Candidate Marks Report

Series : 6 2018

This candidate's script has been assessed using On-Screen Marking. The marks are therefore not shown on the script itself, but are summarised in the table below.

Centre No :		Assessment Code :	H556
Candidate No :		Component Code :	01
Candidate Name :			

Total Marks : 58 / 100

In the table below ‘Total Mark’ records the mark scored by this candidate.
‘Max Mark’ records the Maximum Mark available for the question.

Paper:	H556/01
Paper Total:	58 / 100

Question	Total / Max Mark Mark
1	1 / 1
2	1 / 1
3	1 / 1
4	1 / 1
5	0 / 1
6	1 / 1
7	1 / 1
8	0 / 1
9	0 / 1
10	0 / 1
11	NR / 1
12	NR / 1
13	NR / 1
14	NR / 1
15	0 / 1
16ai	1 / 1
16aii	2 / 2
16aiii	1 / 1
16aiv	2 / 2
16b	1 / 6
17ai	1 / 1
17aii	2 / 2
17aiii	0 / 3
17bi	1 / 1
17bii 1	2 / 2
17bii 2	1 / 1
17bii 3	2 / 2
17ci	0 / 2
17cii	0 / 2
18a	2 / 2

18bi	3 / 3
18bii	2 / 2
18biii	2 / 2
19a	1 / 1
19bi	2 / 2
19bii	1 / 1
20a	2 / 2
20bi	1 / 3
20bii	2 / 2
20biii 1	1 / 2
20biii 2	0 / 2
21a	1 / 2
21b	1 / 3
21c	3 / 3
22ai	1 / 1
22aii	1 / 3
22b	3 / 6
23a	1 / 1
23bi	0 / 3
23bii	1 / 1
23c	4 / 4
24a	1 / 1
24bi	0 / 3
24bii	0 / 1
24biii	0 / 1

SECTION A

You should spend a maximum of 30 minutes on this section.

Write your answer to each question in the box provided.

Answer **all** the questions.

1 Which of the following units is **not** an S.I. base unit?

A ampere

B mole

C volt

D kilogram

Your answer C

[1]

2 Which set of quantities are all scalar?

x **A** acceleration, displacement, velocity

✓ **B** energy, mass, power

x **C** extension, force, gravitational potential energy

x **D** weight, kinetic energy, work done

Your answer B

[1]

3 A metal block of mass 0.28 kg has an initial temperature of 82 °C. It is dropped into cold water. The temperature of the block after 1.2 minutes is 20 °C.
The specific heat capacity of the metal is 130 J kg^{-1} K^{-1}.

What is the average thermal power transferred away from the metal block?

A 31 W

B 41 W

C 1900 W

D 2700 W

$\frac{E}{t} = \frac{mc\Delta\theta}{t}$

Your answer A

[1]

4 The acceleration a of a simple harmonic oscillator is related to its displacement x by the equation

$$a = -25\,x.$$

What is the frequency of the oscillator?

$a = -\omega^2 x$

$25 = (2\pi f)^2$

$5 = 2\pi f$

$= 0.79$

A 0.80 Hz

B 1.3 Hz

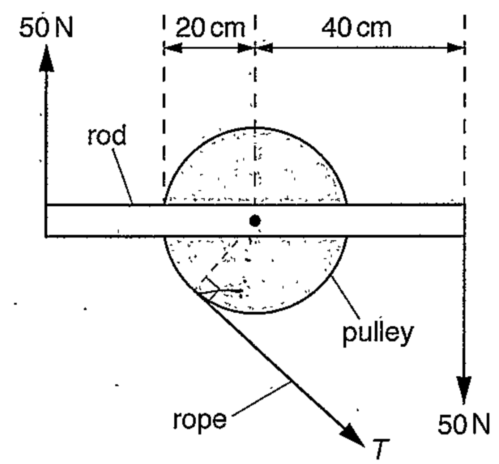
C 4.0 Hz

D 5.0 Hz

Your answer $\boxed{A}$ **[1]**

5 A rod is fixed to a pulley. Two 50 N forces are applied to the ends of the rod as shown. The tension in the rope attached to the pulley is T. The system is in equilibrium.

the centre of a rod



Not to scale

What is the moment of the tension T about the centre of the pulley?

A 10 N m

B 20 N m

C 30 N m

D 40 N m

$M(c)$: TCM = TAM

$50 \times 40 \times 10^{-3} = 20 \times 10^{-3} \times 50 \times T$

Your answer $\boxed{B}$ **[1]**

6 The latent heat of vaporisation of a liquid is 2300 kJ kg^{-1} and it has a molar mass of 0.018 kg mol^{-1}.

What is the energy required to change 30 moles of the liquid to gas?

A 4.1×10^4 J

B 1.2×10^6 J

C 6.9×10^7 J

D 3.8×10^9 J

$E = mL$

$n = 30$

$E = 0.54 \times 2300$

~~$m = nM$~~

$m = nM$

$= 30 \times 0.018$

$= 0.54$

Your answer $\boxed{B}$ **[1]**

7 One end of a spring is fixed and a force F is applied to its other end. The elastic potential energy in the extended spring is E. The spring obeys Hooke's law.

What is the extension x of the spring?

A $x = \dfrac{E}{F}$

B $x = \dfrac{F}{E}$

C $x = \dfrac{2E}{F}$

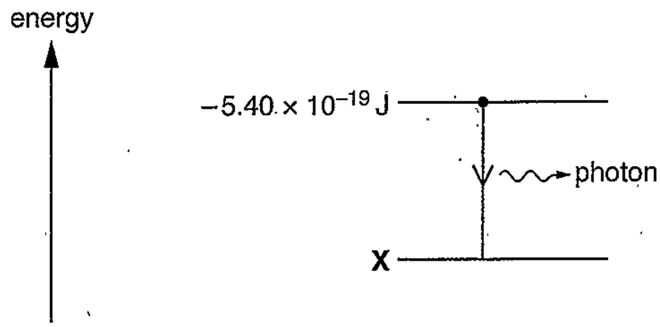
D $x = \dfrac{F}{2E}$

$E = \frac{1}{2} Fx$

$\dfrac{2E}{F}$

Your answer $\boxed{C}$ **[1]**

8 An electron makes a transition between the two energy levels shown below.



This transition produces a photon of frequency 4.10×10^{14} Hz.

What is the value of the energy level **X**?

$\cancel{E = \frac{hc}{\lambda}}$

$E = hf$

A -2.68×10^{-19} J

B -2.72×10^{-19} J

C -5.40×10^{-19} J

D -8.12×10^{-19} J

Your answer B **[1]**

9 A pendulum is oscillating in air and experiences damping.

Which of the following statements is/are correct for the damping force acting on the pendulum?

x 1 It is always opposite in direction to acceleration.
x 2 It is always opposite in direction to velocity.
3 It is maximum when the displacement is zero.

x **A** Only 1 and 2

B Only 2 and 3

C Only 3

✓ **D** 1, 2 and 3

Your answer C **[1]**

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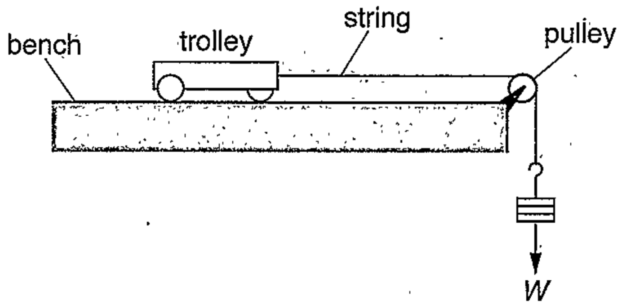
10 A trolley of mass M is pulled along a horizontal table by a force W provided by a mass hanging from the end of a string as shown.



Frictional forces are negligible. The acceleration of free fall is g.

What is the correct equation for the acceleration a of the trolley?

A $a = \dfrac{W}{M}$

$a = \frac{F}{m}$

B $a = g$

C $a = \dfrac{W}{2M}$

D $a = \dfrac{W}{M + \frac{W}{g}}$

Your answer A

[1]

11 The table below shows some data on two wires **X** and **Y**.

Wire	Young modulus of material / GPa	Cross-sectional area of wire / mm^2
X	120	1.0
Y	200	2.0

The wires **X** and **Y** have the same original length. The tension in each wire is the same. Both wires obey Hooke's law.

What is the value of the ratio $\frac{\text{extension of } \mathbf{X}}{\text{extension of } \mathbf{Y}}$?

A 0.30

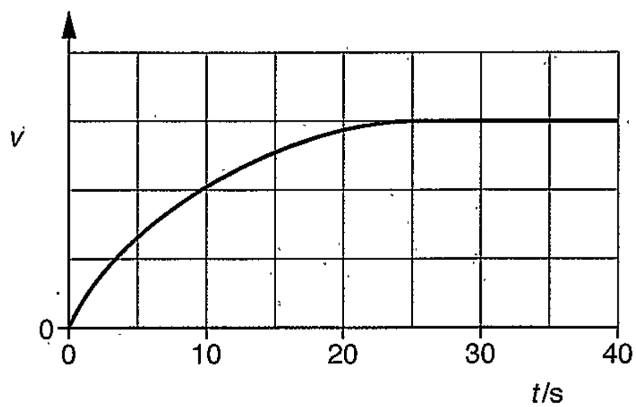
B 1.7

C 2.0

D 3.3

Your answer [1]

12 An object is dropped from rest at time $t = 0$. It falls vertically through the air. The variation of the velocity v with time t is shown below.



Which statement is correct about this object?

A It has constant acceleration.

B It experiences zero drag at $t = 30$ s.

C It has an acceleration of $9.81\,m\,s^{-2}$ at $t = 0$ s.

D It travels the same distance in every successive 10 s.

Your answer [1]

* 0009652295307 *

13 Earth has a mass of 6.0×10^{24} kg and a radius of 6400 km.
A satellite of mass 320 kg is lifted from the Earth's surface to an orbit 1200 km above its surface.

What is the change in the gravitational potential energy of the satellite?

A 9.1×10^{2} J

B 9.9×10^{6} J

C 3.2×10^{9} J

D 3.8×10^{9} J

Your answer [ ] **[1]**

14 The volume of one mole of an ideal gas is V. The gas exerts pressure p and has thermodynamic temperature T.

Which of the following has the units $\text{J mol}^{-1}\text{K}^{-1}$?

A pV

B $\dfrac{p}{T}$

C $\dfrac{V}{T}$

D $\dfrac{pV}{T}$

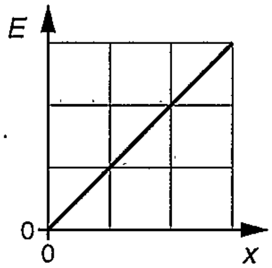
Your answer [ ] **[1]**

* 0009652295308 *

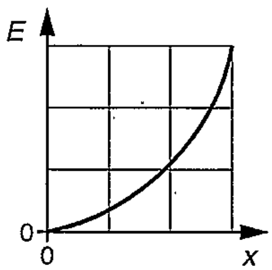
15 An object oscillates with simple harmonic motion.

Which graph **best** shows the variation of its potential energy E with distance x from the equilibrium position?

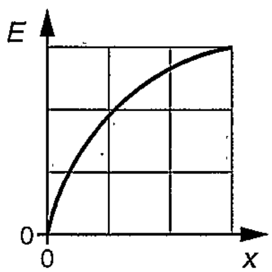
A



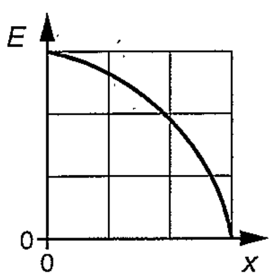
B



C



D



Your answer D **[1]**

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SECTION B

Answer **all** the questions.

16 **(a)** A tennis ball is struck with a racket.
The initial velocity v of the ball leaving the racket is $30.0\,\mathrm{m\,s^{-1}}$ and it makes an angle of 70° to the horizontal as shown in Fig. 16.
Air resistance is negligible

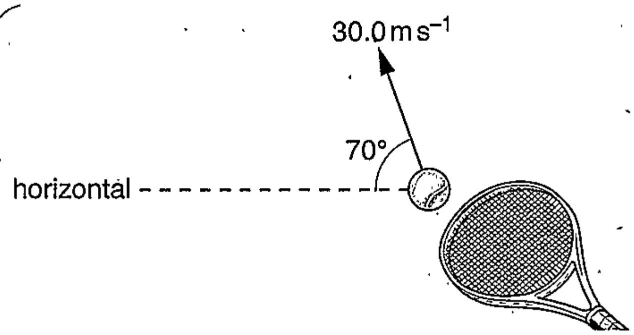


Fig. 16

(i) Calculate the vertical component of the initial velocity of the ball.

$R(\uparrow)$: $v = 30\sin 70 = 28.19$
$= 28.2$

vertical component = ...28.2...... $\mathrm{m\,s^{-1}}$ **[1]**

sf?

(ii) Use your answer in **(i)** to show that the ball reaches a maximum height h of about 40 m.

$R(\uparrow)$:

S	U	V	A	T
?	$30\sin 70$ $= 28.2$	0	-9.81	×

$v^2 = u^2 + 2as$

$s = \dfrac{v^2 - u^2}{2a} = \dfrac{0 - 28.2^2}{2 \times -9.81} = 40.5\,\mathrm{m}$
$= 40 = 41$

h = ...40.5...... m **[2]**

(iii) Explain why the kinetic energy of the ball is not zero at maximum height.

the horizontal component of ~~?~~ velocity is constant ($v \neq 0$) $KE = \frac{1}{2}mv^2$, $KE \neq 0$ **[1]**

(iv) The mass m of the ball is 57.0 g.
Calculate the kinetic energy E_k of the ball when it is at its **maximum** height.

$KE = \frac{1}{2}mv^2$

velocity:
$R(\rightarrow)$: $30\cos 70$

$R(\uparrow)$: 0

$\sqrt{(30\cos 70)^2 + 0^2}$

$= 10.26\ ms^{-1}$

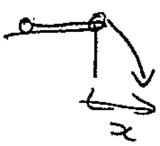
$KE = \frac{1}{2} \times 57\times10^{-3} \times (10.26)^2$

$= ~~0.29924\ J~~$

$= 3.00$

E_k = ~~0.292~~ 3.00 J **[2]**

(b)* A metal ball is rolled off the edge of a horizontal laboratory bench. The initial horizontal velocity of the ball is v. The ball travels a horizontal distance x before it hits the level floor.

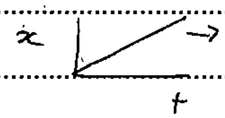


Use your knowledge of projectile motion to suggest the relationship between v and x. Describe how an experiment can be safely conducted to test this relationship and how the data can be analysed.

nor.

horizontal component of velocity remains constant when an object undergoes projectile motion.

$R(\rightarrow)$: $x = vt$



velocity constant.

$y = mx + c$

^

L1

* 0009652295312 *

.... [6]

* 0009652295313 *

17 **(a)** Phobos is one of the two moons orbiting Mars. Fig. 17.1 shows Phobos and Mars.

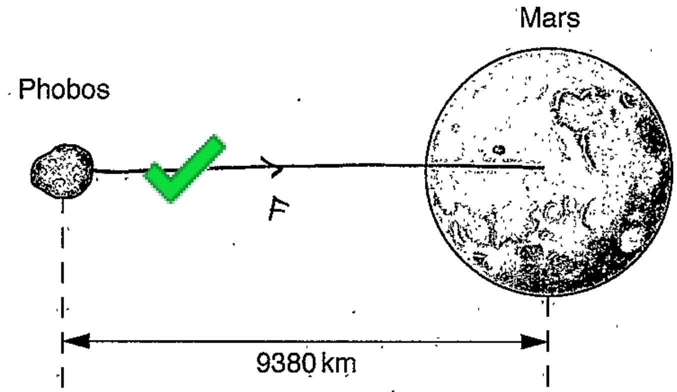


Fig. 17.1

The orbit of Phobos may be assumed to be a circle. The centre of Phobos is at a distance 9380 km from the centre of Mars and it has an orbital speed $2.14 \times 10^3\,\text{m s}^{-1}$.

(i) On Fig. 17.1, draw an arrow to show the direction of the force which keeps Phobos in its orbit. **[1]**

(ii) Calculate the orbital period T of Phobos.

v
r

$$v = \frac{2\pi r}{T}$$

$$T = \frac{2\pi r}{v} = \frac{2\pi \times (9380 \times 10^3)}{2.14 \times 10^3}$$

$$= 2.75 \times 10^4$$

T = 2.75 × 10⁴ s **[2]**

(iii) Calculate the mass M of Mars.

$$T^2 = \frac{4\pi^2}{GM} r^3$$

~~$\frac{T^2}{r^3}$ x M = G~~

$$M = \frac{4\pi^2 \times r^3}{T^2}$$

XP ^

$$= \frac{4\pi^2 \times (9380 \times 10^3)^3}{(2.754 \times 10^4)^2}$$

$= \cancel{4.30}$ $= 4.296 \times 10^{13}$

M = 4.30×10^{13} kg **[3]**

$g \propto \frac{1}{r^2}$

(b) The gravitational field strength at a distance r from the centre of Mars is g.

The table below shows some data on Mars.

g/N kg^{-1}	r/km	lg (g/N kg^{-1})	lg (r/km)
1.19	6000	0.076	3.78
0.87	7000	−0.0605	3.85
0.67	8000	−0.174	3.90
0.53	9000	−0.276	3.95
0.43	10000	−0.367	4.00

(i) Complete the table by calculating the missing values. **[1]**

(ii) Fig. 17.2 shows the graph of lg (g / N kg^{-1}) against lg (r/km).

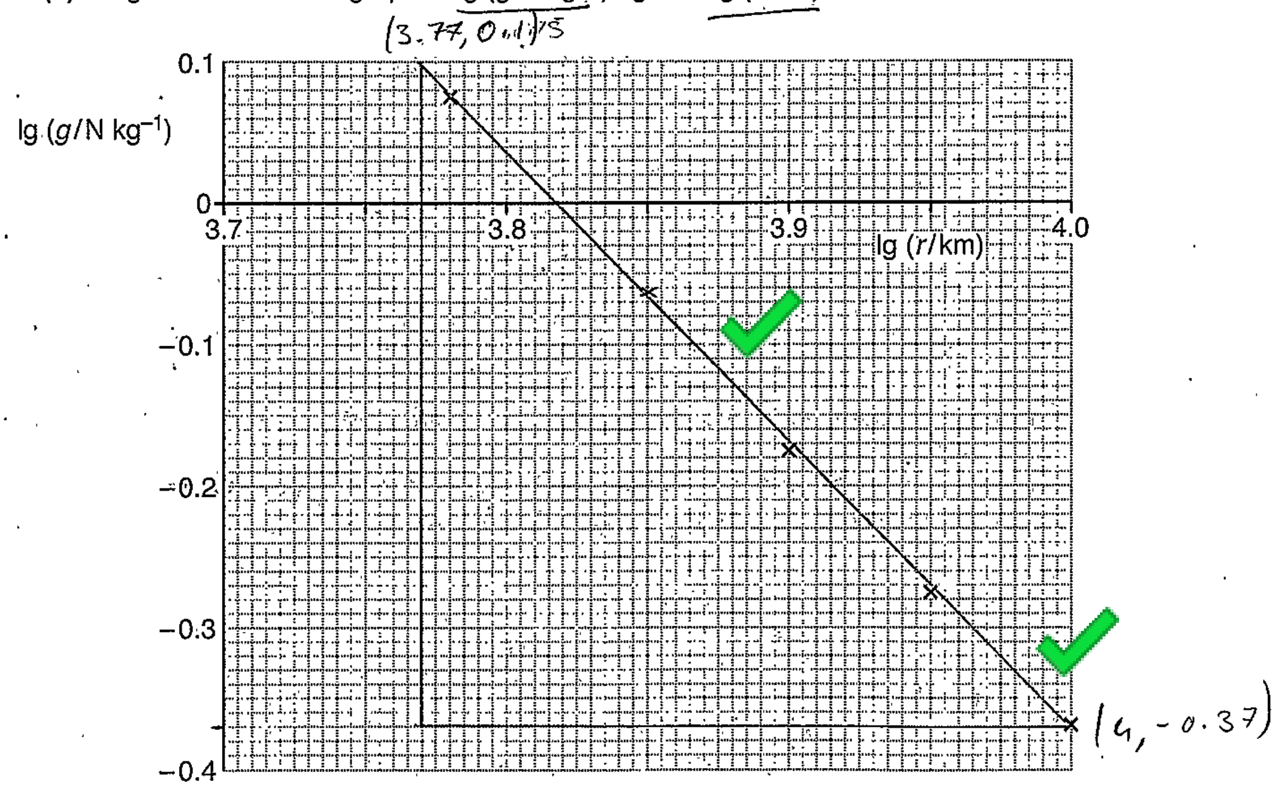


Fig. 17.2

1 Plot the missing data point on the graph and draw the straight line of best fit. **[2]**

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2 Use Fig. 17.2 to show that the gradient of the straight line of best fit is −2.

$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-0.37 - 0.1}{4 - 3.77}$

$= -2.04\ldots$

gradient. $\cancel{m}$ $= -2$

[1]

3 Explain why the gradient of the straight line of best fit is −2.

gravitational field strength is

inversely proportional to $\frac{1}{r^2}$ ...

$g = -\frac{GM}{r^2}$

$\log g = -(\log G + \log m) - \log r^2$

$\log g = -(\log G + \log m) + 2 \log r$

~~$\log g = \log GM + 2 \log r$~~

$\log g = -2 \log r \cancel{+ \log}$ BOD

$y = mx + c$

↳ log g is y axis

↳ log r is x axis

↳ m = gradient

$m = -2$

[2]

(c) In July 2018, the closest distance between the centre of Mars and the centre of Earth will be 5.8×10^{10} m.

Fig. 17.3 shows the variation of the **resultant** gravitational field strength g between the two planets with distance r from the centre of the **Earth**.

$g = -\frac{F}{m}$

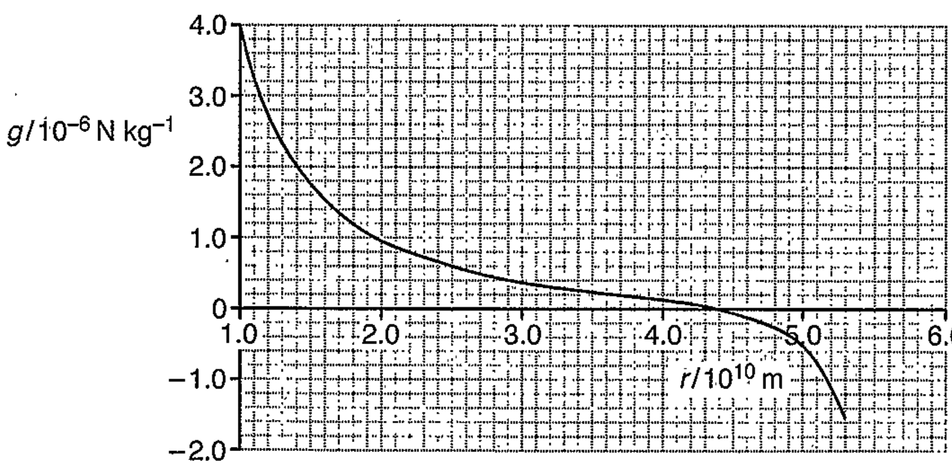


Fig. 17.3

(i) Explain briefly the overall shape of the graph in Fig. 17.3.

~~from 1.0 to~~ from 1.0×10^{10} m to ~~6.0~~ 4.4×10^{10} m, g tends towards zero as r tends towards infinity. As g decreases, ~~r in~~ r increases as $g \propto -\frac{1}{r^2}$ r = radius
g = gravitational field strength [2]

(ii) Use the value of r when $g = 0$ from Fig. 17.3 to determine the ratio

$$\frac{\text{mass of Earth}}{\text{mass of Mars}}.$$

$g = 0$
$\rightarrow r = 4.4 \times 10^{10}$ m

~~for~~ $g = \frac{F}{m}$

$g = \frac{-GM}{r^2}$

$$\frac{\text{mass of Earth}}{\text{mass of Mars}} = \text{..............................} \quad [2]$$

* 0009652295317 *

18 Wind turbines convert the kinetic energy of the wind into electrical energy.
Fig. 18 shows a wind turbine.

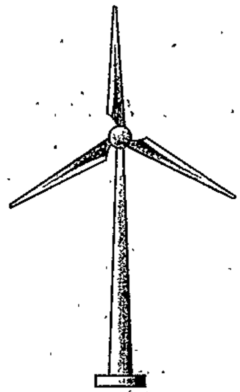


Fig. 18

(a) When the wind speed is $8.0\,\text{m}\,\text{s}^{-1}$, the kinetic energy of the air incident at the turbine per second is $1.2\,\text{MJ}\,\text{s}^{-1}$.
Calculate the mass of the air incident at the turbine per second.

$\cancel{KE = \frac{1}{2}mv^2}$ $KE = \frac{1}{2}mv^2$

$\frac{2KE}{v^2} = m$

$m = \frac{2 \times 1.2 \times 10^6}{8^2}$ $37500\,\text{kg}\,\text{s}^{-1}$

mass per second = ...38000........ $\text{kg}\,\text{s}^{-1}$ **[2]**

(b) A group of engineers are investigating the design of wind turbines.
The maximum **input** power P from the wind is given by the equation

$$P = \frac{1}{2}\rho A v^3$$

where A is the area swept out by the rotating blades, ρ is the density of air and v is the speed of the wind.

(i) Show that the equation is homogeneous with both sides of the equation having the same base units.

$F = ma$
$m \rightarrow kg$
$a \rightarrow m s^{-2}$

LHS:
$P \rightarrow J s^{-1} = \frac{E}{t}$
~~=Ext~~
$E \rightarrow J \rightarrow Nm \rightarrow kg m s^{-2} \times m$
$P \Rightarrow kg m^2 s^{-2} \times s^{-1}$
$= kg m^2 s^{-3}$

RHS:
$\frac{1}{2} \rho A v^3$
$\rho \rightarrow \frac{m}{V}$ $A \rightarrow m^2$
$m \rightarrow kg$
$V \rightarrow m^3$
$v^3 = (m s^{-1})^3$
$\Rightarrow \frac{kg}{m^3} \times m^2 \times m^3 s^{-3}$
$\Rightarrow kg m^2 s^{-3}$

LHS = RHS
∴ homogeneous on both sides.

[3]

(ii) The input power to the wind turbine is 1.2 MW when the wind speed is 8.0 m s^{-1}. The density of air is 1.3 kg m^{-3}.

Calculate the length L of the turbine blades.

$P = \frac{1}{2} \rho A v^3$

$A = \pi r^2$
↳ find r

$\frac{2P}{\rho v^3} = A = \pi r^2$

$r =$

$r^2 = \frac{2P}{\rho v^3 \pi}$

$r = \sqrt{\frac{2 \times 1.2 \times 10^6}{1.3 \times 8^3 \times \pi}} = 33.8 m$

L = ...34.... m **[2]**

(iii) A wind farm is required to produce an output power of 50 MW when the average wind speed is 8.0 m s^{-1}. The efficiency of each wind turbine is 42%.

Calculate the minimum number N of wind turbines required to meet this demand.

→ find input power ~~(Ath~~
→ find output power (eff)
→ no. turbines for 50MW

~~$P = \frac{1}{2} \rho A v^3$~~
input power
$P = \frac{1}{2} \rho A v^3$
~~$= \frac{1}{2} \times 1.3 \times (\pi \times 33.8^2)$~~

Pout

$eff = \frac{P_{out}}{P_{in}} \times 100$

$P = \frac{1}{2} \times 1.3 \times (\pi \times 33.8^2) \times 8^3$
$= 1.19 \times 10^6$ W

$0.42 \times 1.19 \times 10^6 = 5.017 \times 10^5$ W
$50 \times 10^6 \div 5.017 \times 10^5 = 99.66$
$= 100$

N = ...100.... **[2]**

* 0009652295319 *

19 Fig. 19 is an incomplete Hertzsprung-Russell (HR) diagram of stars in our galaxy.

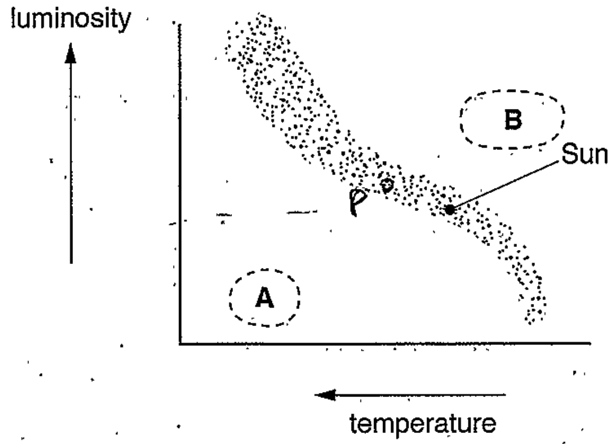


Fig. 19

The position of the Sun on the HR diagram is shown in Fig. 19.

(a) State the type of stars found in regions **A** and **B**.

A ......White Dwarf.............. **B** ......Red Giant........ **[1]**

(b) The Sun is a main sequence star. Its surface temperature is 5800 K. The wavelength of the emitted light at maximum intensity is 550 nm.

Beta Pictoris is also a main sequence star. The wavelength of the emitted light at maximum intensity from this star is 370 nm.

(i) Calculate the surface temperature of Beta Pictoris.

$L = 4\pi r^2 \sigma T^4 \qquad \lambda_{max} \propto \frac{1}{T}$

$T = \frac{\text{Wein's const.}}{\lambda_{max}}$

$\lambda_{max_{Sun}} \times T$
$= 5800 \times 550 \times 10^{-9}$
$= 3.19 \times 10^{-3}$

$T = \frac{3.19 \times 10^{-3}}{370 \times 10^{-9}}$
$= 8.62 \times 10^3 K$

temperature = ...8.6×10^3....... **[2]**

(ii) On Fig. 19, mark the likely position of Beta Pictoris with a letter **P**. **[1]**

→ ~~brighter~~ → hotter

→ ~~less bright~~ → hotter brigh

8.6×10^3 ≈ 8600

20 (a) Use the equations for momentum and kinetic energy to derive an expression for the kinetic energy E_k of a particle in terms of its momentum p and mass m.

$KE = \frac{1}{2} m v^2$ $\cancel{KE=}$

$p = mv$

$v = \frac{p}{m}$

$KE = \frac{1}{2} \times \cancel{m} \times \left(\frac{p^2}{m^2}\right)$

$KE = \frac{1}{2} \frac{p^2}{m}$

[2]

(b) Fig. 20.1 shows an electric motor used to lift and lower a load.

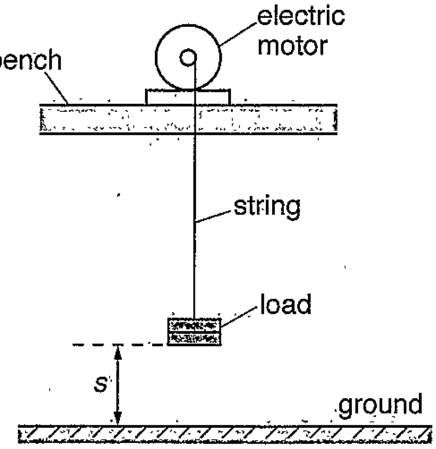
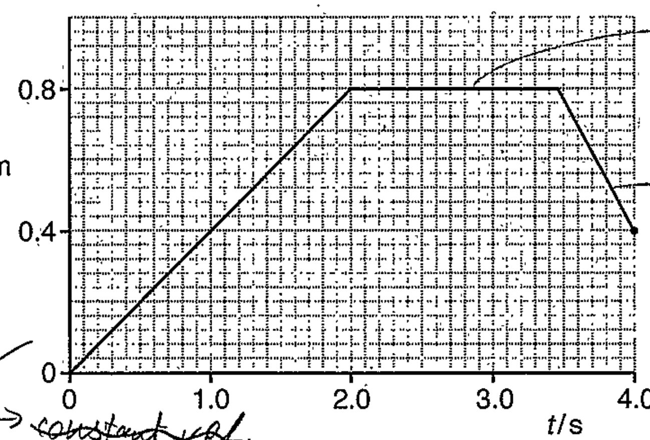


Fig. 20.1

* 0009652295321 *

At time $t = 0$ the load is on the ground with displacement $s = 0$.
Fig. 20.2 shows the variation of the displacement s of the load with time t.

grad = v



stat

constant vel -ive.

~~constant vel.~~
constant vel

Fig. 20.2

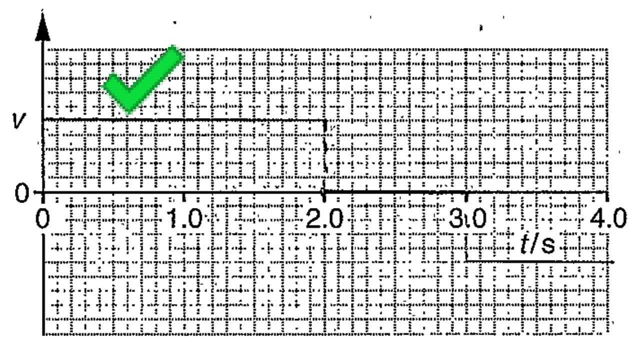


Fig. 20.3

(i) On Fig. 20.3, sketch a graph to show the variation of the velocity v of the load with time t. You do not need to insert a scale on the v axis. **[3]**

(ii) Describe how the kinetic energy and the gravitational potential energy of the load varies from $t = 0$ to $t = 2.0$ s.

V is constant from 0 → 2.0s, so ~~ke~~ kinetic energy is constant. (displacement is increasing at a constant rate from 0→2s, so GPE is increasing at a constant rate. **[2]**

(iii) During the **downward** journey of the load, the string breaks at $t = 4.0$ s. It then falls vertically towards the ground. The mass of the load is 120 g. Air resistance is negligible.

↪ $s = 0.4$

1 Calculate the velocity V of the load just before it hits the ground.

R(↓): s u v a t

0.4 0.4 ? 9.81 x

~~KE = ½ p²/m~~

vel = (y₂ − y₁)/(x₂ − x₁)

$= \frac{0.8 - 0}{2 - 0} = 0.4$

$v^2 = u^2 + 2as$

$v = \sqrt{0.4^2 + 2 \times 0.4 \times 9.81}$

$= 2.83$

$V =$ ......2.8...... ms^{-1} **[2]**

2 The load hits the ground and comes to **rest** in a time interval of 25 ms.

Calculate the average force F exerted by the ground on the load.

$KE = \frac{1}{2} \frac{p^2}{m}$

$\Delta p = F \times t$

$m(v - u) = F \times t$

$F = \frac{120 \times (2.8 - 0.4)}{25 \times 10^{-3}} = 1.17 \times 10^4$

POT XP

$F =$ ......1.2×10^4...... N **[2]**

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21 Fig. 21 shows the drum of a washing machine.

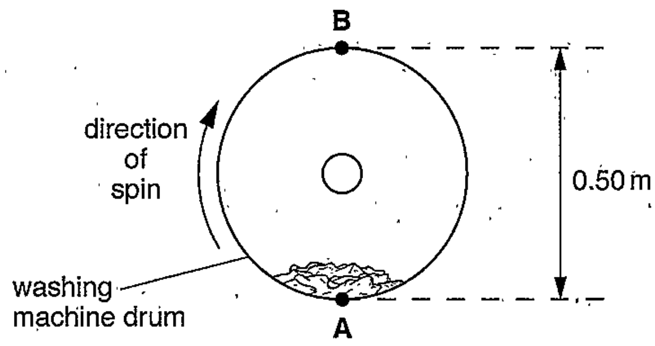

Fig. 21

The clothes inside the drum are spun in a **vertical** circular motion in a clockwise direction.

(a) When the drum is at rest, the weight of the clothes is equal to the normal contact force on the clothes at point **A**.

Explain why these two forces are not an example of Newton's Third Law of motion.

the weight and the normal contact force are acting on the same object not on two different objects. ~~The~~ Weight and normal contact force are not the same force.

.... **[2]**

(b) The drum has diameter 0.50 m. The manufacturer of the washing machine claims that the drum spins at 1600 ± 100 revolutions per minute.

r

↳ ω

Calculate the speed of rotation of the drum and the absolute uncertainty in this value.

radius = 0.25m

$v = \omega r$

% uncert. :

$\frac{100}{1600} \times 100 = 6.25\%$

$v = 1600 \times 0.25$

$= 400$ revs in min^{-1}

↳ mins → seconds

$\frac{400}{60} = 6.6$

$\frac{6.25}{100} \times 6.6 = 0.416$

$= 0.400$

ECF

speed = 6.6 ± ~~0.416~~ 0.4 m s^{-1} **[3]**

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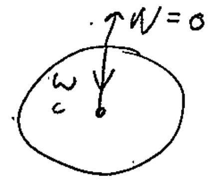
(c) The washing machine is switched off and the speed of the drum slowly decreases. The clothes at the top of the drum at point **B** start to drop off at a certain speed *v*.

At this speed *v*, the normal contact force on the clothes is zero.

Calculate the speed *v*.



at top:
Normal contact force is lowest:
↳ centripetal = weight
= mg

$$F = \frac{\cancel{m}v^2}{r} = \cancel{m}g$$

$$v = \sqrt{gr} = \sqrt{9.81 \times 0.25}$$
$$= 1.57\ ms^{-1}$$

v = 1.6 ms^{-1} **[3]**

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22 (a) A helium atom **X** travelling at $610\,m\,s^{-1}$ makes an elastic collision with a stationary helium atom **Y**. The magnitude of the velocity of **X** after the collision is $258\,m\,s^{-1}$. The directions of the velocities of **X** and **Y** are as shown in Fig. 22.

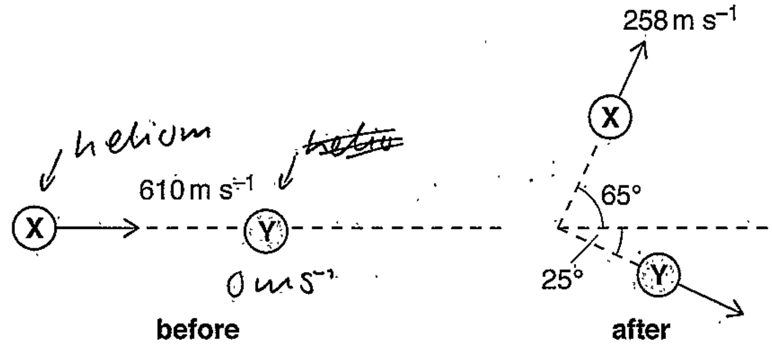

Fig. 22

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

a collision where kinetic energy is conserved **[1]**

(ii) The mass of a helium atom is 6.64×10^{-27} kg.
Calculate the magnitude of the momentum p of **Y** after the collision.

$\rightarrow p = mv$
$\rightarrow$ find m and v of y
cons. momentum:

$R(\rightarrow)$: $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$
$6.64 \times 10^{-27} \times 610 + 0 = 6.64 \times 10^{-27} \times 258 \cos 65 \times m_2 v_2$
$5.5945 = m_y v_y$

~~before~~
$R(\uparrow)$: ~~$KE = \frac{1}{2} m v^2$~~
~~$= \frac{1}{2} \times 610 \times$~~
~~$= \frac{1}{2} \times$~~

p = 5.59 $kg\,m\,s^{-1}$ **[3]**

(b)* There is a lot of helium in the Universe. This was also true of the Earth when it was formed billions of years ago. However, only small traces of helium are now found in the atmosphere of the Earth.

Use the kinetic theory of gases to explain why only small amounts of helium are found in the Earth's atmosphere. Use the information below to do suitable calculations to support your answer.

- typical atmospheric temperature = 10 °C
- mass of helium atom = 6.64×10^{-27} kg
- escape velocity from the Earth = $11\,km\,s^{-1}$

in gases ~~there~~ the molecules have a mean kinetic energy of 5.86×10^{-21} J :

$E_k = \frac{3}{2} kT$

$KE = \frac{3}{2} \times 1.38 \times 10^{-23} \times (10 + 273)$

$= 5.86 \times 10^{-21}$ J

Heavier ~~molecules~~ atoms such as oxygen atoms do not need ~~as~~ a very high velocity to ~~ma~~ maintain a kinetic energy of 5.86×10^{-21} J. However, ~~the~~ lighter atoms such as helium will need a greater velocity to have this kinetic energy as they have a lower mass.

velocity of helium atom with $KE = 5.86 \times 10^{-21}$ J

$KE = \frac{1}{2} mv^2$

$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2 \times 5.86 \times 10^{-21}}{6.64 \times 10^{-27}}}$

$= 1.33 \times 10^3$ ms^{-1}

the escape velocity is the minimum velocity required for a body to posses to escape a gravitational field. The velocity of the helium atom is greater than the escape velocity of the earth, ∴ they escape the earth's gravitational field.

[6]

L2 ^

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23 **(a)** According to the Cosmological principle, the Universe is isotropic, homogeneous and the laws of physics are universal.

State what is meant by the term *homogeneous*.

matter is evenly distributed throughout the universe ..... **[1]**

(b) Astronomers often use absorption spectral lines to determine the relative velocity of distant galaxies. The wavelength of a specific absorption spectral line observed in the laboratory is 280 nm.

The galaxy RXJ1242-11 is 200 Mpc away from the Earth and it has a massive black hole at its centre.

↳ dist
↳ λ

(i) Calculate in nm the wavelength λ of the same spectral line from RXJ1242-11 when **observed** from the Earth. Assume the Hubble constant is $68\,\text{km}\,\text{s}^{-1}\,\text{Mpc}^{-1}$.

→ $v = H_0 d$
~~↳ use doppler equ. to~~
↳ find velocity
→ use doppler equ. to find λ

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

$$\Delta\lambda = \frac{4.216\times10^{26}}{3\times10^{8}} \times 280\times10^{-9}$$

$\lambda_{lab} - \lambda_{obs.} = 3.935\times10^{11}$

~~$\lambda = 280\times10^{-9} - 3.95\times10^{11}$~~

$v = H_0 d$

~~$v = 68\times200$~~

$v = 68 \times 200 \times 10^{6}$

$v = 1.36\times10^{10}$ ~~ms^{-1}~~ pc s^{-1}

$v = 1.36\times10^{10} \times 3.1\times10^{16} = 4.216\times10^{26}\ \text{ms}^{-1}$

~~$\lambda = 3.95\times10^{11}$~~ $3.9349\ldots\times10^{11}$

~~$\lambda = 280\times10^{-9} - 3.95\times10^{11}$~~ $= 2.$

λ = ...3...... nm **[3]**

(ii) State one of the characteristics of a black hole.

~~a body would need an ... velocity~~

escape velocity = speed of light ($3\times10^{8}\,\text{ms}^{-1}$) ..... **[1]**

(c) The Universe evolved from the Big Bang.

Describe the evolution of the Universe up to the formation of the first nuclei.

$t = 0s \rightarrow$ time and space created
$\rightarrow$ universe a singularity
$t = \times 10^{-35}s \rightarrow$ rapid expansion begins
$\rightarrow$ no matter, ~~a~~ just gamma photons
$\rightarrow$ temperature of universe : $\times 10^{28}K$
$t = \times 10^{-6}s \rightarrow$ first fundimental particles form
$t = \times 10^{-3}s \rightarrow$ quarks combine to form hadrons
$\rightarrow$ ~~particles~~ particles created by pair production
~~t = 10~~
$t = 1s \rightarrow$ temperature cools to $\times 10^{9}K$
$\rightarrow$ matter starts to form
($t = 100s \rightarrow$ protons + neutrons fuse to make lightest nuclei) **[4]**

$\times 10^{-35}$
$\times 10^{-6}$
$\times 10^{-}$

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24 A group of students are conducting an experiment to determine the wavelength of monochromatic light from a laser.
Fig. 24.1 shows the laser beam incident normally at a diffraction grating.

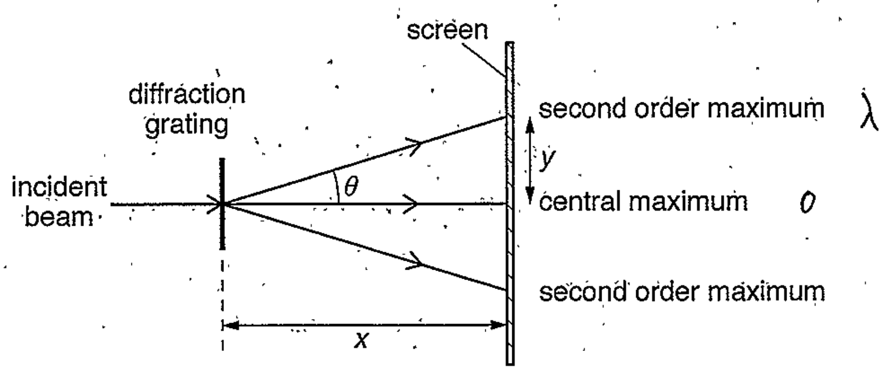
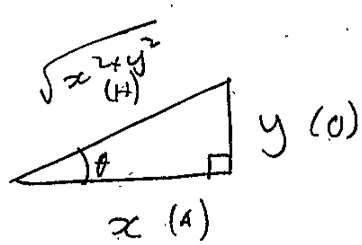


Fig. 24.1

The students use a diffraction grating with 600 lines mm^{-1}. They vary the distance x between the grating and the screen from 1.000 m to 2.000 m. They measure the distance y from the **central** maximum to the **second order** maximum.

(a) The students decide to plot a graph of y against $\sqrt{x^2 + y^2}$.

Show that the gradient of the graph is equal to $\sin\theta$, where θ is the angle between the central maximum and the **second** order maximum.



$\sin\theta = \frac{O}{H}$

$a^2 + b^2 = c^2$

$H^2 = x^2 + y^2$

$H = \sqrt{x^2 + y^2}$

~~gradient of graph = $\frac{\Delta y}{\Delta x}$~~

~~∴ gradient = $\sin\theta = \frac{\Delta y}{\Delta x}$~~

gradient of graph = $\frac{\Delta y}{\Delta \sqrt{x^2+y^2}}$ =

∴ gradient = $\sin\theta = \frac{O}{H} = \frac{y}{\sqrt{x^2+y^2}}$

[1]

(b) Fig. 24.2 shows the graph plotted by the students.

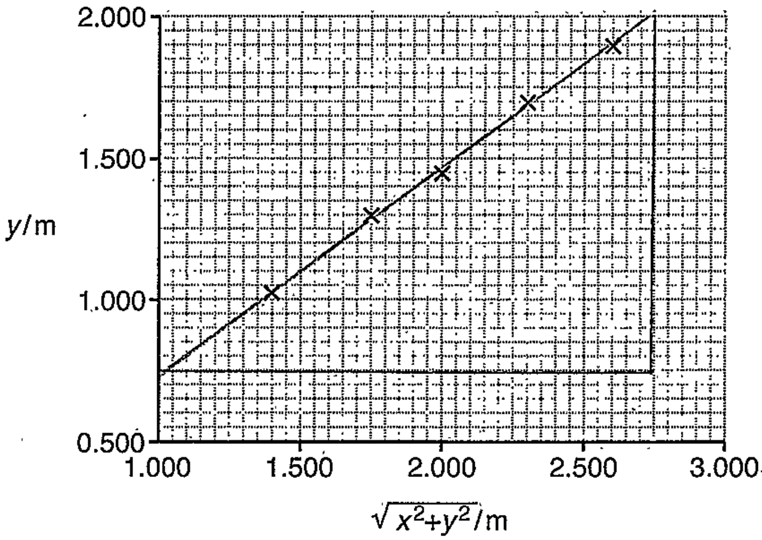


Fig. 24.2

(i) Use Fig. 24.2 to determine an accurate value of the wavelength λ of the light from the laser.

λ = distance from ~~1st order m.~~ central to 2nd order max.

$\lambda = y$

→ find θ, use gradient:

~~m = 2.55 -~~

$m = \frac{2 - 0.75}{2.55 - 1} = 0.806 = \sin\theta$

$\theta = 53.75°$

$\lambda = \frac{ax}{D}$

λ = ... m **[3]**

(ii) Suggest why there are no error bars shown in Fig. 24.2.

no errors recorded.

.... **[1]**

(iii) Suggest how the precision of this experiment may be affected by using a protractor to measure the angle θ.

uncertainty equal to the accuracy of the increment of the protractor .... **[1]**

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

~~22)a) ke before collision:~~

~~$ke_x = \frac{1}{2} mv^2 + 0$~~

~~$= \frac{1}{2} \times 6.64 \times 10^{-27} \times 610^2$~~

~~$= 1.2354 \times 10^{-21}$ J~~

ke after

$\frac{1}{2}$ $ke_x + ke_y$

SEEN

Oxford Cambridge and RSA

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Off Page Comments

Item Name	Comment
24a	Candidate has recognised what the gradient is from the axes. They need delta to show this. They have then compared with opp/hyp for sin theta
23c	Correct order in the mark scheme ('particles created by pair production' ignored)
17aiii	When rearranging Kepler's equation the candidate has omitted G so no marks. C1 is a rearranging mark for the Kepler method (rhs)
16b	One relevant statement but incorrect variables from the equation.
21a	Needs 'not same TYPE of force'
17bii 3	ignore the sign of lg(GM)
23bii	Allow escape velocity > or = speed of light
23bi	v is calculated using quantities with units that do not match
22b	Limited relevant explanation. However correct calculation lifts it to L2.
20bi	Second C1 mark - needs line to extend to 3.5 s Third C1 mark - line needs to extend further in negative v
21b	This is not correct value for omega
22aii	Candidate has made an attempt at conservation of momentum but did not resolve for v2. Gains first marking point only.
24bi	2.55 is an incorrect reading from the graph. It should be 2.75.
19bi	worth noting on MS: lambda * T = 3.19*10^-3