Lecture 2

Which figures are significant?

6.37	3 significant digits
16.03	4 significant digits
170.0	4 significant digits
0.00008	1 significant digit
170	At least 2 significant digits
170.	3 significant digits
1.700×10^2	4 significant digits

What is (0.888/0.66) to the proper number of significant figures?

Answer = 1.3~~4545~~

Topic 2: Motion in One Dimension

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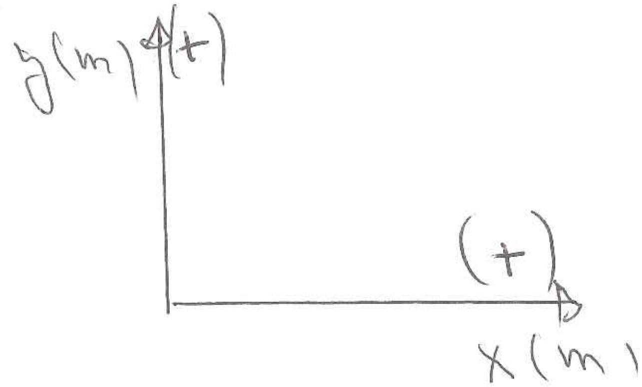
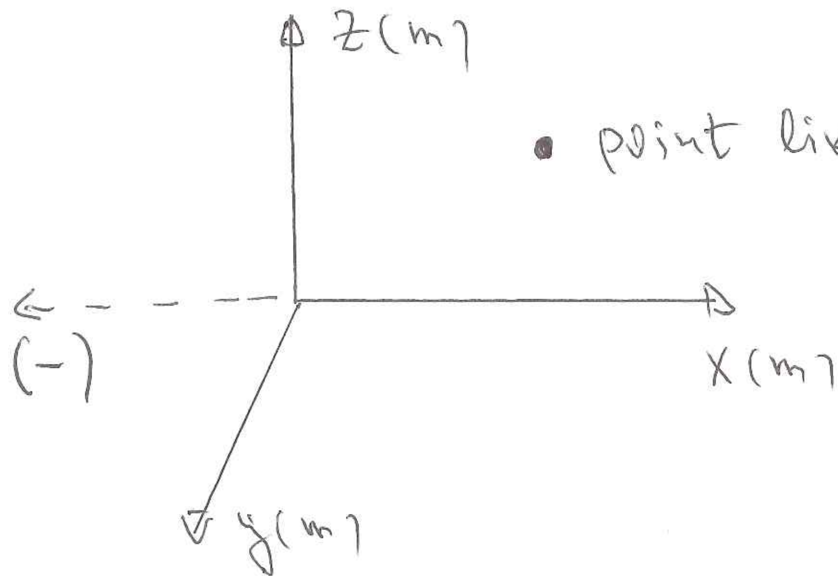
Chapter 2: Motion in One Dimension

- Position and Displacement
- Velocity and Speed
    - Average velocity and average speed
    - Instantaneous velocity and speed
- Acceleration
    - Changes of velocity
    - Instantaneous acceleration
- The Kinematic Equations
- The Free Fall – Gravity

Reference Frames

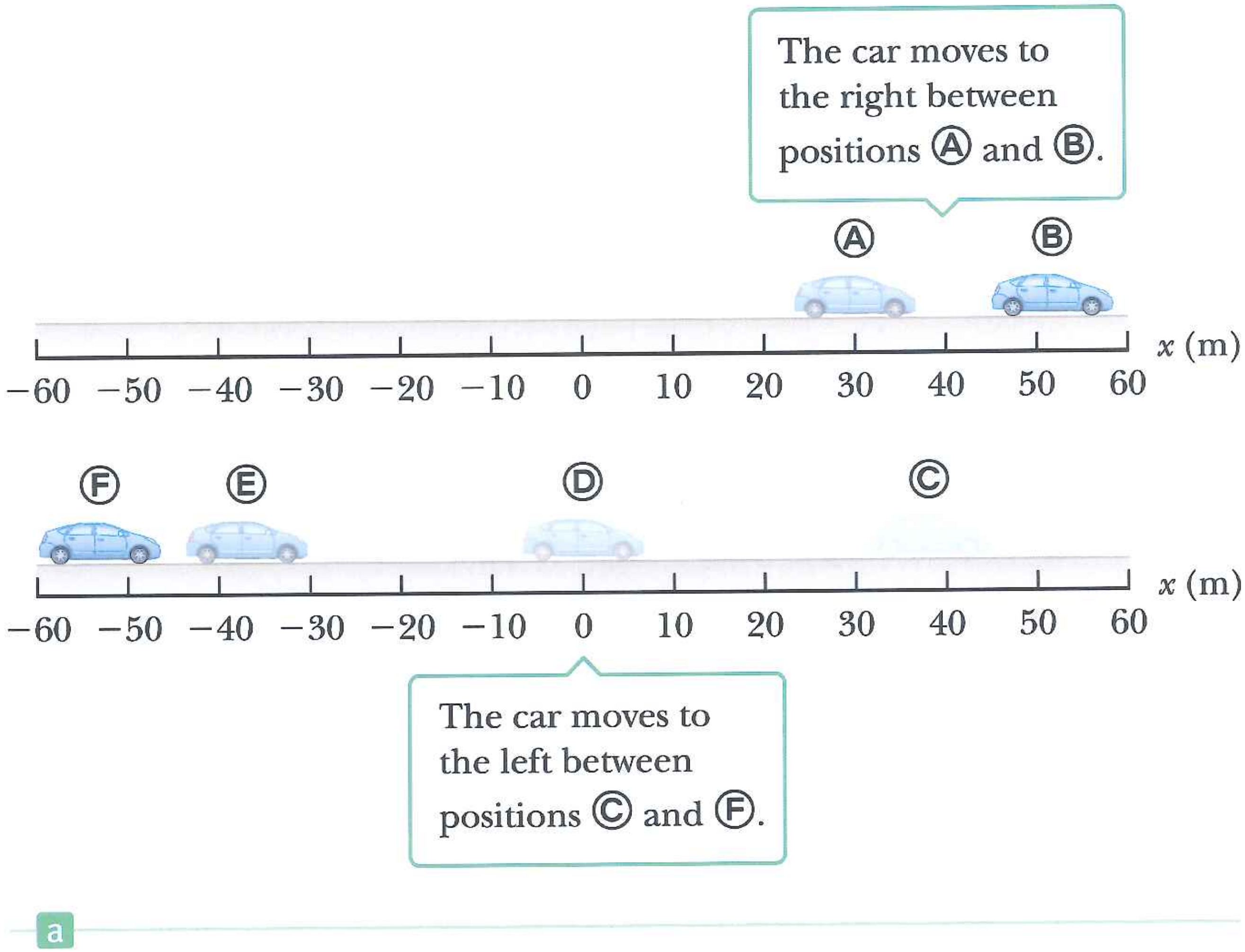


2D



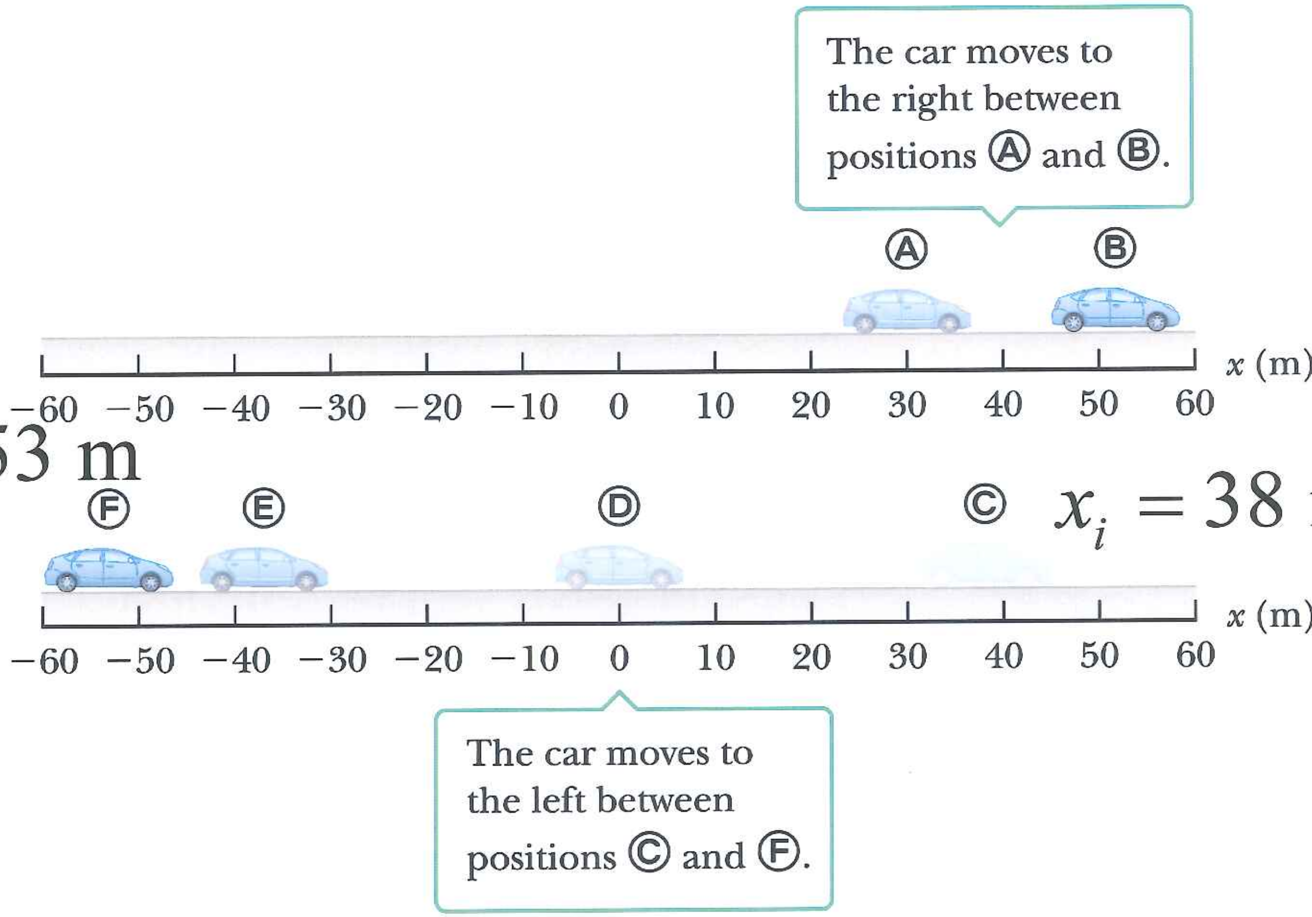
• point like objects

Displacement



$$\Delta x \equiv x_f - x_i \quad \text{SI unit: m}$$

Displacement



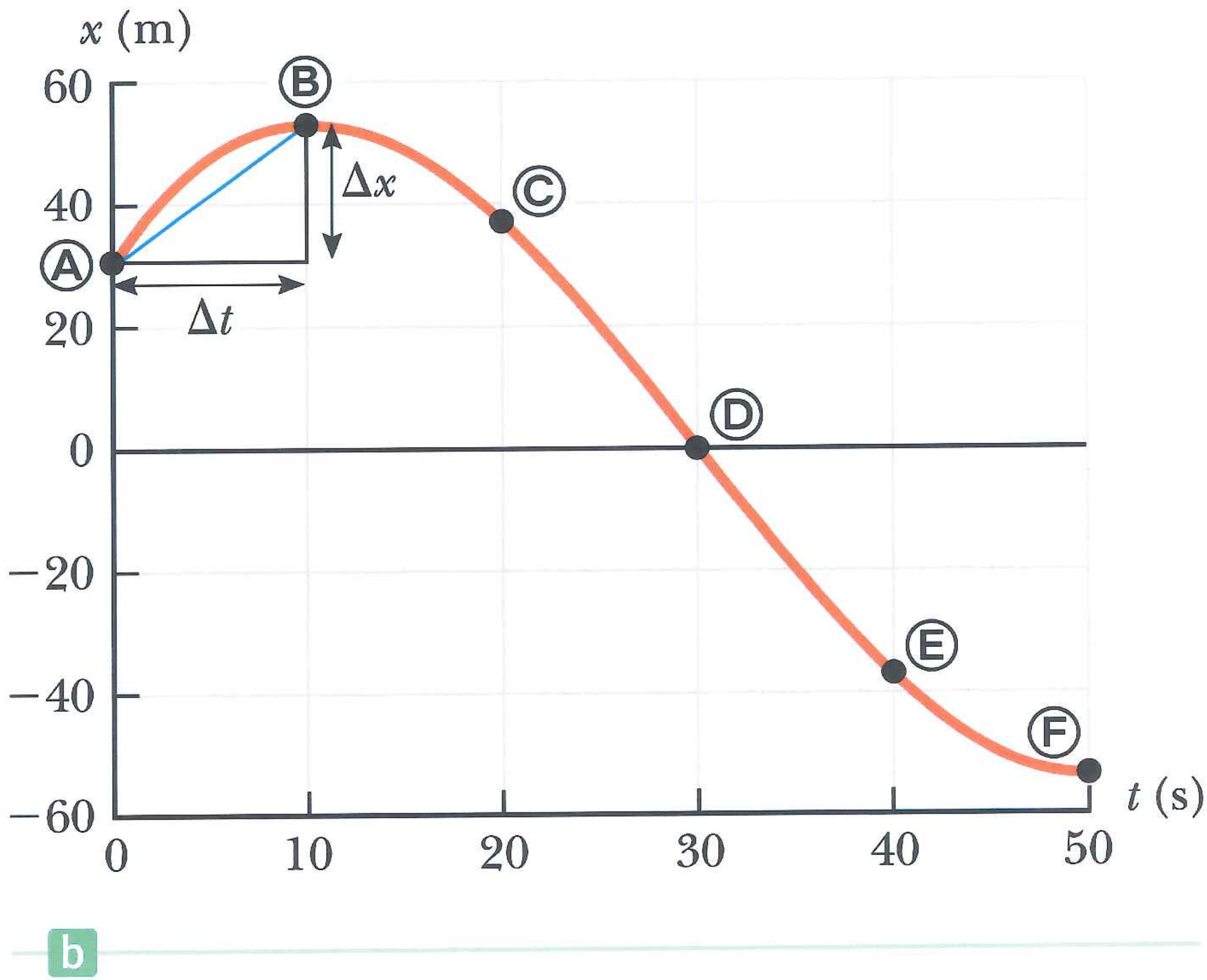
$x_f = -53\text{ m}$

$x_i = 38\text{ m}$

a

$$\Delta x \equiv x_f - x_i = -53\text{ m} - 38\text{ m} = -91\text{ m}$$

Displacement



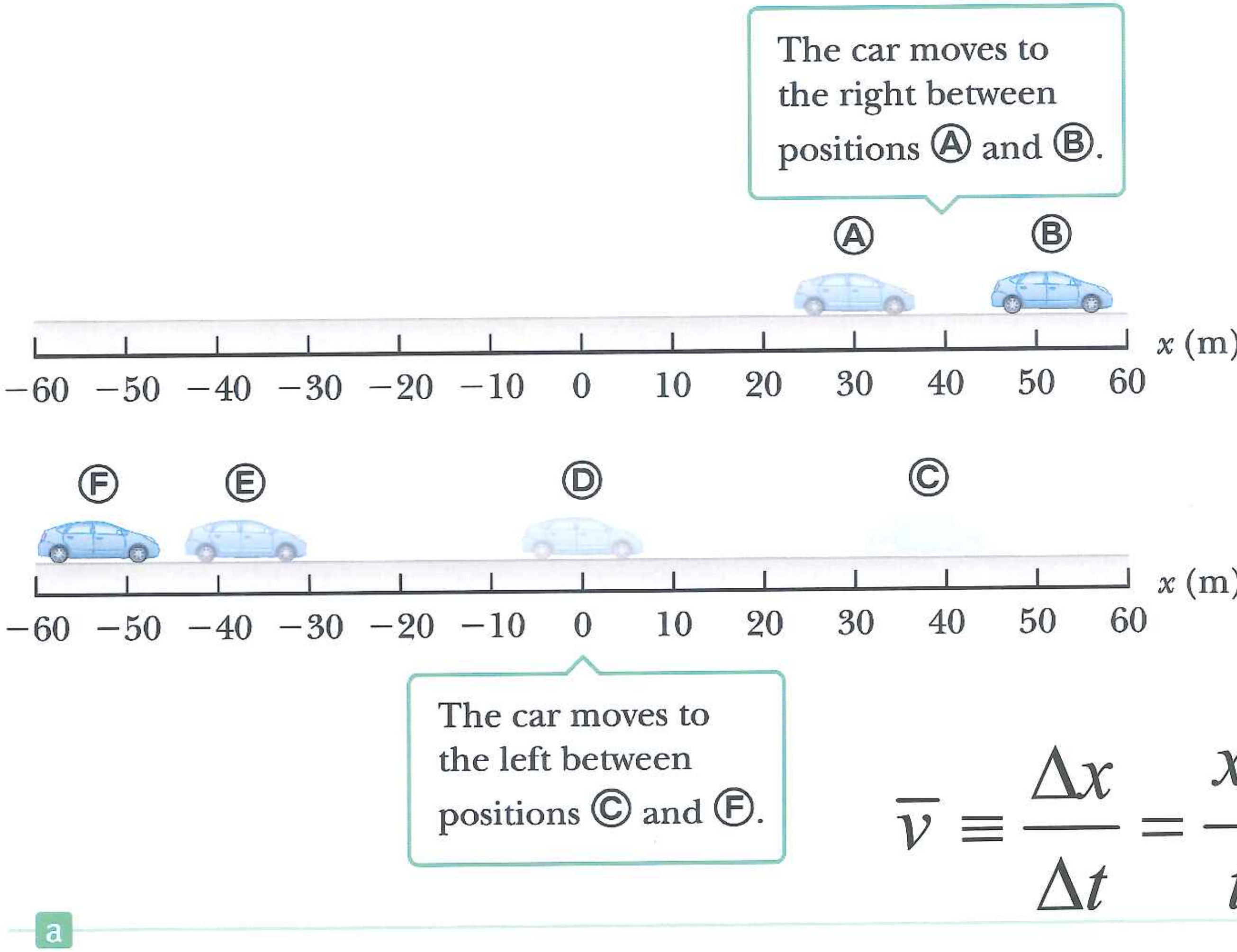
Average Velocity

Average velocity v_{avg} is the displacement Δx divided by the elapsed time interval Δt.

$$v_{avg} = \frac{\Delta x}{\Delta t} \quad \left[\frac{m}{s}\right]$$

If $\Delta x < 0$, then $v_{avg} < 0$; if $\Delta x > 0$, then $v_{avg} > 0$.

Velocity



$$\bar{v} \equiv \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

SI unit: m/s

Velocity

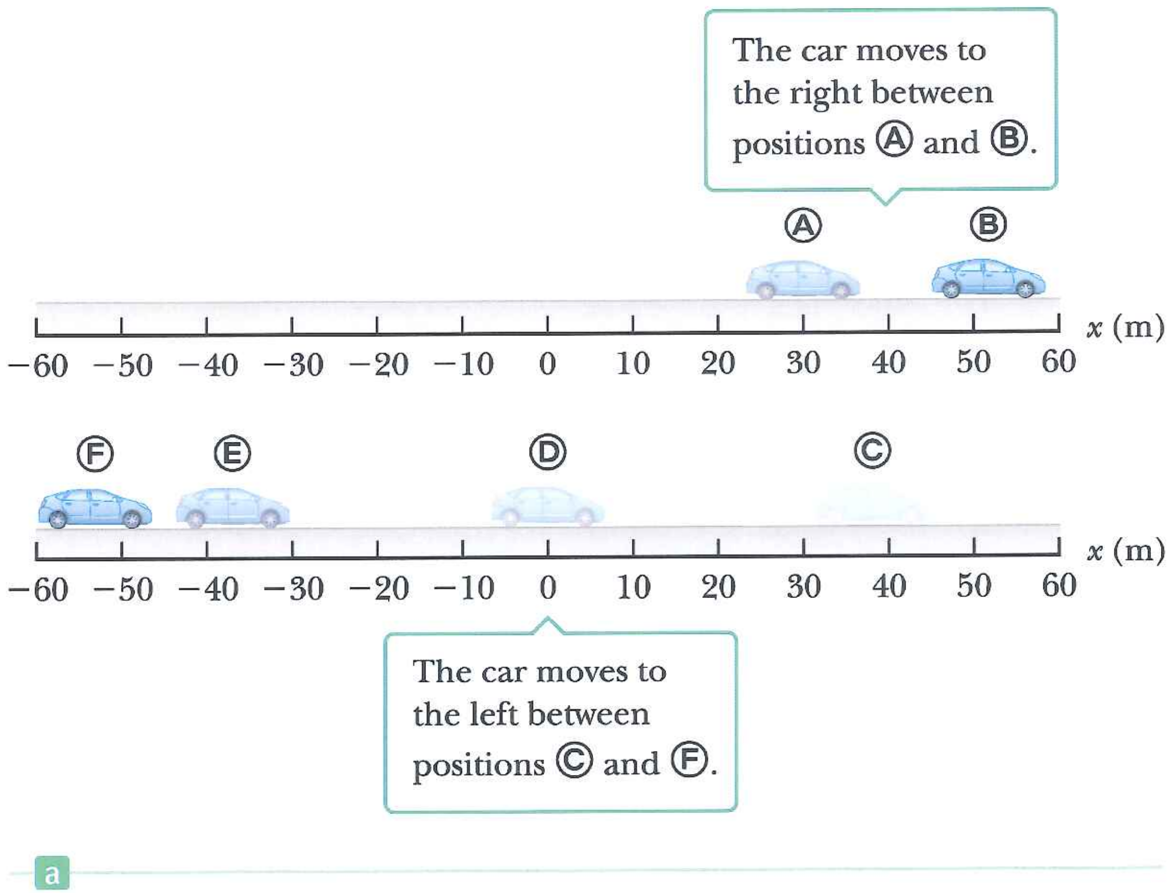


Table 2.1 Position of the Car at Various Times

Position	t (s)	x (m)
Ⓐ	0	30
Ⓑ	10	52
Ⓒ	20	38
Ⓓ	30	0
Ⓔ	40	−37
Ⓕ	50	−53

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} = \frac{52\text{ m} - 30\text{ m}}{10\text{ s} - 0\text{ s}} = 2.2\text{ m/s}$$

velocity

- What is the velocity of a rocket that travels 9000 meters in 12.12 seconds?

d=vt (distance = velocity multiplied by time)

d=9000 m

t=12.12 sec.

solving for v, v=d/t, → d = v · t

v=742.57 m/sec.

Average Speed

Average speed s_{avg} is the total distance traveled in a time interval Δt.

$$s_{avg} = \frac{(distance\ traveled)}{\Delta t}$$

Unlike average velocity, average speed has a magnitude only, so it is always positive.

Velocity

$$\text{Average speed} = \frac{\text{path length}}{\text{elapsed time}}$$

Atlanta to St. Petersburg:

$d = 500\text{ mi}$

$t = 10\text{ h}$

$$\text{average speed} = \frac{500\text{ mi}}{10\text{ h}} = 50\text{ mi/h}$$

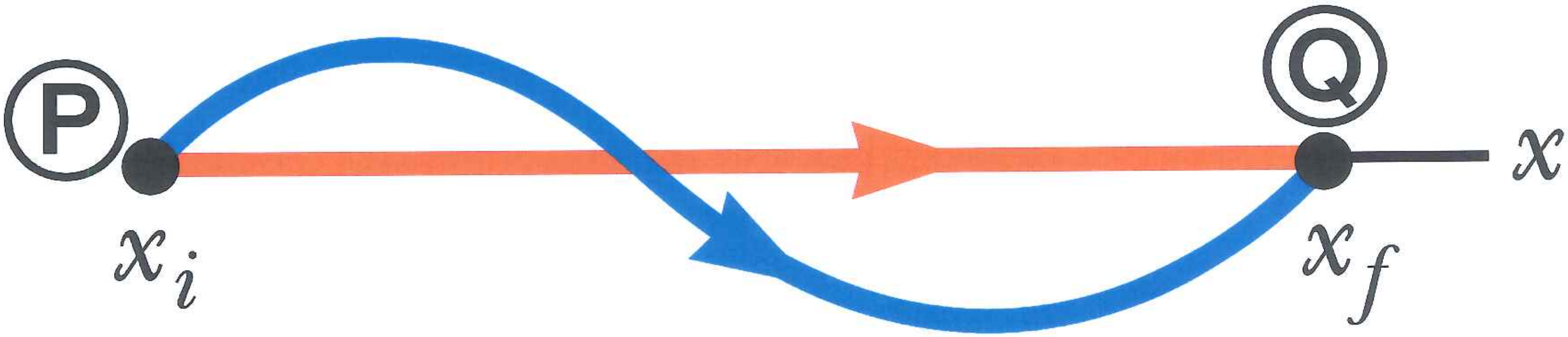
Side trip to Jacksonville:

$d = 600\text{ mi}$

$t = 10\text{ h}$

$$\text{average speed} = \frac{600\text{ mi}}{10\text{ h}} = 60\text{ mi/h}$$

Velocity

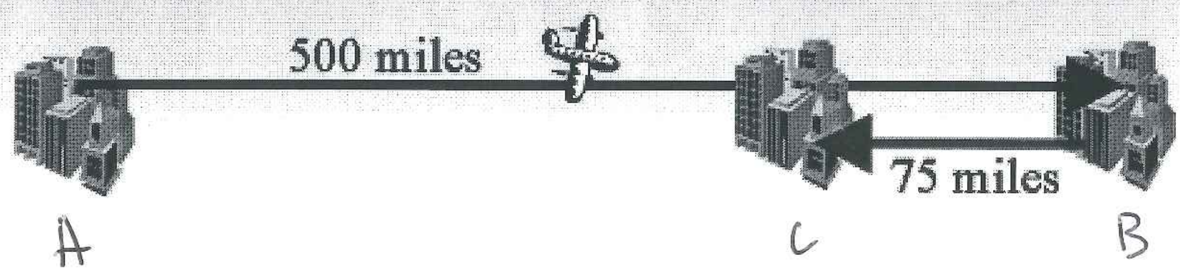


velocities are equal; speeds are different

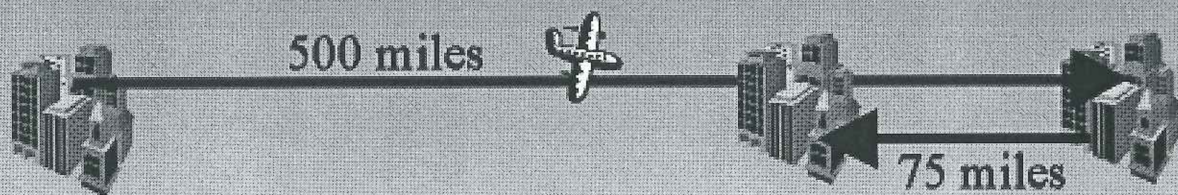
Average Velocity and Average Speed

A pilot flies from Town A 500 mi to Town B in 3.50 h. She then reverses her route and flies 75 mi to Town C in 0.50 h.

- What is her average velocity over her entire flight?
- What is her average speed over her entire flight?



Average Velocity and Average Speed



$\Delta x_1 = +500\ miles$

$\Delta t_1 = 3.5\ hours$

$\Delta x_2 = -75\ miles$

$\Delta t_2 = 0.5\ hours$

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{\Delta x_1 + \Delta x_2}{\Delta t_1 + \Delta t_2} = \frac{(+500\ miles) + (-75\ miles)}{(3.50\ hours) + (0.50\ hours)} = 110\ \frac{miles}{hour}$$

$$s_{avg} = \frac{(total\ distance)}{\Delta t} = \frac{(500\ miles) + (75\ miles)}{(3.50\ hours) + (0.50\ hours)} = 140\ \frac{miles}{hour}$$

7. A motorist drives north for 35. 0 minutes at 85.0 km/h and then stops for 15 minutes. He then continues north, traveling 130 km in 2.0 h.

1. What is his total displacement?
2. What is his average velocity?

2.7 **(a)**

$$\text{Displacement} = \Delta x = (8.50\ \text{km/h})(35.0\ \text{min})\left(\frac{1\ \text{h}}{60.0\ \text{min}}\right) + 130\ \text{km} = \boxed{180\ \text{km}}$$

(b) The total elapsed time is

$$\Delta t = (35.0\ \text{min} + 15.0\ \text{min})\left(\frac{1\ \text{h}}{60.0\ \text{min}}\right) + 2.00\ \text{h} = 2.83\ \text{h}$$

so,

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{180\ \text{km}}{2.84\ \text{h}} = \boxed{63.6\ \text{km}}$$

2. Light travels at a speed of about 3×10^8 m/s.

   a. How many miles does a pulse of light travel in a time interval of 0.1 s, which is about the blink of an eye?

   b. Compare this distance to the diameter of Earth.

2.2 **(a)** At constant speed, $c = 3 \times 10^8$ m/s, the distance light travels in 0.1 s is

$$\Delta x = c(\Delta t) = (3 \times 10^8 \text{ m/s})(0.1 \text{ s})$$
$$= (3 \times 10^7 \cancel{\text{m}})\left(\frac{1 \text{ mi}}{1.609 \cancel{\text{km}}}\right)\left(\frac{1 \cancel{\text{km}}}{10^3 \cancel{\text{m}}}\right) = \boxed{2 \times 10^4 \text{ mi}}$$

(b) Comparing the result of part (a) to the diameter of the Earth, D_E, we find

$$\frac{\Delta x}{D_E} = \frac{\Delta x}{2R_E} = \frac{3.0 \times 10^7 \cancel{\text{m}}}{2(6.38 \times 10^6 \cancel{\text{m}})} \approx \boxed{2.4} \qquad (\text{with } R_E = \text{Earth's radius})$$

3. A person travels by car from one city to another with different constant speeds between pairs of cities. She drives for 30.0 min at 80.0 km/h, 12.0 min at 100 km/h, and 45.0 min at 40.0 km/h and spends 15.0 min eating lunch and buying gas.

1. Determine the average speed for the trip.
2. Determine the distance between the initial and final cities along the route.

2.3 Distances traveled between pairs of cities are

$$\Delta x_1 = v_1(\Delta t_1) = (80.0 \text{ km/h})(0.500 \text{ h}) = 40.0 \text{ km}$$

$$\Delta x_2 = v_2(\Delta t_2) = (100.0 \text{ km/h})(0.200 \text{ h}) = 20.0 \text{ km}$$

$$\Delta x_3 = v_3(\Delta t_3) = (40.0 \text{ km/h})(0.750 \text{ h}) = 30.0 \text{ km}$$

Thus, the total distance traveled is $\Delta x = (40.0 + 20.0 + 30.0) \text{ km} = 90.0 \text{ km}$,

and the elapsed time is $\Delta t = 0.500 \text{ h} + 0.200 \text{ h} + 0.750 \text{ h} + 0.250 \text{ h} = 1.70 \text{ h}$.

(a) $\bar{v} = \dfrac{\Delta x}{\Delta t} = \dfrac{90.0 \text{ km}}{1.70 \text{ h}} = \boxed{52.9 \text{ km/h}}$

(b) $\Delta x = \boxed{90.0 \text{ km}}$ (see above)

Instantaneous Velocity

$$v \equiv \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} \quad \text{SI unit: m/s}$$

Table 2.1

TABLE 2.1 Data Table as Described, Including Average Velocity

Time t (s)	Position x (m)	Average velocity (m/s) with $\Delta t = t - 1.00$ s
1.00	4.711	
1.01	4.779	6.80
1.02	4.848	6.85
1.05	5.056	6.90
1.10	5.411	7.00
1.20	6.151	7.20
1.50	8.611	7.80
2.00	13.629	8.92

Instantaneous Velocity

$$V_{av} = \frac{(13.629 - 4.711)\,m}{(2-1)\,s} = 8.92\,\frac{m}{s}$$

if $\Delta t \to 0$
$V \to 6.8\,\frac{m}{s}$

$$V_{inst} = \lim_{t \to 0} \frac{\Delta x}{\Delta t} = \frac{4.779 - 4.711}{0.01} = 6.8\,\frac{m}{s}$$

Instantaneous Velocity

Table 2.2 Positions of a Car at Specific Instants of Time

t (s)	x (m)
1.00	5.00
1.01	5.47
1.10	9.67
1.20	14.3
1.50	26.3
2.00	34.7
3.00	52.5

Table 2.3 Calculated Values of the Time Intervals, Displacements, and Average Velocities of the Car of Table 2.2

Time Interval (s)	Δt (s)	Δx (m)	$\bar{v}$ (m/s)
1.00 to 3.00	2.00	47.5	23.8
1.00 to 2.00	1.00	29.7	29.7
1.00 to 1.50	0.50	21.3	42.6
1.00 to 1.20	0.20	9.30	46.5
1.00 to 1.10	0.10	4.67	46.7
1.00 to 1.01	0.01	0.470	47.0

$t = 1.00 \text{ s}, x = 5.00 \text{ m}$

$t = 3.00 \text{ s}, x = 52.5 \text{ m}$

$$\frac{\Delta x}{\Delta t} = \frac{52.5 \text{ m} - 5.00 \text{ m}}{3.00 \text{ s} - 1.00 \text{ s}} = 23.8 \text{ m/s}$$

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{0.470 \text{ m}}{0.0100 \text{ s}} = 47 \text{ m/s}$$

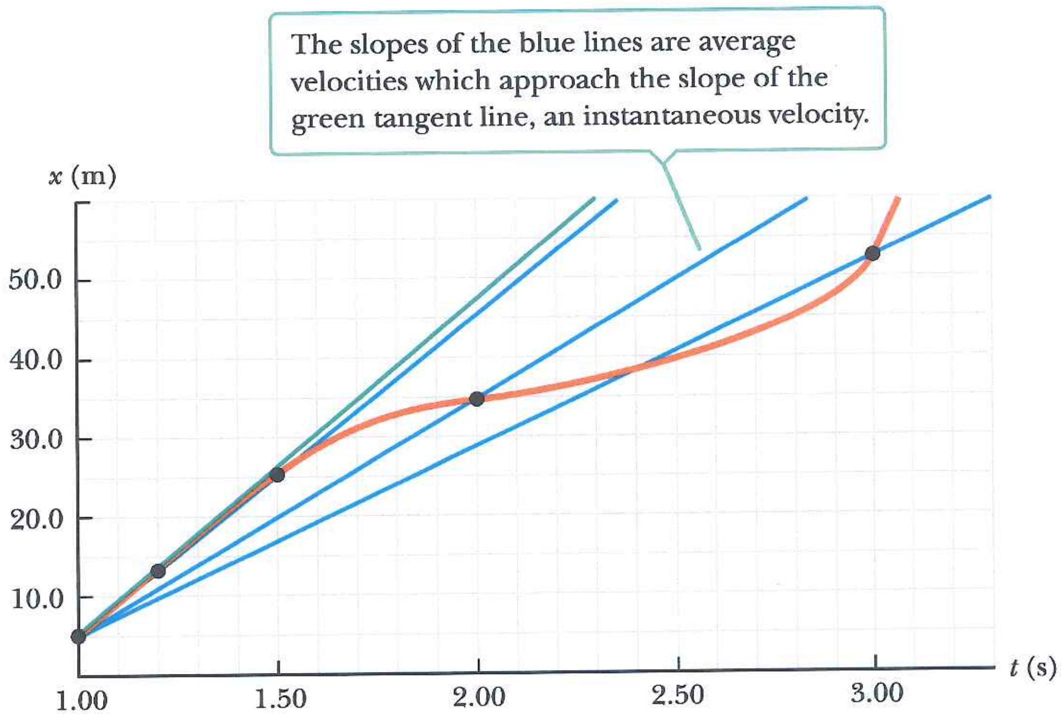
Unnumbered Table Page 24

$V_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$, $V_x = \frac{dx}{dt}$

Initial time (s)	Final time (s)	Δx (m)	Average velocity (m/s)
0.60	0.61	0.0593	5.93
0.60	0.62	0.1196	5.98
0.60	0.63	0.1805	6.02
0.60	0.64	0.2430	6.08
0.60	0.65	0.3063	6.13

V_{inst} at t = 60 sec $= \frac{0.0593\ m}{0.01\ s} = 5.93\ \frac{m}{s}$

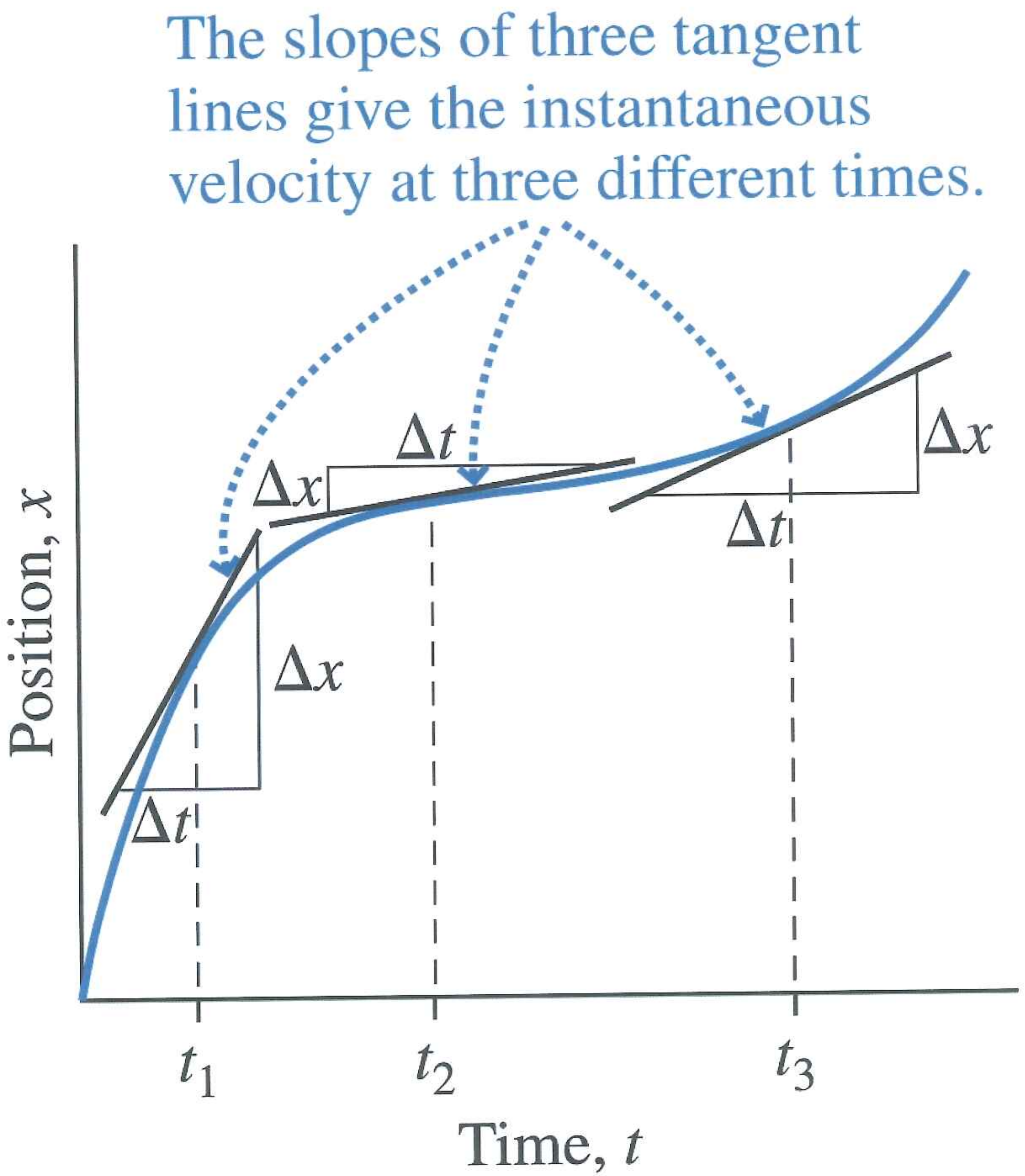
Instantaneous Velocity



The slope of the line tangent to the position-versus-time curve at "a given time" is defined to be the instantaneous velocity at that time.

$$\left.\begin{array}{l}\text{Object 1: instantaneous velocity} = +15\text{ m/s}\\ \text{Object 2: instantaneous velocity} = -15\text{ m/s}\end{array}\right\}\ \text{speed} = 15\text{ m/s}$$

Figure 2.10


The slopes of three tangent lines give the instantaneous velocity at three different times.
Δx
Δt
Δx
Δt
Δx
Δt
Position, x
t1
t2
t3
Time, t