Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

S23-3430UF0-1

3430UF0-1

THURSDAY, 25 MAY 2023 – MORNING

SCIENCE (Double Award)
Unit 6 – PHYSICS 2

HIGHER TIER

1 hour 15 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**5**	
2.	**10**	
3.	**12**	
4.	**10**	
5.	**10**	
6.	**13**	
Total	**60**	

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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(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(a)**.

JUN233430UF0101

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

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}
terra	T	multiply by 1 000 000 000 000	1×10^{12}

Examiner only

Answer **all** questions.

1. (a) When a car stops the overall stopping distance is made up of two distances: the thinking distance and the braking distance.
Increasing speed increases both the thinking distance and the braking distance.

(i) State **one** factor, other than speed, which increases the thinking distance. [1]

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(ii) State **one** factor, other than speed, which increases the braking distance. [1]

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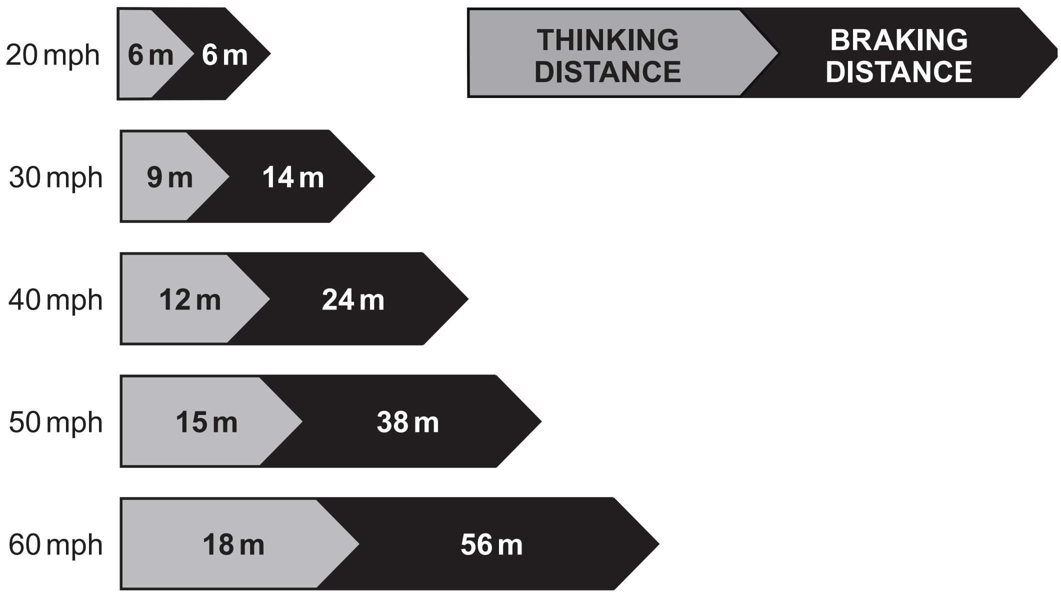
(b) The diagram gives information about stopping distances at different speeds.



On a dangerous road, it is proposed to reduce the speed limit from 40 mph to 20 mph.

Bethan makes the following 3 suggestions.

1. The thinking distance will halve.
2. The braking distance will halve.
3. The overall stopping distance will halve.

Explain whether you agree with each suggestion.
Include data from the diagram to support your answer. [3]

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Turn over.

Examiner only

2. (a) A class investigates radioactive decay.
They model decay using **8-sided** dice.

Each of the 10 groups has 50 dice.
They throw the dice and remove all which land with an 8 facing upwards.
These represent decayed nuclei.
They repeat 7 more times and record the number of dice remaining after each throw.
Each group's results are then added together.

(i) Freya suggests that it is good practice to add the results together to give a larger sample size.
Explain whether you agree. [1]

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(ii) The teacher calculates that after the first throw **around** 440 of the 8-sided dice should remain out of the 500.
Explain how she determined this number. [2]

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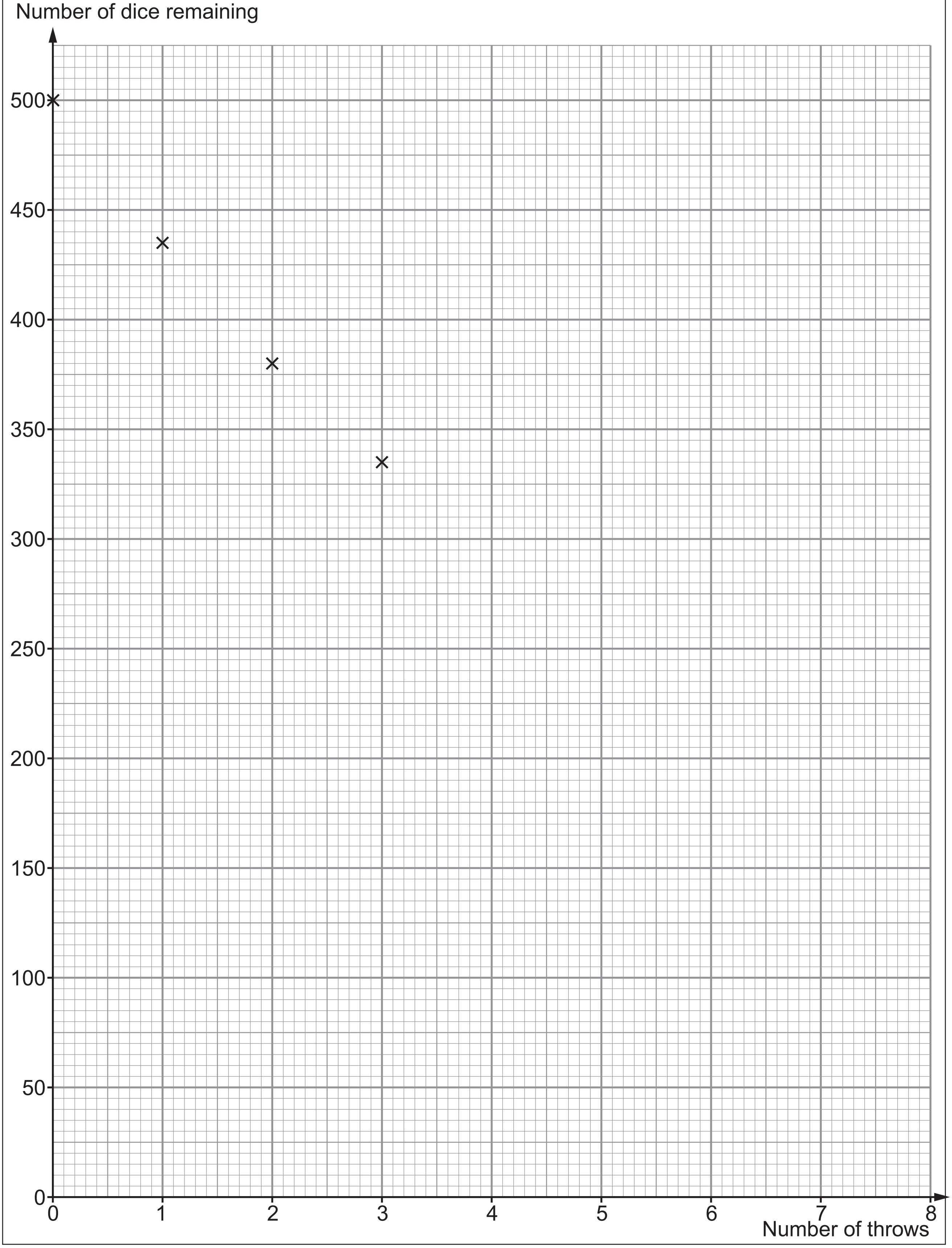
(b) The results from the experiment are given in the table below.

Number of throws	Number of dice remaining
0	500
1	435
2	380
3	335
4	291
5	256
6	224
7	196
8	171

Examiner only

(i) Plot the data on the grid below and draw a suitable curve.
The first 4 points have been plotted for you. [3]



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(ii) **Add lines to the graph** to find the number of throws required to halve the number of dice. This is the half-life.
Give your answer to 1 decimal place. [2]

number of throws = ...

(iii) The experiment is repeated with 10-sided dice.
Ieuan suggests the data could be used to model nuclear decay with a shorter half-life than with 8-sided dice.
Explain whether you agree. [2]

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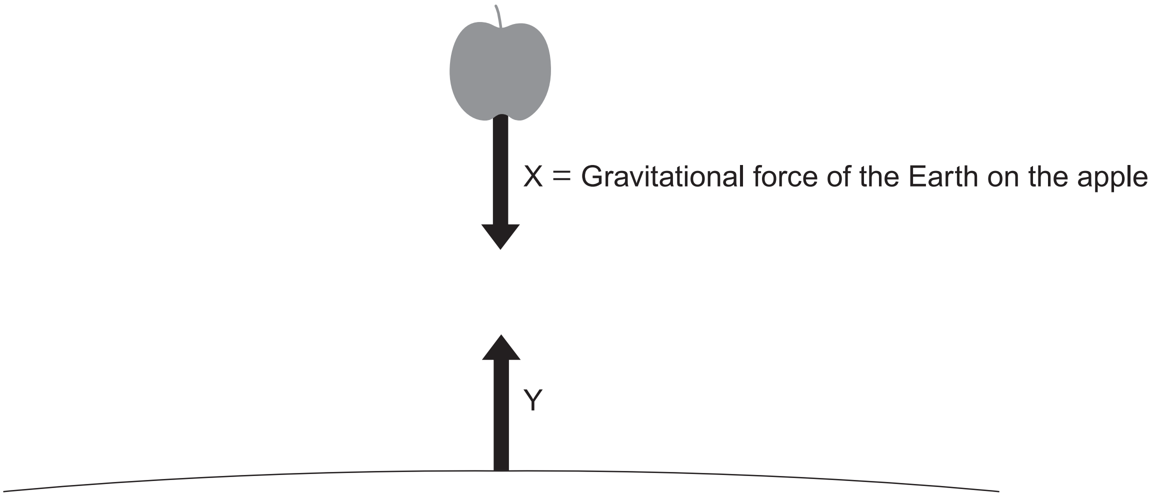
3. Newton's third law states that if a body A exerts a force on body B, body B exerts an equal and opposite force on body A.

(a) The diagram (not to scale) shows an apple of weight 1.5 N falling to the Earth.



(i) Underline the correct word in the brackets to describe force Y. [2]

Force Y is the (**gravitational / magnetic / mass**) force of the apple on the (**air / Earth / Moon**).

(ii) State how the two forces, X and Y, compare. [1]

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(iii) Use an equation from page 2 to calculate the mass of the apple. [2]
(g = 10 N/kg = 10 m/s^2)

mass = ... kg

(b) The apple is dropped from rest.

(i) State the initial acceleration of the apple. [1]

acceleration = ... m/s^2

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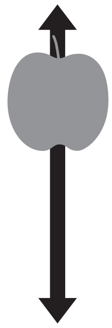
(ii) At some time later in the fall, the air resistance acting on the apple is 0.25 N.



Determine the size of the resultant force acting on the apple. [1]

resultant force = ... N

(iii) Use the equation:

resultant force = mass × acceleration

to calculate the new acceleration of the apple. [3]

acceleration = ... m/s^2

(c) The Apollo 15 astronaut David Scott performed an experiment on the Moon, where there is no air.
He predicted that if a hammer and a feather were dropped together from the same height, they would hit the Moon's surface at the same time.
Explain whether you agree with this prediction. [2]

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3430UF01 09

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4. (a) Radioactive waste contains a mixture of isotopes with a variety of half-lives. The isotopes emit alpha, beta and gamma radiation.
Discuss the safe storage of radioactive waste.
Include in your answer:
- a description of alpha, beta and gamma radiation,
- the properties of alpha, beta and gamma radiation,
- how radioactive waste could be safely stored. [6 QER]

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(b) One isotope of uranium (U) decays naturally by alpha (α) decay into thorium (Th) which in turn decays into protactinium (Pa) by beta (β) decay.

Complete the decay equation for this decay. [4]

$$^{\cdots\cdots}_{\cdots\cdots}\mathrm{U} \rightarrow {}^{231}_{90}\mathrm{Th} + {}^{4}_{\cdots\cdots}\alpha$$

$$^{231}_{90}\mathrm{Th} \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}\mathrm{Pa} + {}^{\cdots\cdots}_{-1}\beta$$

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5. (a) Arcturus is a red giant star, 37 light-years away from Earth.

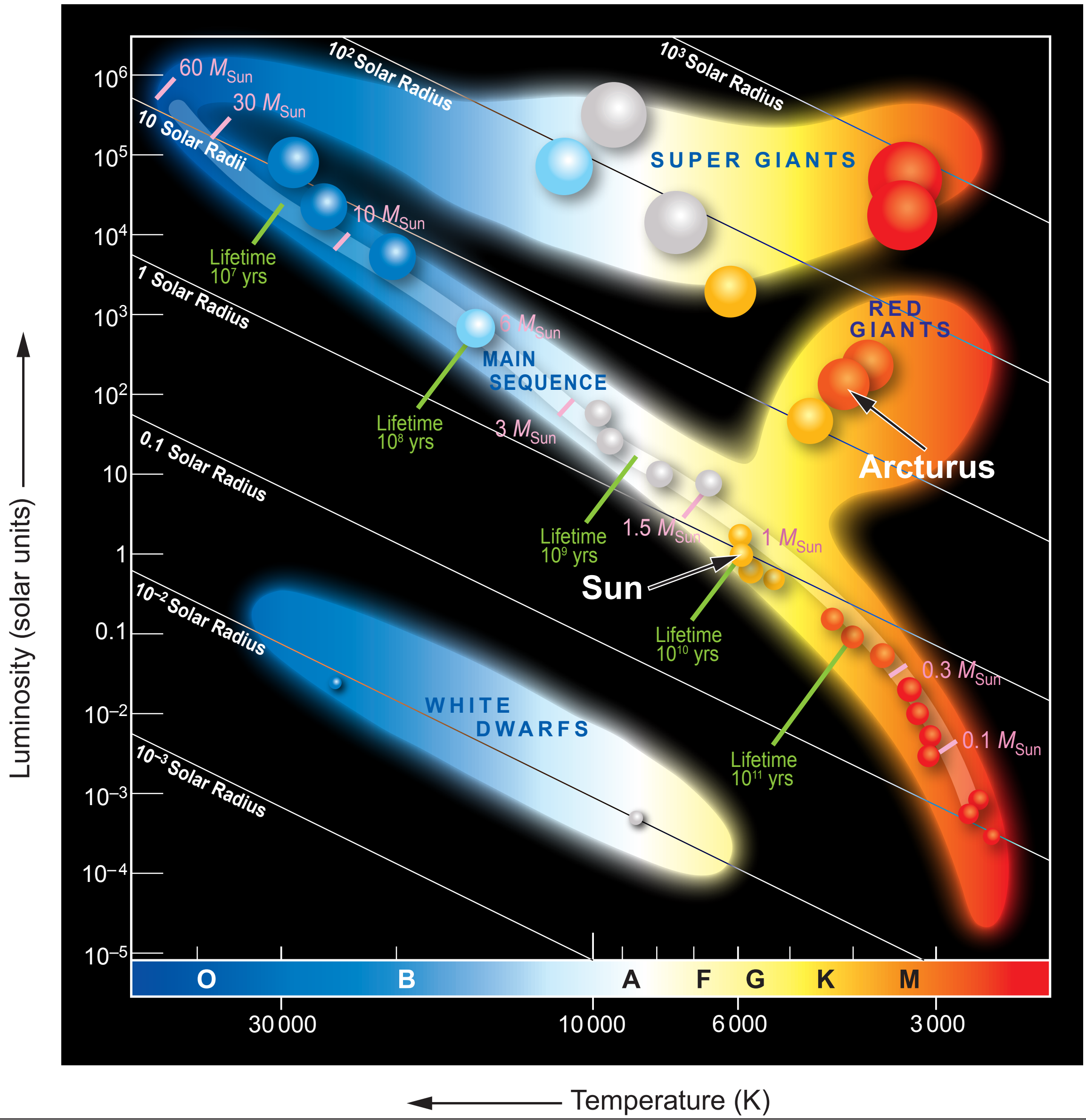
(i) State how long light from Arcturus takes to reach the Earth. [1]

time = ...

(ii) Use your answer to (i) and an equation from page 2 to determine the distance of Arcturus from Earth in metres.
(1 year = 31 600 000 s, speed of light, $c = 3 \times 10^8$ m/s) [3]

distance = ... m

(b) The Hertzsprung-Russell (HR diagram) below shows the properties of different stars.



Examiner only

(i) The Sun and Arcturus have different colours.
Use information from the diagram to compare their other properties. [2]

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(ii) The Sun is currently on the main sequence.
At the end of this stage of its life cycle it will become a red giant like Arcturus.
Explain, in terms of forces **and** fusion, why the Sun will become a red giant. [4]

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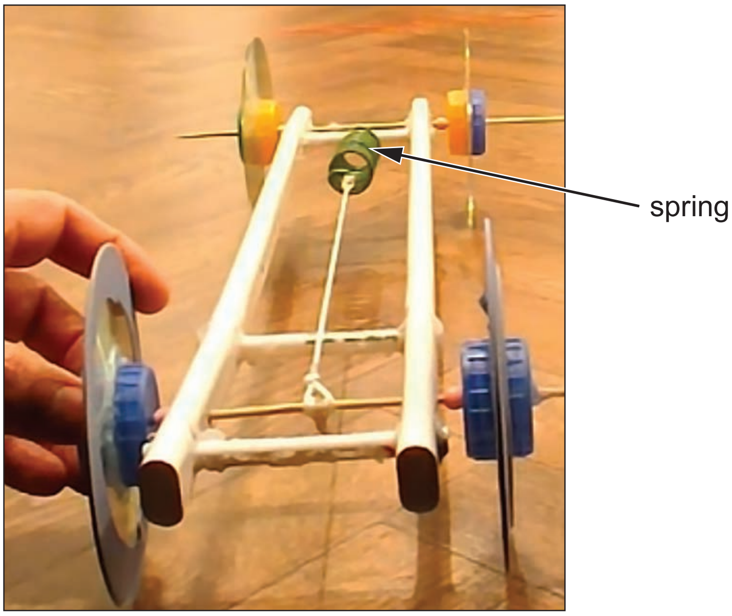
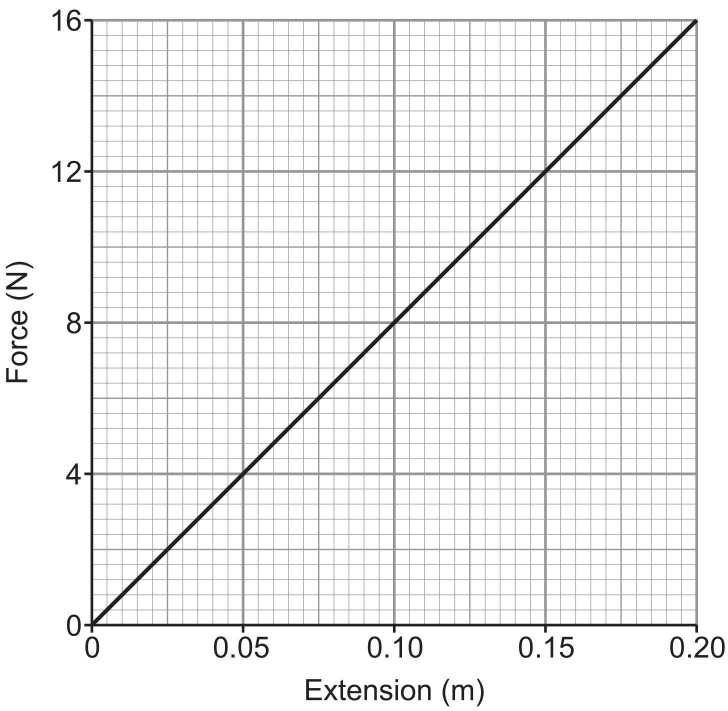
6. Some students make a car powered by a spring.
The spring is stretched as the back wheels on the car are wound-up.



(a) A force-extension graph for the spring used in the car is shown below.



Examiner only

(i) Use the graph and an equation from page 2 to calculate the work done in stretching the spring by 0.15 m. [2]

work done = ... J

(ii) When the car is released the work done in stretching the spring is transferred to the car as kinetic energy.
Use your answer to part (i) and the equation:

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times \text{velocity}^2$$

to calculate the theoretical maximum velocity of the car if its mass is 0.075 kg.
Give the unit with your answer. [4]

velocity = ...

unit = ...

(iii) Explain why, in practice, the car will not reach the theoretical maximum velocity. [2]

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TURN OVER FOR THE REST OF THE QUESTION

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(b) The car's maximum kinetic energy is found to be 0.8 J.
A force brings it to rest in a distance of 1.5 m.

Use the equation:

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

to determine the size of the force. [3]

force = ... N

(c) The spring constant of the spring used in the toy car is 80 N/m.
Maddie suggests that it would be better to use a spring with a spring constant of 160 N/m because for the same extension, double the energy would be stored in the spring.
Explain whether you agree. [2]

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END OF PAPER

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

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