CHAPTER FOUR

4.1 Ex. 4.1

$r_1 = (400\ km\ \hat{k}) + r_{earth} = (400 km + 6371 km)\hat{j} = 6771\ km\hat{j}$

$r_2 = 6771\ km\ @\ -45^\circ \quad r_{2x} = r\cos\theta = 4788\ km\hat{i}$

$r_{2y} = r\sin\theta = -4788\ km\hat{j}$

$\Delta r = r_2 - r_1 = 4788\ km\hat{i} - 4788\ km\hat{j} - 6771\ km\hat{j}$

$= 4788\ km\hat{i} - 11560\ km\hat{j}$

$\Delta r = \sqrt{\Delta r_x^2 + \Delta r_y^2} = \boxed{12510\ km\ @}$

$\theta_r = \tan^{-1}\left(\frac{y}{x}\right) = \boxed{-67.5^\circ}$

Ex. 4.2

$\Delta r_{total} = \sum \Delta r = \left((2.0\hat{i} + \hat{j} + 3.0\hat{k}) + (-\hat{i} + 3.0\hat{k}) - (4.0\hat{i} - 2.0\hat{j} + \hat{k}) + (-3.0\hat{i} + \hat{j} + 2.0\hat{k})\right) \mu m$

$= (2.0\hat{i} + 7.0\hat{k})\ \mu m$

$\Delta r_{total} = \sqrt{\Delta r_x^2 + \Delta r_z^2} = \boxed{9.22\ \mu m\ @}$

$\theta_r = \tan^{-1}\left(\frac{z}{x}\right) = \boxed{77.5^\circ}$

Ex. 4.3

$\vec{r}(t) = 2.0t^2\hat{i} + (2.0 + 3.0t)\hat{j} + 5.0t\hat{k}\ m$

$v(t) = r'(t) = 4.0t\hat{i} + 3.0\hat{j} + 5.0\hat{k}\ \frac{m}{s}$

a) $v(2) = 4.0(2)\hat{i} + 3.0\hat{j} + 5.0\hat{k}\ \frac{m}{s} = \boxed{8.0\hat{i} + 3.0\hat{j} + 5.0\hat{k}\ \frac{m}{s}}$

$|v(2)| = \sqrt{8^2 + 3^2 + 5^2} = \boxed{9.90\ \frac{m}{s}}$

b) $\bar{v}(1,3) = \frac{r(3) - r(1)}{2.0\ s} = \frac{2.0(3^2)\hat{i} + (2.0 + 3.0(3))\hat{j} + 5.0(3)\hat{k} - 2.0\hat{i} - 5.0\hat{j} - 5.0\hat{k}}{2}$

$= (9.0\hat{i} - 1.0\hat{i}) + (11.0\hat{j} - 5.0\hat{j}) + \left(\frac{15.0\hat{k} - 5.0\hat{k}}{2}\right)$

$= \boxed{8.0\hat{i} + 3.0\hat{j} + 5.0\hat{k}\ \frac{m}{s}}$

CQ 4.1 $r(t) = 3.0t^3\hat{i} + 4.0\hat{j}$

a) $v(t) = r'(t) = 9.0t^2\hat{i}$

$v(3) = 9.0(3^2)\hat{i} = \boxed{+81\hat{i}\ \frac{m}{s}}$

b) $\bar{v}(2,4) = \frac{r(4) - r(2)}{4 - 2} = \frac{3.0(4^3)\hat{i} + 4.0\hat{j} - 3.0(2^3)\hat{i} - 4.0\hat{j}}{2\ s}$

$= \boxed{84\hat{i}\ \frac{m}{s}}$

4.2 Ex. 4.4

$v(t) = 5.0t\hat{i} + t^2\hat{j} - 2.0t^3\hat{k}\ \frac{m}{s}$

a) $a(t) = v'(t) = 5.0\hat{i} + 2t\hat{j} - 6t^2\hat{k}\ \frac{m}{s^2}$

b) $a(2.0) = 5.0\hat{i} + 2(2.0)\hat{j} - 6(2^2)\hat{k}\ \frac{m}{s^2} = 5.0\hat{i} + 4.0\hat{j} - 24.0\hat{k}\ \frac{m}{s^2}$

$|a(2)| = \sqrt{5^2 + 4^2 + 24^2} = \boxed{24.8\ \frac{m}{s^2}}$

Ex. 2.5 $\vec{r}(t) = (10t - t^2)\hat{i} + 5t\hat{j} + 5t\hat{k}$ m

a) $\vec{v}(t) = \vec{r}'(t) = (10 - 2t)\hat{i} + 5\hat{j} + 5\hat{k}$ m/s

b) $\vec{a}(t) = \vec{r}''(t) = -2\hat{i}$ m/s²

c) the object starts from the origin and has a constant negative acceleration in the x-direction. The object moves linearly in the y and z directions.

CYU 4.2

$\vec{a}(t) = a\hat{i} + b\hat{j} + c\hat{k}$ m/s²

$\vec{v}(t) = \int \vec{a}\,dt = at\hat{i} + bt\hat{j} + ct\hat{k}$ m/s + C m/s

Ex. 4.6 → x, ↑ y

a) $\vec{v}(t) = 2.1$ m/s @ $-15°$ $v_x = v\cos\theta = 2.03$ m/s

$\vec{a}(t) = (2.0\hat{i} - 0.54\hat{j})$ m/s² $a_y = a\sin\theta = -0.54$ m/s²

$\vec{v}(t) = \int \vec{a}\,dt = 2.0t\hat{i} - 0.54t\hat{j} + C_1$ m/s

$\vec{v}(0) = C_1 = 4.1\hat{i} - 1.1\hat{j}$ m/s

$\vec{v}(t) = \boxed{(2.0t + 4.1)\hat{i} - (0.54t + 1.1)\hat{j}\ \text{m/s}}$

$\vec{x}(t) = \int \vec{v}\,dt = (t^2 + 4.1t)\hat{i} - (0.27t^2 + 1.1t)\hat{j}$ m $+ C_2$

$\vec{x}(0) = C_2 = 75.0\hat{i} - 50.0\hat{j}$ m

$\vec{x}(t) = \boxed{(t^2 + 4.1t + 75.0)\hat{i} - (0.27t^2 + 1.1t + 50.0)\hat{j}\ \text{m}}$

b) $\vec{x}(10.0) = \boxed{216\hat{i} - 88\hat{j}\ \text{m}}$

$\vec{v}(10.0) = \boxed{24.1\hat{i} - 6.5\hat{j}\ \text{m}}$

4.3

Ex. 4.7 $v_0 = 70.0$ m/s @ $75.0°$

a) $v_{0x} = v_0\cos\theta = 18.1$ m/s $v_{0y} = v_0\sin\theta = 67.6$ m/s

$v_{fy}^2 = v_{0y}^2 + 2a_y\Delta y$ $\Delta y = \frac{-v_{0y}^2}{2a_y} = -(67.6\ \text{m/s})^2/2(-9.8\ \text{m/s}^2) = \boxed{233\ \text{m}}$

b) $v_{fy} = v_{0y} + a_y t$ $t = \frac{-v_{0y}}{a} = -(67.6\ \text{m/s})/-9.8\ \text{m/s}^2 = \boxed{6.90\ \text{s}}$

c) $\Delta x = \bar{v}_x t = v_{0x} t = (18.1\ \text{m/s})(6.90\ \text{s}) = \boxed{125\ \text{m}}$

d) $r_{total} = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(125\text{m})^2 + (233\text{m})^2} = \boxed{264\ \text{m}\ @}$

$\theta_{r\,total} = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{233\text{m}}{125\text{m}}\right) = \boxed{61.8°}$

CYU 4.3

a) origin - edge at cliff @ ground level ↓ t → t

b) $v_{0x} = \bar{v}_x = \frac{\Delta x}{t}$ c) $\Delta y = v_{0y}t + \frac{1}{2}a_y t^2$

d) $v_{fy} = \sqrt{2a_y\Delta y} = \sqrt{2(9.8\ \text{m/s}^2)(100\text{m})}$ $v_{fy}^2 = v_{0y}^2 + 2a_y\Delta y$ $v_{fy} = v_{0y} + at$

$= 44.3$ m/s ↓ $v_{fx} = v_{0x} = 15.0$ m/s $v_f = \sqrt{v_{fy}^2 + v_{fx}^2} = \boxed{46.8\ \text{m/s}}$

$\theta_{vf} = \tan^{-1}\left(\frac{v_{fy}}{v_{fx}}\right) = \tan^{-1}(44.3\ \text{m/s}/15.0\ \text{m/s}) = \boxed{71.3°\ \text{below horiz.}}$

↑+ →+

Ex. 4.8 $v_0 = 30\ m/s$ @ $45°$

a) $v_{0x} = v_0 \cos\theta = 30\ m/s (\cos 45) = 21.2\ m/s$

$v_{0y} = v_0 \sin\theta = 30\ m/s \sin 25 = 21.2\ m/s$

$\Delta y = v_{0y}t + \frac{1}{2}at^2$

$\frac{1}{2}(-9.8\ m/s^2)t^2 + (21.2\ m/s)t - 10\ m = 0$

$-4.9\ m/s^2\, t^2 + 21.2\ m/s\, t - 10\ m = 0$

$t = \frac{-21.2 \pm \sqrt{21.2^2 - 4(-4.9)(-10)}}{2(-4.9)} = 0.539\ s,\ \boxed{3.79\ s}$

b) $v_{fy} = v_{0y} + at = 21.2\ m/s + (-9.8\ m/s^2)(3.79\ s)$

$= -15.9\ m/s$

$v_f = \sqrt{v_{fy}^2 + v_{fx}^2} = \sqrt{(-15.9\ m/s)^2 + (21.2\ m/s)^2} = \boxed{26.5\ m/s}$

$\theta_{v_f} = \tan^{-1}\left(\frac{v_{fy}}{v_{fx}}\right) = \boxed{36.9°\ \text{below horiz.}}$ ** t-x-t book error

Ex. 4.9

a) $R = \frac{v_0^2 \sin 2\theta}{g}$ $v_0 = \sqrt{\frac{gR}{\sin 2\theta}} = \sqrt{\frac{(9.8\ m/s^2)(90\ m)}{\sin(2\cdot 30°)}} = \boxed{31.9\ m/s}$ v_{x0}

b) $v_0 = \sqrt{\frac{gR}{\sin 2\theta}} = \sqrt{\frac{(9.8\ m/s^2)(90\ m)}{\sin(2\cdot 70)}} = \boxed{37.0\ m/s}$ v_{x0}

c) 1st $y = (\tan\theta_0)x - \left(\frac{g}{2(v_0\cos\theta_0)^2}\right)x^2$

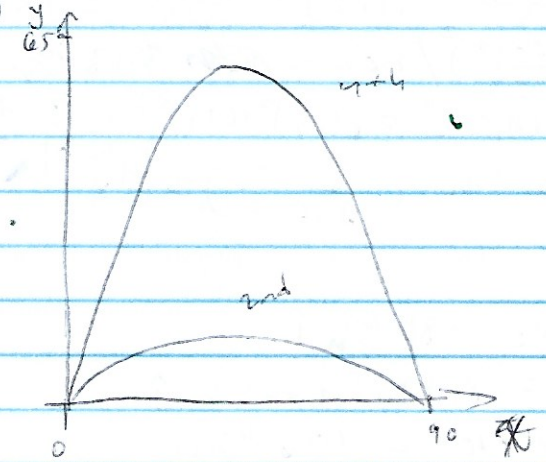
$= \tan(30)x - \left(\frac{9.8\ m/s^2}{2(31.9\cos 30)^2}\right)x^2$

$= \boxed{0.58x - 0.0064x^2}$

4th $y = \tan(70)x - \left(\frac{9.8\ m/s^2}{2(37.0\cos 70)^2}\right)x^2$

$= 2.75x - 0.0306x^2$] switched in textbook

d)



(graphing calculator)

CYU 4.4

$R = \frac{v_0^2 \sin 2\theta}{g}$

$R_{30} = 0.866\frac{v_0^2}{g}$

$R_{70} = 0.643\frac{v_0^2}{g}$

30° ball has greater range

4.4 Ex. 4.10

$a_c = \frac{v_0^2}{r}$ $\quad r = v_0^2/a_c = (134.1\ m/s)^2 / 9.8\ m/s^2 =$ **1835 m**

4.5 cyd

$v = \sqrt{gr} = \sqrt{(980.0\ cm/s^2)(20.0\ cm)} = 134\ cm/s = 1.34\ m/s$

Ex. 4.11

$v(t) = (5\times10^4)\ m/s$

$x(t) = \int v\,dt = 5\times10^4\ t + C_1$ m

$x(0) = 0.175\ m = C_1$

$x(t) = (5\times10^4)t + 0.175\ m$

$T = \frac{c}{v} = \frac{2\pi r}{v} = \frac{2\pi(0.175\ m)}{5\times10^4\ m/s} = 2.2\times10^{-7}\ s$

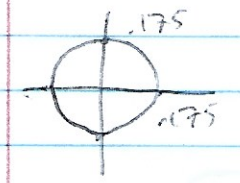
$\omega = \frac{2\pi}{T} = 2\pi/2.2\times10^{-7}\ s = 2.9\times10^{+7}\ rad/s$

$r(t) = A\cos\omega t\,\hat{i} + A\sin\omega t\,\hat{j}$

$= 0.175\ m\cos(2.9\times10^{-7}t)\,\hat{i} + 0.175\ m\sin(2.9\times10^{-7}t)\,\hat{j}$

$r(2\times10^{-7}\ s) = 0.175\ m\cos(2.9\times10^{+7}\times2.00\times10^{-7})\,\hat{i} + 0.175\ m\sin(2.9\times10^{+7}\times2.00\times10^{-7})\,\hat{j}$

$= 0.155\ m\,\hat{i} - 0.0813\ m\,\hat{j}$



Ex. 4.12

$v(t) = 4.0\ m/s - \frac{6.0\ m}{t^2}$

$a(t) = v'(t) = \frac{12.0\ m\cdot s^2}{t^3}$ $\quad a(2) = \frac{12.0\ m\cdot s^2}{(2^3)} = 1.5\ m/s^2$

$a_c = \frac{v^2}{r} = \left(4.0\ m/s - \frac{6.0\ m\cdot s}{2^2}\right)^2 / 2.0\ m = 3.13\ m/s^2$

$a_{total} = \vec{a}_c + \vec{a}_t = \sqrt{a_t^2 + a_c^2} = \sqrt{(1.5)^2 + (3.1)^2} = 3.4\ m/s^2$

$\theta_{ch} = \tan^{-1}\left(\frac{a_t}{a_c}\right) = \tan^{-1}\left(\frac{1.5\ m/s^2}{3.13\ m/s^2}\right) = 45^\circ$

4.5 Ex. 4.13 

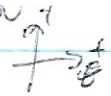
$v_t = -70\ km/h\,\hat{j}$ $\quad v_c = +80\ km/h\,\hat{i}$

$v_{car,truck} = -\vec{v}_t + \vec{v}_c = 80\ km/h\,\hat{i} + 70\ km/h\,\hat{j}$

$v_{c/t} = \sqrt{v_x^2 + v_y^2} = \sqrt{80^2 + 70^2} = 106\ km/h$

$\theta_{c/t} = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{+70}{80}\right) = 41.2^\circ$ NOTE

CYU 4.6



$v_{B/R} = +4.5 \frac{m}{s}\hat{j}$

$v_{R/E} = +3.0 \frac{m}{s}\hat{i}$

$v_{BE} = v_{BR} + v_{RE} = 3.0\frac{m}{s}\hat{i} + 4.5\frac{m}{s}\hat{j} = \sqrt{v_x^2 + v_y^2} = \boxed{5.41 \frac{m}{s}}$

$\theta_v = \tan^{-1}\left(\frac{4.5}{3.0}\right) = \boxed{56.3^\circ \text{ N of E}}$

Ex. 4.14

$v_{PA} = +300 \text{ km/h}\,\hat{i}$ $v_{AE} = 90 \text{ km/h} @ 45^\circ + 180^\circ = -63.6\,\hat{i} - 63.6\,\hat{j}$ m/s

a) $v_{PE} = \vec{v}_{PA} + \vec{v}_{AE} = (300 - 63.6)\hat{i} - 63.6\hat{j}$ m/s

$= 236\,\hat{i} - 63.6\,\hat{j}$ m/s

$= \sqrt{v_x^2 + v_y^2} = \boxed{244 \frac{m}{s}}$

b) $\theta = \tan^{-1}\left(\frac{y}{x}\right) = \tan^{-1}\left(\frac{63.6}{236}\right) = \boxed{15.1^\circ}$

CYU 4.1 $R(t) = 3.0t^3\hat{i} + 4.0\hat{j}$

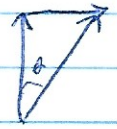
b) $\bar{v}_{2,4} = \frac{r(4) - r(2)}{2\text{ s}} = \frac{3.0(4^3) - 3.0(2^3)\hat{i}}{2} = \boxed{84 \text{ m/s}}$

Ex. 4.12

$\theta = \tan^{-1}\left(\frac{3.13 \text{ m/s}}{1.5 \text{ m/s}}\right) = \boxed{64.2^\circ}$

CYU 4.6

$\theta_v = \tan^{-1}\left(\frac{v_{AE}}{v_{BR}}\right) =$



$\tan^{-1}\left(\frac{3.0 \text{ m/s}}{4.5 \text{ m/s}}\right) = 33.7^\circ \text{ E of N}$

Ex. 4.14 $v_{PA} = 300 \text{ km/h}\,\hat{j}$ $v_{AE} = 90 \text{ km/h} @ 225^\circ$

$= -63.6\,\hat{i} - 63.6\,\hat{j}$ km/h

a) $\vec{v}_{PE} = \vec{v}_{PA} + \vec{v}_{AE} = 300 \text{ km/h}\,\hat{j} - 63.6 \text{ km/h}\,\hat{i} - 63.6 \text{ km/h}\,\hat{j}$

$= 236.4\,\hat{j} - 63.6 \text{ km/h}\,\hat{i}$

$= \sqrt{236.4^2 + 63.6^2} = \boxed{245 \text{ m/s}}$

b) $\theta = \tan^{-1}\left(\frac{63.6 \text{ km/h}}{300 \text{ km/h}}\right) = \boxed{12.0^\circ}$

CYU 4.1 – $\vec{v}_{2,4} = 54.0\,\hat{i}$ m/s

Ex. 4.14 – $\vec{v}_{PE} = \boxed{230 \text{ km/h}}$

Ch. 4 EOO

1) Straight line

5) No

9) The dime b/c it fell first

13) It is moving at the same speed as a car

17) $\vec{r} = (1.0\hat{i} - 4.0\hat{j} + 6.0\hat{k})$

21) $\sum \Delta x = 5.0\text{ km}\hat{i} + 10.0\cos(110)\text{km}\hat{i} + 10.0\sin(110)\text{km}\hat{j} - 8.0\text{ km}\hat{i}$

$= -6.4\text{ km}\hat{i} + 9.4\text{ km}\hat{j}$

25) $\sum \Delta x = 20.00\text{m}\hat{j} + 20{,}000\text{ km}\cos 30\hat{i} + 20{,}000\sin 30\hat{j}\text{ km}$

$= 17.3\text{ km}\hat{i} + 10.02\text{ km}\hat{j}$

29) a) $v(t) = r'(t) = 6.0t\hat{i} - 21t^2\hat{j} + 10t^{-3}\hat{k}\ \frac{m}{s}$

b) $a(t) = v'(t) = 6.0\hat{i} - 42t\hat{j} - 30t^{-4}\hat{k}\ \frac{m}{s^2}$

c) $v(2.0) = [12.0\hat{i} - 84\hat{j} + 1.26\hat{k}]\ \frac{m}{s}$

d) $v(1.0) = 6.0\hat{i} - 21\hat{j} + 10\hat{k} = [24\ \frac{m}{s}]$

$v(3.0) = 18\hat{i} - 190\hat{j} + 14.4\hat{k}\ \frac{m}{s} = [191\ \frac{m}{s}]$

e) $\bar{v}_{1,2} = \frac{r(2) - r(1)}{t} = 12\hat{i} - 56\hat{j} - 7.1\hat{k} - 3.0\hat{i} + 7.0\hat{j} + 5.0\hat{k}\ \frac{m}{s}$

$= 9.0\hat{i} - 49\hat{j} - 2.1\hat{k}\ \frac{m}{s}$

33) a) $\Delta y = v_{0y}t + \frac{1}{2}gt^2$ $t = \sqrt{\frac{2\Delta y}{g}} = \sqrt{\frac{2(1.5\text{m})}{9.8\frac{m}{s^2}}} = [0.55\text{s}]$

b) $\Delta x = v_{0x}t = [200\frac{m}{s})(0.55\text{s}) = [110\text{ m}]$

37) a) $t = \sqrt{\frac{2\Delta y}{a}} = \sqrt{\frac{2(8000\text{m})}{9.8\frac{m}{s^2}}} = 12.8\text{s}$

$\Delta x = v_{0x}t = (300\frac{m}{s} + 500\frac{km}{h} \times \frac{1000\text{m}}{1\text{km}} \times \frac{1\text{h}}{3600\text{s}})(12.8\text{s}) = [5620\text{ m}]$

b) $v_{fy} = v_{0y} + at = (9.8\frac{m}{s^2})(12.8\text{s}) = 125\frac{m}{s}$

$v_{fx} = v_{0x} = (300\frac{m}{s} + 500\frac{km}{h}) = 439\frac{m}{s}$

$v_f = \sqrt{v_{fy}^2 + v_{fx}^2} = [456\frac{m}{s}]$

41) $v_0 = 2.0\frac{m}{s}\hat{i} + 20\frac{m}{s}\hat{j}$

$\Delta y = v_{0y}t + \frac{1}{2}gt^2$ $4.9t^2 + 2.0t - 100 = 0$

$t = \frac{-2 \pm \sqrt{2^2 + 4 \cdot 4.9 \cdot 100}}{9.8} = 4.32\text{s}$

$\Delta x = v_{0x}t = (20\frac{m}{s})(4.32\text{s}) = [86.4\text{ m}]$

45) $v_0 = 30\frac{m}{s}\ @ 53^\circ = [18.1\hat{i} + 24.0\hat{j})\ \frac{m}{s}$

a) $\Delta y = v_{0y}t + \frac{1}{2}at^2$ $v_{fy} = v_{0y} + at$ $t = \frac{-v_0}{a}$

$= \frac{(-24.0\frac{m}{s})}{-9.8\frac{m}{s^2}} = 2.45\text{s}$ $\Delta y = (24.0\frac{m}{s})(2.45\text{s}) + \frac{1}{2}(-9.8\frac{m}{s^2})(2.45\text{s})^2$

$= [29.4\text{ m}]$

b) $\Delta x = v_{0x}t = (18.1\frac{m}{s})(2.45\text{s}) = [44.3\text{ m}]$

[45]

c) $\Delta y = v_{0y} t + \frac{1}{2} a t^2$

$-4.9t^2 + 24.0t + 100\,m = 0$

$t = \frac{-24 \pm \sqrt{24^2 + 4(4.9)(100)}}{-9.8} = \boxed{7.59\,s}$

d) $R = \frac{v_0^2 \sin 2\theta}{g} = \frac{(30\,m/s)^2 \sin(2 \cdot 53°)}{9.8\,m/s^2} = \boxed{88.3\,m}$

c) $x_f = x_0 + v_x t \quad y_f = y_0 + v_{0y} t + \frac{1}{2} a_y t^2$

$r(t) = (x_0 + v_x t)\hat{i}\,m + (y_0 + v_{0y} t + \frac{1}{2} a_y t^2)\hat{j}\,m$ ($y_0 = 100\,m$)

$r(2.0\,s) = (18.1\,m/s)(2.0\,s)\hat{i} + [100\,m + (24.0\,m/s)(2.0\,s) + \frac{1}{2}(-9.8\,m/s^2)(2.0\,s)^2]\hat{j}\,m$

$= 36.2\hat{i} + \boxed{128.4\hat{j}}\,m$

$r(4.0\,s) = \boxed{72.4\hat{i} + 117.6\hat{j}\,m}$

$r(4.0\,s) = \boxed{106.6\hat{i} + 67.6\hat{j}\,m}$

49) a) $R = \frac{v_0^2 \sin 2\theta}{g} = (15\,m/s)^2 \sin(2 \times 45°)/3.7\,m/s^2 = \boxed{160.8\,m}$

b) $R = \frac{v_0^2 \sin 2\theta}{g} = (15\,m/s)^2 \sin(30)(4.8/6) = \boxed{138\,m}$

53) $R = \frac{v_0^2 \sin 2\theta}{g} = (230\,m/s)^2 \sin(20)/9.8\,m/s^2 = \boxed{518.5\,m}$

57) $R = \frac{v_0^2 \sin 2\theta}{g} \quad \theta = \frac{1}{2}\sin^{-1}\left(\frac{gR}{v_0^2}\right) = \frac{1}{2}\sin^{-1}\left(\frac{(9.8\,m/s^2)(69.0\,m)}{(35.8\,m/s)^2}\right)$

$= \boxed{15.9°}$

61) $a_c = \frac{v^2}{r} = (20\,m/s)^2/10\,m = \boxed{40\,m/s^2}$

65) $a_c = \frac{v^2}{r} = (35\,m/s)^2/108 \times 10^9\,m = \boxed{1.13 \times 10^{-7}\,m/s^2}$

69) a) $r(t') = r(s') = \int v\,dt = (4.0\hat{i} + 3.0\hat{j} + 5.0\hat{k})t\,m/s \quad [t = 0]$

b) $\vec{r}(t) = -r^{\vec{}}(t')$

c) $v(t) = -v^{\vec{}}(t')$ d) $a(t) = -\vec{a}(t')$

73) $v_{still} = 9.00\,m/s$

a) $v_a = \Delta x/t = 6{,}000\,m/(60.0\,min \times 60\,s/1\,min) = 5.00\,m/s$

$v_{wind} = v_a - v_{still} = \boxed{-4.00\,m/s}$

b) $t = \frac{\Delta x}{v} = (6{,}000\,m)/(9.00\,m/s + 4.00\,m/s) = \boxed{462\,s} = \boxed{7.69\,min}$

77) $v_{bs} = 15\,km/h\ @\ -45° \quad v_{bw} = 25\,km/h\ @\ 45°$

$= (10.6\hat{i} - 10.6\hat{j})\,km/h \quad = (17.7\hat{i} + 17.7\hat{j})\,km/h$

$v_{rw} = v_{rb} + v_{bw} = (-10.6\hat{i} + 10.6\hat{j} + 17.7\hat{i} + 17.7\hat{j})\,km/h$

$= 7.1\hat{i} + 28.3\hat{j}\,km/h$

$v_{wr} = -v_{rw} = -7.1\hat{i} - 28.3\hat{j}\,km/h = \boxed{29.2\,km/h\ @}$

$\theta = \tan^{-1}\left(\frac{-28.3}{-7.1}\right) = \boxed{256°}$

81) $a_c = \frac{v^2}{r} = \frac{(60.0\ \text{km/h})^2}{150\ \text{m}} = \frac{\left(60.0\ \frac{\text{km}}{\text{h}} \times \frac{1000\ \text{m}}{1\ \text{km}} \times \frac{1\ \text{h}}{3600\ \text{s}}\right)^2}{150.0} = 1.85\ \text{m/s}^2$

$a_t = \frac{\Delta v}{t} = \frac{-9.0\ \text{km/h}}{4\ \text{s}} = \left(-9.0\ \frac{\text{km}}{\text{h}} \times \frac{1000\ \text{m}}{1\ \text{km}} \times \frac{1\ \text{h}}{3600\ \text{s}}\right)/4\ \text{s} = -2.5\ \text{m/s}^2$

$a_{total} = \sqrt{a_c^2 + a_t^2} = \sqrt{(1.85)^2 + (-2.5)^2} = 3.1\ \text{m/s}^2$

85) $v_{t5} = v_0 + at = (3.00\ \text{m/s}^2)(5.0\ \text{s}) = 15.0\ \text{m/s}$

$a_c = \frac{v^2}{r} = (15.0\ \text{m/s})^2/1.5\ \text{m} = 150\ \text{m/s}^2$

$a_{total} = \sqrt{a_c^2 + a_t^2} = \sqrt{150^2 + 3.00^2} = 150\ \text{m/s}^2$

$\theta = \tan^{-1}\left(\frac{a_t}{a_c}\right) = \tan^{-1}\left(\frac{3.00\ \text{m/s}^2}{150\ \text{m/s}^2}\right) = 88.9^\circ$ from tangential

89) $\Delta x = r_2 - r_1 \qquad r_2 = \Delta x + r_1 = (2.5\hat{i} + 3.2\hat{j} - 1.2\hat{k} + 1.5\hat{j} + 4.0\hat{k})\ \text{m}$

$= (2.5\hat{i} + 4.7\hat{j} + 2.8\hat{k})\ \text{m}$

93) $R = \frac{v_0^2 \sin 2\theta}{g} \qquad R_1 = \frac{v_0^2}{g}\sin(2\cdot 45) = \frac{v_0^2}{g} = 8.0\ \text{m}$

$R_2 = \frac{v_0^2}{g}\sin(2\cdot 30) = 0.866\frac{v_0^2}{g}$

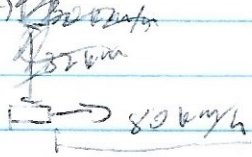
$R_2 = 0.866(R_1) = 0.866(8.0\ \text{m}) = 6.93\ \text{m}$

he loses $8.0 - 6.93\ \text{m} = 1.1\ \text{m}$

97) $\omega = \frac{2\pi}{T} = \frac{2\pi}{1\ \text{day}} = \frac{2\pi}{8.64\times10^4\ \text{s}} = 7.27\times10^{-5}\ \text{rad/s}$

$v = r\omega = (42.3\times10^6\ \text{m})(7.27\times10^{-5}\ \text{rad/s}) = 3.08\times10^3\ \text{m/s}$

$a_c = \frac{v^2}{r} = (3.08\times10^3\ \text{m/s})^2/42.3\times10^6\ \text{m} = 7.28\times10^{-5}$

101) 

$v_{TE} = 80\ \text{km/h} = +22.2\ \text{m/s}\,\hat{i}$

$v_{CE} = 50\ \text{km/h} = +13.9\ \text{m/s}\,\hat{j}$

$v_{TC} = +v_{TE} + v_{CE} = +22.2\ \text{m/s}\,\hat{i} + 13.9\ \text{m/s}\,\hat{j}$

$r(t) = \int v\,dt = +22.2t\,\hat{i} + 13.9t\,\hat{j} + C_1 \quad C_1 = -3.2\times10^4\ \text{m}\,\hat{i}$ m

$= (-3.2\times10^4 + 22.2t)\,\hat{i} + 13.9t\,\hat{j}$ m

$r(t) = \sqrt{(-3.2\times10^4\ \text{m} + 22.2t)^2 + (13.9t)^2} \qquad r^2 = (-3.2\times10^4 + 22.2t)^2 + (13.9t)^2$

$2r\,r'(t) = 0 \qquad 2(-3.2\times10^4\ \text{m} + 22.2t)(22.2) + 2(13.9t)(13.9) = 0$

$493t + 386t = 1.42\times10^6\ \text{m} \qquad 879t = 1.42\times10^6\ \text{m}$

$t = 1615\ \text{s}$

b) $r(1615) = \sqrt{(-3.2\times10^4 + (22.2)(1615))^2 + (13.9(1615))^2}$

$= 22.8\ \text{km}$

$1615\ \text{s} \times \frac{1\ \text{min}}{60\ \text{s}} \times \frac{1\ \text{hr}}{60\ \text{min}} = 0.45\ \text{hr}$

9) both fall at the same time

29) c) $v(2.0) = [2.0\hat{i} - 8\hat{j} + 1.25\hat{k}]\ m/s$

d) $v(3.0)_z = 10(3^{-3}) = 0.37\ \hat{k}$

e) $v_{1/2} = r(2) - r(1)/1 = (12\hat{i} - 5\hat{j} - 1.25\hat{k}) - (3.0\hat{i} + 7\hat{j} + 5.0\hat{k})\ m/s$

$= 9.0\hat{i} - 4\hat{j} + 3.7\hat{k}\ m/s$

45) $v_{fy} = v_{oy} + a_y t \quad v_{fy}^2 = v_{oy}^2 + 2a_y \Delta y$

$\Delta y = \frac{-v_{oy}^2}{2a_y} = -(24.0\ m/s)^2 / 2 / (-9.8\ m/s^2) = 29.4\ m$

$t = \frac{-v_{oy}}{a} = \frac{(-24.0\ m/s)}{-9.8\ m/s^2} = 2.45\ s$

b) $\Delta x = v_{ox} t = (18.1\ m/s)(2.45\ s) = 44.3\ m$

d) $v_{oy} t + \frac{1}{2} a t^2$

$-4.9t^2 + 24.0t + 100m$

$t = \frac{-24 \pm \sqrt{24^2 + 4 \cdot 4.9 \cdot 100}}{-9.8} = 7.59\ s$

$\Delta x = v_{ox} t = (18.1\ m/s)(7.59\ s) = 137\ m$

c) $r(t) = v_{ox} t\hat{i} + (v_{oy} t + \frac{1}{2} a_y t^2)\hat{j}\ m$

$r(2)_y = v_{oy}(t) + \frac{1}{2}(-9.9) t^2 = 24.0\ m/s\,(2.0\ s) + (-4.9)(2.0\ s)^2$

$= 28.4\ \hat{j}\ m$

$r(4.0) = (18.1\ m/s)(4.0\ s)\hat{i} + (24.1\ m/s)(4.0\ s)\hat{j} - (4.9)(4.0\ s)^2$

$= 72.4\ \hat{i} + 18.0\ \hat{j}\ m$

$r(6.0\ s)_y = (24.1\ m/s)(6.0\ s) - (4.9)(6.0\ s)^2 = -31.8\ \hat{j}\ m$

65) $T_{Mars} = 725\ days = 1.9 \times 10^7\ s$

$\omega = \frac{2\pi}{T} = 3.31 \times 10^{-7}\ rad/s \quad v = r\omega = (1.08 \times 10^{11}\ m)(3.31 \times 10^{-7}\ rad/s)$

$= 3.57 \times 10^4\ m/s$

$a_c = \frac{v^2}{r} = (3.57 \times 10^4\ m/s)^2 / 1.08 \times 10^{11}\ m$

$= 0.0118\ m/s^2$

69) b) $r(t) = r'(t) + (4.0\hat{i} + 3.0\hat{j} + 5.0\hat{k})\ m$

c) $v(t) = v'(t) + (4.0\hat{i} + 3.0\hat{j} + 5.0\hat{k})\ t\ m/s$

d) $a(t) = a'(t)$

77) $\theta = \tan^{-1}\left(\frac{+7.1}{28.3}\right) = 14.1°$

97) $a_c = \frac{v^2}{r} = (3.0 \times 10^3 \frac{m}{s})^2 / 4.23 \times 10^7 = \boxed{0.224 \frac{m}{s^2}}$

101) $v_{TG} = 80 \frac{km}{h}\hat{i} \quad v_{CG} = 50 \frac{km}{h}\hat{j}$

a) $v_{TC} = 80 \frac{km}{h}\hat{i} + 50 \frac{km}{h}\hat{j}$

$r_{TC} = \int v_{TC}\,dt = 80t\ km\,\hat{i} + 50t\ km\,\hat{j} + C_1, \quad C_1 = -32\ km$

$= (-32 + 80t)\hat{i} + 50t\,\hat{j}\ m$

$|r^2| = (-32 + 80t)^2 + (50t)^2$

$(r^2)' = 0 \qquad 2r\frac{dr}{dt} = 0$

$2(-32 + 80t)(80) + 2(50t)(50) = 0$

$12800t = 5120 \qquad 17800\,t = 5120$

$t = \boxed{0.29\ h}$

b) $r(0.29\ h) = \sqrt{(-32 + 80t)^2 + (50t)^2}$

$= \boxed{17.0\ km}$

45) a) 29.4 m

b) 54 m

c) $r(4.0\ s) \approx 17.6\ m$

69) b) $r(t) = r'(t) + (4.0\hat{i} + 3.0\hat{j} + 5.0\hat{k})t\ m$

c) $v(t) = r'(t) + (4.0\hat{i} + 3.0\hat{j} + 5.0\hat{k})\ \frac{m}{s}$