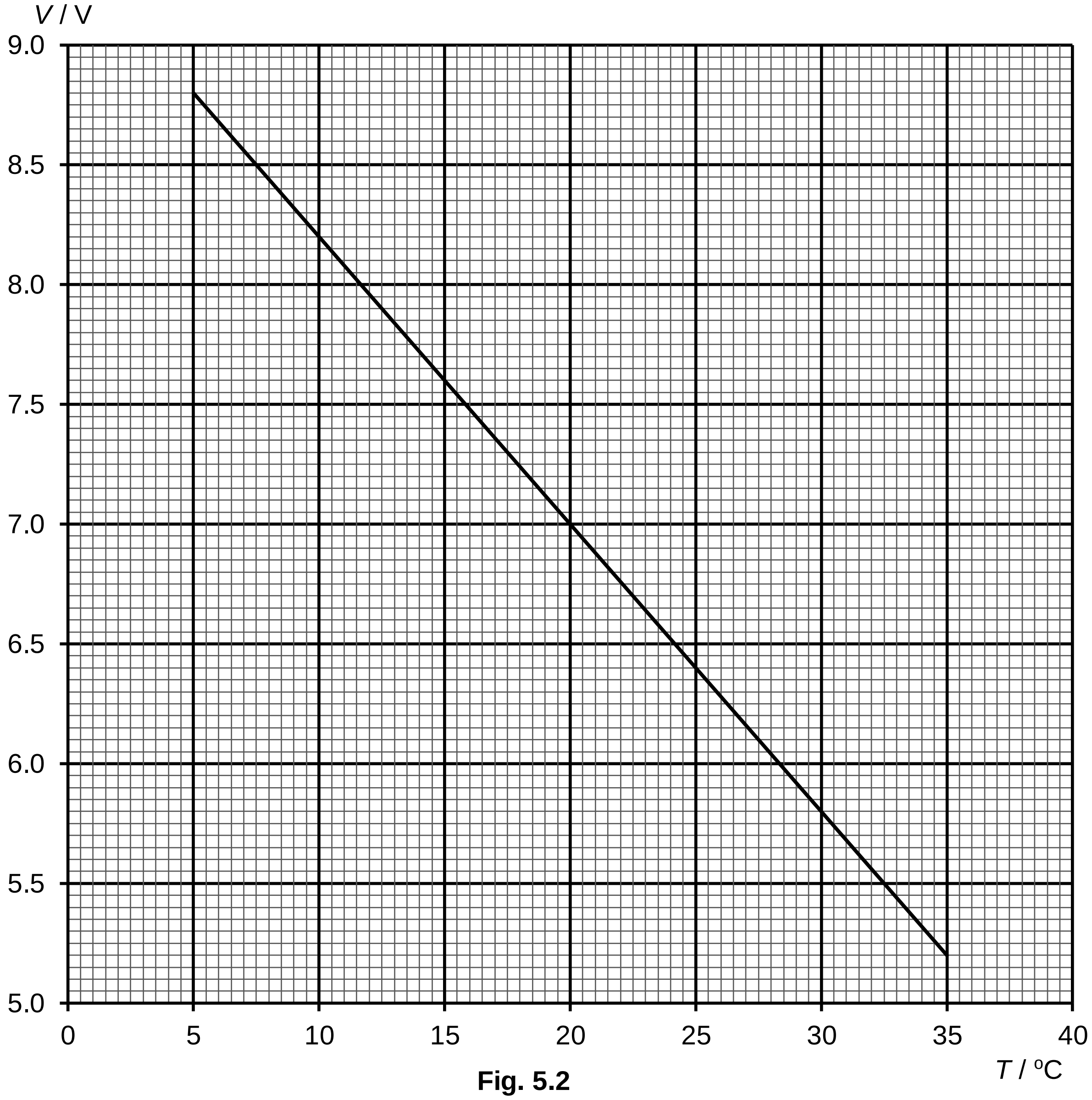


**Fig. 5.2**

Use Fig. 5.2 to determine the constants $\mu$ and $T_R$.

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$\mu$ = .............................. V $^oC^{-1}$

$T_R$ = .............................. $^o$C [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 = .............................. $^o$C [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]

## 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 $1.0 \times 10^{30}$ kg and $4.0 \times 10^{30}$ kg respectively, are placed at an initial distance $1.5 \times 10^{8}$ km apart in space and are far away from other massive bodies, as shown in Fig. 6.1.

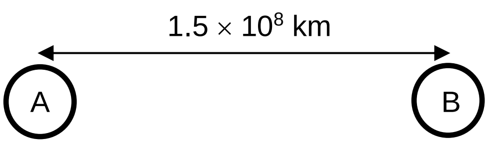


**Fig. 6.1**

**(i)** Sketch the graph of gravitational field strength $g$ against distance $x$ from A, and the corresponding graph of gravitational potential $\phi$ 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.

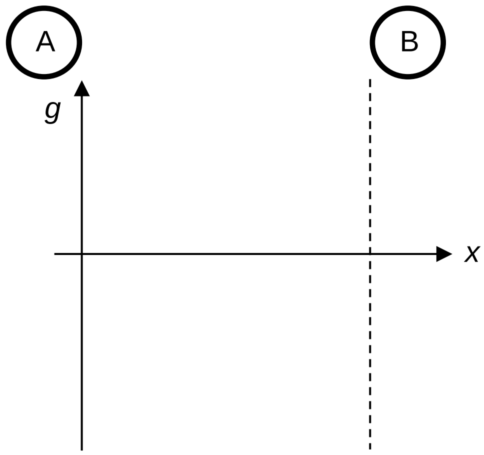


**Fig. 6.2**

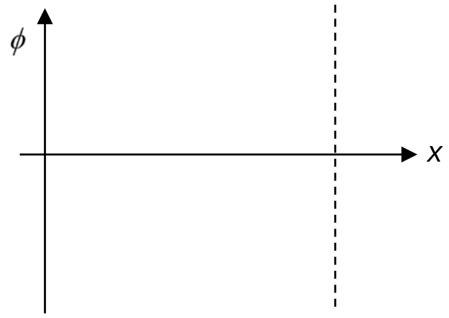


**Fig. 6.3**

[4]

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**(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.

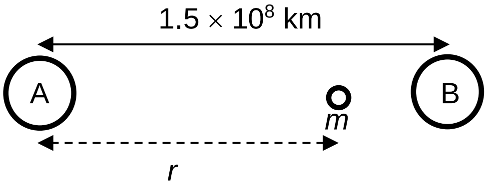


**Fig. 6.4**

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**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]