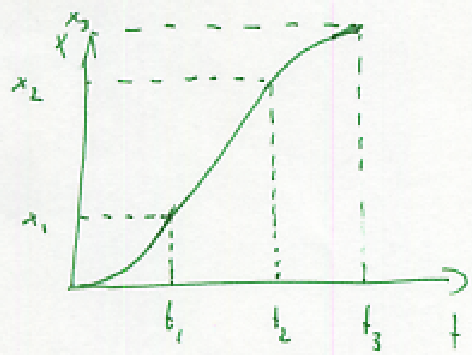
Chapter 2

Total 24.5

30 :



(a) $v = at$

$20\,m/s = 2.0\,\frac{m}{s^2} \cdot t_1 \quad \rightarrow \quad t_1 = 10\,s$

$\rightarrow \quad t_3 = 10\,s + 20\,s + 5.0\,s = 35\,s$

(b) $x_1 = \frac{1}{2} a\, t_1^{\,2} = \frac{1}{2} \cdot 2.0\,\frac{m}{s^2} \cdot (10\,s)^2 = 100\,m$ (Phase I)

$\Delta x_{12} = 20\,\frac{m}{s} \cdot 20\,s = 400\,m$ (Phase II)

$0 = 20\,\frac{m}{s} + a_{stop} \cdot 5.0\,s$ (Phase III)

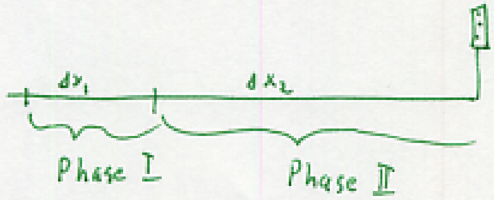
$\rightarrow \quad a_{stop} = -4.0\,\frac{m}{s^2}$

$\Delta x_{23} = 20\,\frac{m}{s} \cdot 5.0\,s - \frac{1}{2} \cdot 4.0\,\frac{m}{s^2} \cdot (5.0\,s)^2 = 50\,m$

$\rightarrow \quad x_3 = 100\,m + 400\,m + 50\,m = 550\,m.$

$\rightarrow \quad \bar{v} = \frac{x_3}{t_3} = \frac{550\,m}{35\,s} = 16\,\frac{m}{s}.$

41. 1



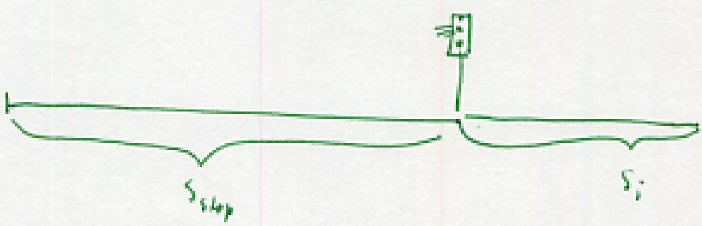
$\Delta x_1 = v_0 \cdot t_r$

$0^2 = v_0^2 + 2a\Delta x_2$

$\rightarrow \Delta x_2 = -\frac{v_0^2}{2a}$

$\rightarrow S_{stop} = \Delta x_1 + \Delta x_2 = v_0 t_r - \frac{v_0^2}{2a}$

42. 1



$S_{stop} + S_i = v_0 \cdot t_{yellow}$

$\rightarrow t_{yellow} = \frac{S_{stop} + S_i}{v_0} = t_r - \frac{v_0}{2a} + \frac{S_i}{v_0}$

0.5

45.

$v_f = 0$

$\Delta y = 7.5\,m$

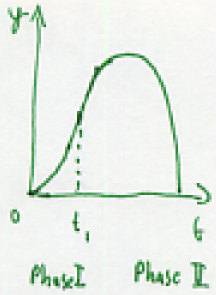
$\rightarrow 0 = v_0^2 - 2g\Delta y$

$v_0^2 = 2g\Delta y = 2 \cdot 9.8\,\frac{m}{s^2} \cdot 7.5\,m$

$\rightarrow v_0 = 12\,\frac{m}{s}$

49.

1.5



(a) Phase I:

$$v_f^2 = v_i^2 + 2a\Delta y = \left(50.0\frac{m}{s}\right)^2 + 2 \cdot 2.00\frac{m}{s^2} \cdot 150\,m$$

$$v_f = 55.68\,\frac{m}{s}$$

Phase II:

$$v_i = 55.68\,\frac{m}{s}$$

$$v_f = 0$$

$$0 = v_i^2 - 2g\Delta y$$

$$\rightarrow \Delta y = \frac{v_i^2}{2g} = \frac{3100\,\frac{m^2}{s^2}}{2 \cdot 9.8\frac{m}{s^2}} = 158\,m$$

→ Maximum height $150m + 158m = 308m$

(b) Phase I:

$$v_f = v_i + a\Delta t_I$$

$$\Delta t_I = \frac{v_f - v_i}{a} = 2.84\,s$$

Phase II:

$$v_f = v_i - g\Delta t_{II}$$

$$\Delta t_{II} = \frac{v_i}{g} = 5.68\,s$$

→ time to reach max. height $5.68\,s + 2.84\,s = 8.52\,s$

(c) Phase III:

$$-308\,m = -\frac{1}{2}g\Delta t_{III}^2$$

$$\Delta t_{III}^2 = \frac{2 \cdot 308\,m}{9.80\frac{m}{s^2}}$$

$$\Delta t_{III} = 7.93\,s$$

time in the air: $8.52\,s + 7.93\,s = 16.4\,s$

1.5

59. (a) $y = v_0 t - \frac{1}{2} g t^2$

$$-19.6\,m = 14.7\,\frac{m}{s} \cdot t_1 - \frac{1}{2}\, 9.80\,\frac{m}{s^2} \cdot t_1^2$$

$$t_1 = \frac{14.7 \pm \sqrt{14.7^2 + 2 \cdot 9.80 \cdot 19.6}}{9.80}\,s = \frac{14.7 + 24.5}{9.80}\,s = 4.00\,s$$

$$-19.6\,m = -14.7\,\frac{m}{s} \cdot t_2 - \frac{1}{2} \cdot 9.80\,\frac{m}{s^2} \cdot t_2^2$$

$$t_2 = \frac{-14.7 + 24.5}{9.80}\,s = 1.00\,s$$

$$\rightarrow \Delta t = t_1 - t_2 = 3.00\,s$$

(b) the two velocities are the same.

$$v_f^2 = v_i^2 - 2g\,\Delta y = \left(14.7\,\frac{m}{s}\right)^2 + 2 \cdot 9.80\,\frac{m}{s^2} \cdot 19.6\,m \; \cancel{= 24.5\,\frac{m}{s}}$$

$$\rightarrow v_f = 24.5\,\frac{m}{s}$$

(c) $y_1 = 14.7\,\frac{m}{s} \cdot 0.800\,s - \frac{1}{2} \cdot 9.80\,\frac{m}{s^2}\,(0.800\,s)^2 = 8.62\,m$

$y_2 = -14.7\,\frac{m}{s} \cdot 0.800\,s - \frac{1}{2} \cdot 9.80\,\frac{m}{s^2}\,(0.800\,s)^2 = -14.9\,m$

$$\rightarrow \Delta y = y_1 - y_2 = 23.5\,m$$

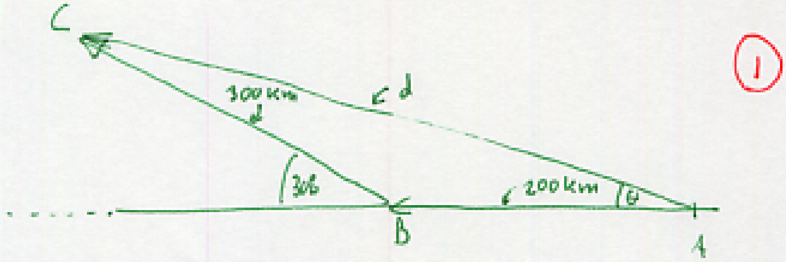
66. $-15.0\,m = -\frac{1}{2} \cdot 9.80\,\frac{m}{s^2} \cdot t_1^2 \longrightarrow t_1 = 1.749\,s$ 0.5

$-25.0\,m = -\frac{1}{2} \cdot 9.80\,\frac{m}{s^2} \cdot t_2^2 \longrightarrow t_2 = 2.258\,s$

$$\rightarrow \Delta t = t_2 - t_1 = 0.509\,s$$

Chapter 3

2. (a)



$d^2 = \sqrt{x^2+y^2}$

$x = 200\text{ km} + 300\text{ km} \cos 30.0° = 459.8\text{ km}$

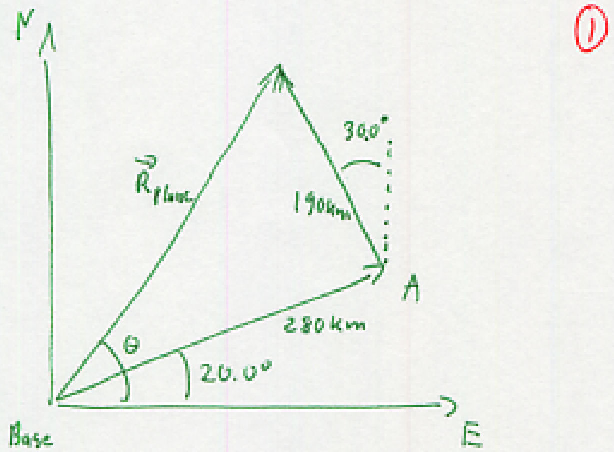
$y = 300\text{ km} \cdot \sin 30.0° = 150\text{ km}$

$\rightarrow d = 484\text{ km}.$

(b) $\tan\theta = \frac{y}{x}$

$\theta = 18.1°$ N of W.

5.



$R_{p/x} = 280\text{ km} \cdot \cos 20.0° - 190\text{ km} \cdot \sin 30.0° = 168\text{ km}$

$R_{p/y} = 280\text{ km} \cdot \sin 20.0° + 190\text{ km} \cdot \cos 30.0° = 260\text{ km}$

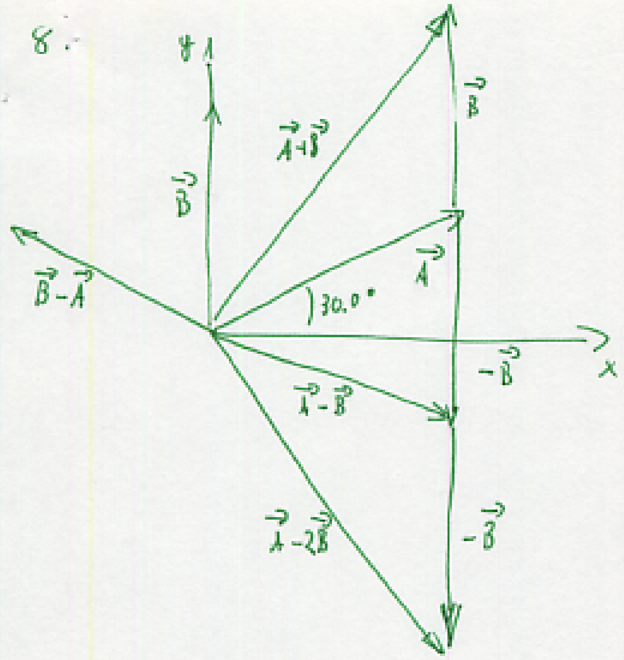
$\rightarrow R_p = 310\text{ km}$

$\tan\theta = \frac{260}{168}$

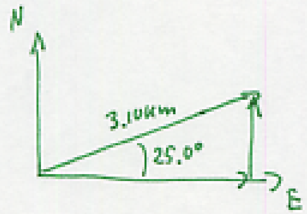
$\rightarrow \theta = 57°$ N of E

→ Dist. from Lake B to the base is 310 km
dir. from Lake B of the base is 57° S of W.

8. 1



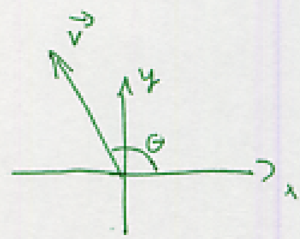
10. 0.5



$D_x = 3.10\,\text{km} \cdot \cos 25.0° = 2.81\,\text{km}$ E

$D_y = 3.10\,\text{km} \cdot \sin 25.0° = 1.31\,\text{km}$ N

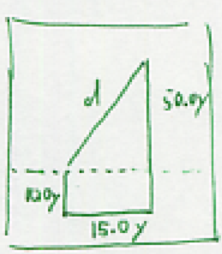
13. $\vec{v} = (-25.0, 40.0)$ 0.5



$v = \sqrt{25.0^2 + 40.0^2} = 47.2$ units

$\tan\theta = \dfrac{40.0}{-25.0} \rightarrow \theta = -58.0° + 180° = 122°.$

14. 0.5

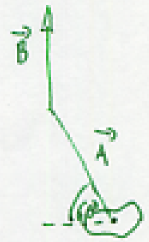


$d_x = 15.0\,y$

$d_y = -10.0\,y + 50.0\,y = 40.0\,y$

$\rightarrow d = \sqrt{d_x^2 + d_y^2} = 42.7\,y.$

15.



0.5

$$\vec{A} = 3h \cdot \left(-41.0\,\tfrac{km}{h}\cos 60°,\ 41.0\,\tfrac{km}{h}\sin 60°\right) = (-61.5\,km,\ 106\,km)$$

$$\vec{B} = 1.50h \cdot \left(0,\ 25.0\,\tfrac{km}{h}\right) = (0,\ 37.5\,km)$$

$$\rightarrow \vec{R} = \vec{A} + \vec{B} = (-61.5\,km,\ 144\,km)$$

$$\rightarrow R = 157\,km$$

17. 1

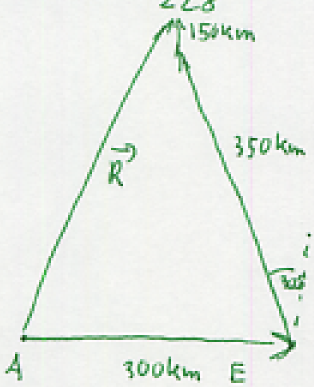
$$R_x = 175\,km \cdot \cos 30.0° - 150\,km \cdot \sin 20.0° - 190\,km = -89.7\,km$$

$$R_y = 175\,km \cdot \sin 30.0° + 150\,km \cdot \cos 20.0° + 0 = 228\,km$$

$$\rightarrow R = 245\,km$$

$$\tan\theta = \frac{89.7}{228} \rightarrow \theta = 21.5°\ W\ of\ N$$

20.



1

$$R_x = 300\,km - 350\,km \cdot \sin 30° + 0 = \cancel{475\,km}\ \ 125\,km$$

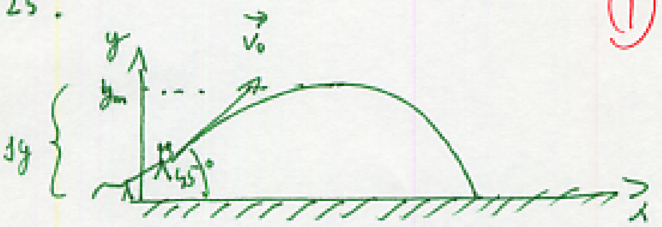
$$R_y = 0 + 350\,km \cdot \cos 30° + 150\,km = 453\,km$$

(a) $\tan\theta = \frac{125\,km}{453\,km} \rightarrow \theta = 15.4°\ E\ of\ N$

(b) $R = 470\,km$.

Chapter 3

25. 1



$\vec{V}_0 = (v_0 \cos 45°, \; v_0 \sin 45°)$

$v_{0/y} = v_0 \sin 45°$

$V_{t/y}^2 = v_{0/y}^2 - 2g\Delta y$

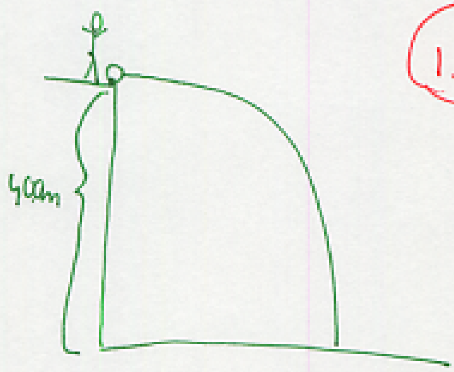
$v_{0/y}^2 = 2g\Delta y$

$v_0^2 \underbrace{\sin^2 45°}_{\frac{1}{2}} = 2g\Delta y$

$v_0^2 = 4g\Delta y = 4 \cdot 9.80 \frac{m}{s^2} \cdot 12 ft \cdot \frac{1m}{3.281 ft} = 143 \frac{m^2}{s^2}$

$v_0 \approx 12 \frac{m}{s}$

34. 1.5



1st Phase (Ball falls off the cliff)

y-component:

$-40.0m = -\frac{1}{2} g t_1^2$

$\rightarrow t_1^2 = \frac{2 \cdot 40.0m}{9.80 \frac{m}{s^2}}$

$\rightarrow t_1 = 2.857 s \approx 2.86 s$

x-component

$x = v_0 t_1$ (x and v_0 unknown)

$\rightarrow$ need to determine x first!

Phase II (Sound is travelling)

$$v_s \cdot t_2 = \sqrt{y^2 + x^2}$$

$$v_s \cdot (3.00s - t_1) = \sqrt{y^2 + x^2}$$

$$\rightarrow \sqrt{x^2+y^2} = 343\,\frac{m}{s} \cdot (3.00s - 2.86s) = 48.02\,m \approx 48.0\,m \qquad (\text{alt. } 49.2\,m)$$

$$x^2 = (48.0\,m)^2 - (40.0\,m)^2$$

$$\rightarrow x = 26.6\,m \qquad (\text{alt. } 28.6\,m)$$

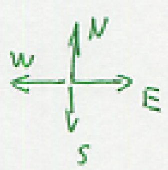
Insert this into the x-component of the 1st Phase:

$$26.6\,m = v_0 \cdot 2.86\,s$$

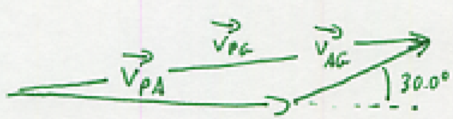
$$\rightarrow v_0 = 9.30\,\frac{m}{s} \qquad (\text{alt. } 10.0\,\frac{m}{s})$$

(This problem is very sensitive to rounding the intermediate results. Strictly, the final result should be given to one digit, but 3 digits is also ok.)

35.



1



$$\vec{v}_{PA} = (300\,\frac{mi}{h}, 0)$$

$$\vec{v}_{AG} = (100\,\frac{mi}{h} \cdot \cos 30.0°, 100\,\frac{mi}{h} \cdot \sin 30.0°)$$

$$\rightarrow \vec{v}_{PG} = \vec{v}_{PA} + \vec{v}_{AG} = (300\,\frac{mi}{h} + 100\,\frac{mi}{h} \cdot \cos 30.0°, 100\,\frac{mi}{h} \cdot \sin 30.0°) =$$

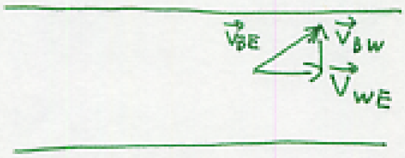
$$= (386.6\,\frac{mi}{h}, 50.0\,\frac{mi}{h})$$

$$v_{PG} = \sqrt{(386.6\,\frac{mi}{h})^2 + (50.0\,\frac{mi}{h})^2} = 390\,\frac{mi}{h}$$

$$\tan\theta = \frac{50.0}{386.6} \quad \rightarrow \theta = 7.37° \text{ N of E}$$

38.

1



(a) $\vec{V}_{BE} = \vec{V}_{BW} + \vec{V}_{WE}$

$\vec{V}_{BW} = (0,\ 10.0\,\frac{m}{s})$

$\vec{V}_{WE} = (1.50\,\frac{m}{s},\ 0)$

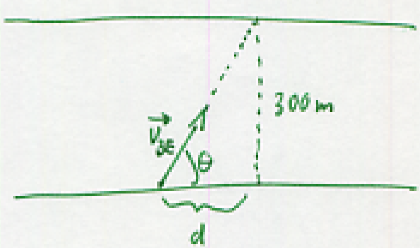
$\rightarrow \vec{V}_{BE} = (1.50\,\frac{m}{s},\ 10.0\,\frac{m}{s})$

$V_{BE} = \sqrt{(1.50\,\frac{m}{s})^2 + (10.0\,\frac{m}{s})^2} = 10.1\,\frac{m}{s}$

$\tan\theta = \frac{10.0}{1.50}$

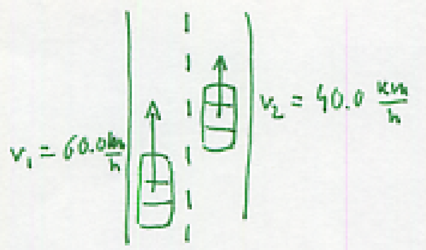
$\rightarrow \theta = 81.5°$ N of E

(b)



$d = \frac{300\,m}{\tan\theta} = \frac{300\,m \cdot 1.50\,\frac{m}{s}}{10.0\,\frac{m}{s}} = 45.0\ m.$

41.



1

$$V_{12} = V_1 - V_2 = 20.0\,\frac{km}{h}$$ (relative velocity of the two cars)

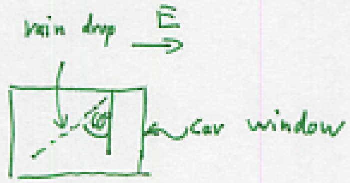
$$V_{12} = 20.0\,\frac{km}{h} \cdot \frac{1000\,m}{km} \cdot \frac{h}{3600\,s} = 5.56\,\frac{m}{s}$$

$$\Delta x = 100\,m$$

$$\Delta x = V_{12} \cdot t$$

$$t = \frac{\Delta x}{V_{12}} = 18.0\,s$$

45.



1

$$\vec{V}_{RC} = (-V_{RC} \cdot \sin 60.0^\circ,\ -V_{RC} \cos 60.0^\circ)$$

$$\vec{V}_{RG} = (0,\ -V_{RG})$$

$$\vec{V}_{CG} = (50.0\,\frac{km}{h},\ 0)$$

$$\vec{V}_{RG} = \vec{V}_{RC} + \vec{V}_{CG}$$

$$\rightarrow \quad 0 = -V_{RC} \cdot \sin 60.0^\circ + 50.0\,\frac{km}{h}$$ (x-comp.)

$$\rightarrow \quad V_{RC} = \frac{50.0\,\frac{km}{h}}{\sin 60.0^\circ} = 57.7\,\frac{km}{h}$$ at an angle of 60° West of the vertical

$$-V_{RG} = -V_{RC} \cdot \cos 60^\circ = -\frac{50.0\,\frac{km}{h}}{\tan 60.0^\circ}$$

$$\rightarrow \quad V_{RG} = 28.9\,\frac{km}{h}$$ downward.

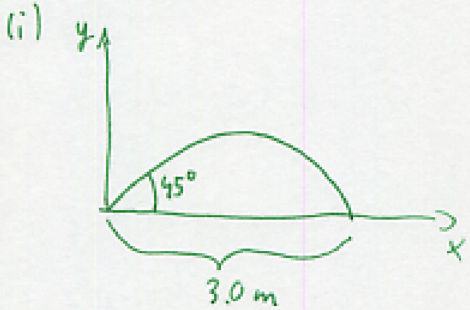
51: Divide into 3 Problems:

(i) Jump on the Earth

(ii) Jump on the Moon

(iii) Jump on the Mars

(i)



x-component:

$$x_E = v_{0/x} \cdot t = v_0 \cdot \cos 45° \cdot t = \frac{\sqrt{2}\, v_0}{2} \cdot t$$

$$\rightarrow t = \frac{2 x_E}{\sqrt{2}\, v_0}$$

y-component:

$$y = v_{0/y} \cdot t - \frac{1}{2} g t^2 = v_0 \sin 45° \cdot t - \frac{1}{2} g_E t^2$$

$$\rightarrow 0 = \frac{\sqrt{2} v_0}{2} \cdot t - \frac{1}{2} g_E t^2$$

$$\rightarrow \sqrt{2} v_0 = g_E t$$

$$\rightarrow \sqrt{2} v_0 = g_E \cdot \frac{2 x_E}{\sqrt{2} v_0}$$

$$\rightarrow v_0^2 = g_E x_E$$

(Note that this formula also works on the Moon / Mars, if we replace g_E by g_{Moon} / g_{Mars}.)

(ii) Moon:

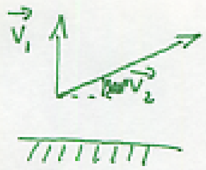
$$v_0^2 = g_{Moon} x_{Moon}$$

$$\rightarrow x_{Moon} = \frac{v_0^2}{g_{Moon}} = \frac{g_E}{g_{Moon}} x_E = 6 \cdot x_E = 18\,m.$$

(iii) Mars

$$x_{Mars} = \frac{g_E}{g_{Mars}} x_E = \frac{3.0m}{0.38} = 7.9\,m.$$

56.



1

$v_{2/y/0}$ has to be the same as $v_{1/y/0}$!

$\rightarrow$ Need to find $v_{1/y/0} = v_{1/0}$!

$$-v_{1/0} = v_{1/0} - g \cdot t$$

$$\rightarrow v_{1/0} = \frac{1}{2} g t = \frac{9.80\frac{m}{s^2} \cdot 3.00s}{2} = 14.7\frac{m}{s}$$

Determine $v_{2/0}$:

$$v_{2/y/0} = v_{2/0} \cdot \sin 30.0°$$

$$\rightarrow v_{2/0} = \frac{v_{1/0}}{\sin 30.0°} = 29.4\frac{m}{s} .$$

65.

(a) (i) $v_{IW,up} = v_{IE} - v_{WE} = \frac{0.560m}{0.800s} - (-0.500\frac{m}{s}) = 1.20\frac{m}{s}$. 1

(ii) $v_{IW,down} = 0$

(b) $\Delta x = \Delta x_1 + \Delta x_2 = 1.2\frac{m}{s} \cdot 0.800s + 0 = 0.960m$

(c) since the insect is in average in rest w.r.t. the shore,

$$\overline{v_{IW}} = -v_{WE} = -(-0.500\frac{m}{s}) = 0.500\frac{m}{s} .$$