9478 H2 PHYSICS

JC 1 PROMO EXAM PAST YEAR PAPERS 2

MEASUREMENTS

KINEMATICS

DYNAMICS

FORCES

WORK, ENERGY POWER

CIRCULAR MOTION

GRAVITATIONAL FIELD

OSCILLATIONS

TEMPERATURE & IDEAL GASES

FIRST LAW OF THERMODYNAMICS

WAVE MOTION

NANYANG JUNIOR COLLEGE
JC1 PHYSICS TEAM
SCIENCE DEPARTMENT
2025

Data

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

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm / r$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal 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	=	$R_1 + R_2 + \dots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \dots$
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	λ	=	$\ln 2 / t_{1/2}$

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

PHYSICS 9749/01

Paper 1 Multiple Choice **28 September 2017**

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 **14** printed pages.

1 The resistance R of a conductor is defined as the ratio of potential difference across it to current through it. Which of the following is an acceptable unit of R?

A V A **B** kg A^{-2} m^2 s **C** kg m^2 s^{-3} **D** kg C^{-2} m^2 s^{-1}

2 On a map, the distance of towns P and Q from town T are measured to a precision of ±0.5 cm as 38.5 cm and 43.5 cm respectively. If the scale of the map is 1:20 000, which of the following best expresses how much further town Q is from town T on the ground compared to town P?

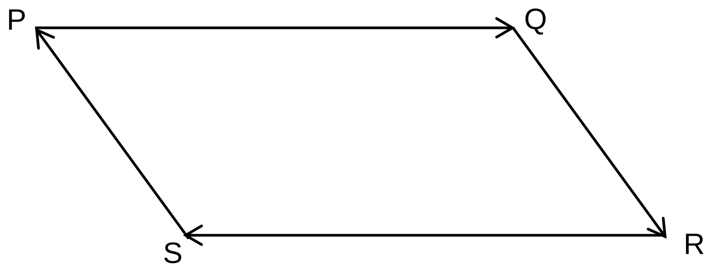
A 1.00 km ± 20%

B 1.0 km ± 20%

C 0.100 km ± 4%

D 0.1 km ± 4%

3 PQRS is a parallelogram made up of four vectors PQ, QR, RS and SP.

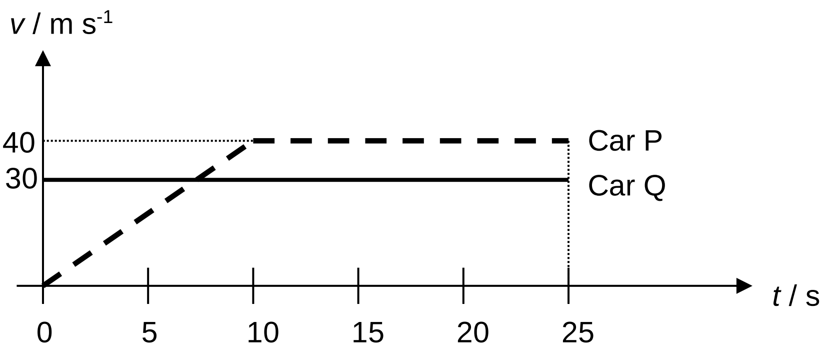


At time $t = 0$, the velocities of cars X and Y are represented by the vectors PQ and –SP respectively. At $t = 10$ s, both cars are moving with the same velocity.

Between $t = 0$ and $t = 10$ s, car X undergoes a change in velocity represented by the vector QR. What is the change in velocity of car Y during the same time period and its final velocity?

	change in velocity	final velocity
A	RS	–QS
B	RS	QS
C	–RS	PR
D	–RS	–PR

4 The figure below shows the velocity-time graph of two cars moving along the same road. If both cars were at the same point at t = 0 s, at what time will they meet again?

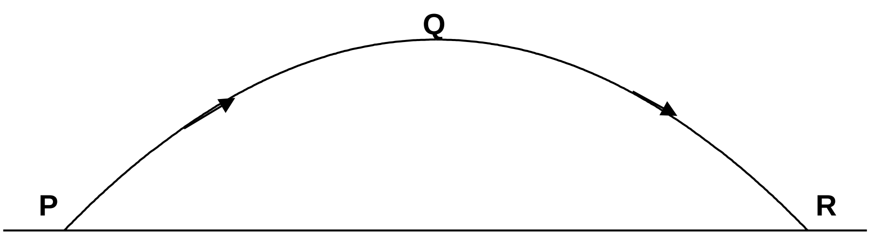


A 7.5 s **B** 15 s **C** 20 s **D** 25 s

5 A projectile is projected at an angle θ above the ground. When it reaches its maximum height of 10 m, it has a speed of 20 m s^{-1}. The value of θ is

A 26° **B** 35° **C** 45° **D** 67°

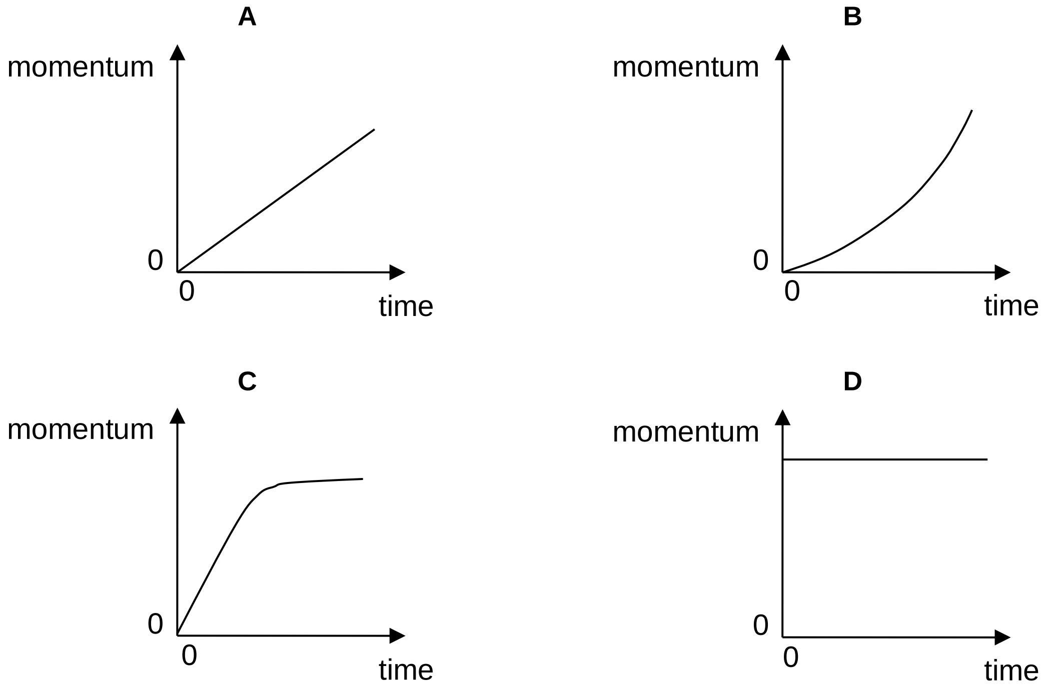
6 In the absence of air resistance, a stone thrown from **P** follows a parabolic path, reaching the highest point at **Q**, and finally landing at **R**.



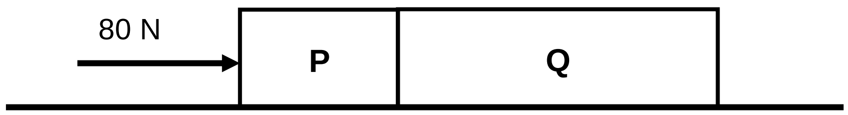
Which of the following statements is true?

A The velocity of the stone at **Q** is zero because it has reached maximum height.
B The time taken to reach **Q** from **P** is greater than the time taken to reach **R** from **Q**.
C The acceleration of the stone between **P** and **Q** is positive and the acceleration between **Q** and **R** is negative**.**
D The speed of the stone is the same at **P** and **R**.

7 Which graph best shows the variation with time of the momentum of a body accelerated by a constant force?

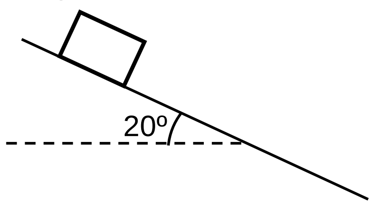


8 Box P and Q of masses 1.0 kg and 4.0 kg respectively are being pushed along a rough, horizontal surface by a constant force of 80 N. The two boxes slide across the rough surface with a constant velocity of 2.0 m s^{-1} to the right. The frictional force acting on box P is 25 N. The force exerted by box Q on box P is



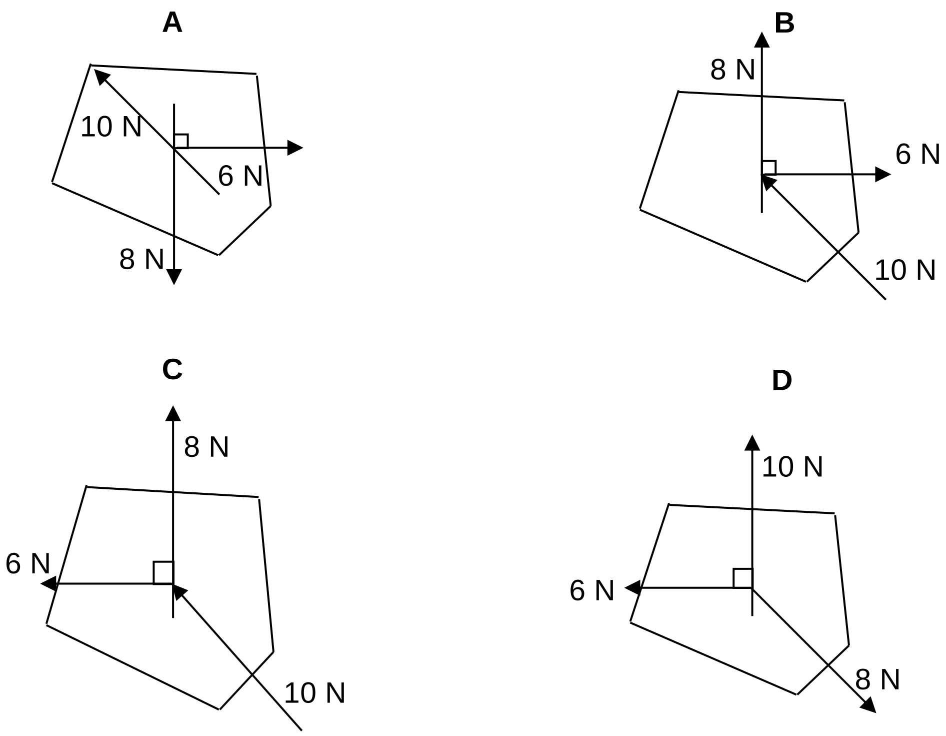
A 52 N **B** 55 N **C** 64 N **D** 80 N

9 A block of mass 1.2 kg slides down a smooth slope from rest as shown below. What is the momentum of the block along the slope after 4.0 s?



A 13 kg m s^{-1} **B** 16 kg m s^{-1} **C** 37 kg m s^{-1} **D** 44 kg m s^{-1}

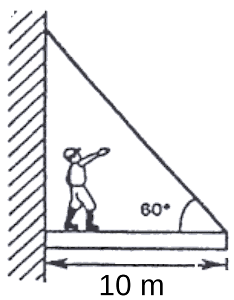
10 Three coplanar forces, 10 N, 8 N and 6 N act on a flat object. Which one of the following shows the flat object in equilibrium under the action of the forces?



11 A submarine descends vertically at a constant velocity. The three forces acting on the submarine are viscous drag, upthrust and weight. Which relationship between the magnitudes of the forces is correct?

A weight < drag
B weight = drag
C weight < upthrust
D weight > upthrust

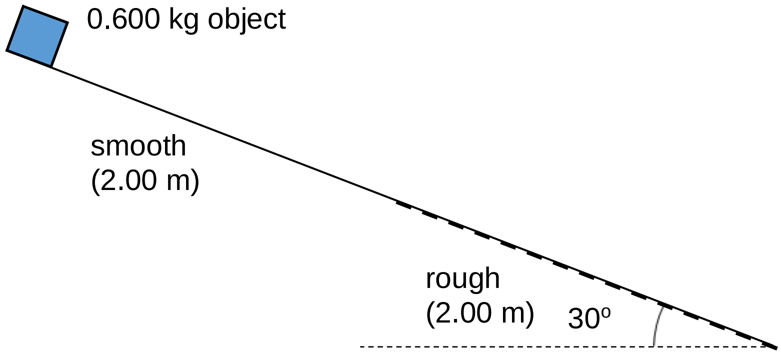
12 A uniform horizontal beam of length 10 m and weight 200 N is attached to a wall as shown below.
The far end of the beam is supported by a cable which makes an angle of 60° with respect to the beam. A 500 N boy stands 2.0 m from the wall. The tension in the cable is 230 N.



The force exerted by the wall on the beam is

A 150 N **B** 470 N **C** 510 N **D** 620 N

13 A plane inclined at 30° to the horizontal consists of a 2.00 m smooth portion at the top and a 2.00 m rough portion at the bottom.



A 0.600 kg object is released from rest at the top of the plane. Assuming that it experiences a constant frictional force of 7.50 N from the rough portion, what is the total distance travelled by the object before it comes to a stop?

A 2.44 m **B** 2.65 m **C** 2.78 m **D** 3.29 m

14 A car is moving horizontally at a constant velocity of 12 m s^{-1}. The driving force provided by the engine of the car is 500 N.

Which of the following statements is correct?

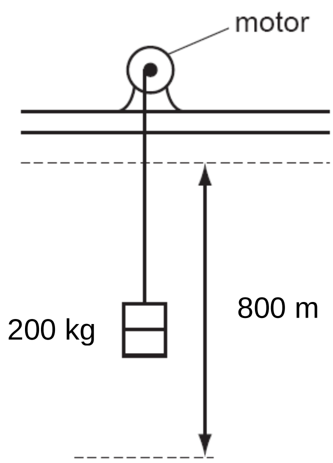
A The net force on the car is 500 N.

B The power provided by the engine is 42 W.

C The work done by the engine to maintain constant velocity is 42 J.

D The rate of energy lost by the car is 6.0 kW.

15 An electric motor is required to raise a 200 kg mass at constant speed through a vertical height of 800 m in 4.0 minutes.



The efficiency of the motor is 75%. What is the electrical power supplied to the motor?

A 4.9 kW **B** 8.7 kW **C** 26 kW **D** 520 kW

16 Two identical particles P and Q are set to travel in circular paths of the same radius. P moves in a vertical circle while Q moves in a horizontal circle. Both move with the same uniform speed.

Which one of the following statements concerning the *net force* acting on P and Q is true?

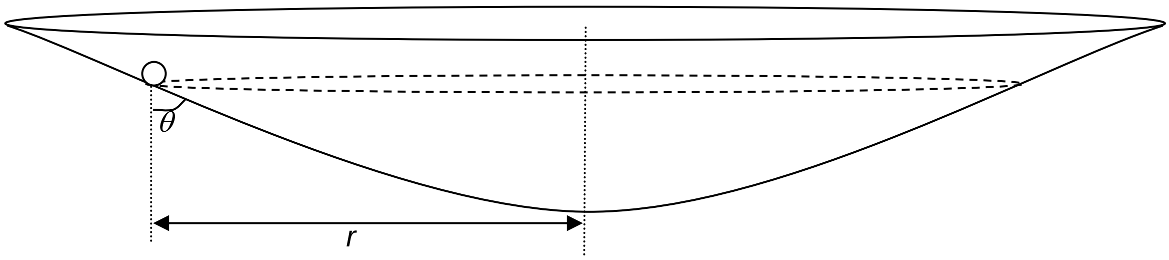
A The magnitudes of the net forces on P and Q are not constant throughout the motion and are not equal to each other.

B The magnitudes of the net forces on P and Q are not constant throughout the motion but are always equal to each other.

C The magnitudes of the net forces on P and Q remain constant throughout the motion but are not equal to each other.

D The magnitudes of the net forces on P and Q remain constant throughout the motion and are always equal to each other.

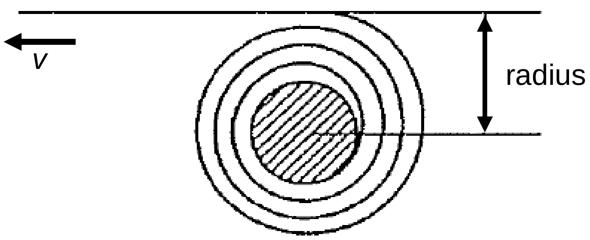
17 A sphere of mass m moves along a smooth horizontal circular path of radius r in a transparent bowl with a constant linear speed v. The side view of the bowl is as shown below.



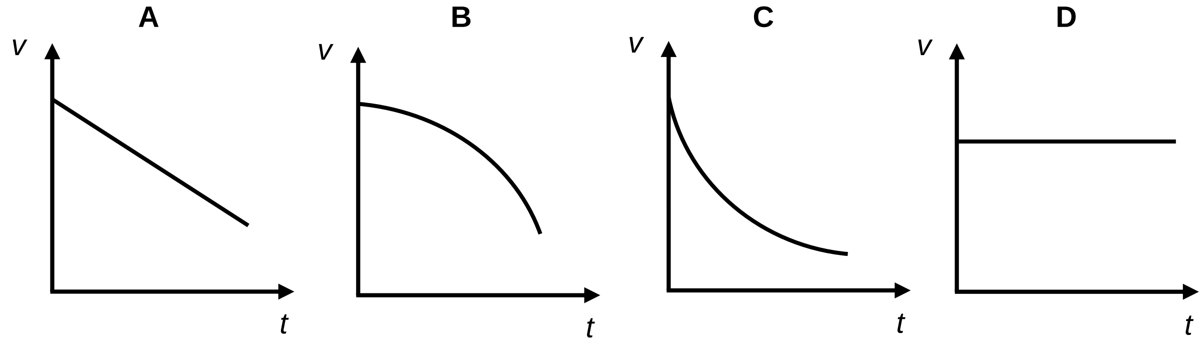
Which of the following gives the expression for angle θ?

A $\tan^{-1}\left(\frac{rg}{v^2}\right)$ **B** $\tan^{-1}\left(\frac{v^2}{rg}\right)$ **C** $\sin^{-1}\left(\frac{mv^2}{r}\right)$ **D** $\sin^{-1}(mg)$

18 A straight length of tape unwinds from a roll rotating about a fixed axis with constant angular velocity. The radius of the roll decreases at a steady rate.



Which of the following graphs correctly shows how the variation of speed v at which the tape moves away from the roll with time t?



19 Which of the following statements about gravitational field is correct?

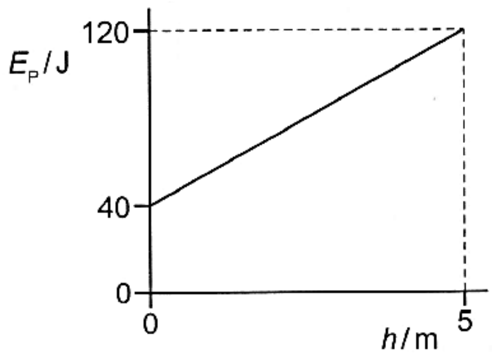
A The gravitational potential increases with the strength of the field.

B The field is directed towards increasing potential.

C The gravitational potential must be zero where the strength of the field is maximum.

D The strength of the field must be zero where gravitational potential is maximum.

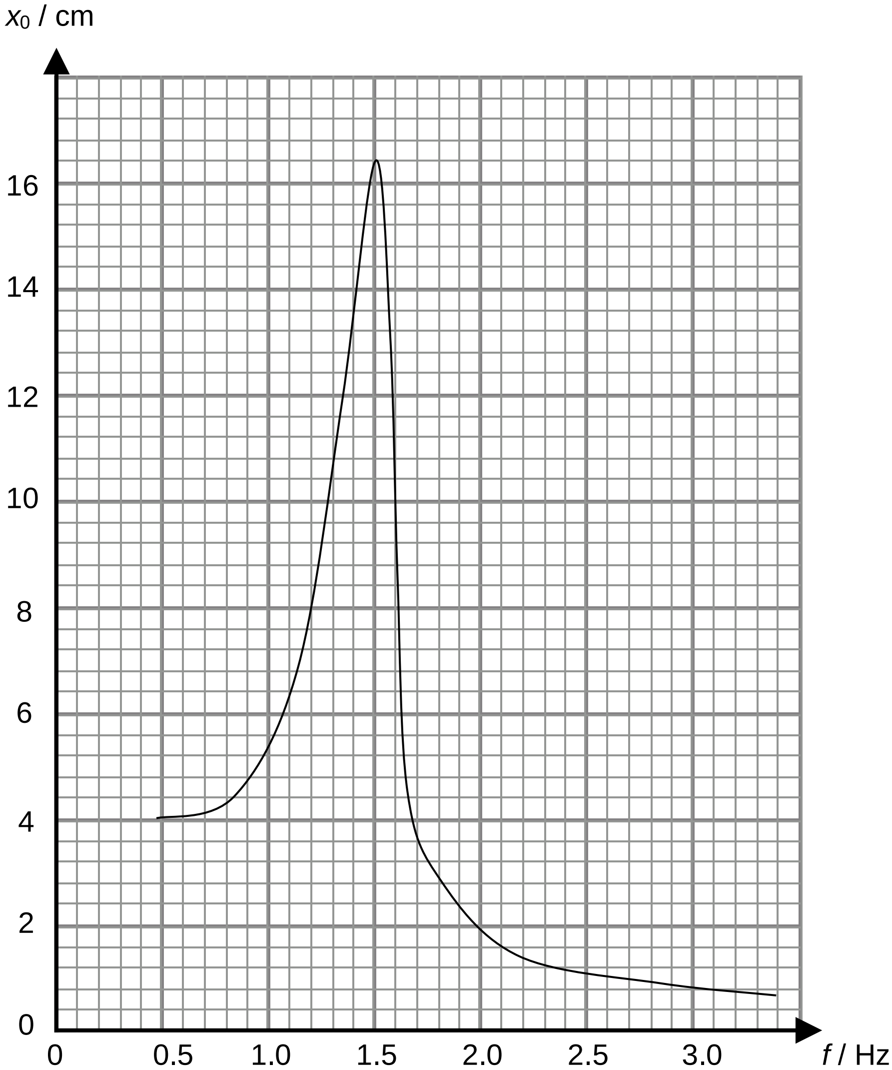
20 The graph below shows how the gravitational potential energy E_p of an object near Mars' surface varies with height h.



Assuming that Mars' gravitational field is uniform, the gravitational force that Mars exert on the object is

A 8.0 N **B** 16 N **C** 24 N **D** 32 N

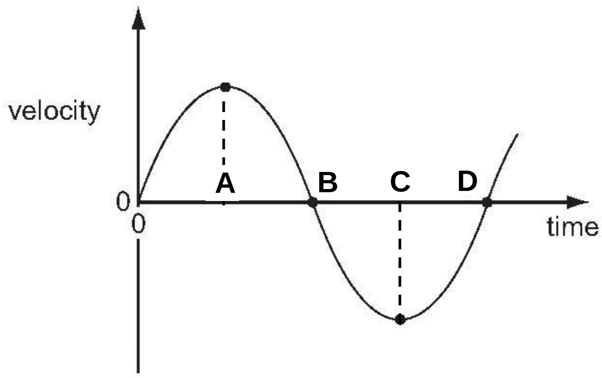
21 The diagram below shows the variation with driving frequency f of the amplitude x_0 of a machine undergoing forced oscillation.



At resonance, which of the following correctly shows the maximum linear velocity and whether the machine experiences any damping?

	velocity / m s^{-1}	damping
A	1.55	No
B	1.55	Yes
C	14.6	No
D	14.6	Yes

22 The figure below shows the variation with time of the velocity for a mass oscillating vertically on the end of a spring. Taking the upward direction to be positive, which of the points shows the time at which the mass experiences maximum upward acceleration?



23 A particle performs simple harmonic motion with maximum acceleration of 5.0 m s^{-2} and maximum speed of 3.0 m s^{-1}. What is the frequency of the particle's oscillation?

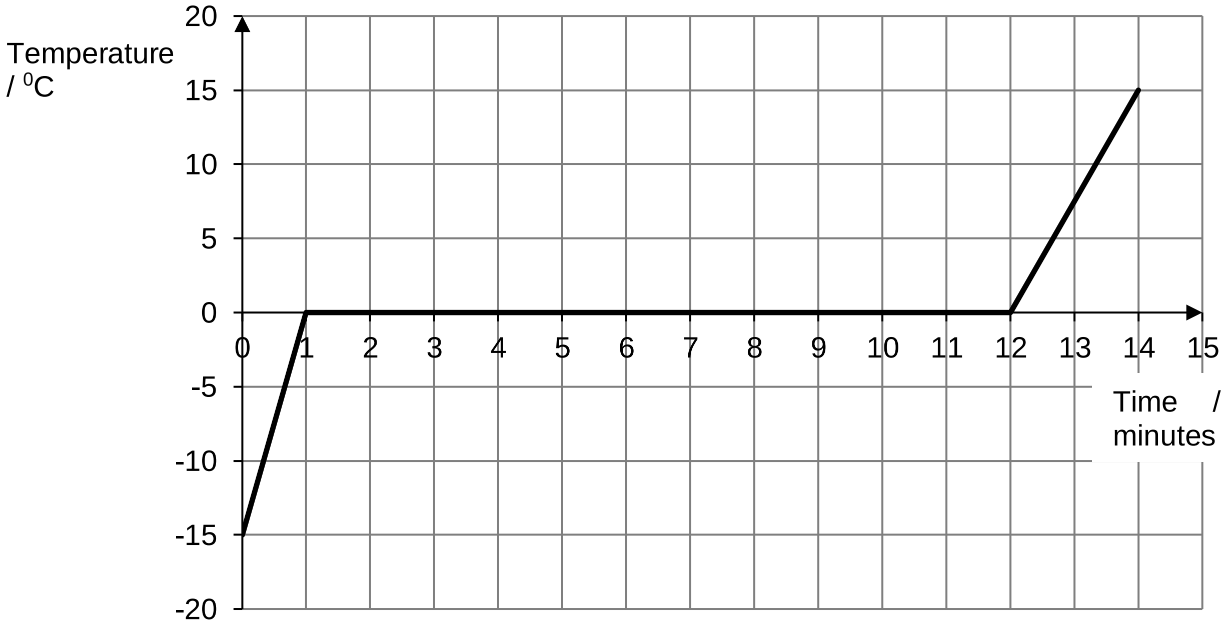
A 0.095 Hz

B 0.27 Hz

C 0.60 Hz

D 1.7 Hz

24 A block of ice is heated at a constant rate by a 0.25 kW heater. The graph below shows how the temperature of the ice and subsequently water changes with time.



Given that the specific latent heat of fusion of water is 3.3 × 10^5 J kg^{-1} and that there is no heat loss to surroundings, what is the mass of the block of ice?

A 0.023 kg **B** 0.045 kg **C** 0.50 kg **D** 8.3 kg

25 A cylinder contains a mixture of helium and argon gas in thermal equilibrium. The gases are assumed to be ideal.

Which of the following statements is correct about the mixture?

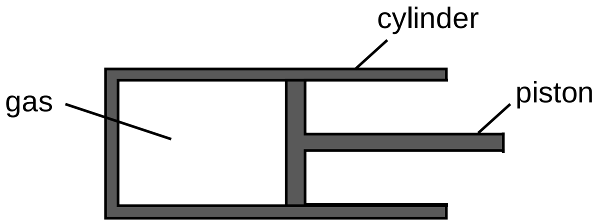
A The average kinetic energy of the particles of both gases is the same.

B The particles of both gases have the same root-mean-square speed.

C All the particles move at the same speed.

D Both gases must have the same number of moles because they are in thermal equilibrium.

26 An ideal gas is contained in a cylinder fitted with a piston, as shown.



Process 1 is an isothermal process whereby the piston is moved inwards slowly so that the volume of the gas is reduced slowly to half its initial volume. The work done on the gas is W_1 and the final temperature of the gas is θ_1.

Process 2 is an adiabatic process whereby the piston is moved inwards suddenly so that the volume of the gas is reduced to half its initial volume. The work done on the gas is W_2 and the final temperature of the gas is θ_2.

Which of the following correctly describes work done on the gas and the final temperature of the gas in Processes 1 and 2?

	work done on gas	final temperature of gas
A	W_1 is the same as W_2	θ_1 is the same as θ_2
B	W_1 is the same as W_2	θ_1 is less than θ_2
C	W_1 is less than W_2	θ_1 is less than θ_2
D	W_1 is less than W_2	θ_1 is greater than θ_2

27 A point source emits sound with a power of 60.0 W. A small microphone of area 0.75 cm^2 detects the sound at a distance of 5.0 m from the source. What is the power detected by the microphone?

A 1.4×10^{-5} W

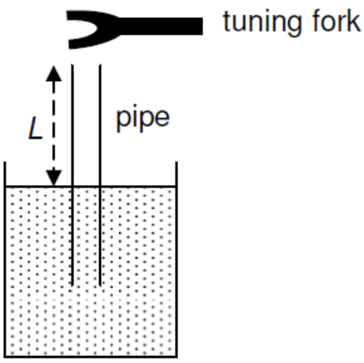
B 7.2×10^{-5} W

C 1.4×10^{-3} W

D 1.9×10^{-1} W

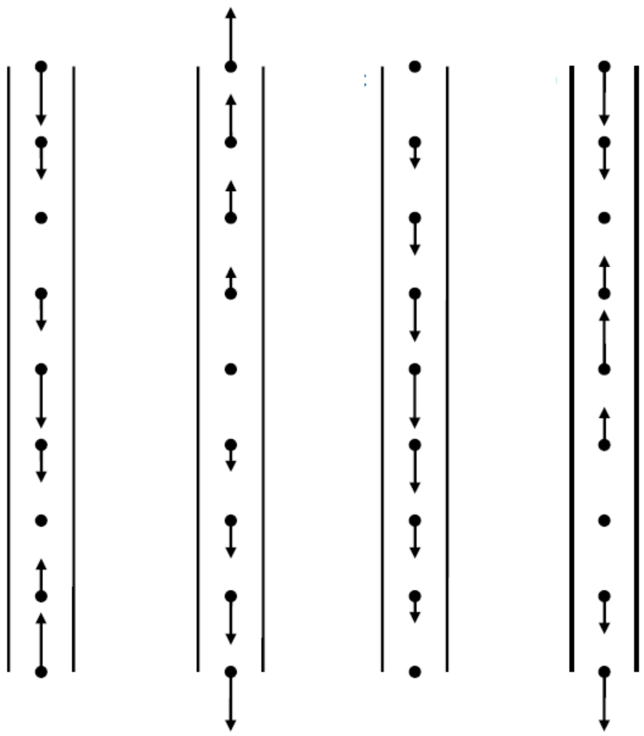
28 A small open pipe is initially submerged in water with its top end just above the surface of the water. A tuning fork vibrating at frequency 600 Hz is placed over the top of the pipe. The pipe is slowly raised such that a series of loud sounds is heard. The second loud sound is heard when the length of pipe above water is *L*.

The experiment is repeated with another tuning fork of unknown frequency *f* and in this instance, the second loud sound is heard when the length of pipe above water is 3*L*. Given that the speed of sound in air is 300 m s^{-1}, what is the value of *f*?



A 110 Hz **B** 200 Hz **C** 360 Hz **D** 400 Hz

29 A stationary longitudinal wave has been set up in a pipe of length *L*. For a stationary wave of wavelength *L*, which diagram shows the displacement of the air molecules from the equilibrium at a particular instant?



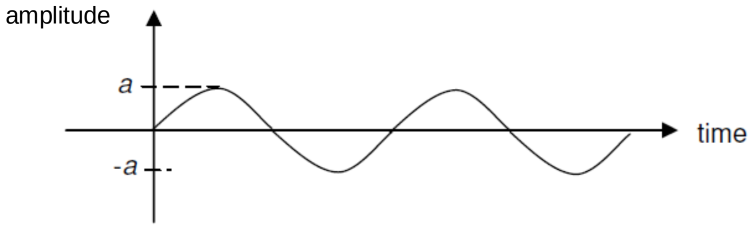
A **B** **C** **D**

30 S_1 and S_2 are two water wave generators of equal frequency. The water waves meet at point P away from the generators.

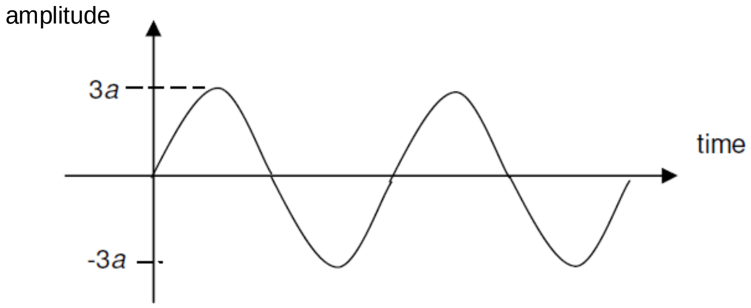
When only S_1 is switched on, amplitude of the wave at P is 2a. When only S_2 is switched on, amplitude of the wave at P is a. When both S_1 and S_2 are switched on, the two waves arrive in anti-phase.

Which of the following shows the amplitude of the resultant wave at P when both generators are switched on?

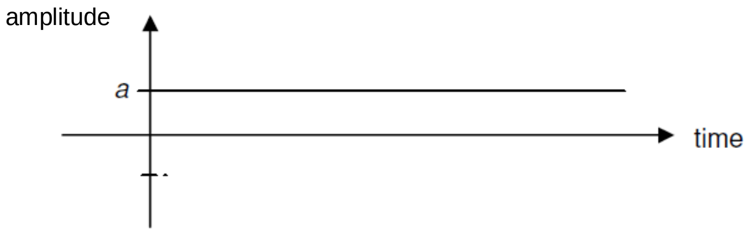
A



B



C



D

End of Paper

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

CANDIDATE NAME

CLASS

TUTOR'S NAME

PHYSICS 9749/02

Paper 2 Structured Questions

28 September 2017

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	/8
2	/9
3	/7
4	/16
Deductions	
Total	/40

This document consists of **12** printed pages and **1** blank page.

For Examiner's Use

Answer ALL questions.

1 Four men A, B, C and D are pushing an object of mass 125 kg which is initially moving at 2.50 m s^{-1} in the direction 35° above the negative x-axis as shown in Fig. 1.1.

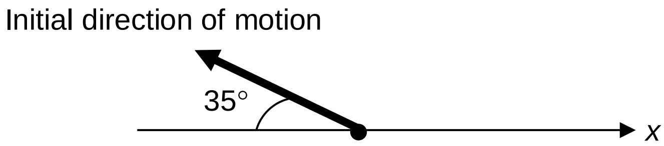


Fig. 1.1

Under the influence of the forces, the object then moves at 5.30 m s^{-1} in the direction 45° above the positive x-axis.

(a) Determine the change in velocity of the object.

magnitude of change in velocity = ... m s^{-1}

direction of change in velocity = ... [3]

(b) Given that the forces are exerted over 3.7 s, calculate the net force acting on the object.

net force = ... N [2]

For Examiner's Use

(c) The forces exerted by A, B and C are as shown in Fig. 1.2.

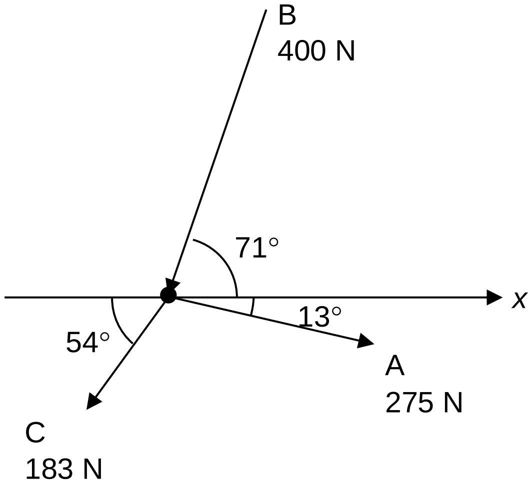


Fig. 1.2

Hence, determine the force exerted by D.

magnitude of force = ... N

direction of force = ... [3]

For Examiner's Use

2 Fig. 2.1 shows a safety test conducted to study the extent of damage caused during a car crash onto a hard stationary block that is fixed to the ground. The combined mass of the car and dummy is 1000 kg.

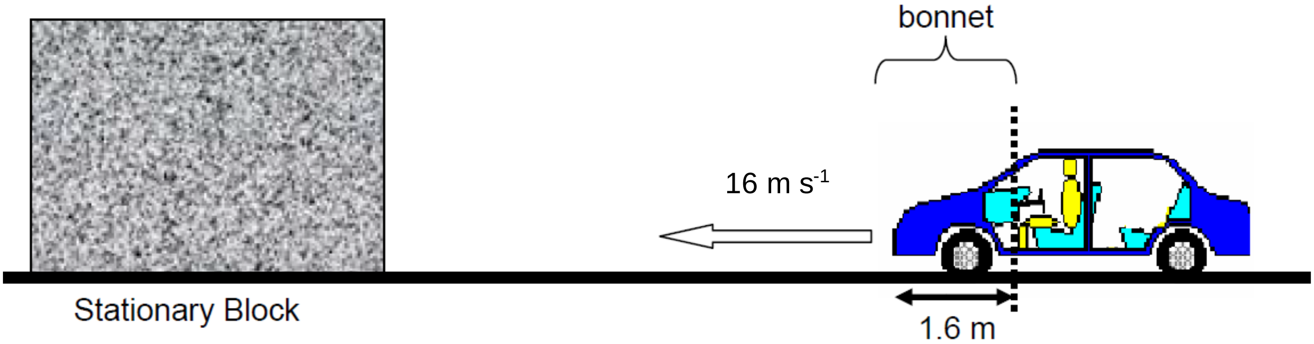


Fig. 2.1

(a) **(i)** If the car is traveling at a constant speed of 16 m s^{-1}, calculate the impulse required to act on the car to cause it to come to a complete stop.

impulse = ... kg m s^{-1} [1]

(ii) During every crash, the bonnet is designed to crumple the entire distance of 1.6 m so that the dummy can escape unscathed. The crash constant, *k*, of the bonnet is defined as the average force per unit distance crumpled.

If the car comes to a complete stop in 0.19 s, determine its crash constant, *k*.

k = ... N m^{-1} [2]

(iii) Explain whether the principle of conservation of momentum is applicable in this collision.

....

....

.... [1]

(b) Two identical cars A and B of mass 1000 kg are traveling with speeds of 10 m s^{-1} and 20 m s^{-1} respectively as shown in Fig. 2.2.

Fig. 2.2

(i) If both cars coalesce together after collision, calculate the final velocity of the cars.

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

(ii) Hence, calculate the corresponding loss in the total kinetic energy of both cars.

loss in total kinetic energy = ... J [2]

(iii) Explain which car experiences a larger force during the collision.

....

....

.... [2]

3 A Hot Wheels toy set consists of a toy car and a track forming a vertical circular loop of radius r. The toy car is launched from the bottom of the loop with a minimum speed v_{min} such that it just barely remains in contact with the track at the top.

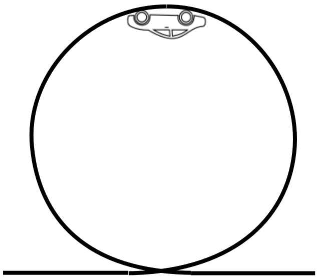


Fig. 3.1

(a) **(i)** On Fig. 3.1 above, draw a labelled arrow for each force exerted on the toy car at the top of the loop. [1]

(ii) Show that $v_{min} = \sqrt{5rg}$.

[3]

(b) In 2012, a scaled-up version of the toy was built to set a new world record as shown in Fig. 3.2. In this stunt, two race cars entered the bottom of the loop with a speed of 23.1 m s^{-1} and completed the loop successfully.

Fig. 3.2

(i) The actual radius of the loop used in the stunt was 10.0 m. Calculate the centripetal acceleration experienced by the cars at the bottom of the loop.

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

(ii) Hence, determine the force exerted by the car on the driver who has a mass of 75.0 kg at the bottom of the loop.

force = ... N [2]

For Examiner's Use

4 Fig 4.1 gives the schedule of Train P as it makes its stops on its route from Annecy to Faulkner and back.

Towns	**Arrive (hh:mm)**	**Depart (hh:mm)**	**Distance from Annecy (km)**
Annecy	–	07:10	–
Bloom	08:10	08:20	
Carhill	09:50	10:00	
Denison	12:20	12:30	340
Eagen	14:30	14:40	480
Faulkner	15:30	16:00	540
Eagen	16:50	17:00	480
Denison	18:40	18:50	340
Carhill	20:20	20:30	
Bloom	22:00	22:10	
Annecy	23:10	–	–

Fig 4.1

Fig 4.2 is a chart that allows the station master to track the position of Train P at any time during its operation.

(a) Fill in Fig 4.1 with the distances of Bloom and Carhill from Annecy. [2]

(b) Complete the line chart on Fig 4.2 for Train P's return journey. [3]

(c) Using Fig 4.2, determine the legs in Train P's entire route with the highest speed and lowest speed.

Highest speed: from .... to ....

Lowest speed: from .... to... [2]

(d) Explain what the answers to **(c)** suggest about the elevation of the towns in the legs stated.

....

....

.... [2]

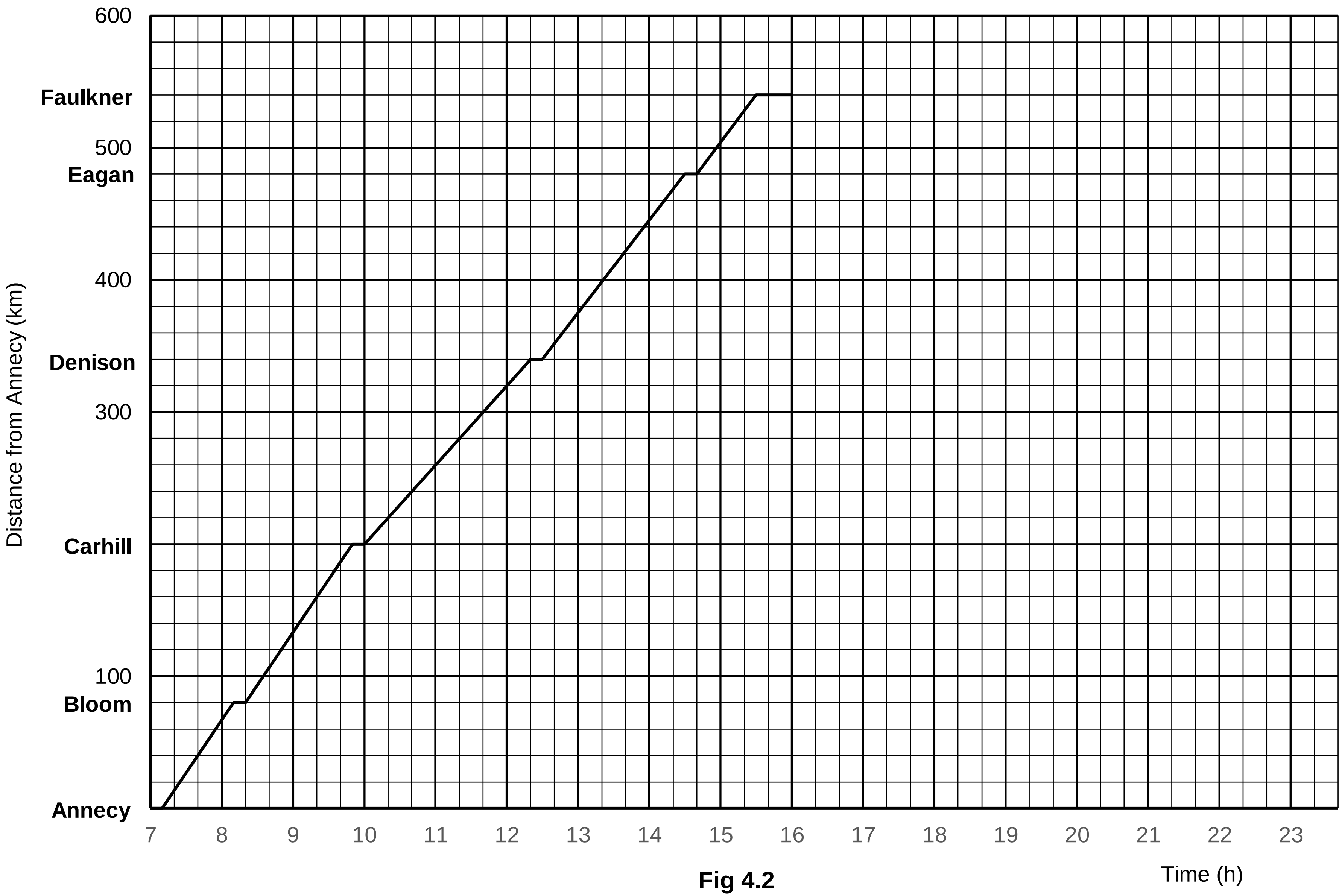

600
Faulkner
500
Eagan
400
Denison
300
Carhill
100
Bloom
Annecy
Distance from Annecy (km)
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Time (h)

Fig 4.2

(e) Calculate the average speed of Train P when travelling between Eagen and Faulkner.

average speed = ... km h^{-1} [2]

(f) The value in **(e)** for both directions of travel is lower than the average speed for the rest of the route. Suggest a reason for this.

....

....

.... [1]

(g) Train P, like many others, uses coal for fuel. Fig 4.3 shows how fuel efficiency for coal-fuelled trains has increased from 1980 to 2010. The average energy density of coal is 40 GJ per m^3.

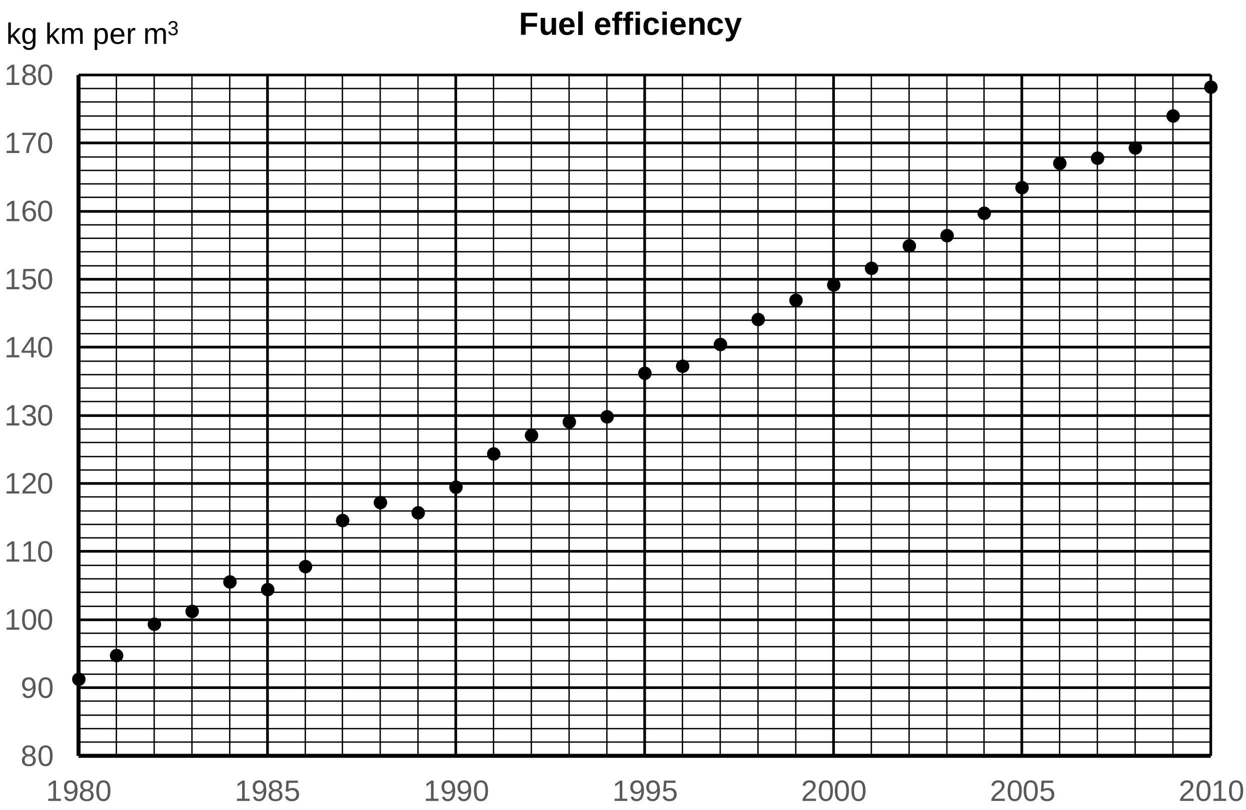


Fig 4.3

(i) Using the trend indicated in Fig 4.3, estimate the value of fuel efficiency in the year 2030 in kg km per m^3.

fuel efficiency = ... kg km per m^3 [3]

(ii) Using your answer in **(g)(i)**, estimate for the year 2030 the average amount of coal consumed per adult male in m^3 when he travels from Annecy to Faulkner. Present your reasoning clearly.

amount of coal = ... m^3 [1]

End of Paper

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

CANDIDATE NAME	

CLASS		TUTOR'S NAME	

PHYSICS

9749/03

Paper 3 Structured Questions

4 October 2017

2 hours 10 minutes

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	/8
2	/10
3	/8
4	/7
5	/9
6	/6
7	/20
8	/20
9	/12
Deductions	
Total	/80

This document consists of **22** printed pages.

For Examiner's Use

Section A

Answer ALL the questions in this section.

1 Trap-jaw ants are a species of ants with jaws that can open to 180° and snap shut in a few microseconds. In an experiment, researchers plotted the variation with time of the velocity of the ants' jaws in Fig. 1.1. Each line represents one of the ant's jaws.

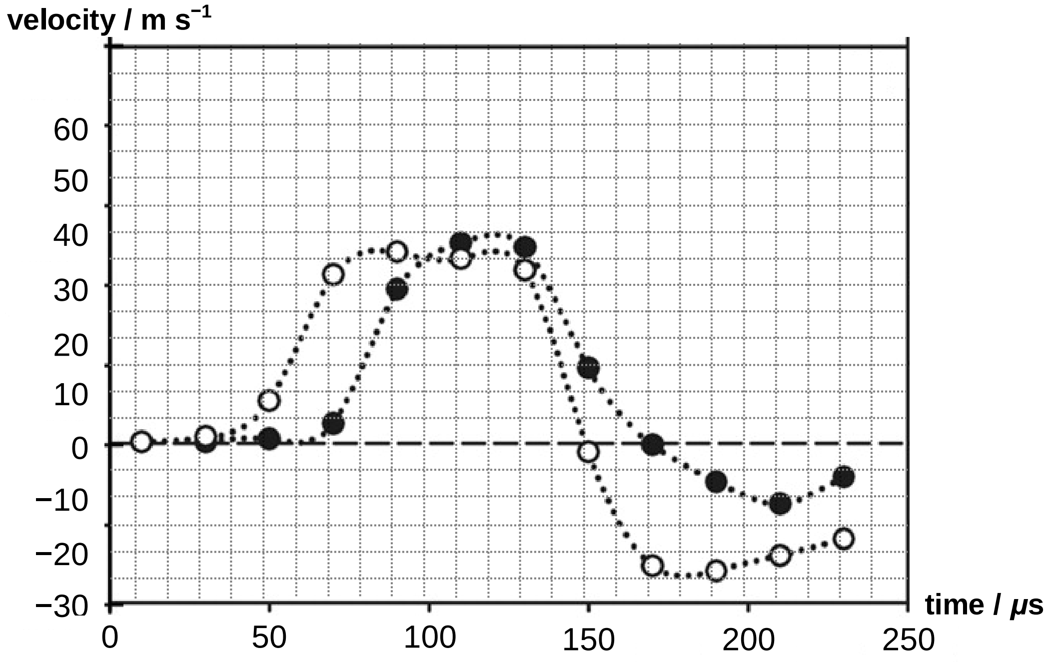


Fig. 1.1

(a) From the values in Fig. 1.1, estimate the maximum acceleration of the ant's jaws.

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

(b) The trap-jaw ant is able to project itself into the air by directing its open jaws downwards and closing them. By doing so, it is able to reach a height of 8.30 cm and cover a horizontal distance of 3.10 cm when it returns to the ground. Effects of air resistance are negligible.

(i) Determine the vertical component of the ant's initial velocity.

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

(ii) Hence or otherwise, determine the magnitude and direction of the ant's initial velocity.

magnitude of velocity = ... m s^{-1}

direction = ... [3]

(c) On the axes below, sketch the speed-time graph of the ant's trajectory, from the moment it leaves the ground to the moment it touches the ground again. Include appropriate values on the axes.

[2]

For Examiner's Use

2 **(a)** **(i)** *The gravitational field strength on the surface of Mars is 3.7 N kg^{-1}.* Explain what this statement means.

....

....

.... [1]

(ii) A satellite is orbiting about Mars. The satellite is constantly attracted towards Mars by gravitational attraction. Explain why the satellite does not fall towards Mars.

....

.... [1]

(iii) The mean radius of Mars is 3.4×10^6 m and the orbital period of the satellite is 24.6 hours. Using information from **(a)(i)**, determine the height of the satellite above Mars' surface.

height = ... m [3]

(b) Fig 2.1 shows the variation with distance r from the centre of Mars of the gravitational field, g, due to Mars.

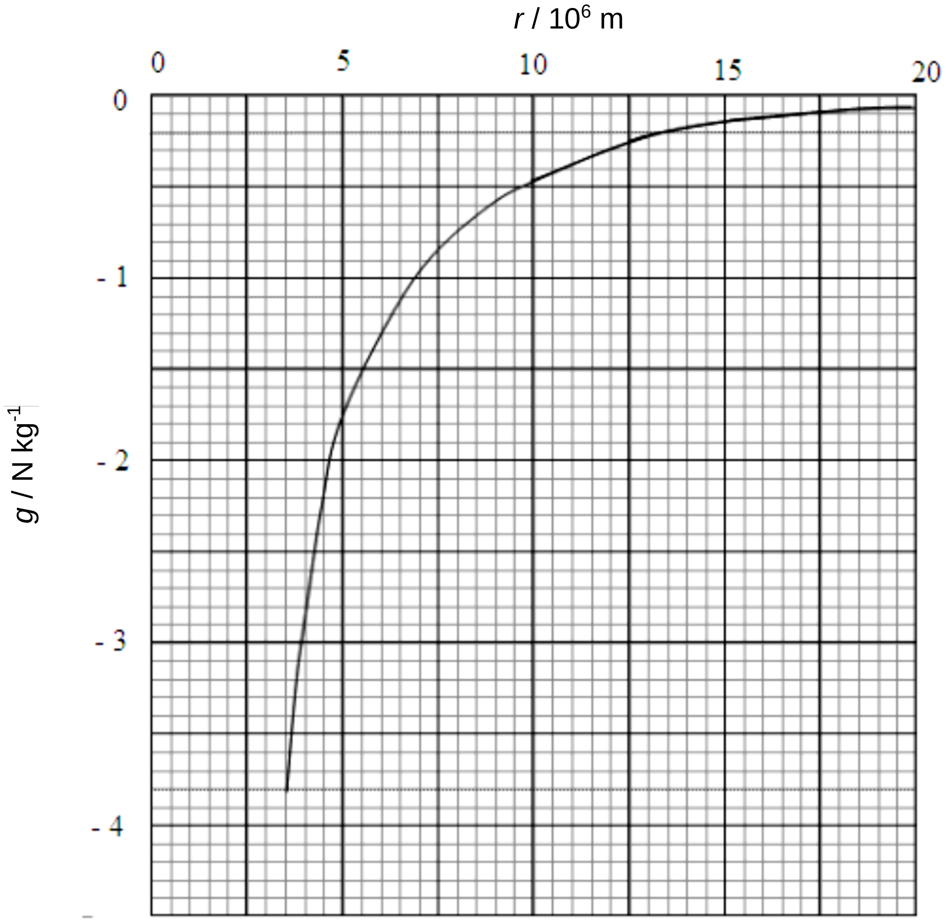


Fig 2.1

(i) Use Fig. 2.1 to estimate the energy required for a mass of 1.0 kg to escape from the gravitational field of Mars, starting at the planet's surface.

energy required = ... J [2]

(ii) Hence calculate the escape speed for the 1.0 kg mass.

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

(iii) State and explain whether your answer to **(b)(ii)** will be different for a 100 kg instead of a 1 kg mass.

....

.... [1]

3 **(a)** **(i)** State the *First Law of Thermodynamics*.

....

....

.... [1]

(ii) Explain the meaning of the term *internal energy*.

....

.... [1]

(b) The diesel cycle is the thermodynamic cycle which approximates the pressure and volume of the combustion chamber of the diesel engine, invented by Rudolph Diesel in 1897.

An ideal gas undergoes the diesel cycle which comprises four processes:
Process A - compressing the gas in a very short time
Process B - heating the gas at constant pressure
Process C - expanding the gas in a very short time
Process D - cooling the gas at constant volume

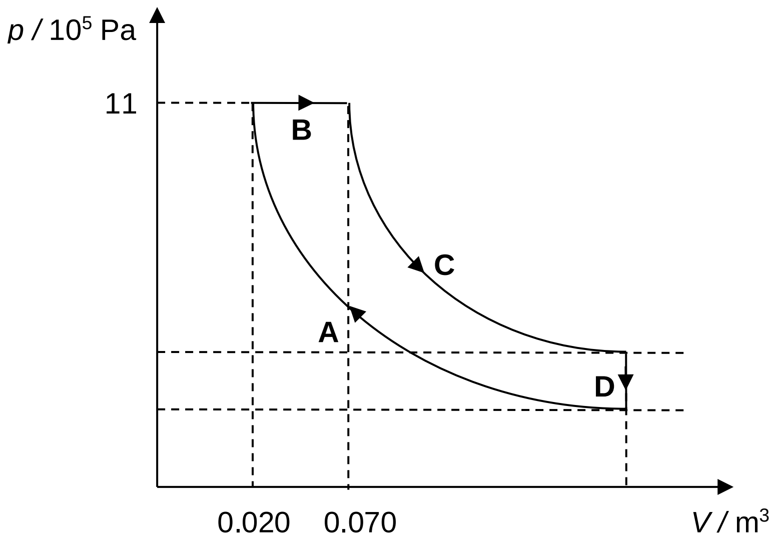


Fig. 3.1

For Examiner's Use

(i) Calculate the work done by the gas during process B.

work done by gas = ... J [2]

(ii) Table 3.1 is a table of energy changes during one cycle. Complete the table with appropriate values. [4]

Process	work done on gas, ***W*** / kJ	heat supplied to gas, ***Q*** / kJ	increase in internal energy, ***ΔU*** / kJ
A	+ 201		
B		+ 74	
C	- 185		
D		- 35	

Table 3.1

For Examiner's Use

4 **(a)** Distinguish between longitudinal and transverse waves.

....

....

....

.... [2]

(b) State a phenomenon associated with transverse waves but is not observed with longitudinal waves.

.... [1]

(c) Three polarisers P, Q and R are placed such that the polarising directions of P and R are perpendicular as shown in Fig. 4.1. The polariser Q is rotated about the common axis with an angular velocity ω.

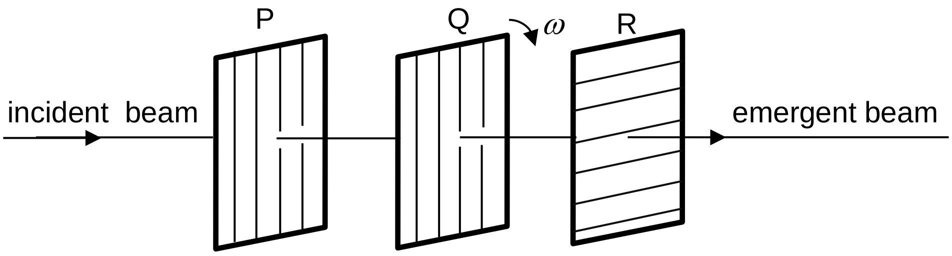


Fig. 4.1

(i) Express the angular displacement θ of polariser Q in terms of ω and time of rotation, t.

[1]

(ii) The incident light on polariser P is unpolarised and has intensity I_0. Derive an expression for the intensity of the beam emerging from polariser R in terms of I_0, ω and t.

[3]

5 A crane is used to lift a 1000 kg cement block as shown in Fig 5.1. The total mass of the crane is 5000 kg and its centre of gravity is at G.

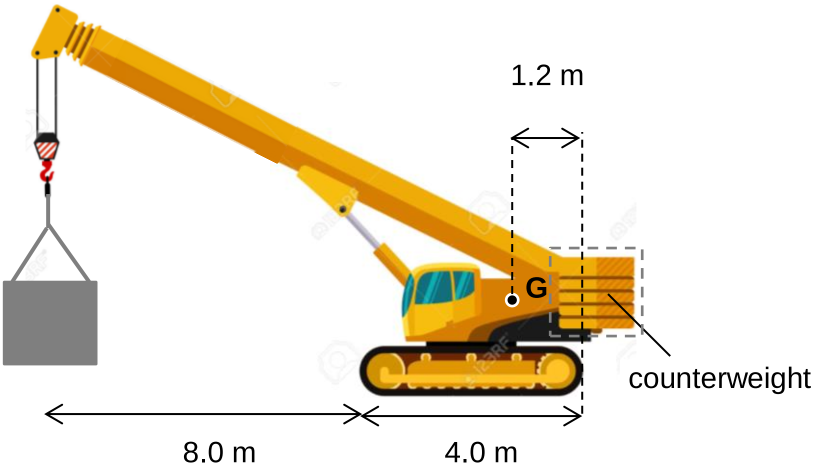


Fig 5.1

(a) Draw labelled arrows on Fig 5.1 to show all the forces acting on the crane. Pay attention to the position of these forces. [2]

(b) Calculate the magnitude of the force exerted by the ground and its perpendicular distance from G.

magnitude of force = ... N

perpendicular distance = ... m [3]

(c) Calculate the maximum load the crane can lift without tipping over.

maximum load = ... kg [2]

(d) The crane has a heavy counterweight right at the rear end. Explain its purpose and why it is at the rear end of the crane.

....

....

.... [2]

6 A projectile is fired from the ground at an angle 35° above the horizontal with speed 23 m s^{-1} as shown in Fig. 6.1. At the top of the trajectory, the projectile splits into two fragments of masses *m* and 2*m*, and they separate in opposite directions.

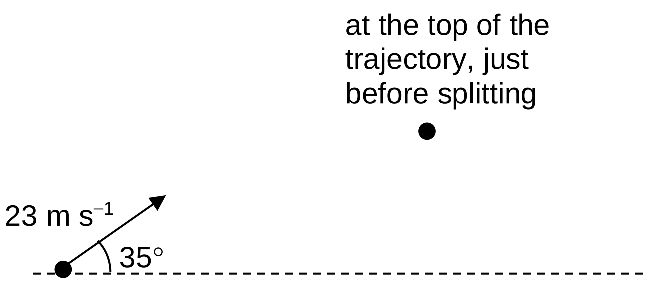


Fig. 6.1

(a) Calculate the speed of the projectile just before splitting.

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

(b) Given that the fragment of mass *m* returns to the point of projection, prove that the speed of the fragment of mass 2*m* after splitting is 37.7 m s^{-1}.

[2]

For Examiner's Use

(c) Calculate the distance between the two fragments upon landing on the ground.

distance = ... m [3]

Section B

*Answer **ONE** question from this section.*

7 **(a)** Fig. 7.1 shows the force-extension graph of a light spring.

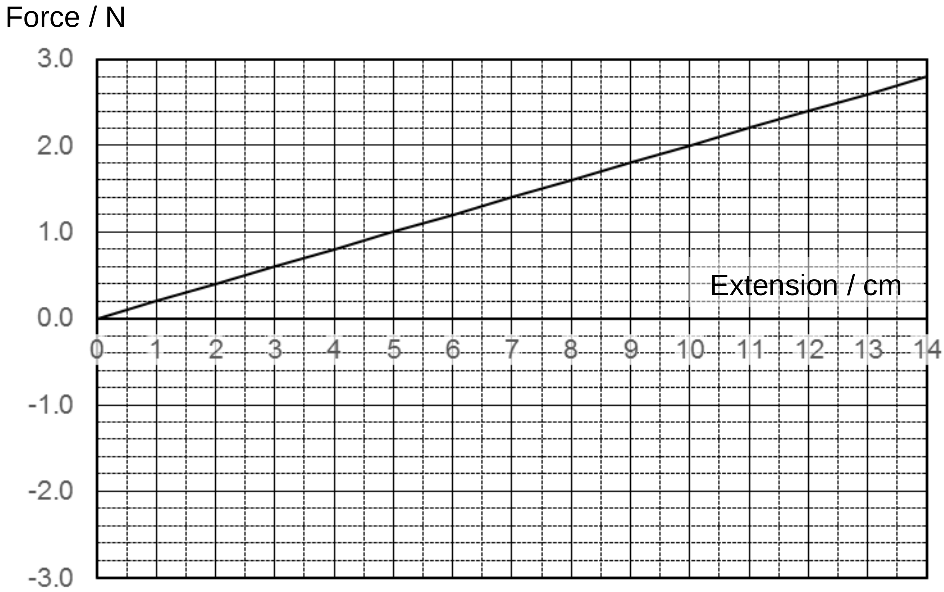


Fig. 7.1

A 0.200 kg mass is freely suspended from a fixed point O using the spring, as shown in Fig. 7.2.

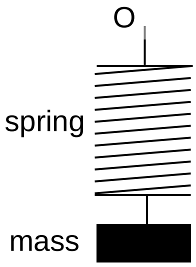


Fig. 7.2

(i) On Fig. 7.1, draw the graph to show the variation of the resultant force on the mass with extension of the spring when there are no forces acting on it other than its weight and that exerted by the spring. [2]

(ii) The mass is initially held with the spring extended by 12.0 cm and then released. Explain how your graph in **(i)** shows that the subsequent motion of the mass is simple harmonic.

....

....

.... [2]

For Examiner's Use

(iii) By finding the gradient of the graph, show that the natural frequency of the mass-spring oscillator is 1.6 Hz.

[3]

(iv) Calculate the maximum speed of the mass and the extension of the spring when this speed is attained.

maximum speed = ... m s^{-1}

extension of spring = ... m [3]

(b) The mass-spring oscillator in **(a)** is now vertically oscillated using a mechanical vibrator of variable frequency. The amplitude of the oscillator varies with the frequency of the vibrator as shown in Fig. 7.3.

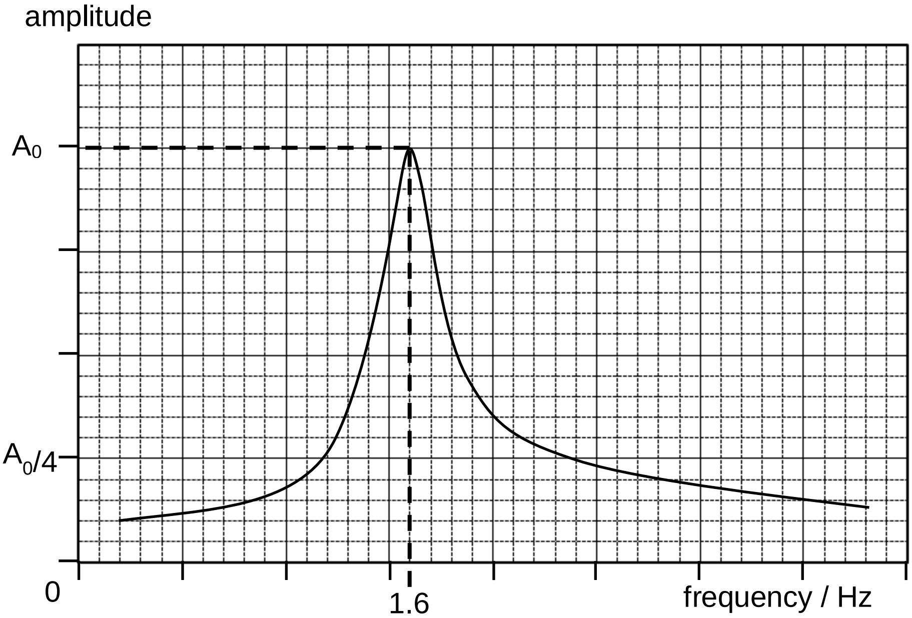


Fig. 7.3

For Examiner's Use

(i) The amplitude is very large within a very narrow range of frequencies. Explain why this is so.

....

....

.... [2]

(ii) The amplitude of the oscillator at 1.6 Hz can be decreased to ¼ of its original value by increasing the degree of damping. Draw another frequency response graph on Fig. 7.3 to show this. Label this graph D. [2]

(iii) Suggest how the effect in **(b)(ii)** can be achieved in practice for a mass-spring oscillator.

....

....

.... [1]

(iv) The amplitude of the oscillator at 1.6 Hz can also be decreased to ¼ of its original value by modifying the natural frequency of the oscillator. Draw another frequency response graph on Fig. 7.3 to show this. Label this graph N. [2]

(v) Suggest how the effect in **(b)(iv)** can be achieved in practice for a mass-spring oscillator.

....

....

.... [1]

(c) Describe an example in which resonance is desirable.

....

....

.... [2]

8 A ball of mass 2.0 kg is released from point A on a **rough** curved plane. It moves through a vertical height of 80 m and a distance *d* along the curved plane until it reaches point B with a speed of 3.6 m s^{-1}.

From point B it slides down a **smooth** straight plane inclined at angle of 30° and distance 0.500 m before it hits the spring at point C. The ball compresses the spring and comes to a stop at point D. The spring has a spring constant of 1500 N m^{-1}.

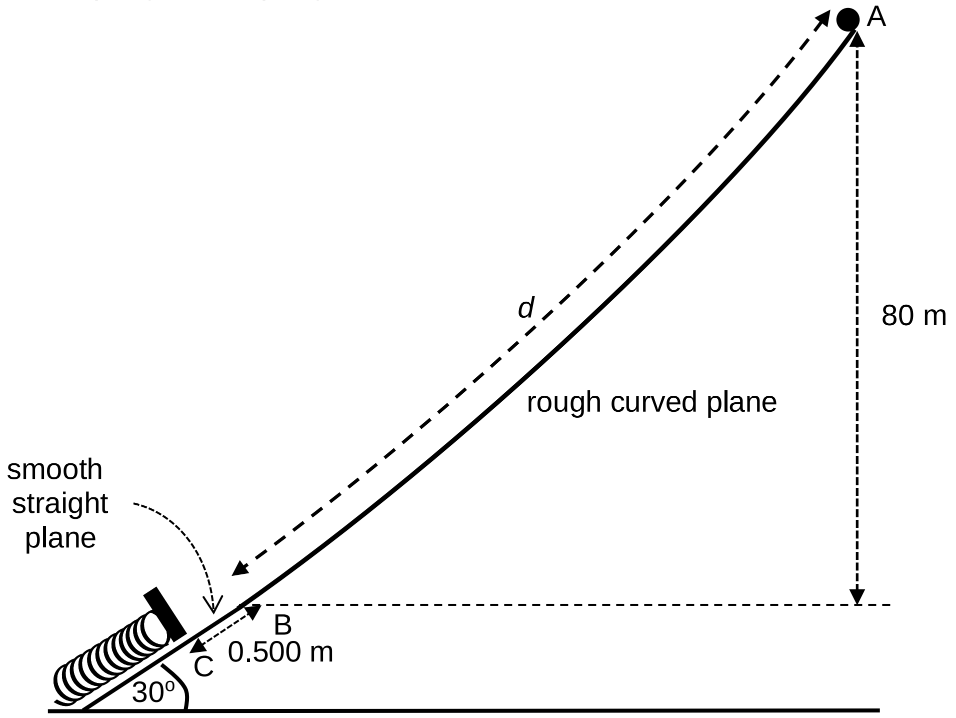


Fig. 8.1

(a) **(i)** On Fig. 8.1, draw an arrow labeled as *P* to show the total contact force of the curved plane on the ball at point A. [1]

(ii) Explain why the work done on the ball by *P* as it moves from A to B is not *P* x *d*.

....

....

.... [2]

(b) Calculate the work done by friction force along the curved plane AB.

work done = ... J [2]

(c) Given that the ball has a specific heat capacity of 380 J kg^{-1} K^{-1}, calculate the increase in the temperature of the ball at point B. State an assumption made in your calculation.

Assumption:

....

....

increase in temperature = ... ^{o}C [3]

(d) (i) Given that *e* is the maximum compression of the spring, write down an expression, in terms of *e*, for the loss of height of the ball from point B until it comes to rest at point D.

[1]

(ii) Use energy considerations show that the value of *e* is 0.16 m.

[3]

(e) **(i)** Taking the gravitational potential energy at point D to be zero, fill in Table 8.2 with the values of kinetic energy E_k, gravitational potential energy E_G, elastic potential energy E_P, and total energy E_T of the ball at points B, C and D. [3]

	Kinetic energy E_k	**Gravitational potential energy E_G**	**Elastic potential energy E_P**	**Total energy E_T**
Point B			0	
Point C			0	
Point D	0	0		

Table 8.2

(ii) On the Fig. 8.3, sketch labeled graphs to show the variation with distance along the line BCD of

1. the kinetic energy E_k,
2. the gravitational potential energy E_G,
3. the elastic potential energy E_P, and
4. total energy E_T of the ball.

[4]

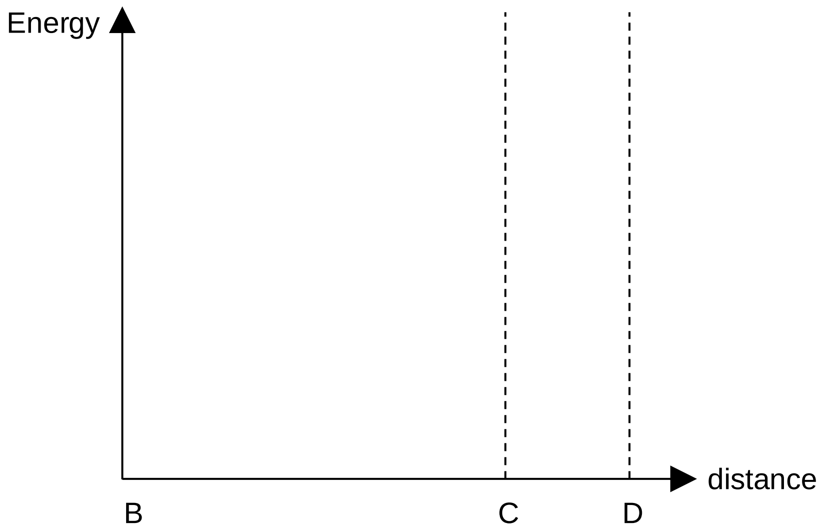


Fig 8.3

(f) "*Due to conservation of energy, the conversion of energies is reversible. If the spring is compressed at point D by the same amount as stated in* ***(d)(ii)*** *and released, the ball can be projected up the plane to reach point A.*"

Explain whether you agree with the above statement.

....

....

.... [1]

Section C

Answer the question from this section.

9 A student wishes to determine the Young modulus E of wood from the period of oscillation of a loaded wooden rule, as shown in Fig. 9.1.

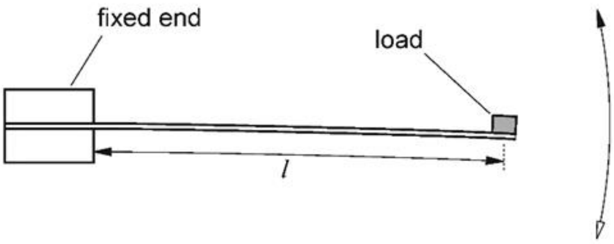


Fig 9.1

An equation relating the period of oscillation T to the overhanging length l of the rule is

$$T^2 = \frac{k\,l^3}{E}$$

The constant k is given by

$$k = \frac{16\pi^2 M}{w\,d^3}$$

where M is the mass of the load, w is the width of the rule and d is the thickness of the rule.

Design a laboratory experiment to determine the Young modulus of wood. You should draw a diagram showing the arrangement of your equipment. In your account, you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) how to analyse the data,

(e) how to determine E,

(f) the safety precautions to be taken.

[12]

For Examiner's Use

Diagram

For Examiner's Use

.... [12]

End of Paper

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

PHYSICS

9749/01

Paper 1 Multiple Choice

5 October 2016

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 **14** printed pages.

[Turn over

1 A student performs a simple experiment to determine the value of an unknown quantity *X*.

It is known that *X* is affected by the acceleration of the body in the experiment.

X is found to be = –2.45 N.

Which of the following provides evidence that *X* is a vector quantity?

A The negative sign in *X* only.

B The unit of *X* only.

C *X* is affected by acceleration which is a vector quantity.

D Both the negative sign in *X* and the unit of *X*.

2 A flat head drill bit is used to drill holes of a small depth. The drill bit can drill holes with a diameter of (40.0 ± 0.5) mm. The depth of the hole has an uncertainty of ±1 mm.

If the percentage uncertainty of the volume of the hole is less than 10%, what is the minimum depth, in mm, which the drill bit can make?

A 15 **B** 14 **C** 13 **D** 12

3 An artillery gun sited at the top of a cliff fires a shell horizontally so as to hit a target 2.0 km horizontally away from the bottom of the cliff.

If the cliff is 180 m high, the initial velocity of the shell is

A 54 m s^{-1} **B** 99 m s^{-1} **C** 110 m s^{-1} **D** 330 m s^{-1}

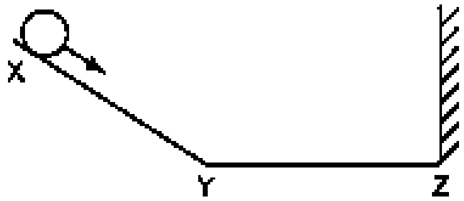
4 In order that a train can stop safely, it passes a signal showing a yellow light before it reaches another signal showing a red light. The train driver applies the brake at the yellow light and this results in a uniform deceleration, and the train stops exactly at the red light.

The distance between the red and yellow lights is *x*.

What must the minimum distance between the lights be, without changing the deceleration of the train, if the train speed is increased by 20 %?

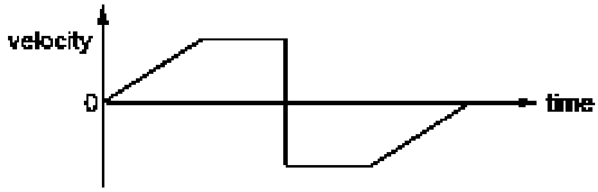
A 1.20*x* **B** 1.25*x* **C** 1.44*x* **D** 1.56*x*

5 A ball is released from rest on a smooth slope XY.
It moves down the slope, along a smooth horizontal surface YZ and rebounds inelastically at Z. Then it moves back to Y and comes to rest momentarily somewhere on XY.

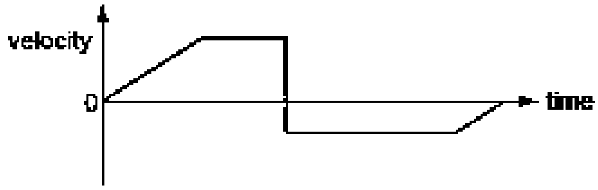


Which velocity-time graph represents the motion of the ball?

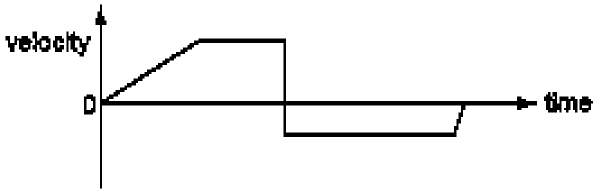
A



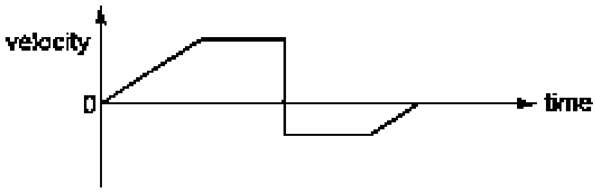
B



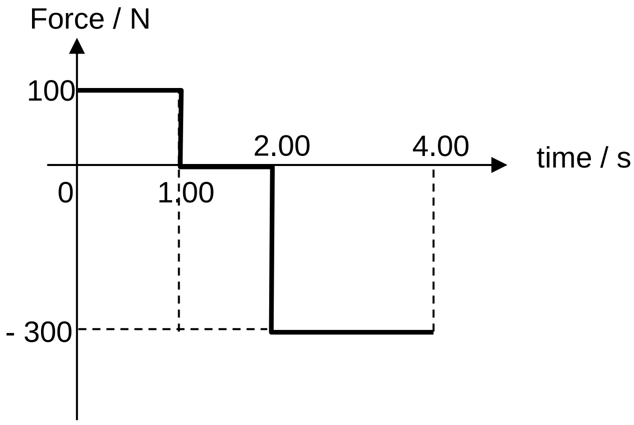
C



D



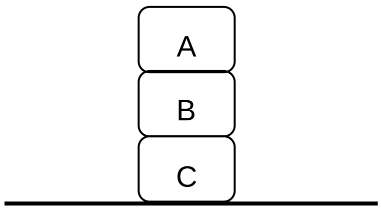
6 An object, initially moving with a velocity 92.0 m s^{-1}, experiences a force which varies with time as shown below.



If the object has a mass of 8.50 kg, what is the final velocity of the object after 4.00 s?

A 174 m s^{-1} **B** 163 m s^{-1} **C** 33.2 m s^{-1} **D** -151 m s^{-1}

7 Three objects A, B and C are stacked on top of one another on the ground.



Which of the following statements is correct?

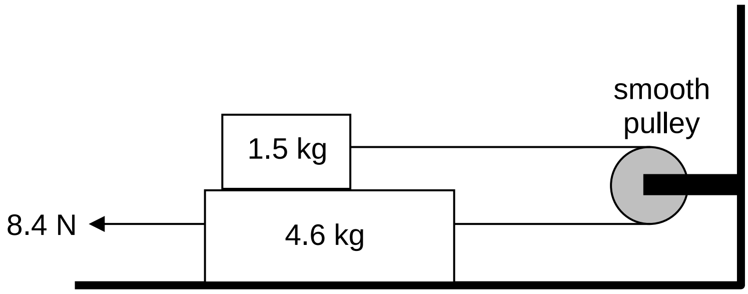
A The force exerted by object B on object C is equal to the weight of object B.

B The force exerted by object C on object B is greater than the force exerted by object A on object B.

C The weight of object A and the force exerted by object B on object A are an action-reaction pair of forces.

D The normal contact force exerted by the ground on object C is equal to the weight of object C.

8 The diagram below shows 2 blocks connected together via a light inextensible string over a smooth pulley. The top block has a mass of 1.5 kg and the mass of the bottom block is 4.6 kg. The bottom block is pulled with a force of 8.4 N. Assume that all surfaces (except the pulley) exert a constant frictional force of 1.8 N.



What is the initial acceleration of the 1.5 kg block?

A 0.49 m s^{-2} **B** 0.79 m s^{-2} **C** 1.1 m s^{-2} **D** 1.4 m s^{-2}

9 An object, made from two equal masses joined by a light rod, falls with uniform speed through air. The rod remains horizontal.

Which of the following statements is true?

A It is not in equilibrium because it is falling steadily.

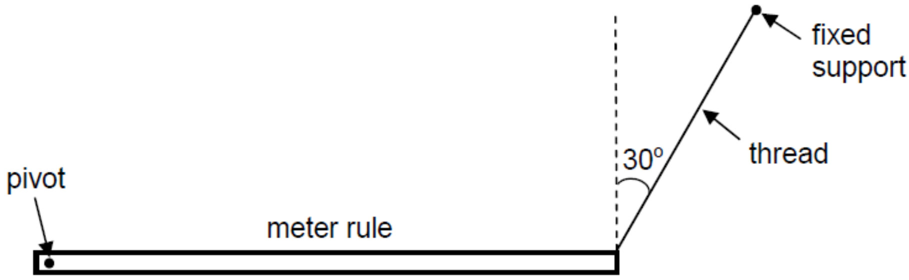
B It is not in equilibrium because it is in motion.

C It is not in equilibrium because there is a resultant torque.

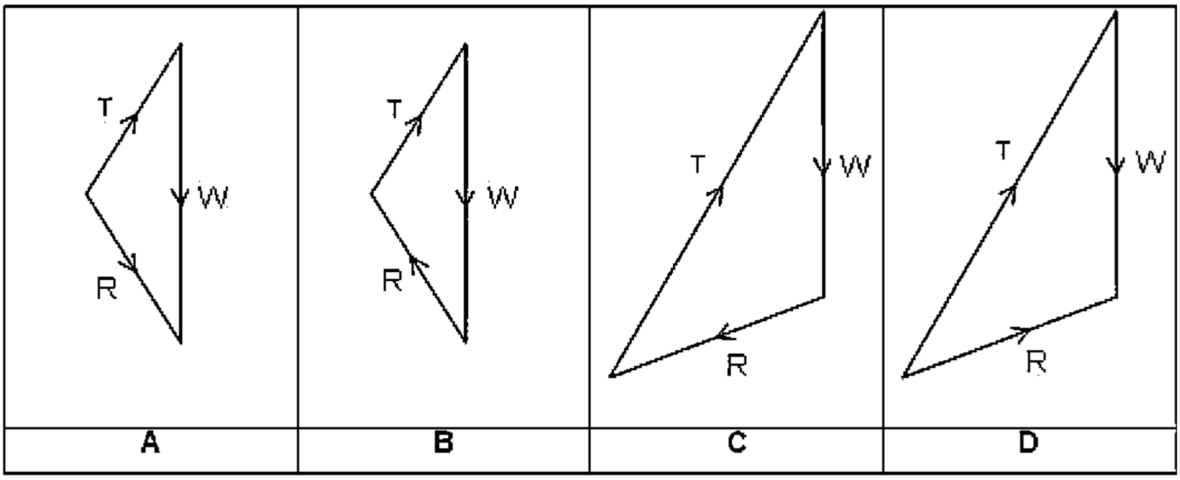
D It is in equilibrium because there is no resultant force and no resultant torque.

10 A pivoted metre rule is supported in equilibrium horizontally by a thread inclined at 30^o to the vertical.

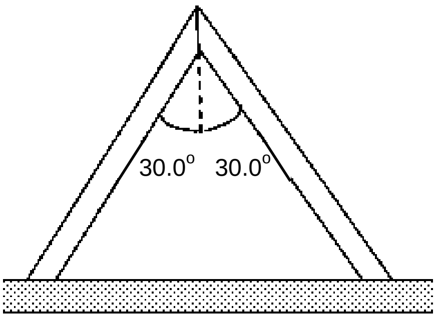
The three forces acting on the rule are its weight W, the tension T in the thread, and the reaction force R at the pivot.



Which of these diagrams, drawn to scale, represents the magnitudes and directions of these three forces?



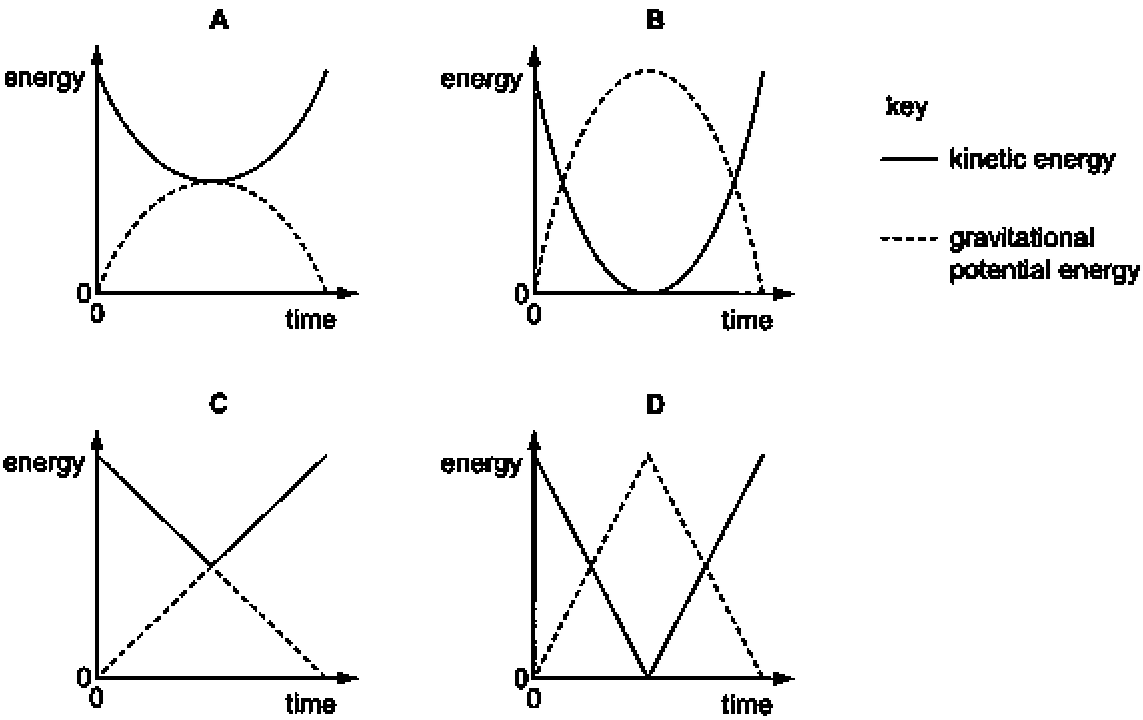
11 The diagram below shows an inverted "V" made of two uniform boards. Each board weighs 200 N.



Each side has the same length and makes a 30° angle with the vertical. Assuming that the frictional force at the point of contact between the two boards is negligible, the magnitude of the static frictional force that acts on the lower end of each leg of the inverted "V" is

A 58 N **B** 115 N **C** 225 N **D** 346 N

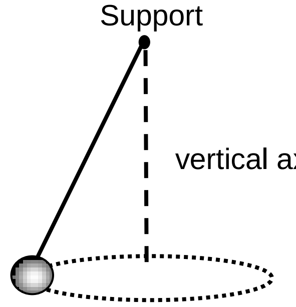
12 A goalkeeper kicks a football so that it leaves the pitch at an angle of 45º to the horizontal. Which graph below represents the variation of kinetic energy and gravitational potential energy of the football during the time of flight? Assume that air resistance can be ignored.



13 A car of mass m has an engine which can deliver power P. What is the minimum time in which the car can be accelerated from rest to a speed v?

A $\dfrac{P}{mv}$ **B** $\dfrac{2P}{mv^2}$ **C** $\dfrac{mv^2}{P}$ **D** $\dfrac{mv^2}{2P}$

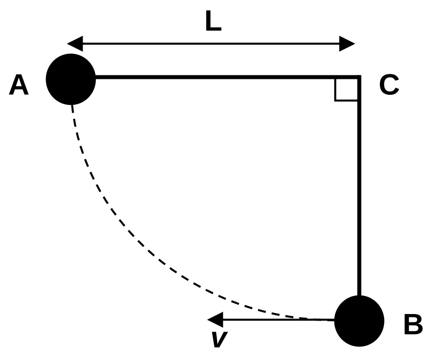
14 A pendulum is swung in such a way that it performs uniform circular motion along the horizontal plane as shown.



Which of the following statements about the motion is correct?

A The momentum of the bob is conserved because there is no net force acting on it.
B The bob is in equilibrium because the tension in the string balances its weight.
C The kinetic energy of the bob is constant because no work is done on it.
D The acceleration is constant because the tension is constant.

15 A simple pendulum consists of a bob of mass m at the end of a light and inextensible thread of length L. The other end of the thread is fixed at C. The bob swings upwards in a vertical plane through point B with velocity v such that it is just able to reach A.

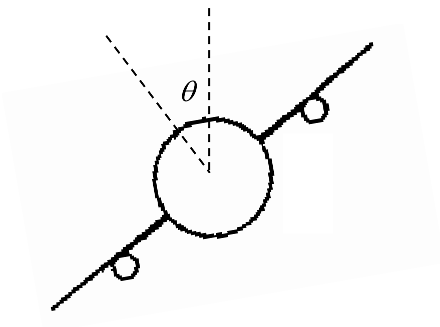


What is the tension in the thread as the bob passes point B?

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

16 When the aircraft Concorde is moving in a horizontal plane at a constant speed of 650 m s^{-1}, its turning circle has a radius of 80 km.

When making a turn to the left, what should be the angle of tilt θ, from the vertical, as shown in the diagram below?



A 28^o **B** 33^o **C** 40^o **D** 62^o

17 The acceleration due to gravity on the surface of a planet of radius r is g. A satellite is revolving at the altitude $2r$ above the surface of the planet. The orbital period of the satellite can be expressed as

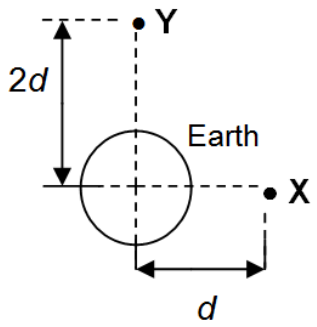
A $2\pi\sqrt{\frac{r}{g}}$ **B** $2\pi\sqrt{\frac{3r}{g}}$ **C** $2\pi\sqrt{\frac{9r}{g}}$ **D** $2\pi\sqrt{\frac{27r}{g}}$

18 A satellite of mass 1 kg is moved from an orbit where the gravitational potential is -80 MJ kg^{-1} to another orbit where the gravitational potential is -40 MJ kg^{-1}.

What is the increase in its total energy?

A –40 MJ **B** –20 MJ **C** 20 MJ **D** 40 MJ

19 X and Y are two points above the Earth's surface and at distances of d and $2d$ respectively from the centre of the Earth as shown below.



The gravitational potential at Y is -400 kJ kg^{-1}. When a 2.00 kg mass is taken from Y to X, the work done on the mass by the external force is

A –800 kJ **B** –400 kJ **C** 400 kJ **D** 800 kJ

20 A mass attached to the lower end of a vertical spring performs simple harmonic motion.

Which of the following statements is correct?

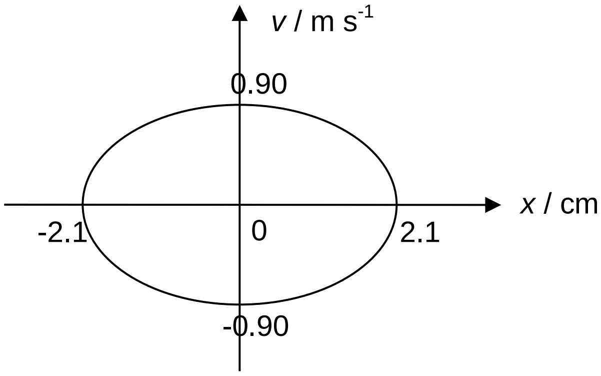
A When the kinetic energy of the oscillator is equal to its potential energy, the oscillator is neither at the rest position nor at its maximum displacement position.

B The kinetic energy of the oscillator is a maximum when the tension in the spring is a maximum.

C The velocity of the mass is zero when its acceleration is zero.

D The acceleration of the mass is a maximum when it passes through the centre of its oscillation.

21 The figure below shows how the velocity v of a simple harmonic oscillator varies with its displacement x.



What is the frequency of the oscillation?

A 0.0030 Hz **B** 0.30 Hz **C** 6.8 Hz **D** 43 Hz

22 How does damping help lessen damage caused to buildings during an earthquake?

A It reduces the resonant frequency of the building.

B It reduces the amplitude of oscillation of the building.

C It reflects the energy from the earthquake back into the Earth's crust.

D It changes the frequency of the earthquake such it is not equal to that of the building's frequency.

23 There is one temperature, about 0.01 ^{0}C, at which water, water vapour and ice can co-exist in equilibrium.

Which statement about the properties of the molecules at this temperature is correct?

A Ice molecules have more microscopic potential energy than the water molecules.

B The mean kinetic energy of the water molecules is greater than the mean kinetic energy of the ice molecules.

C Water vapour molecules are less massive than water molecules.

D Water vapour molecules have the same mean square speed as ice molecules and water molecules.

24 Which of the following is not an assumption of the kinetic theory of gases?

A The volume of each particle is negligible compared to the volume of the gas.

B The mean kinetic energy of a particle is proportional to its thermodynamic temperature.

C No energy is lost when the particles collide with the walls of the container.

D The particles exert negligible forces of attraction and repulsion on each other.

25 A partially inflated and sealed balloon is placed inside a bell jar. The jar is then evacuated (air is taken out of the jar but not the balloon) with no change in temperature.

Which of the following statements is correct?

A The volume of the balloon decreases.

B The pressure inside the balloon increases.

C The air particles inside the balloon make less collisions per unit time with the walls of the balloon.

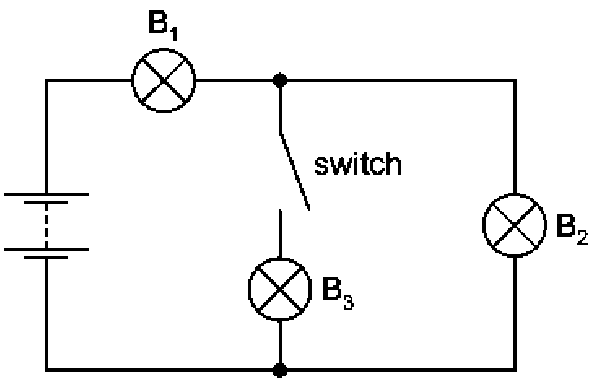
D The air particles inside the balloon move faster.

26 A long piece of wire has a resistance of 2.0 Ω. It is cut into 40 equal lengths and these are connected in parallel to form a multi-stranded cable.

What is the resistance of the cable?

A $1.3 \times 10^{-3}\ \Omega$ **B** $0.05\ \Omega$ **C** $80\ \Omega$ **D** $3.2 \times 10^{3}\ \Omega$

27 B_1, B_2 and B_3 are three identical lamps. They are connected to a battery with zero internal resistance as shown.

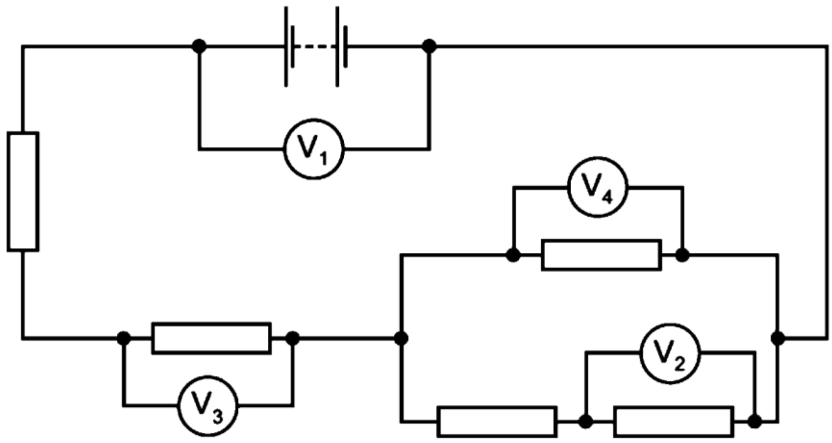


Initially the switch is closed. The switch is then opened and lamp B_3 goes out.

What happens to the brightness of lamps B_1 and B_2 when the switch is opened?

	brightness of lamp B_1	brightness of lamp B_2
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

28 In the circuit shown, all the resistors are identical.



The reading on voltmeter V_1 is 8.0 V and the reading on voltmeter V_2 is 1.0 V.

What are the readings on the other voltmeters?

	reading on voltmeter V_3 / V	reading on voltmeter V_4 / V
A	1.5	1.0
B	3.0	2.0
C	4.5	3.0
D	6.0	4.0

29 A mechanical wave of frequency 300 Hz travels along a railway line at 6 km s^{-1}. Two points on the railway line which are 250 cm apart are out of phase by

A 0 rad **B** π / 4 rad **C** π / 2 rad **D** π rad

30 A plane wave of amplitude *A* is incident on a surface area *S* placed so that it is perpendicular to the direction of travel of the wave. The energy per unit time intercepted by the surface is *E*.

The amplitude of the wave is reduced to 0.5 *A* and the area of the surface is increased to 2*S*. How much energy per unit time is intercepted by this surface?

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

H

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

CANDIDATE NAME

CLASS

TUTOR'S NAME

PHYSICS

9749/02

Paper 2 Short Structured Questions

5 October 2016

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	
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3	
4	
5	
Total	

This document consists of **11** printed pages.

[Turn over

For Examiner's Use

1 The rate of flow of thermal energy $\frac{Q}{t}$ in a material is given by

$$\frac{Q}{t} = \frac{CA(\Delta T)}{x}$$

where A is the cross-sectional area of the material,
x is the thickness of the material,
ΔT is the temperature difference across the thickness of the material, and
C is a constant.

(a) Determine the base units of C.

base units = ... [2]

(b) An experiment is conducted to determine the value of C. The rate of flow of thermal energy $\frac{Q}{t}$ is found for different values of x, for the same conductor, same A and same ΔT.

The graph of $\frac{Q}{t}$ is plotted against $\frac{1}{x}$ as shown in Fig. 1.1.

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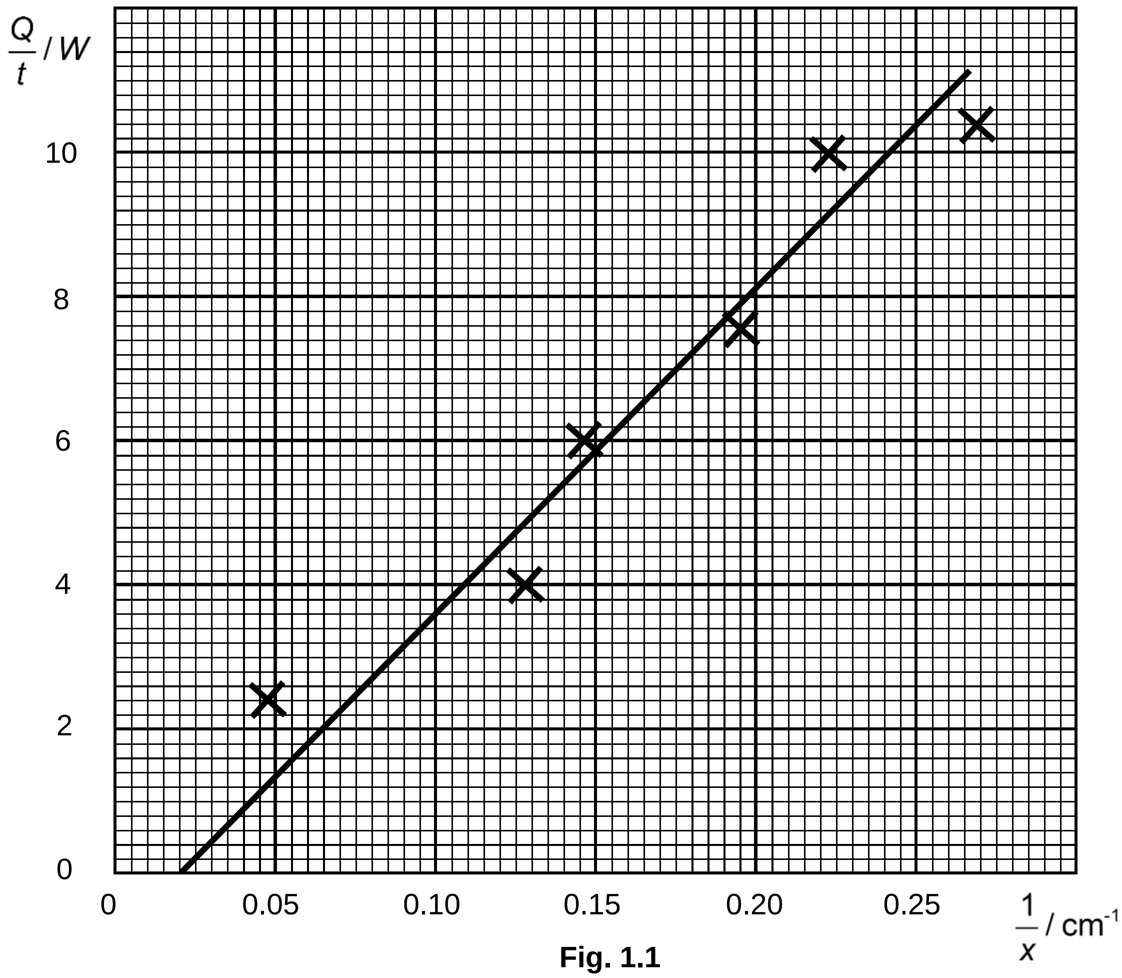

Fig. 1.1

(i) State the feature of the graph that indicates the presence of random error in the experiment.

....

.... [1]

(ii) With reference to Fig 1.1, state and explain whether the accuracy of *C* is affected by the presence of systematic error in the experiment.

....

....

....

.... [2]

(iii) Different types of materials are known to have different values of *C*. Suggest one possible factor that could affect the value of *C*.

....

.... [1]

For Examiner's Use

2 **(a)** Define linear momentum.

....

.... [1]

(b) Fig. 2.1 shows an airboat of mass 420 kg which is propelled forward by a propeller generating a column of air backward.

Fig. 2.1

(i) By using Newton's laws, show that the forward thrust acting on the airboat is given by

$$F = \pi r^2 \rho v^2$$

where ρ is the density of air, r is the effective radius of propeller and v is the speed of the air moving backward. [3]

(ii) Calculate the initial acceleration of the airboat when r = 0.70 m, v = 20 m s^{-1} and ρ = 1.2 kg m^{-3}.

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

(iii) By considering the airboat and the air generated as a system, explain why the total momentum of this system is not conserved when the airboat is moving at a constant speed.

....

....

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....

....[2]

3 **(a)** Define the *moment* of a force.

....

.... [2]

(b) State the two conditions necessary for a body to be in static equilibrium.

1. ....

....

2. ....

.... [2]

(c) A torque wrench is a type of spanner for tightening a nut and bolt to a particular torque, as illustrated in Fig. 3.1.

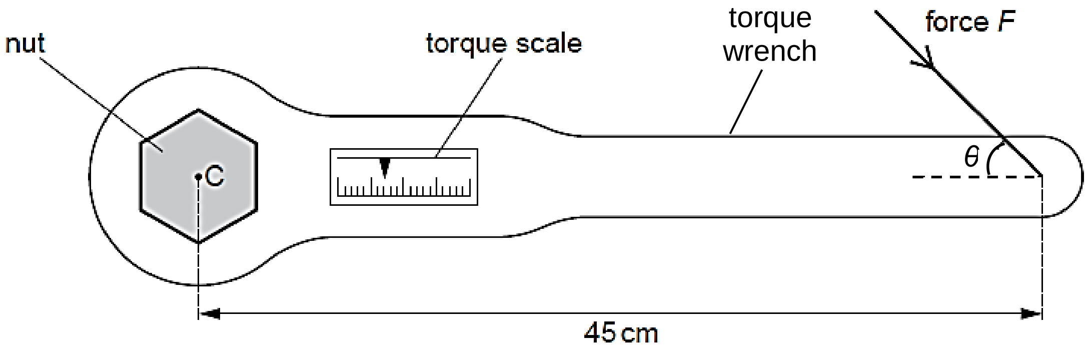

Fig. 3.1

The wrench is put on the nut and a force is applied to the handle. A scale indicates the torque applied.

The wheel nuts on a particular car must be tightened to a torque of 130 N m. This is achieved by applying a force F to the wrench at a distance of 45 cm from its centre of rotation C. This force F may be applied at any angle θ to the axis of the handle, as shown in Fig. 3.1.

For the minimum value of F required to achieve this torque,

(i) state the value of the angle θ that should be used, and explain your reasoning.

θ = ... ° [1]

Reasoning:

....

....

.... [1]

(ii) Calculate the magnitude of F.

F = ... N [2]

4 (a) Define *gravitational field strength*.

....

....

.... [1]

(b) **(i)** Show that a body projected from Earth (assumed to be stationary) with a speed v equal to or greater than $\sqrt{\frac{2GM_E}{R_E}}$ will never return to Earth.

It is given that M_E = mass of Earth and R_E = radius of Earth. [1]

(ii) Fig. 4.1 gives the values of the radius R and mass M of the Earth and Sun.

	***R* / m**	***M* / kg**
Earth	6.0×10^{6}	6.0×10^{24}
Sun	7.0×10^{8}	2.0×10^{30}

Fig. 4.1

The speed v mentioned in **(b)(i)** is known as the escape speed from Earth. Given that the escape speed from Earth is 1.1×10^{4} m s^{-1}, determine the escape speed from Sun.

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

(c) Two stars of mass M and $2M$, a distance of $3R$ apart, rotate in circles about their common centre of mass O, as shown in Fig. 4.2.

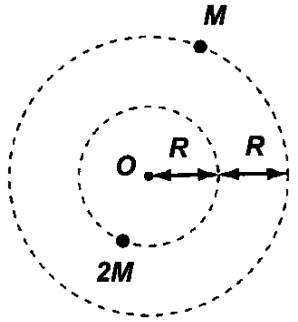

Fig. 4.2

The period of this binary star system is 3.42×10^{5} s. The value of M is 3.14×10^{30} kg.

(i) Show that the gravitation force of attraction between the two stars is given by $\dfrac{1.46\times10^{50}}{R^2}$. [1]

(ii) Determine the distance R.

R = ... m [3]

(d) An astronaut in a space capsule orbits around the Earth in a circular path. The astronaut appears to float inside the capsule. A student suggests that the astronaut floats because there is no gravitational force acting on him.

State and explain whether the student's suggestion is valid.

....

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.... [2]

5 A small boat parked at the dock bobs up and down in the water as shown in Fig. 5.1.

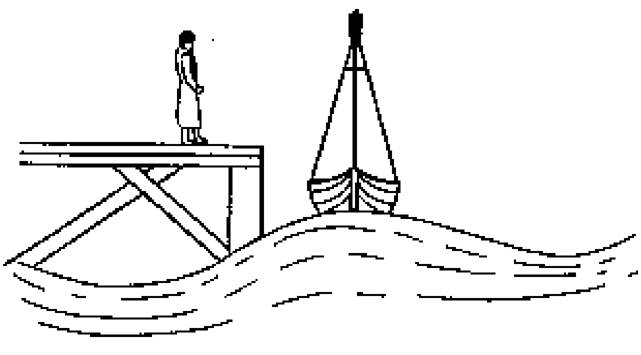

Fig. 5.1

A boy standing at the dock observes that the boat exhibits simple harmonic motion. The boat's displacement y, in metres, follows a sinusoidal relationship with respect to time t, and is described by the equation

$$y = 0.30\cos\left(\frac{\pi t}{3}\right)$$

The water waves travel at a speed of 30 m s^{-1} and the mass of the boat is 1.2×10^3 kg.

(a) Define *simple harmonic motion*.

……………………………………………………………………………………………………..

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

(b) State the amplitude of motion of the boat.

amplitude = …………………… m [1]

(c) Determine the frequency of oscillation of the boat.

frequency = …………………… Hz [2]

(d) Draw a clearly-labeled velocity versus time graph on Fig. 5.2 to represent two cycles of motion of the boat.

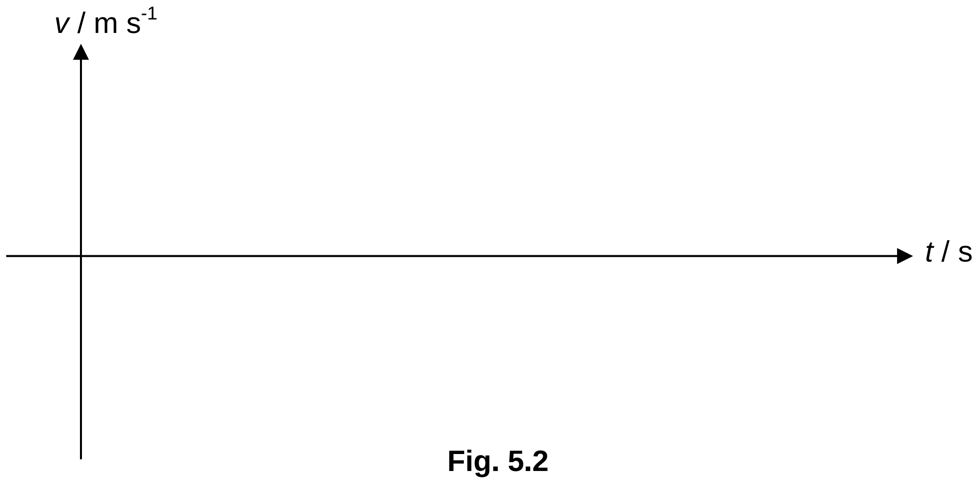

Fig. 5.2

[3]

(e) Hence determine the total energy of the boat.

total energy of the boat = …………………… J [2]

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

CANDIDATE NAME

CLASS

TUTOR'S NAME

PHYSICS

9749/03

Paper 3 Longer Structured Questions

30 September 2016

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	
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Section B	
7	
Total	

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

[Turn over

Section A

1 (a) One of the equations of motion may be written as $v = u + at$.

(i) Name and define the quantity represented by the symbol a.

....

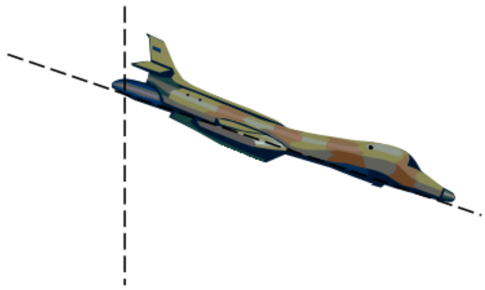
....[1]

(ii) The quantity represented by the symbol a may be either positive or negative. State the significance of having a negative value of a with positive value of u.

....

....[1]

(b) A dive bomber, diving at an angle of 53° with the horizontal, releases a bomb at an altitude of 730 m. The bomb hits the ground 5.0 s after being released.



(i) Show that the bomber is diving at a speed of 150 m s^{-1}.

[2]

(ii) Calculate the final velocity of the bomb just before it strikes the ground.

velocity = ... m s^{-1}

direction = ... [2]

(iii) **1.** Sketch a vector diagram (not drawn to scale) to show the change in velocity of the bomb between the moment of release and when it strikes the ground. [1]

2. Hence calculate the magnitude of the change in velocity of the bomb between the moment of release and when it strikes the ground.

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

2 On a frictionless airtrack, cart A of mass 200 g moves towards cart B with velocity 2.0 cm s^{-1}, while cart B of mass 300 g moves towards cart A with velocity 5.0 cm s^{-1}, as illustrated in Fig. 2.1.

Magnetic repulsion prevents the bumpers from making contact even at the point of closest approach.

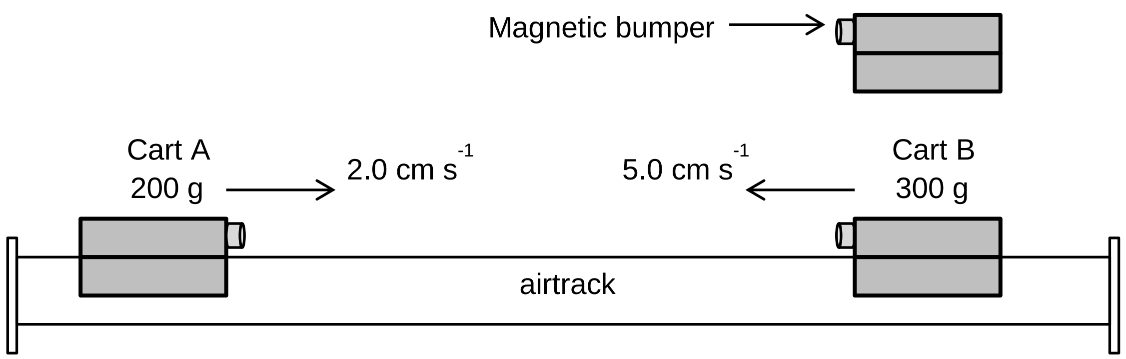


Fig. 2.1

Fig. 2.2 shows how the velocity of each cart varies with time.

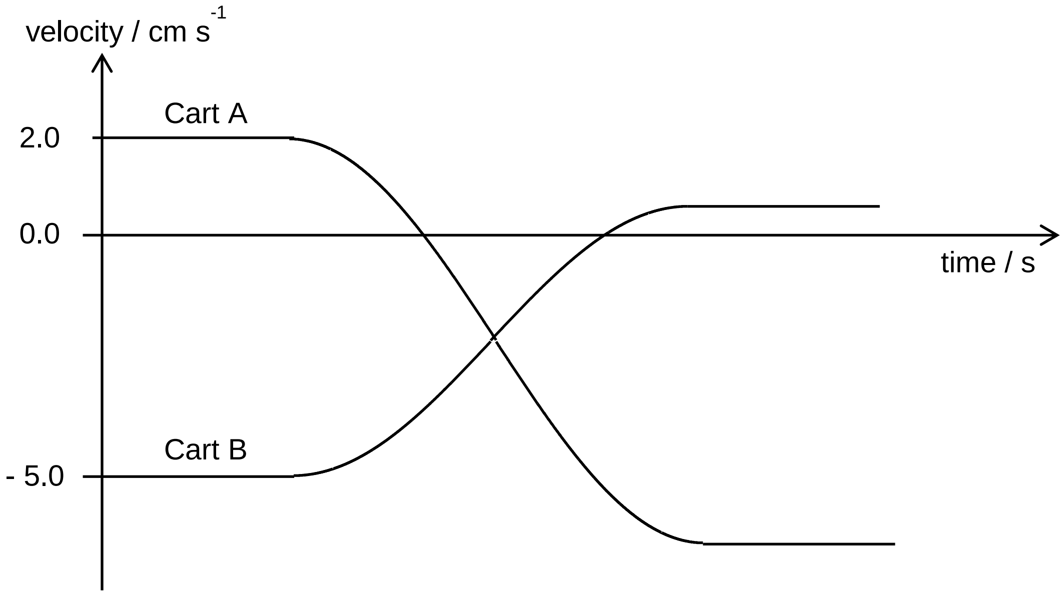


Fig. 2.2

(a) **(i)** At one instant during the interaction between the carts, they are travelling in the same direction with the same speed. Calculate this speed.

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

(ii) In Fig. 2.2, mark t_c on the time-axis to indicate the time at which the carts are at their distance of closest approach. [1]

(iii) Determine the maximum amount of magnetic potential energy stored during the interaction between the carts.

maximum energy = …………………… J [2]

(b) The polarity of the magnetic bumper of cart A is reversed, so the carts are now magnetically attracted to each other. As a result, the carts are always locked together after a collision. Assuming that carts A and B are initially far away from each other and moving towards each other with the same velocities as in **(a)**, the variation with time of the **total** kinetic energy of the carts is shown in Fig 2.3.

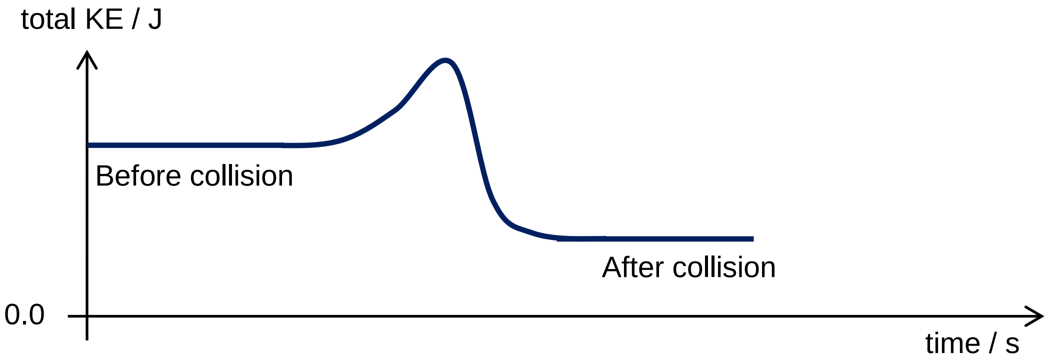


Fig. 2.3

(i) Explain why the total kinetic energy of the carts increased before the carts collided.

....

....

.... [1]

(ii) Explain why the total kinetic energy of the carts decreased after the collision.

....

....

.... [1]

3 **(a)** Define *work done*.

....

.... [1]

For Examiner's Use

(b) A body of mass m is raised through a height h at constant speed near the surface of Earth, where the gravitational field strength is g.

Derive an expression for its gain in gravitational potential energy in terms of m, h and g.

[2]

(c) A 4.00 kg mass slides down a frictionless plane with an initial speed v. The frictionless plane is inclined at an angle of 30^o, as shown in Fig. 3.1.

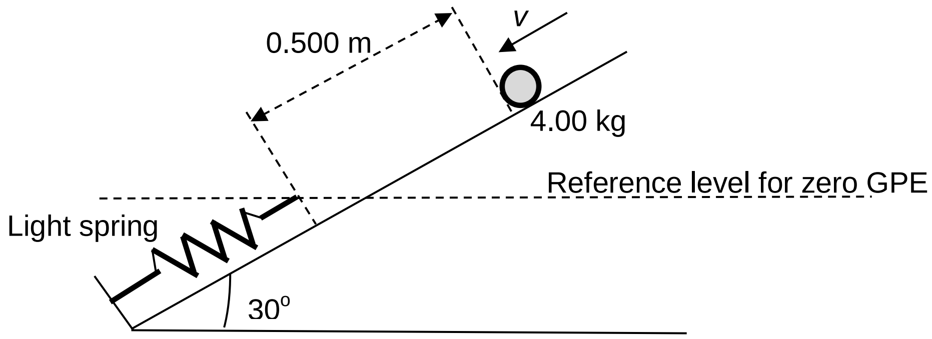


Fig. 3.1

After sliding down a distance of 0.500 m, the mass comes into contact with a light spring that is initially at its natural length and has a spring constant of 5000 N m^{-1}. The mass then slides down an additional 0.100 m before it comes to rest momentarily.

The gravitational potential energy (GPE) is taken to be zero at the reference level shown in Fig. 3.1.

(i) Calculate the gravitational potential energy of the mass at its initial position before sliding down the plane.

gravitational potential energy = …………………… J [1]

For Examiner's Use

(ii) Determine the elastic potential energy stored within the spring-mass system at the point of maximum compression of the spring.

elastic potential energy = …………………… J [2]

(iii) Determine the value of v, the initial speed of the mass.

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

(iv) State and explain how the value of v determined in **(c)(iii)** will change, if at all, should there be friction along the slope. Assume that the maximum compression of the spring remains the same.

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....[1]

4 A ball is suspended from a point **O** by an inextensible string **OA** of length L as shown in the Fig. 4.1 below. It is projected from **A** with a velocity v, perpendicular to **OA**. The string remains taut throughout the motion in a vertical circle.

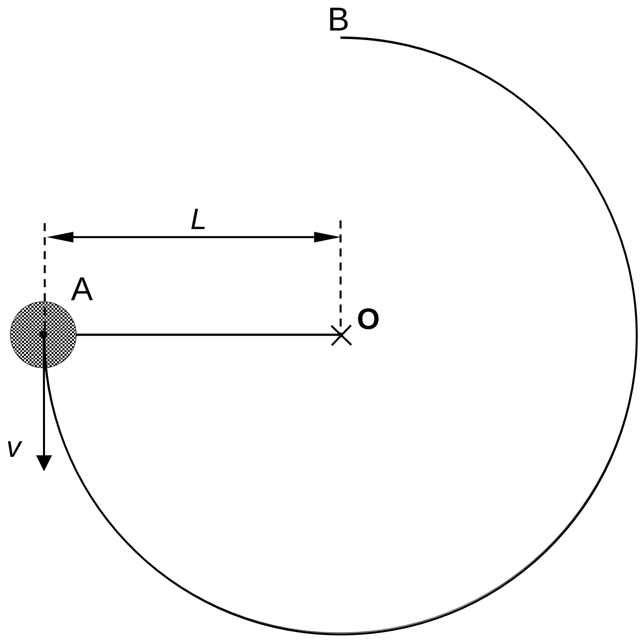
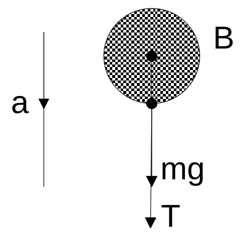


Fig. 4.1

(a) If the string is just taut when the ball reaches point **B**, determine the speed of the ball at point **B**, in terms of g and L only.



speed = ... [3]

(b) Hence determine the minimum speed v with which the ball should be projected from **A** to reach point **B**, in terms of g and L only.

minimum speed v = ... [2]

(c) If the string breaks at the *lowest point* of its motion, draw, on Fig. 4.2, the subsequent path taken by the ball. [2]

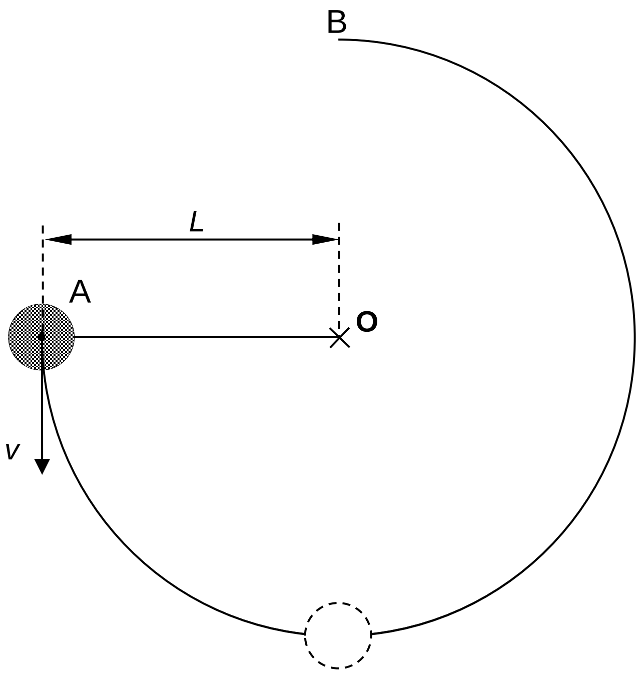


Fig. 4.2

(d) The ball is now fixed to a light rod of the same length. State and explain clearly how the new minimum speed v' with which the ball should be projected from **A** for it to just reach **B**, compares with v in **(b)**.

....

....

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....

.... [2]

5 (a) Distinguish between *electromotive force* and *potential difference*.

....

....

....

....

.... [2]

(b) A battery of electromotive force (e.m.f.) 12 V and internal resistance r is connected in series to two resistors, each of constant resistance X, as shown in Fig. 5.1.

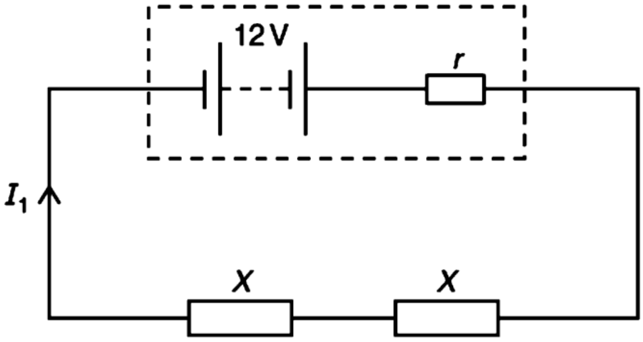


Fig. 5.1

The current I_1 supplied by the battery is 1.2 A.

The same battery is now connected to the same two resistors in parallel, as shown in Fig. 5.2.

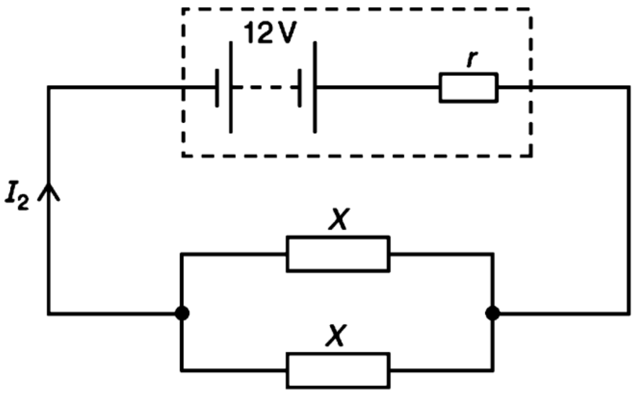


Fig. 5.2

The current I_2 supplied by the battery is 3.0 A.

For Examiner's Use

(i) Determine the values of X and r.

X = ... Ω

r = ... Ω [3]

(ii) **1.** In order to determine a more accurate value of r, five more sets of different readings of the total current in the circuit are required. State the minimum additional number of resistors with resistance X required to obtain a total of seven readings.

number = ... [1]

2. With more readings of the total current in the circuit available, explain how a more accurate value of r can be obtained from an appropriate graph plotted.

....

....

....

....

....[2]

(c) **(i)** Calculate the ratio

$$\frac{\text{power transformed in one resistor of resistance } X \text{ in Fig. 5.1}}{\text{power transformed in one resistor of resistance } X \text{ in Fig. 5.2}}$$

ratio = ... [1]

(ii) State and explain which of the two arrangements in Fig. 5.1 and Fig. 5.2 has a larger efficiency with regard to power transfer from the battery to both resistors, each of resistance *X*.

....

....

....

.... [2]

(d) The resistors in Fig. 5.1 and Fig. 5.2 are replaced by identical 12 V filament lamps.

Explain why the resistance of each lamp, when connected in series, is not the same as the resistance of each lamp when connected in parallel.

....

....

.... [1]

6 Solar planet Jupiter has sixty-seven known moons with different orbital period T (in days) and average orbital radius r (in metres). Data for six of them are shown in Fig. 6.1 below.

Satellite	***T* / days**	***r* / 10^9 m**
Sinope	758	23.7
Leda	239	11.1
Callisto	16.7	1.88
Europa	3.55	0.671
Io	1.77	0.422
Metis	0.295	0.128

Fig. 6.1

(a) Suggest why average values of r need to be taken.

....

.... [1]

(b) It is expected that the moons obey the relation

$$T\,r^{n} = k$$

where n and k are constants.

Explain how the relation may be verified by plotting a graph of lg T against lg r.

....

....

.... [2]

For Examiner's Use

(c) Some of the data from Fig. 6.1 are used to plot the graph of Fig. 6.2.

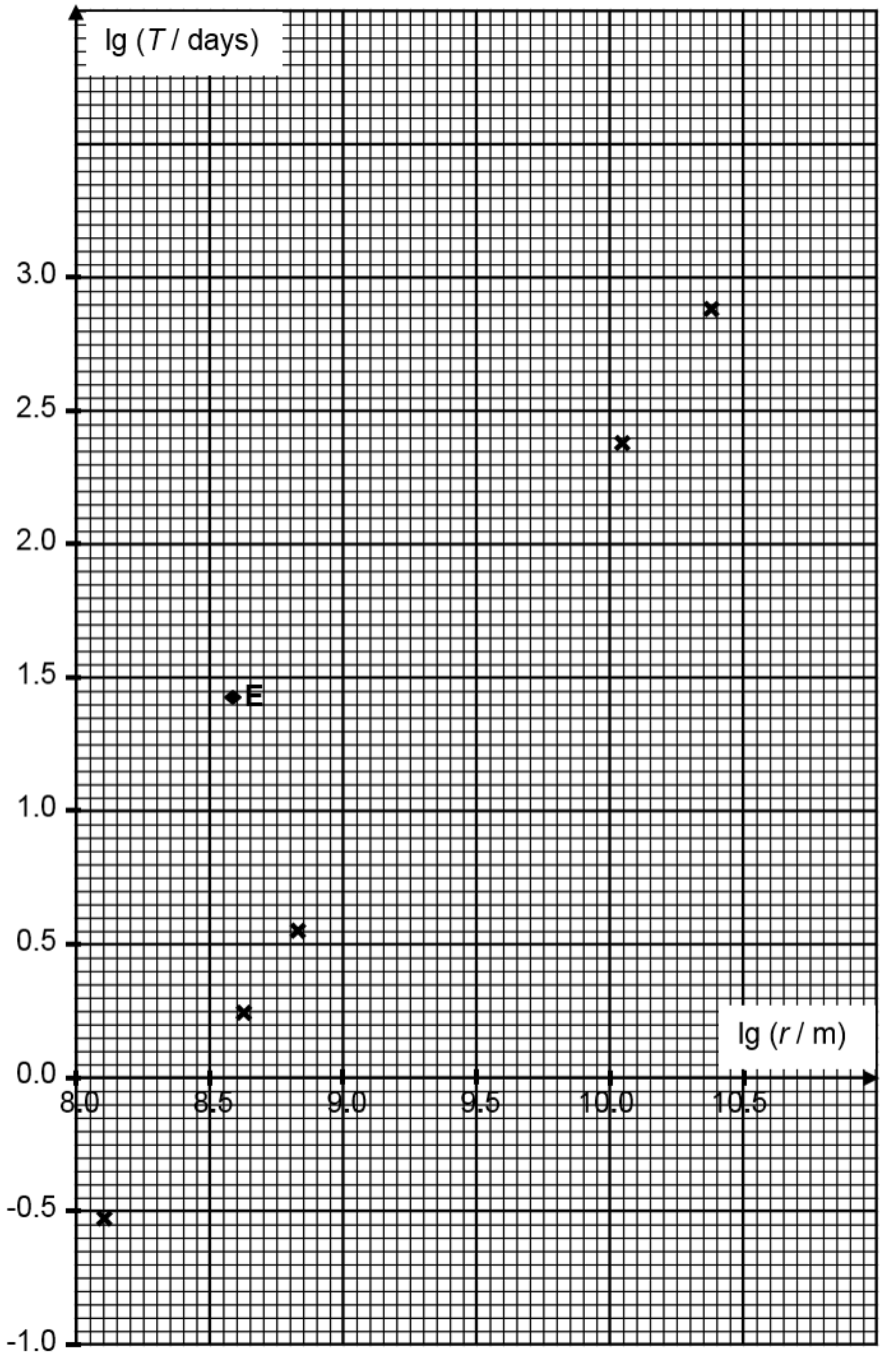


Fig. 6.2

(i) On Fig. 6.2,

1. Plot the point corresponding to Callisto. State the coordinates and label it **C**. [2]

2. Draw the line of best fit for the six points. Ignore Point **E**, the diamond data point. [1]

(ii) Determine the values of the constants n and k. Ignore their units.

n = ...

k = ... [4]

(iii) Kepler's Third Law of Planetary Motion states that $T^2 \propto r^3$. State and explain whether your answer to **(ii)** is in agreement with Kepler's Third Law.

....

....

.... [2]

(iv) Another moon, Thermisto, has a period of 130 days. Use Fig. 6.2 to determine the orbital radius of Thermisto.

radius = ... m [2]

(v) Earth's moon has an orbital radius of 0.385×10^9 m and a period of 27.3 days. Point **E** is plotted on Fig. 6.2 using this information.

Suggest why point **E** deviates from the line of best fit drawn in **(c)(i)**.

....

.... [1]

For Examiner's Use

Section B

7 **(a)** A jeweller wishes to harden a sample of pure gold by mixing it with some silver so that the mixture contains 5.0 % silver by mass.

The jeweller melts some pure gold and then adds the correct mass of silver. The initial temperature of the silver is 27 °C.

	gold	**silver**
melting point / K	1340	1240
specific heat capacity (for both solid and liquid) / J kg^{-1} K^{-1}	129	235
specific latent heat of fusion / kJ kg^{-1}	628	105

Fig. 7.1

Calculate, using the data in Fig. 7.1, the initial temperature of the melted pure gold so that the final mixture of gold and silver (both in liquid form) is at the melting point of pure gold. Assume no energy is lost to the surrounding.

temperature = ... K [5]

(b) State what is meant when temperature is described to be on an absolute scale.

....

....

.... [2]

(c) Explain what is meant by the statement "The internal energy of a sample of copper wire is 20000 kJ".

....

....

.... [2]

(d) Air is mainly made up of nitrogen and oxygen. The mass of one nitrogen molecule is 4.65×10^{-26} kg while the mass of one oxygen molecule is 5.31×10^{-26} kg.

Calculate the ratio

$$\frac{\text{root mean square speed of one oxygen molecule at 200 °C}}{\text{root mean square speed of one nitrogen molecule at 100 °C}}$$

Assume both nitrogen and oxygen are ideal gases.

ratio = ... [2]

(e) Fig. 7.2 shows the compression of an ideal gas at 27 °C such that no thermal energy enters or leaves the gas.

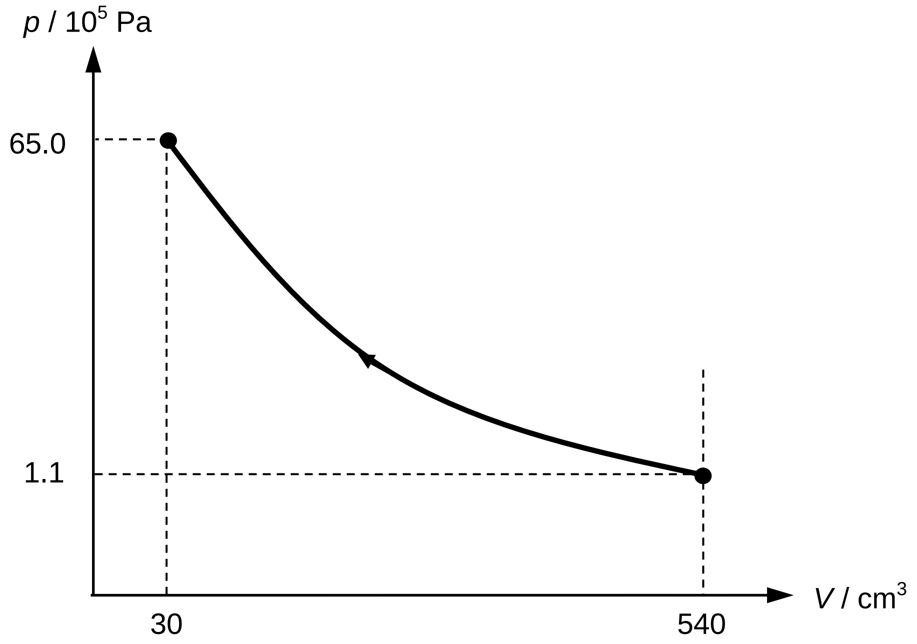


Fig. 7.2

(i) Calculate the temperature of the gas after the compression.

temperature = ... K [2]

(ii) Using the First Law of Thermodynamics, explain why the temperature of the air changed during the compression.

....

....

....

....

....

....

.... [4]

(f) The gas in the cylinder of a diesel engine undergoes a cycle of changes in pressure, volume and temperature. One such cycle, for an ideal gas, is shown in Fig. 7.3.

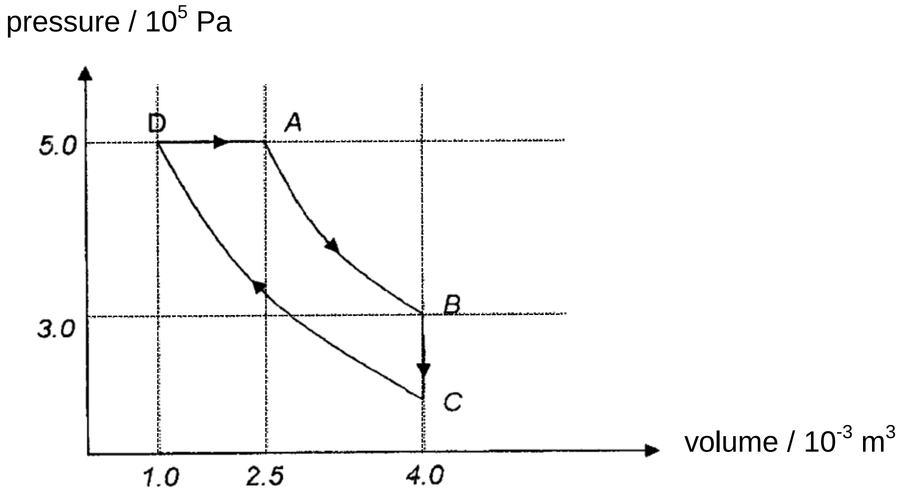


Fig. 7.3

Using Fig. 7.3, fill in the blanks in Fig. 7.4. [3]

Section of cycle	Heat supplied to gas / J	Work done on gas / J	Increase in internal energy of gas / J
A to B	0		- 300
B to C	- 450		
C to D	0	650	
D to A			

Fig. 7.4

NANYANG JUNIOR COLLEGE
JC 1 PROMOTIONAL EXAMINATION
Higher 2

PHYSICS 9646/01

Paper 1 Multiple Choice

6 October 2015

60 minutes

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-two** 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 **13** printed pages.

[Turn over

1 What is a reasonable estimate of the number of human heartbeats in an average lifetime?

A 10^7 **B** 10^8 **C** 10^9 **D** 10^{11}

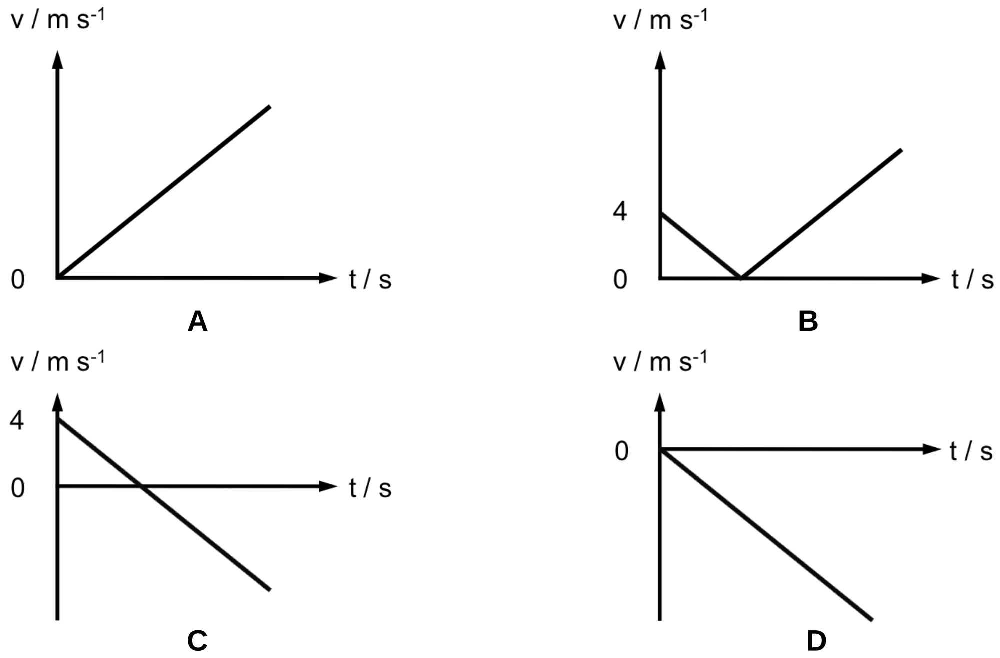
2 What are the base units of specific heat capacity?

A $m\ s^2\ K^1$ **B** $m\ s^{-2}\ K^{-1}$ **C** $m^2\ s^{-1}\ K^{-1}$ **D** $m^2\ s^{-2}\ K^{-1}$

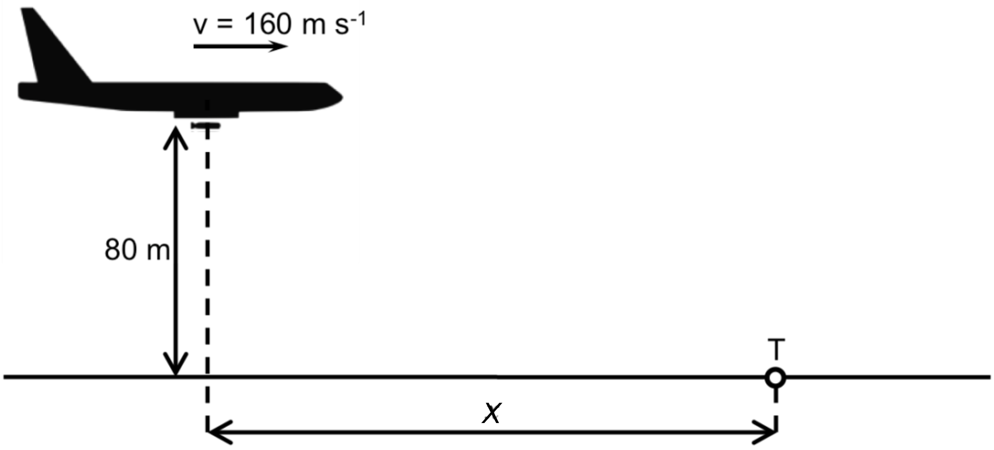
3 In an experiment to determine the acceleration of free fall g, the period of oscillation T and length l of a simple pendulum were measured. The uncertainty in the measurement of l was estimated to be 1%, and that of T, 4%. The value of g is determined using the formula $T = 2\pi\sqrt{\frac{l}{g}}$. What is the uncertainty in the calculated value for g?

A 3% **B** 5% **C** 7% **D** 9%

4 A sandbag is released from a hot air balloon when it is 10 m above the ground and ascending at a velocity of 4.0 m s^{-1}. Which of the following graphs best illustrates how the velocity of the sandbag will vary with time?



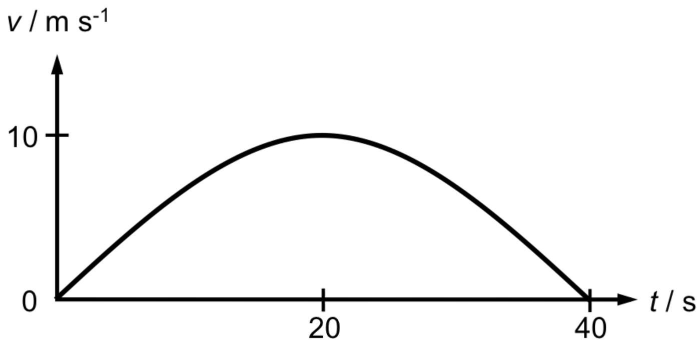
5 An aircraft drops a bomb as it flies horizontally near its target T.



If the effect of air resistance is negligible, the bomb will hit the target T if x is approximately

A 160 m **B** 320 m **C** 650 m **D** 2560 m

6 The velocity-time graph below shows the motion of a body travelling in a straight line.



Which of the following statements is a correct interpretation of the graph?

A During the first 20 seconds of the motion, the object accelerates and travels a distance of 200 m.

B The acceleration of the object increases during the first 20 s to become a maximum when the velocity is 10 m s^{-1}.

C The acceleration of the object when t = 5 s is equal to the acceleration when t = 35 s.

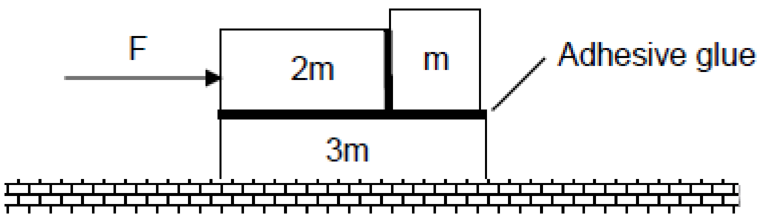
D The object decelerates during the final 20 s of its motion with the largest deceleration occurring at t = 40 s.

7 A football, moving with kinetic energy K and momentum p, hits a skateboard causing it to move and the football rebounds along its original path. Assume there is no friction force acting on skateboard. The collision is inelastic.

Which of the following correctly shows the kinetic energy of the football and the football-skateboard as a system, and the magnitude of the momentum of the football and the football-skateboard as a system, after this collision?

	Kinetic energy		Magnitude of momentum	
	of football	of football-skateboard system	of football	of football-skateboard system
A	K	0	p	p
B	$< K$	K	$< p$	p
C	$< K$	$< K$	$< p$	p
D	$< K$	$< K$	$< p$	$< p$

8 Three blocks of different masses are glued together as shown below. The system is accelerated along a smooth horizontal surface by a force F. What is the net force acting on the mass $2m$?



A $F/3$ **B** $2F/3$ **C** F **D** insufficient information to conclude

9 A ball falls vertically and bounces on the ground.

Which of the following statements correctly describes the forces acting on/by the ball while it is in contact with the ground?

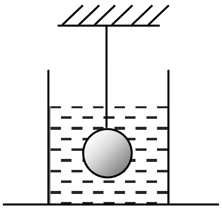
A The force that the ball exerts on the ground is always equal to the weight of the ball.

B The force that the ball exerts on the ground is always equal in magnitude and opposite in direction to the force the ground exerts on the ball.

C The force that the ball exerts on the ground is always smaller than the weight of the ball.

D The weight of the ball is always equal and opposite to the force that the ground exerts on the ball.

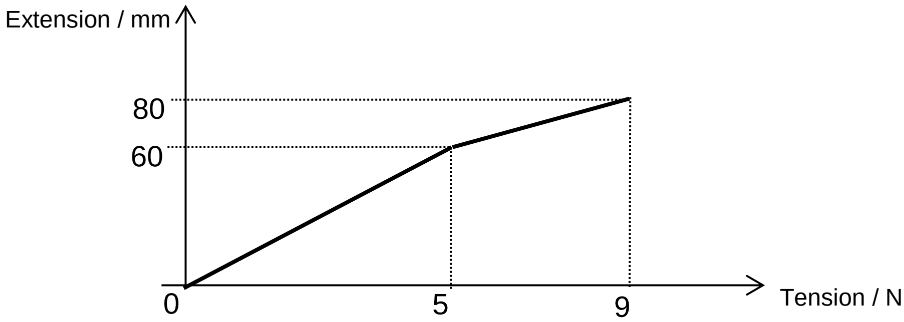
10 A beaker holding some water is resting on a horizontal table. The total weight of the beaker and water is 30 N. A solid object is suspended as shown below. It has a weight of 10 N in air and displaces 0.82 kg of water when fully immersed in the water.



The force that the beaker exerts on the table is

A 22 N **B** 32 N **C** 38 N **D** 40 N

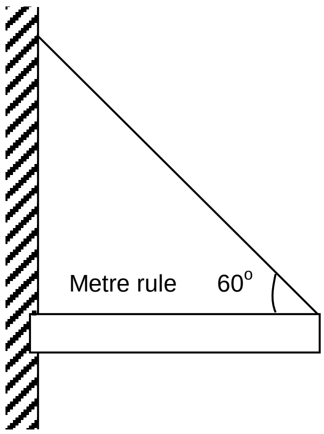
11 An object is placed in a tensile-testing machine, which extended it by known amounts, and the tension is measured. The graph below represents the variation of extension with tension.



What is the work done on the sample when it is extended from 60 mm to 80mm?

A 0.14 J **B** 0.28 J **C** 0.43 J **D** 0.72 J

12 A uniform metre rule is hinged at the wall at one end and supported by a string at the other end as shown below.



If the weight of the rule is 2.0 N and the string makes an angle of 60^{o} with the rule, what is the tension in the string?

A 1.0 N **B** 1.2 N **C** 2.0 N **D** 2.3 N

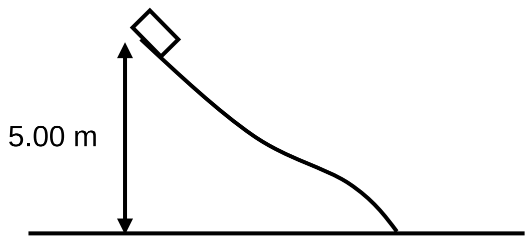
13 A small metal sphere of mass m is moving through a viscous liquid. When it reaches its terminal velocity v, which of the following describes the kinetic energy and potential energy of the sphere?

	kinetic energy	gravitational potential energy
A	increases at a rate of mgv	decreases at a rate of mgv
B	increases at a rate of mgv	decreases at a rate of ($\frac{1}{2}mv^2$ - mgv)
C	constant and equal to $\frac{1}{2}mv^2$	decreases at a rate of mgv
D	constant and equal to $\frac{1}{2}mv^2$	decreases at a rate of (mgv - $\frac{1}{2}mv^2$)

14 A block slides from rest down a frictionless ramp of height h. It reaches speed v at the bottom. To reach a speed of $2v$, another block of twice the mass would need to slide down a ramp of height

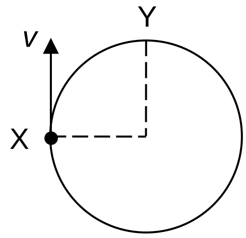
A $1.4h$ **B** $2h$ **C** $4h$ **D** $8h$

15 A 50.0 kg block is released from rest at a height of 5.00 m above the ground as shown. It then travels a distance of 10.0 m along a curved slope to the ground. The final speed of the block at the end of the slope is only 4.90 m s^{-1} because a constant resistive force acts on it during the descent. What is the resistive force acting on the block?



A 185 N **B** 550 N **C** 2450 N **D** 22500 N

16 A body of mass m moves in a horizontal circle of radius r at a constant speed v. When the body moves from X to Y as shown below, which pair of expressions correctly gives the work done by the centripetal force and the change in linear momentum of the body?



	Work done	Change in linear momentum
A	0	$\sqrt{2}\, mv$
B	0	$2\, mv$
C	$\frac{1}{2} mv^2$	$\sqrt{2}\, mv$
D	$\frac{1}{2} mv^2$	$2\, mv$

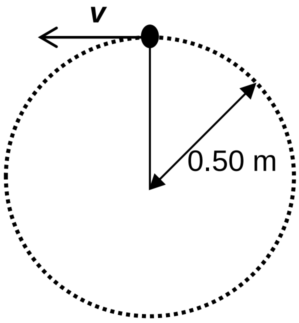
17 A car of mass 1000 kg is expected to move around a corner with a radius of curvature of 200 m.

If the speed limit is 25 m s^{-1}, what should be the value of the banking angle θ such that there is no dependence on friction to maintain circular motion?

A 17.7° **B** 45.0° **C** 72.3° **D** 76.3°

18 A ball of mass 0.10 kg is attached to a string and swung in a vertical circle of radius 0.50 m as shown below. At the top of the circle, the tension in the string is 6.2 N.

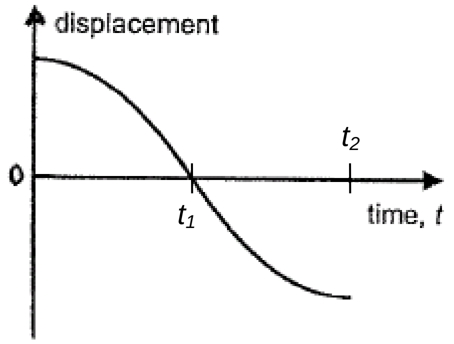
What is the speed of the ball v at this instant?



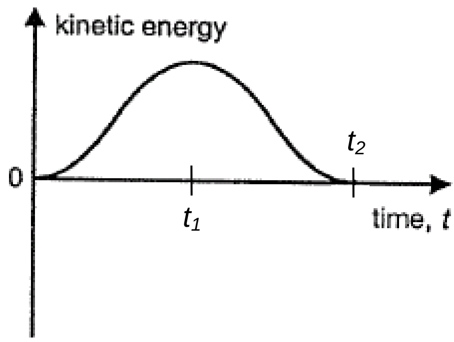
A 5.1 m s^{-1} **B** 6.0 m s^{-1} **C** 26 m s^{-1} **D** 36 m s^{-1}

19 A body is undergoing simple harmonic motion. The graphs below show the variation of displacement, velocity, kinetic energy and force with time *t* during part of the motion. Which one of the following graphs must be **incorrect** because it is not consistent with the others?

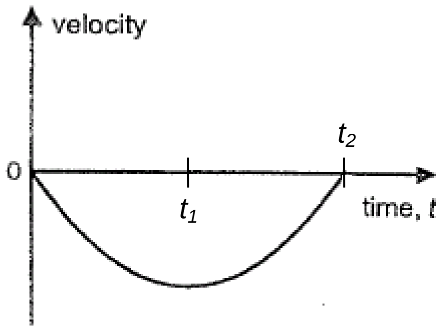
A



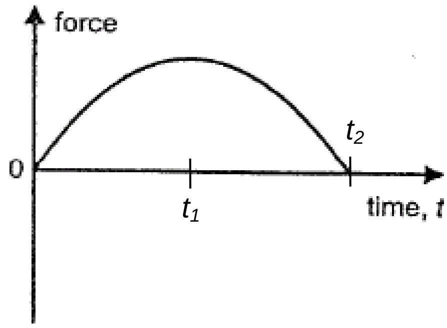
B



C



D



20 A satellite drifts from a lower orbital radius to a higher orbital radius, farther away from the earth. What happens to its angular velocity and orbital speed?

	Angular velocity	**Orbital speed**
A	Decrease	Decrease
B	Decrease	No change
C	Decrease	Increase
D	No change	Decrease

21 Which of the following statements about geostationary orbits is true?

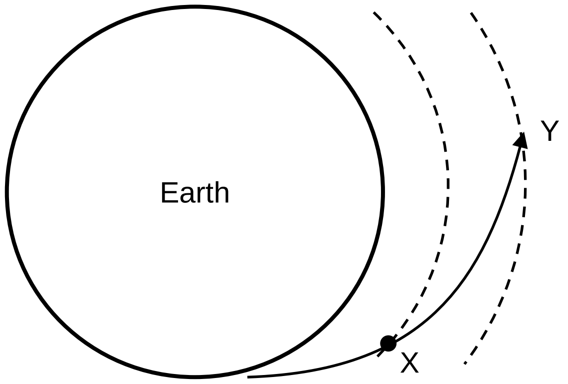
A As the mass of satellite in geostationary orbit decreases, its orbital velocity must increase.

B A geostationary orbit can take place in any direction around Earth, as long as the plane of orbit passes through the centre.

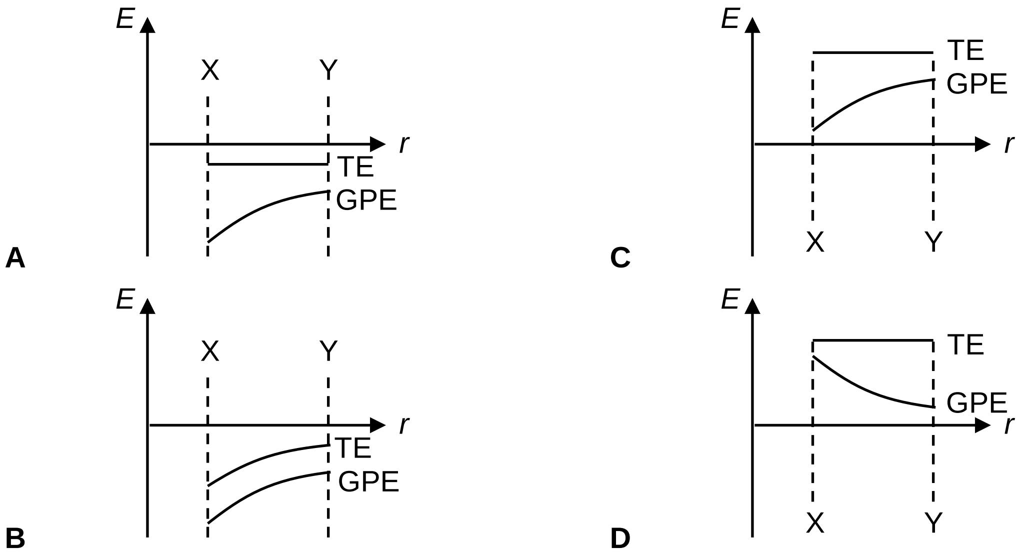
C There is only one possible orbital speed for geostationary orbit.

D The orbital period of a geostationary satellite must match the orbital period of Earth around the Sun.

22 During a Space Shuttle launch, the shuttle travels from point X to point Y as shown in the diagram below, without any force being exerted from its boosters.



Which of the following graphs shows how the gravitational potential energy **(GPE)** and total energy **(TE)** of the Space Shuttle change as it travels from X to Y?



23 In order to check the speed of a camera shutter, the camera was used to photograph a mass hung on a spring vibrating in front of a vertical scale. The extreme positions of the mass were at the *105 mm* and *205 mm* marks. The photograph showed that while the shutter was opened, the mass moved from the *155 mm* mark to the *180 mm* mark.

If the period of the mass was 2 seconds, the shutter remained open for

A 1.00 s **B** 0.50 s **C** 0.25 s **D** 0.17 s

24 Which one of the following is an effect of an increase in damping in a forced oscillation?

A The amplitude at resonance increases

B The natural frequency at resonance increases

C The total energy of the system increases

D The period of the driven oscillator at resonance increases

25 The temperature of a hot liquid in a container of negligible heat capacity falls at a rate of 2 K per minute just before it begins to solidify. The temperature then remains steady for 20 minutes for all the liquid to be solidified.

What is the value of the ratio of $\dfrac{\text{specific heat capacity of liquid}}{\text{specific latent heat of fusion}}$?

A $\dfrac{1}{40}\ \text{K}^{-1}$ **B** $\dfrac{1}{10}\ \text{K}^{-1}$ **C** $10\ \text{K}^{-1}$ **D** $40\ \text{K}^{-1}$

26 Which of the following is **not** an advantage of the continuous flow method for determining specific heat capacities of fluids?

A The heat capacity of the apparatus is not required.

B The heat loss to the surrounding is kept minimal.

C The rate of heat loss to the surrounding is not required.

D The temperature of the apparatus is maintained during steady state.

27 An ideal gas exerts a pressure of 60 kPa when its temperature is 400 K and the number of molecules present in unit volume is N. Another sample of the same gas exerts a pressure of 30 kPa when its temperature is 300 K. How many molecules are present in unit volume of this second sample?

A $2N/3$ **B** $3N/4$ **C** $4N/3$ **D** $3N/2$

28 A cylindrical container of diameter 400 mm contains water at rest. If a drop of water is released onto the centre of the container, a completely circular wavefront can be produced on the surface of the water, which travels outwards at a speed of 250 mm s^{-1}. What are the radius and direction of the circular wavefront 1.00 s later?

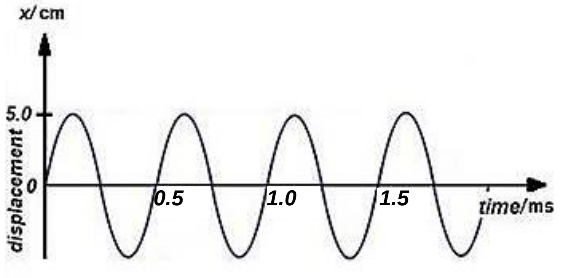
A 50 mm, outwards

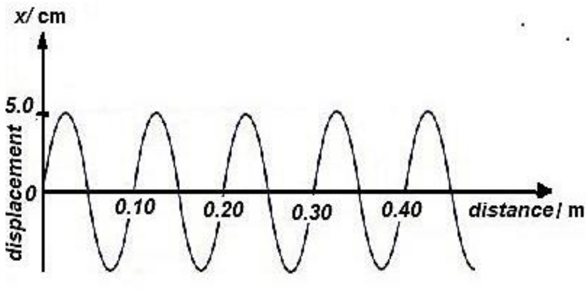
B 50 mm, inwards

C 150 mm, inwards

D 150 mm, outwards

29





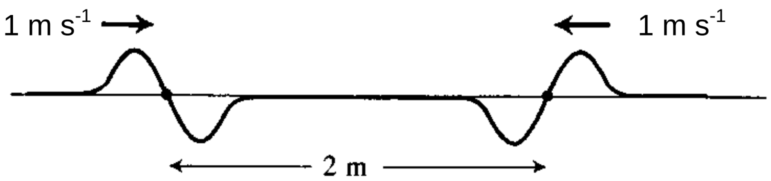
The diagram on the left shows the displacement variation with respect to time of a particle in a sound wave. The diagram on the right shows the displacement variation of the sound wave with respect to distance. The velocity of the sound wave in this medium is

A 50 m s^{-1} **B** 100 m s^{-1} **C** 200 m s^{-1} **D** 330 m s^{-1}

30 A point source emits sound wave of constant frequency with a constant power *P*. A sound intensity *I* and wave amplitude *A* is detected at a distance of 5.0 m away from the source. What would be the intensity and amplitude detected at 10.0 m away from the source?

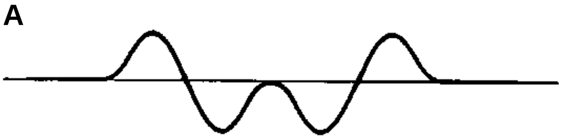
	intensity	amplitude
A	*I* /4	*A/4*
B	*I* /4	*A/2*
C	*I* /4	*A/16*
D	*I* /2	*A/2*

31



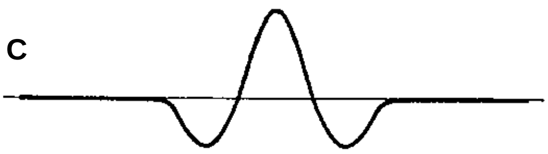
Two wave pulses on a string, as shown in the above diagram, are approaching each other at 1 m s^{-1}. Within the next 3 seconds, it is NOT possible for the shape of the string to be

A



B

C



D

32 A stationary wave is formed in the air in an open tube as represented in the diagram. How many antinodes are formed by a stationary wave of twice the frequency?

A 2 **B** 4 **C** 5 **D** 6

H

NANYANG JUNIOR COLLEGE
JC1 PROMOTIONAL EXAMINATION
Higher 2

CANDIDATE NAME	

CLASS		TUTOR'S NAME	

PHYSICS 9646/02

Paper 2 Structured Questions **6 October 2015**

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	/ 8
2	/ 8
3	/ 8
4	/ 9
5	/ 8
6	/ 7
Total	48

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

1 **(a)** Distinguish between an *accurate* and a *precise* experiment in terms of its systematic and/or random errors.

…………………………………………………………………………………………………...

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

(b) In an experiment to determine the acceleration due to free fall *g*, a student releases a ball from rest at the top of a building and measures the time taken for the fall. Although he uses a measuring tape, with a precision of 1 mm, he reported the height as (75.0 ± 0.1) m. The experiment is repeated twice with the duration of fall stated as (3.8 s ± 3%).

(i) Suggest a reason why the student reported the uncertainty for the height as 0.1 m, instead of 0.001 m.

……...………………………………………………………………………………………

……………………………………………………………………………………………

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

(ii) Determine the acceleration due to free fall *g* using the data given above.

acceleration due to free fall, g = …………………………………. m s^{-2} [2]

(iii) Write down the expression for the fractional uncertainty of *g*, and hence, determine its value.

fractional uncertainty of g = …………………………………. [2]

(iv) Hence, calculate the absolute uncertainty, Δg, of the acceleration due to free fall.

absolute uncertainty of g = ………………………………… m s^{-2} [1]

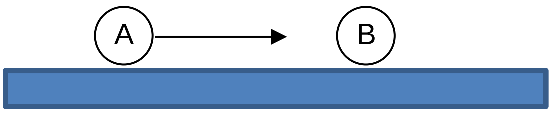
2 **(a)** State the principle of conservation of linear momentum.

……..…………………………………………………………………………………………...

……………………………………………………………………………………………………...

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

(b) A billiard ball A collides head-on with a stationary billiard ball B of mass 150 g as shown below.



The force exerted on ball B by ball A varies with time as shown in Fig. 2.1.

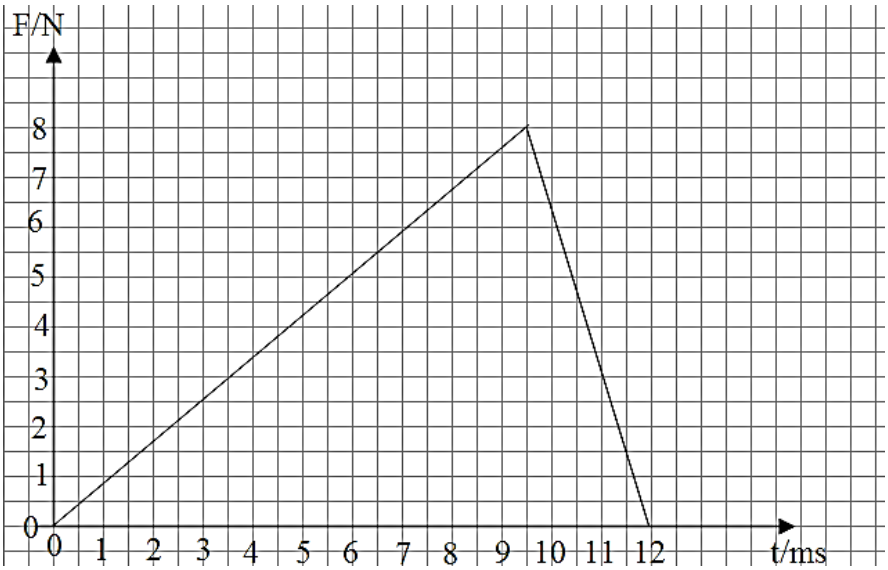


Fig. 2.1

Calculate the

(i) impulse delivered to ball A,

impulse = …………………………………. N s [2]

(ii) velocity of ball B after the collision.

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

(c) Ball B travels towards the edge of the table. When ball B reaches the table edge, its speed drops to zero as it rolls off from the table edge. A net is placed 1.0 m below the table to catch the ball. Ball B lands on the net and is brought to a complete stop in 0.50 s. Calculate the average force exerted on the net by ball B.

average force = …………………………………. N [3]

3 A uniform glass rod of length 18 cm and mass 60 g is at rest inside a 12 cm deep glass tumbler as shown in Fig. 3. The interior wall of the tumbler is smooth while the bottom of the tumbler is rough.

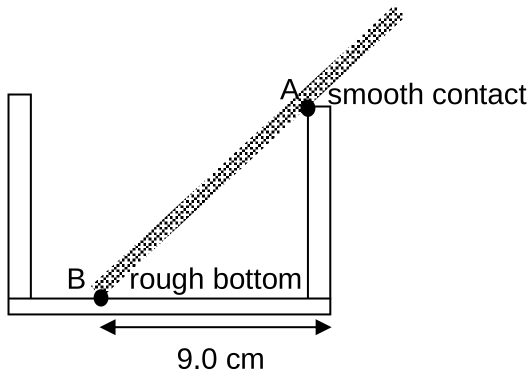


Fig. 3

(a) Calculate the magnitude of the force exerted on the glass rod at

(i) A,

force = …………………………………. N [3]

(ii) B.

force = …………………………………. N [3]

(b) Determine the angle between the force in **(a)(ii)** and the glass bottom.

angle = …………………………………. ° [2]

4 Hera, of mass 50.0 kg, skies over a snow hump with a radius of curvature of 10.0 m as shown in Fig. 4.1.

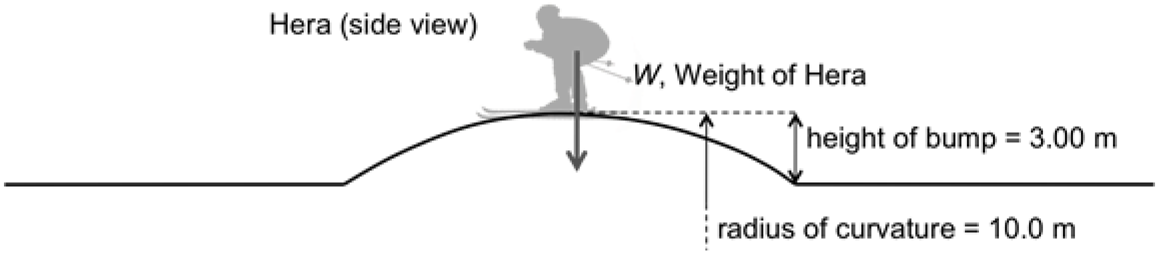


Fig. 4.1

(a) The weight of Hera, **W**, is drawn on Fig. 4.1. On the same figure, draw the force by the snow hump on her, and label it as **P**. [1]

(b) Assuming that Hera just loses contact with the snow hump at the peak of the hump, show that her speed at the peak is 9.90 m s^{-1}.

[2]

(c) Given that the peak of the hump is 3.0 m above ground level, determine the minimum speed she must possess at the start of the hump in order to lose contact with the hump at its peak.

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

After clearing the hump, Hera proceeds to ski horizontally along a circular snow bank with a radius of curvature of 30.0 m at a constant speed, as shown in Fig. 4.2. She experiences a sideward friction of 11.0 N.

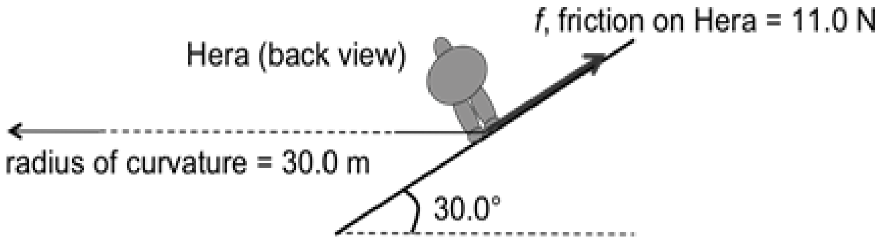


Fig. 4.2

(d) Show that the normal contact force acting on Hera is 560 N.

[1]

(e) Calculate the speed she has to maintain in order to complete the motion. Explain your working.

speed = …………………………………. m s^{-1} [3]

5 **(a)** The First Law of Thermodynamics can be expressed mathematically as

$$\Delta U = Q + W$$

State what each of the symbols used in the equation above represents.

…………………………………………………………………………………………………...

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

(b) A fixed mass of gas undergoes a cycle of changes of pressure, volume and temperature as illustrated in Fig. 5.1 below. The gas is assumed to be *ideal*.

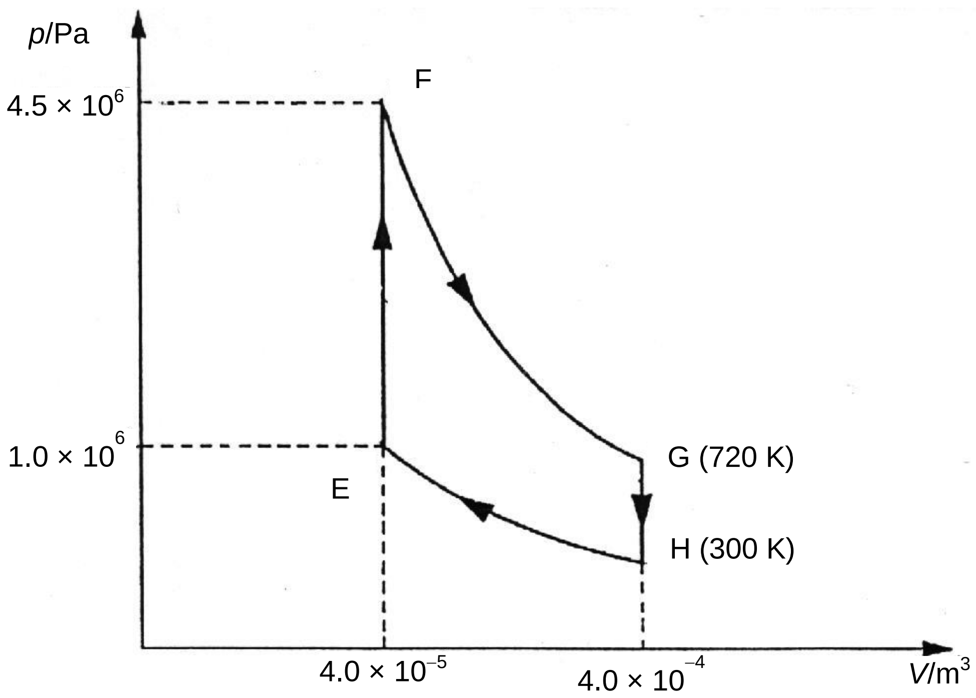


Fig. 5.1

(i) Fig. 5.2 is a table of energy changes for the process HE. Given that HE is an isothermal process, complete Fig. 5.2 using (+), (–) or (0).

Increase in internal energy of gas, ΔU	Heating supplied to gas, Q	Work done on gas, W

Fig. 5.2

[1]

(ii) FG is an adiabatic process in which no heat is transferred to or from the gas. Suggest how such a process can be achieved.

………………………………………………………………………………………………..

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

(iii) Calculate the amount of gas, in moles, involved in the cycle.

amount of gas = ………………………………….. mol [2]

(iv) Find the *decrease* in internal energy of the gas for the process GH given that the molar heat capacity of the gas at constant volume is 20.8 J mol^{-1} K^{-1}.

decrease in internal energy = ………………………………….. J [2]

(v) State and explain the net increase in internal energy of the gas through one complete cycle.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

6 **(a)** Describe what is meant by a *longitudinal wave*.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

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

(b) Fig. 6 below shows the display on a C.R.O. as sound waves travelling to the right pass through a point in air. The time-base is set to 2 ms/div. The amplitude of the sound wave is measured on the y-axis. Take the positive direction to be rightwards.

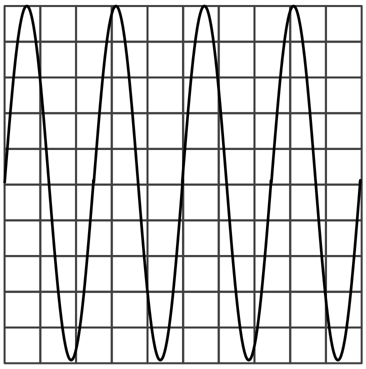


Fig. 6

(i) Determine the frequency of the sound wave.

frequency = …………………………………. Hz [1]

(ii) Given that the speed of sound in air is 330 m s^{-1}, calculate the wavelength of the sound wave.

wavelength = …………………………………. m [1]

(iii) On Fig. 6, mark a point where the sound pressure is minimum. Label it as **P**, and explain your answer.

………………………………………………………………………………………

………………………………………………………………………………………

……..…………………………………………………………………………… [2]

(c) On Fig. 6, sketch another graph to show what happens to the wave if the area through which it passes is doubled. Explain your answer.

……...

……...

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

END OF PAPER

H

NANYANG JUNIOR COLLEGE
JC1 PROMOTIONAL EXAMINATION
Higher 2

CANDIDATE NAME

CLASS

TUTOR'S NAME

PHYSICS 9646/03

Paper 3 Longer Structured Questions **29 September 2015**

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.

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	/ 10
2	/ 10
3	/ 10
4	/ 10
5	/ 20
6	/ 20
Deductions	
Total	80

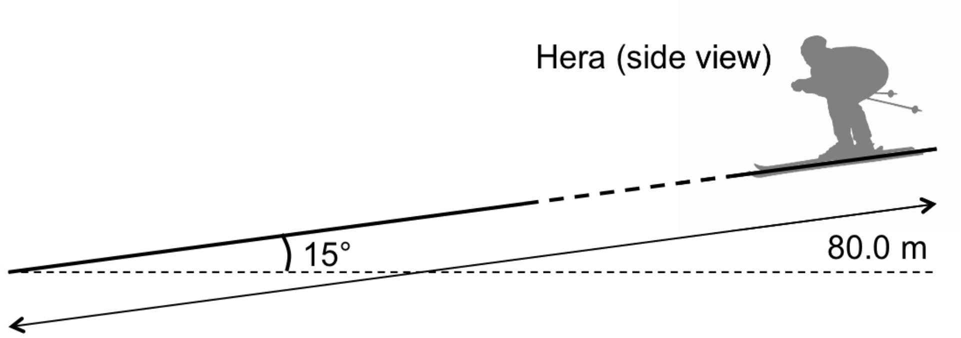
This document consists of **19** printed pages.

1 **(a)** Define acceleration.

....

.... [1]

(b) Hera, who has a mass of 50.0 kg, is initially at rest. She skies down a snow slope for a distance of 80.0 m before skiing off a short cliff.



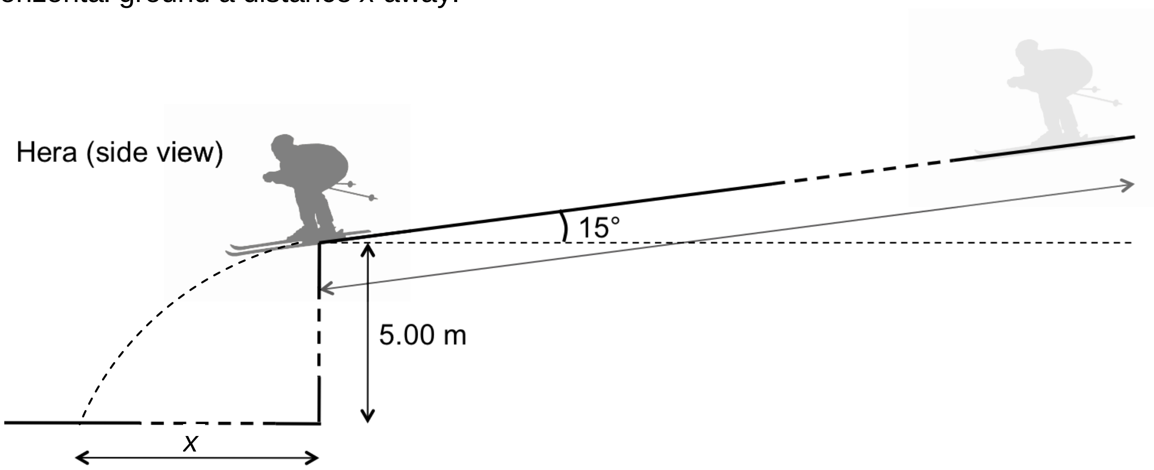
(i) Calculate the acceleration of Hera while she is sliding down the slope.

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

(ii) Hence show that the speed of Hera just as she leaves the slope is $20.2\ m\ s^{-1}$.

[1]

The snow slope ends with a 5.00 m vertical cliff. Hera skies off the cliff and lands on horizontal ground a distance *x* away.



(iii) Calculate the time taken for Hera to land on the ground after skiing off the cliff.

time taken = ... s [2]

(iv) Determine *x*, the horizontal distance from the edge of the cliff at which Hera lands.

x = ... m [2]

(c) After Hera lands on the ground, she continues to ski with a constant velocity of 10.0 m s^{-1}. Her friend Zeus, who was initially 20.0 m behind her, begins to ski from rest at a constant acceleration of 0.30 m s^{-2}.

Calculate the time taken for Zeus to catch up with her.

time taken = ... s [3]

2 **(a)** A car starts from rest and travels upwards along a straight road inclined at 5.0° to the horizontal, as illustrated in Fig. 2.1.

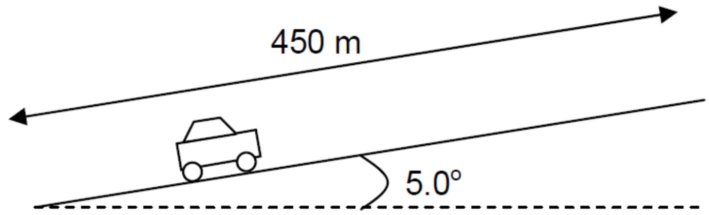


Fig. 2.1

The length of the road is 450 m and the car has a mass of 800 kg. The speed of the car increases to 28 m s^{-1} at the top of the slope within 32.1 s. The constant power output of the engine is 5.00×10^4 W.
Determine, for this car traveling up the slope,

(i) the gain in kinetic energy,

gain in kinetic energy = ... J [1]

(ii) the gain in gravitational potential energy.

gain in gravitational potential energy = ... J [2]

(iii) Determine the useful output power of the car.

useful output power = ... W [2]

(iv) Hence calculate the efficiency of the car engine.

efficiency = ... % [1]

(v) It is said that the rest of the input energy of the engine has been converted to thermal energy (heat) which is all wasted. Comment on this statement.

....

....

.... [1]

(b) A gramophone shown in Fig. 2.2 is used to play LP, long play record.

Fig. 2.2

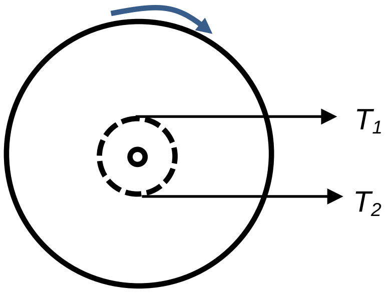


Fig. 2.3

Fig. 2.3 shows the turntable of the gramophone. The axle of the turntable (in dotted line) has a diameter of 5.0 cm. A rubber belt goes around the axle and is coupled to a motor. The tensions in the rubber belt used to turn the turntable are T_1 and T_2 respectively. Their values differ by 34.7 N.

(i) Calculate the net torque on the turntable by the rubber belt alone.

net torque = ... N m [1]

(ii) The turntable rotates at a constant rate of $33\frac{1}{3}$ revolutions per minute. Calculate the work done per second by the rubber belt.

work done per second = ... J s^{-1} [2]

3 Spring A with spring constant k is attached to a body of mass m as shown. The spring has an unstretched length of 20.0 cm, as shown in Fig. 3.1.

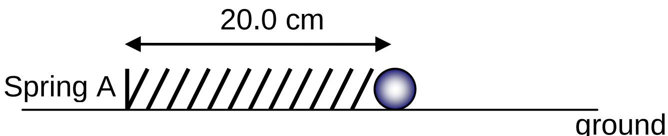


Fig. 3.1

(a) **(i)** Show that when the body is displaced by a distance x and then released, its acceleration at the point of release is given by the following equation

$$a = -\frac{k}{m}x$$

[2]

(ii) Hence give an expression for the angular frequency ω of the body's oscillation in terms of k and m.

[1]

(b) A second spring, spring B, with spring constant $2k$ is attached to the body. Spring B has the same unstretched length of 20.0 cm, as shown in Fig. 3.2.

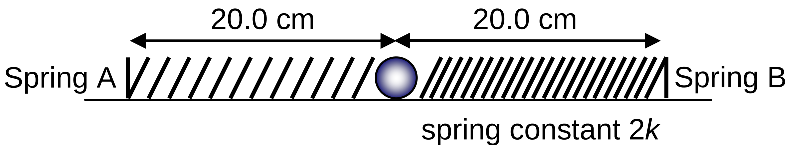


Fig. 3.2

The body is displaced by a distance x to the left and the horizontal forces acting on the body are as shown in Fig. 3.3.

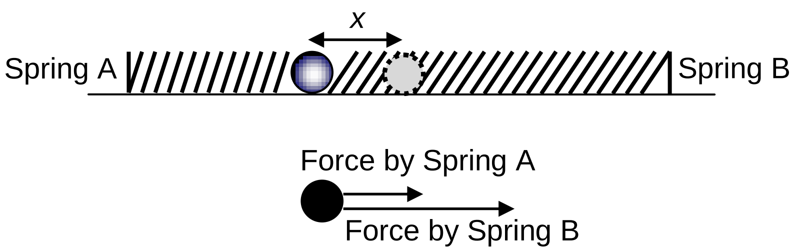


Fig. 3.3

(i) Explain why the two forces are acting in the same direction.

....

....

.... [2]

(ii) Given that m = 1.5 kg and k = 10 N m^{-1}, determine the period of oscillation of the body.

period = ... s [2]

(iii) Suggest why the actual value of the period may deviate from the value calculated in **(b)(ii)**.

....

.... [1]

(c) Stabilising systems, such as the 728-ton mass damper in Taipei 101 skyscraper, consist of a central mass that is able to undergo oscillation. They are employed to stabilise buildings in earthquake-prone regions. When the building sways, the central mass is displaced from its equilibrium position.

Explain why such systems need to be damped, and suggest an appropriate degree of damping.

....

....

.... [2]

4 **(a)** State the Principle of Superposition.

....

.... [1]

(b) Sound produced by the loudspeaker L shown has a frequency of 4.0×10^3 Hz. The sound waves arrive at microphone M via two different paths, LXM and LYM. The left-tube is fixed in position, while the right-tube is a sliding-section. At position M, the sound waves from the two paths interfere.

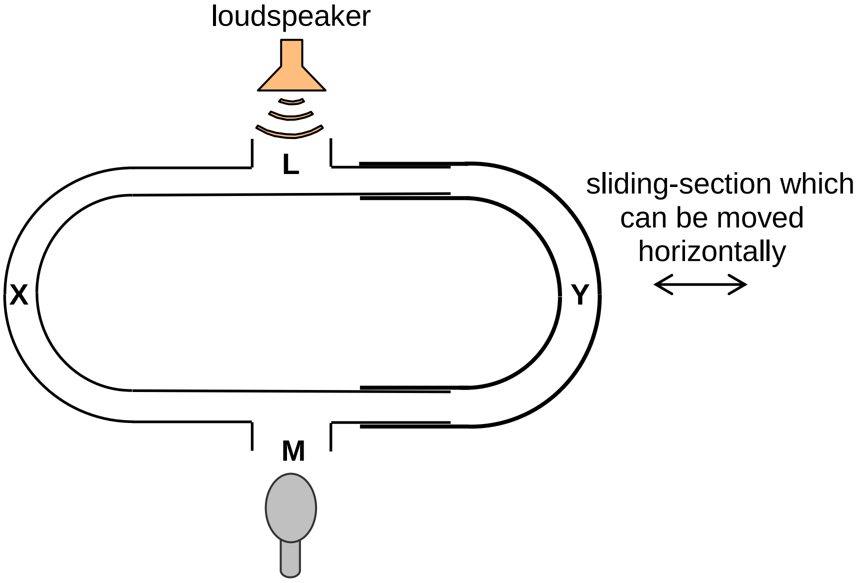


Fig. 4

Initially, the lengths of paths LXM and LYM are equal. The sliding-section is then pulled out horizontally by 0.020m, and the loudness at microphone M changes from a maximum to its immediate minimum.

(i) Determine the path difference between the two waves after the sliding-section is pulled out.

path difference = ... m [1]

(ii) Calculate the speed at which sound travels through the tube.

speed = ... m s^{-1} [3]

(iii) When the opening at M is sealed, explain why a standing wave is set up in the tube.

....

....

....

.... [2]

(iv) The frequencies of the sound produced by the loudspeaker ranges from 40 Hz to 4.0 kHz. Estimate the optimal diameter of the loudspeaker in order to achieve the maximum diffraction of sound waves. Explain your answer.

....

....

.... [3]

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

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

Fig. 5.1 illustrates a cantilever of length *L* loaded with a point load *P* at its end. A vertical deflection *y* of the free end of the cantilever will result from the loading.

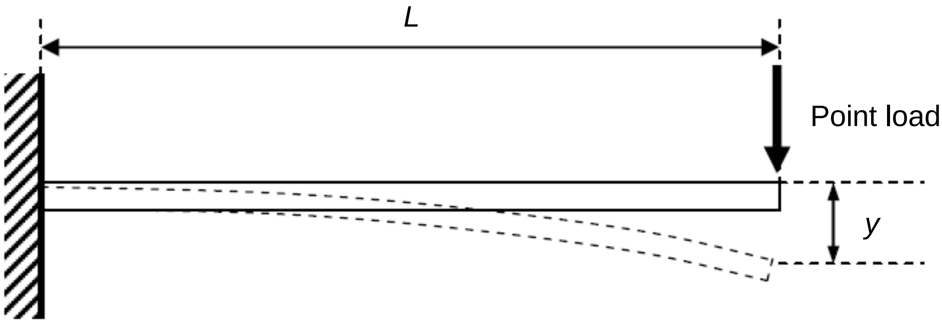


Fig. 5.1

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

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

where

k is a constant
b = breadth of cantilever
h = height of cantilever

(a) The student first used two steel cantilevers to investigate the relationship between *y*, *P* and *L*. He first kept *L* constant and varied *P* to obtain the results as shown in Fig. 5.2.

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

Fig. 5.2

The graph showing the relationship between *y* and *P* for Cantilever A has been sketched on Fig. 5.3. Some of the data points of Cantilever B have also been plotted in Fig. 5.3.

(i) Complete Fig. 5.2. [1]

(ii) On Fig. 5.3, plot the point for P = 40 N and sketch the graph to show the relationship between *y* and *P* for Cantilever B.

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

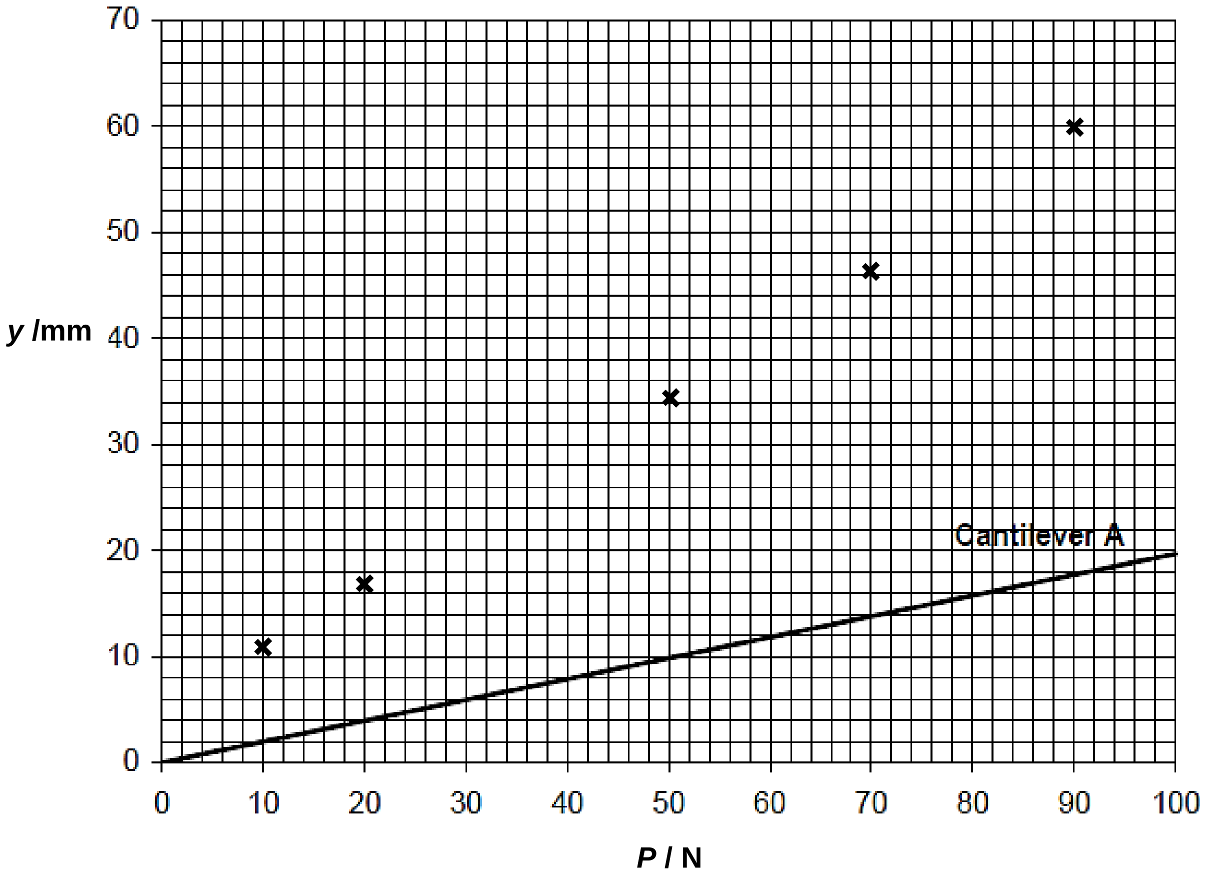


Fig. 5.3 [2]

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

....

....

.... [2]

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

....

....

.... [2]

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

.... [1]

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

....

.... [1]

(b) The student continued his investigation by keeping P constant and varying L, obtaining the results for Cantilever A as shown in Fig. 5.4.

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

Fig. 5.4

These results did not suggest direct proportionality between y and L. The student proceeded to sketch a graph showing the variation of lg y against lg L as shown in Fig. 5.5.

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

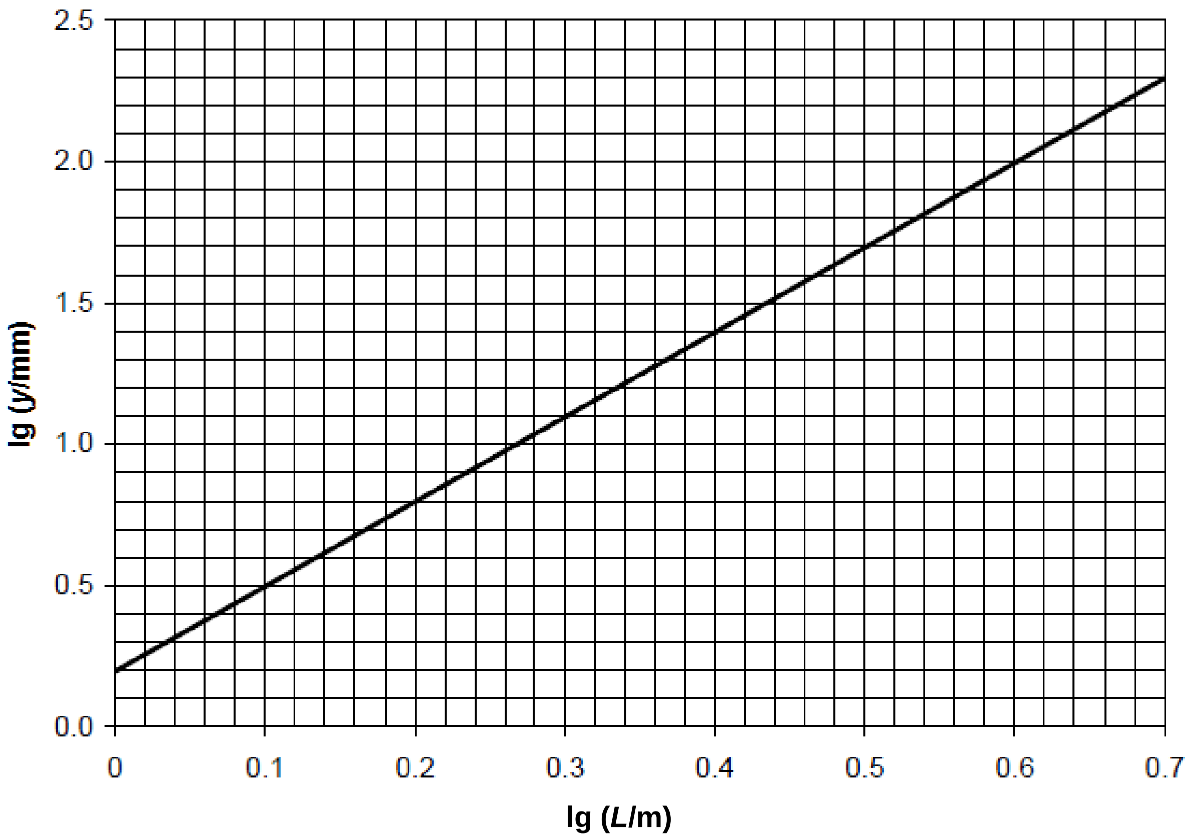


Fig. 5.5

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

gradient = ... [2]

(ii) Hence discuss whether the data in Fig. 5.4 support Equation 1.

....

....

.... [2]

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

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

[2]

(ii) A steel cantilever has breadth 0.12 m, height of 0.040 m and length of 2.0 m as shown in Fig. 5.6. If a point load of 1.0 kN is applied at the end, a vertical deflection of 2.0 cm was measured at the end.

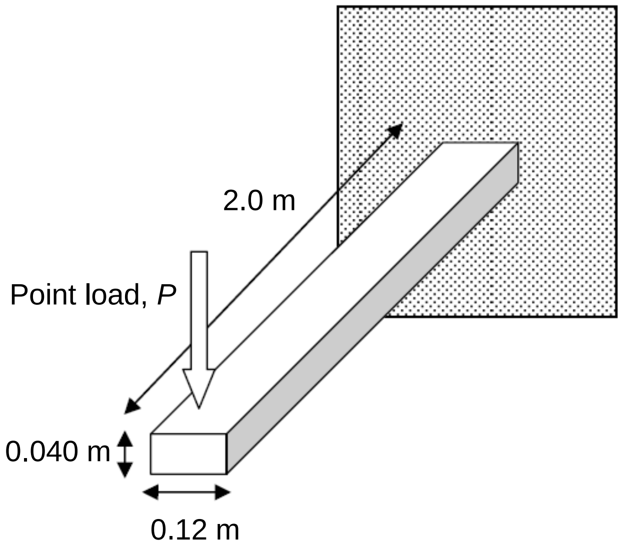


Fig. 5.6

Calculate the Young's Modulus of steel.

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

(iii) To increase the maximum allowable load for a given vertical deflection, the student proposed to orientate the direction of the steel cantilever in **(c)(ii)** differently to the new orientation as shown in Fig. 5.7.

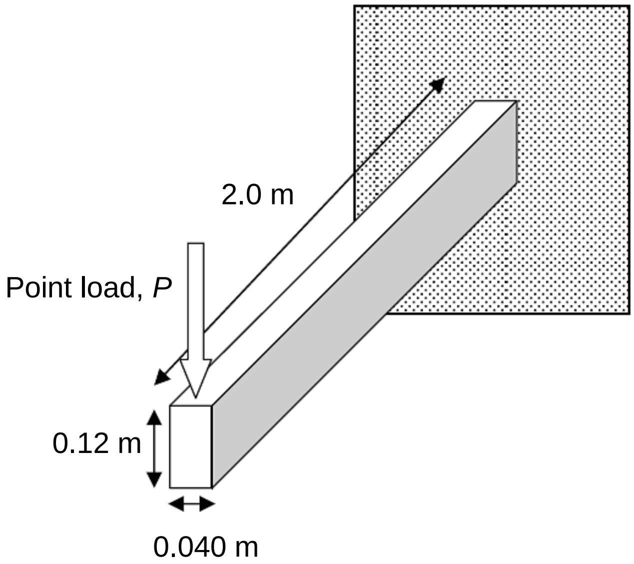


Fig. 5.7

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

....

....

....

.... [2]

(iv) In the construction industry, steel beams normally come in an "I" shape with a cross section as shown in Fig. 5.8.

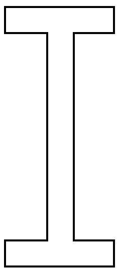


Fig. 5.8

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

....

.... [1]

6 **(a)** **(i)** Define gravitational field strength.

....

.... [1]

(ii) Define gravitational potential.

....

.... [1]

(iii) State how gravitational field strength is related to gravitational potential.

....

.... [1]

(b) A binary star system consists of two stars P and Q, with masses M_1 and M_2 respectively, rotating about a common centre. The centres of the two stars are separated by a distance $R = 1.2 \times 10^{10}$ m. The total gravitational potential due to both stars at any point along a line joining their centres is ϕ.

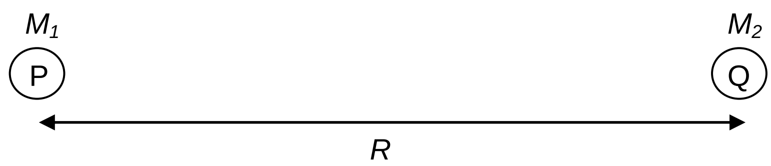


Fig. 6.1 shows how ϕ varies with the distance x from the centre of star P.

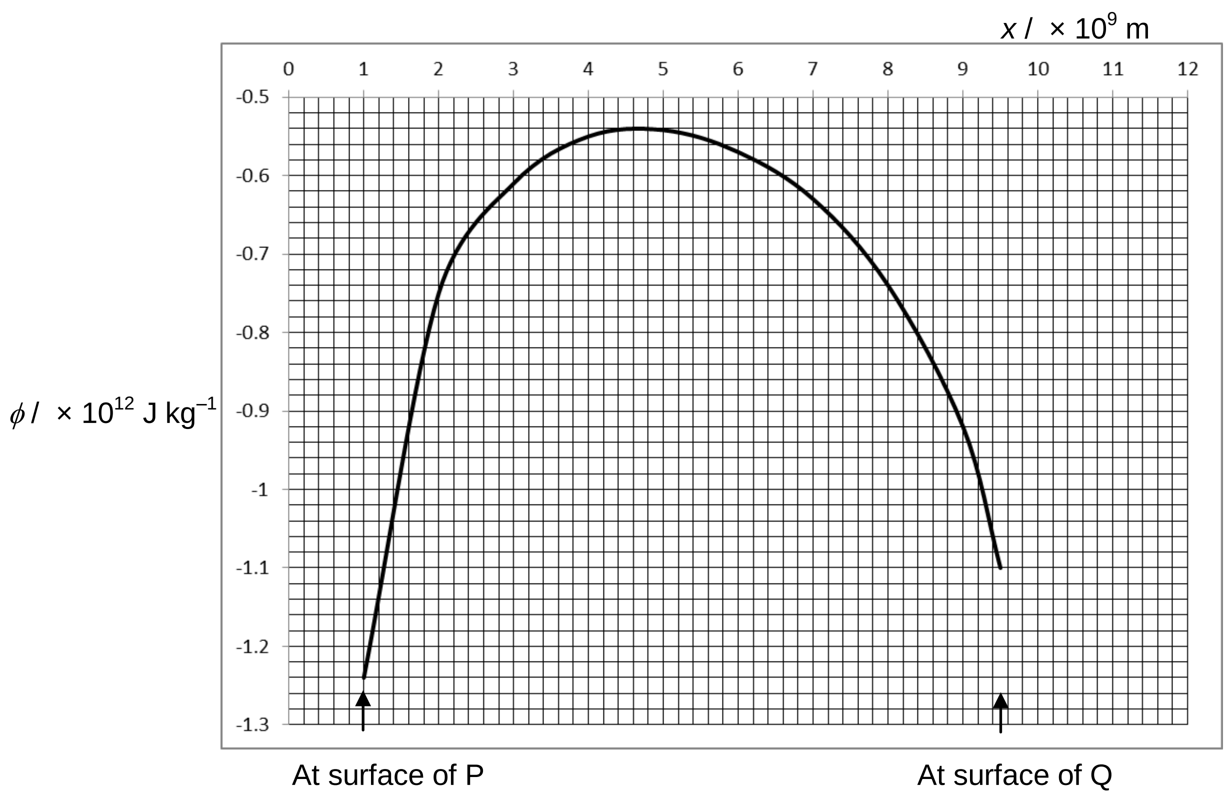


Fig. 6.1

(i) Describe the feature of the graph which shows that the masses of stars P and Q are different.

....

.... [1]

(ii) State the kinetic energy per unit mass required by a particle to completely escape from the gravitational field of the binary star system.

.... [1]

(iii) Calculate the minimum speed at which a particle should be ejected from the surface of Q to reach the surface of P.

minimum speed = ... m s^{-1} [3]

(iv) State the distance *x* from the center of P to the point at which the gravitational field strength due to the two stars is zero.

.... [1]

(v) Hence determine the ratio M_1 / M_2.

M_1 / M_2 = ... [3]

(c) The Earth may be considered to be a uniform sphere of radius 6380 km with its mass of 5.98 $\times 10^{24}$ kg concentrated at its centre.

A mass of 1.00 kg on the Equator rotates about the axis of the Earth with a period of 1.0 day (8.64×10^4 s).

Calculate, to three significant figures,

(i) the gravitational force F_G of attraction between the mass and the Earth,

F_G = ... N [2]

(ii) the centripetal force F_C on the 1.00 kg mass,

F_C = ... N [2]

(iii) the difference in magnitude of the forces calculated in **(c)(i)** and **(c)(ii)**.

difference in magnitude of forces = ... N [2]

(d) By reference to your answers in **(c)**, suggest, with a reason, a value for the acceleration of free fall at the Equator.

. .

....

....

....

.... [2]

END OF PAPER