



3420UB0-1

THURSDAY, 22 MAY 2025 – 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.

A separate Data 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.	5	
6.	7	
7.	5	
8.	8	
9.	7	
10.	15	
Total	80	

Answer ALL questions.

- 1 (a) When the driver of a vehicle needs to make an emergency stop, the overall stopping distance is made up of two parts, called the thinking distance and the braking distance.**

$$\begin{array}{l} \text{overall} \\ \text{stopping} \\ \text{distance} \end{array} = \begin{array}{l} \text{thinking} \\ \text{distance} \end{array} + \begin{array}{l} \text{braking} \\ \text{distance} \end{array}$$

- (i) An average driver drives at 13 m/s and has a reaction time of 0.70 s. TABLE 1 in the separate diagram booklet shows the Highway Code's thinking and braking distances for an average driver.**

A Formula 1 racing driver is driving the same car at the same speed. The reaction time of this driver is half the time of an average driver.

COMPLETE TABLE 1. [3 marks]

(Turn over)

1 (a)(ii)

During wet weather, the braking distance doubles.

One student suggests that the overall stopping distance for an average driver also doubles.

Consider whether this statement is true. [2 marks]

Space for calculations.

(Turn over)

1 (b) Seatbelts provide the most effective way of protecting yourself when travelling in a car.

Explain how a seatbelt protects a driver from injury during a head-on collision. [2 marks]

7

(Turn over)

- 2 Americium-241 decays by alpha particle emission to produce neptunium (Np) as shown by the following nuclear decay equation.**



- (a)(i) COMPLETE the nuclear decay equation. [2 marks]**

(Turn over)

2 (a)(ii)

Complete the following sentence about the nuclear structure of americium-241. [3 marks]

A NUCLEUS of americium-241 contains

_____ **protons,**

_____ **neutrons and**

_____ **electrons.**

(Turn over)

2 (b) The mass of americium in a new smoke detector is 0.25 micrograms with an activity of 32 kBq. Calculate the mass that has an activity of 128 kBq. [2 marks]

mass = _____ micrograms

(Turn over)

2 (c) Some americium-241 with an initial activity of 128 kBq decays for a number of years as shown by GRAPH 2.1 in the separate diagram booklet.

(i) DRAW LINES ON GRAPH 2.1 to show that the half-life of americium-241 is 420 years. [2 marks]

(ii) State the time it would take for the activity to fall to a $\frac{1}{4}$ (25%) of its initial activity. [1 mark]

time = _____ years

(Turn over)

2 (c)(iii)

Americium-241 is difficult to detect when its activity falls to about 3%. Theresa states that the activity will fall to about 3% after 2000 years. Explain whether she is correct.

CONTINUE DIAGRAM 2.2 in the separate diagram booklet to show your working. [3 marks]

13

(Turn over)

- 3** **TABLE 3.1** in the separate diagram booklet gives some information about four planets in our solar system.

USE ONLY INFORMATION FROM TABLE 3.1 to answer the following questions.

- (a) State the property from TABLE 3.1 that tells us that Saturn is much bigger than the Earth. [1 mark]**

(Turn over)

**3 (b) Use the data for Mars and Saturn to explain whether the orbital period is directly proportional to the orbit circumference. [2 marks]
Space for calculation.**

(Turn over)

3 (c) At one point in time, all four planets are in line with the Sun as shown in DIAGRAM 3.2 in the separate diagram booklet.

**(i) After how many years would the four planets next be in the same position?
[1 mark]**

_____ years

**(ii) COMPLETE DIAGRAM 3.3 in the separate diagram booklet to show the positions of the four planets after 15 years.
LABEL THE PLANETS CLEARLY.
Earth has been positioned for you.
[3 marks]**

7

(Turn over)

- 4 Giant stars have masses that are many times bigger than our Sun. Describe AND explain the life cycle of these giant stars from birth to death. [6 marks QER]**

continue answer on the next page

(Turn over)

(Turn over)

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continue answer on the next page
(Turn over)

6

5 Nuclear reactors use the fission of uranium-235 to produce electrical power as shown in DIAGRAM 5 in the separate diagram booklet.

(a) State the function of a moderator in a nuclear reactor AND why it is needed. [2 marks]

(Turn over)

5 (b) Explain the role of control rods in a nuclear reactor. [3 marks]

5

(Turn over)

- 6** Some school students test a bicycle, along a straight track using a new cycling computer. They measure 100 m along the track. They mark the finishing line at this point. The brakes are applied by the cyclist when they reach the marked **FINISHING LINE**. The velocity-time graph, drawn from the test results, is shown in **GRAPH 6** in the separate diagram booklet.

- (a)** Determine the time for which the cyclist was travelling at a velocity of 6 m/s or more. [1 mark]

time = _____ s

(Turn over)

**6 (b) Describe the motion in each region
(AB, BC, CD) of GRAPH 6.
No calculations are required.
[4 marks]**

(Turn over)

6 (c) Use GRAPH 6 and information from the separate data booklet to determine whether the measured 100 m for the test was accurate. Space for calculations. [2 marks]

7

(Turn over)

- 7** **DIAGRAM 7** in the separate diagram booklet shows spring **A**. It extends by 0.04 m when a weight of 5 N is hung from it.
- (a)** Use an equation from the separate data booklet and the information above to calculate the spring constant of spring **A**. [2 marks]

spring
constant
of spring **A** = _____ N/m

(Turn over)

7 (b) The spring constant of ANOTHER SPRING (spring B) is double the spring constant of spring A. Calculate the extension of spring B for the same 5 N load. [1 mark]

extension of spring B = _____ m

(Turn over)

7 (c) Use the information in parts (a) and (b) and the equation:

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

to compare the energy stored in each of the two springs when supporting the 5 N load.

**(W = work done or energy stored,
 F = force, x = extension) [2 marks]**

energy stored in spring A = _____ J

energy stored in spring B = _____ J

continue answer on the next page

(Turn over)

5

8 Students carry out an experiment to investigate moments.

A moment is the turning effect of a force.

(a)(i) A force is measured in newtons and distance is measured in metres. State the unit of the moment of a force. [1 mark]

8 (a)(ii)

**State the principle of moments.
[2 marks]**

(Turn over)

8 (b) The weight of a metre ruler acts at its midpoint (i.e. its 50 cm mark).

The students set up the apparatus shown in DIAGRAM 8 in the separate diagram booklet.

Using the principle of moments, they conclude that the weight, W , of the ruler is 1 N AND that its mass is therefore 100 g.

Use equations from the separate data booklet to show whether you agree with both of the students' conclusions. [5 marks]

answer on the next page

(Turn over)

8

- 9** **DIAGRAM 9** in the separate diagram booklet shows a number of spectra of light from stars in different galaxies.
- The **BOTTOM** spectrum is from a star in our own galaxy, the Milky Way. The black lines on the others show a similar pattern.

- (a)** **Explain how the black lines are formed. [3 marks]**

continue answer on the next page

(Turn over)

9 (b) Explain how the study of spectra like these from distant galaxies supports the Big Bang model. [4 marks]

continue answer on the next page

(Turn over)

7

- 10 As shown in DIAGRAM 10.1 in the separate diagram booklet, a skydiver of mass 90 kg falls from rest at a height of 5000 m to a height of 3000 m and the parachute is opened some time later.**

THE TERMINAL SPEED OF 50 m/s IS ACHIEVED AT A HEIGHT OF 4500 m.

[Earth's gravitational field strength, $g = 10 \text{ N/kg}$]

(Turn over)

10 (a)

**Use an equation from the separate data booklet to calculate the LOSS OF POTENTIAL ENERGY of the skydiver between 5000 m and 3000 m.
[3 marks]**

loss of potential energy = _____ J

(Turn over)

10 (b)

Use an equation from the separate data booklet to calculate the kinetic energy of the skydiver at a height of 3000 m. [3 marks]

kinetic energy = _____ J

(Turn over)

10 (c)

In the following question parts you will need to consider the fall of 2000 m FROM 5000 m TO 3000 m shown in DIAGRAM 10.1.

- (i) I. Use your answers to parts (a) and (b) to calculate the work done by air resistance during this 2000 m fall.
[1 mark]**

work done = _____ J

(Turn over)

10 (c)(i)

II. Use the equation:

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

to calculate the mean force of air resistance acting on the skydiver during this 2000 m fall. [2 marks]

mean force = _____ N

(Turn over)

10 (c)(ii)

The air resistance at terminal speed is 900 N.

State the weight of the skydiver.

Explain your answer. [2 marks]

(Turn over)

10 (c)(iii)

DRAW A GRAPH in GRAPH 10.2 in the separate diagram booklet to show how the air resistance force changes with distance over this 2000 m fall. [4 marks]

15

END OF PAPER

(Turn over)

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

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

[illegible]



GCSE

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PHYSICS – Unit 2:

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HIGHER TIER

**1 hour 45 minutes plus your additional
time allowance**

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 _____

TABLE 1

	Reaction time (s)	Thinking distance (m)	Braking distance (m)	Overall stopping distance (m)
Average driver	0.70	9	14	23
Formula 1 racing driver	0.35			

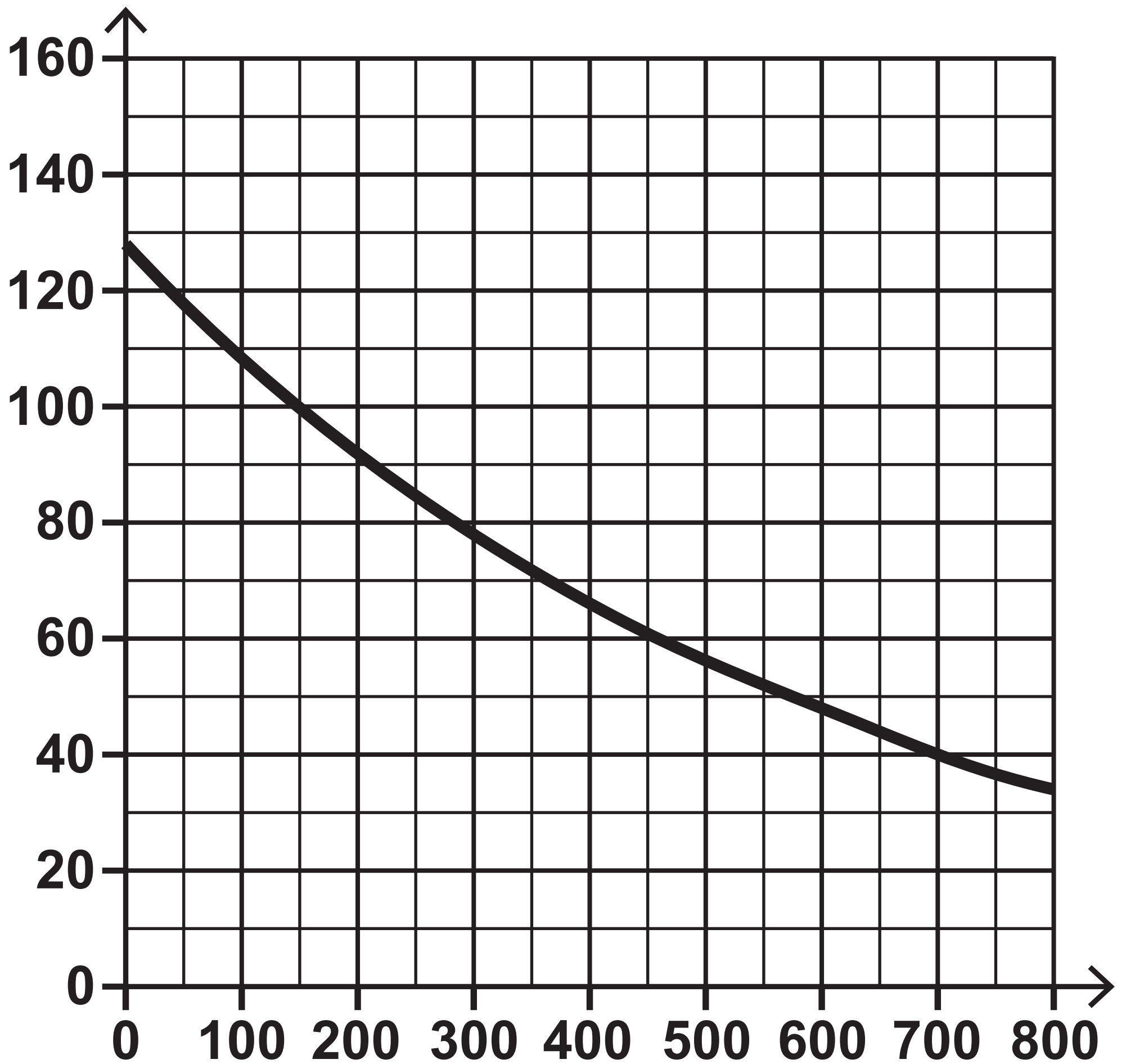
GRAPH 2.1**Activity (kBq)****Time (years)**

DIAGRAM 2.2

ACTIVITY

100%



50%



TIME

0 years



420 years



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TURN OVER

TABLE 3.1

Planet	Orbital period (Earth years)	Orbit circumference (AU)
Earth (E)	1	6.28
Mars (M)	2	9.43
Jupiter (J)	12	32.68
Saturn (S)	30	59.71

TABLE 3.1 continued

P	Orbital speed (× 10 ⁴ km/h)	Planet diameter (km)	Mass (× 10 ²⁴ kg)
(E)	10.7	12 800	5.97
(M)	8.1	6784	0.64
(J)	4.7	143 360	1900
(S)	3.5	120 320	568

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DIAGRAM 3.2

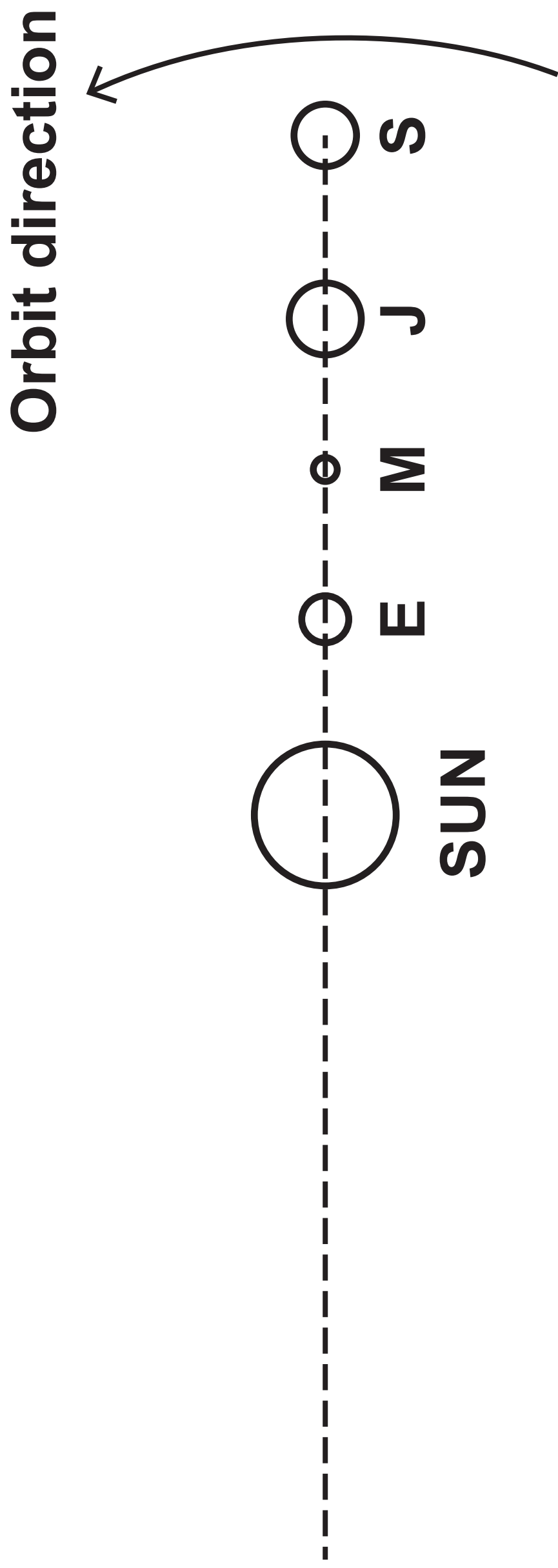


DIAGRAM 3.3

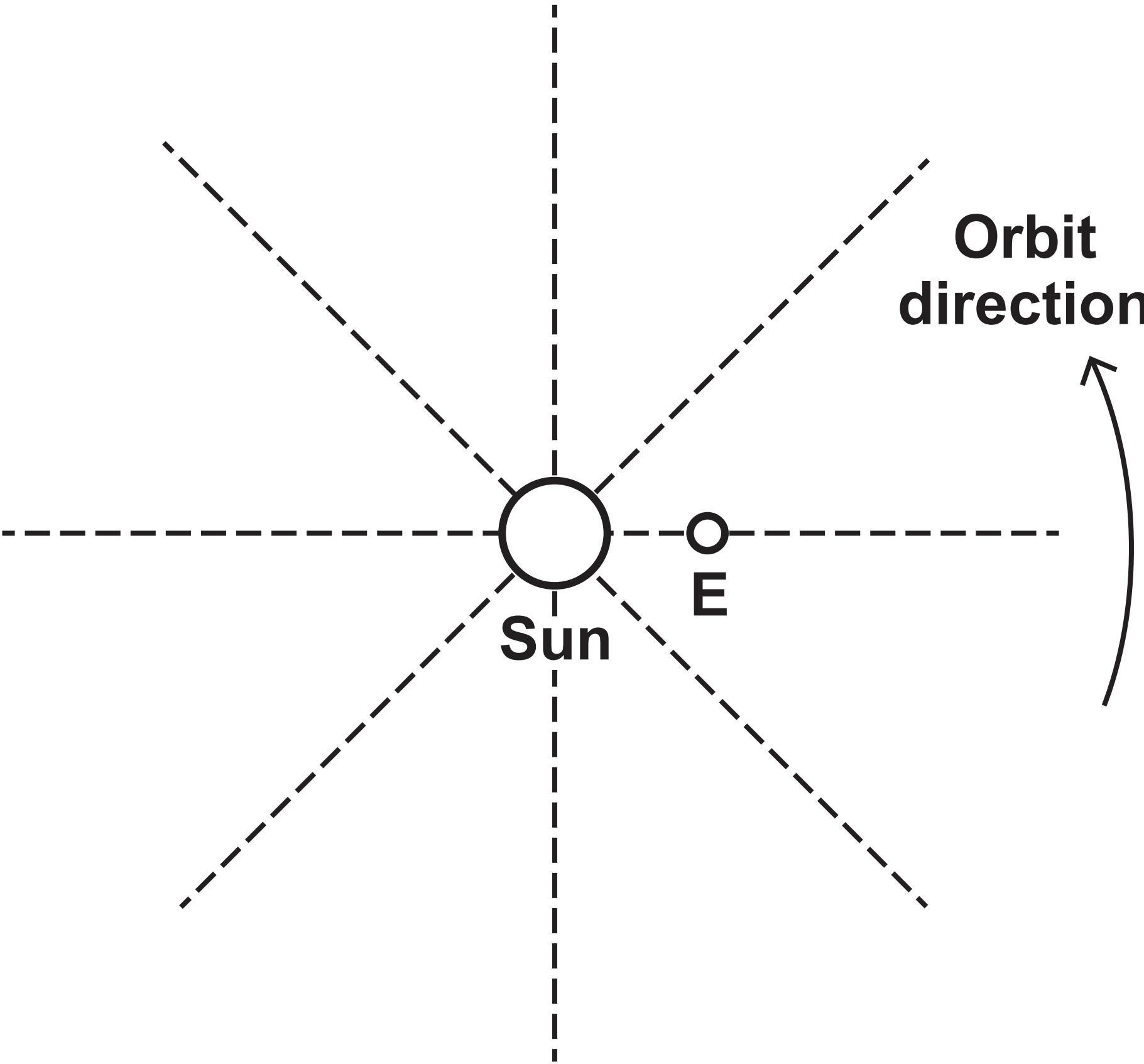
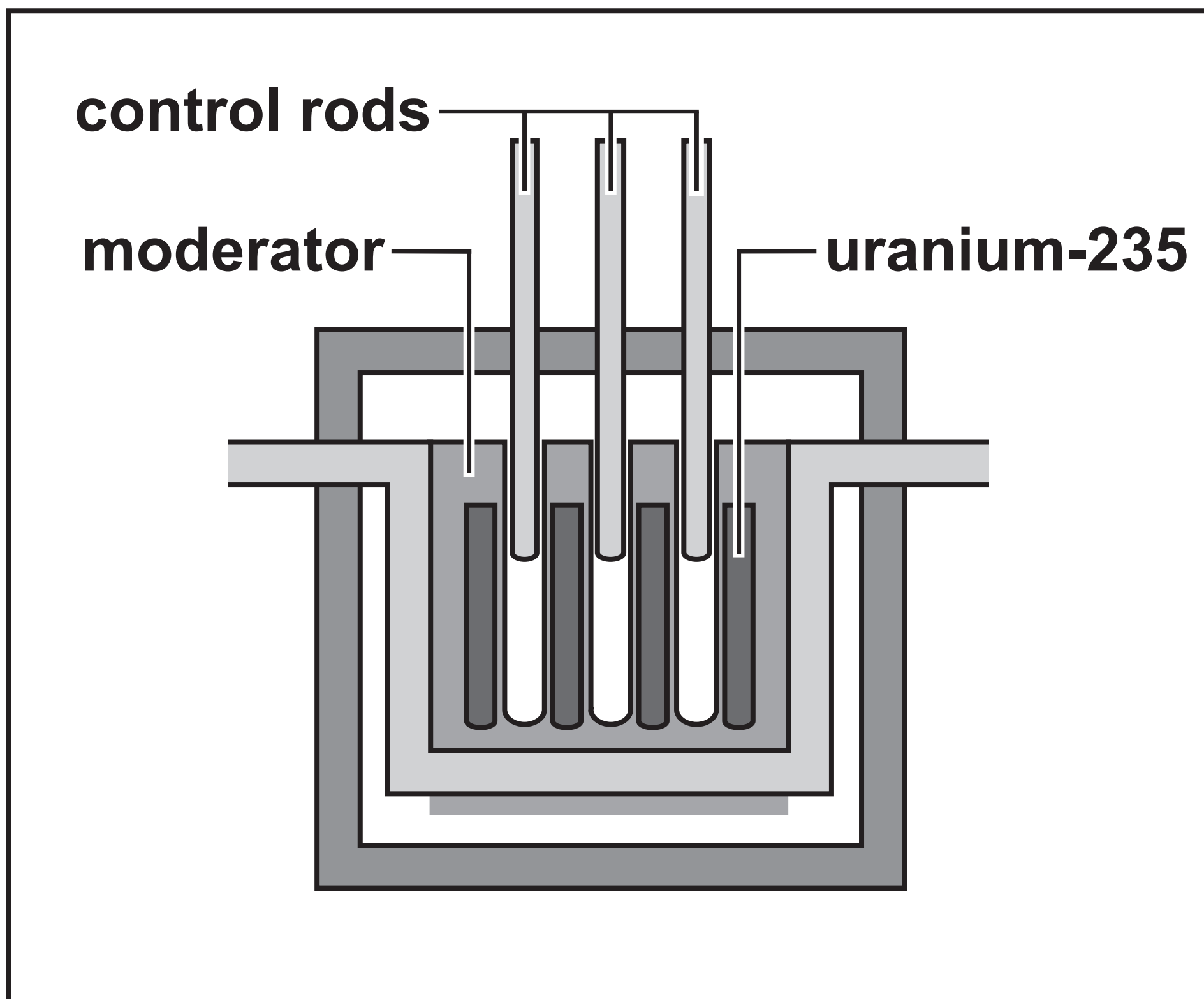


DIAGRAM 5



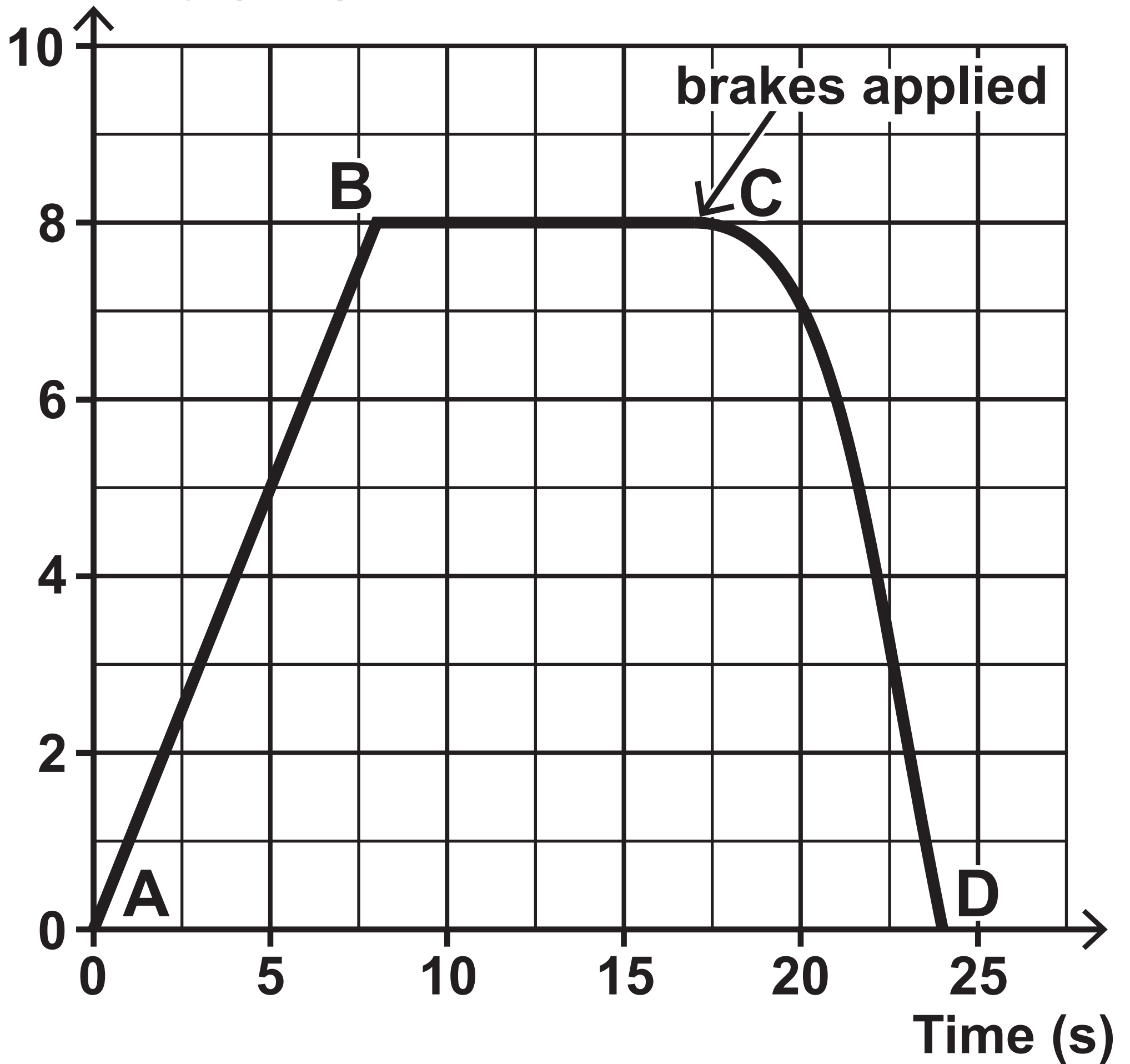
GRAPH 6**Velocity (m/s)**

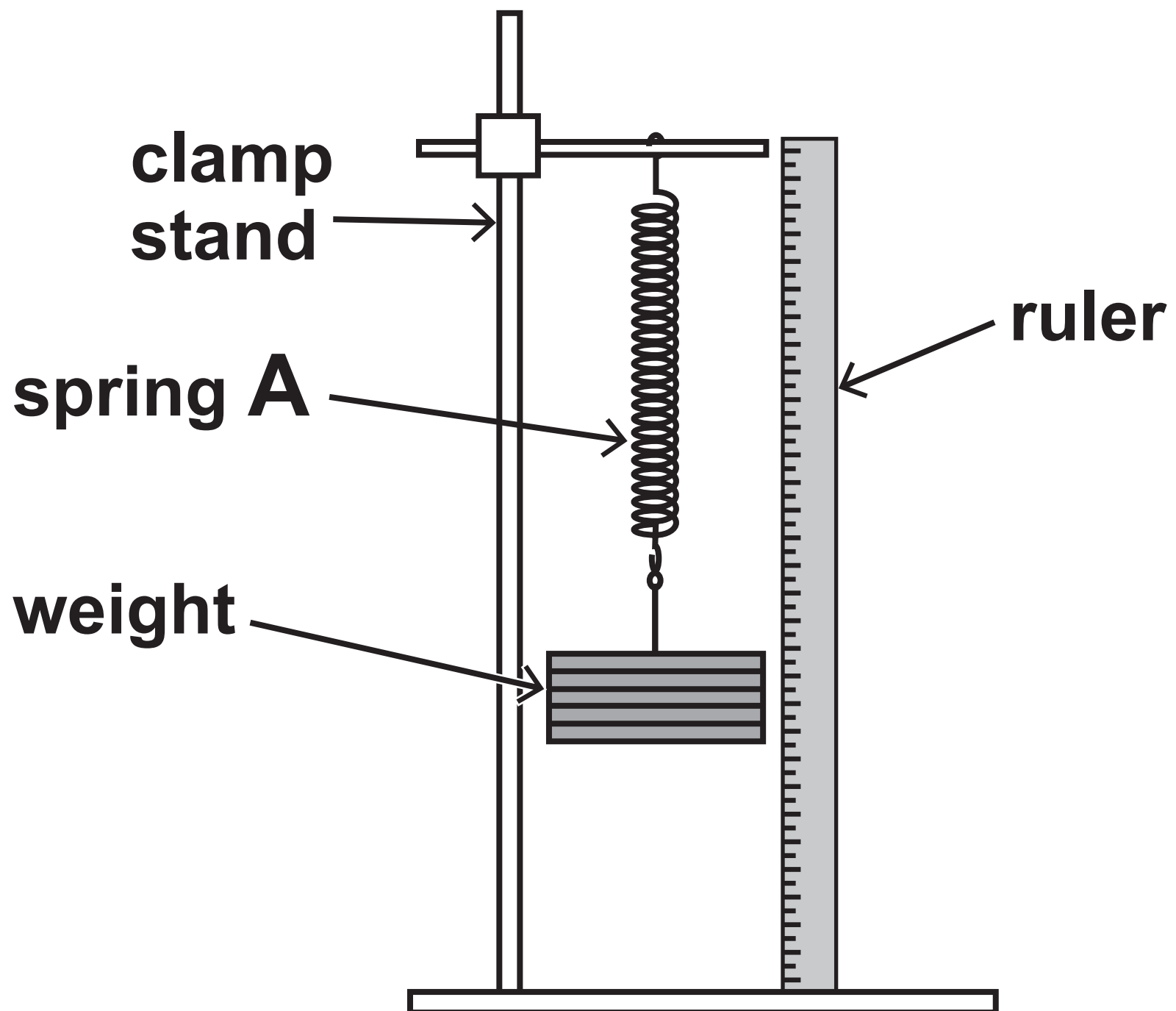
DIAGRAM 7

DIAGRAM 8

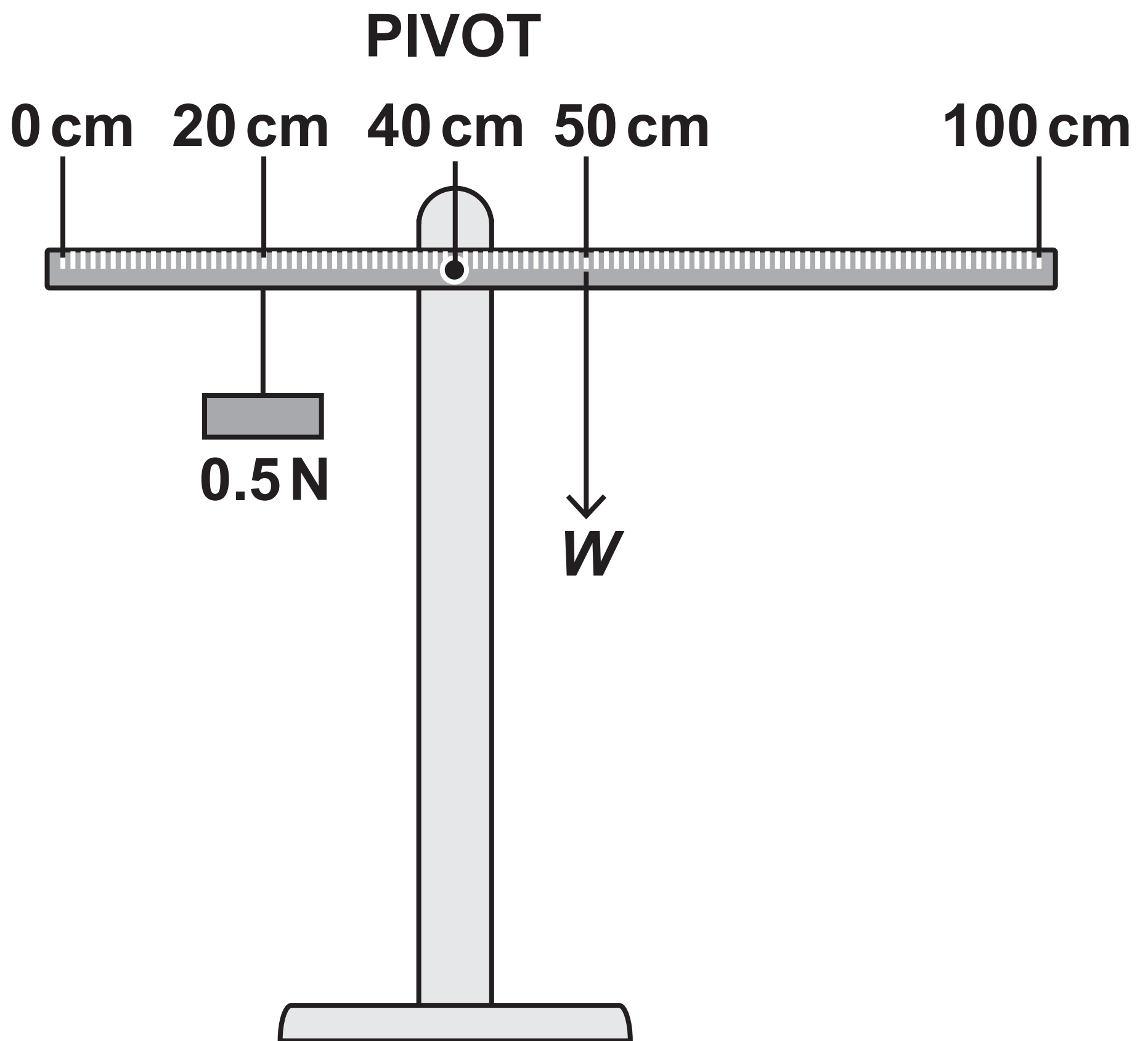


DIAGRAM 9

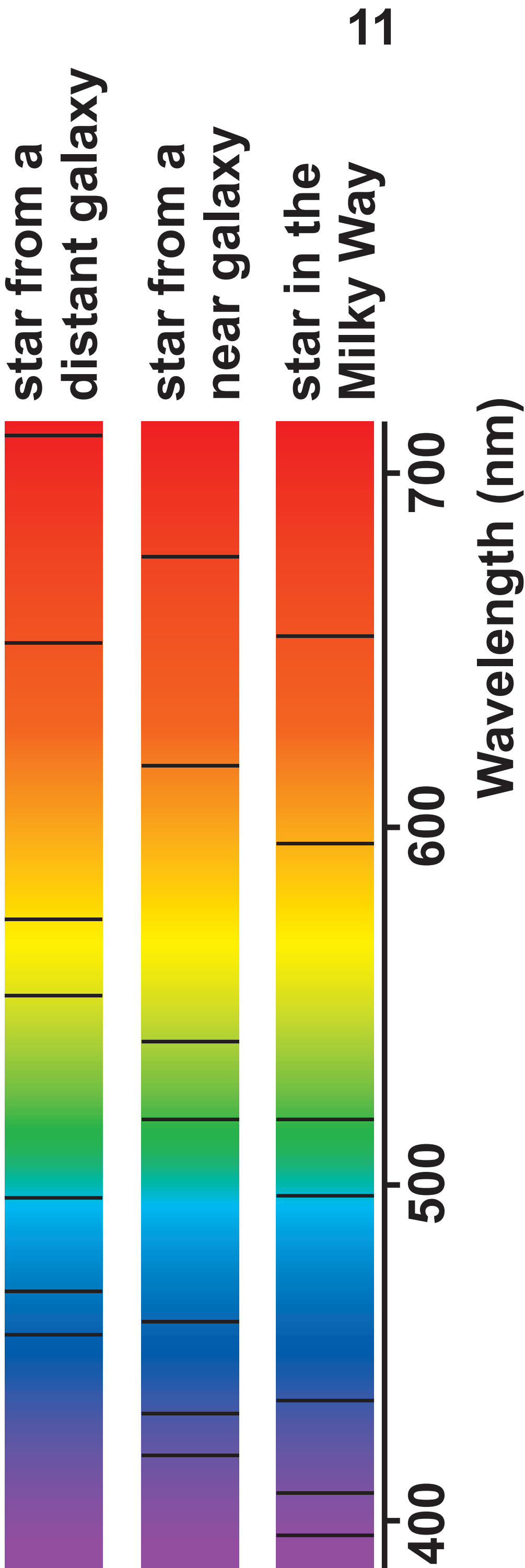
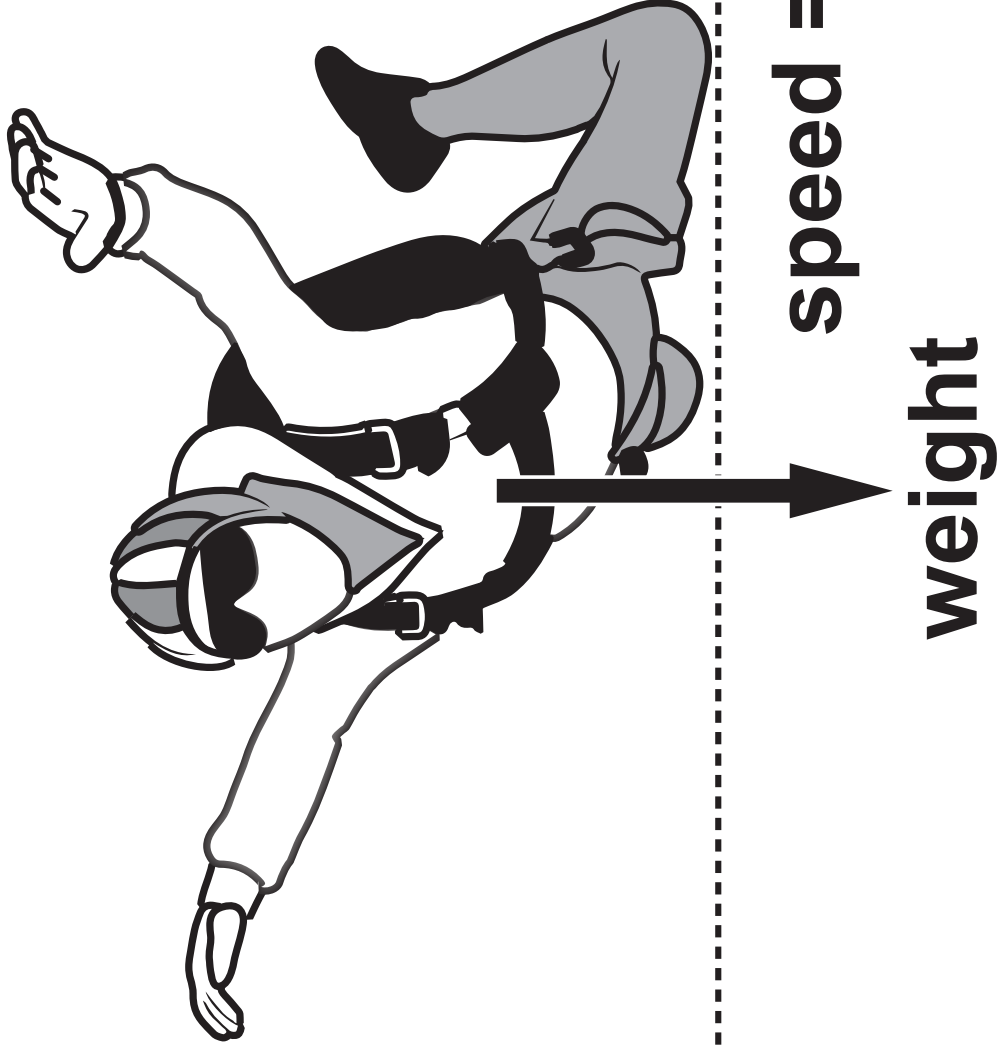


DIAGRAM 10.1

5000 m

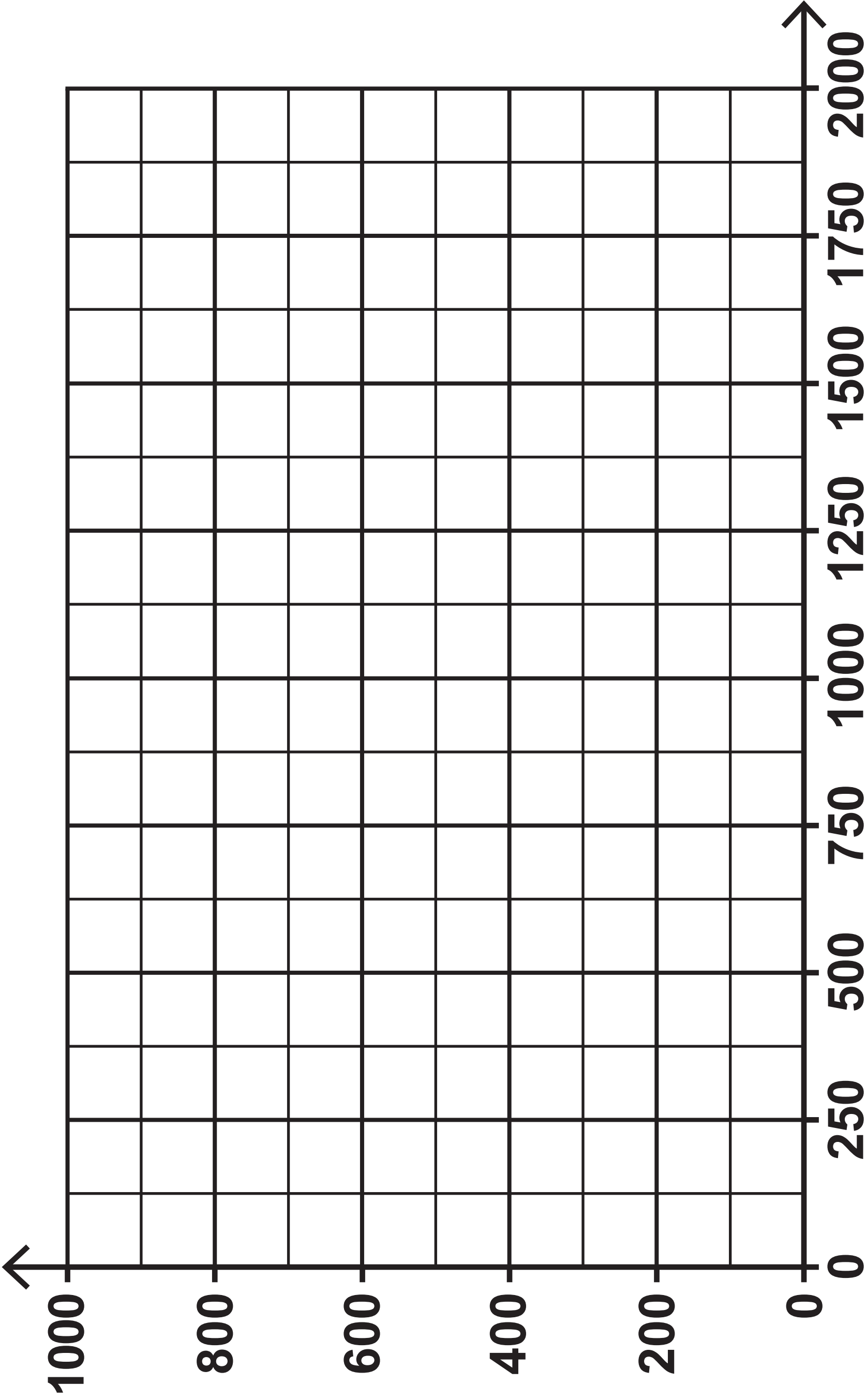
4500 m

3000 m



GRAPH 10.2

Air resistance (N)



Distance fallen (m)



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PHYSICS – Unit 2:

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HIGHER TIER

**1 hour 45 minutes plus your additional
time allowance**

Data Booklet

Equations and SI multipliers

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TURN OVER

EQUATIONS

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

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

$$\text{acceleration} = \text{gradient of velocity-time graph}$$

$$\text{distance travelled} = \text{area under a velocity-time graph}$$

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

$$\text{weight} = \text{mass} \times \begin{array}{c} \text{gravitational} \\ \text{field} \\ \text{strength} \end{array} \quad W = mg$$

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

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

$$\begin{array}{c} \text{change} \\ \text{in} \\ \text{potential} \\ \text{energy} \end{array} = \text{mass} \times \begin{array}{c} \text{gravitational} \\ \text{field} \\ \text{strength} \end{array} \times \begin{array}{c} \text{change} \\ \text{in} \\ \text{height} \end{array}$$

$$PE = mgh$$

$$\text{force} = \begin{array}{c} \text{spring} \\ \text{constant} \end{array} \times \text{extension} \quad F = kx$$

$$\begin{array}{c} \text{work done} \\ \text{in stretching} \end{array} = \begin{array}{c} \text{area under a} \\ \text{force-extension} \\ \text{graph} \end{array} \quad W = \frac{1}{2} Fx$$

$$\text{momentum} = \text{mass} \times \text{velocity} \quad p = mv$$

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

u = initial velocity

v = final velocity

t = time

a = acceleration

x = displacement

$$\mathbf{v = u + at}$$

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

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

$$\mathbf{v^2 = u^2 + 2ax}$$

moment = force × distance

$$\mathbf{M = Fd}$$

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 by 1 000 000 000	1×10^9
tera	T	multiply by 1 000 000 000 000	1×10^{12}