AL AMAL LEARNING CENTER

PHYSICS KEY BOOK

Class 9 | Unit 2

KINEMATICS

NUMERICALS

What is inside

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1	Formulas and how to solve a numerical
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About this part

Solved numericals for Class 9 Physics Unit 2: speed, velocity, acceleration, free fall, and distance–time and speed–time graphs. Each answer shows the steps, because every step carries marks.

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PART KINEMATICS

Formulas you need

Quantity	Formula	SI unit
Speed	$v = \Delta d \div \Delta t$, or $v = s \div t$	m/s
Average speed	total distance ÷ total time	m/s
Velocity	$v = \Delta d \div \Delta t$, using displacement	m/s
Acceleration	$a = (v_f - v_i) \div \Delta t$	m/s²
Free fall	$v_f = v_i + g\,t$, where $g = 9.8$ m/s²	m/s
Gradient of distance–time graph	$\Delta s \div \Delta t$ = speed	m/s
Gradient of speed–time graph	$\Delta v \div \Delta t$ = acceleration	m/s²
Area under speed–time graph	rectangle = $v \times t$; triangle = ½ × $v \times t$	m

Unit conversions: km/h ÷ 3.6 = m/s | m/s × 3.6 = km/h | 1 km = 1000 m | 1 h = 3600 s

How to solve a numerical

1. Write what is **given** and what is **required**.
2. **Change units** first (for example km/h to m/s).
3. Pick the right **formula** and put the values in.
4. Calculate and write the **unit** with the answer.
5. Check that the answer makes sense (a negative acceleration means slowing down).

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PART 1 SOLVED EXAMPLES

Example 2.1: Reaction time of a batsman

Question. Shoaib Akhtar bowled at 161.3 km/h in the 2003 World Cup. If the batsman is 17.5 m from the bowler, what is the reaction time for the delivery?

Given	Working	Answer
v = 161.3 km/h s = 17.5 m	v = 161.3 × 1000 ÷ 3600 = 44.8 m/s t = s ÷ v = 17.5 ÷ 44.8	**t = 0.39 s**

Example 2.2: Fastest train in the world

Question. Shanghai's Maglev train travels 30 km in 7 minutes 30 seconds. What is its speed in m/s and km/h?

	Given	Working	Answer
a	Δs = 30 km = 30 000 m Δt = 7 min 30 s = 450 s	v = Δs ÷ Δt = 30 000 ÷ 450	**66.67 m/s**
b	66.67 m/s	66.67 × 3600 ÷ 1000	**240 km/h**

Example 2.3: Velocity of a car

Question. A car travels a curvy track of length 800 m in 40 s. The straight path between start and end is 600 m. Find (a) the average speed and (b) the average velocity.

	Given	Working	Answer
a	Distance = 800 m Time = 40 s	Average speed = distance ÷ time = 800 ÷ 40	**20 m/s**
b	Displacement = 600 m Time = 40 s	Average velocity = displacement ÷ time = 600 ÷ 40, directed from start to end	**15 m/s**

> **Note:** The textbook divides 600 m by 36 s and prints 16.67 m/s. That uses a different time. For this 40 s journey, the average velocity is 15 m/s.

Example 2.4: Acceleration of a cheetah

Question. A cheetah increases its speed from zero to 26.8 m/s in 3 s. If it runs towards the east, find its acceleration.

Given	Working	Answer
v_i = 0 m/s v_f = 26.8 m/s (east) Δt = 3 s	a = (v_f − v_i) ÷ Δt = (26.8 − 0) ÷ 3	**8.93 m/s² east**

> **Note:** A typical car has an acceleration of only 3 to 4 m/s². The textbook prints 9.93 m/s², but 26.8 ÷ 3 = 8.93.

Example 2.5 (gravity): Time to reach the ground

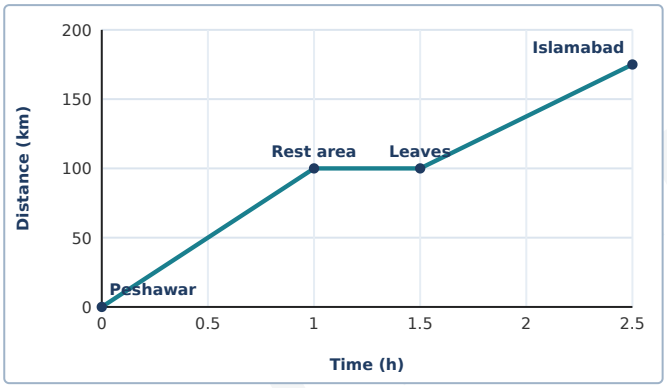
Question. A block of mass 2 kg is left at the top of a building. It strikes the ground at 78.5 m/s. How long does it take to reach the ground? (Ignore air resistance.)

Given	Working	Answer
$v_i = 0$ m/s $v_f = 78.5$ m/s $g = 9.8$ m/s² (mass 2 kg is not needed)	$g = (v_f - v_i) \div \Delta t$, so $\Delta t = (v_f - v_i) \div g$ $\Delta t = (78.5 - 0) \div 9.8 = 8.01$	**$\Delta t \approx 8$ s**

The mass does not matter in free fall.

Example 2.5 (graph): Peshawar to Islamabad through M1

Question. A car travels from Peshawar to Islamabad on the motorway and stops for 30 minutes at a rest area. Find its speed in km/h and m/s for (a) Peshawar to the rest area, (b) the rest area to Islamabad, (c) Peshawar to Islamabad.



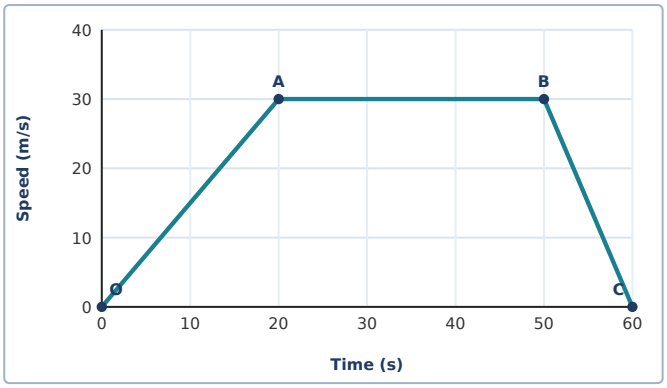
Speed = gradient of the distance–time graph = $\Delta s \div \Delta t$.

	Part	Δs	Δt	Speed (km/h)	Speed (m/s)
a	Peshawar to rest area	100 − 0 = 100 km	1 − 0 = 1 h	100 ÷ 1 = **100 km/h**	100 000 ÷ 3600 = **27.78 m/s**
b	Rest area to Islamabad	175 − 100 = 75 km	2.5 − 1.5 = 1 h	75 ÷ 1 = **75 km/h**	75 000 ÷ 3600 = **20.83 m/s**
c	Whole journey	175 − 0 = 175 km	2.5 − 0 = 2.5 h	175 ÷ 2.5 = **70 km/h**	175 000 ÷ 9000 = **19.44 m/s**

Note: The textbook prints 100 km/h for part (b). But 75 km in 1 hour is 75 km/h, and its own m/s answer (20.83) is correct. For part (c), 2.5 h = 9000 s.

Example 2.6: Graphical representation of the speed of a car

Question. A car increases its speed from zero to 30 m/s in 20 s, moves with uniform speed for the next 30 s, then brakes and stops uniformly in 10 s. Use the speed–time graph to find (a) the acceleration in the first 20 s, from 20 s to 50 s and in the last 10 s, (b) the total distance, (c) the average speed.



Acceleration = slope of the graph (Δv ÷ Δt). Distance = area under the graph.

	Given	Working	Answer
a	OA: 0 → 30 m/s in 20 s	(30 − 0) ÷ (20 − 0) = 30 ÷ 20	**1.5 m/s²**
a	AB: 30 m/s from 20 s to 50 s	(30 − 30) ÷ (50 − 20) = 0 ÷ 30	**0 m/s²**
a	BC: 30 → 0 m/s in 10 s	(0 − 30) ÷ (60 − 50) = −30 ÷ 10	**−3 m/s² (slowing down)**
b	Area under OABC	Triangle ½ × 30 × 20 = 300 m Rectangle 30 × 30 = 900 m Triangle ½ × 30 × 10 = 150 m Total = 300 + 900 + 150	**1350 m**
c	Total distance = 1350 m Total time = 60 s	Average speed = distance ÷ time = 1350 ÷ 60	**22.5 m/s**

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PART 2 EXERCISE NUMERICALS

1. Convert the following

	Given	Working	Answer
a	160 km/h into m/s	160 × 1000 ÷ 3600 (or 160 ÷ 3.6)	**44.44 m/s**
b	36 m/s into km/h	36 × 3600 ÷ 1000 (or 36 × 3.6)	**129.6 km/h**
c	15 km/h² into m/s²	1 h² = 3600² = 12 960 000 s² 15 × 1000 ÷ 12 960 000	**0.00116 m/s²**
d	1 m/s² into km/h²	1 m = 1/1000 km, 1 s = 1/3600 h 3600² ÷ 1000 = 12 960 000 ÷ 1000	**12 960 km/h²**

2. Cyclist and car

Question. In 10 s, a cyclist increases speed from 5 km/h to 7 km/h, while a car moves from rest to 20 km/h in the same time. Calculate and compare the accelerations.

	Given	Working	Answer
a	Cyclist: $\Delta v = 7 - 5 = 2$ km/h	2 ÷ 3.6 = 0.556 m/s $a = \Delta v \div \Delta t = 0.556 \div 10$	**0.056 m/s²**
b	Car: $\Delta v = 20 - 0 = 20$ km/h	20 ÷ 3.6 = 5.56 m/s a = 5.56 ÷ 10	**0.556 m/s²**
c	Compare	0.556 ÷ 0.056	**Car's acceleration is 10 times the cyclist's**

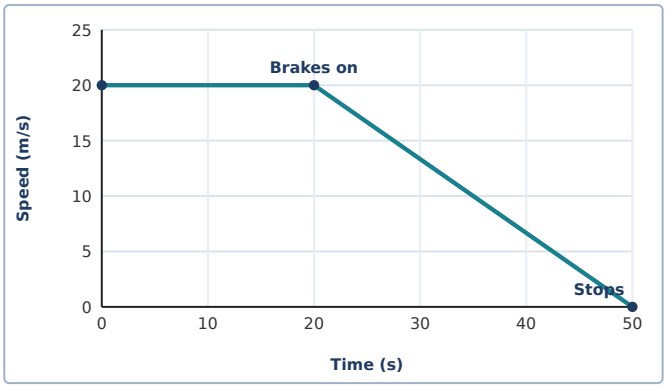
3. Ball thrown straight up

Question. A ball is thrown straight up and takes 2 s to reach the top. What was the speed with which it was thrown up?

Given	Working	Answer
t = 2 s $v_f = 0$ at the top $a = -g = -9.8$ m/s²	$v_f = v_i - g\,t$ $0 = v_i - 9.8 \times 2$	**v_i = 19.6 m/s**

4. Uniform velocity, then braking

Question. A car moves with a uniform velocity of 20 m/s for 20 s. Then the brakes are applied and it comes to rest with uniform deceleration in 30 s. Plot the speed–time graph and calculate the distance travelled.



	Given	Working	Answer
a	Rectangle: 0 to 20 s at 20 m/s	20 × 20 = 400 m	**400 m**
b	Triangle: 20 s to 50 s	½ × 20 × 30 = 300 m	**300 m**
c	Total distance	400 + 300	**700 m**

> **Note:** The textbook's answer key prints 1 km. With the data given in the question, the distance is 700 m.

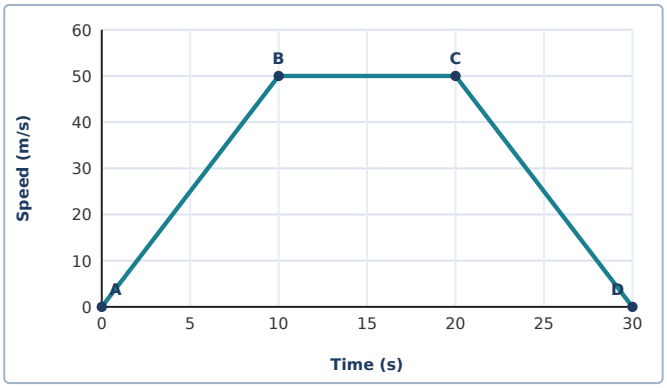
5. Girl on a racing bicycle

Question. A girl on a racing bicycle moves in a straight line at 50 km/h. Her speed changes at a constant rate and she stops after 60 s. What is her acceleration?

Given	Working	Answer
v_i = 50 km/h = 50 ÷ 3.6 = 13.89 m/s v_f = 0 Δt = 60 s	$a = (v_f - v_i) \div \Delta t = (0 - 13.89) \div 60$	**−0.23 m/s²**

The negative sign means deceleration: her speed decreases by 0.23 m/s every second.

6. Questions on a speed–time graph



	Segment	Working	Answer
a	AB (0 to 10 s)	(50 − 0) ÷ 10 = +5 m/s²	**Acceleration**
	BC (10 to 20 s)	(50 − 50) ÷ 10 = 0 m/s²	**Zero acceleration**
	CD (20 to 30 s)	(0 − 50) ÷ 10 = −5 m/s²	**Deceleration**
b	Distance, 10 s to 20 s	Constant 50 m/s, so rectangle: 50 × 10	**500 m**

Note: The textbook's key lists the segments as “OA, BC, AB”. According to the figure they are AB, BC and CD. The distance (500 m) matches the key.

Quick practice (Can you tell?)

Try these yourself, then check the answers.

Question	Working	Answer
A train travels 90 km in 1.5 hours. Find its speed in km/h and m/s.	90 ÷ 1.5 = 60 km/h; 60 ÷ 3.6	**60 km/h = 16.67 m/s**
A bike speeds up from 4 m/s to 16 m/s in 6 s. Find its acceleration.	(16 − 4) ÷ 6	**2 m/s²**
A stone is dropped from a cliff. How fast is it moving after 4 s?	$v_f = 0 + 9.8 \times 4$	**39.2 m/s downward**