A1

A. Motion Terminology

1. a) $\Delta d = 700\,m + 1200\,m$
$= 1900\,m$

b) $\Delta\vec{d} = 700\,m[E] + 1200\,m[W]$
$= -700\,m[W] + 1200\,m[W]$
$= 500\,m[W]$

c) $35\,min \xrightarrow{\times 60\,s/min} 2100\,s$

$v = \frac{1900\,m}{2100\,s}$
$= 0.90\,m/s$

d) $\vec{v} = \frac{500\,m[W]}{2100\,s}$
$= 0.24\,m/s\,[W]$

2. a) $\Delta d = 1000\,m + 1000\,m$
$= 2000\,m$

b) $\Delta\vec{d} = 1000\,m[W] + 1000\,m[E]$
$= -1000\,m[E] + 1000\,m[E]$
$= 0\,m[E]$

3. $\Delta t = \frac{\Delta d}{v}$
$= \frac{128\,cm}{4.0\,cm/min}$
$= 32\,min$

Hilroy

A2

4. $\vec{v} = \frac{862m[E]}{240s}$ $4.0min = 240s$

$= 3.6 m/s [E]$

5. a) $\Delta\vec{d} = 70.0m[W] + 30.0m[E] + 30.0m[W]$

$= 70.0m[W] - 30.0m[W] + 30.0m[W]$

$= 70.0m[W]$

$\vec{v} = \frac{\Delta\vec{d}}{\Delta t}$ $8.0min = 480s$

$= \frac{70.0m[W]}{480s}$

$= 0.146 m/s [W]$

b) $\Delta d = 70.0m + 30.0m + 30.0m$

$= 130.0m$

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

$= \frac{130.0m}{}$

(B1)

B. 1D Motion and Motion Graphs

1. a) bc and de (Hint: an object will have an acceleration if it is speeding up OR slowing down)

b) ab and ef

c) fg

d) $\Delta\vec{d} = \vec{d}_{25} - \vec{d}_{10}$
$= 40m[N] - 10m[N]$
$= 30m[N]$

e) (i) $0\,m/s\,[N]$

(ii) $\vec{v}_{av} = \dfrac{40-10}{25-10}$
$= 2\,m/s\,[N]$

(iii) $\vec{v}_{av} = \dfrac{50-40}{40-25}$
$= 0.67\,m/s\,[N]$

(iv) $\vec{v}_{av} = \dfrac{60-50}{55-40}$
$= 0.67\,m/s\,[N]$

(v) $0\,m/s\,[N]$

(vi) $\vec{v}_{av} = \dfrac{30-60}{75-65}$
$= -3\,m/s\,[N]$ or $3\,m/s\,[S]$

f) $\vec{v}_{inst} = \dfrac{25-10}{25-15}$
$= 1.5\,m/s\,[N]$

tangent should be drawn on graph

Answers may vary

(B2)

2. a) a (section a is the only segment that starts at a point with a y-coordinate of 0 m/s [E])

b) c

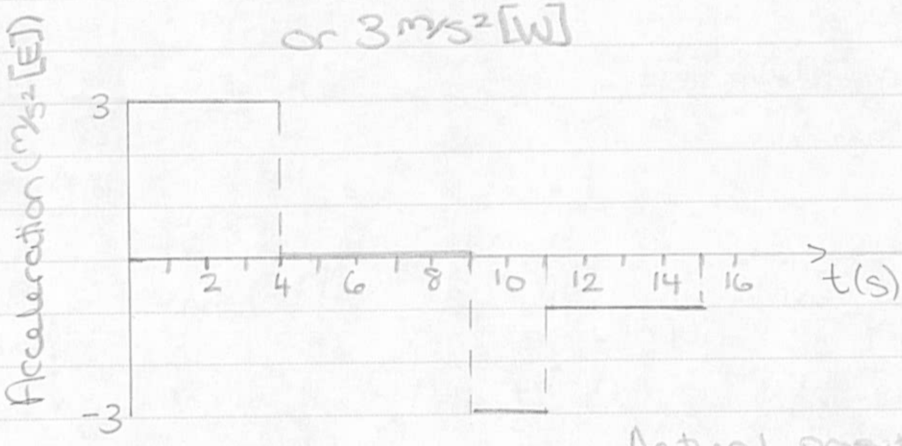
c) (i) $\vec{a}_{av} = \frac{12-0}{4-0}$
$= 3\ m/s^2\ [E]$

(ii) $\vec{a}_{av} = 0\ m/s^2\ [E]$

(iii) $\vec{a}_{av} = \frac{6-12}{11-9}$
$= -3\ m/s^2\ [E]$
or $3\ m/s^2\ [W]$

(iv) $\vec{a}_{av} = \frac{10-6}{15-11}$
$= 1\ m/s^2\ [E]$

d)



e) (i) $\Delta d_A = \frac{1}{2}(4)(12)$
$= 24\ m\ [E]$

(ii) $\Delta d_B = (5)(12)$
$= 60\ m\ [E]$

(iii) $\Delta d_C = \frac{1}{2}(12+6)(2)$
$= 18\ m\ [E]$

(iv) $\Delta d_D = \frac{1}{2}(6+10)(4)$
$= 32\ m\ [E]$

Actual position req'd for f.

$d_A = 0 + \Delta d_A$
$= 24\ m\ [E]$

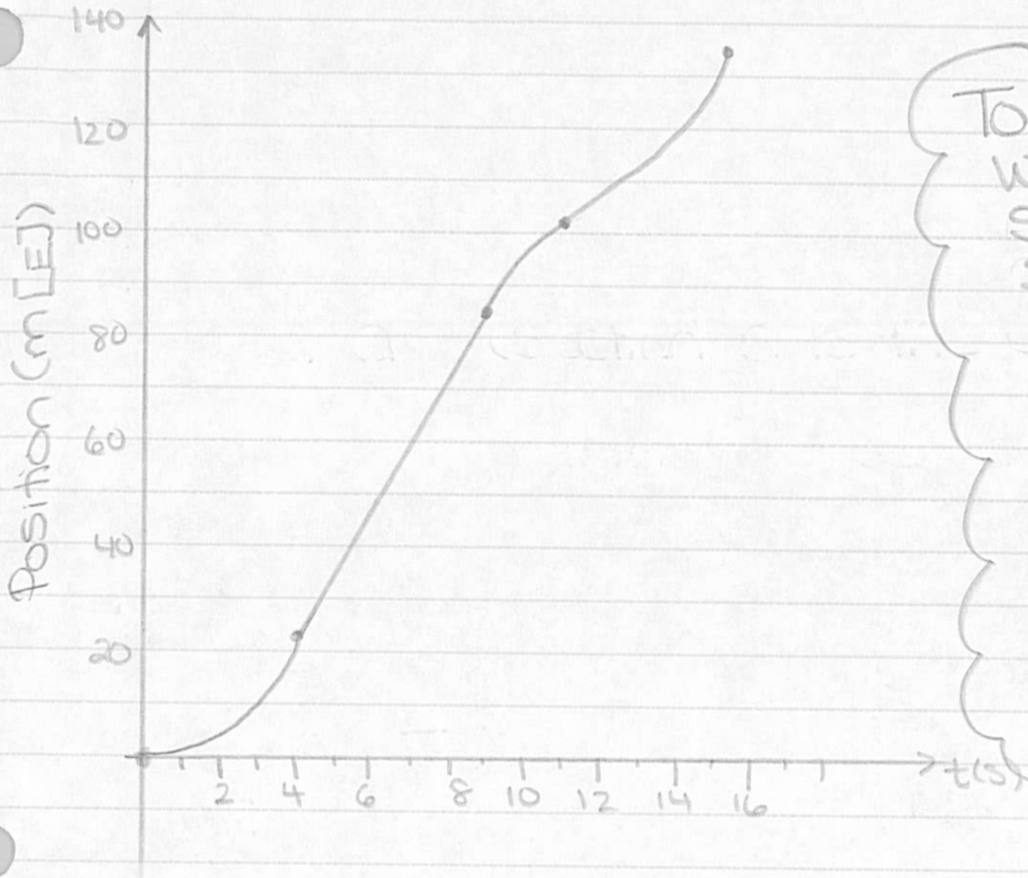
$d_B = 24\ m\ [E] + \Delta d_B$
$= 84\ m\ [E]$

$d_C = 84\ m\ [E] + \Delta d_C$
$= 102\ m\ [E]$

$d_D = 102\ m\ [E] + \Delta d_D$
$= 134\ m\ [E]$

B3

f)



To determine whether segments should be straight or curved, consider acceleration.

no acceleration
→ straight

constant acceleration (nonzero)
→ curved

C. Equations of Uniform Acceleration

1. $\vec{v}_i = 0\ m/s\ [f]$
   $\vec{v}_f = 150\ m/s\ [f]$
   $\Delta t = 0.040\ s$
   $\vec{a} = ?$

   $\vec{v}_f = \vec{v}_i + \vec{a}\Delta t$
   $150 = 0 + a(0.040)$
   $\vec{a} = 3750\ m/s^2\ [f]$

2. $\vec{v}_i = 25.0\ m/s\ [S]$
   $\vec{a} = 1.20\ m/s^2\ [S]$
   $\Delta t = 3.00\ s$
   $\vec{v}_f = ?$

   $v_f = v_i + a\Delta t$
   $= 25.0 + 1.20(3.00)$
   $= 28.6\ m/s\ [S]$

3. $v_i = 25.0\ m/s\ [S]$
   $a = 3.50\ m/s^2\ [N]$
   $= -3.50\ m/s^2\ [S]$
   $\Delta t = 3.00\ s$
   $v_f = ?$

   $v_f = v_i + a\Delta t$
   $= 25.0 + (-3.50)(3.00)$
   $= 14.5\ m/s\ [S]$

4. $\Delta d = 33\ cm\ [f]$
   $= 0.33\ m\ [f]$
   $v_f = 0\ m/s\ [f]$
   $\Delta t = 0.0020\ s$
   $v_i = ?$

   $\Delta d = \left(\frac{v_i + v_f}{2}\right)\Delta t$
   $0.33 = \left(\frac{v_i + 0}{2}\right)(0.0020)$
   $v_i = 330\ m/s\ [f]$

C2

5. $v_i = 0\ m/s\ [d]$
$a_y = 9.8\ m/s^2\ [d]$
$\Delta d_y = 20.0\ m\ [d]$

a) $\Delta t = ?$
$\Delta d_y = v_{iy}\Delta t + \frac{1}{2}a\Delta t^2$
$20.0 = 0\Delta t + \frac{1}{2}(9.8)\Delta t^2$
$\Delta t = 2.0203\ s$

b) If $t = 0.50\ s$, $v_f = ?$
$v_f = v_i + a\Delta t$
$= 0 + (9.8)(0.50)$
$= 4.9\ m/s\ [d]$

6. Car $v_i = 0\ m/s\ [E]$
$a = 3.1\ m/s^2\ [E]$ uniform acceleration

Truck $v = 15\ m/s\ [E]$ uniform motion
($d = v\Delta t$)

a) At $t = 2.0\ s$
Car: $\Delta d = 0(2.0) + \frac{1}{2}(3.1)(2.0)^2$
$= 6.2\ m$

Truck: $\Delta d_T = (15)(2.0)$
$= 30.\ m$

At $t = 8.0\ s$
Car: $\Delta d_C = 0(8.0) + \frac{1}{2}(3.1)(8.0)^2$
$= 99.2\ m$

$\Delta d_T = (15)(8)$
$= 120\ m$

C3

b)

$$\Delta d_c = \Delta d_T$$

$$0\Delta t + \frac{1}{2}(3.1)\Delta t^2 = 15\Delta t$$

$$1.55\Delta t^2 = 15\Delta t$$

$$1.55\Delta t^2 - 15\Delta t = 0$$

$$\Delta t(1.55\Delta t - 15) = 0$$

$\Delta t = 0$ or $1.55\Delta t - 15 = 0$

$$\Delta t = 9.6774$$

∴ the vehicles will pass eachother after ~9.7 s.

c) Can use car OR truck because the displacement will be the same.

Car:

$$\Delta d = 0(9.6774) + \frac{1}{2}(3.1)(9.6774)^2$$
$$= 145.1607 \text{ m}$$

Truck

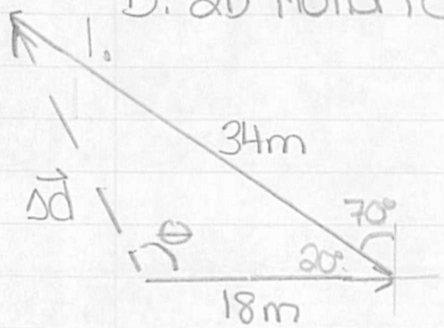
$$\Delta d = (15)(9.6774)$$
$$= 145.1610 \text{ m}$$

∴ they will pass eachother ~1.5×10^2 m in front of the traffic light.

(D1)

D. 2D Motion and Methods for Vector Algebra

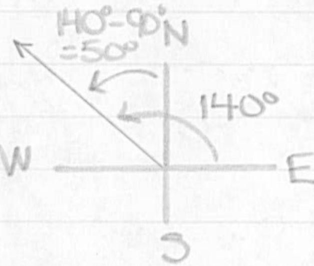
1.



$$\Delta d^2 = 18^2 + 34^2 - 2(18)(34)\cos 20°$$
$$= 329.8162$$
$$\Delta d = 18.1808\text{ m}$$

$$34^2 = 18^2 + 18.1808^2 - 2(18)(18.1808)\cos\theta$$
$$1156 = 654.5415 - 654.5088\cos\theta$$
$$\theta = 140°$$

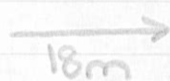
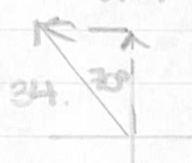
Let's look at our angle:

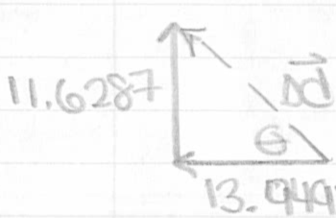


Will give related acute angle if using sine law (ambiguous)

∴ the displacement is ~18 m [N50°W]

OR

Sketch	x comp	y comp
	18 m[E]	0m[N]
	$34\sin 70°$ $= 31.9495\text{m}[W]$	$34\cos 70°$ $= 11.6287\text{ m}[N]$
Total	13.9495m[W]	11.6287m[N]



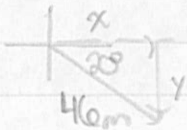
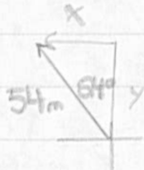
$$\Delta d = \sqrt{13.9495^2 + 11.6287^2}$$
$$= 18.1608$$

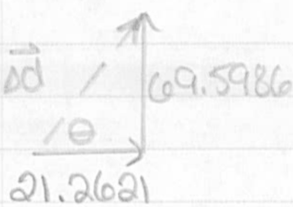
slightly different due to rounding

$$\theta = \tan^{-1}\left(\frac{11.6287}{13.9495}\right)$$
$$= 39.8155°$$

∴ displacement is ~18 m [W40°N] (or [N50°W])

2.

Sketch	x comp	y comp
	$46\cos 20°$ $= 43.2259\text{m}[E]$	$46\sin 20°$ $= 15.7329\text{m}[S]$
	$54\sin 24°$ $= 21.9638\text{m}[W]$	$54\cos 24°$ $= 49.3315\text{m}[N]$
	$0\text{m}[E]$	$36\text{m}[N]$
Total	$21.2621\text{m}[E]$	$69.5986\text{m}[N]$



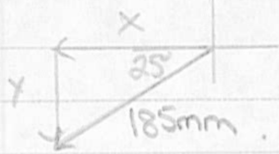
$\Delta d = \sqrt{69.5986^2 + 21.2621^2}$
$= 72.7739$

$\theta = \tan^{-1}\left(\frac{69.5986}{21.2621}\right)$
$= 73.0123°$

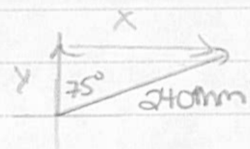
∴ the displacement is 73 m [E 73° N]

(D3)

3. a) Sketch | xcomp | ycomp

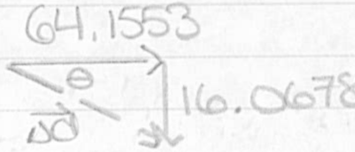


$185\cos 25°$ $= 167.6669\,mm\,[W]$ | $185\sin 25°$ $= 78.1844\,mm\,[S]$



$240\sin 75°$ $= 231.8222\,mm\,[E]$ | $240\cos 75°$ $= 62.1166\,mm\,[N]$

Total $64.1553\,mm\,[E]$ $16.0678\,mm\,[S]$



$\Delta d = \sqrt{64.1553^2 + 16.0678^2}$
$= 66.1368\,mm$

$\theta = \tan^{-1}\left(\frac{16.0678}{64.1553}\right)$
$= 14.0606°$

∴ the displacement of the snail is ~66mm [E14°S]

b) $\vec{v}_{av} = \frac{\Delta \vec{d}}{\Delta t}$

$= \frac{66.1368\,mm\,[E14°S]}{14\,s}$

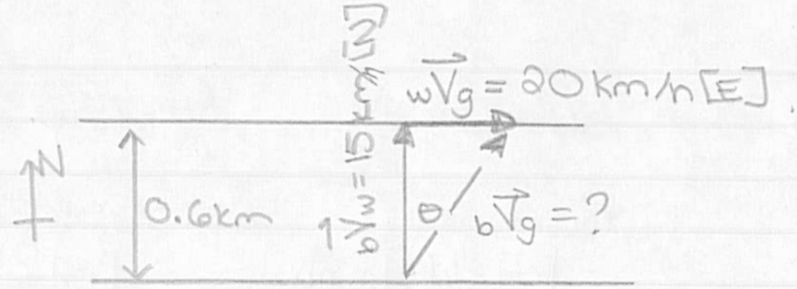
$= 4.7241\,mm/s\,[E14°S]$

∴ the snail's average velocity is ~4.7 mm/s [E14°S]

Hilroy

D4

4.



a) Using vertical values

$$\Delta \vec{v} = \frac{\Delta \vec{d}}{\Delta t} \rightarrow \Delta t = \frac{\Delta \vec{d}}{\vec{v}}$$

$$\Delta t = \frac{0.6\ km\ [N]}{15\ km/h\ [N]}$$
$$= 0.04\ h\ [N]$$

b) Using horizontal values:

$$\Delta d = v \Delta t$$
$$= (20\ km/h\ [E])(0.04\ h)$$
$$= 0.8\ km\ [E]$$

c) $|{}_b\vec{V}_g| = \sqrt{15^2 + 20^2}$
$= 25\ km/h$

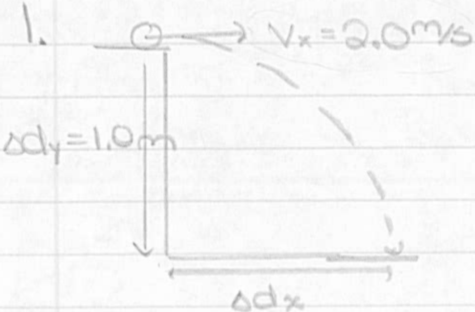
$$\theta = \tan^{-1}\left(\frac{20}{15}\right)$$
$$= 53^\circ$$

$\therefore$ the boat's resultant velocity is 25km/h [N53°E]

E1

E. Projectile Motion

1.



x comp	y comp
$v_x = 2.0$ m/s [f]	$v_{iy} = 0$ m/s [d]
$\Delta d_x = ?$	$a_y = 9.8$ m/s² [d]
$\Delta t = ?$	$\Delta d_y = 1.0$ m [d]
	$\Delta t = ?$
	$v_{fy} = ?$

$\Delta d_y = v_{iy}\Delta t + \frac{1}{2}a\Delta t^2$
$1.0 = 0\Delta t + \frac{1}{2}(9.8)\Delta t^2$
$\Delta t = 0.4518$ s

$\Delta d_x = (2.0)(0.4518)$
$= 0.9035$ m

∴ it will land 0.90 m in front of the table.

2.

x comp	y comp
N/A	$v_{iy} = 325$ m/s [up]
	$a_y = 9.8$ m/s² [d]

a) $v_{fy} = 0$ m/s [u]
$\Delta d_y = ?$

$v_{fy}^2 = v_{iy}^2 + 2a\Delta d_y$
$0^2 = 325^2 + 2(-9.8)\Delta d_y$
$\Delta d = 5389.0306$ m

∴ it will rise 5389 m above the 2.4 m from which it was launched.

b) $a_y = 9.8$ m/s² [down]

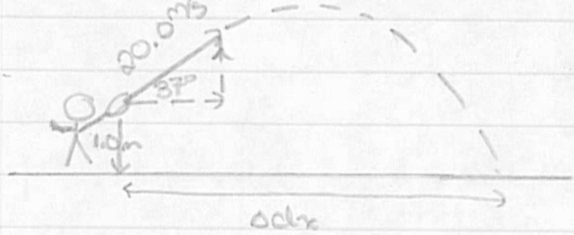
c) $-2.4 = 325\Delta t + \frac{1}{2}(-9.8)\Delta t^2$
$\Delta t = -0.007384$ or 66.3339 s

d) $v_{fy} = v_f$ since there is no x-component

$v_f^2 = 325^2 + 2(-9.8)(-2.4)$
$v_f = 325.0633$

∴ final velocity is $\approx 3.3 \times 10^2$ m/s [down].

3.



x comp

$V_x = 20\cos 37°$

$= 15.9727$ m/s [f]

$\Delta d_x = ?$

$\Delta t = ?$

y comp

$V_{iy} = 20\sin 37°$

$= 12.0363$ m/s [u]

$a_y = 9.8$ m/s² [d]

$\Delta d_y = 1.0$ m [d]

$V_{fy} = ?$

$\Delta t = ?$

a) $\Delta d_y = V_{iy}\Delta t + \frac{1}{2}a\Delta t^2$

$1.0 = -12.0363\Delta t + \frac{1}{2}(9.8)\Delta t^2$

$\Delta t = 2.5368$ s or -0.0804 s

∴ it will be in the air for 2.5 s

b) $\Delta d_x = (15.9727)(2.5368)$

$= 40.5195$

∴ It will travel ~41 m [forward]

c) @ max height $V_{fy} = 0$ m/s [up]

$V_{iy} = 12.0363$ m/s [u]

$a_y = 9.8$ m/s² [d]

$\Delta d_{ymax} = ?$

$V_{fy}^2 = V_{iy}^2 + 2a_y\Delta d_{ymax}$

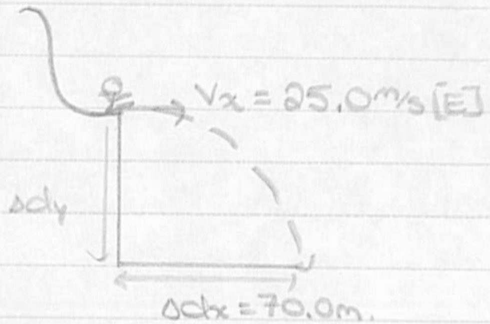
$0^2 = 12.0363^2 + 2(-9.8)\Delta d_{max}$

$\Delta d_{ymax} = 7.3915$

∴ the max height is 7.4 m.

E3

4.



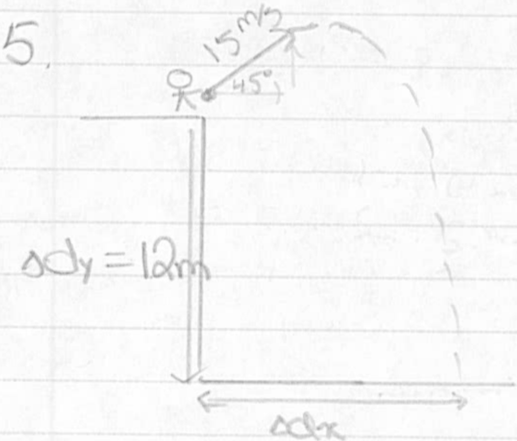
x comp	y comp
$v_x = 25.0 m/s [E]$	$v_{1y} = 0 m/s [d]$
$d_x = 70.0 m [E]$	$a_y = 9.8 m/s^2 [d]$
$\Delta t = ?$	$\Delta d_y = ?$
	$\Delta t = ?$
	$v_{fy} = ?$

$$\Delta t = \frac{d_x}{v_x} = \frac{70.0}{25.0} = 2.80 s$$

$$\Delta d_y = v_{1y}\Delta t + \frac{1}{2}a\Delta t^2 = 0(2.80) + \frac{1}{2}(9.8)(2.80)^2 = 38.416$$

∴ the ramp was 38.4m above the ground.

5.



x comp	y comp
$v_x = 15\cos 45°$	$v_{1y} = 15\sin 45°$
$= 10.6066 m/s [E]$	$= 10.6066 m/s [up]$
$\Delta d_x = ?$	$a_y = 9.8 m/s^2 [d]$
$\Delta t = ?$	$\Delta d_y = 12 m [d]$
	$v_{fy} = ?$
	$\Delta t = ?$

a) $\Delta d_y = v_{1y}\Delta t + \frac{1}{2}a\Delta t^2$

$12 = (-10.6066)\Delta t + \frac{1}{2}(9.8)\Delta t^2$

$\Delta t = 2.9850 s$ or $-0.8204 s$

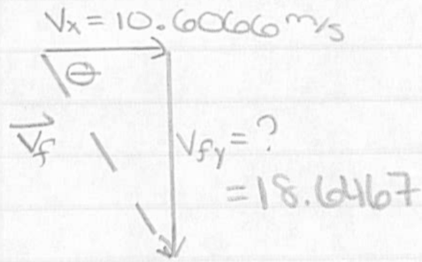
∴ it will be in the air for ~3.0s.

Hilroy

b) $\Delta d_x = (10.60606)(2.9850)$
$= 31.66607$

∴ it will land ~32m in front of the cliff.

c) $\vec{v}_f = \vec{v}_x + \vec{v}_{fy}$



$$V_{fy}^2 = V_{iy}^2 + 2a_y\Delta d_y$$
$$= (-10.6066)^2 + 2(9.8)(12)$$
$$= 347.6999$$
$$V_{fy} = 18.6467 \text{ m/s [d]}$$

$$V_f = \sqrt{10.60606^2 + 18.6467}$$
$$= 21.4522 \text{ m/s}$$

$$\theta = \tan^{-1}\left(\frac{18.6467}{10.6066}\right)$$
$$= 60.3680^\circ$$

∴ the final velocity is ~21 m/s [60° below horizontal]