Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3420U20-1

S23-3420U20-1

THURSDAY, 25 MAY 2023 – MORNING

PHYSICS – Unit 2:
Forces, Space and Radioactivity

FOUNDATION TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**7**	
2.	**7**	
3.	**8**	
4.	**9**	
5.	**9**	
6.	**14**	
7.	**6**	
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 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 **7**.

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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	Symbol	Conversion factor	Multiplier
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}

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Answer **all** questions.

1. (a) The table below contains statements about the motion of an object and the forces acting on it.
For each statement, place **one** tick (✓) to show which law it applies to.
One row has been completed as an example. [3]

Statement	Newton's 1st Law	Newton's 2nd Law	Newton's 3rd Law
A skydiver accelerates when the forces are unbalanced.	✓		
This law can be written as $F = ma$.			
A train will not move from rest unless acted on by a resultant force.			
When it is fired, a rifle exerts a force on a bullet. The bullet exerts an equal and opposite force on the rifle.			

(b) A ball is dropped from rest (u = 0 m/s) from a window.
It takes a time, t = 1.2 s to reach the ground.

(i) Use the equation:

$$v = u + at$$

to calculate the speed, v, of the ball as it hits the ground. [2]
(Acceleration, a = 10 m/s^2)

v = ... m/s

(ii) Use your answer above for v and the equation:

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

to calculate the distance, x, of the window above the ground. [2]

x = ... m

7

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2. Caesium has many isotopes.
One of these is caesium-137.

(a) The symbol for the isotope caesium-137 is $^{137}_{55}Cs$.

Tick (✓) the box next to the symbol of another isotope of caesium. [1]

$^{137}_{54}Cs$ ☐

$^{133}_{55}Cs$ ☐

$^{138}_{57}Cs$ ☐

(b) When caesium-137 decays, beta particles are emitted from unstable nuclei.

(i) Tick (✓) the box next to the correct statement about unstable nuclei. [1]

They have too many electrons ☐

They have too many protons ☐

The number of neutrons and protons is unbalanced ☐

(ii) Tick (✓) the box next to the correct symbol for a beta particle. [1]

$^{1}_{-1}\beta$ ☐

$^{0}_{-1}\beta$ ☐

$^{-1}_{0}\beta$ ☐

(iii) Tick (✓) the box next to the correct statement about a beta particle. [1]

It is a helium nucleus ☐

It is an electromagnetic wave ☐

It is a high energy electron ☐

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(c) The activity of a sample of caesium-137 is 160 units.
It has a half-life of 30 years.

(i) Underline **one** number in the brackets to complete the sentence. [1]

After 30 years, the activity of the caesium-137 sample will be (**20** / **40** / **80**) units.

(ii) Jason says the activity of the sample will be zero after 60 years.
Explain whether you agree with Jason. [2]

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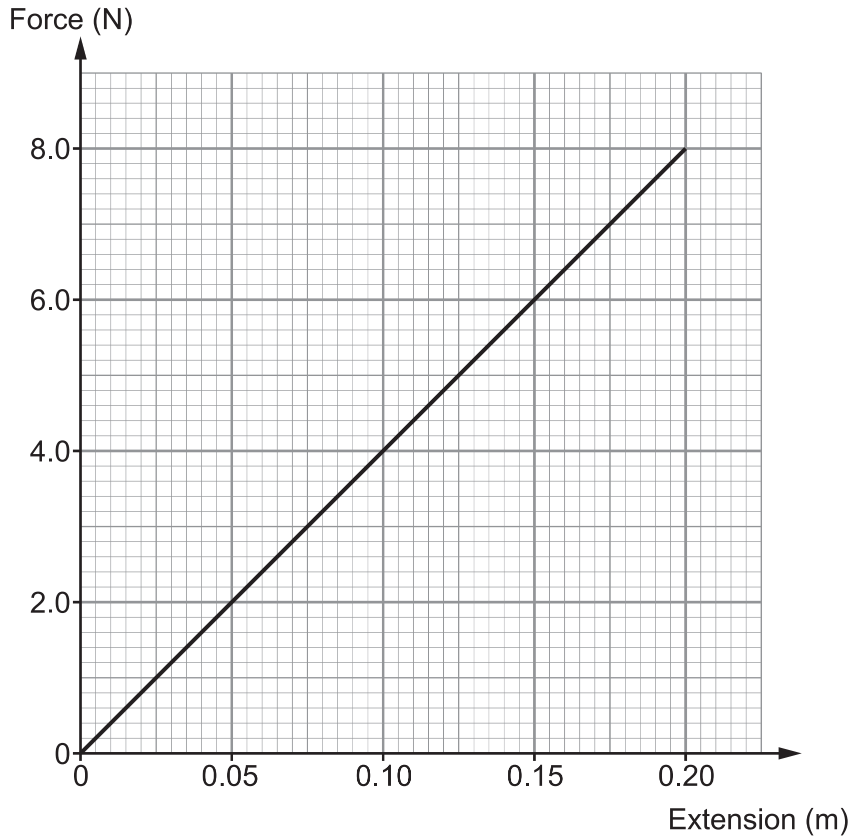
3. (a) Students carry out an experiment on a spring.
The length of the spring is measured for each force and extensions are calculated.
The force-extension graph is shown below.



Use the equation:

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

and the graph to calculate the spring constant in N/m for a force of 8.0 N. [2]

spring constant = ... N/m

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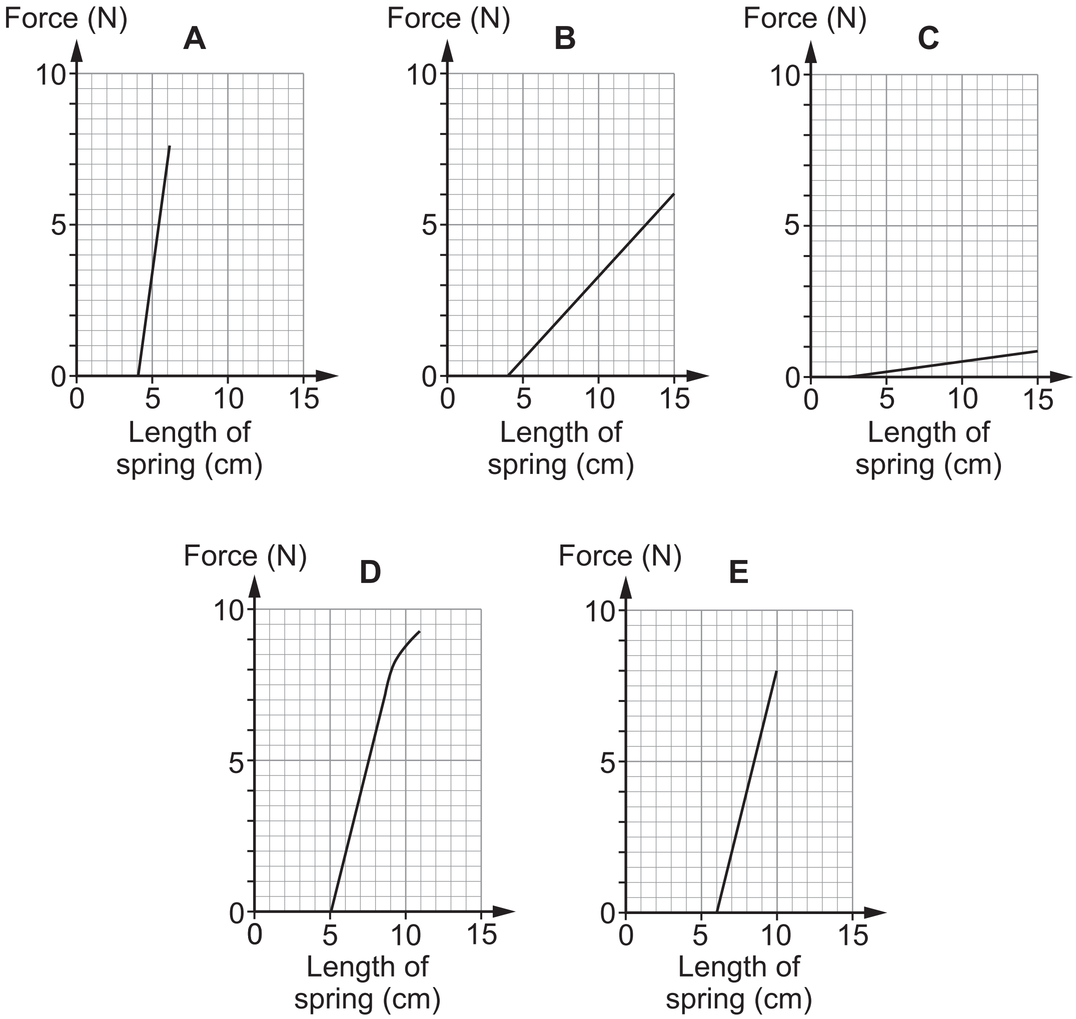
(b) The following graphs were obtained when students in a class used forces to stretch five different springs, **A**, **B**, **C**, **D** and **E**.
These students measured the lengths of each spring with different forces and did not calculate extension.
All graphs are drawn on axes with the same scales.



(i) Use the graphs above to answer the following questions about springs **A** to **E**.

I. State which spring is easiest to stretch. .... [1]

II. State which spring has the biggest unstretched length. .... [1]

III. State which spring has the same spring constant as **D**. .... [1]

IV. State which spring is stretched beyond its elastic limit. .... [1]

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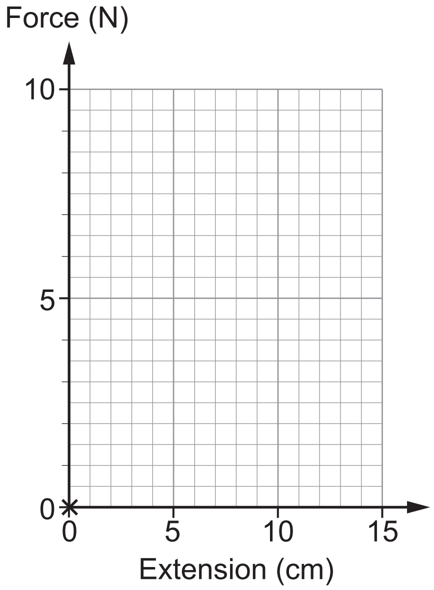
(ii) They decided to calculate extensions and draw the **force-extension** graph for Spring **E**.
Draw this graph on the axes below.
The first point has been plotted for you. [2]



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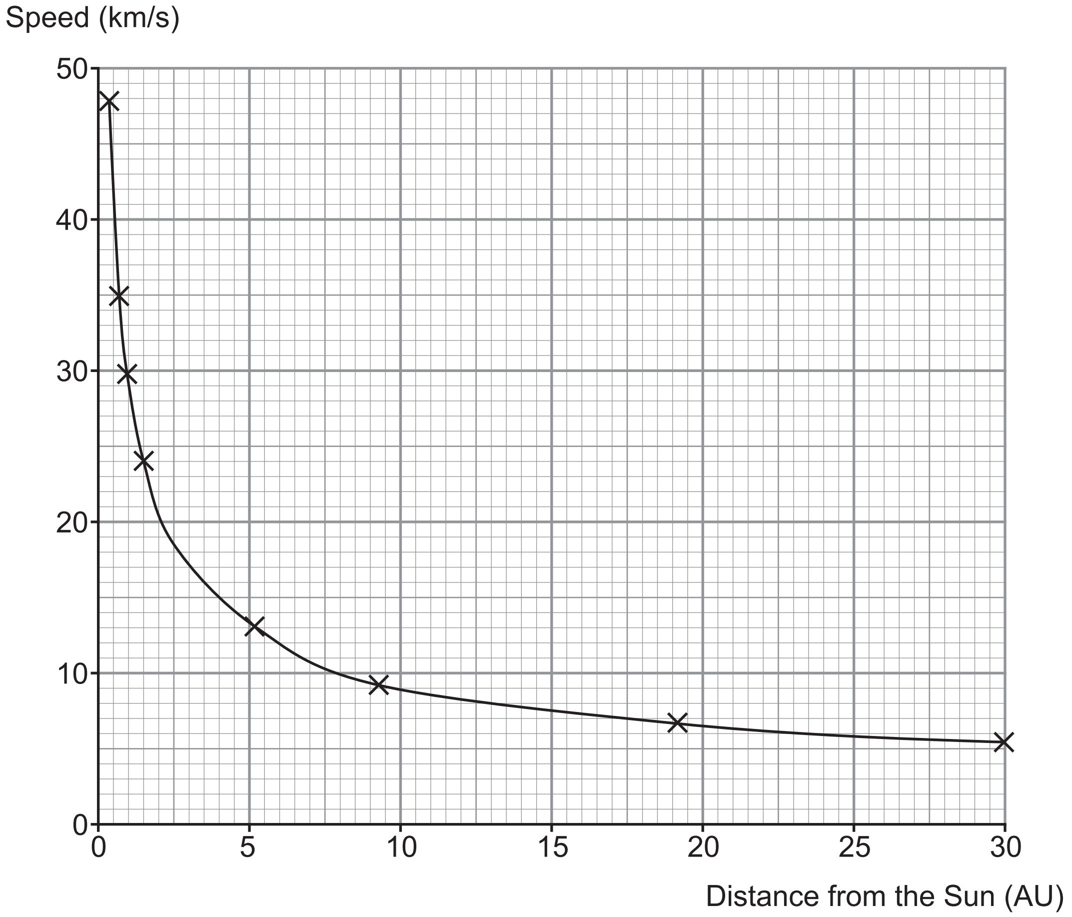
4. There are eight planets in orbit around the Sun in our solar system.
The graph shows how their orbital speeds depend on their distance from the Sun.



(a) Describe the relationship between the speed of the planets and their distance from the Sun. [2]

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(b) Use the information in the graph to **complete the table**. [2]

Planet	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Speed (km/s)	47.9	....	29.8	24.1	13	9.7	6.8	5.4
Distance from the Sun (AU)	0.4	0.7	1	1.5	5.2	9.5	19.2	....

(c) Name the planet that is about twice as far as Saturn from the Sun. [1]

....

(d) The distances on the graph are given in AU (astronomical units).
Use the table to state what distance one AU represents. [1]

....

(e) The asteroid belt is between the orbits of Mars and Jupiter.
Paula states that the mean orbital speed of asteroids is 18 km/s.
Owain states that the asteroid belt is 10 AU from the Sun.
Use the data in the table above to explain whether you agree with Paula or with Owain. [3]

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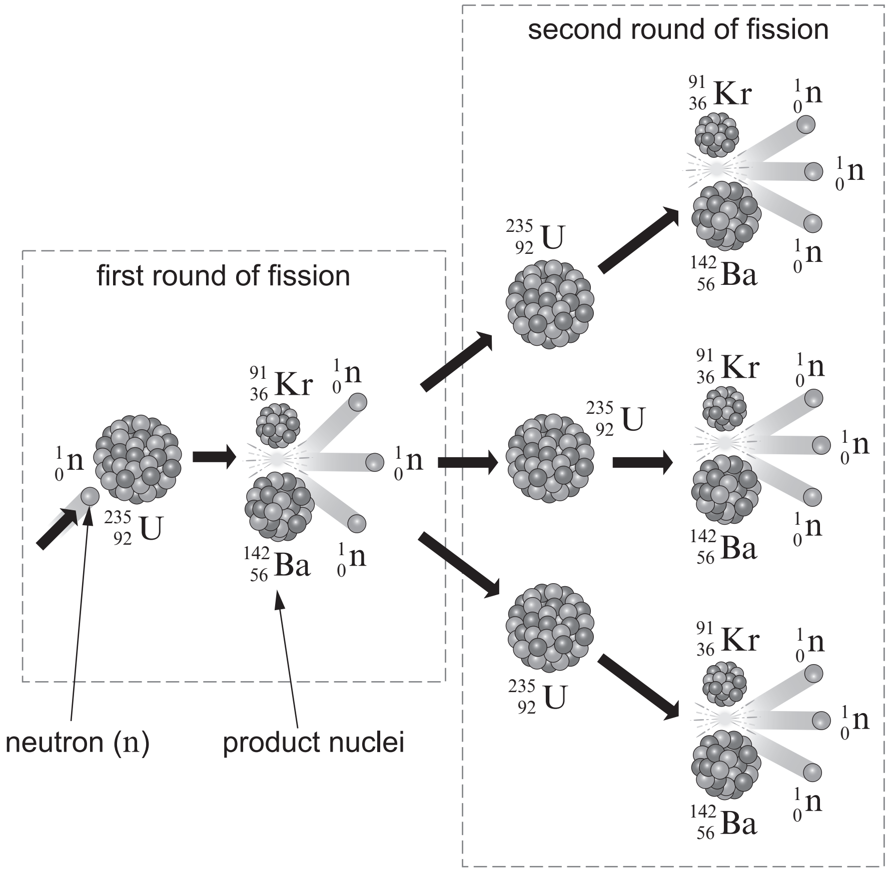
5. The diagram shows one possible chain reaction in the fission of uranium–235 ($^{235}_{92}\mathrm{U}$) by a single neutron ($^{1}_{0}\mathrm{n}$).
The product nuclei, krypton (Kr) and barium (Ba), are radioactive.



During the first round of fission, 2 product nuclei are created and 3 neutrons are released.

(a) Tick (✓) the **three** boxes next to the correct statements below. [3]

One neutron splits to create three other neutrons.	☐
The proton numbers of barium and krypton add to give the proton number of uranium-235.	☐
Nuclear fission takes in energy from the nucleus.	☐
During the second round of fission, another 9 neutrons are released.	☐
During the second round of fission, another 6 product nuclei are created.	☐
An atom of uranium-235 has 92 neutrons in its nucleus.	☐

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(b) Use words from the box to complete the following sentences about a nuclear reactor. Each word may be used once, more than once or not at all.

absorb	**one**	**two**	**three**	**fuel**	**moderator**
emit	**concrete**	**reactor**	**control**		

(i) Neutrons are slowed down by the .... so uranium nuclei can .... them. [2]

(ii) .... rods absorb fission neutrons so only .... of these neutrons goes on to produce further fission. [2]

(iii) In an emergency, ... rods are dropped fully into the nuclear .... [2]

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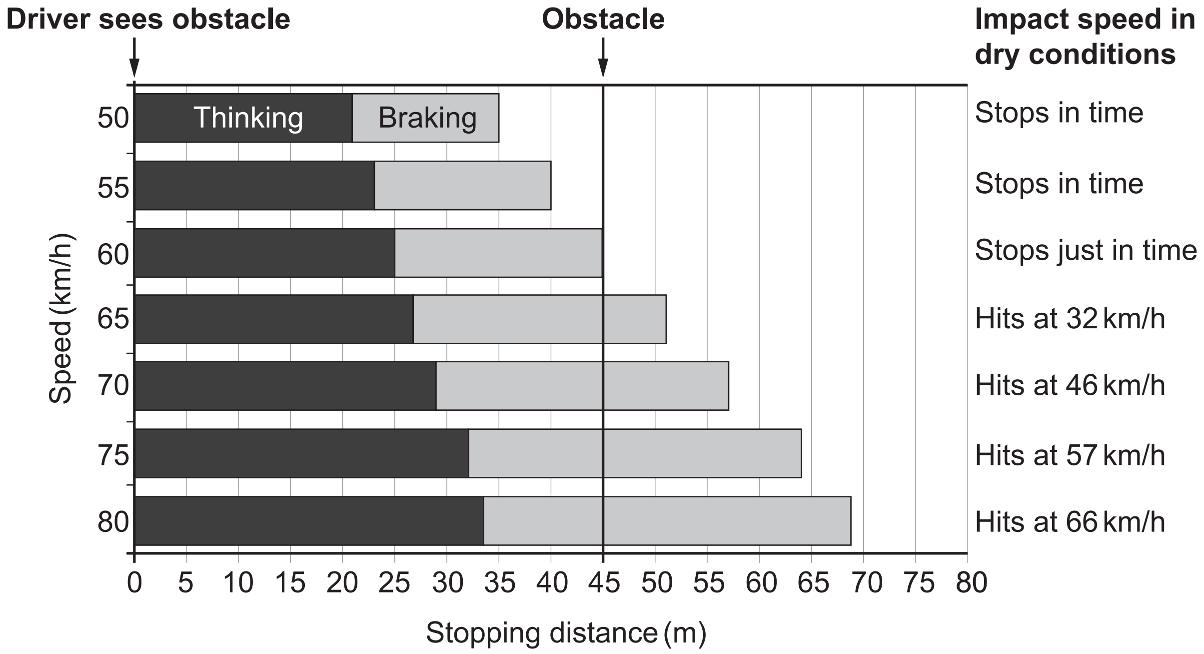
6. The chart below is used by traffic collision investigators. It gives the thinking, braking and stopping distances of cars driven at different speeds by an alert driver on a dry road.

Stopping distance is given by the following equation:

stopping distance = thinking distance + braking distance

An alert driver notices an obstacle 45 m away on the road ahead. The position of this obstacle is represented by the dark vertical line. If there is a collision, the chart also shows the impact speed with the obstacle.



(a) Use the information in the chart to answer the following questions.

(i) State the stopping distance for a speed of 50 km/h. .... m [1]

(ii) State the speed at which the car stops just in time. .... km/h [1]

(iii) State the speed which gives a braking distance of 35 m. .... km/h [1]

Examiner only

(iv) Tiredness doubles **thinking** distance for some drivers.
Gareth claims that, for these tired drivers travelling at 60 km/h, the stopping distance becomes 90 m.
With the aid of calculations, explain whether you agree with the claim. [3]

....

....

(v) Use the equation:

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

and information from the chart for a car travelling at 60 km/h (17 m/s), to calculate the **thinking time** of an alert driver. [3]

Thinking time = ... s

(b) A car is travelling at 70 km/h on a dry road when it starts to rain causing the road to become **wet**.
Complete the table below.
In each box, add either increases, decreases, or stays the same. [3]

Thinking distance	Braking distance	Stopping distance	Impact speed
....	....	increases	....

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(c) Seat belts **and** crumple zones work together to keep the occupants of a car safe in the event of a head-on collision.
Complete the table by placing a tick (✓) in the column that matches with the action.
One has been done as an example. [2]

Action	Seat belt	Crumple zone
Increases the time of the collision		✓
Reduces force on the car		
Prevents driver continuing through the windscreen		

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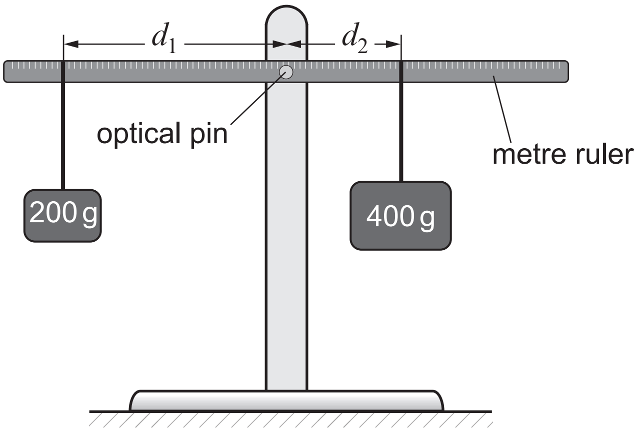
7. Describe how you would use the apparatus listed below and shown in the diagram to investigate the principle of moments. [6 QER]

List of apparatus:
- metre ruler with small hole at centre
- 2 × 100 g mass hangers
- 8 × 100 g masses
- 2 × loops of cotton
- clamp stand, boss and clamp
- optical pin and cork
- small piece of plasticine



Include in your answer:
- How you will set up the apparatus
- What measurements you will take
- How you will analyse your results to show the principle of moments.

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6

Turn over.

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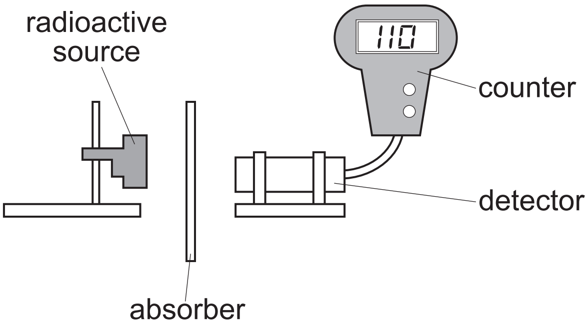
8. A teacher uses the apparatus below to demonstrate the penetrating properties of alpha, beta and gamma radiation.



(a) The teacher explains that there is a possibility of exposure to radiation from the source. Complete the risk assessment below. [2]

Hazard	Risk	Control measure
Nuclear radiation is ionising	....	....

(b) After the experiment the teacher gives the students some data about the radioactive source, cobalt-60, to analyse.
The data are given in the table below.

Absorber	Count rate (counts per second)
no absorber	256
paper	256
aluminium	110
lead	50

Use the data to answer the following questions.

(i) Explain how the data show that cobalt-60 does not emit alpha particles. [1]

....

....

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(ii) Explain how the data show that cobalt-60 emits beta and gamma radiation. [2]

....

....

....

(iii) The teacher tells the class that counts due to background radiation are included in the results in the table.

I. State **one** cause of background radiation. [1]

....

II. State how the results in the table should be corrected for background radiation. [1]

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7

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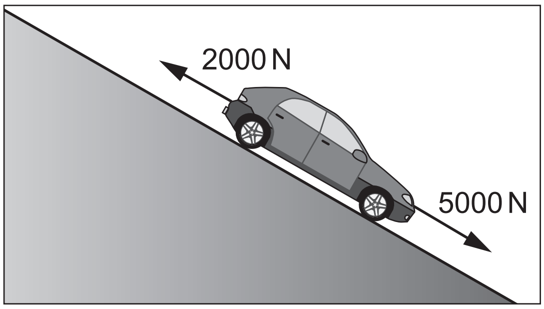
9. The diagram shows a car rolling down a slope. Two of the forces acting on the car are labelled.



(a) The car has a **weight** of 10 000 N. Use the equation:

$$\text{mass} = \frac{\text{weight}}{\text{gravitational field strength}}$$

to calculate the mass of the car. [2]
(Gravitational field strength, g, = 10 N/kg)

mass = ... kg

(b) Use the information in the diagram to answer the following questions.

(i) Calculate the resultant force acting down the slope. [2]

resultant force = ... N

(ii) Use your answers from parts (a) and (b)(i) and the equation:

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

to calculate the acceleration of the car at the instant shown and state the unit. [3]

acceleration = ...

unit = ...

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(iii) I. Explain how the resultant force on the car changes as it speeds up. [2]

....

....

....

II. State how this change in resultant force affects the acceleration of the car. [1]

....

(c) At the bottom of the slope the car continues horizontally at a constant speed of 12 m/s with a kinetic energy of 72 000 J.

(i) State **one** reason why the potential energy at the top of the hill must have been greater than 72 000 J. [1]

....

(ii) At the bottom of the hill a braking force is applied which stops the car over a distance of 15 m.

Use the equation:

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

to calculate the braking force. [2]

braking force = ... N

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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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