



GCSE

3420UB0-1

THURSDAY, 25 MAY 2023 – MORNING

PHYSICS – Unit 2:

**Forces, Space and Radioactivity
HIGHER TIER**

1 hour 45 minutes plus your additional time allowance

Surname _____

First name(s) _____

Centre Number _____

Candidate Number 0 _____

ADDITIONAL MATERIALS

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

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball-point pen or your usual method.

Write your name, centre number and candidate number in the spaces provided on the front cover.

Answer ALL questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional pages 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.

(Turn over)

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	7	
2.	13	
3.	7	
4.	6	
5.	9	
6.	16	
7.	22	
Total	80	

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TURN OVER

Equations

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

$$\text{acceleration [or deceleration]} = \frac{\text{change in velocity}}{\text{time}} \quad a = \frac{\Delta v}{t}$$

acceleration = gradient of a velocity-time graph

distance travelled = area under a velocity-time graph

resultant force = mass \times acceleration $F = ma$

weight = mass \times gravitational field strength $W = mg$

work = force \times distance $W = Fd$

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

change in potential energy = mass \times gravitational field strength \times change in height

$$PE = mgh$$

force = spring constant \times extension $F = kx$

work done in stretching = area under a force-extension graph $W = \frac{1}{2} Fx$

momentum = mass \times velocity $p = mv$

force = $\frac{\text{change in momentum}}{\text{time}}$ $F = \frac{\Delta p}{t}$

u = initial velocity

$$v = u + at$$

v = final velocity

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

t = time

a = acceleration

$$x = ut + \frac{1}{2} at^2$$

x = displacement

$$v^2 = u^2 + 2ax$$

moment = force \times 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 1 000 000 000	1×10^9
terra	T	multiply 1 000 000 000 000	1×10^{12}

(Turn over)

Answer ALL questions.

1 A teacher uses the apparatus shown in DIAGRAM 1.1 in the separate diagram booklet 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 in TABLE 1.2 in the separate diagram booklet. [2 marks]

(b) After the experiment the teacher gives the students some data about the radioactive source, cobalt-60, to analyse.

The data are given in TABLE 1.3 in the separate diagram booklet.

Use the data to answer the following questions.

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

1 (b)(ii)

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

(Turn over)

1 (b)(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 mark]

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

7

2 **DIAGRAM 2.1** in the separate diagram booklet 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 marks]

(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 marks]

resultant force = _____ N

(Turn over)

2 (b)(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 marks]

acceleration = _____

unit = _____

2 (b)(iii)

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

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

- 2 (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 mark]
-

- (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 marks]

braking force = _____ N

3 Alpha Centauri is a star of similar size to our Sun.

It is 4.37 light years from Earth.

It is a main sequence star.

(a) State how long light takes to travel from Alpha Centauri to Earth. [1 mark]

time = _____

(b)(i) Explain, in terms of named forces, why Alpha Centauri is currently stable. [2 marks]

3 (b)(ii)

Explain, in terms of named forces, the next stage in the life of Alpha Centauri. [2 marks]

(c) Explain why the mass of hydrogen present in Alpha Centauri will decrease as it gets older. [2 marks]

7

- 5 Some students carry out an experiment to determine the relationship between the force applied to a spring and its extension.

They use the apparatus shown in **DIAGRAM 5.1** in the separate diagram booklet.

They collect data by loading and then unloading the spring. Their results are shown in **TABLE 5.2** in the separate diagram booklet.

- (a) The uncertainty in extension is given by:

$$\text{uncertainty in extension} = \frac{\text{maximum value of extension} - \text{minimum value of extension}}{2}$$

- (i) State the mass with the greatest uncertainty in extension. [1 mark]

value of mass = _____ g

- (ii) Calculate this uncertainty. [2 marks]

uncertainty = _____ cm

(Turn over)

5 (b) Suggest how the students could adapt the apparatus to reduce the uncertainty in their results. [1 mark]

(c) Explain how they could use ALL of the results to determine a mean value for the spring constant. [3 marks]

5 (d) The students determine the spring constant to be 22.3 N/m.

The true value of the spring constant is 22.2 N/m.

Explain what this tells the students about their data. [2 marks]

9

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$$\frac{1}{U} + \frac{n}{0} \rightarrow \frac{1}{0} + \frac{n}{0}$$

- 6 In one example of the process of nuclear fission of uranium-235, it is suggested that isotopes of caesium and rubidium and a number of neutrons



are produced.

TABLE 6.1 in the separate diagram booklet gives information about the particles in the nuclei of the isotopes named above.

- (a) On the opposite page, write a balanced nuclear equation for the fission decay of uranium into caesium and rubidium. [4 marks]

6 (b)(i)

Explain the purpose of the moderator in a fission reactor. [2 marks]

(ii)

Explain how the rate of reaction can be increased in a nuclear reactor. [3 marks]

6 (c) The caesium isotope produced in this fission reaction has a half-life of 64 s.

The rubidium isotope has a half-life of 4 s.

At time, $t = 0$ the mass of caesium present is 131 072 g.

The same mass of rubidium is also present.

(i) Calculate the mass of caesium present after 64 s. [1 mark]

mass of caesium = _____ g

(ii) i. Calculate how many half-lives of rubidium occur in 64 s. [1 mark]

number of half-lives = _____

(Turn over)

6 (c)(ii) continued

- II. After 32 seconds, 512 g of rubidium remains.
Calculate the mass of rubidium remaining
after 64 s. [3 marks]

mass = _____ g

- (iii) Initially the ratio of mass of caesium to mass
of rubidium was 1:1.

Explain how this ratio changes with time.
[2 marks]

16

(Turn over)

7 **DIAGRAM 7.1** in the separate diagram booklet 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.

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) State how the following information in the chart for a speed of 70 km/h would compare if the tyre treads on the car are worn below the legal limit. [3 marks]

(i) Thinking distance

(ii) Braking distance

(iii) Impact speed

(Turn over)

7 (b) Use the information in **DIAGRAM 7.1** to answer the following questions about a car travelling at 60 km/h which **DECELERATES TO A STOP**.

(10km/h = 2.8 m/s)

- (i) **COMPLETE TABLE 7.2** in the separate diagram booklet. [4 marks]
- (ii) Using the information in **TABLE 7.2**, calculate the **THINKING TIME** of the driver. [3 marks]

thinking time = _____ s

- (iii) Use the equation:

$$v^2 = u^2 + 2ax$$

and the information in **TABLE 7.2** to calculate the deceleration of the car. [3 marks]

deceleration = _____ m/s²

(Turn over)

7 (c) The chart shows that a car travelling faster than 60 km/h will not stop in time and therefore collides with the obstacle.

(i) Explain, in terms of Newton's 1st Law, how seat belts provide protection during a collision. [2 marks]

(ii) Explain, in terms of Newton's 3rd law, why the car and the obstacle are damaged during a collision. [2 marks]

7 (c)(iii)

Explain, in terms of Newton's 2nd law, why cars have crumple zones. [2 marks]

7 (d) The Royal Society for the Prevention of Accidents (RoSPA) says that “The majority of pedestrian casualties (in the UK) occur in built-up areas: 22 of the 26 child pedestrians and 264 of the 372 adult pedestrians who were killed in 2017, died on roads in built-up areas.”

They strongly feel that reducing the speed limit in built-up areas from 50 km/h to 35 km/h would greatly improve these accident statistics.

**Explain whether you agree with RoSPA.
[3 marks]**

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



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DIAGRAM BOOKLET

This Diagram Booklet MUST be handed in to the invigilators and sent for marking.

Surname _____

First name(s) _____

Centre Number _____

Candidate Number 0 _____

DIAGRAM 1.1

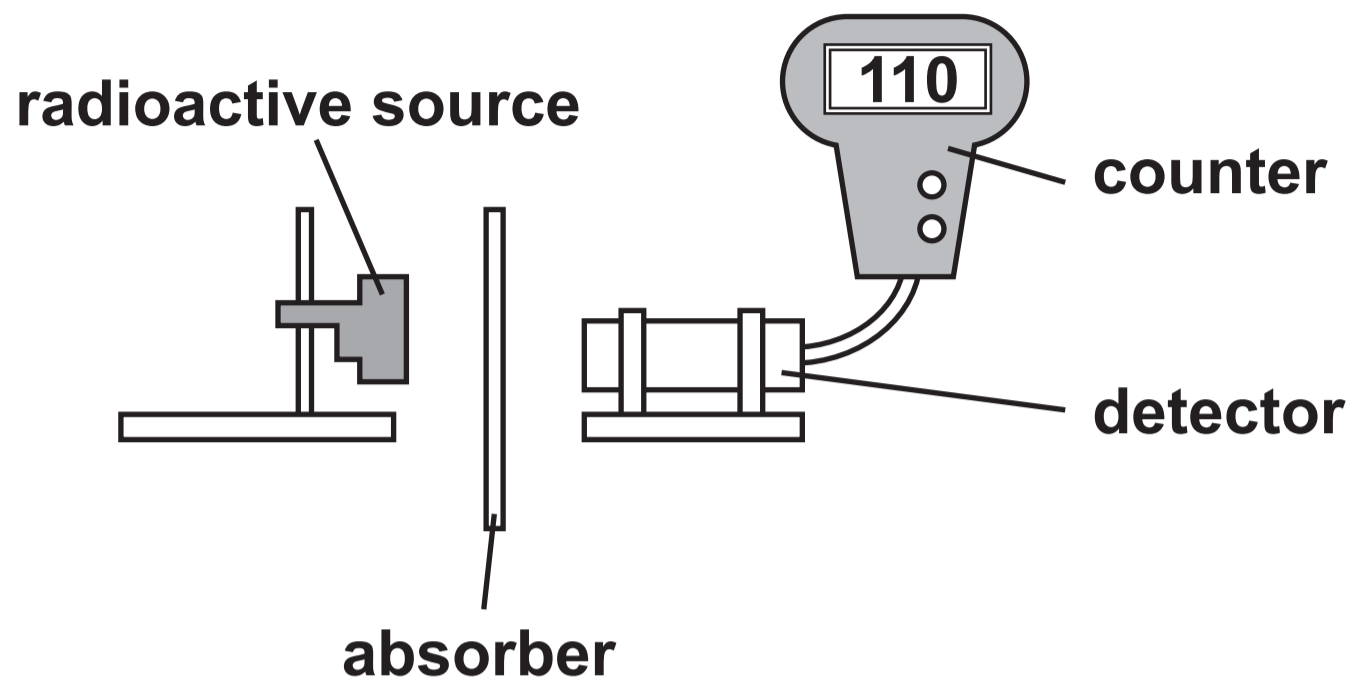


TABLE 1.2

Hazard	Risk	Control Measure
Nuclear radiation is ionising		

TABLE 1.3

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

DIAGRAM 2.1

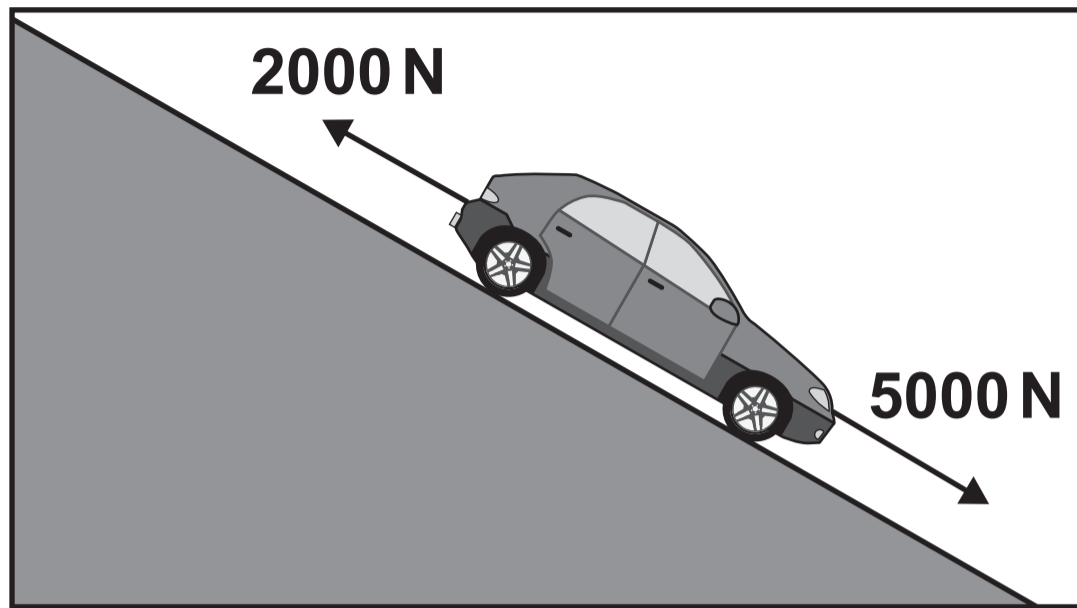


DIAGRAM 4.1

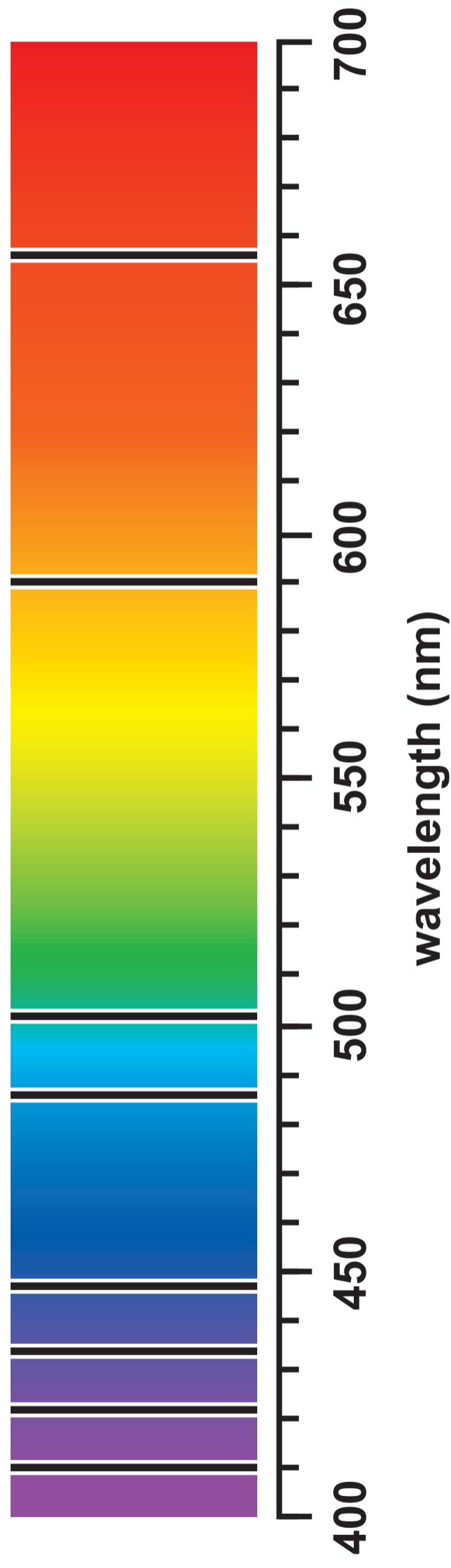


TABLE 4.2

Element	Wavelength (nm)
helium	447, 502
iron	431, 467, 496, 527
hydrogen	410, 434, 486, 656
sodium	590

DIAGRAM 5.1

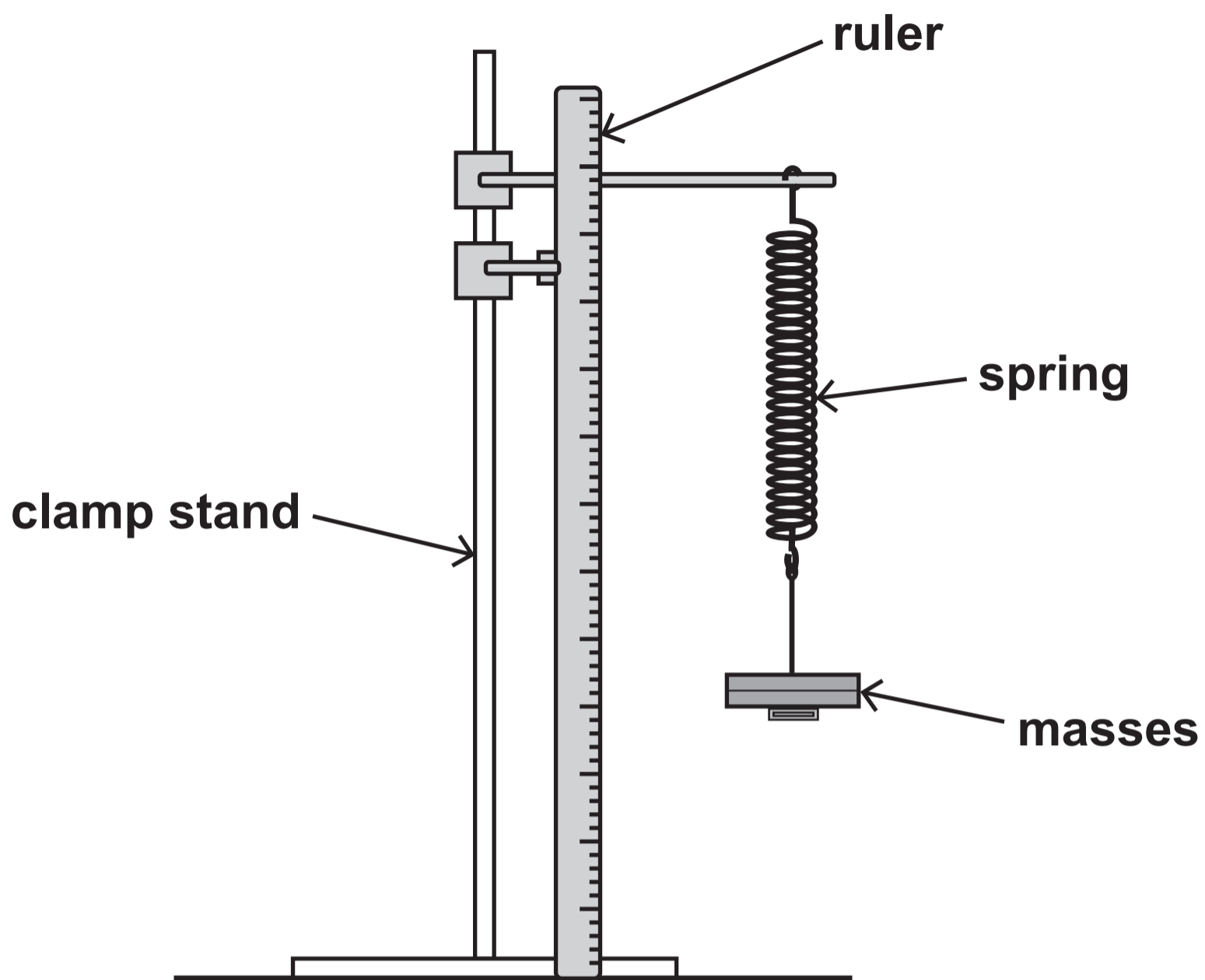


TABLE 5.2

Mass (g)	Force (N)	Extension (cm)	
		Loading	Unloading
0	0	0.0	0.0
100	1	4.4	4.2
200	2	8.9	9.3
300	3	13.6	13.7
400	4	18.2	18.5
500	5	22.5	22.5

TABLE 6.1

Element	Symbol	Number of protons in the nucleus	Number of neutrons in the nucleus
uranium	U	92	143
caesium	Cs	55	85
rubidium	Rb	37	55

DIAGRAM 7.1

Driver sees obstacle **Obstacle** **Impact speed in dry conditions**

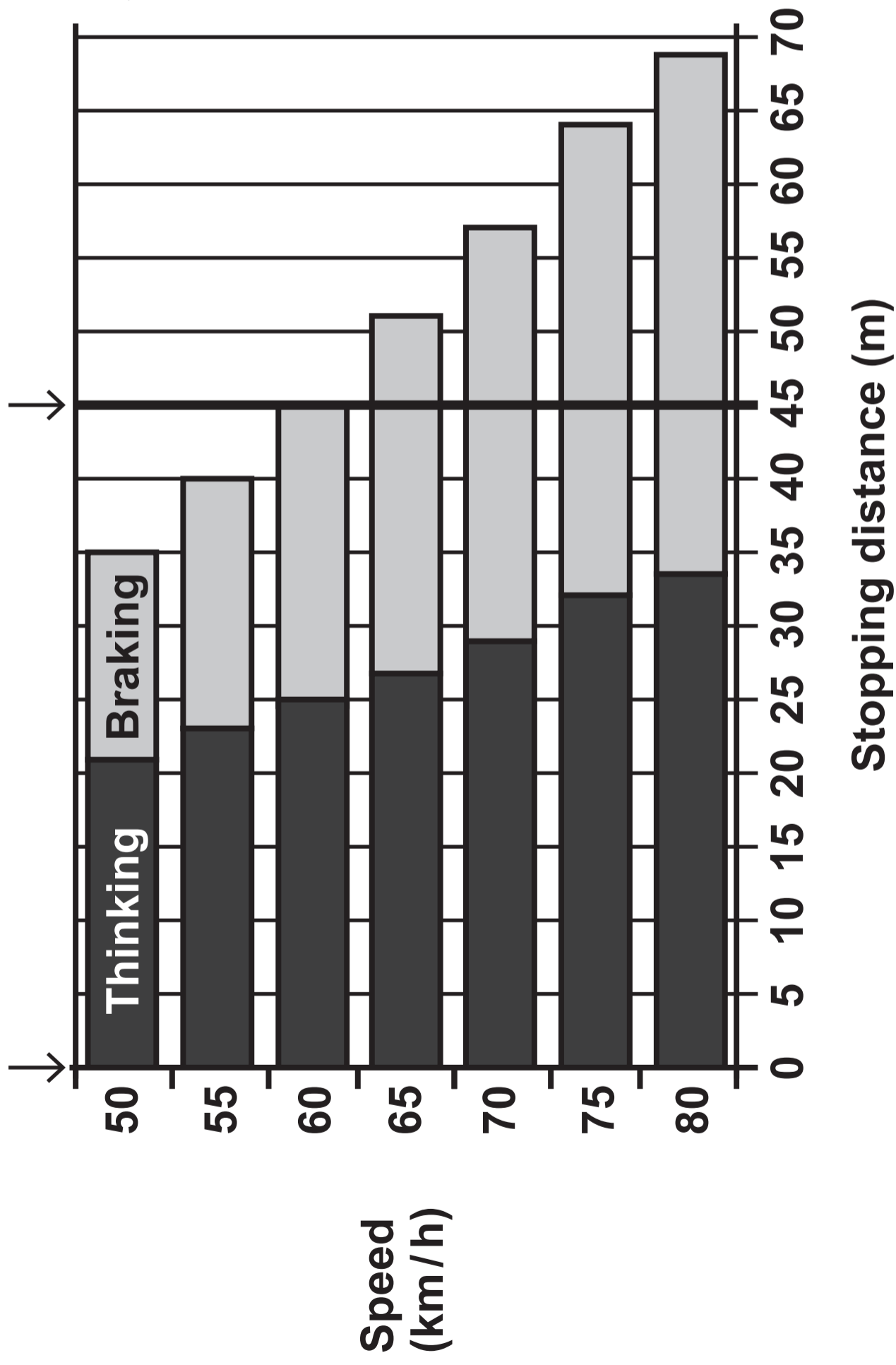


TABLE 7.2

Initial speed (km/h)	60
Initial speed (m/s)	_____
Thinking distance (m)	_____
Braking distance (m)	_____
Stopping distance (m)	_____