Candidate Name	Centre Number					Candidate Number				
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GCSE

PHYSICS

UNIT 2: FORCES, SPACE and RADIOACTIVITY

HIGHER TIER

SAMPLE ASSESSMENT MATERIALS

(1 hour 45 minutes)

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**11**	
2.	**11**	
3.	**10**	
4.	**8**	
5.	**6**	
6.	**12**	
7.	**11**	
8.	**11**	
Total	**80**	

ADDITIONAL MATERIALS
In addition to this paper you will require a calculator.

INSTRUCTIONS TO CANDIDATES
Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.
Write your name, centre number and candidate number in the spaces at the top of this page
Answer all questions.
Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES
The number of marks is given in brackets at the end of each question or part-question.
Question **5** is a quality of extended response (QER) question where your writing skills will be assessed.

Equations

$\text{speed} = \dfrac{\text{distance}}{\text{time}}$	
$\text{acceleration [or deceleration]} = \dfrac{\text{change in velocity}}{\text{time}}$	$a = \dfrac{\Delta v}{t}$
acceleration = gradient of a velocity-time graph	
distance travelled = area under a velocity-time graph	
resultant force = mass × acceleration	$F = ma$
weight = mass × gravitational field strength	$W = mg$
work = force × distance	$W = Fd$
$\text{kinetic energy} = \dfrac{\text{mass x velocity}^2}{2}$	$\text{KE} = \frac{1}{2}mv^2$
change in potential energy = mass × gravitational field strength × change in height	$\text{PE} = mgh$
force = spring constant × extension	$F = kx$
work done in stretching = area under a force-extension graph	$W = \frac{1}{2}Fx$
momentum = mass × velocity	$p = mv$
$\text{force} = \dfrac{\text{change in momentum}}{\text{time}}$	$F = \dfrac{\Delta p}{t}$
u = initial velocity v = final velocity t = time a = acceleration x = displacement	$v = u + at$ $x = \dfrac{u+v}{2}t$ $x = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2ax$
moment = force × distance	$M = Fd$

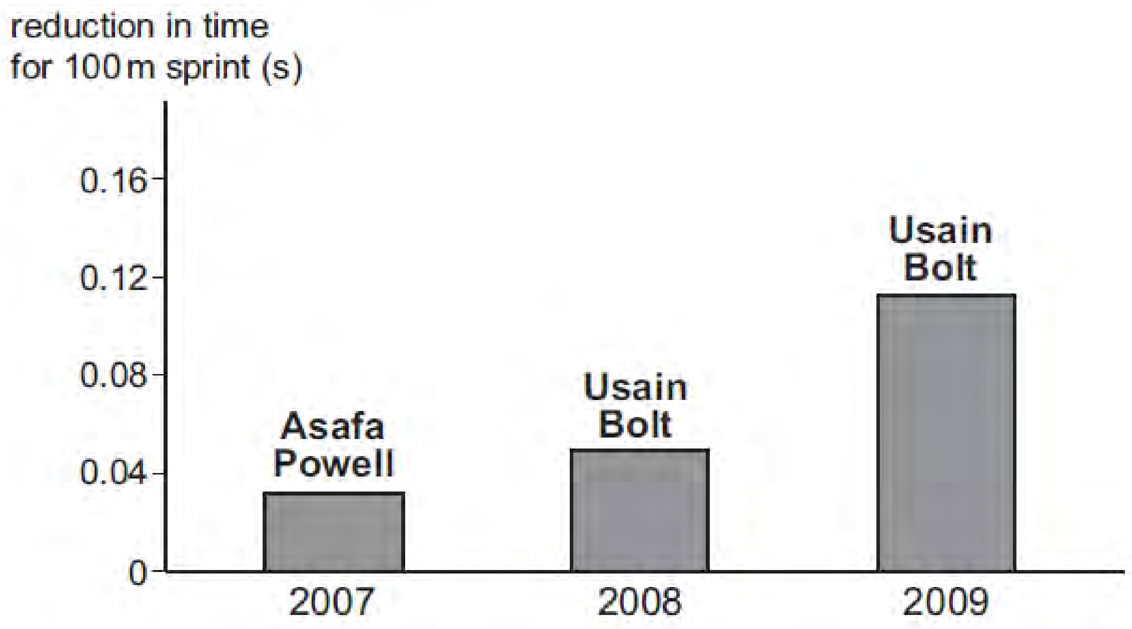
SI multipliers

Prefix	Multiplier
p	1×10^{-12}
n	1×10^{-9}
μ	1×10^{-6}
m	1×10^{-3}

Prefix	Multiplier
k	1×10^{3}
M	1×10^{6}
G	1×10^{9}
T	1×10^{12}

Answer **all** *questions*

1. Usain Bolt was born in Jamaica in August 1986 and is the fastest man alive. He has run the 100 m in record breaking times as shown in the following chart of world record breakers since 2006.



Though good running form is useful in increasing speed, fast and slow runners have been shown to move their legs at nearly the same rate – it is the force exerted by the leg on the ground that separates fast sprinters from slow. Top short-distance runners exert as much as four times their body weight on the running surface. For this reason, muscle mass in the legs, relative to total body weight, is a key factor in achieving a high speed.

Usain Bolt reached his top speed of 12.4 m/s at 60 m and only maintained it for 20 m in the Berlin world championships' 100 m race.

The following list shows the top times achieved in a 100 m race in the 10 years up to 2015.

Year	Athlete	Time (s)
2005	Asafa Powell	9.77
2006	Asafa Powell	9.77
2007	Asafa Powell	9.74
2008	Usain Bolt	9.69
2009	Usain Bolt	9.58
2010	Tyson Gay	9.78
2011	Usain Bolt	9.76
2012	Usain Bolt	9.63
2013	Usain Bolt	9.77
2014	Justin Gatlin	9.77
2015	Justin Gatlin	9.74

(Source: IAAF)

After the Berlin race of 2009, Bolt made the following statement following his world record time of 9.58 s.

"When I clocked 9.72 seconds to set the world 100 m record in New York (May 2008), I knew I could do better; when I ran 9.69 to win gold at the Olympics, I knew there was a lot more to come; and now, having run 9.58 in Berlin, I believe I can go even faster."

(a) What is the total time that Usain Bolt has improved on Asafa Powell's world record of 2007? [1]

time = ……………. s

(b) Use an equation from page 2 to calculate Usain Bolt's mean speed when he ran his final record time. Give the unit of speed with your answer. [3]

mean speed = ……………..
unit = …………......

(c) Explain why top sprinters need to be physically strong. [2]

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(d) When the gun is fired and the race starts, suggest why top sprinters try to exert as large a backwards force as they are able onto the starting blocks. [2]

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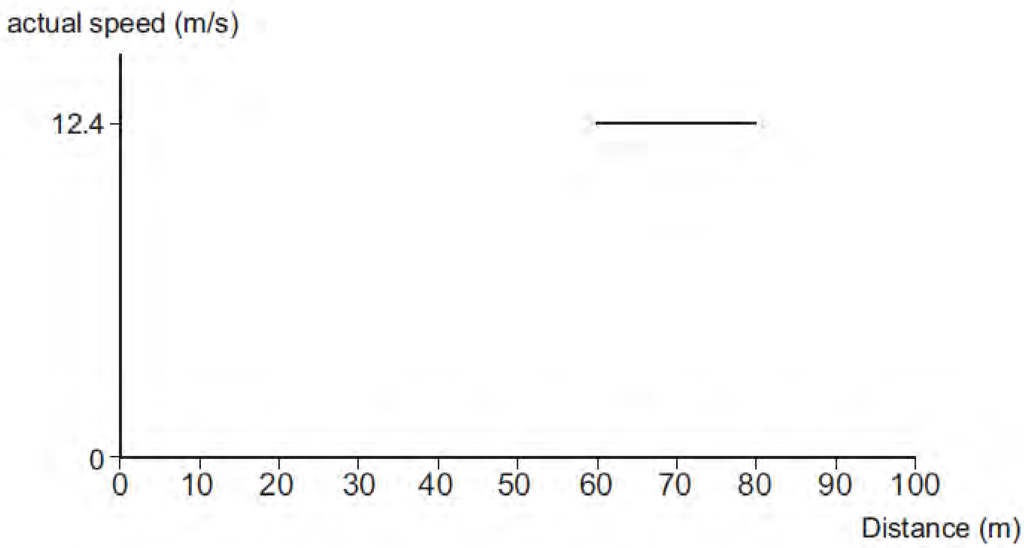
(e) The graph below shows part of the race in which Bolt set the fastest time ever for the 100 m sprint in the Berlin world championships in 2009.

Draw lines before and after the one shown to show how you think his speed would have changed over the 100 m distance. [3]



11

2. (a) Explain the motion of a cricket ball that is hit high in to the air by a batsman and falls to a fielder. [3]

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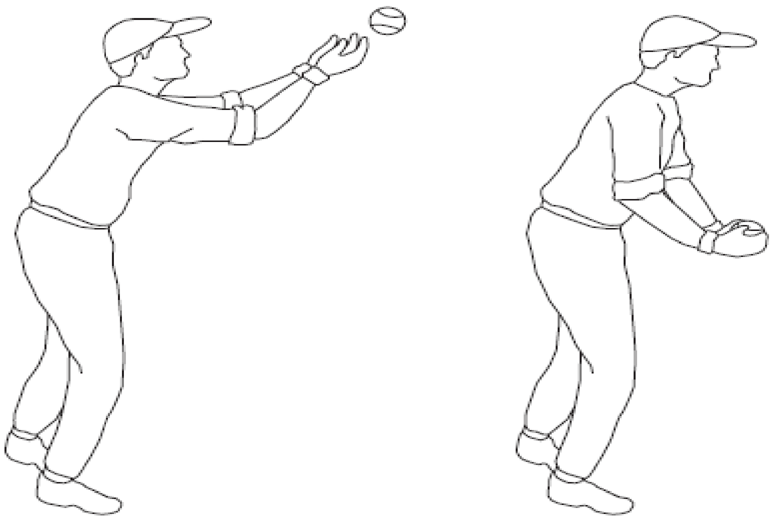
(b) A cricketer catches and stops a ball of mass 0.16 kg which is moving at a speed of 40 m/s.



(i) Use the equation:

momentum = mass × velocity

to calculate the change in momentum of the ball. [2]

momentum change =………………… kg m/s

(ii) Use an equation from page 2 to calculate the force applied by the cricketer if the ball is stopped in 0.4 seconds. [2]

force =……………… N

(iii) If the cricketer halves the time taken to stop the ball, state the size of the force. [1]

force = ………………. N

(c) Using the ideas involved in this question, state what advice you would give a parachutist when landing and explain the physics behind your answer. [3]

Advice: ……………………………………………………………………………..

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Physics behind the advice: …………………………………………………………

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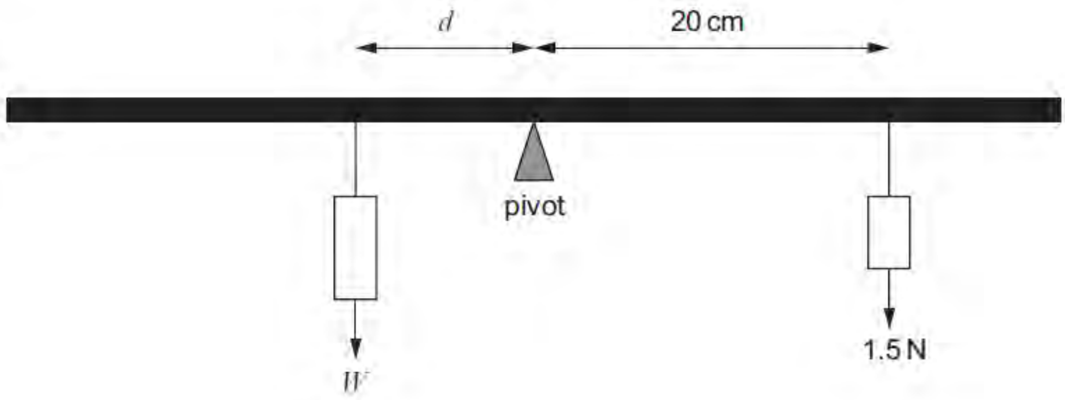
11

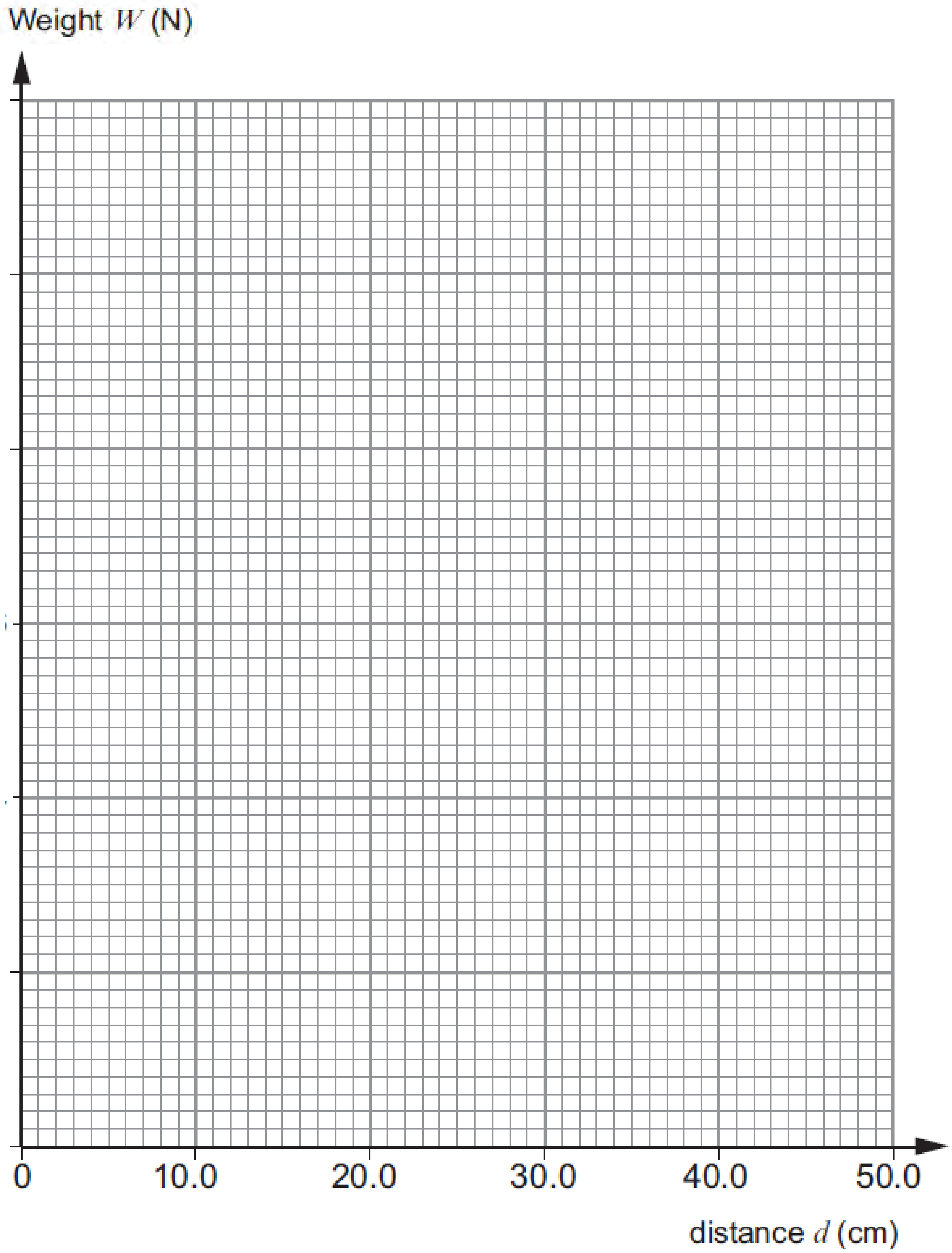
3. See-saws, tower cranes and even simple levers are all things that rely on an understanding of moments in their design. Classes of students the world over study moments to get an understanding of the principles involved. In one such class students carried out the following experiment. They set up a metre ruler to balance at its mid-point and then placed weights at different distances from the centre to get it to balance. One of the weights, W, was changed through the experiment and its distance, d, from the pivot (centre of the ruler) was also changed. The other, balancing weight, of 1.5 N was kept constant and its distance from the pivot was also kept constant at 20 cm. This is shown below.



The results from one group are shown below.

Left side		Right side	
W (N)	Distance d (cm)	Weight (N)	Distance (cm)
4.0	7.5	1.5	20.0
3.0	10.0	1.5	20.0
1.5	20.0	1.5	20.0
1.0	30.0	1.5	20.0
0.75	40.0	1.5	20.0
0.60	50.0	1.5	20.0

(a) (i) Plot a graph of the values of W against values of d on the grid below. [3]



(ii) Describe how the weight, W, changes as the distance, d, changes. [2]

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(iii) One student in the group stated that when W was 1.5 N, a change of force by 0.5 N would change the distance by 5.0 cm. Explain whether this statement is true. [2]

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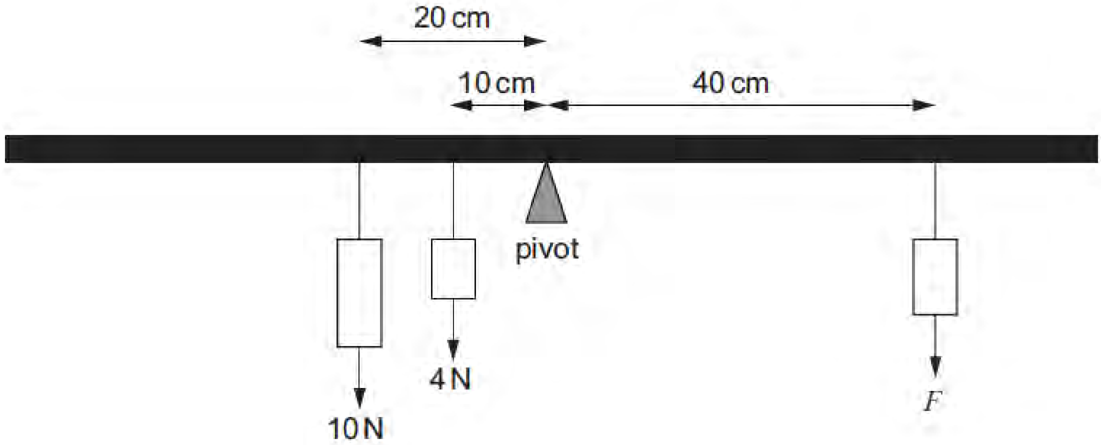
(b) Another student predicted that if the value of W was 10 N and they placed a second force of 4 N on the same side at a distance of 10 cm from the pivot, the value of the force F that would be needed on the right hand side at a distance of 40 cm to balance the ruler would be 5 N. Was the student's prediction correct? Explain your answer. [3]



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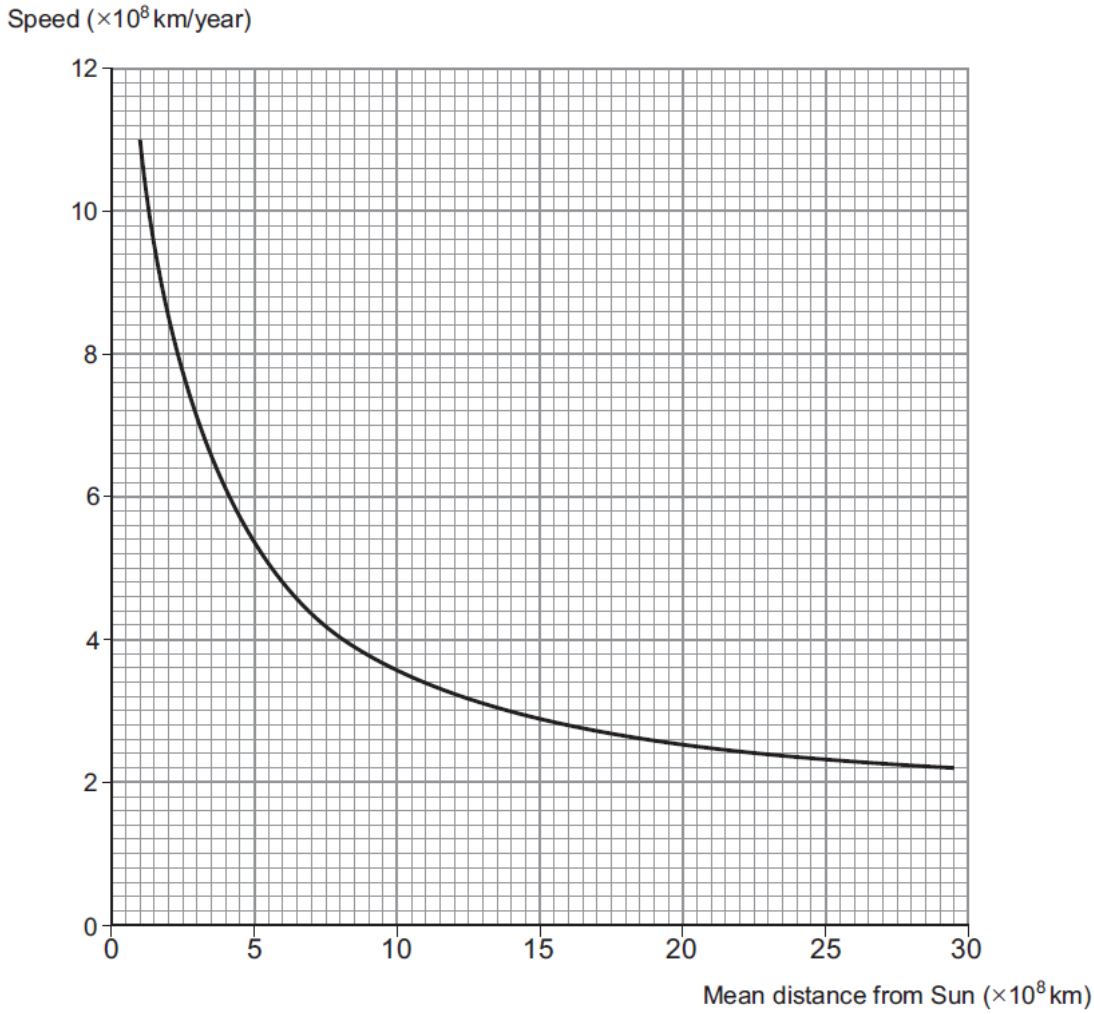
10

4. Our solar system is made up of 8 planets, each of which may or may not have a moon or moons orbiting them, many asteroids and some dwarf planets. The planets orbit the Sun. For planet Earth the orbit time is one year. The number of years that a planet takes to orbit the Sun depends on its distance from the Sun in the way shown in the table below.
The table gives data on six of the planets in the solar system.

Planet	Mean distance from the Sun ($\times 10^8$ km)	Mean surface temperature (°C)	Time for one orbit of the Sun (years)
Venus	1.10	480	0.62
Earth	1.50	22	1.00
Mars	2.25	-23	1.88
Jupiter	7.80	-150	11.86
Saturn	14.00	-180	29.46
Uranus	29.00	-210	84.01

The graph shows how the orbital speed of the planets changes with their distance from the Sun.



Use data from the table and graph to answer the following questions.

(a) What is the orbital speed of Saturn? ………………… km/year [1]

(b) A dwarf planet, Ceres, is 700 km in diameter and has an orbital speed of 5.8×10^8 km/year. It travels 2.67×10^9 km in making one orbit of the Sun.

(i) Use the graph to find the distance of Ceres from the Sun. [1]

distance = …………………… km

(ii) Use the equation:

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

to calculate the orbital time of Ceres. [2]

orbital time = …………… years

(c) Estimate the mean temperature on Ceres, show your working or explain how you arrived at your answer. [2]

mean temperature = ……………. °C

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(d) State **two** reasons why Ceres takes longer than Earth to complete one orbit of the Sun. [2]

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2. ………………………………………………………………………………………

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8

5. Describe the evidence that supports the hot Big Bang model for the origin of the universe. [6 QER]

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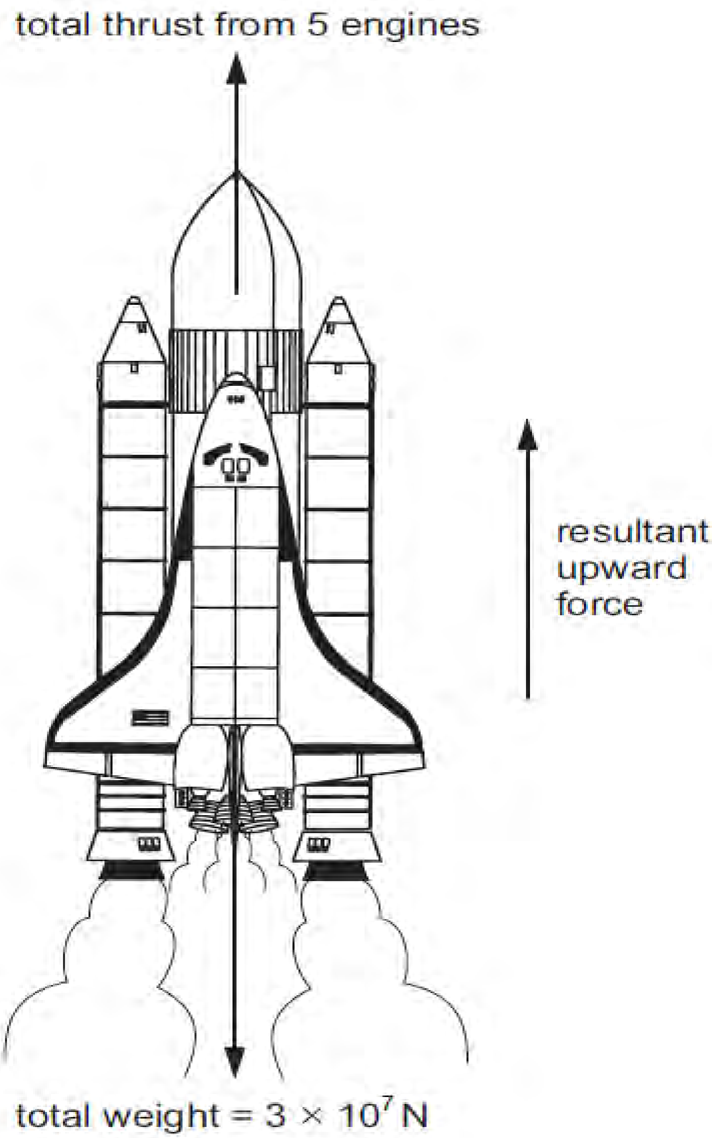
6. The diagram shows a space shuttle just after taking off from its launch pad.



On take-off, America's shuttle used 2 booster engines each providing 12.5 MN of thrust along with the shuttle's 3 engines that each provided 1.8 MN. The shuttle and booster maintain a constant thrust for the first 6 minutes achieving an upward velocity of 27 000 km/h (7 500 m/s) in this time.

(a) Calculate the total thrust of all the engines at take-off. [2]

total thrust = ………………………. MN

(b) Use an equation from page 2 with your answers above to calculate the initial acceleration at take-off. [g = 10 N/kg] [4]

initial acceleration = …………………. m/s^2

(c) Use an equation from page 2 to calculate the mean acceleration over the first 6 minutes. [3]

mean acceleration = …………. m/s^2

(d) During the first six minutes, the rockets produce a constant thrust. Explain why the mean acceleration over the first six minutes is much bigger than the initial acceleration of the rocket. [3]

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12

7. Isotopes of iodine can be used to study the thyroid gland in the body.
A small amount of the radioactive isotope is injected into a patient and the radiation is detected outside the body. Three isotopes that could be used are
$^{123}_{53}I$, $^{131}_{53}I$ and $^{132}_{53}I$. They have half-lives of 13.22 hours, 8 days and 13.2 hours respectively.

(a) Answer the following question in terms of the numbers of particles.
Compare the structures of the **nucle**i of $^{123}_{53}I$ and $^{131}_{53}I$. [2]

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(b) The nucleus of $^{131}_{53}I$ decays into xenon (Xe) by giving out beta (β) and gamma (γ) radiation.

(i) What is beta radiation? [1]

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(ii) Complete the equation below to show the decay of I-131. [2]

$$^{131}_{53}I \rightarrow \, ^{....}_{54}Xe + \, ^{0}_{....}\beta + \gamma$$

(c) The isotope $^{123}_{53}I$ decays by gamma emission. Explain why it is better to use $^{123}_{53}I$ than $^{131}_{53}I$ as a medical tracer. [2]

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(d) (i) I-131 has a half-life of 8 days. Explain what this statement means. [2]

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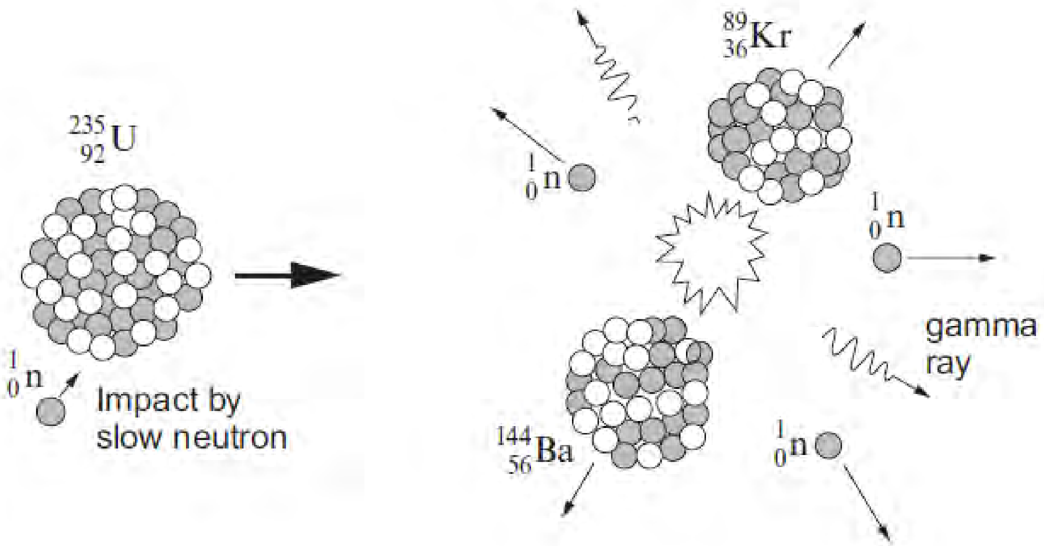
(ii) Following the nuclear power station disaster in Japan 2011, people living in the area were given non-radioactive iodine 127 ($^{127}_{53}I$) supplement tablets to reduce their intake of iodine-131 that leaked from the reactor. Calculate the length of time that people had to take the supplement before the activity of iodine-131 reduced to approximately 3% of its original value immediately after the leak. [2]

time = ……… days

11

8. The diagram below shows an example of a nuclear fission reaction in which a neutron strikes an atom of $^{235}_{92}U$.



The three neutrons released in the reaction have high energies and move very fast.

(a) State which part of the nuclear reactor core is designed to reduce the neutrons' high energies and explain why the reduction in energy is necessary. [3]

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(b) (i) Only 1 of the 3 neutrons released is needed to maintain a controlled chain reaction. Describe how the others are stopped inside the reactor. [2]

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(ii) Describe how the fission reactions inside a nuclear reactor can be shut down completely. [2]

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(c) (i) Write a balanced nuclear equation for the reaction shown above. [2]

$$\longrightarrow$$

(ii) If the barium nucleus in the diagram above is released with the same **kinetic energy** as a neutron, explain why the size of its velocity would only be **one twelfth** ($\frac{1}{12}$) of the velocity of a neutron. [2]

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11