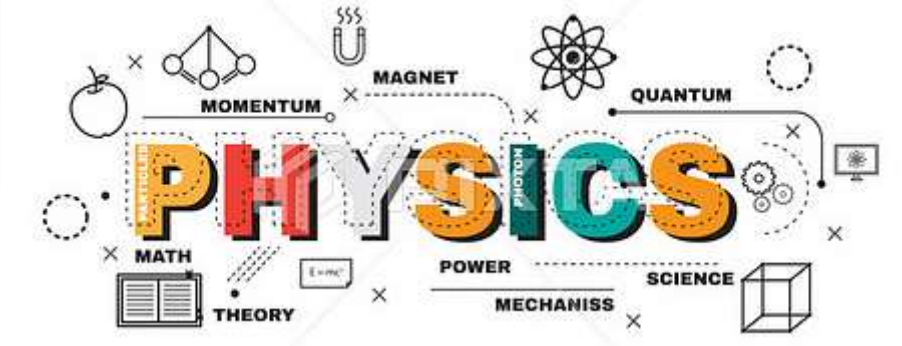


CHAPTER [2]

Motion Along a Straight Line

[PHYS 101] · General Physics I

Kuwait University

PREPARED BY

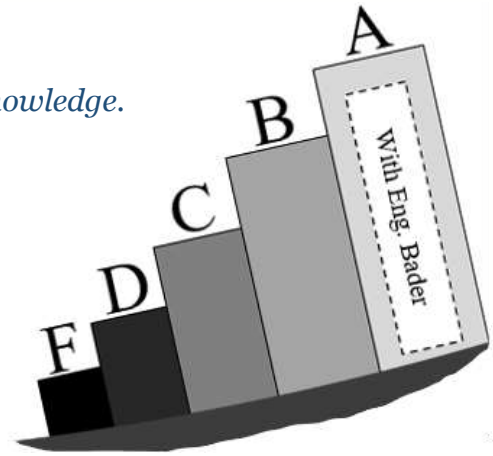
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> *Imagination is more important than knowledge.*
>
> — Albert Einstein





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1) The Four Key Quantities (unit)

Quantity	Symbol (unit)	Meaning
Position	x (m)	Location of the object on the x-axis
Displacement	Δx (m)	$\Delta x = x_f - x_i$
Velocity	v (m/s)	Rate of change of position with time
Acceleration	a (m/s²)	Rate of change of velocity with time

2) Displacement (Δx) and Distance (D) (unit = m)

$\Delta x = x_f - x_i$

The distance (D) = the length of the path traveled by the object from xi to x_f.

- **Displacement (Δx):** positive → motion to the right ($x_f > x_i$) | zero → object did not move, or moved and returned | negative → motion to the left (xf < xi).
- **Distance (D):** positive → the object moved | zero → the object did not move.

3) Average x-Velocity (v_{av-x}) and Average Speed (v_{av}) (unit = m/s)

$v_{av-x} = \Delta x / \Delta t \qquad v_{av} = D / \Delta t$

- **v_{av-x}:** positive (Δx > 0) → motion to the right | zero (Δx = 0) → no net motion | negative (Δx < 0) → motion to the left.
- **v_{av}:** positive → the object moved | zero → the object did not move.

4) Instantaneous x-Velocity (v_x) and Instantaneous Speed (v) (unit = m/s)

$v_x = dx/dt \qquad v = |v_x| = |dx/dt|$

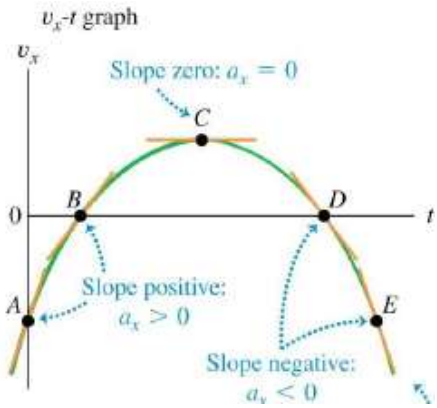
- **v_x:** positive → moving right at this instant | zero → at rest at this instant | negative → moving left at this instant.
- *NOTE: when the object changes its direction of motion along the x-axis, then at this instant $v_x = 0$.*

5) Average Acceleration (aav−x) and Instantaneous Acceleration (ax) (unit = m/s²)

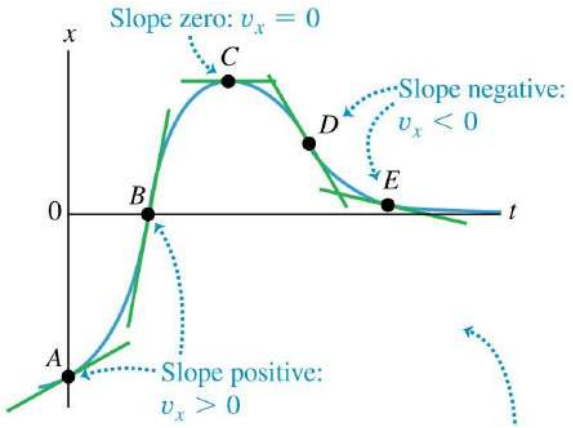
$a_{av} = \Delta v/\Delta t = (v_f - v_i) / (t2 - t1) \qquad a = dv/dt = d^2x/dt^2$

- **Positive x-acceleration:** moving right and speeding up, or moving left and slowing down.
- **Negative x-acceleration:** moving right and slowing down, or moving left and speeding up.
- If the object is speeding up, the sign of a is the same as the sign of v.
- If the object is slowing down, the sign of a is opposite to the sign of v.

6) Reading x–t and v_x–t Graphs



- **On an x–t graph:** the slope of the tangent at any point = the instantaneous x-velocity at that point. Steeper slope → greater speed. Slope = 0 → $v_x = 0$ (turning point).
- **On a v_x–t graph:** the slope of the tangent at any point = the instantaneous acceleration at that point. Steeper slope → greater acceleration. Slope = 0 → $a_x = 0$.
- **Area under a v_x–t graph** between two times = the displacement Δx during that interval.



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7) Motion with Constant Acceleration (a = constant)

Equation of Motion	t	xf	vxf	ax
$v_f = v_i + at$	✓	—	✓	✓
$x_f = x_i + v_i t + ½ at^2$ $(\Delta x = v_i t + ½ at^2)$	✓	✓	—	✓
$v_f^2 = v_i^2 + 2a(\Delta x)$	—	✓	✓	✓
$\Delta x = ½ (v_i + v_f)\, t$	✓	✓	✓	—

8) Freely Falling Bodies

$a_y = -g = -9.8\ m/s^2 \approx -10\ m/s^2$ $\quad (g = 9.8\ m/s^2 \approx 10\ m/s^2)$

- *Constant acceleration acting downward, whether the object is rising, falling, or momentarily at rest at the top.*

$v_{yf} = v_{yi} - g\,t$

$y_f = y_i + v_{yi}\,t - ½\,g\,t^2$ $\quad (\Delta y = v_{yi}\,t - ½\,g\,t^2)$

$v_{yf}^2 = v_{yi}^2 - 2\,g\,\Delta y$

$\Delta y = ½\,(v_{yi} + v_{yf})\,t$

9) Quick Reference — Sign Convention

- Take up / right as positive unless the problem states otherwise.
- At the highest point of a vertical throw: $v_y = 0$, but $a_y = -g \neq 0$ (acceleration never vanishes in free fall).
- Speed = $|v|$, always ≥ 0; velocity carries a sign that shows direction.

10) Worked-Example Checklist

- Choose and label the positive direction (up/right) before writing any equation.
- List the known quantities (t, x or y, v_{xi} or v_{yi}, v_{xf} or v_{yf}, a) and identify the unknown.
- Pick the equation of motion that contains exactly the known and unknown quantities (see the table in Section 7).
- For vertical motion, set $a_y = -g$ (or $-9.8\ m/s^2$, or $-10\ m/s^2$ as instructed) and reuse the same four equations with y instead of x.
- Check the sign of the final answer against the physical situation (e.g., a falling object should have negative Δy if down is negative).

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Ch2: Motion Along a Straight Line

Slides Questions Chapter 2

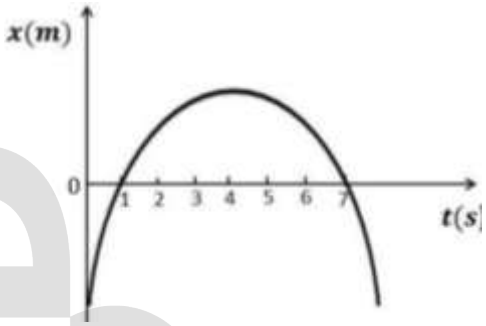
Q1: A dragster starts at position $x_i = 15$ m at time $t_i = 1.0$ s and reaches position $x_f = 260$ m at time $t_f = 4.0$ s. (a) Find the displacement Δx of the dragster. (b) Find its average x-velocity v_{av-x} during this interval.

Q2: The position of a particle moving along the x-axis is given by $x(t) = (18 + 20t - 5t^2)$, where x is in m and t is in s. What is the average velocity during the time interval $t = 1$ s to $t = 3$ s?

Q3: A particle moving along the x-axis has a position given by $x = (30t - 3t^3)$ m, where t is in s. What is the acceleration (in m/s^2) at the moment the particle changes its direction?

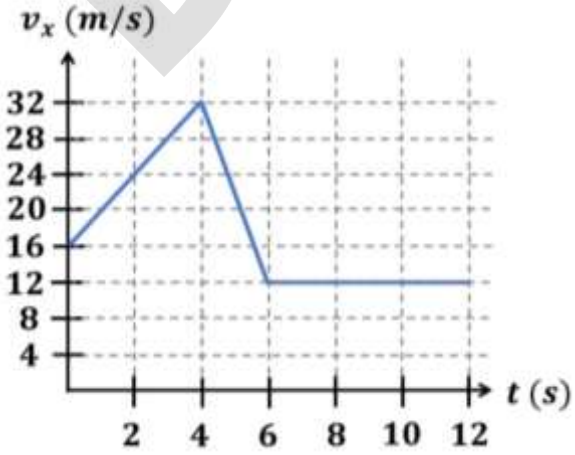
Q4: The figure below describes the position of an object moving along the x-axis as a function of time. Which one of the following statements is correct at $t = 1$ s?

(a) The velocity of the object is zero.
(b) The acceleration of the object is zero.
(c) The velocity of the object is positive.
(d) The acceleration of the object is positive.



Q5: An object is moving along the x-axis. Its velocity changes with time as shown in the v_x–t graph below.

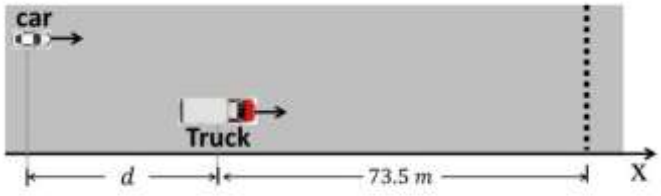
(a) What is the initial velocity of the object (at t=0s)
(b) Find the average acceleration between $t = 4$ s and $t = 6$ s.
(c) Find the acceleration at $t = 8$ s.
(d) Find the distance covered by the object in the interval from $t = 0$ s to $t = 4$ s.



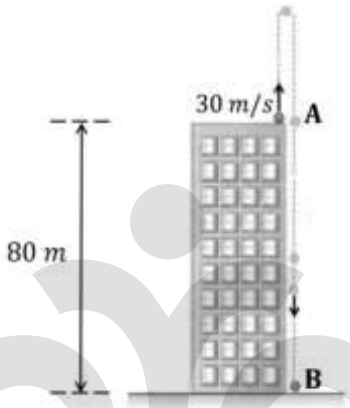
Q6: An object speeding up with constant acceleration covers the distance between two points 84 m apart in 7.0 s. Its velocity as it passes the second point is 16 m/s. What are (a) its velocity at the first point and (b) its acceleration?

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Q7: A car and a truck start from rest at the same instant, with the car initially at distance *d* behind the truck, as shown. The truck has a constant acceleration of 3 m/s^2, and the car has an acceleration of 4 m/s^2. The car overtakes the truck after the truck has moved 73.5 m. Find the initial distance (*d*) between the truck and the car.



Q8: A stone is thrown vertically upward from point A at the top of a building 80 m high, as shown. Its initial speed is 30 m/s. Find:



(a) The total time it takes to reach the ground (point B).
(b) The velocity just before it hits the ground.
(c) The average velocity.

Q9: A duck swims with a constant speed of 2 m/s toward a bridge. The bridge is 45 m above the water. A stone is released from rest from the bridge and hits the duck.



(a) How far was the duck when the stone was released?
(b) Calculate the speed of the stone just before it touches the duck.

Q10: A ball is dropped from rest from the top of a building. If the total time it takes to reach the ground is 5.0 seconds, find (a) the height of the building and (b) the average speed of the ball from the initial to final point.

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Question 1

Dragster: x_i=15 m at t_i=1.0 s; x_f=260 m at t_f=4.0 s. Find (a) ΔX (b) $v_{av\text{-}x}$.

$\Delta X = x_f - x_i = 260 - 15 = 245$ m

$v_{av\text{-}x} = \Delta X / \Delta t = 245 / (4.0 - 1.0) = 245 / 3.0$

✓ **Answer: Δ x = 245 m, $v_{av\text{-}x}$ = 81.7 m/s**

Question 2

$x(t) = 18 + 20t - 5t^2$ (m). Find average velocity from t=1 s to t=3 s.

$x(1) = 18+20(1)-5(1)^2 = 33$ m $x(3) = 18+20(3)-5(3)^2 = 33$ m

$v_{av\text{-}x} = (x(3)-x(1)) / (3-1) = (33-33) / 2$

✓ **Answer: $v_{av\text{-}x}$ = 0 m/s**

Question 3

$x = 30t - 3t^3$ (m). Find the acceleration at the instant the particle changes direction (v=0).

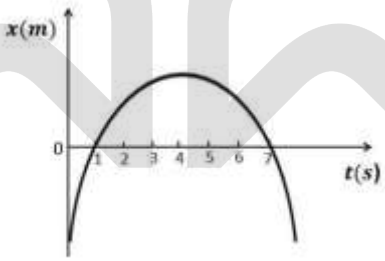
$v = dx/dt = 30 - 9t^2 = 0 \rightarrow t^2 = 30/9 = 3.33 \rightarrow t = 1.83$ s

$a = dv/dt = -18t = -18(1.83)$

✓ **Answer: a = -32.9 m/s²**

Question 4

Which statement is correct at t=1 s? (a) v=0 (b) a=0 (c) v>0 (d) a>0



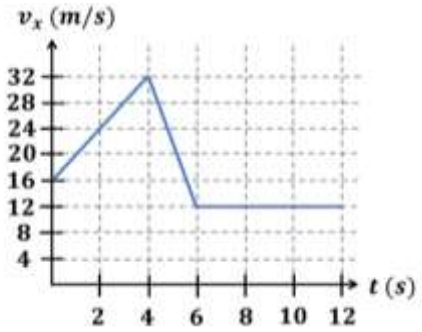
at t=1 s the x-t curve is rising steeply (positive slope) → v > 0

(the curve is concave-down everywhere, so a<0 throughout - not one of the offered options)

✓ **Answer: (c) The velocity of the object is positive.**

Question 5

From the v_x-t graph, find (a) v at t=0 (b) a_avg from t=4 s to t=6 s (c) a at t=8 s (d) distance from t=0 to t=4 s.



(a) v(0) = 16 m/s (read directly from the graph)

(b) $a_{avg} = (v(6) - v(4)) / (6 - 4) = (12 - 32) / 2$

(c) from t=6 s to 12 s, v is constant at 12 m/s → a(8 s) = 0

(d) distance = area under v-t from 0 to 4 s (trapezoid) = (1/2)(16+32)(4)

✓ **Answer: (a) 16 m/s (b) -10 m/s² (c) 0 (d) 96 m**

Question 6

Constant acceleration covers 84 m in 7.0 s; velocity at the 2nd point is 16 m/s. Find (a) velocity at the 1st point (b) acceleration.

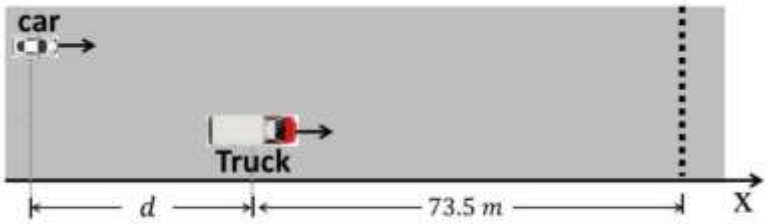
$\Delta X = (1/2)(v_1+v_2)\, t$ → $84 = (1/2)(v1+16)(7.0)$ → $v_1+16 = 84/3.5 = 24.0$

$a = (v_2 - v_1) / t = (16 - 8.0) / 7.0$

✓ **Answer: v1 = 8.0 m/s, a = 1.14 m/s²**

Question 7

Car and truck start from rest together; car is distance d behind truck. a_{truck}=3 m/s², a_{car}=4 m/s². Car overtakes truck after the truck has moved 73.5 m. Find d.



truck: $73.5 = (1/2)(3)t^2$ → $t^2 = 49.0$ → t = 7.0 s

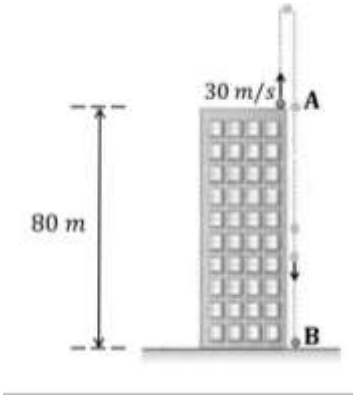
car (from its own start) at t=7.0 s: $x_{car} = (1/2)(4)(7.0)^2 = 98.0$ m

overtaking → $x_{car} - d = x_{truck}$ → $d = 98.0 - 73.5$

✓ **Answer: d = 24.5 m**

Question 8

Stone thrown up from A (80 m building), v_0=30 m/s. Find (a) total time to reach B (b) velocity just before landing (c) average velocity.



(up positive, g=10 m/s²): $y = v_0 t - (1/2)g t^2 \rightarrow -80 = 30t - 5t^2$

$5t^2 - 30t - 80 = 0 \rightarrow t^2 - 6t - 16 = 0 \rightarrow t = [6+\sqrt{(6^2+4(16))}] / 2 = [6+10]/2$

(b) v = v0 − gt = 30 − 10(8.0) = -50 m/s (downward)

(c) v_avg = Δ y / Δ t = (− 80) / 8.0

✓ **Answer: (a) t = 8.0 s (b) v = 50 m/s downward (c) v_{avg} = 10 m/s downward**

Question 9

Duck swims at constant 2 m/s toward a bridge 45 m above the water. A stone is dropped from rest and hits the duck. Find (a) initial distance of duck from the point below the bridge (b) speed of stone just before impact.



fall time (g=10 m/s²): $45 = (1/2)(10)t^2 \rightarrow t^2 = 9.0 \rightarrow t = 3.0$ s

(a) distance = $v_{duck} \times t = 2 \times 3.0$

(b) $v = g t = 10 \times 3.0$ (check: $v=\sqrt{(2 \times 10 \times 45)}$)

✓ **Answer: (a) 6.0 m (b) 30 m/s**

Question 10

Ball dropped from rest; total fall time = 5.0 s. Find (a) height of building (b) average speed.

(a) $h = (1/2)g t^2 = (1/2)(10)(5.0)^2$

(b) $v_{avg} = h / t = 125 / 5.0$

✓ **Answer: (a) h = 125 m (b) v_avg = 25 m/s**

--- End of solutions ---

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Ch2: Motion Along a Straight Line

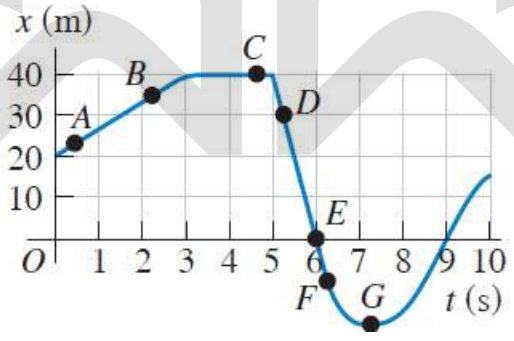
Book Questions Chapter 2
Exercises

2.1: A car travels in the +x-direction on a straight and level road. For the first 4.00 s of its motion, the average velocity of the car is v_{av-x} = 6.25 m/s. How far does the car travel in 4.00 s?

2.6: A Honda Civic travels in a straight line along a road. The car's distance x from a stop sign is given as a function of time t by the equation $x(t) = at^2 - bt^3$, where a = 1.50 m/s^2 and b = 0.0500 m/s^3. Calculate the average velocity of the car for each time interval: (a) t = 0 to t = 2.00 s; (b) t = 0 to t = 4.00 s; (c) t = 2.00 s to t = 4.00 s.

2.8: CALC A bird is flying due east. Its distance from a tall building is given by $x(t) = 28.0\text{ m} + (12.4\text{ m/s})t - (0.0450\text{ m/s}^3)t^3$. What is the instantaneous velocity of the bird when t = 8.00 s?

2.11: A test car travels in a straight line along the x-axis. The graph in Fig. E2.11 (see textbook) shows the car's position x as a function of time. Find its instantaneous velocity at points A through G.



2.14: CALC A race car starts from rest and travels east along a straight and level track. For the first 5.0 s of the car's motion, the eastward component of the car's velocity is given by $v_x(t) = (0.860\text{ m/s}^3)t^2$. What is the acceleration of the car when v_x = 12.0 m/s?

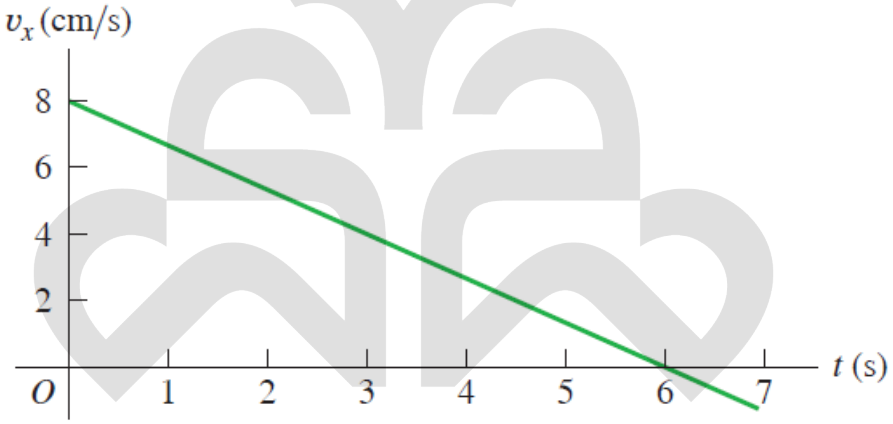
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2.17: CALC The position of the front bumper of a test car under microprocessor control is given by $x(t) = 2.17\ m + (4.80\ m/s^2)t^2 - (0.100\ m/s^6)t^6$. (a) Find its position and acceleration at the instants when the car has zero velocity. (b) Draw *x*-*t*, *vx*−*t*, and *ax*−*t* graphs for the motion of the bumper between $t = 0$ and $t = 2.00$ s.

2.21: A Fast Pitch. The fastest measured pitched baseball left the pitcher's hand at a speed of 45.0 m/s. If the pitcher was in contact with the ball over a distance of 1.50 m and produced constant acceleration, (a) what acceleration did he give the ball, and (b) how much time did it take him to pitch it?

2.26: A cat walks in a straight line, which we shall call the x-axis, with the positive direction to the right. As an observant physicist, you make measurements of this cat's motion and construct a graph of the feline's velocity as a function of time (Fig. E2.26, see textbook). (a) Find the cat's velocity at $t = 4.0$ s and at $t = 7.0$ s. (b) What is the cat's acceleration at $t = 3.0$ s? At $t = 6.0$ s? At $t = 7.0$ s? (c) What distance does the cat move during the first 4.5 s? From $t = 0$ to $t = 7.0$ s? (d) Assuming that the cat started at the origin, sketch clear graphs of the cat's acceleration and position as functions of time.

Figure E2.26



2.44: An egg is thrown nearly vertically upward from a point near the cornice of a tall building. The egg just misses the cornice on the way down and passes a point 30.0 m below its starting point 5.00 s after it leaves the thrower's hand. Ignore air resistance. (a) What is the initial speed of the egg? (b) How high does it rise above its starting point? (c) What is the magnitude of its velocity at the highest point? (d) What are the magnitude and direction of its acceleration at the highest point? (e) Sketch a_y−*t*, v_y−*t*, and *y*-*t* graphs for the motion of the egg.

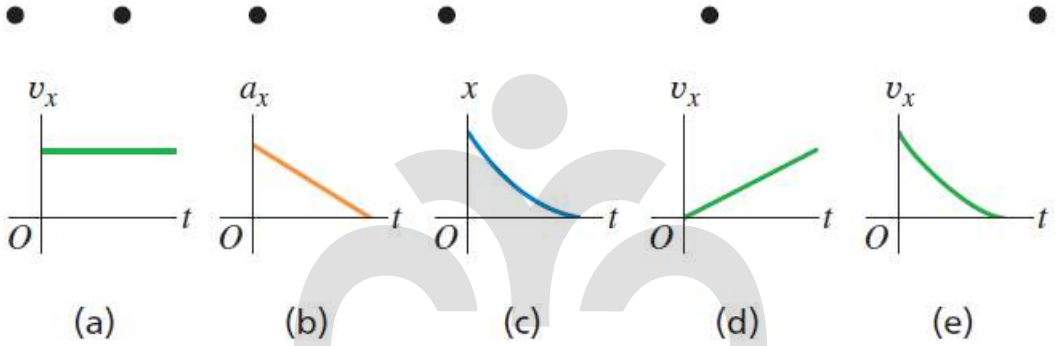
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2.83: CALC Cars A and B travel in a straight line. The distance of A from the starting point is given as a function of time by $x_A(t) = at + bt^2$, with $a = 2.60$ m/s and $b = 1.20$ m/s^2. The distance of B from the starting point is $x_B(t) = \gamma t^2 - \delta t^3$, with $\gamma = 2.80$ m/s^2 and $\delta = 0.20$ m/s^3. (a) Which car is ahead just after the two cars leave the starting point? (b) At what time(s) are the cars at the same point? (c) At what time(s) is the distance from A to B neither increasing nor decreasing? (d) At what time(s) do A and B have the same acceleration?

Questions

Q2.2: The black dots at the top of Fig. Q2.2 represent a series of high-speed photographs of an insect flying in a straight line from left to right (in the positive *x*-direction). Which of the graphs in Fig. Q2.2 most plausibly depicts this insect's motion?

Figure Q2.2



Q2.3: Can an object with constant acceleration reverse its direction of travel? Can it reverse its direction twice? In both cases, explain your reasoning.

Q2.6: Under what conditions does the magnitude of the average velocity equal the average speed?

Q2.10: Can you have zero acceleration and nonzero velocity? Use a $v_x - t$ graph to explain.

Q2.17: A dripping water faucet steadily releases drops 1.0 s apart. As these drops fall, does the distance between them increase, decrease, or remain the same? Prove your answer.

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Exercises

2.1

$v_{av\text{-}x}$ = 6.25 m/s for the first 4.00 s. How far does the car travel?

$\Delta X = v_{av\text{-}x} \times \Delta t = 6.25 \times 4.00$

✓ **Answer: ΔX = 25.0 m**

2.6

$x(t) = at^2 - bt^3$, a=1.50 m/s², b=0.0500 m/s³. Find $v_{av\text{-}x}$ for (a) 0-2.00 s (b) 0-4.00 s (c) 2.00-4.00 s.

x(0)=0 x(2.00) = 1.50(4.00)− 0.0500(8.00) = 5.60 m x(4.00) = 1.50(16.0)− 0.0500(64.0) = 20.80 m

(a) $v_{av\text{-}x}$ = (5.60− 0)/(2.00− 0)

(b) $v_{av\text{-}x}$ = (20.80− 0)/(4.00− 0)

(c) $v_{av\text{-}x}$ = (20.80− 5.60)/(4.00− 2.00)

✓ **Answer: (a) 2.80 m/s (b) 5.20 m/s (c) 7.60 m/s**

2.8

$x(t) = 28.0 + 12.4t - 0.0450t^3$ (m). Find v at t=8.00 s.

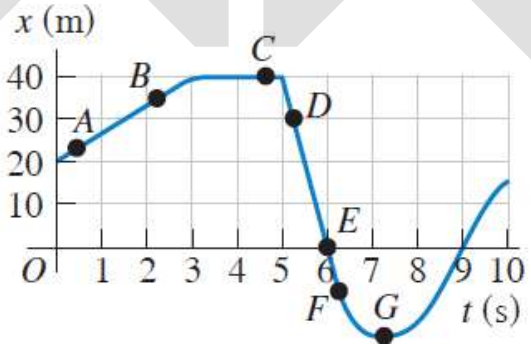
$v(t) = dx/dt = 12.4 - 0.135t^2$

$v(8.00) = 12.4 - 0.135(64.0)$

✓ **Answer: v = 3.76 m/s**

2.11

Using Fig. E2.11, find the instantaneous velocity (slope of the x-t curve) at points A through G.



v = slope of the tangent line to the x-t curve at each point (values estimated from the graph):

A ≈ +6.67 m/s B ≈ +6.67 m/s C ≈ 0 D ≈ -40 m/s

E ≈ -40 m/s (steepest drop) F ≈ -40 m/s G ≈ 0 (local minimum)

✓ **Answer: v_A=6.67, v_B=6.67, v_C=0, v_D=-40, v_E=-40, v_F=-40, vG=0 (m/s, approximate, read from the graph)**

2.14

$v_x(t) = (0.860\ m/s^3)t^2$. Find the acceleration when vx = 12.0 m/s.

$12.0 = 0.860t^2 \rightarrow t = \sqrt{(12.0/0.860)} = 3.74$ s

$a(t) = dv_x/dt = 1.72t \rightarrow a = 1.72(3.74)$

✓ **Answer: a = 6.42 m/s^2**

2.17

$x(t) = 2.17 + 4.80t^2 - 0.100t^6$ (m).

Find (a) position and acceleration when v=0. (b) x-t, vx-t, ax-t equations for 0-2.00 s.

$v(t) = dx/dt = 9.60t - 0.600t^5 = 0 \rightarrow t(9.60 - 0.600t^4)=0 \rightarrow t=0$ or $t^4=16.0 \rightarrow t=2.00$ s

$a(t) = dv/dt = 9.60 - 3.00t^4$

at t=0: x=2.17 m, $a=9.60\ m/s^2$

at t=2.00 s: $x = 2.17+4.80(4.00)- 0.100(64.0) = 14.97$ m, $a = 9.60- 3.00(16.0) = -38.4\ m/s^2$

(b) plot x(t), $v(t)=9.60t-0.600t^5$, $a(t)=9.60-3.00t^4$ for 0<=t<=2.00 s

✓ **Answer: t=0: x=2.17 m, $a=9.60\ m/s^2$. t=2.00 s: x=14.97 m, $a=-38.4\ m/s^2$**

2.21

Ball leaves the hand at 45.0 m/s after 1.50 m of constant acceleration, starting from rest. Find (a) a (b) time.

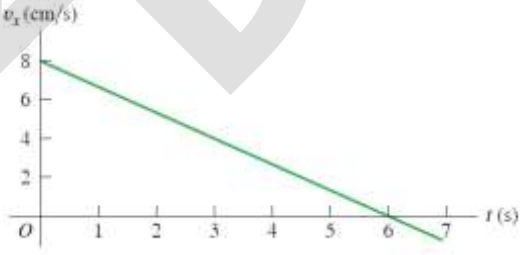
(a) $v^2 = v_0^2 + 2a\Delta X \rightarrow 45.0^2 = 0 + 2a(1.50) \rightarrow a = 2025/3.00$

(b) $v = v_0+at \rightarrow 45.0 = 675t \rightarrow t = 45.0/675$

✓ **Answer: $a = 675\ m/s^2$, t = 0.0667 s**

2.26

Figure E2.26



From Fig. E2.26 (vx-t line, 8 cm/s at t=0 to 0 at t=6s),

find (a) v at t=4.0 s, 7.0 s

(b) a at t=3.0, 6.0, 7.0 s

(c) distance in first 4.5 s, and 0-7.0 s.

line: $v_x(t) = 8 - (4/3)t$ (cm/s) (slope = (0− 8)/(6− 0) = -4/3 cm/s^2, constant for the whole line)

(a) v(4.0) = 8− (4/3)(4.0) = 2.67 cm/s v(7.0) = 8− (4/3)(7.0) = -1.33 cm/s

(b) straight line → $a = -4/3 = -1.33\ cm/s^2$ at all three times (3.0, 6.0, 7.0 s)

(c) 0-4.5 s (v always positive): distance = (1/2)(8+2)(4.5) = 22.5 cm

0-7.0 s: 0-6 s gives (1/2)(8)(6)=24 cm; 6-7 s gives (1/2)(1.33)(1)=0.67 cm (opposite direction) → total = 24+0.67

✓ **Answer: (a) 2.67, -1.33 cm/s (b) -1.33 cm/s^2 (all three) (c) 22.5 cm; 24.7 cm total distance**

2.44

Egg thrown up; 5.00 s later it passes a point 30.0 m below its start. Find (a) v0 (b) max height (c) v at highest point (d) a at highest point.

(up positive, g=10 m/s²): $-30.0 = v_0(5.00) - (1/2)(10)(5.00)^2 = 5.00v0 - 125$

$5.00v_0 = -30.0+125 = 95.0 \rightarrow v_0 = 95.0/5.00$

(b) $0 = v_0^2 - 2gh \rightarrow h = v_0^2/(2g) = 19.0^2/20$

(c) at the highest point v=0 (by definition)

(d) $a = -g = -10$ m/s² (gravity is unchanged, even at the top)

✓ **Answer: (a) v_0=19.0 m/s (b) h=18.1 m (c) v=0 (d) a=-10 m/s^2 (downward)**

2.83

$x_A(t)=at+bt^2$ (a=2.60 m/s, b=1.20 m/s²); $x_B(t)=\gamma t^2 - \delta t^3$ (γ=2.80 m/s², δ=0.20 m/s³). Find (a) which car leads just after t=0 (b) when they meet (c) when their separation is momentarily constant (d) when their accelerations are equal.

(a) $v_A(0) = a = 2.60$ m/s, $v_B(0) = 0 \rightarrow$ A pulls ahead immediately (nonzero initial velocity vs. zero)

(b) $x_A=x_B$: $2.60t+1.20t^2 = 2.80t^2 - 0.20t^3 \rightarrow t(t^2 - 8.00t+13.0)=0$

t=0, or $t = [8.00 \pm \sqrt{(64.0 - 52.0)}]/2 = [8.00 \pm \sqrt{(12.0)}]/2$

(c) same speed ($v_A=v_B$): $2.60+2.40t = 5.60 - 0.60t^2 \rightarrow t^2 - 5.33t+4.33=0 \rightarrow t=[5.33 \pm \sqrt{(11.11)}]/2$

(d) same acceleration: $a_A=2b=2.40$, $aB=2\gamma - 6\delta t = 5.60 - 1.20t \rightarrow 2.40=5.60 - 1.20t$

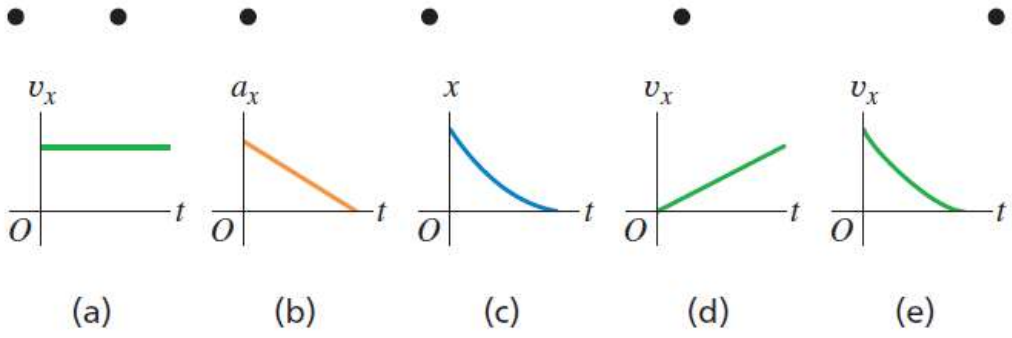
✓ **Answer: (a) A leads (b) t=2.27 s and t=5.73 s (c) t=1.00 s and t=4.33 s (d) t=2.67 s**

Questions

Q2.2

The photo dots show an insect flying in the +x-direction. Which graph in Fig. Q2.2 best depicts its motion?

Figure Q2.2



successive photo dots are spaced farther apart over each equal time interval → the insect covers more distance each interval → it is speeding up (constant positive acceleration)

✓ **Answer: (d) - v_x increases linearly with t**

Q2.3

Can an object with constant acceleration reverse direction? Can it reverse direction twice?

$v(t) = v_0 + at$ is a straight line in t (for constant, nonzero a) → it can cross v=0 at most once

✓ **Answer: Yes, it can reverse direction once (e.g. a ball thrown upward); it cannot reverse twice under one constant acceleration.**

Q2.6

Under what conditions does the magnitude of the average velocity equal the average speed?

$|v_{av\text{-}x}| = |\Delta x| / \Delta t$ average speed = (total distance) / Δ t

✓ **Answer: Only when the object never reverses direction during the interval, so distance = |displacement|.**

Q2.10

Can you have zero acceleration and nonzero velocity?

$a=0 \rightarrow v(t)=v_0=\text{constant} \neq 0$ (a horizontal line on the v_x-t graph, at any nonzero height)

✓ **Answer: Yes - any motion at constant nonzero velocity (a=0).**

Q2.17

Drops fall from a faucet 1.0 s apart. As they fall, does the distance between them increase, decrease, or stay the same?

drop 1 (released at t=0): $y_1 = (1/2)g\,t^2$ drop 2 (released 1.0 s later): $y_2 = (1/2)g(t-1.0)^2$

separation: $\Delta y = y_1 - y_2 = (1/2)g[t^2-(t-1.0)^2] = (1/2)g(2t-1.0) = gt - g/2$

✓ **Answer: Increases - the gap ($\Delta y = gt - g/2$) grows linearly with t, since the earlier drop keeps gaining speed on the later one.**

--- End of solutions ---