Surname	Centre Number	Candidate Number
Other Names		0

GCSE – NEW

3420U20-1

S18-3420U20-1

PHYSICS – Unit 2:
Forces, Space and Radioactivity

FOUNDATION TIER

WEDNESDAY, 23 MAY 2018 – AFTERNOON

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**4**	
2.	**9**	
3.	**7**	
4.	**9**	
5.	**8**	
6.	**7**	
7.	**16**	
8.	**7**	
9.	**13**	
Total	**80**	

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ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a ruler.

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. If you run out of space use the additional page at the back of the booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **7(a)**.

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Equations

speed = $\dfrac{\text{distance}}{\text{time}}$	
acceleration [or deceleration] = $\dfrac{\text{change in velocity}}{\text{time}}$	$a = \dfrac{\Delta v}{t}$
acceleration = gradient of a velocity-time graph	
resultant force = mass × acceleration	$F = ma$
weight = mass × gravitational field strength	$W = mg$
work = force × distance	$W = Fd$
force = spring constant × extension	$F = kx$
momentum = mass × velocity	$p = mv$
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	$v = u + at$ $x = \dfrac{u + v}{2}\,t$
moment = force × distance	$M = Fd$

SI multipliers

Prefix	Multiplier
m	1×10^{-3}
k	1×10^{3}
M	1×10^{6}

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Answer **all** *questions.*

1. *(a)* Light from distant galaxies is changed as it travels through the Universe.

Tick (✓) the **three** correct statements below. [3]

The wavelengths of light from distant galaxies have decreased.	☐
Distant galaxies look red.	☐
Absorption spectra from distant galaxies show red shift.	☐
The Universe has expanded since the light was given out from distant galaxies.	☐
Light received from our Sun is shifted to the blue end of the spectrum.	☐
The Sun's absorption spectrum shows no red shift.	☐

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(b) Name the model of the origin of the Universe that is supported by cosmological red shift. [1]

....

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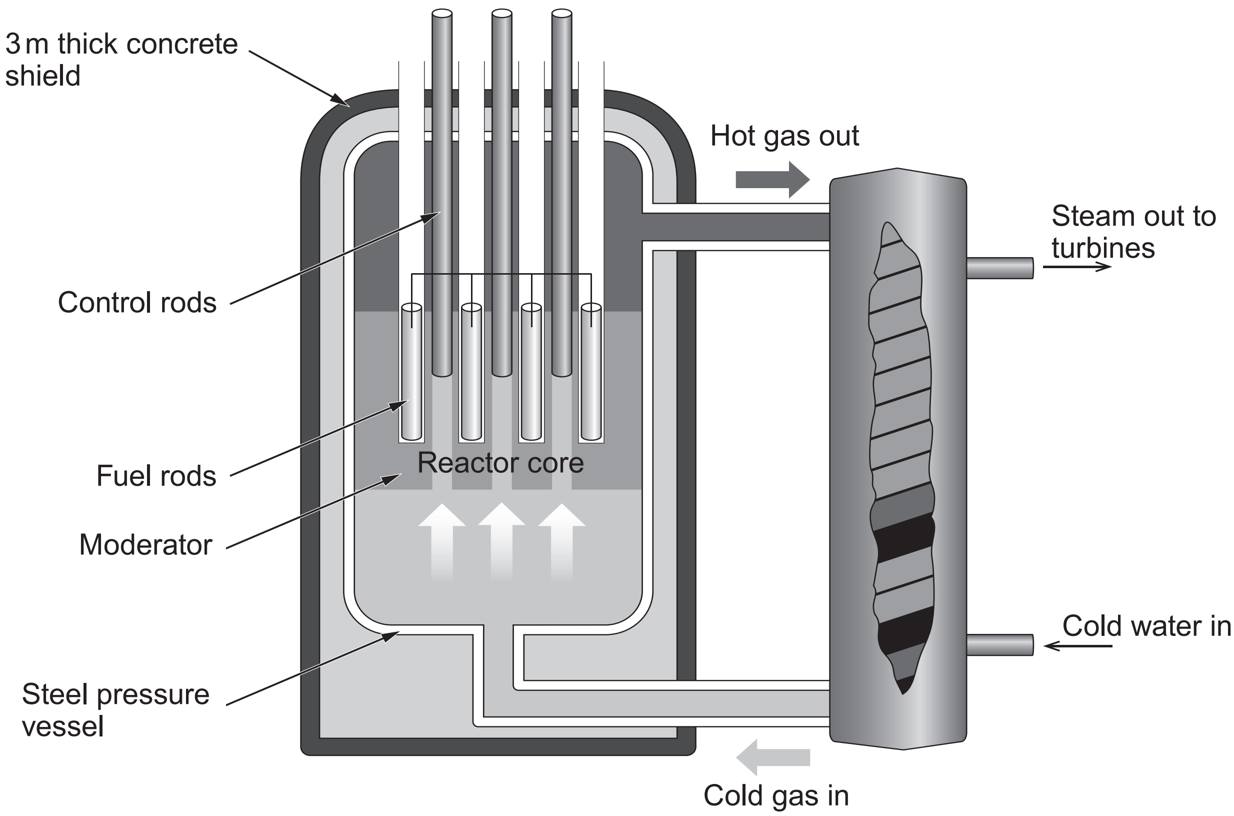
2. The half-life of a radioactive substance is the time taken for its activity to reduce by half.

(a) **Complete the following diagram** to show the count rate at the times shown. The substance has a starting count rate of 800 counts per minute (cpm) and a half-life of 5 hours. [2]

count rate at the start		count rate after 5 hours		count rate after 10 hours
800 cpm	→	.... cpm	→	.... cpm

(b) The following diagram shows a nuclear fission reactor in which the uranium fuel is contained inside a steel pressure vessel which is surrounded by a 3 m thick concrete shield.



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A uranium nucleus can split apart, forming two smaller nuclei in a nuclear reactor. One possible nuclear reaction is shown below in which a nucleus of uranium forms nuclei of tellurium (Te) and zirconium (Zr).

$$^{235}_{92}\mathrm{U} + ^{1}_{0}\mathrm{n} \longrightarrow ^{137}_{52}\mathrm{Te} + ^{97}_{40}\mathrm{Zr} + 2^{1}_{0}\mathrm{n}$$

(i) State the number of neutrons released in this reaction. .... [1]

(ii) Complete the following sentences about the nuclear reactor by underlining the correct word or phrase in each bracket. [4]

A nucleus of uranium is made to split into two smaller nuclei when it captures (**one / two / three**) neutron(s).

For fission to occur, the neutron(s) to be captured must be (**fast moving / stationary / slow moving**) and this takes place in the (**moderator / control rods / fuel rods**).

An uncontrolled chain reaction is prevented by using (**control rods / a moderator / concrete shielding**).

(c) State **two** reasons why it is difficult to store waste material from nuclear power stations. [2]

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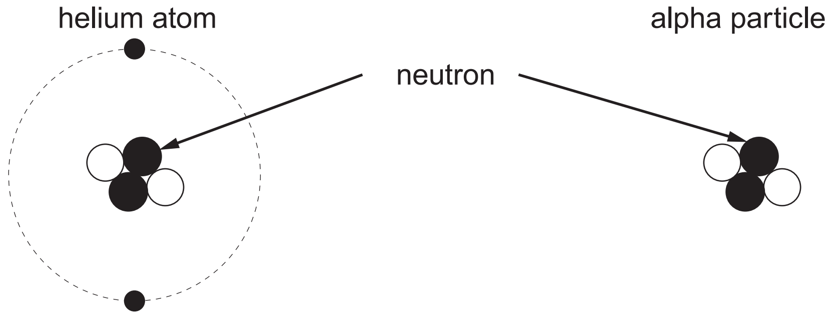
3. A student correctly draws diagrams of a helium atom and an alpha particle.



(i) One similarity between the structure of the helium atom and the alpha particle has been given in the table below. State **one** other similarity and **one** difference between them. [2]

Similarities	Difference
They both have 2 neutrons.	....

(ii) A nucleus of polonium-210 decays by alpha particle emission to form lead (Pb), which is a stable element, according to the following reaction.

$$^{210}_{84}\text{Po} \longrightarrow {}^{4}_{2}\alpha + {}^{\cdots\cdots}_{\cdots\cdots}\text{Pb}$$

Complete the nuclear decay equation above. [2]

(iii) State why this isotope of polonium is radioactive. [1]

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(iv) Explain why, in 2006, the Russian Alexander Litvinenko died within weeks of swallowing some polonium-210. [2]

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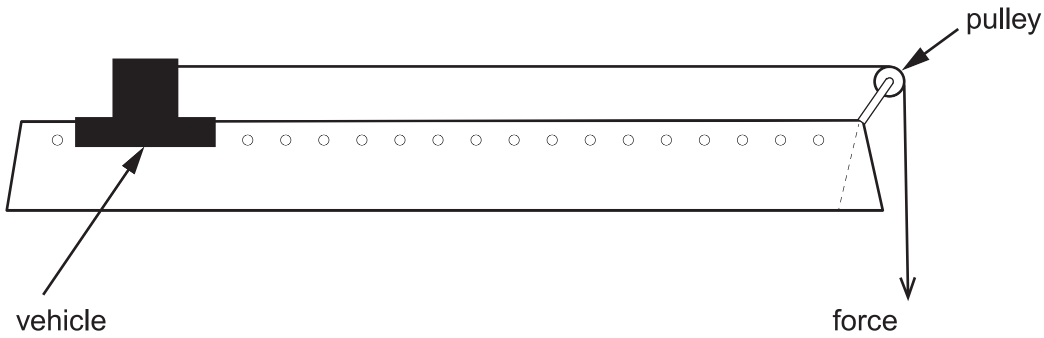
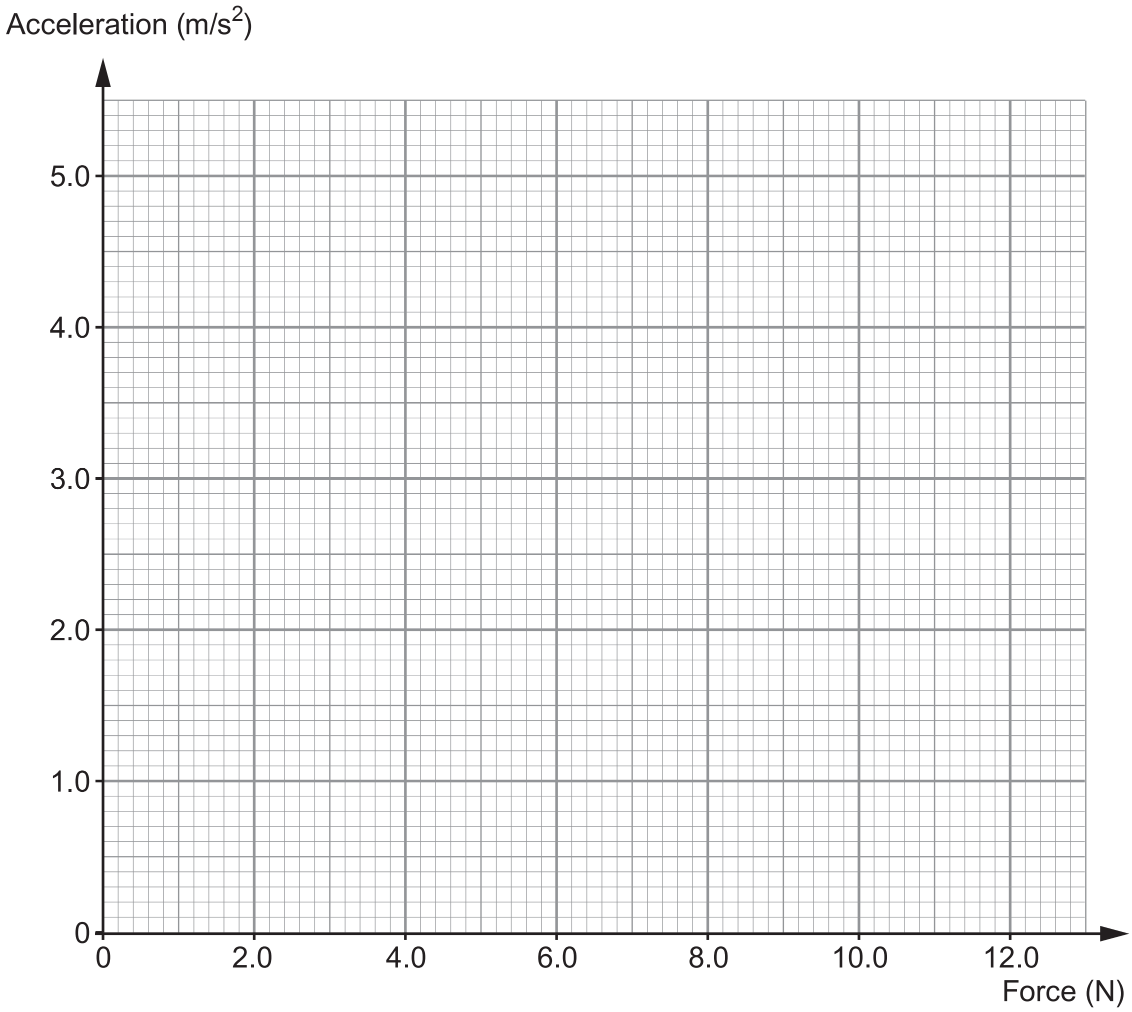
4. In a class experiment, a group of students use a force to accelerate a vehicle along a frictionless air track.



The acceleration of the vehicle is measured by a computer and the results are shown below.

Force (N)	2.0	4.0	8.0	10.0	12.0
Acceleration (m/s^2)	0.8	2.6	3.2	4.0	4.8

(a) Plot the data on the grid below and draw a suitable line. [3]



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(b) (i) Use the graph to find the force that produces an acceleration of 2.0 m/s^2. [1]

Force = ... N

(ii) Use the equation:

$$\text{mass} = \frac{\text{resultant force}}{\text{acceleration}}$$

to calculate the mass of the vehicle. [2]

Mass = ... kg

(iii) Another group of students in the class carry out the same experiment but they use a vehicle of greater mass. **Draw a line on the graph** to show how the acceleration would change for the same values of force. [1]

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(c) Eric suggests that if a force of 16 N is applied to the original vehicle the acceleration will be 5.6 m/s^2. Use the data to consider whether this suggestion is correct. [2]

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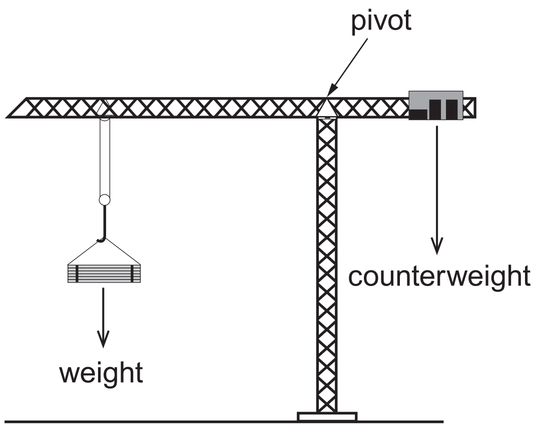
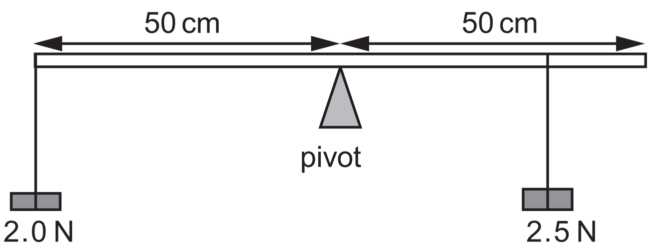
5. The diagram shows a tower crane used on a new building in the centre of Cardiff. A weight is lifted on the long arm and a counterweight on the short arm keeps the crane from toppling over.



(a) A group of students investigate a model of the crane by hanging weights from a horizontal metre ruler.



They hang a 2.0 N weight at one end, 50 cm from the pivot and another weight of 2.5 N somewhere on the other side of the pivot to make it balance.

(i) Use the equation:

$$\text{moment} = \text{force} \times \text{distance}$$

to calculate the anticlockwise moment (in N cm) of the 2 N weight about the pivot. [2]

Moment = ... N cm

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(ii) Use your answer to part (i) and the equation:

$$\text{distance} = \frac{\text{moment}}{\text{force}}$$

to calculate the distance that the 2.5 N weight should be placed from the pivot for the ruler to balance. [2]

Distance = ... cm

(iii) Explain why it would be impossible to balance the 2 N weight on the end of the ruler if the 2.5 N weight is replaced with a 1.5 N weight. [2]

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(b) A particular tower crane is capable of lifting a maximum mass of 15 000 kg.
Use the equation:

$$\text{weight} = \text{mass (kg)} \times \text{gravitational field strength}$$

to calculate the weight of this mass. [2]
[gravitational field strength, g = 10 N/kg]

Weight = ... N

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6. Cars are tested so that the manufacturers know what happens to the passengers during a collision.

In one such test, a car of mass 1 500 kg travelling with an energy of 127 500 J strikes a solid barrier and stops. The force applied to the car by the barrier is 500 000 N.

(a) (i) Name the energy that the car possesses due to its motion. [1]

....

(ii) State the work done by the barrier to stop the car. [1]

Work done = ... J

(b) (i) Use the equation:

$$\text{distance} = \frac{\text{work}}{\text{force}}$$

to calculate the distance over which the force acts. [2]

Distance = ... m

Examiner only

(ii) I. State **one** feature of cars that is designed to keep the driver safer in a head-on collision. [1]

....

II. Explain how this safety feature keeps the driver safer. [2]

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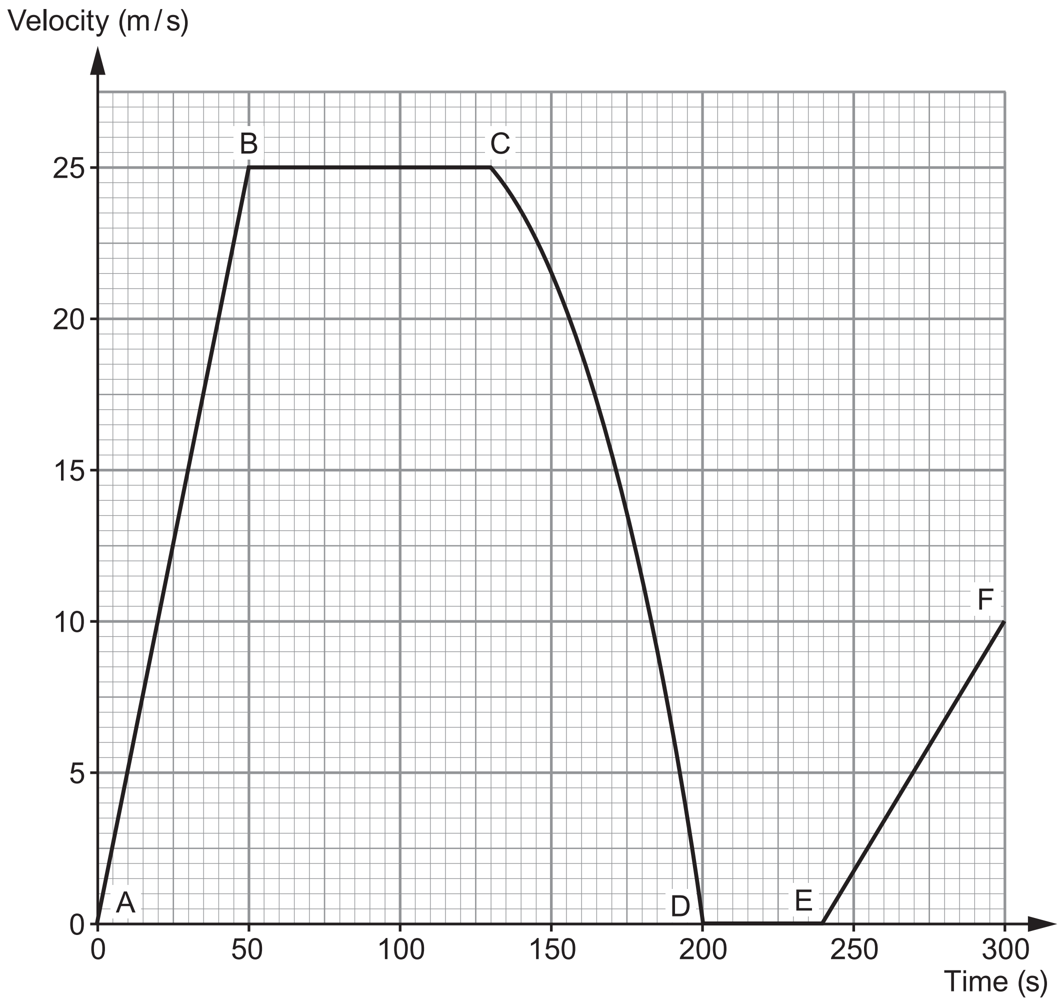
7. The velocity-time graph below shows part of the motion of an empty school bus.



(a) Use values from the graph to describe the motion of the bus over the time shown. [Note that no calculations are required as part of your answer.] [6 QER]

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(b) Refer to the graph to answer the following questions. The mass of the bus is 10 000 kg.

(i) Use an equation from page 2 to calculate its change in momentum between A and B. [2]

Change in momentum = ... kg m/s

(ii) Use an equation from page 2 to calculate the resultant force that acts on the bus between A and B. [2]

Resultant force = ... N

(iii) Use the equation:

distance = speed × time

to calculate the distance travelled between B and C.

[2]

Distance = ... m

Examiner only

(iv) Another identical bus travels the same distance as in part (iii). However, it travels at a slower, constant speed. State **two** ways that **its line on the graph** would be different from the one shown. [2]

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(c) Explain, using the idea of inertia, how the acceleration of a bus filled with school children would compare with the acceleration of the empty bus. [2]

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8. A new timer, in the shape of a ball, has been produced. When it is released it starts a built-in stop clock. When the ball next hits something the timer stops. The time taken is displayed on its screen.

A teacher uses the ball timer for an experiment. He holds the ball out of his third floor classroom window and then carefully releases it. The time taken to fall is recorded in a table. The ball is dropped 5 times during the experiment.

Drop number	1	2	3	4	5
Time (s)	1.48	1.10	1.52	1.54	1.46

(a) Explain how the teacher could find out if the results are reproducible. [2]

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(b) **Circle** the result in the table which is most likely to be anomalous. [1]

(c) Calculate the mean time for the ball timer to fall. [2]

Mean time to fall = ... s

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(d) The mean impact velocity of the ball on the ground is 14.2 m/s.
Use the equation:

$$x = \frac{u + v}{2}\, t$$

to calculate the drop height of the ball. [2]

Drop height = ... m

7

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9. In 1992 scientists first detected a planet orbiting a star outside our Solar System. Hundreds of these exoplanets have been found since. **Table 1** shows the stars that have been discovered with 6 or more exoplanets in orbit, along with information about our Sun.

Table 1

Name of star	Distance of star from Earth (l-y)	Mass of star (compared to the Sun)	Temperature of star (K)	Number of planets in orbit
Sun	0.00002	1.0	5770	8
HR 8832	21	0.8	4700	7
HD 10180	127	1.1	5910	7
Kepler 90	2500	1.1	5930	7
HD 40307	42	752.0	4980	6
HD 127	206	0.7	870	6
Kepler 20	950	0.9	5470	6
Kepler 11	2000	1.0	5680	6

(a) (i) Tick (✓) the **two** correct statements below. [2]

Four stars have the same mass. ☐

Light travelling from Kepler 90 takes the longest time to reach Earth. ☐

The range of star temperatures is 5060 K. ☐

Hotter stars have more planets in orbit around them. ☐

Star HR 8832 is double the distance of star HD 40307 away from Earth. ☐

(ii) State **two** reasons, using evidence from **Table 1**, why scientists predict that the star Kepler 11 is most likely to have a Solar System similar to ours. [2]

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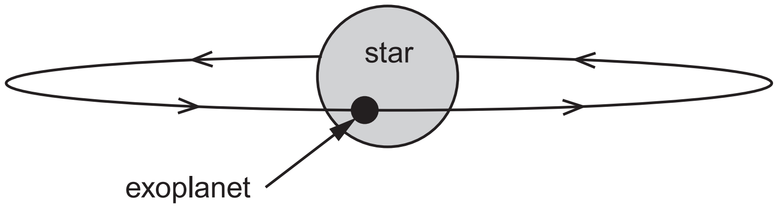
(b) Exoplanets can't be detected directly because they don't give out their own light. One method of detection is to look for a slight dip in the light intensity from the star. This happens when the exoplanet passes in front of the star during its orbit. This is called a transit.



(i) Why does the detected light intensity decrease during a transit? [1]

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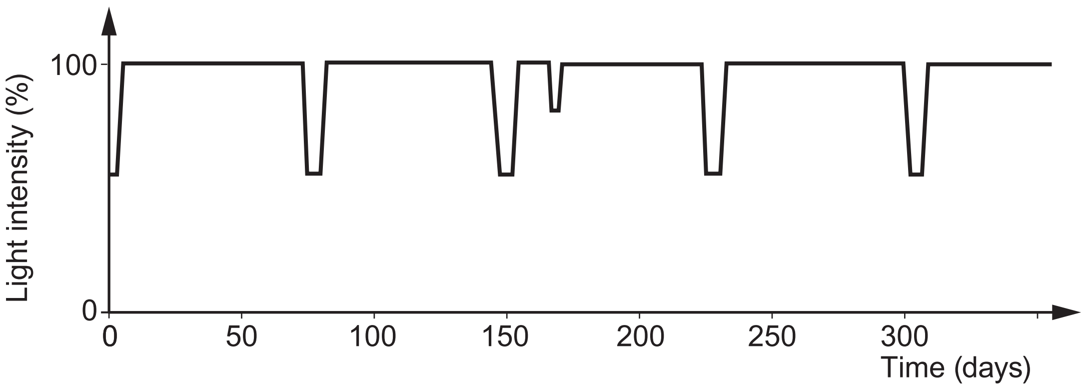
(ii) A pupil finds a graph on the internet that shows the measured light intensity detected from a star against time.



I. Calculate the orbit time, in days, of the exoplanet. [2]

Orbit time = ... days

II. The pupil correctly suggests that there may be two exoplanets in orbit around this star. What evidence is there to back up this claim? [1]

....

III. During a transit some of the light from the star passes through the exoplanet's atmosphere. An absorption spectrum is produced. Explain how the absorption spectrum arises and is used to identify gases in its atmosphere. [2]

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Turn over.

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(c) **Table 2** shows data collected for all the exoplanets in orbit around the star called Kepler 11. They are listed in order of increasing distance.

Table 2

Exoplanet	Mass (compared to Earth)	Time for one orbit (days)	Temperature (K)	Orbit radius (AU)
b	1.9	10.3	871	0.09
c	2.9	13.0	807	0.11
d	7.3	22.7	659	0.16
e	8.0	32.0	596	0.20
f	2.0	46.7	525	....
g	25.0	118.4	386	0.47

(i) Compare the **trend** in temperature with orbit radius of the planets around Kepler 11 to the planets in our Solar System where Venus is the hottest. [2]

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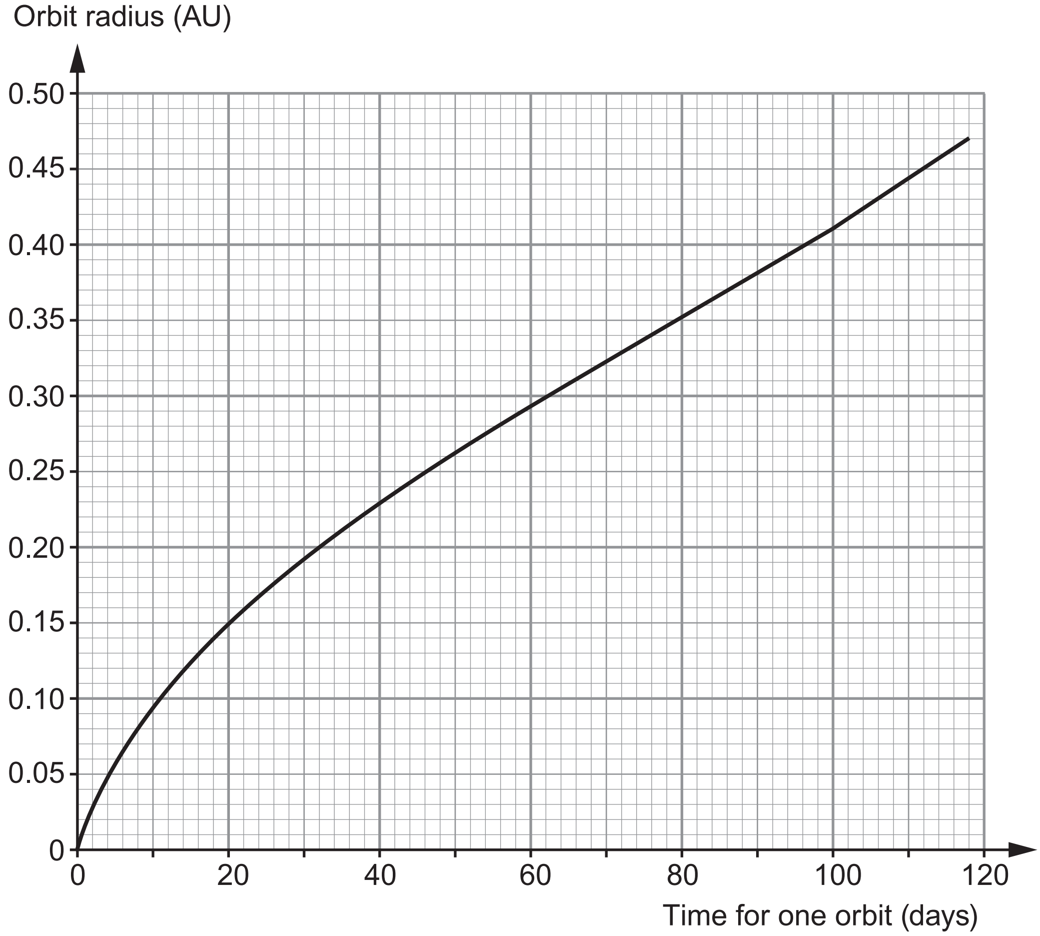
(ii) Some of the data from the table is used to plot a graph.



The orbit time of **exoplanet f** was found using the transit method. Its orbit time was measured as 46.7 days. Use the graph to **complete Table 2** with an estimate of a value for the missing orbit radius. [1]

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END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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