Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3420UB0-1

S25-3420UB0-1

THURSDAY, 22 MAY 2025 – MORNING

PHYSICS – Unit 2:
Forces, Space and Radioactivity

HIGHER TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**7**	
2.	**13**	
3.	**7**	
4.	**6**	
5.	**5**	
6.	**7**	
7.	**5**	
8.	**8**	
9.	**7**	
10.	**15**	
Total	**80**	

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ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

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(s) at the back of the booklet, taking care to number the question(s) correctly.

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 **4**.

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Equations

speed = $\frac{\text{distance}}{\text{time}}$	
acceleration [or deceleration] = $\frac{\text{change in velocity}}{\text{time}}$	$a = \frac{\Delta v}{t}$
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	$W = Fd$
kinetic energy = $\frac{\text{mass} \times \text{velocity}^2}{2}$	$\text{KE} = \frac{1}{2} mv^2$
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	$p = mv$
force = $\frac{\text{change in momentum}}{\text{time}}$	$F = \frac{\Delta p}{t}$
u = initial velocity v = final velocity t = time a = acceleration x = displacement	$v = u + at$ $x = \frac{u + v}{2} t$ $x = ut + \frac{1}{2} at^2$ $v^2 = u^2 + 2ax$
moment = force × distance	$M = Fd$

SI multipliers

Prefix	Symbol	Conversion factor	Multiplier
pico	p	divide by 1 000 000 000 000	1×10^{-12}
nano	n	divide by 1 000 000 000	1×10^{-9}
micro	µ	divide by 1 000 000	1×10^{-6}
milli	m	divide by 1000	1×10^{-3}
centi	c	divide by 100	1×10^{-2}

kilo	k	multiply by 1000	1×10^{3}
mega	M	multiply by 1 000 000	1×10^{6}
giga	G	multiply by 1 000 000 000	1×10^{9}
tera	T	multiply by 1 000 000 000 000	1×10^{12}

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Answer **all** questions.

1. (a) When the driver of a vehicle needs to make an emergency stop, the overall stopping distance is made up of two parts, called the thinking distance and the braking distance.

overall stopping distance = thinking distance + braking distance

(i) An average driver drives at 13 m/s and has a reaction time of 0.70 s.
The table below shows the Highway Code's thinking and braking distances for an average driver.

A Formula 1 racing driver is driving the same car at the same speed.
The reaction time of this driver is half the time of an average driver.
Complete the following table. [3]

	Reaction time (s)	Thinking distance (m)	Braking distance (m)	Overall stopping distance (m)
Average driver	0.70	9	14	23
Formula 1 racing driver	0.35	…………………	…………………	…………………

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(ii) During wet weather, the braking distance doubles.
One student suggests that the overall stopping distance for an average driver also doubles.
Consider whether this statement is true. [2]
Space for calculations.

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……

(b) Seatbelts provide the most effective way of protecting yourself when travelling in a car.
Explain how a seatbelt protects a driver from injury during a head-on collision. [2]

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7

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2. Americium-241 decays by alpha particle emission to produce neptunium (Np) as shown by the following nuclear decay equation.

$$^{241}_{95}\text{Am} \rightarrow \,^{\dots\dots}_{\dots\dots}\text{Np} + \,^{4}_{2}\alpha$$

(a) (i) **Complete** the nuclear decay equation. [2]

(ii) Complete the following sentence about the nuclear structure of americium-241. [3]

A **nucleus** of americium-241 contains .... protons,

.... neutrons and .... electrons.

(b) The mass of americium in a new smoke detector is 0.25 micrograms with an activity of 32 kBq.
Calculate the mass that has an activity of 128 kBq. [2]

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mass = ... micrograms

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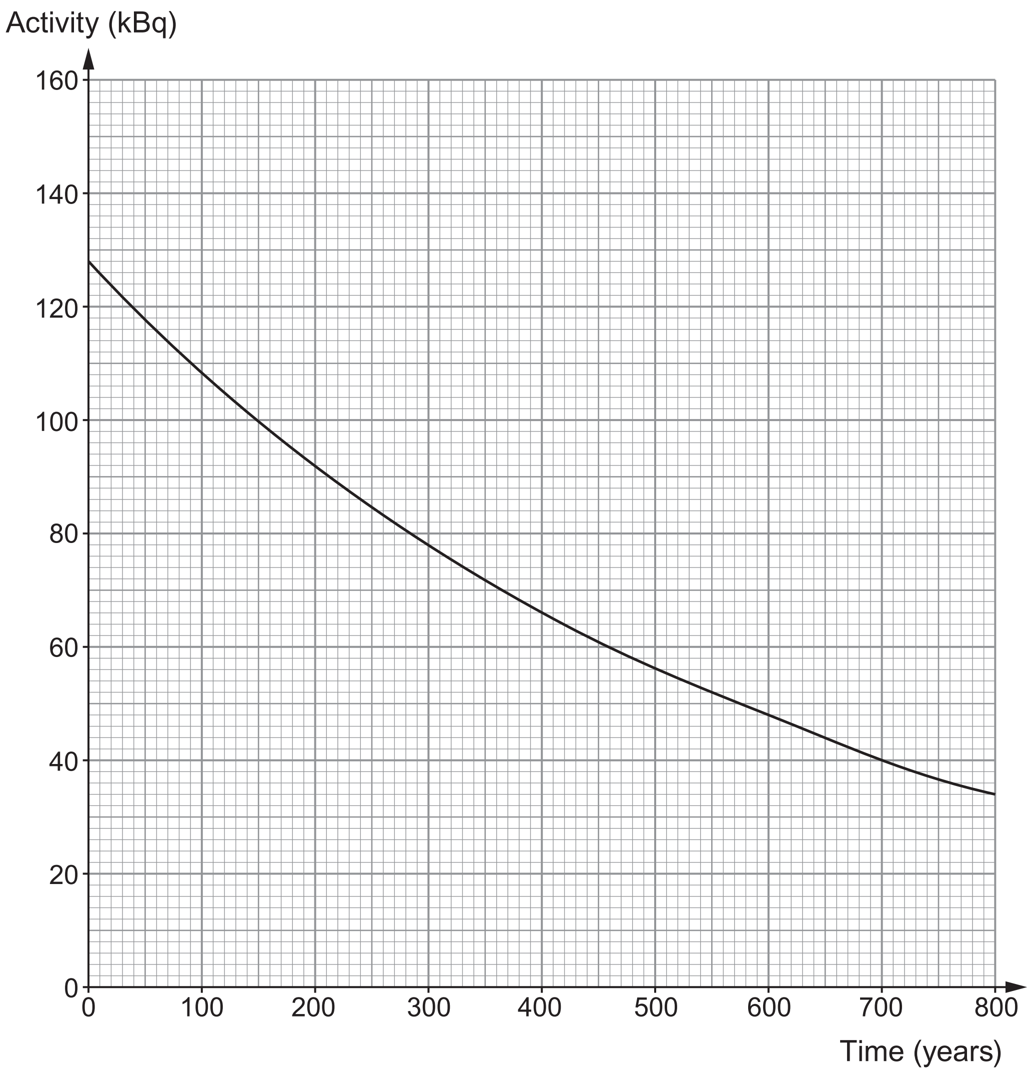
(c) Some americium-241 with an initial activity of 128 kBq decays for a number of years as shown by the graph below.



(i) **Draw lines on the graph** to show that the half-life of americium-241 is 420 years. [2]

(ii) State the time it would take for the activity to fall to a $\frac{1}{4}$ (25%) of its initial activity. [1]

time = ... years

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(iii) Americium-241 is difficult to detect when its activity falls to about 3%.
Theresa states that the activity will fall to about 3% after 2000 years.
Explain whether she is correct.
Continue the diagram to show your working. [3]

Activity	**Time**
100%	0 years
↓	↓
50%	420 years
↓	↓

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13

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Turn over.

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3. The table gives some information about four planets in our solar system.

Planet	Orbital period (Earth years)	Orbital speed ($\times 10^4$ km/h)	Orbit circumference (AU)	Planet diameter (km)	Mass ($\times 10^{24}$ kg)
Earth (E)	1	10.7	6.28	12 800	5.97
Mars (M)	2	8.1	9.43	6784	0.64
Jupiter (J)	12	4.7	32.68	143 360	1900
Saturn (S)	30	3.5	59.71	120 320	568

Use only information from the table to answer the following questions.

(a) State the property from the table that tells us that Saturn is much bigger than the Earth. [1]

....

(b) Use the data for Mars and Saturn to explain whether the orbital period is directly proportional to the orbit circumference. [2]
Space for calculation.

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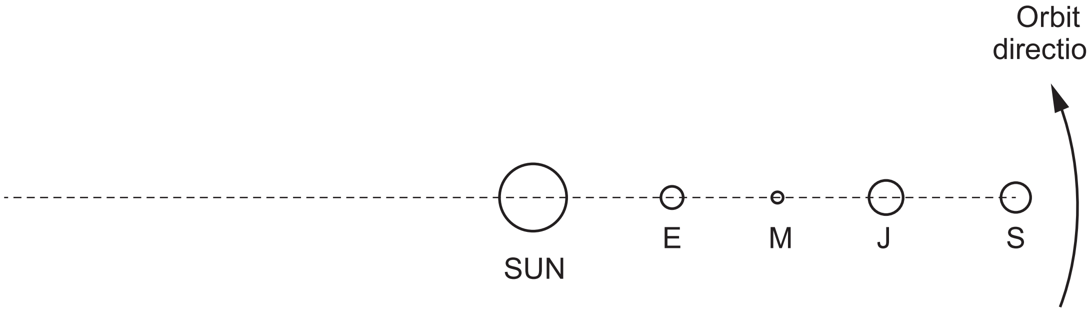
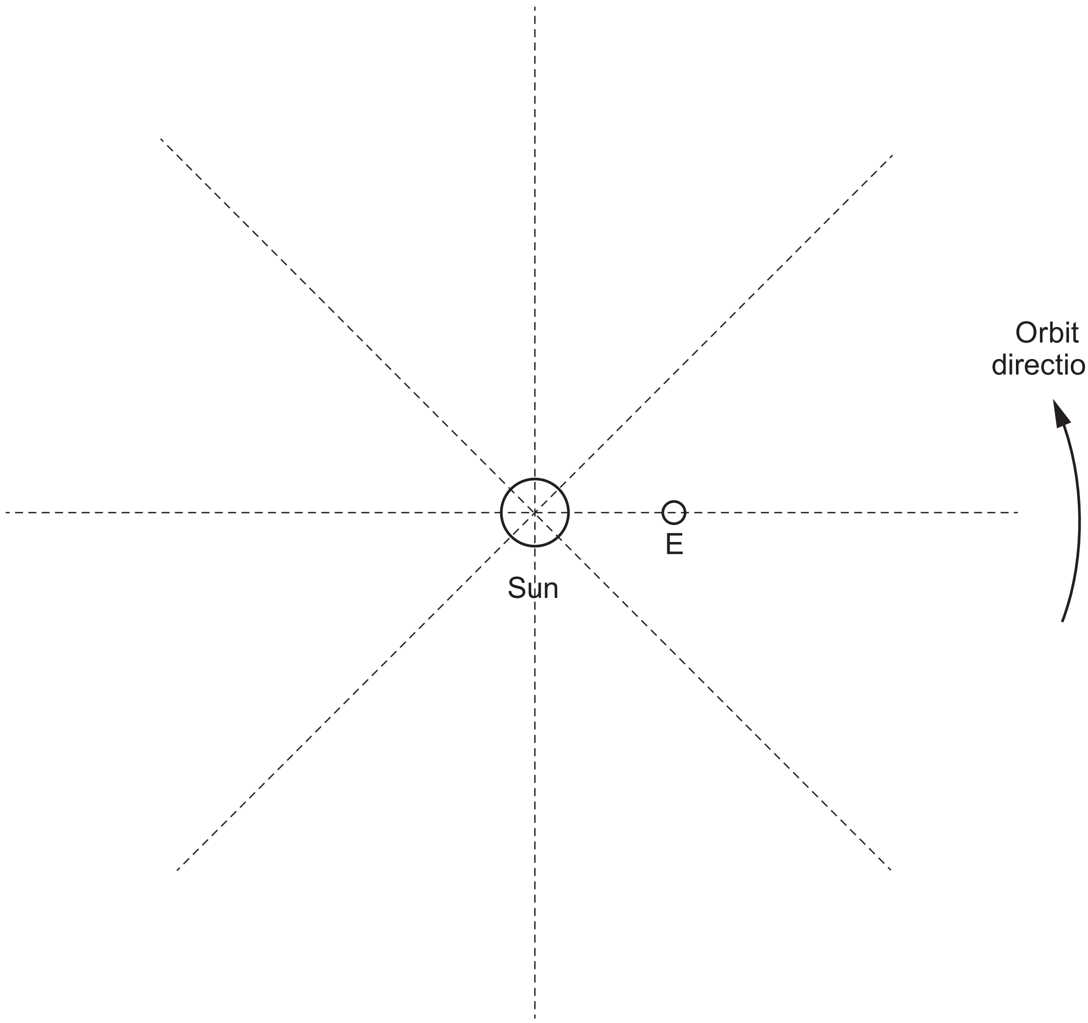
(c) At one point in time, all four planets are in line with the Sun as shown below.



(i) After how many years would the four planets next be in the same position? [1]

.... years

(ii) **Complete the diagram** below to show the positions of the four planets after 15 years.
Label the planets clearly.
Earth has been positioned for you. [3]



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 (3420UB0-1) **Turn over.**

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4. Giant stars have masses that are many times bigger than our Sun.
Describe **and** explain the life cycle of these giant stars from birth to death. [6 QER]

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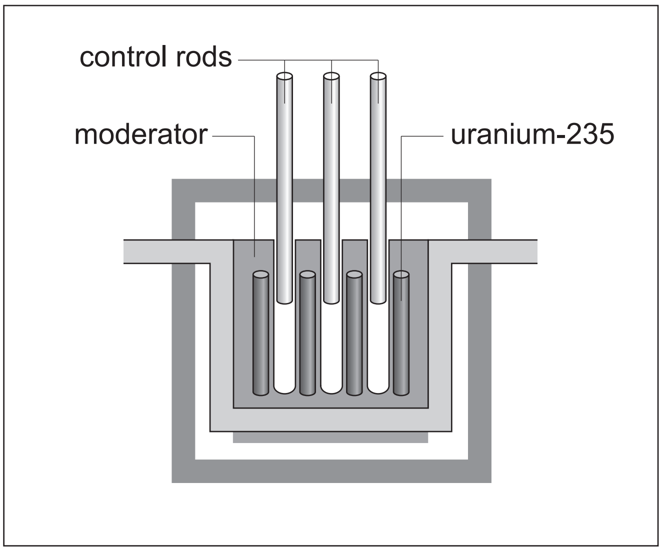
5. Nuclear reactors use the fission of uranium-235 to produce electrical power.



(a) State the function of a moderator in a nuclear reactor **and** why it is needed. [2]

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(b) Explain the role of control rods in a nuclear reactor. [3]

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5

Turn over.

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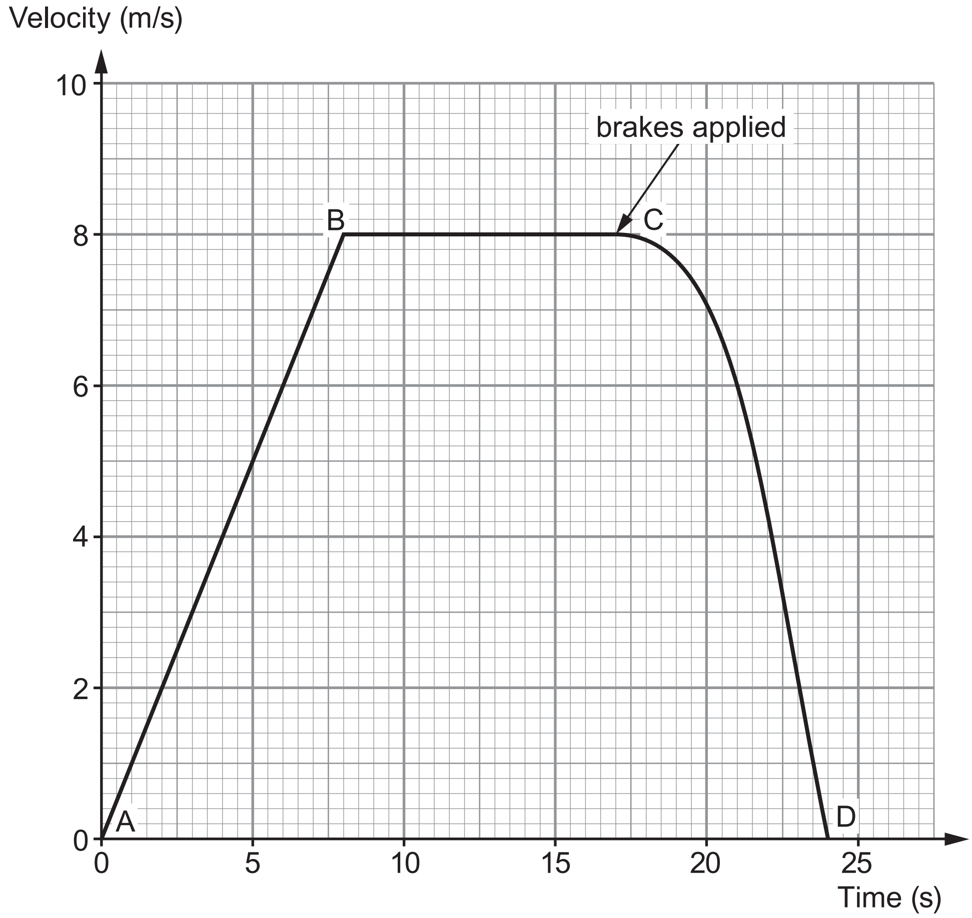
6. Some school students test a bicycle, along a straight track using a new cycling computer.
They measure 100 m along the track.
They mark the finishing line at this point.
The brakes are applied by the cyclist when they reach the marked **finishing line**.
The velocity–time graph, drawn from the test results, is shown.



(a) Determine the time for which the cyclist was travelling at a velocity of 6 m/s or more. [1]

time = ... s

Examiner only

(b) Describe the motion in each region (AB, BC, CD) of the graph.
No calculations are required. [4]

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(c) Use the graph and information from page 2 to determine whether the measured 100 m for the test was accurate. [2]
Space for calculations.

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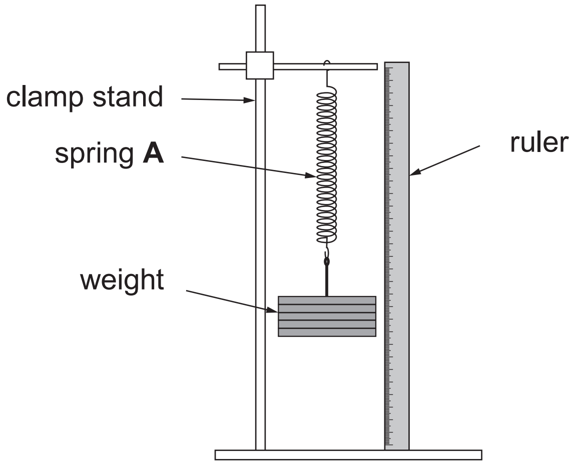
7

Examiner only

7. The diagram shows spring **A**.
It extends by 0.04 m when a weight of 5 N is hung from it.



(a) Use an equation from page 2 and the information above to calculate the spring constant of spring **A**. [2]

spring constant of spring **A** = ... N/m

(b) The spring constant of **another spring** (spring **B**) is double the spring constant of spring **A**.
Calculate the extension of spring **B** for the same 5 N load. [1]

extension of spring **B** = ... m

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(c) Use the information opposite and the equation:

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

to compare the energy stored in each of the two springs when supporting the 5 N load.
(W = work done or energy stored, F = force, x = extension) [2]

energy stored in spring **A** = ... J

energy stored in spring **B** = ... J

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5

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8. Students carry out an experiment to investigate moments.
A moment is the turning effect of a force.

(a) (i) A force is measured in newtons and distance is measured in metres.
State the unit of the moment of a force. [1]

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(ii) State the principle of moments. [2]

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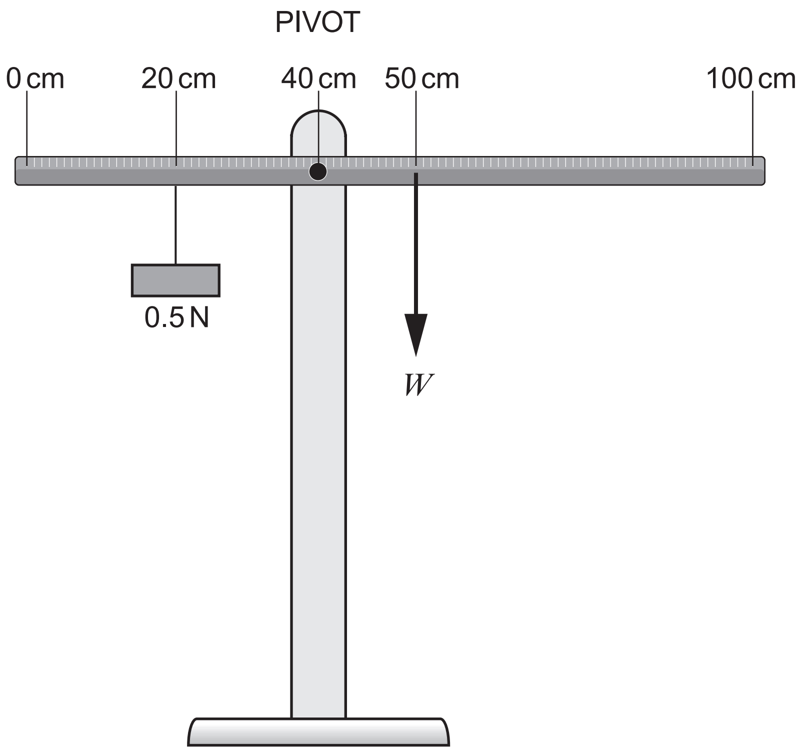
(b) The weight of a metre ruler acts at its midpoint (i.e. its 50 cm mark).
The students set up the following apparatus.
Using the principle of moments, they conclude that the weight, W, of the ruler is 1 N **and** that its mass is therefore 100 g.



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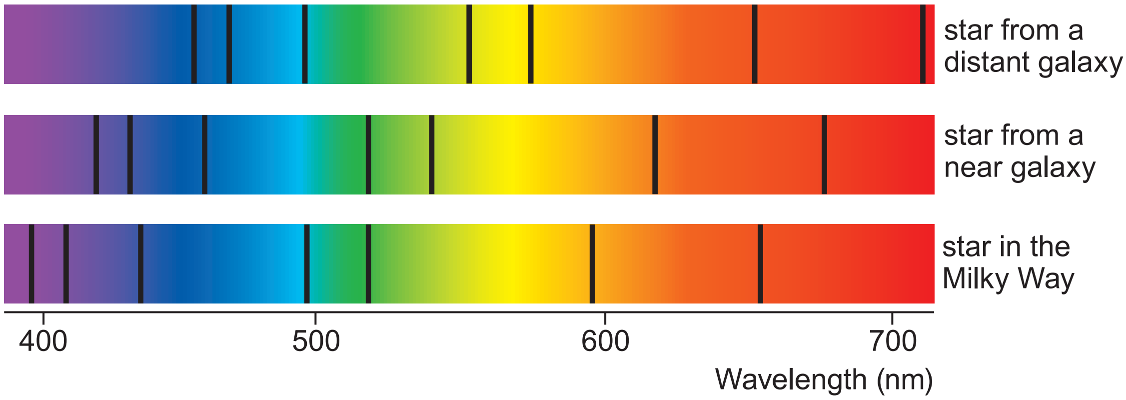
Use equations from page 2 to show whether you agree with both of the students' conclusions. [5]

8

Examiner only

9. The diagram below shows a number of spectra of light from stars in different galaxies.
The **bottom** spectrum is from a star in our own galaxy, the Milky Way.
The black lines on the others show a similar pattern.



(a) Explain how the black lines are formed. [3]

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(b) Explain how the study of spectra like these from distant galaxies supports the Big Bang model. [4]

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7

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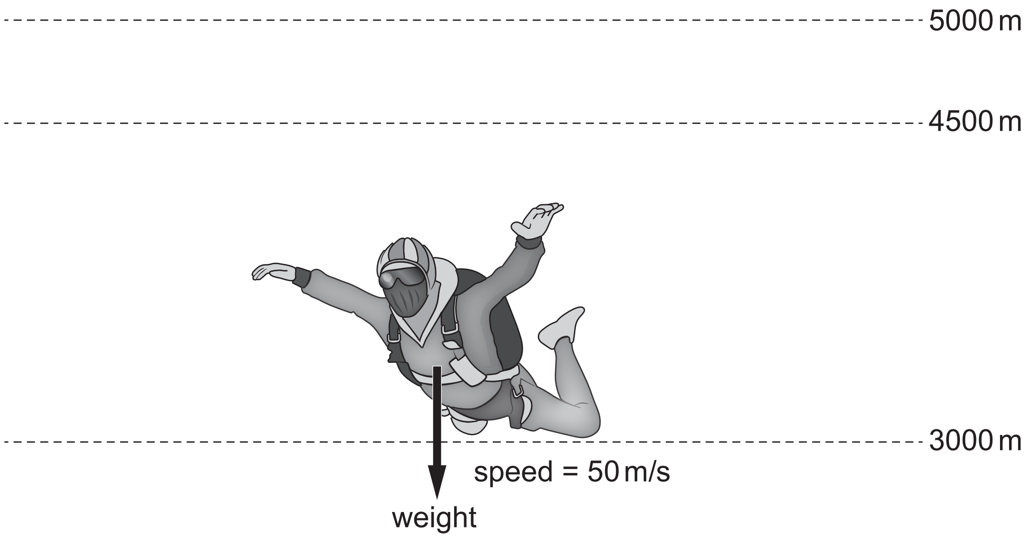
10. A skydiver of mass 90 kg falls from rest at a height of 5000 m to a height of 3000 m and the parachute is opened some time later.
The terminal speed of 50 m/s is achieved at a height of 4500 m.



[Earth's gravitational field strength, g = 10 N/kg]

(a) Use an equation from page 2 to calculate the **loss of potential energy** of the skydiver between 5000 m and 3000 m. [3]

loss of potential energy = ... J

(b) Use an equation from page 2 to calculate the kinetic energy of the skydiver at a height of 3000 m. [3]

kinetic energy = ... J

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(c) In the following question parts you will need to consider the fall of 2000 m **from 5000 m to 3000 m** shown in the diagram.

(i) I. Use your answers to parts (a) and (b) to calculate the work done by air resistance during this 2000 m fall. [1]

work done = ... J

II. Use the equation:

work done = force × distance

to calculate the mean force of air resistance acting on the skydiver during this 2000 m fall. [2]

mean force = ... N

(ii) The air resistance at terminal speed is 900 N.
State the weight of the skydiver.
Explain your answer. [2]

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TURN OVER FOR THE LAST PART OF THE QUESTION.

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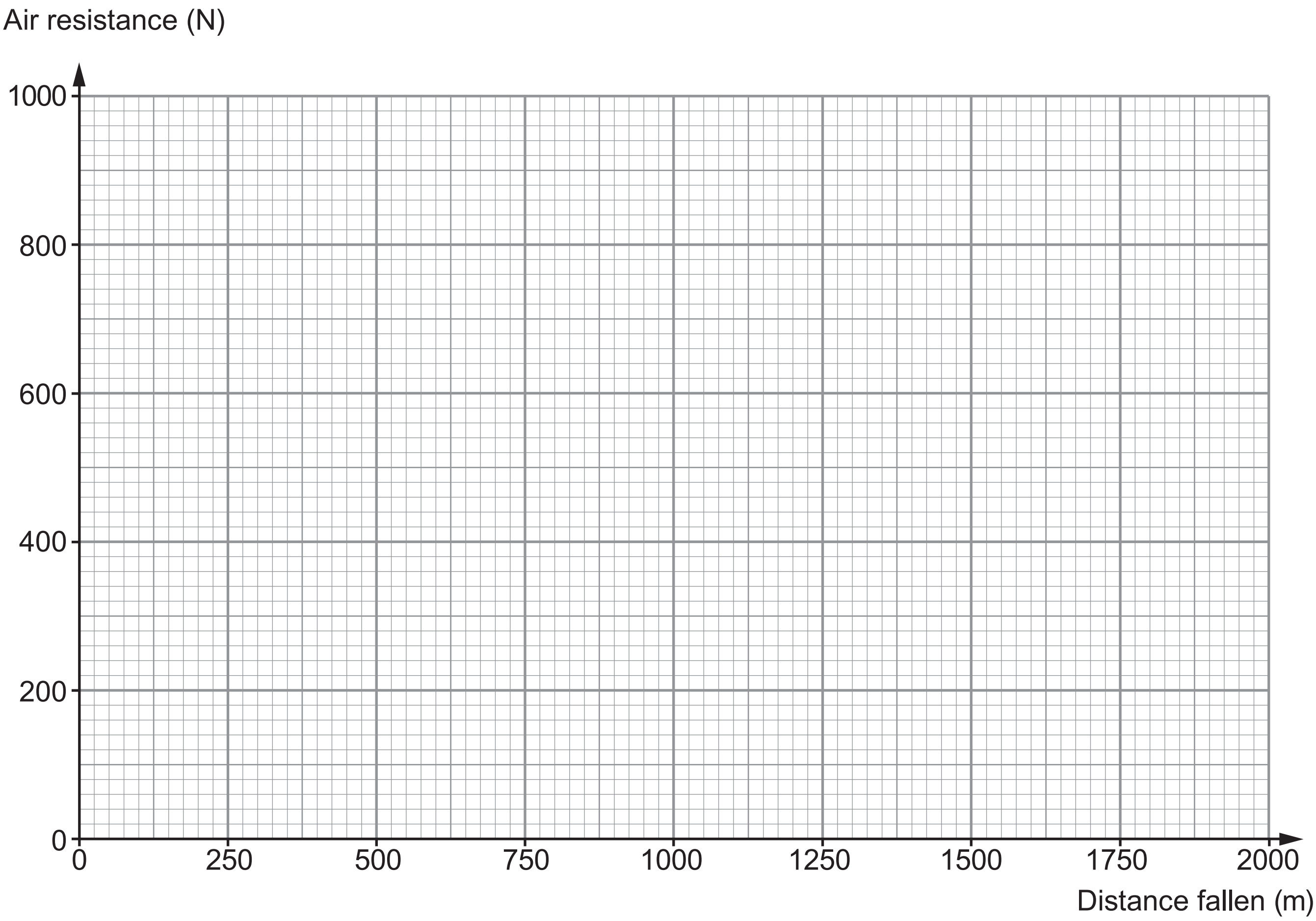
(iii) **Draw a graph** to show how the air resistance force changes with distance over this 2000 m fall. [4]



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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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