Surname	Centre Number	Candidate Number
First name(s)		0

GCSE – CONTINGENCY

3420U40-1

Z22-3420U40-1

THURSDAY, 23 JUNE 2022 – AFTERNOON

PHYSICS – Unit 2:
Forces, Space and Radioactivity

FOUNDATION TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**3**	
2.	**3**	
3.	**9**	
4.	**3**	
5.	**10**	
6.	**7**	
7.	**7**	
8.	**11**	
9.	**7**	
10.	**10**	
11.	**10**	
Total	**80**	

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01

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 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 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 **8(a)**.

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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	
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 = $\frac{\text{change in momentum}}{\text{time}}$	$F = \frac{\Delta p}{t}$
u = initial velocity v = final velocity t = time a = acceleration x = displacement	$v = u + at$ $x = \frac{u + v}{2}\,t$
moment = force × distance	$M = Fd$

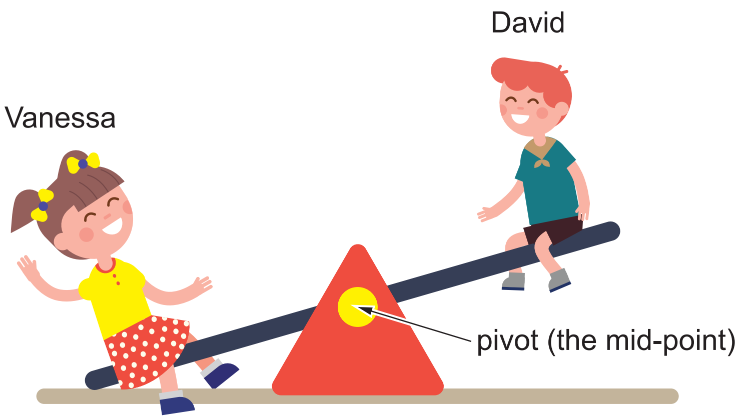
SI multipliers

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

Examiner only

Answer **all** questions.

1. (a) The picture shows Vanessa and David sitting on a see-saw.



The see-saw in the diagram is not balanced because Vanessa is heavier than David.

Place a **tick (✓)** in **one** box alongside the correct statement below. [1]

Vanessa and David can't balance the see-saw because they have different weights.	☐
If Vanessa moves nearer the pivot, the see-saw can be balanced.	☐
For the see-saw to balance, they **must** sit at the ends.	☐

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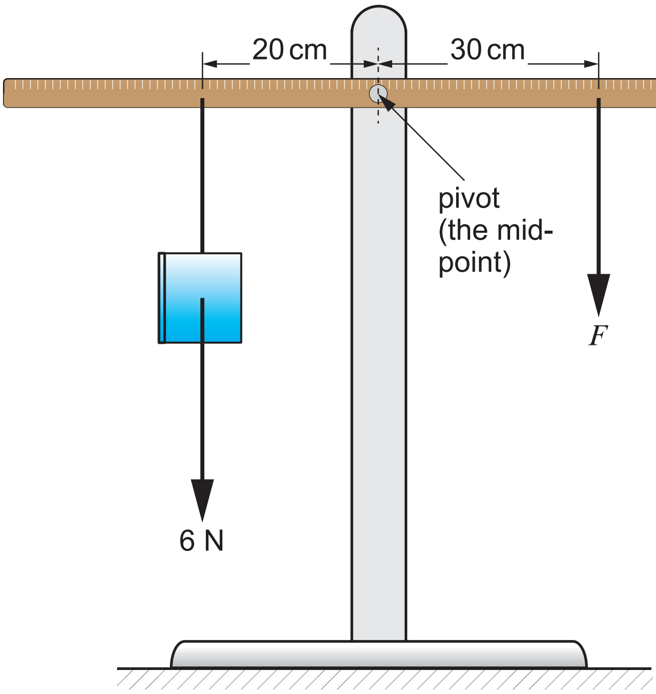
(b) A metre ruler is hung from its mid-point. A book weighing 6 N is 20 cm from the pivot. It is balanced by a force, F as shown in the diagram.



Use the equation:

$$F = \frac{6 \times 20}{\text{distance}}$$

to calculate the value of the force, F. [2]

force, F = ... N

3

Examiner only

2. Underline the correct word or phrase from each bracket to complete the sentences below. [3]

Cosmic **(microwave / material / metre)** background radiation is often referred to as CMBR.

As this radiation travelled through space its wavelength **(decreased / stayed the same / increased)**.

The background radiation in space began with **(the formation of the Sun / the Big Bang / the formation of the Milky Way)**.

3

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3. The following table contains data about four of the planets that orbit the Sun.

	Distance from Sun (million km)	Surface temperature (°C)	Diameter (units)	Mass (units)	Gravitational field strength, g (N/kg)
Earth	150	15	10	60	10.0
Mars	230	–65	5	6	3.7
Saturn	1435	–140	100	5700	9.0
Venus	108	464	10	49	9.0

(adapted from planetary fact sheet NASA)

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

(a) Underline the correct word in each of the sentences below. [3]

(i) The planet nearest the Sun is **(Earth / Mars / Saturn / Venus)**.

(ii) The coldest planet is **(Earth / Mars / Saturn / Venus)**.

(iii) The biggest planet is **(Earth / Mars / Saturn / Venus)**.

(b) (i) State the gravitational field strength on Venus. [1]

.... N/kg

(ii) Use the equation:

weight = mass × gravitational field strength on Venus

to calculate the weight of an object of mass 80 kg on Venus. [2]

weight = ... N

(iii) Name a planet on which an object of mass 80 kg would have the same weight as on Venus. [1]

....

Examiner only

(c) One student, Ceri, says that planets with the same diameter have the same mass. Explain whether you agree with this statement. [2]

....

....

....

9

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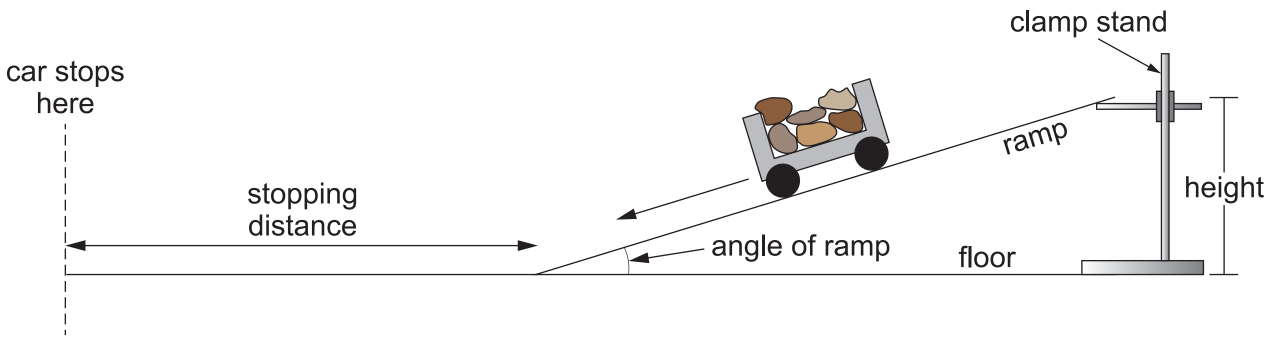
4. In a class experiment, some students investigate the stopping distance of a toy car after it travels down a ramp.
In their experiment, they add stones to the toy to investigate whether its total weight affects its stopping distance along the flat floor.



(a) State the **dependent** variable. [1]

....

(b) The students are asked to investigate other variables that would affect its stopping distance.
Using the same apparatus given, state **two** other independent variables they could investigate. [2]

1. ....

2. ....

3

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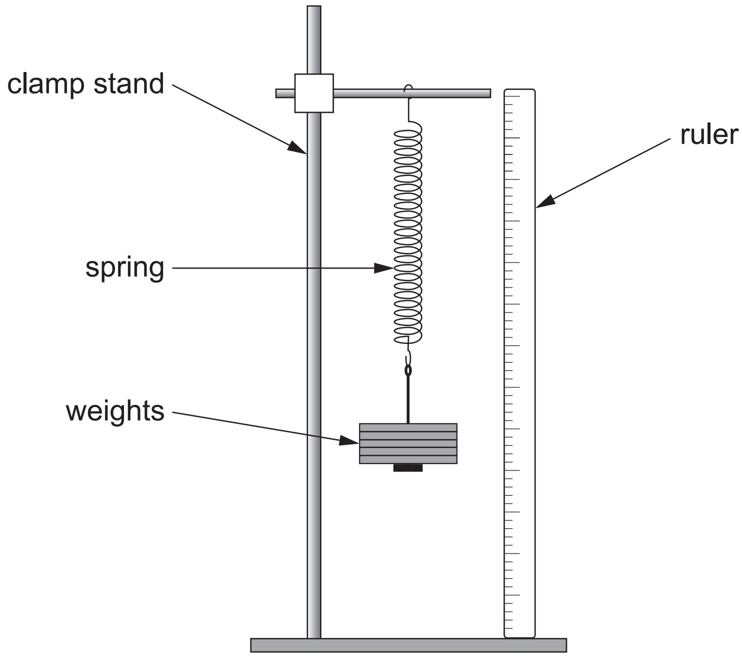
5. The diagram shows the apparatus used by a group of students when investigating the stretching of a spring.



The spring is loaded and then unloaded.
Its extension is determined when different weights are added.
Their results are shown below.

Force (N)	Extension when loading (cm)	Extension when unloading (cm)	Mean extension (cm)
0.0	0.0	0.0	0.0
1.0	3.9	4.1	4.0
2.0	8.0	8.0	8.0
4.0	16.0	16.0	16.0
5.0	20.2	19.8	20.0
6.0	23.7	24.3	24.0
7.0	28.0	28.0	28.0

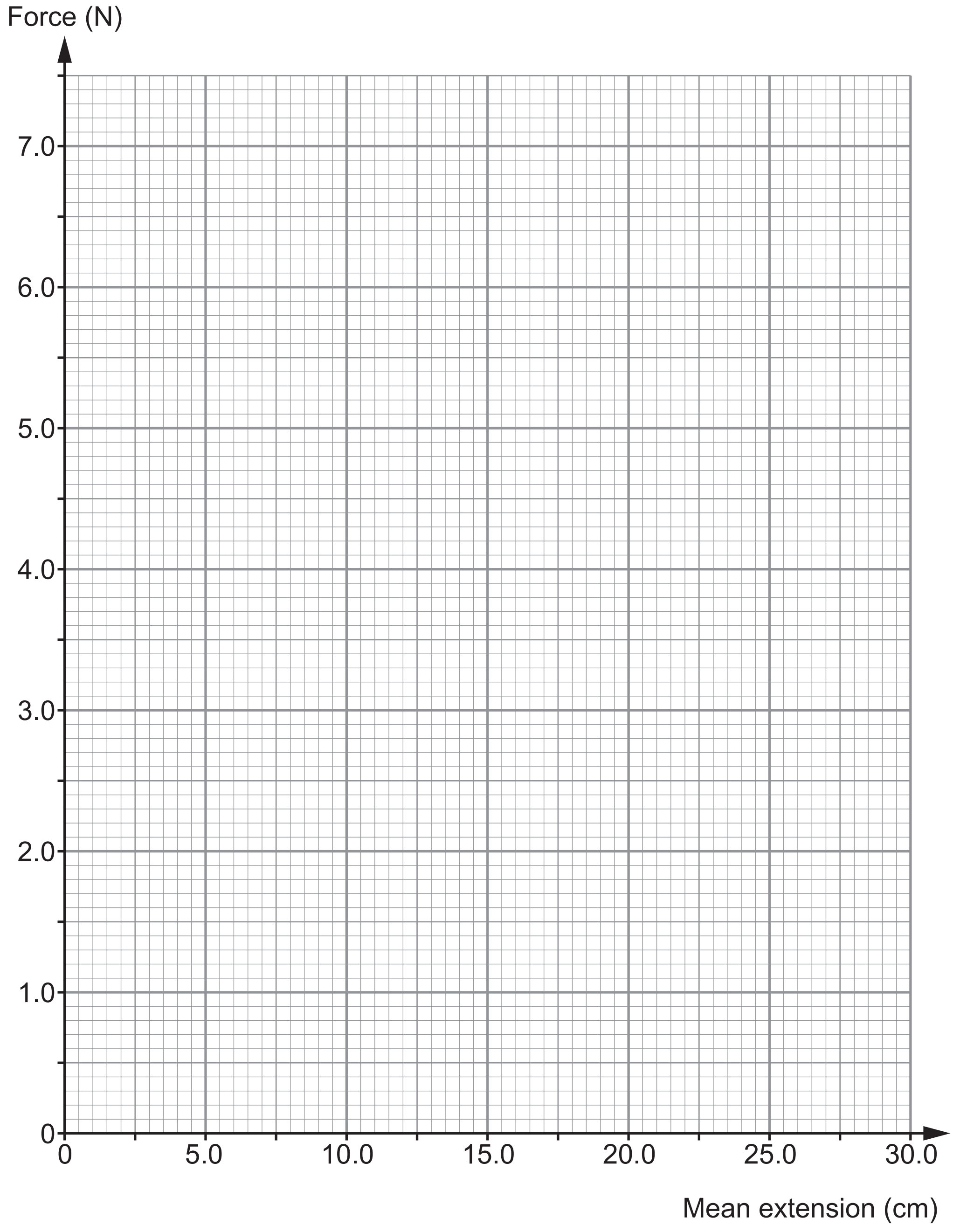
(a) State the **two** measurements that need to be taken to determine the extension of the spring. [2]

1. ....

2. ....

Examiner only

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



(c) Use your graph to determine the extension for a force of 2.5 N. [1]

extension = ... cm

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(d) Use your answer from part (c) and the equation:

$$\text{spring constant} = \frac{\text{force}}{\text{extension}}$$

to calculate the spring constant for a force of 2.5 N. [2]

spring constant = ... N/cm

(e) Explain how you could check whether the results of this investigation are reproducible. [2]

....

....

....

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6. You are exposed to natural sources of background radiation all the time. The level of background radiation varies depending on where you live.

(a) (i) Name **one** cause of background radiation. [1]

....

(ii) Give a reason why the level of background radiation depends on where you live. [1]

....

....

(b) Having an X-ray taken of part of the body exposes the person to ionising radiation. The following table gives the effect on the body from X-rays.

X-ray	Radiation's effect on the body	
	Radiation dose (units)	Equivalent number of hours of background radiation
chest	100	200
hand	1	2
dental	5	10

(i) State which X-ray gives the most risk to the patient and give a reason for your answer. [2]

X-ray ....

Reason ....

....

(ii) A person has 1 chest X-ray and 4 dental X-rays in his lifetime.
Toni suggests that this is equivalent to 240 hours of extra background radiation.
Use data from the table to decide whether you agree with this suggestion. [3]
Space for calculation.

....

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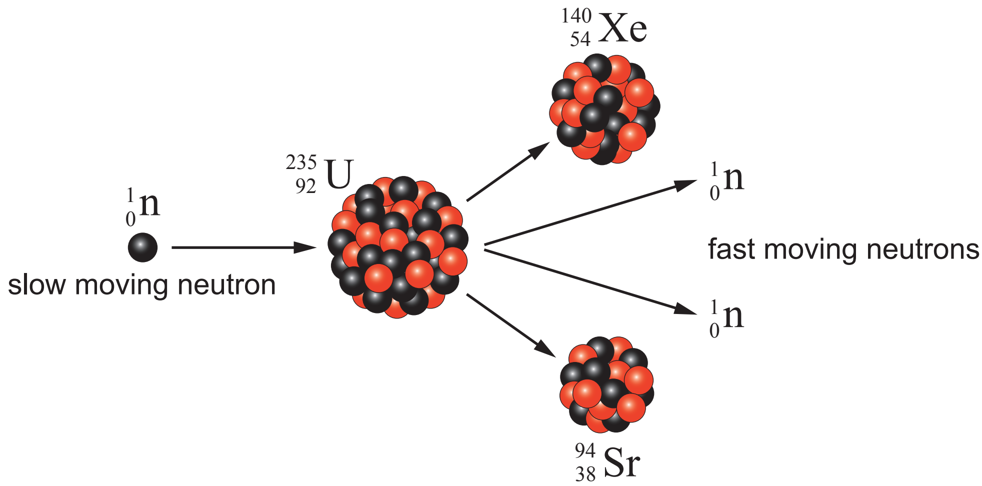
7. The diagram shows the fission of a uranium (U) nucleus by a slow-moving neutron ($^{1}_{0}n$).
This reaction can take place in a nuclear reactor.
The fission produces nuclei of xenon (Xe) and strontium (Sr) and further neutrons.



(a) Explain the function of the moderator in a nuclear reactor. [2]

....

....

....

(b) **Complete the nuclear equation** for the reaction shown in the diagram above. [3]

$$^{1}_{0}n + \, ^{235}_{92}U \longrightarrow \text{.....................} + \text{.....................} + \text{..........}\,^{1}_{0}n$$

(c) In the nuclear reaction shown above, only one of the neutrons causes further fission.

Underline the correct word from each bracket below to complete the sentences correctly. [2]

The other neutron is **(emitted / absorbed / reflected)**.
This is done by **(control / fuel / moderator)** rods.

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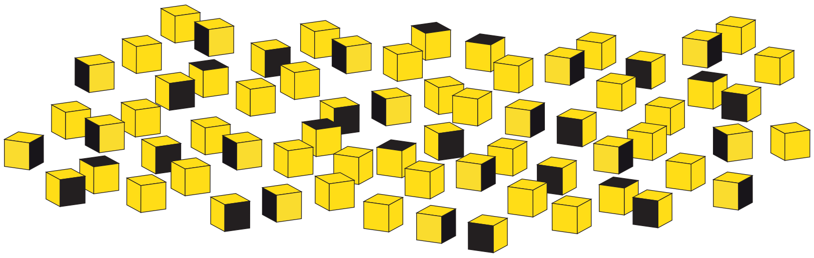
Examiner only

8. The atoms of radioactive substances decay at random.

(a) Students are given 200 cubes each with one side coloured black.
Describe how they would use the cubes to model radioactive decay **and** find the half-life. [6 QER]



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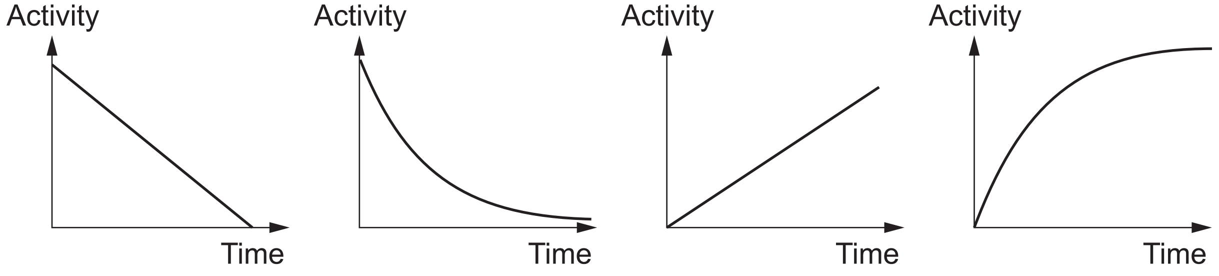
Examiner only

(b) An activity-time graph can be drawn for a radioactive substance.

Place a **tick (✓)** in the box beneath the graph that shows how the activity of a radioactive substance changes with time. [1]



(c) In an extension to their experiment, each group of students in a class is given 270 6-sided dice.
After each throw they remove the dice that show a ONE or a SIX facing upwards.

Their results are shown below.

Number of throws	Number of ONES removed	Number of SIXES removed	Number of dice remaining
0			270
1	40	....	185
2	37	30	118
3	18	17	....
4	14	14	55
5	10	9	36

(i) After the **first throw**, how many ONES would you have **expected** to be removed? [1]

number of ONES expected ....

(ii) **Complete the table.** [2]

(iii) Why does combining results from several groups of students better model radioactive decay? [1]

....

11

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9. A student aims to improve his fitness.
Starting from rest, he can accelerate at $a = 2\,\text{m/s}^2$ for a time, $t = 4\,\text{s}$.

Use the information above to answer the following questions.

(a) (i) State the value of the initial velocity, u. [1]

initial velocity, u = ... m/s

(ii) Use the equation:

$$v = u + at$$

to calculate his final velocity, v. [2]

final velocity, v = ... m/s

(b) Use the equation:

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

to calculate the distance travelled, x, in this time of 4 s. [2]

distance, x = ... m

(c) The student thinks that there are two ways that he could increase his acceleration.
1. Reducing body mass.
2. Increasing the strength of his legs.

Explain whether you agree with his ideas. Use $a = \frac{F}{m}$. [2]

....

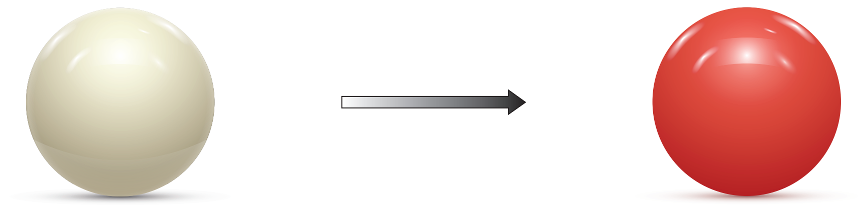
....

....

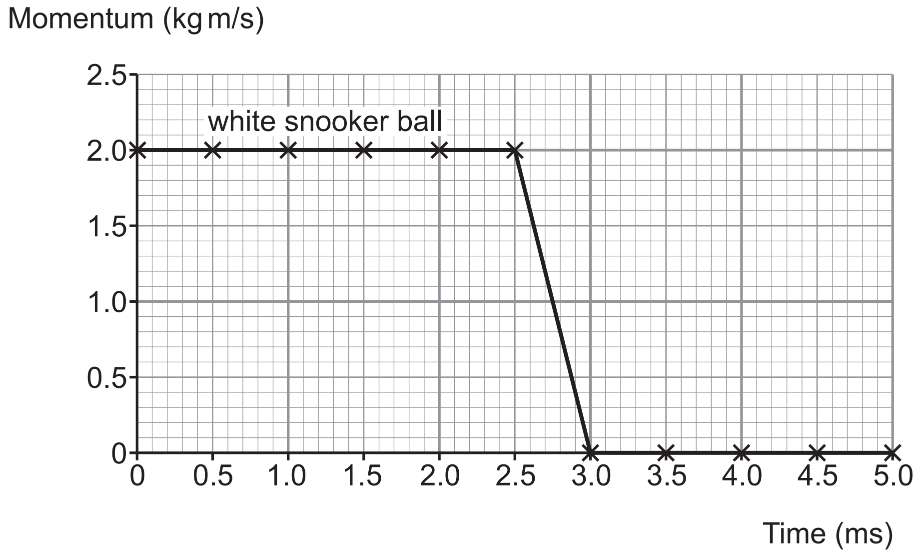
7

Examiner only

10. A white snooker ball, rolling to the right, collided with a **stationary** red snooker ball at a time of 2.5 ms.
Each snooker ball has a mass 0.16 kg.



The graph below shows the momentum of the **white snooker ball** before and after the collision.



(a) Use information from the graph to answer the following questions.

(i) State the initial momentum of the white snooker ball. [1]

initial momentum = ... kg m/s

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(ii) Use the equation:

$$\text{initial velocity} = \frac{\text{initial momentum}}{\text{mass}}$$

to calculate the initial velocity of the white snooker ball. [2]

initial velocity = ... m/s

(iii) The collision takes a time of 0.5 ms. State this time in seconds. [1]

time = ... s

(iv) Use the equation:

$$\text{resultant force} = \frac{\text{change in momentum}}{\text{time}}$$

to calculate the resultant force on the white snooker ball during the collision. [2]

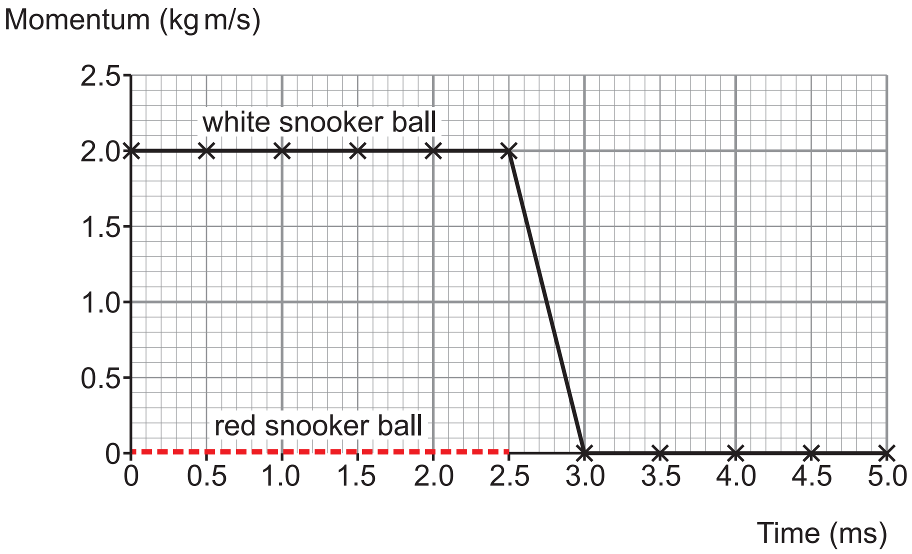
resultant force = ... N

(b) (i) Underline the correct word or phrase from each of the brackets below which correctly completes the sentence. [2]

The law of conservation of momentum states that the total momentum before a collision is **(less than / equal to / greater than)** the total momentum after a collision provided **(no / small / large)** external forces act.

Examiner only

(ii) The momentum of the red snooker ball, between 0.0 and 2.5 ms, has been added to the original graph. It is shown as a red dotted line.
Complete the graph below to show the momentum of the red snooker ball from 2.5 ms to 5.0 ms. [2]



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11. A group of students investigate how the surface area of a falling paper cake case affects its terminal speed.

- Cake case 1 has a mass of 0.5 g and a surface area of 100 cm^2.
- Cake case 1 is dropped from a height of 1.80 m but only timed over the final 1.50 m of the fall.

The students' results are shown in the table below.

Drop time (s)			Mean drop time (s)	Drop distance (m)
Attempt 1	Attempt 2	Attempt 3		
0.96	0.92	0.94	....	1.50

(a) (i) The students decide there are no anomalies. Explain why. [1]

....

(ii) **Complete the table** to show the mean drop time. [1]
Space for calculation.

(b) The experiment is repeated with cake case 2.
It has the same shape and the same mass as cake case 1.
However, cake case 2 has a surface area of 50 cm^2.
The students correctly calculate the terminal speed for both cake cases.

Cake case 1		
Mass (g)	Surface area (cm^2)	Terminal speed (m/s)
0.5	100	1.6

Cake case 2		
Mass (g)	Surface area (cm^2)	Terminal speed (m/s)
0.5	50	2.3

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(i) A cake case reaches terminal speed when its weight is balanced by air resistance. **Tick (✓)** the **three** correct statements. [3]

Cake case 2 has the same terminal speed as cake case 1.	☐
Cake cases 1 and 2 have identical weight.	☐
At terminal speed, cake case 1 experiences a greater value of air resistance than cake case 2.	☐
At terminal speed, both cake cases experience identical values of air resistance.	☐
At terminal speed, cake case 1 experiences a smaller value of air resistance than cake case 2.	☐
At terminal speed, both cake cases have zero acceleration.	☐

(ii) Before the experiment was carried out the students made the following prediction:

"If the surface area of the cake case is halved its terminal speed will double."

Use data from the tables on the previous page to explain whether their prediction was correct. [2]

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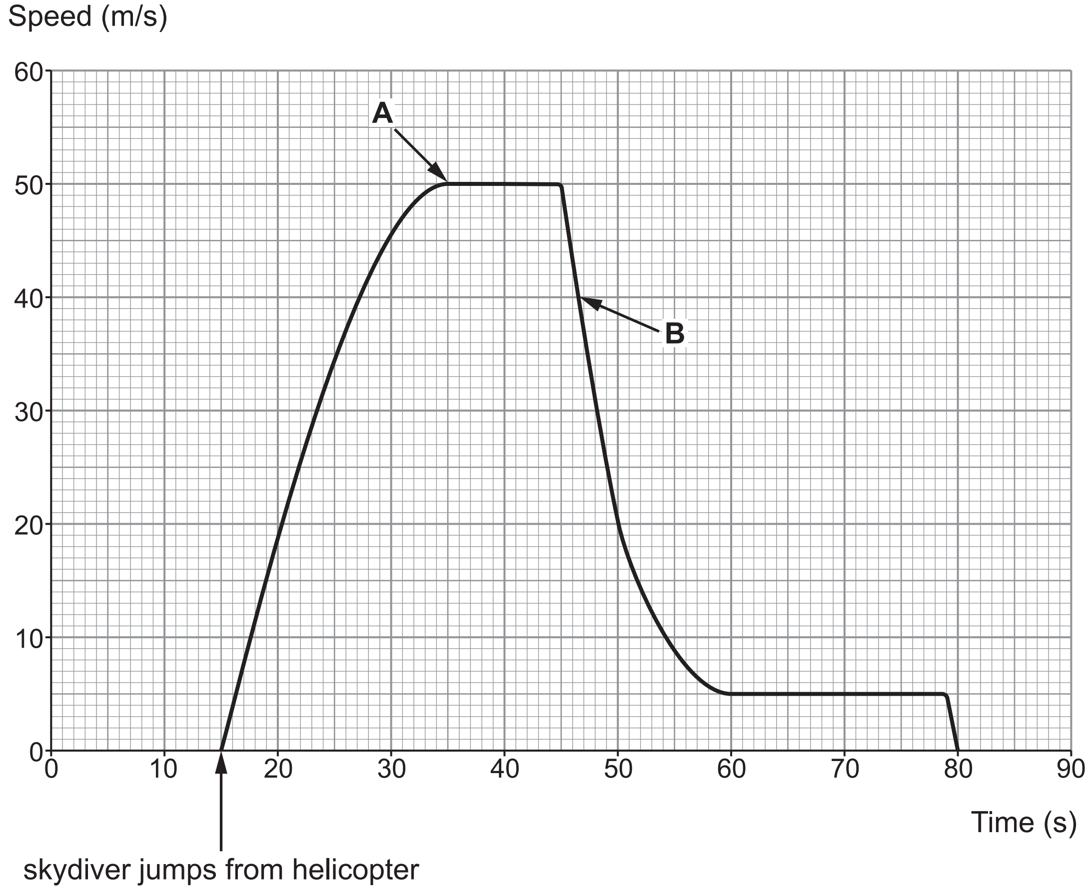
(c) A skydiver sits at the doorway of a helicopter for 15 s before jumping. His speed is recorded and displayed on the graph below.



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

The skydiver lands on the ground 80 s after jumping from the helicopter.	☐
The terminal speed after the parachute is opened is $\frac{1}{10}$th of the terminal speed before the parachute is opened.	☐
The skydiver's weight is greatest at the point labelled **B** on the graph.	☐
The parachute is opened 30 s after the skydiver leaves the helicopter.	☐
At point **B** the weight of the skydiver is greater than the air resistance.	☐
At point **A** the skydiver stops accelerating.	☐

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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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