ALNOJOUM ACADEMY

أكاديمية النجوم

Chapter 2
Motion Along a Straight Line

Written solutions to the textbook problems

PHYS 105 | Prince Sultan University | 25 solved problems

What this chapter covers

2.1 Position, Displacement and Average Velocity

2.2 Instantaneous Velocity and Speed

2.3 Acceleration

2.4 Constant Acceleration

2.5 Free-Fall Acceleration

All key formulas are on the next page.

Watch out

- Distance is always positive; displacement can be positive, negative or zero.
- Average speed ≠ |average velocity| when the motion changes direction.
- Choose a positive direction first and give v and a their signs.
- At the top of a vertical throw v = 0 but a = −g (not zero).
- Convert km/h and mi/h to m/s before using the equations (1 mi = 1609 m).

Problems in this file

1 Walking to the library, the park and back

2 Olympic 200-m dash

3 A hopping kangaroo

4 Radio signal to the Moon and back

5 A finch riding a tortoise

6 An expectant father pacing

7 Position given by an equation

8 A 747 taking off

9 A sprinter at the starting gun

10 A jet landing (stops in 13.0 s)

11 Motorcycle v–t graph

12 A horse slowing down

13 A train leaving the station

14 Finding the initial velocity

15 A jet landing (stops in 949 m)

16 Braking at a red light

17 A boat speeding up

18 Sliding down on a toboggan

19 The Detonator ride

20 Two cars on a highway

21 A rocket blasting off

22 A lava bomb

23 A volcano on Io

24 Bill and Ted on the diving boards

25 An angry basketball player

Every problem has a QR code that opens its full video solution.

Mr. Abdullah Abdelfattah · alnojoumacademy.com · @Chem31Phys

Chapter 2

Key formulas

Organized by the sections of the Chapter 2 slides (2.1 – 2.5).

2.1 Position, Displacement and Average Velocity

Displacement	$\Delta x = x_f - x_i$	Vector: +, − or 0; distance is always +
Average velocity	$v_{av} = \dfrac{\Delta x}{\Delta t}$	Vector, m/s
Average speed	$s_{av} = \dfrac{\text{total distance}}{\text{total time}}$	Scalar, always +

2.2 Instantaneous Velocity and Speed

Instantaneous velocity	$v = \lim_{\Delta t \to 0} \dfrac{\Delta x}{\Delta t} = \dfrac{dx}{dt}$	Slope of the x–t graph
Speed	$\lvert v \rvert$	Magnitude of the velocity

2.3 Acceleration

Average acceleration	$a_{av} = \dfrac{\Delta v}{\Delta t} = \dfrac{v_f - v_i}{t_f - t_i}$	m/s²
Instantaneous acceleration	$a = \dfrac{dv}{dt} = \dfrac{d^2x}{dt^2}$	Slope of the v–t graph
Speeding up / slowing down	same sign of $v, a \rightarrow$ speeds up	Opposite signs → slows down

2.4 Constant Acceleration

Missing x − x_0	$v = v_0 + at$	Use only when a is constant
Missing v	$x - x_0 = v_0 t + \frac{1}{2} a t^2$	
Missing t	$v^2 = v_0^2 + 2a(x - x_0)$	
Missing a	$x - x_0 = \frac{1}{2}(v_0 + v)t$	v_{av} = ½(v$_0$ + v)

2.5 Free-Fall Acceleration

Free-fall acceleration	$a = -g = -9.81\ \text{m/s}^2$	Upward taken as +; same for every mass
Use the same equations	$y - y_0 = v_0 t - \frac{1}{2} g t^2, \quad v = v_0 - gt$	
At the highest point	$v = 0, \quad a = -g$	a is NOT zero at the top

ALNOJOUM ACADEMY

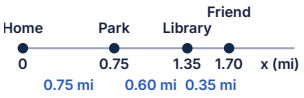
PROBLEM 1

Walking to the library, the park and back

Distance · Displacement

Watch the video

Use Figure 2-20 (positions on a straight street). (a) You walk from your home to the library, then to the park: find the distance traveled and your displacement. (b) You walk from the park to your friend's house, then back to your house: find the distance traveled and your displacement.



GIVEN $x_{home} = 0 \quad x_{park} = 0.75\ \text{mi} \quad x_{library} = 1.35\ \text{mi} \quad x_{friend} = 1.70\ \text{mi}$ **FIND** $d,\ \Delta x$

SOLUTION

(a) Distance adds every leg; displacement is final − initial position.

$$d = 1.35 + 0.60 = 1.95\ \text{mi}, \qquad \Delta x = x_{park} - x_{home} = 0.75\ \text{mi}$$

(b) Park → friend's house is 0.95 mi, and friend's house → home is the full 1.70 mi.

$$d = 0.95 + 1.70 = 2.65\ \text{mi}, \qquad \Delta x = x_{home} - x_{park} = 0 - 0.75 = -0.75\ \text{mi}$$

ANSWER **(a)** $1.95\ \text{mi},\ +0.75\ \text{mi}$ **(b)** $2.65\ \text{mi},\ -0.75\ \text{mi}$

PROBLEM 2

Olympic 200-m dash

Average speed · Unit conversion

Watch the video

Joseph DeLoach set an Olympic record in 1988 in the 200-m dash with a time of 19.75 s. What was his average speed in meters per second and in miles per hour?

GIVEN $d = 200\ \text{m} \quad t = 19.75\ \text{s} \quad 1\ \text{mi} = 1609\ \text{m}$ **FIND** s_{av}

SOLUTION

$$s_{av} = \frac{d}{t} = \frac{200}{19.75} = 10.13\ \text{m/s}$$

$$10.13\ \frac{\text{m}}{\text{s}} \times \frac{1\ \text{mi}}{1609\ \text{m}} \times \frac{3600\ \text{s}}{1\ \text{h}} = 22.7\ \text{mi/h}$$

ANSWER $10.1\ \text{m/s} = 22.7\ \text{mi/h}$

PROBLEM 3

A hopping kangaroo

Constant speed · Unit conversion

Watch the video

Kangaroos have been clocked at 65 km/h. (a) How far can a kangaroo hop in 3.2 minutes at this speed? (b) How long will it take to hop 0.25 km?

GIVEN $v = 65\ \text{km/h} = 18.06\ \text{m/s}$ $t = 3.2\ \text{min} = 192\ \text{s}$ **FIND** $d,\ t$

SOLUTION

(a)

$$d = vt = (18.06)(192) = 3.47 \times 10^3\ \text{m} = 3.47\ \text{km}$$

(b)

$$t = \frac{d}{v} = \frac{250\ \text{m}}{18.06\ \text{m/s}} = 13.8\ \text{s}$$

ANSWER **(a)** $3.47\ \text{km}$ **(b)** $13.8\ \text{s}$

PROBLEM 4

Radio signal to the Moon and back

Constant speed

Watch the video

Radio waves travel at the speed of light (about 186,000 mi/s = 3.00×10^8 m/s). How long does it take a radio message to travel from Earth to the Moon and back? (Earth–Moon distance = 3.84×10^8 m.)

GIVEN $c = 3.00 \times 10^8\ \text{m/s}$ $d_{EM} = 3.84 \times 10^8\ \text{m}$ **FIND** t

SOLUTION

The signal covers the Earth–Moon distance twice.

$$t = \frac{2d_{EM}}{c} = \frac{2(3.84 \times 10^8)}{3.00 \times 10^8} = 2.56\ \text{s}$$

ANSWER $2.56\ \text{s}$

PROBLEM 5

A finch riding a tortoise

Average speed

Watch the video

A finch rides on a tortoise walking at 0.060 m/s. After 1.2 min the finch flies off in the same direction for another 1.2 min at 12 m/s. What was its average speed for the 2.4-min interval?

GIVEN $v_1 = 0.060\ \text{m/s}$ $v_2 = 12\ \text{m/s}$ $t_1 = t_2 = 72\ \text{s}$ **FIND** s_{av}

SOLUTION

Distance in each part:

$$d_1 = (0.060)(72) = 4.32\ \text{m}, \qquad d_2 = (12)(72) = 864\ \text{m}$$

$$s_{av} = \frac{d_1 + d_2}{t_{total}} = \frac{4.32 + 864}{144} = 6.03\ \text{m/s}$$

ANSWER $6.0\ \text{m/s}$

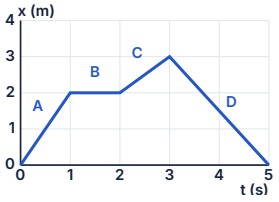
PROBLEM 6

An expectant father pacing

x–t graph Velocity = slope

Watch the video

The position–time graph of a pacing father is shown. Without calculation, state whether his velocity is positive, negative or zero on segments (a) A, (b) B, (c) C, (d) D. Then calculate the velocity on segments (e) A, (f) B, (g) C, (h) D.



FIND $v =$ slope of x–t

SOLUTION

The velocity is the slope of the x–t graph: rising → +, flat → 0, falling → −.

(e)–(h)

$$v_A = \frac{2-0}{1-0} = 2\ \text{m/s}, \quad v_B = \frac{2-2}{2-1} = 0, \quad v_C = \frac{3-2}{3-2} = 1\ \text{m/s}, \quad v_D = \frac{0-3}{5-3} = -1.5\ \text{m/s}$$

ANSWER **(a–d)** $+,\ 0,\ +,\ -$ **(e–h)** $2,\ 0,\ 1,\ -1.5\ \text{m/s}$

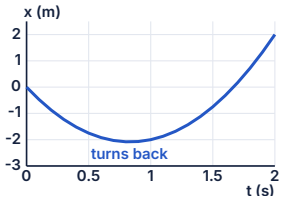
PROBLEM 7

Position given by an equation

Average velocity · Average speed

Watch the video

The position of a particle is x = (−5 m/s)t + (3 m/s^2)t^2. (a) Plot x versus t from t = 0 to t = 2 s. (b) Find the average velocity from t = 0 to t = 1 s. (c) Find the average speed from t = 0 to t = 1 s.



GIVEN $x = -5t + 3t^2$ FIND $v_{av},\ s_{av}$

SOLUTION

(a) Values: t = 0, 0.5, 1, 1.5, 2 s → x = 0, −1.75, −2, −0.75, 2 m (graph above).

(b)

$$v_{av} = \frac{x(1) - x(0)}{1 - 0} = \frac{-2 - 0}{1} = -2\ \text{m/s}$$

(c) The particle reverses direction when v = dx/dt = −5 + 6t = 0, at t = 0.833 s, where x = −2.08 m. So it moves 2.08 m backward, then 0.08 m forward:

$$d = 2.083 + 0.083 = 2.17\ \text{m}, \qquad s_{av} = \frac{2.17}{1} = 2.17\ \text{m/s}$$

Average speed ≠ |average velocity| when the motion changes direction.

ANSWER **(b)** $-2\ \text{m/s}$ **(c)** $2.17\ \text{m/s}$

PROBLEM 8

A 747 taking off

Average acceleration

Watch the video

A 747 airliner reaches its takeoff speed of 173 mi/h in 35.2 s. What is the magnitude of its average acceleration?

GIVEN $v_i = 0$ $v_f = 173\ \text{mi/h} = 77.3\ \text{m/s}$ $\Delta t = 35.2\ \text{s}$ FIND a_{av}

SOLUTION

$$a_{av} = \frac{v_f - v_i}{\Delta t} = \frac{77.3 - 0}{35.2} = 2.20\ \text{m/s}^2$$

ANSWER $2.20\ \text{m/s}^2$

PROBLEM 9

A sprinter at the starting gun

Constant acceleration

Watch the video

At the starting gun, a runner accelerates at 1.9 m/s^2 for 5.2 s, then her acceleration is zero for the rest of the race. What is her speed (a) at t = 2.0 s and (b) at the end of the race?

GIVEN $a = 1.9\ \text{m/s}^2\ (0 \le t \le 5.2\ \text{s})$ $v_i = 0$ FIND v

SOLUTION

(a)

$$v = at = (1.9)(2.0) = 3.8\ \text{m/s}$$

(b) After 5.2 s the speed stays constant:

$$v = (1.9)(5.2) = 9.88\ \text{m/s}$$

ANSWER **(a)** $3.8\ \text{m/s}$ **(b)** $9.9\ \text{m/s}$

PROBLEM 10

A jet landing (stops in 13.0 s)

Average acceleration Direction

Watch the video

A jet lands traveling due east at 115 m/s and comes to rest in 13.0 s. What are the magnitude and direction of its average acceleration?

GIVEN $v_i = +115\ \text{m/s (east)}$ $v_f = 0$ $\Delta t = 13.0\ \text{s}$ FIND a_{av}

SOLUTION

Take east as +:

$$a_{av} = \frac{0 - 115}{13.0} = -8.85\ \text{m/s}^2$$

The negative sign means the acceleration points west (opposite to the motion).

ANSWER $8.85\ \text{m/s}^2$ west

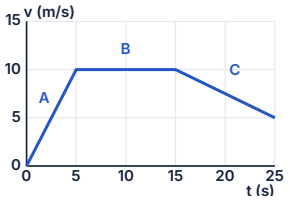
PROBLEM 11

Motorcycle v–t graph

v–t graph | Acceleration = slope

Watch the video

A motorcycle moves according to the velocity–time graph shown. Find its average acceleration during segments (a) A, (b) B and (c) C.



FIND $a = \text{slope of } v\text{–}t$

SOLUTION

$$a_A = \frac{10-0}{5-0} = 2.0\ \text{m/s}^2, \quad a_B = \frac{10-10}{15-5} = 0, \quad a_C = \frac{5-10}{25-15} = -0.50\ \text{m/s}^2$$

ANSWER $2.0,\ 0,\ -0.50\ \text{m/s}^2$

PROBLEM 12

A horse slowing down

Constant acceleration

Watch the video

Running with an initial velocity of +11 m/s, a horse has an average acceleration of −1.81 m/s^2. How long does it take the horse to decrease its velocity to +6.5 m/s?

GIVEN $v_i = 11\ \text{m/s}$ $v_f = 6.5\ \text{m/s}$ $a = -1.81\ \text{m/s}^2$ **FIND** t

SOLUTION

$$t = \frac{v_f - v_i}{a} = \frac{6.5 - 11}{-1.81} = 2.49\ \text{s}$$

Extra: distance covered in this time

$$\Delta x = \frac{v_f^2 - v_i^2}{2a} = \frac{6.5^2 - 11^2}{2(-1.81)} = 21.8\ \text{m}$$

ANSWER $2.49\ \text{s}$

PROBLEM 13

A train leaving the station

Constant acceleration

Watch the video

A train accelerating from rest reaches 4.7 m/s in 5.0 s. If its acceleration stays constant, what is its speed after an additional 6.0 s?

GIVEN $v_i = 0 \quad v_1 = 4.7\ \text{m/s at } t = 5.0\ \text{s}$ **FIND** $v \text{ at } t = 11\ \text{s}$

SOLUTION

$$a = \frac{4.7}{5.0} = 0.94\ \text{m/s}^2, \qquad v = 4.7 + (0.94)(6.0) = 10.3\ \text{m/s}$$

ANSWER $10.3\ \text{m/s}$

PROBLEM 14

Finding the initial velocity

Constant acceleration

Watch the video

A particle has an acceleration of +6.24 m/s^2 for 0.300 s. At the end of this time its velocity is +9.31 m/s. What was its initial velocity?

GIVEN $a = 6.24\ \text{m/s}^2 \quad t = 0.300\ \text{s} \quad v_f = 9.31\ \text{m/s}$ **FIND** v_i

SOLUTION

$$v_i = v_f - at = 9.31 - (6.24)(0.300) = 7.44\ \text{m/s}$$

ANSWER $+7.44\ \text{m/s}$

PROBLEM 15

A jet landing (stops in 949 m)

v² equation | Direction

Watch the video

Landing at 81.9 m/s and traveling due south, a jet comes to rest in 949 m. Assuming constant acceleration, find the magnitude and direction of its acceleration.

GIVEN $v_i = -81.9\ \text{m/s (south)}$ $v_f = 0$ $\Delta y = -949\ \text{m}$ **FIND** a

SOLUTION

Take north as +:

$$a = \frac{v_f^2 - v_i^2}{2\Delta y} = \frac{0 - (81.9)^2}{2(-949)} = +3.53\ \text{m/s}^2$$

Positive → the acceleration points north, opposite to the motion (the jet is slowing down).

ANSWER $3.53\ \text{m/s}^2$ north

PROBLEM 16

Braking at a red light

Average velocity | Constant acceleration

Watch the video

You brake from 12 m/s, heading due west, until you stop. (a) What was your average velocity during braking (constant deceleration)? (b) If the car stops in 35 m, how much time does this take?

GIVEN $v_i = 12\ \text{m/s (west)}$ $v_f = 0$ $d = 35\ \text{m}$ **FIND** v_{av}, t

SOLUTION

(a) For constant acceleration:

$$v_{av} = \frac{v_i + v_f}{2} = \frac{12 + 0}{2} = 6.0\ \text{m/s west}$$

(b)

$$t = \frac{d}{v_{av}} = \frac{35}{6.0} = 5.83\ \text{s}$$

ANSWER **(a)** $6.0\ \text{m/s}$ west **(b)** $5.8\ \text{s}$

PROBLEM 17

A boat speeding up

Average velocity · Constant acceleration

Watch the video

Starting from rest, a boat increases its speed to 4.12 m/s with constant acceleration. (a) What is its average speed? (b) If it takes 4.77 s to reach this speed, how far has it traveled?

GIVEN $v_i = 0 \quad v_f = 4.12\ \text{m/s} \quad t = 4.77\ \text{s}$ FIND $v_{av},\ \Delta x$

SOLUTION

(a)

$$v_{av} = \frac{0 + 4.12}{2} = 2.06\ \text{m/s}$$

(b)

$$\Delta x = v_{av} t = (2.06)(4.77) = 9.83\ \text{m}$$

ANSWER **(a)** $2.06\ \text{m/s}$ **(b)** $9.83\ \text{m}$

PROBLEM 18

Sliding down on a toboggan

Constant acceleration · $x \propto t^2$

Watch the video

A child slides down a hill on a toboggan with an acceleration of 1.8 m/s^2, starting from rest. How far has she traveled in (a) 1.0 s, (b) 2.0 s, (c) 3.0 s?

GIVEN $a = 1.8\ \text{m/s}^2 \quad v_i = 0$ FIND Δx

SOLUTION

$$\Delta x = \tfrac{1}{2}at^2: \quad \tfrac{1}{2}(1.8)(1.0)^2 = 0.90\ \text{m}, \quad \tfrac{1}{2}(1.8)(2.0)^2 = 3.6\ \text{m}, \quad \tfrac{1}{2}(1.8)(3.0)^2 = 8.1\ \text{m}$$

Doubling the time multiplies the distance by 4; tripling it multiplies it by 9.

ANSWER $0.90\ \text{m},\ 3.6\ \text{m},\ 8.1\ \text{m}$

PROBLEM 19

The Detonator ride

Average acceleration · Unit conversion

Watch the video

On the Detonator ride, passengers accelerate straight downward from rest to 45 mi/h in 2.2 s. What is their average acceleration?

GIVEN $v_f = 45\ \text{mi/h} = 20.1\ \text{m/s}$ $\Delta t = 2.2\ \text{s}$ **FIND** a_{av}

SOLUTION

$$a_{av} = \frac{20.1 - 0}{2.2} = 9.14\ \text{m/s}^2\ \text{downward}$$

ANSWER $9.1\ \text{m/s}^2\ \text{down}$

PROBLEM 20

Two cars on a highway

Equations of motion · Meeting time

Watch the video

At t = 0, car 1 passes mile marker 0 heading east at 20.0 m/s and speeding up at 2.5 m/s^2. At the same time, car 2 is 1.0 km east of marker 0 heading west at 30.0 m/s and slowing down at 3.2 m/s^2. (a) Write x–t equations for both cars (east positive). (b) When do the cars pass each other?

GIVEN $x_{01} = 0,\ v_{01} = +20.0,\ a_1 = +2.5$ $x_{02} = 1000\ \text{m},\ v_{02} = -30.0,\ a_2 = +3.2$ **FIND** $x(t),\ t$

SOLUTION

(a) Car 2 moves west (–) but slows down, so its acceleration is +.

$$x_1 = 20t + 1.25t^2, \qquad x_2 = 1000 - 30t + 1.6t^2$$

(b) Set $x_1 = x_2$:

$$0.35t^2 - 50t + 1000 = 0 \rightarrow t = \frac{50 - \sqrt{50^2 - 4(0.35)(1000)}}{2(0.35)} = 23.9\ \text{s}$$

The other root (119 s) is rejected — the cars meet the first time at 23.9 s. Note: the equations assume car 2 keeps the same acceleration (as stated in the problem); a real car would stop after 30/3.2 = 9.4 s.

ANSWER **(b)** $t \approx 24\ \text{s}$

PROBLEM 21

A rocket blasting off

Constant acceleration

Watch the video

A rocket moves straight upward from rest with constant acceleration. After 3.0 s it is at a height of 77 m. (a) What are the magnitude and direction of its acceleration? (b) What is its speed at this time?

GIVEN $v_i = 0 \quad t = 3.0\ \text{s} \quad \Delta y = 77\ \text{m}$ FIND $a,\ v$

SOLUTION

(a)

$$\Delta y = \tfrac{1}{2}at^2 \rightarrow a = \frac{2(77)}{(3.0)^2} = 17.1\ \text{m/s}^2\ \text{upward}$$

(b)

$$v = at = (17.1)(3.0) = 51.3\ \text{m/s}$$

ANSWER **(a)** $17\ \text{m/s}^2$ up **(b)** $51\ \text{m/s}$

PROBLEM 22

A lava bomb

Free fall Direction of velocity

Watch the video

A volcano launches a lava bomb straight upward at 28 m/s. Taking upward as positive, find the speed and direction of motion of the lava bomb (a) 2.0 s and (b) 3.0 s after it is launched.

GIVEN $v_0 = +28\ \text{m/s} \quad a = -9.81\ \text{m/s}^2$ FIND v

SOLUTION

(a)

$$v = 28 + (-9.81)(2.0) = +8.38\ \text{m/s}$$

(b)

$$v = 28 + (-9.81)(3.0) = -1.43\ \text{m/s}$$

Positive → still rising; negative → already falling back down.

ANSWER **(a)** $8.4\ \text{m/s}$ up **(b)** $1.4\ \text{m/s}$ down

PROBLEM 23

A volcano on Io

Free fall · Maximum height

Watch the video

A volcano on Io (a moon of Jupiter) ejects material to a height of about 2.00×10^5 m. The acceleration of gravity on Io is 1.80 m/s^2. Find the initial speed of the ejected material.

GIVEN $h = 2.00 \times 10^5\ \text{m}$ $g_{Io} = 1.80\ \text{m/s}^2$ $v_{top} = 0$ **FIND** v_0

SOLUTION

$$0 = v_0^2 - 2g_{Io}h \rightarrow v_0 = \sqrt{2(1.80)(2.00 \times 10^5)} = 849\ \text{m/s}$$

ANSWER $849\ \text{m/s}$

PROBLEM 24

Bill and Ted on the diving boards

Equations of motion · Free fall

Watch the video

Bill steps off a 3.0-m-high diving board and drops to the water. At the same time, Ted jumps upward at 4.2 m/s from a 1.0-m-high board. With the origin at the water's surface and upward positive, write y-versus-t equations of motion for Bill and Ted.

GIVEN $y_{0,Bill} = 3.0\ \text{m},\ v_0 = 0$ $y_{0,Ted} = 1.0\ \text{m},\ v_0 = +4.2\ \text{m/s}$ $a = -9.81\ \text{m/s}^2$ **FIND** $y(t)$

SOLUTION

Use $y = y_0 + v_0t - \tfrac{1}{2}gt^2$ with the origin at the water:

$$y_{Bill} = 3.0 - 4.91t^2, \qquad y_{Ted} = 1.0 + 4.2t - 4.91t^2 \quad (\text{y in m, t in s})$$

Check: at t = 0, Bill is at y = 3.0 m and Ted at y = 1.0 m; each reaches the water when y = 0.

ANSWER $y_B = 3.0 - 4.91t^2,\ y_T = 1.0 + 4.2t - 4.91t^2$

PROBLEM 25

An angry basketball player

Free fall | Symmetry of flight

Watch the video

A basketball player throws the ball straight down to the floor. The ball bounces straight up and returns to the floor 2.8 s after first striking it. What was the ball's greatest height above the floor?

GIVEN $t_{up+down} = 2.8\ \text{s}$ $t_{up} = 1.4\ \text{s}$ **FIND** h_{max}

SOLUTION

The time up equals the time down, so the ball falls from the top for 1.4 s:

$$h_{max} = \tfrac{1}{2}gt^2 = \tfrac{1}{2}(9.81)(1.4)^2 = 9.6\ \text{m}$$

ANSWER $9.6\ \text{m}$

ALNOJOUM ACADEMY

Answer summary

Problem	Topic	Key physics idea	Final answer(s)
1	Walking to the library, the park and back	Distance ≠ displacement	**(a)** $1.95\ \text{mi},\ +0.75\ \text{mi}$ **(b)** $2.65\ \text{mi},\ -0.75\ \text{mi}$
2	Olympic 200-m dash	Average speed + units	$10.1\ \text{m/s} = 22.7\ \text{mi/h}$
3	A hopping kangaroo	d = vt	**(a)** $3.47\ \text{km}$ **(b)** $13.8\ \text{s}$
4	Radio signal to the Moon and back	Round trip: 2d	$2.56\ \text{s}$
5	A finch riding a tortoise	Total distance / total time	$6.0\ \text{m/s}$
6	An expectant father pacing	Velocity = slope of x–t	**(a–d)** $+,\ 0,\ +,\ -$ **(e–h)** $2,\ 0,\ 1,\ -1.5\ \text{m/s}$
7	Position given by an equation	Speed ≠ |velocity| when direction changes	**(b)** $-2\ \text{m/s}$ **(c)** $2.17\ \text{m/s}$
8	A 747 taking off	a = Δv/Δt	$2.20\ \text{m/s}^2$
9	A sprinter at the starting gun	Acceleration stops → constant v	**(a)** $3.8\ \text{m/s}$ **(b)** $9.9\ \text{m/s}$
10	A jet landing (stops in 13.0 s)	Sign of a gives direction	$8.85\ \text{m/s}^2$ west
11	Motorcycle v–t graph	Acceleration = slope of v–t	$2.0,\ 0,\ -0.50\ \text{m/s}^2$
12	A horse slowing down	v = v₀ + at	$2.49\ \text{s}$
13	A train leaving the station	v = v₀ + at	$10.3\ \text{m/s}$
14	Finding the initial velocity	v₀ = v − at	$+7.44\ \text{m/s}$
15	A jet landing (stops in 949 m)	v² = v₀² + 2aΔx	$3.53\ \text{m/s}^2$ north
16	Braking at a red light	v_av = (v₀ + v)/2	**(a)** $6.0\ \text{m/s}$ west **(b)** $5.8\ \text{s}$
17	A boat speeding up	Δx = v_av·t	**(a)** $2.06\ \text{m/s}$ **(b)** $9.83\ \text{m}$
18	Sliding down on a toboggan	Δx = ½at²	$0.90\ \text{m},\ 3.6\ \text{m},\ 8.1\ \text{m}$
19	The Detonator ride	a = Δv/Δt	$9.1\ \text{m/s}^2$ down
20	Two cars on a highway	Set x₁ = x₂	**(b)** $t \approx 24\ \text{s}$
21	A rocket blasting off	Δy = ½at²	**(a)** $17\ \text{m/s}^2$ up **(b)** $51\ \text{m/s}$
22	A lava bomb	Free fall: a = −g	**(a)** $8.4\ \text{m/s}$ up **(b)** $1.4\ \text{m/s}$ down
23	A volcano on Io	v² = v₀² − 2gh	$849\ \text{m/s}$
24	Bill and Ted on the diving boards	y = y₀ + v₀t − ½gt²	$y_B = 3.0 - 4.91t^2,\ y_T = 1.0 + 4.2t - 4.91t^2$
25	An angry basketball player	t_up = t_down	$9.6\ \text{m}$

g = 9.81 m/s² is used throughout. Answers are rounded to the significant figures given in each problem.