ANSWERS

1.1 Position, distance & displacement

(MOTION)

sc, sd $(\vec{d}, \Delta d, \Delta\vec{d})$

p. 13

\# 1, 2, 3, 4, 5a, 5b, 6a

① a) scalar - No direction b) vector - Magnitude & direction

c) time is always scalar & linear measurement has no direction

② a) $\vec{d}$ and $\Delta\vec{d}$ are both vectors but $\vec{d}$ (position) states where something else relative to a predetermined reference point whereas $\Delta\vec{d}$ (displacement) inferences movement. An object moves from $\vec{d}_1$ to $\vec{d}_2$.

b) Δd and $\Delta\vec{d}$: both infer movement from one spot to the next but $\Delta\vec{d}$ is a straight line measurement & includes [direction] whereas Δd is how far "the feet travel" which is not necessarily a straight line. Δd has no [direction].

③

N ↑ → E

$\vec{d}_2$ ←------ $\vec{d}_1$

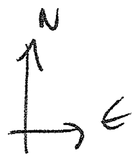
$\vec{d}_2$ = 76 m [W] $\vec{d}_1$ = 25 m [W]

*

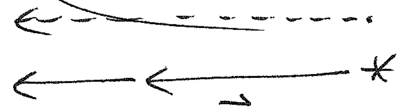
$\Delta\vec{d} = \vec{d}_2 - \vec{d}_1$

$= 51$ m [W]

5 a) Don't use scale, just labelled diagrams.



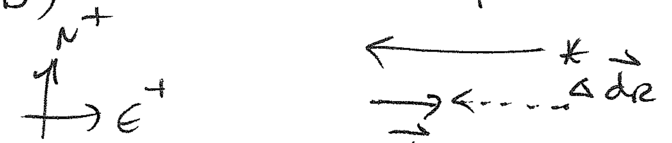
$\vec{\Delta d_R} = 13\text{ m [W]}$



$\vec{\Delta d_2} = 3.0\text{ [W]}$ $\vec{\Delta d_1} = 10\text{ m [W]}$

Remember $\vec{\Delta d_R}$ = "resultant" displacement.

b)



$\vec{\Delta d_1} = 10\text{ m [W]}$

$\vec{\Delta d_R}$

$\vec{\Delta d_2} = 3.0\text{ m [E]}$

Remember: Add vectors "tail-to-tip"

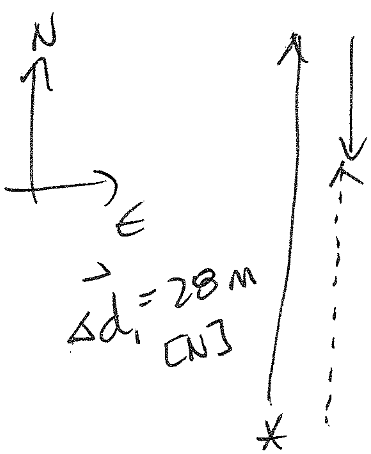
$\therefore \vec{\Delta d_R} = \underline{7.0\text{ m [W]}}$

... or....

$$\vec{\Delta d_R} = \vec{\Delta d_1} + \vec{\Delta d_2}$$
$$= (-10) + (+3)$$
$$= -7.0\text{ m [E]}$$
$$\text{or } \underline{+7.0\text{ m [W]}}$$

Remember: [direction] is always the one you set as +ve

c)



$\vec{\Delta d_1} = 28\text{ m [N]}$

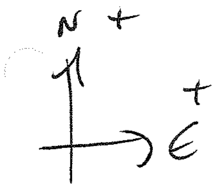
$\vec{\Delta d_2} = 7.0\text{ m [S]}$

$\vec{\Delta d_r} = \underline{21\text{ m [N]}}$

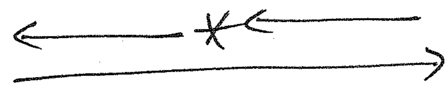
... or ...

$$\vec{\Delta d_R} = \vec{\Delta d_1} + \vec{\Delta d_2}$$
$$= +28 + (-7)$$
$$= \underline{+21\text{ m [N]}}$$

5 d)



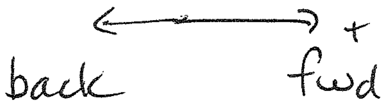
$\vec{\Delta d}_1 = 7.0$ km [W] $\quad \vec{\Delta d}_3 = 5.0$ km [W]

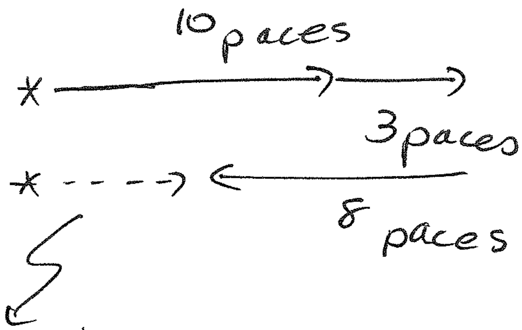


$\vec{\Delta d}_2 = 12$ km [E]

$\therefore \vec{\Delta d}_R = 0$ km !

6 a



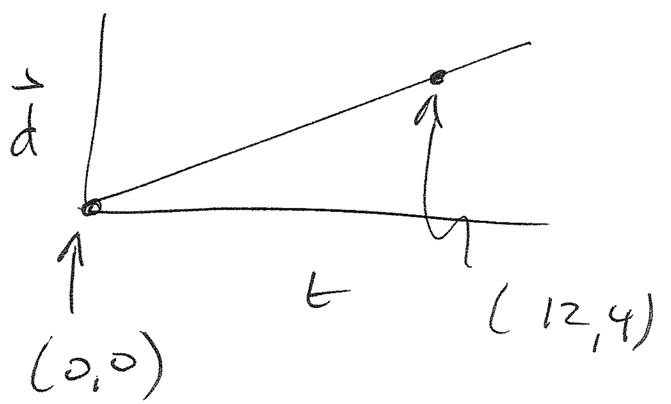


$\vec{\Delta d}_R = 5$ paces [fwd]

1.2 Speed & Velocity #1, 4, 6, 7, 8

(1) speed ⇒ in m/s but no direction!
velocity ⇒ in m/s but [direction] given.

(4)



pick 2 "friendly" points that are easy to read accurately.

$$\text{velocity} = \frac{\Delta d}{t} = \underline{\underline{\text{slope}}}$$

$$= \frac{12-0}{4-0} = \underline{3\ \text{m/s [W]}}$$

(6) $\vec{v} = 3.2$ m/s [S]
$t = 12$ s
$\Delta\vec{d} = ?$

$$\Delta\vec{d} = \vec{v}t$$
$$= (3.2)(12)$$
$$= \underline{\underline{38\ \text{m [S]}}}$$

(7) $\Delta d = 16$ m

$$\vec{v} = 100\ \frac{\text{km}}{\text{h}} \times \frac{1000\ \text{m}}{1\ \text{km}} \times \frac{1\ \text{h}}{3600\ \text{s}} = 27.8\ \text{m/s}$$

$t = ?$

$$t = \frac{\Delta d}{v} = \frac{16\ \text{m}}{27.8\ \text{m/s}} = \underline{\underline{0.58\ \text{s}}}$$

(8) $\Delta d = 8.864 \text{ km [S]} = 8864 \text{ m}$

$t = 0.297 \cancel{\text{min}} \times \dfrac{60 \text{ s}}{1 \cancel{\text{min}}} = 17.82 \text{ s}$

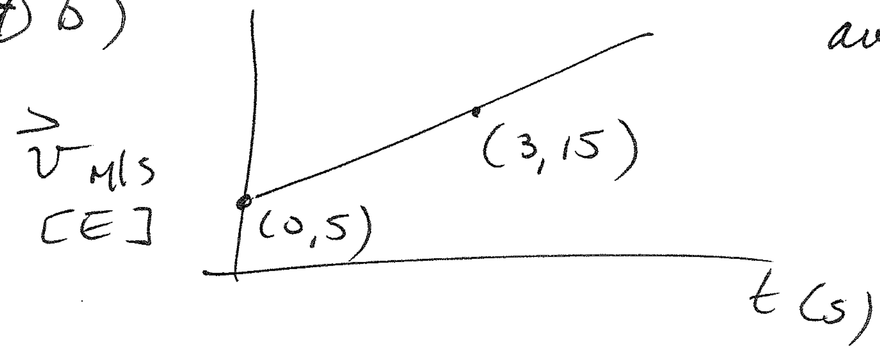
$v = ?$

$$v = \frac{\Delta d}{t} = \frac{8864 \text{ m}}{17.82 \text{ s}} = 498 \text{ m/s}$$

$$\approx \underline{500 \text{ m/s}}$$

1.3 Acceleration p.30 # 4b, 5, 6, 8, 9, 10, 11

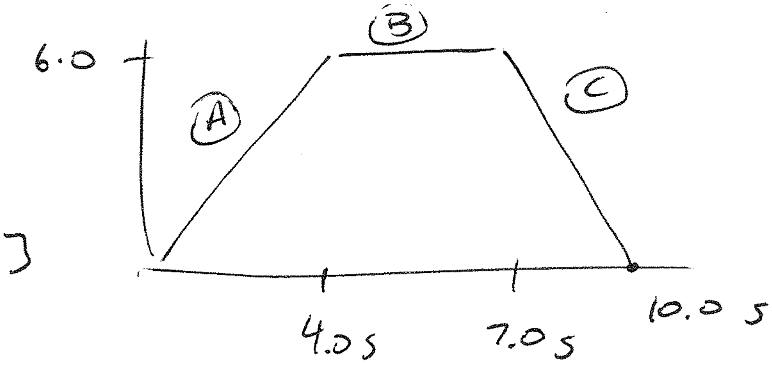
4 b)



average acceleration
$= \text{slope}$
$= \dfrac{15-5}{3-0}$
$= \underline{3.3 \text{ m/s [E]}}$

5 granted 10 m/s = 10 m/s
so the rate of moving has not changed + that is our traditionally understanding of acceleration. However the direction changed from [N] to [S] and in physics terms, this is a change in velocity over a period of time ∴ it is acceleration. (velocity by definition has magnitude and direction - if either change, you have $\vec{a}$)

(6)



a) A → + acceleration → object speeding up from rest in westerly direction

B → zero acceleration + constant velocity = 6.0 m/s [W]

C → - acceleration → object slowing down but continually travelling [W] until it stops @ 10.0 s. * it never travels easterly.

(8) G: $a = 0.53 \text{ m/s}^2$

$v_1 = 0.68 \text{ m/s [N]}$

$v_2 = 0.89 \text{ m/s [N]}$

R: $t = ?$

A: $a = \frac{v_2 - v_1}{t}$ $\left(a = \frac{\Delta v}{t}\right)$

S: $t = \frac{0.89 - 0.68}{0.53} = 0.40 \text{ s}$

P: It takes 0.40 s

(9) a) $a = +2.90\ m/s^2\ [S] = \underline{-2.90\ m/s^2\ [N]}$

$t = 5.72\ s$

$V_2 = 0$ ("rest")

$V_1 = ?$

I like $-a$ here because car is ~~slowing~~ down. It would have been travelling [N] if braking causes acceleration [S].

$\cancel{V_2} = V_1 + at$

$0 = V_1 + (-2.90)(5.72)$

$16.59 = V_1$ $\therefore$ initially going $\underline{16.6\ m/s\ [N]}$

b) if object is slowing down

$\therefore$ $\vec{V_1}$ and $\vec{a}$ must have opposite signs.

I normally attach +ve sign to initial velocity.

$\therefore$ $\vec{V_1} =$ +ve

$a =$ −ve

(10)

W ⟵⟶ E +

again, I like $\vec{v_1}$ to be +ve.

$\therefore$ $v_1 = 6.0\ m/s\ [E]$ ⟵ all [direction] must be same!

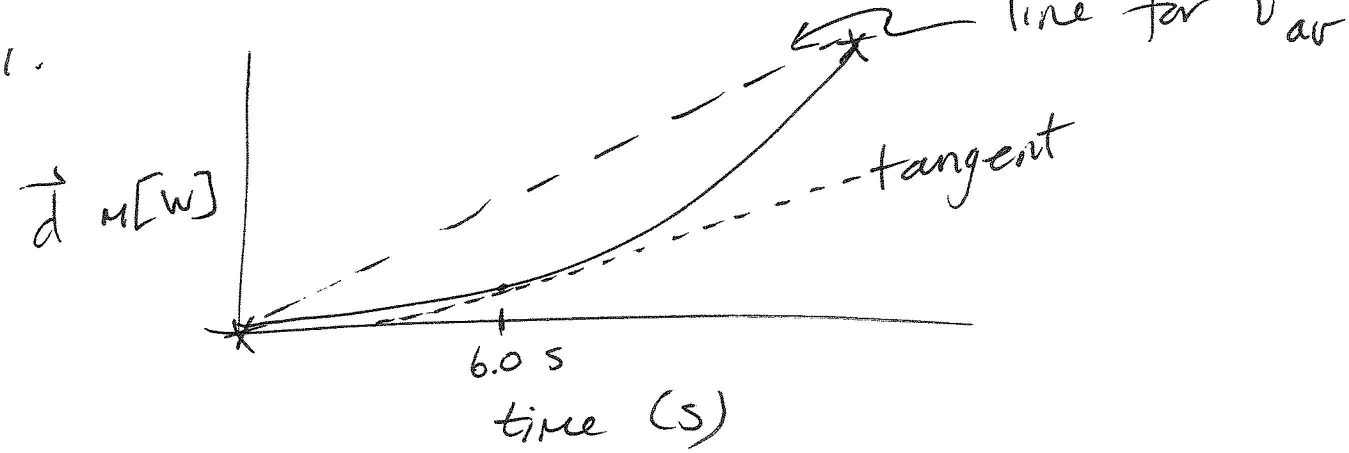
$v_2 = 7.3\ m/s\ [W] = -7.3\ m/s\ [E]$

$t = 0.094\ s$

$$a = \frac{\Delta V}{t} = \frac{V_2 - V_1}{t} = \frac{-7.3-(6.0)}{0.094} = -141.5\ m/s^2\ [E]$$

$= {}^{+}140\ m/s^2\ [W]$!

11.



a) $\vec{v}_{inst}$ @ 6.0 $\Rightarrow$ hard to do because it is <u>Not</u> a straight line

∴ draw a tangent & take slope of it.

I got ~ <u>21 m/s [W]</u>

b) $\vec{v}_{av}$ for the whole motion $\Rightarrow$ you accomplish this by drawing a straight line between start * and end * of time period. This gives you <u>total</u> Δd (rise) and <u>total</u> Δt (run)

the slope of this line - - - - -

is $\frac{rise}{run} = \bar{v}_{av}$

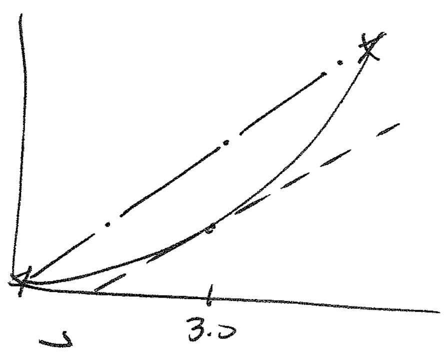
I got <u>20 m/s [W]</u>

1.4 – 3 Graphs   p. 35 #1,3

①

How do you determine?	Given…	Read Graph	Take slope	Find area
position	d/t graph	✓		
velocity	d/t graph		✓	
velocity	v/t graph	✓		
acceleration	v/t graph		✓	
acceleration	a/t graph	✓		
* displacement	v/t graph			✓

③



☺ ∴ +a acceleration

a) $\vec{d}$ at $t = 5.0$ s? ⇒ Read graph $\vec{d} = 45$ m [S]

b) $\vec{v}_{inst}$ at $t = 3.0$ s? ⇒ Slope of tangent

$\vec{v}_{inst} \approx$ 10 m/s [S]

c) $\vec{v}_{av}$ ~~0→6~~ 0 → 6 s ⇒ Connect 2 points *

and determine slope of line

$v_{av} \sim$ 11 m/s [S]

1.5 - 5 Key Acceleration Formulas

(1) $v_1 = 0$ m/s ("from rest")

$a = 2.0$ m/s^2 [N]

$t = 15$ s

$\Delta d = ?$

$\Delta d = \cancel{v_1 t}^{\,0} + \frac{1}{2}at^2$

$= 0 + \frac{1}{2}(2)(15)(15)$

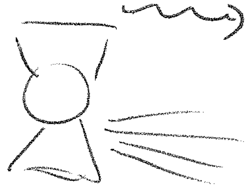
$= 225$ m

$\boxed{\text{Car moves } 225 \text{ m [N]}}$

$\sim 230 \text{ m} = 2.3 \times 10^2$

$\rightarrow +$

(2) $v_1 = 20$ m/s [E]



$v_2 = 0$ m/s $t = 12$ s

retro-rockets
(backwards rockets)

$a = ?$ $a = \frac{v_2 - v_1}{t} = \frac{0 - 20 \text{ m/s}}{12} = -1.6\dot{6}\dot{6}$

acceleration $= -1.7$ m/s^2 [E]

$\boxed{\text{or } 1.7 \text{ m/s}^2 \text{ [W]}}$

repeat initially with +ve

$\Delta d = ?$ $\cancel{v_2^2 = v_1^2 + 2a\Delta d}$

oops! $\cancel{0^2 = (20)(20)}$

(try not to use a calculated value)

$\Downarrow$

$$\Delta d = \left(\frac{v_2 + v_1}{2}\right)t$$

$$\Delta d = \left(\frac{0 + 20}{2}\right)(12) = 120 \text{ m [E]}$$

$\therefore$ spacecraft moves 120 m [E]

---

(3) $v_1 = 15$ m/s [W]

$a = 7.0 \text{ m/s}^2 \text{ [E]} = -7.0 \text{ m/s}^2 \text{ [W]}$

$t = 4.0$ s

must have same direction.

v_1 and a have different signs $\therefore$ helicopter slowing down

$v_2 = v_1 + at$

$v_2 = 15 + (-7.0)(4)$

$= 15 - 28$

$v_2 = -13$ m/s [W]

$\boxed{= +13 \text{ m/s [E]}}$

---

(4) A $v_{const} = 20.0$ m/s

$\Delta d = 1.0 \text{ km} = 1000$ m

$t = ?$

constant speed $\therefore v = \frac{\Delta d}{t}$

B $v_1 = 0$ [fwd]

$a = 0.333 \text{ m/s}^2$ [fwd]

$\Delta d = 1000$ m

$t = ?$

$\therefore \Delta d = v_1 t + \frac{1}{2}at^2$

The lowest time is the winner

A $t = \frac{\Delta d}{v} = \frac{1000}{20} = \underline{50\,s}$

B $\Delta d = \cancel{v_1 t}^{0} + \frac{1}{2}at^2$

$1000\,\cancel{\Delta d} = \frac{1}{2}(0.333)(t^2$

$2000 = 0.333t^2$

$\sqrt{6006} = t$

$t = \underline{77.\cancel{4}9\,s} = 77\,s$

A wins by 27 s (77 − 50)

5 $V_1 = 5$ m/s

$V_2 = 7.5$ m/s

$\Delta d = 50.0$ m

$a = ?$

$V_2^2 = V_1^2 + 2ad$

$(7.5)(7.5) = (5)(5) + 2a(50)$

$56.25 = 25 + 100a$

$a = \frac{56.25 - 25}{100}$

$\boxed{a = 0.31\ \text{m/s}^2\ [\text{fwd}]}$

6 $t = 4.0$ s

$V_1 = 0$ ("from rest")

$\Delta d = 4.50 \times 10^2$ m $= 450$ (altitude is vertical displacement)

$a = ?$

⇓

$d = \cancel{v_1}^{0} t + \frac{1}{2} a t^2$

$450 = 0 + \frac{1}{2} a (4)(4)$

$450 = 8a$

$a = 56 \text{ m/s}^2$ [up]

$V_2 = ?$

* try not to use calculated values

try to use givens only.

$\Delta d = \left(\frac{\cancel{V_1}^{0} + V_2}{2}\right) t$

$450 = \left(\frac{V_2}{2}\right)(4)$

$450 = \frac{4V_2}{2}$

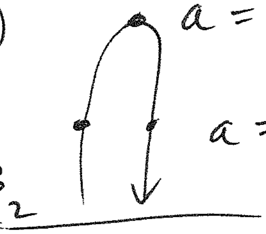
$450 = 2V_2$

$V_2 = 225 \text{ m/s}$ [up] $\approx$ $2.3 \times 10^2 \text{ m/s}$ [up]

1.6 ⇒ Free Fall

p. 43 # 3, 4, 5, 6, 7

(3) $a = -9.8\ m/s^2$

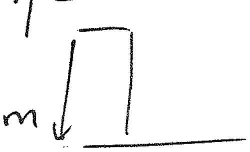


$a = -9.8\ m/s^2$ $a = -9.8\ m/s^2$ ↑ up +

acceleration due to gravity is <u>constant</u>

- even at apex $a \neq 0\ m/s^2$!

(4) ↑ ⊕



1.5 m

$a = -9.8\ m/s^2$

$\Delta d = -1.5$

a) $v_1 = 0$ $t = ?$

(watch signs)

(you can set ↓ ⊕ it works!)

$$d = \cancel{v_1 t}^{\,0} + \tfrac{1}{2} a t^2$$

$$-1.5 = \tfrac{1}{2}(-9.8)t^2$$

$$-1.5 = -4.9\,t^2$$

$$\sqrt{0.306} = t$$

$$\underline{t = 0.55\ s}$$

b) $a = -9.8\ m/s^2$

$\Delta d = -0.75\ m$

+ ↑ $v_1 = 0$

$v_2 = ?$

$$v_2^2 = \cancel{v_1^2}^{\,0} + 2ad$$

$$v_2 = \sqrt{2(-9.8)(-0.75}$$

$$v_2 = \pm 3.8\ m/s$$

remember $\sqrt{25} = -5$ and $+5$

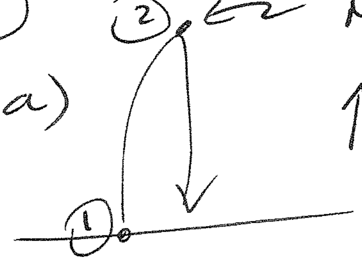
we want $-v$ since ↑ +

$\therefore\ v_2 = -3.8\ m/s$ [up]

or $v_2 = 3.8\ m/s$ [down]

(5)

a)



← max height

↑ (+)

$a = -9.8\ m/s^2$

$v_2 = 0$

$v_1 = 80.0\ m/s$

$\Delta d = ?$

$\cancel{v_2^2}^{\,0} = v_1^2 + 2ad$

$0 = (80)(80) + 2(-9.8)\, d$

$\dfrac{-6400}{-19.8} = d$

$\underline{d = 323\ m}$ [up] $\left(= 3.2 \times 10^2\ m \text{ [up]} \right)$

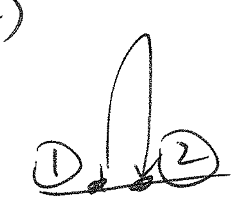
b) same diagram as a). Try not to use a calculated value (as it might be wrong). $\underline{t = ?}$

$\therefore\ a = \dfrac{v_2 - v_1}{t}$

$\therefore\ t = \dfrac{v_2 - v_1}{a} = \dfrac{0 - 80}{-9.8} = \underline{8.2\ s}$

c)

+↑



$v_1 = 80.0\ m/s$

$a = -9.8\ m/s^2$

$\Delta d = 0$ (*)

$t = ?$

$\cancel{d}^{\,0} = v_1 t + \tfrac{1}{2} a t^2$

$0 = (80)(t) + \tfrac{1}{2}(-9.8)\, t^2$

$-80\cancel{t} = -4.9\, t^{\cancel{2}}$

$-80 / -4.9 = t$

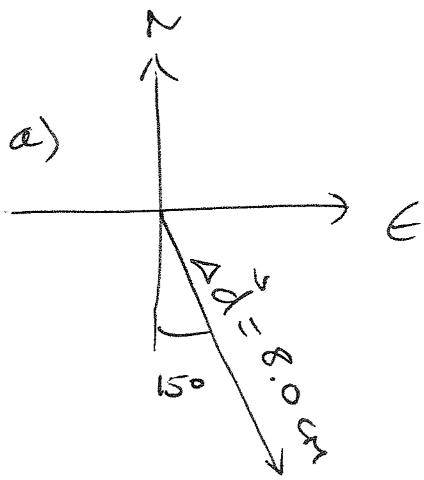
$\underline{t = 16\ s}$

2.1 Motion in 2 Dimensions (Vector Addition)

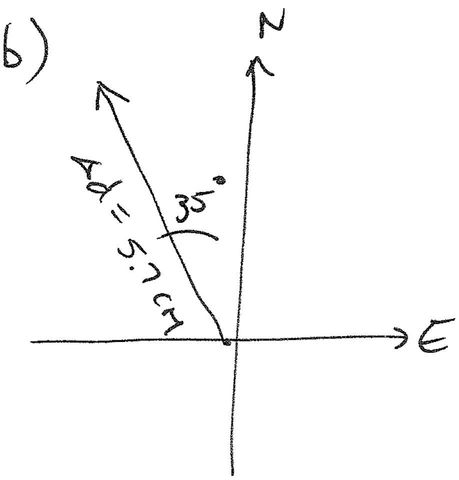
p. 65 # 1, 2, 4, 5

Remember: Add tail-to-tip.
Resultant? "Start @ start + end @ end"

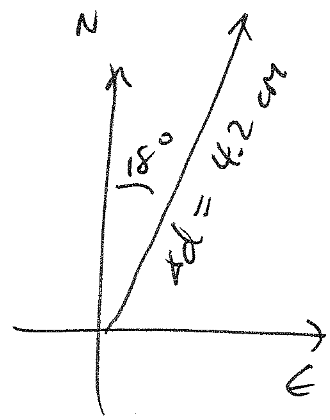
① a)



b)

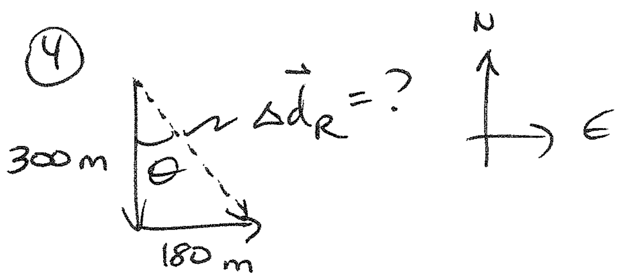


c)



② a) [E 75° S] b) [W 55° N] c) [E 72° N]

④



$\Delta\vec{d} = \sqrt{300^2 + 180^2}$

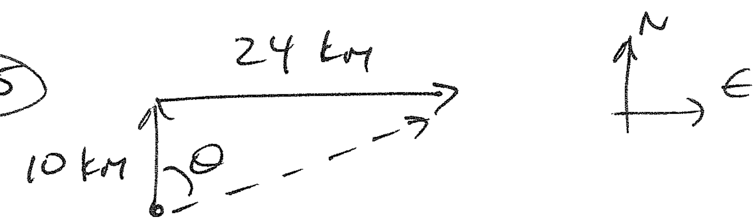
$= 350$ m

$\theta = \tan^{-1}\left(\frac{180}{300}\right)$

$\theta = 31°$

$\therefore \Delta\vec{d}_R = 350\text{ m }[S\ 31°\ E]$

⑤



$\Delta\vec{d} = \sqrt{10^2 + 24^2}$

$\Delta d = 26$ km

$\theta = \tan^{-1}\left(\frac{24}{10}\right)$

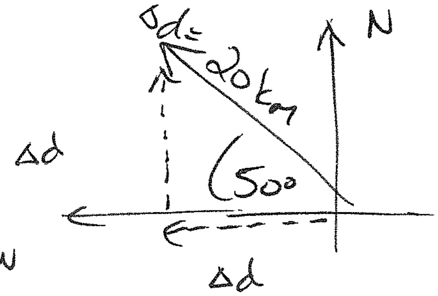
$\theta = 67°$

$\therefore \Delta\vec{d}_R = 26\text{ km }[N\ 67°\ E]$

2.2 - Solving Motion in 2 dimensions

p. 75 # 1a, 2, 3, 5, 6, 8*

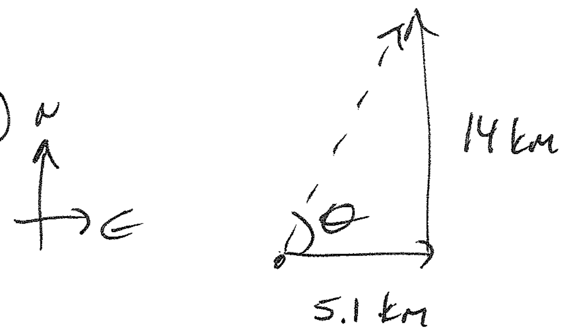
(1a)



$\therefore \Delta d_x = (\cos 50°)(20) = 12.9$ m [W]

$\Delta d_y = (\sin 50°)(20) = 15.3$ m [N]

(2)

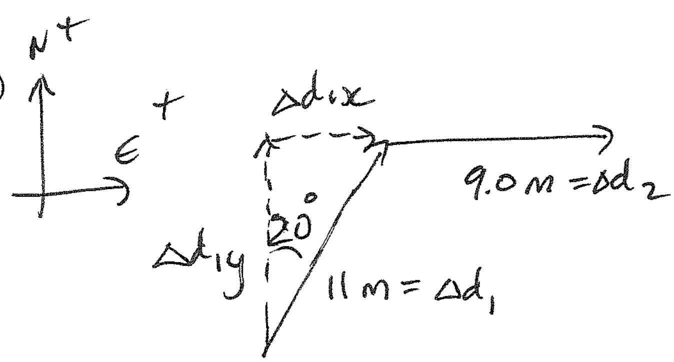


$\Delta d_R = \sqrt{5.1^2 + 14^2} = 14.9$

$\theta = \tan^{-1}\left(\frac{14}{5.1}\right) = 70°$

$\therefore \Delta \vec{d}_R = 15$ km [E 70° N]

(3)



* need to have all x + y vectors.

Δd_2 is O.K.! :)

Δd_1 is Not

$\Delta d_1 \Rightarrow$ components

$\therefore \Delta d_y = (\cos 20)(11) = 10.3$ m [N]

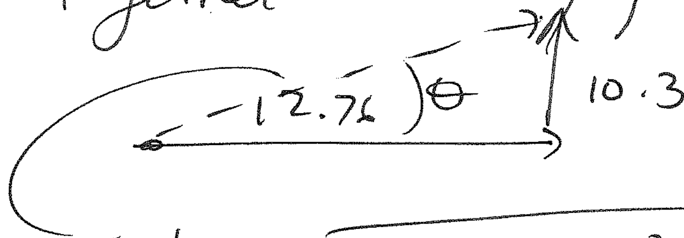
$\Delta d_x = (\sin 20)(11) = 3.76$ m [E]

Add

	x	y
	$\Delta d_{1x} = +3.76$	$\Delta d_{1y} = +10.3$
	$\Delta d_2 = +9.0$	
	12.76	10.3

} watch signs!

Add together with x/y vectors

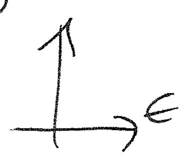


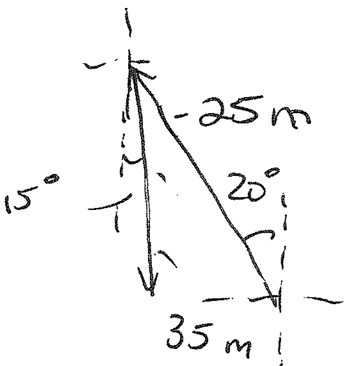
$\Delta d_r = \sqrt{12.76^2 + 10.3^2} = 16\ m$

$\theta = \tan^{-1}\left(\frac{10.3}{12.76}\right) = 39°$

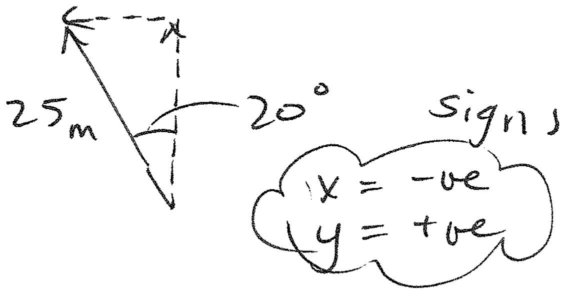
$\therefore \Delta d_R = 16\ m\ [E\ 39°\ N]$

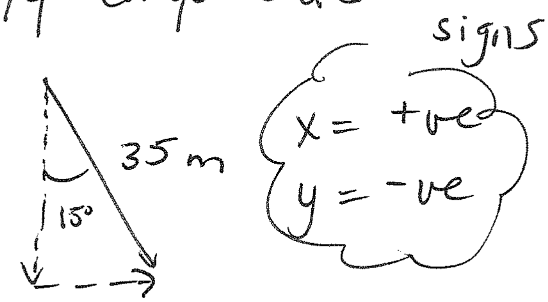
(5)





Break both vectors into x/y components





You will have 2 x vectors + 2 y vectors

Add them. Careful with +/- signs.

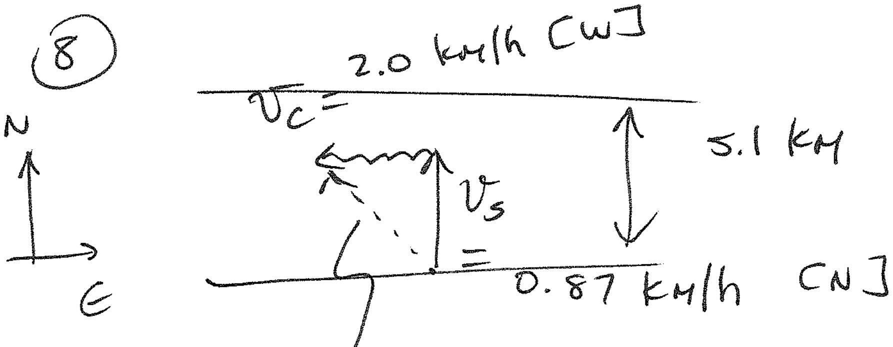
	x	y
	—	—
	—	—
Total	x	y

(5) Add total x + y together with a diagram.

solve with
- pythagorean
- trig.

(6) - similar to #5 except vector #1 is all <u>x</u>
You only need to break vector #2 into components

(8)



resultant velocity (swimmer drifts downstream)

a) time to cross?
* must you velocity vector that is <u>collinear</u> to distance $\uparrow \Delta d = 5.1\ km$ $\uparrow v = 0.87\ km/h$

$t = \frac{d}{v} = \frac{5.1}{0.87} = $ <u>5.9 hours to cross</u>

b) how far downstream? * must use <u>downstream velocity</u>

$\overleftarrow{\Delta d = ?}$

$\overleftarrow{v_c = 2.0\ km/h}$

time to cross = 5.86 h
(unrounded)

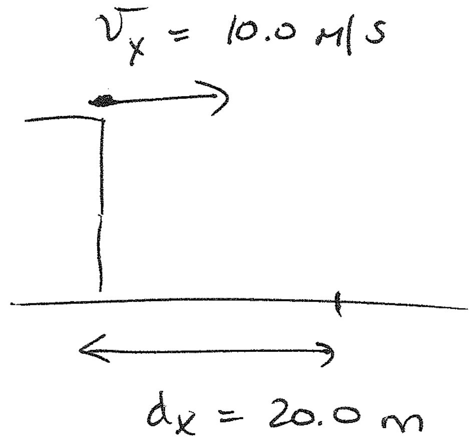
$d = vt$
$= (2.0)(5.86)$

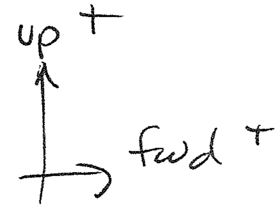
<u>$\Delta d = 12\ km$</u>

2.3 Projectiles

p. 81 # 2, 4, 6, 7

(2)





$a_y = -9.8$ m/s^2

$t = ?$

x	y
$v_x = 10.0$	$v_{1y} = 0$ m/s
$d_x = 20.0$ m	$a = -9.8$ m/s^2

I can use horizontal components - easy! Constant velocity.

$$t = \frac{\Delta d}{v} = \frac{20}{10} = \underline{2.0\ s}$$

How high is tower? $\Delta d_y = ?$

Now I know $t = 2.0$ s

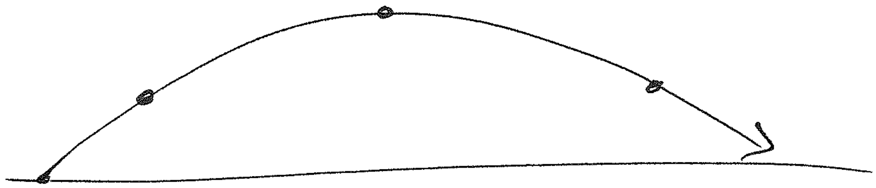
$$\therefore d = \cancel{v_1 t}^{\,0} + \tfrac{1}{2} a t^2$$

$$d = 0 + \tfrac{1}{2}(-9.8)(2)(2) = -19.6 \text{ m [up]}$$

$\therefore$ ball travels 20 m [down]

$\therefore$ tower is $\underline{20 \text{ m tall}}$

4



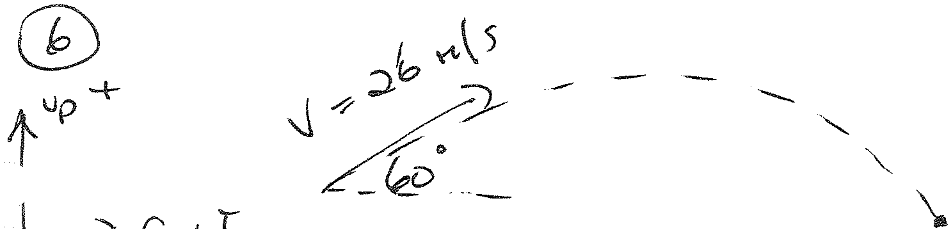
(x) acceleration horizontally → is considered zero.

no air friction is assumed.

$\therefore v = \frac{\Delta d}{t}$

(y) acceleration everywhere is $-9.8\ m/s^2$ [up]

6



$\Delta d_y = 0\,m$

26 m/s, 60°

$V_{1y} = (\sin 60)(26) = \underline{22.5\ m/s}$ [up]

$V_x = (\cos 60)(26) = \underline{13\ m/s}$ [fwd]

This question is about ↕ vertical trip.

$\therefore$ y

$V_1 = 22.5\ m/s$

$a = -9.8\ m/s^2$

$V_2 = 0$

$d = ?$

(2) max height

(1)

$\cancel{V_2^2} = V_1^2 + 2ad$

$0 = (22.5)(22.5) + 2(-9.8)d$

$-506.25 = -19.8\,d$

$\Delta d = 26\ m$ [up]

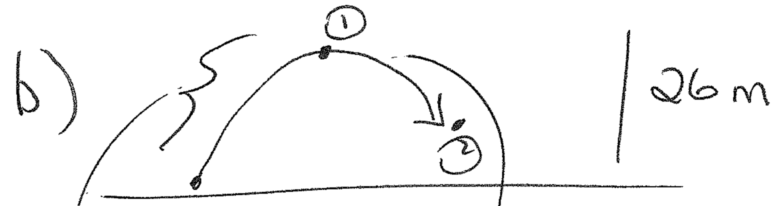
$t = ?$

$a = \frac{\cancel{V_2} - V_1}{t}$

$t = -22.5 / -9.8$

$t = 2.3\,s$ to reach max height

b)



$t = 2.3$ s. $\quad t = ?$ well $V_1 = 0$

$a = -9.8$ m/s^2

$\Delta d = -\left(\frac{26}{3}\right) = -13$

$t = ?$

$\therefore d = \cancel{v_1}^{0} t + \frac{1}{2} a t^2$

$-13 = \frac{1}{2}(-9.8) t^2$

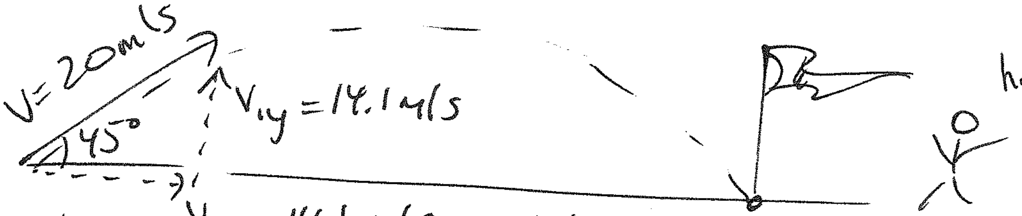
$-13 = -4.9 t^2$

$t = 1.6$ s

2.3 s $\quad$ 1.6 s

$\therefore$ Takes $2.3 + 1.6 = \underline{3.9 \text{ s}}$

7



use trig. $\quad \Delta d_x = ?$

Find time in 'y' plane 1st

$a = -9.8$ m/s^2

$V_1 = 14.1$ m/s

$\Delta d = 0$

$t = ?$

$\cancel{d}^{0} = v_1 t + \frac{1}{2} a t^2$

$-14.1 t = -4.9 t^2$

$t = \underline{1.70 \text{ s}}$

$\therefore d_x = ?$

$d_x = V_x t$

$= (14.1)(1.7)$

$d_x = \underline{24 \text{ m}}$

Max height? Δd_y

1 2

$V_{1y} = 14.1$ m/s

$a = -9.8$ m/s^2

$V_2 = 0$

$\Delta d = ?$

$\cancel{V_2^2}^{0} = V_1^2 + 2ad$

$0 = (14.1)(14.1) + 2(-9.8) d$

$\underline{d_y = 10 \text{ m}}$ Max height