wjec cbac **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 may 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

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

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

acceleration = gradient of a velocity-time graph

distance travelled = area under a velocity-time graph

$$\text{resultant force} = \text{mass} \times \text{acceleration} \qquad F = ma$$

$$\text{weight} = \text{mass} \times \text{gravitation field strength} \qquad W = mg$$

$$\text{work} = \text{force} \times \text{distance} \qquad W = Fd$$

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

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 $p = mv$

(Turn over)

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

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 $\qquad$ $M = Fd$

SI MULTIPLIERS

Prefix	Symbol	Conversion factor	Multiplier
pico	p	divide by 1 000 000 000 000	1×10^{-10}
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 1 0000	1×10^{-3}
centi	c	divide by 1 000	1×10^{-2}

(Turn over)

Prefix	Symbol	Conversion factor	Multiplier
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}

(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.

(Turn over)

1 (b) continued
Use the data to answer the following questions.

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

continue on the next page (Turn over)

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]

(Turn over)

1 (b)(iii) continued

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

7

(Turn over)

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

(Turn over)

2 (b) Use the information in DIAGRAM 2.1 in the separate diagram booklet 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 = ______________________

(Turn over)

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]

____

____

(Turn over)

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]

(Turn over)

2 (c)(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

13

(Turn over)

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 = ______________________

(Turn over)

3 (b)(i)

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

(Turn over)

3 (b)(ii)

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

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

7

(Turn over)

4 DIAGRAM 4.1 in the separate diagram booklet shows a spectrum from a star.

The spectrum is crossed by dark lines.

TABLE 4.2 in the separate diagram booklet gives information about the wavelengths of lines to be found in a spectrum if the element is present in the atmosphere of the star.

- **Explain how the dark lines arise on the spectrum.**
- **Explain which elements are present in the star's atmosphere. [6 marks QER]**

continue answer on next page (Turn over)

continue answer on next page (Turn over)

continue answer on next page (Turn over)

6

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

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 the equation on the opposite page.

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

value of mass = ______________________ g

(Turn over)

5 (a)(ii)
Calculate this uncertainty. [2 marks]

uncertainty = ____________________ cm

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

____

____

(Turn over)

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

(Turn over)

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

(Turn over)

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$$\frac{\_\_\_\_\_}{\_\_\_\_\_}U + {}^{1}_{0}n \rightarrow \_\_\_\_\_ + \_\_\_\_\_ + \_\_\_\_\_ \; {}^{1}_{0}n$$

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**

$$^{1}_{0}n$$

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]**

(Turn over)

6 (b)(i)

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

(Turn over)

6 (b)(ii)

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

(Turn over)

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

(Turn over)

6 (c)(ii)

I. Calculate how many half-lives of rubidium occur in 64 s. [1 mark]

number of half-lives = ____________________

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

mass = ____________________ g

(Turn over)

6 (c)(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

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.

(Turn over)

7 (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 in the separate diagram booklet 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

(Turn over)

7 (b)(iii)
Use the equation:

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

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

deceleration = ____________________ m/s^2

(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]

____

____

____

____

____

____

(Turn over)

7 (c)(ii)

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

(Turn over)

7 (c)(iii)

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

(Turn over)

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]

____

____

____

____

continue answer on next page (Turn over)

22

END OF PAPER

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______________________

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DIAGRAM 1.1

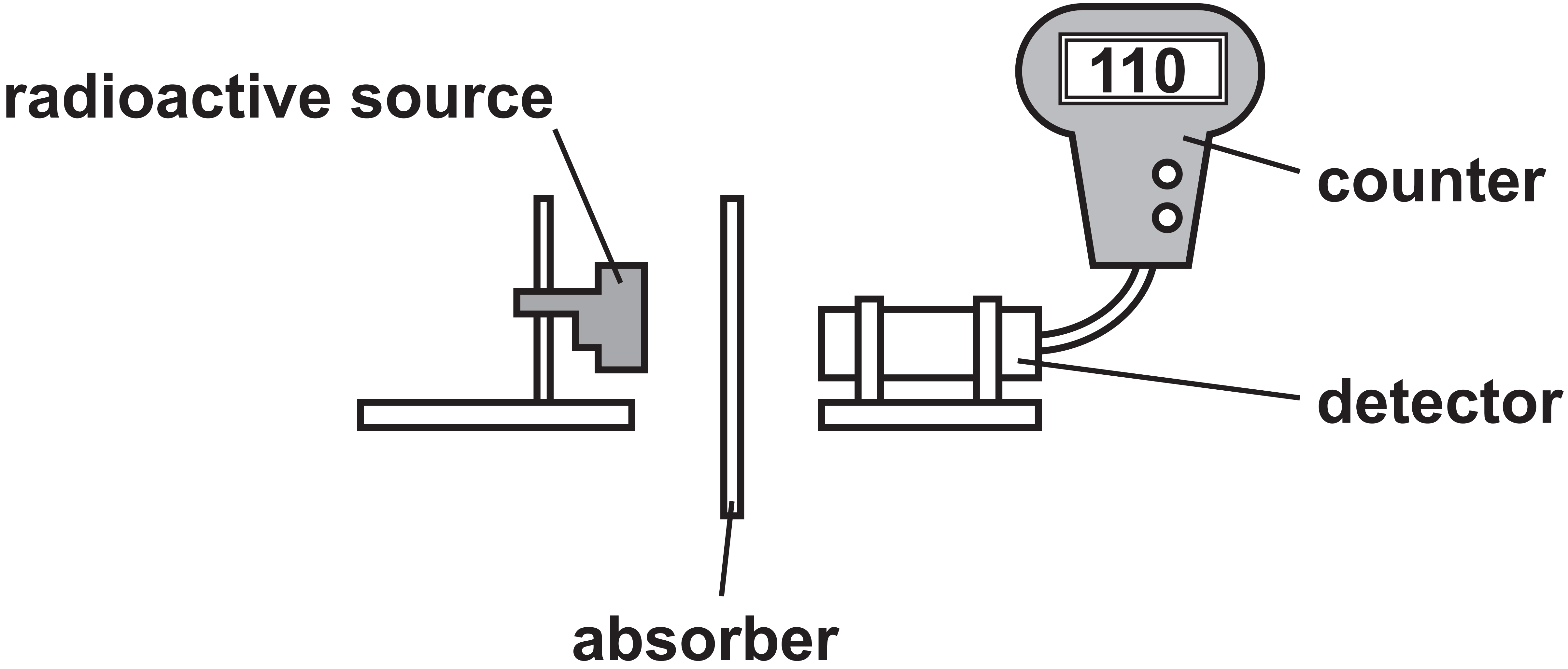

TABLE 1.2

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

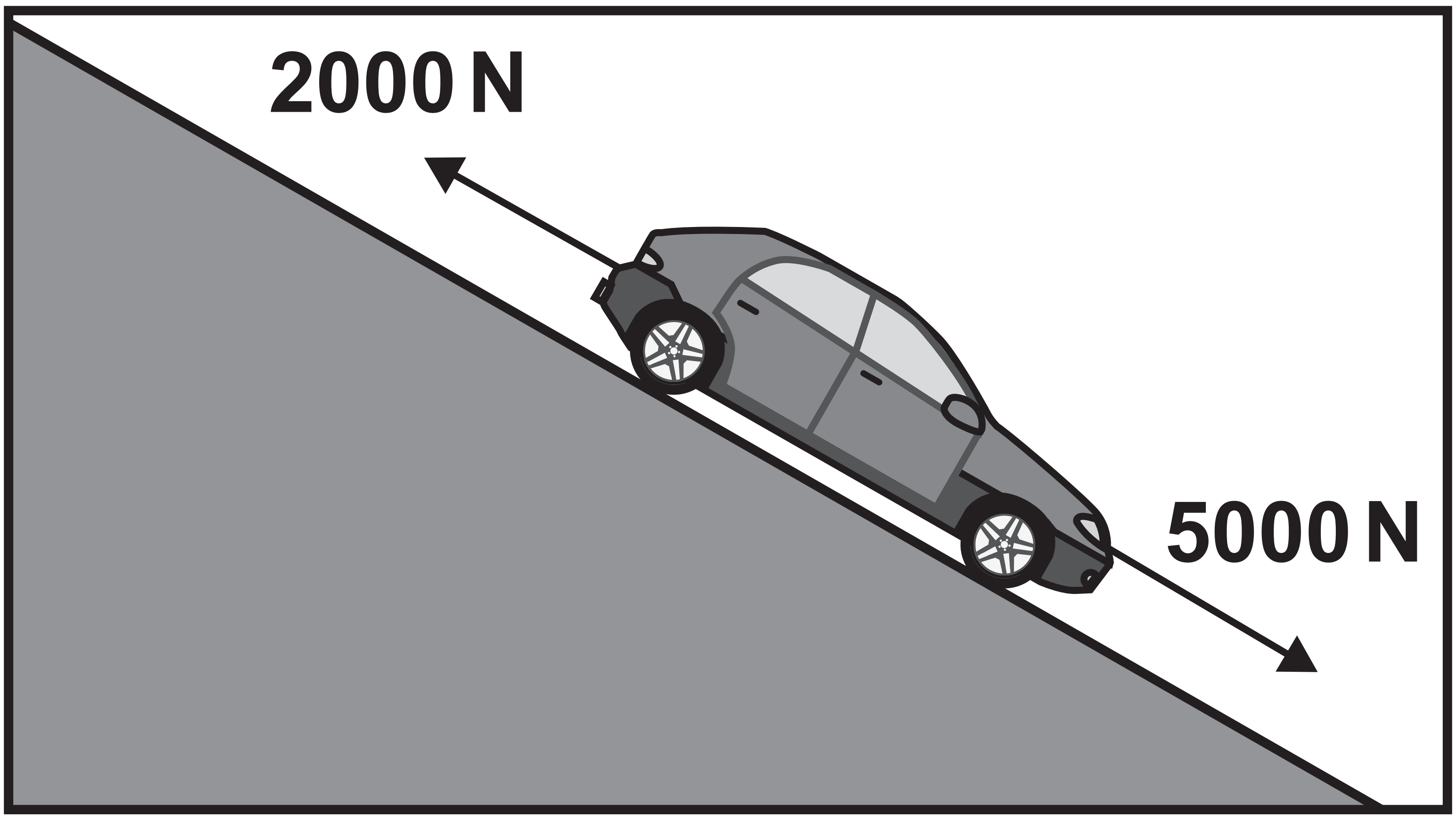

DIAGRAM 4.1

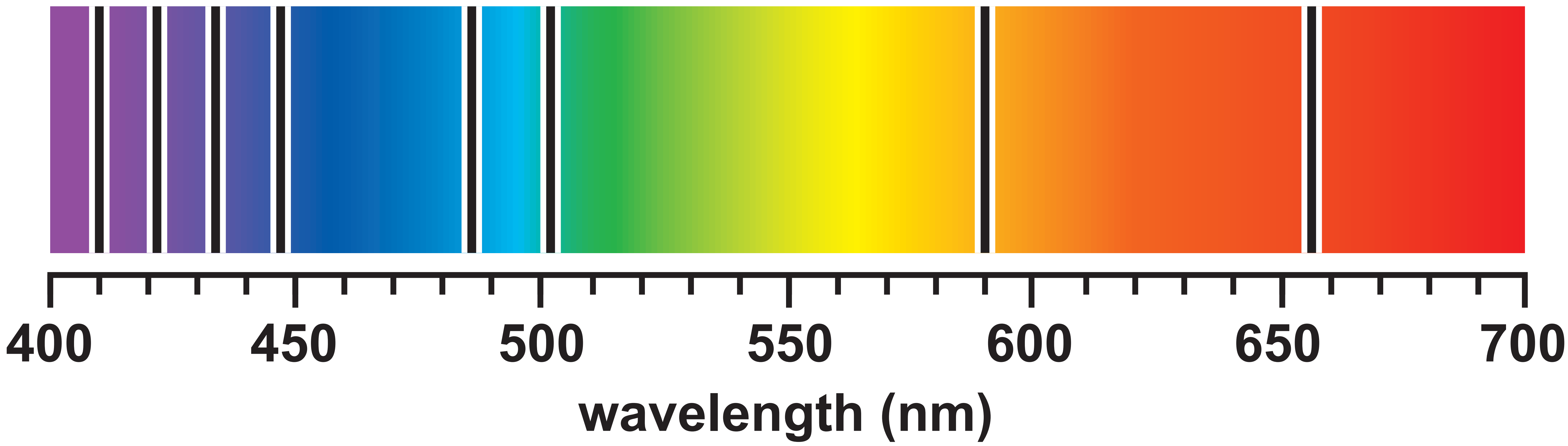

TABLE 4.2

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

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DIAGRAM 5.1

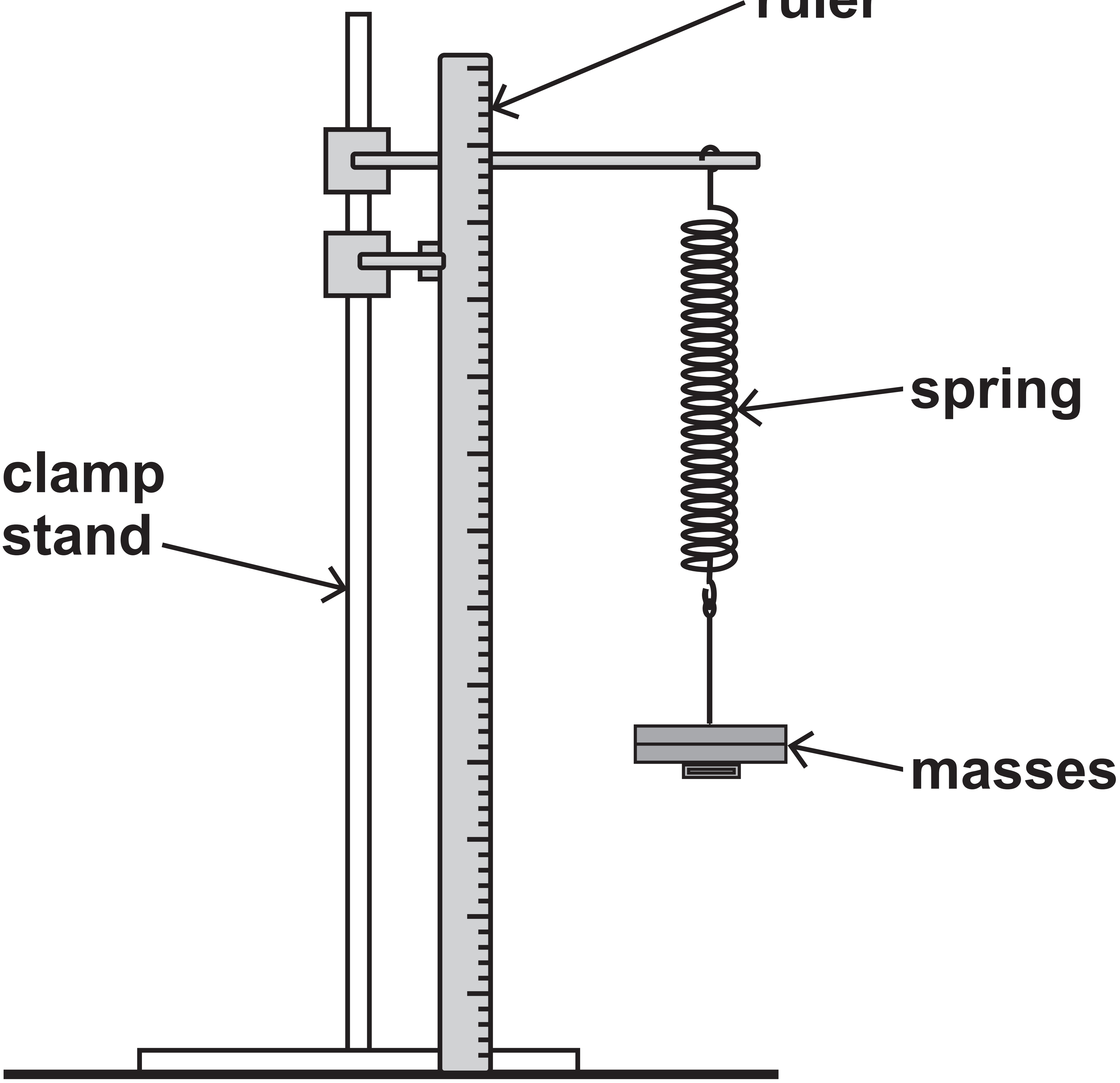

TABLE 5.2

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

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TURN OVER

DIAGRAM 7.1

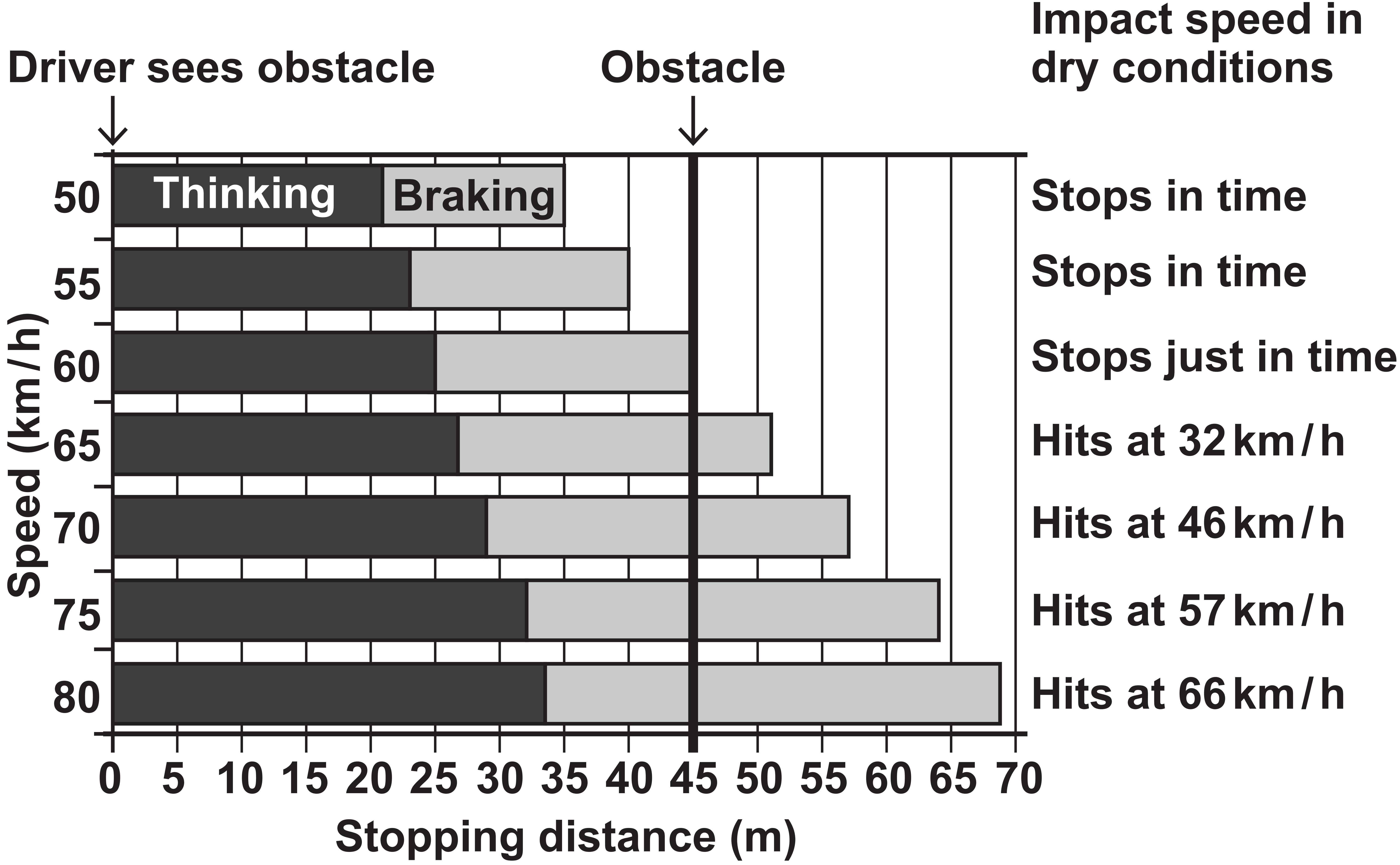
Driver sees obstacle
Obstacle
Impact speed in dry conditions
Thinking
Braking
Speed (km/h)
50
55
60
65
70
75
80
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
Stopping distance (m)
Stops in time
Stops in time
Stops just in time
Hits at 32 km/h
Hits at 46 km/h
Hits at 57 km/h
Hits at 66 km/h

TABLE 7.2

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