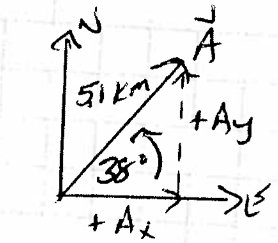
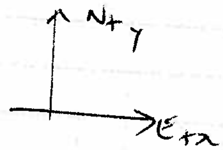
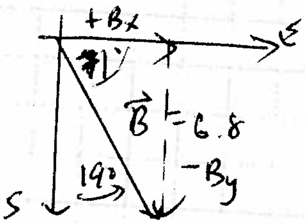
Kinematics Review

9)







a) $\vec{A}+\vec{B}+\vec{C}=0$

$\vec{C}=-\vec{A}-\vec{B}$

$=-(\vec{A}+\vec{B})$

$\vec{C}=?$

$C_x=-(\vec{A}+\vec{B})_x$ + $C_y=-(\vec{A}+\vec{B})_y$

$(\vec{A}+\vec{B})_x = 5.1\cos 38 + 6.8\cos 71°$

$= 6.2327$

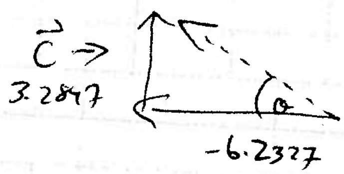
$C_x = -6.2327$

$(\vec{A}+\vec{B})_y = 5.1\sin 38 + (-6.8\sin 71°)$

$= -3.2897$

$C_y = +3.2897$

$\therefore \vec{C} \rightarrow$



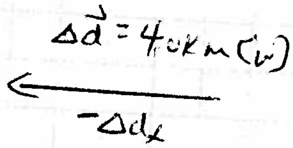
$C = \sqrt{6.2327^2 + -3.2897^2}$

$= 7.05$

$\theta = \tan^{-1}\left(\frac{3.2897}{6.2327}\right) = 27.8°$

$\therefore \vec{C} =$ 7.1 km [28° N of W]

b) $\Delta\vec{d} = 4.0$ km (W)



$\therefore \vec{A}+\vec{B}+\vec{C} = 4.0$ km [W]

$\vec{C} = 4.0$ km (W) $- (\vec{A}+\vec{B})$

$= 4.0$ km (W) $- \vec{A} - \vec{B}$

$= \Delta\vec{d} - \vec{A} - \vec{B}$

$C_x = \Delta d_x - A_x - B_x$

$= -4.0 - 5.1\cos 38 - 6.8\cos 71$

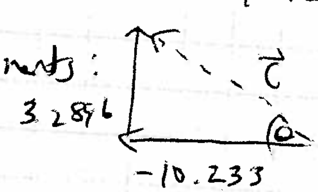
$= -10.233$

$C_y = \Delta d_y - A_y - B_y$

$= 0 - 5.1\sin 38 - (-6.8\sin 71)$

$= 3.2896$

Combining components:

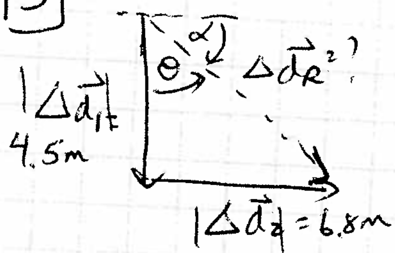


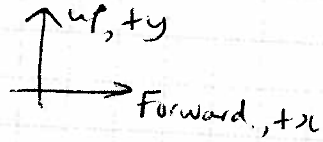
$C = \sqrt{3.2896^2 + 10.233^2} = 10.74$

$\theta = \tan^{-1}\left(\frac{3.29}{10.23}\right) = 17.8°$

$\therefore \vec{C} =$ 11 km [18° N of W]

15]





(2)

$\Delta d_R = \sqrt{4.5^2 + 6.8^2} = 8.154\ m$

$\Delta t = 5.0s.$

$\Delta \vec{d}_R = ?$

$\vec{V}_{av} = ?$

$V_{av} = ?$

$\theta = Tan^{-1}\left(\frac{6.8}{4.5}\right) = 56.5°$ and $\alpha = 90° - \theta$

$= 90° - 56.5°$

$= 33.495°$

$\therefore \Delta \vec{d}_R = 8.2m$ [33° below the horizontal]

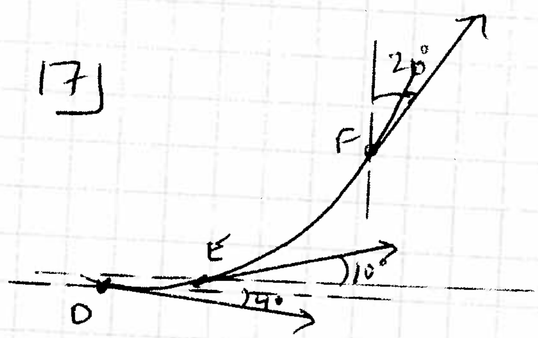
Avg. velocity:

$\vec{V}_{av} = \frac{\Delta \vec{d}_R}{\Delta t} = \frac{8.2m \text{ [33° below horizontal]}}{5.0s} = 1.6$ m/s [33° below horizontal]

Avg. speed:

$V_{av} = \frac{\Delta d.}{\Delta t} = \frac{6.8m + 4.5m}{5.0s} = 2.26 m/s \simeq 2.3 m/s$

17]



* angles measured directly on diagram

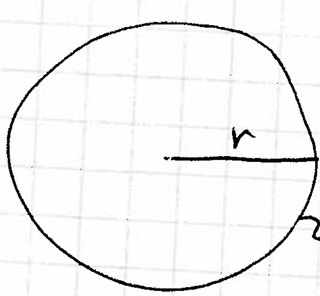
$|\vec{v}| = 100$ km/h

$\vec{V}_D = 100$ km/h [40° S of E]

$\vec{V}_E = 100$ km/h [10° N of E]

$\vec{V}_F = 100$ km/h [20° E of N]

28]



$r = 1.08 \times 10^{11} m$

$T = 1.94 \times 10^7 s$

↳ Δd for 1 cycle is $2\pi r$

a) $V_{av} = ?$ $V_{av} = \frac{\Delta d}{\Delta t}$

$= \frac{2\pi r}{T}$

$= \frac{2\pi(1.08 \times 10^{11} m)}{(1.94 \times 10^7 s)}$

$= 3.50 \times 10^4$ m/s

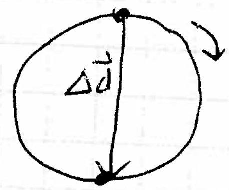
28 Continued

b) $\vec{v}_{av} = ?$

$\Delta\vec{d} = ?$

$\Delta t = T/2 = 0.970 \times 10^7 s$

$= 9.70 \times 10^6 s$



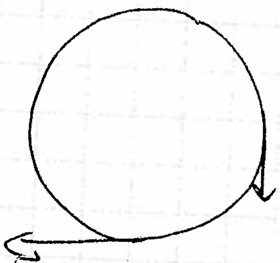
$|\Delta\vec{d}| = 2r = 2(1.08 \times 10^{11} m)$

$= 2.16 \times 10^{11} m$

$|\vec{v}_{av}| = \left|\frac{\Delta\vec{d}}{\Delta t}\right| = \frac{2.16 \times 10^{11} m}{9.70 \times 10^6 s}$

$= 2.23 \times 10^4 m/s$

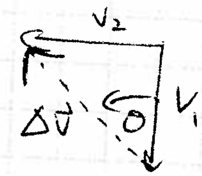
c)



To find average acceleration:

$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$

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



$|\Delta\vec{v}| = \sqrt{3.50 \times 10^4 m/s^2 + 3.50 \times 10^4 m/s^2}$

$= 4.947 \times 10^4 m/s$

$|\vec{a}| = \frac{|\Delta\vec{v}|}{\Delta t} = \frac{4.947 \times 10^4 m/s}{(1.94 \times 10^7 s/4)} = 1.02 \times 10^{-2} m/s^2$

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31)

$v_x = ?$ $\quad \Delta d_x = 16m$ $\quad v_{iy} = 0.0 m/s$ $\quad g = 9.80 m/s^2$ $+\downarrow$

$\Delta d_y = -1.5m$

up, $\leftarrow +$, down $+$

In a given time interval, Δt the projectile moves forward 16m and falls 1.5m

horizontal: $\Delta t = \frac{\Delta d_x}{v_x}$

Vertical: $\Delta d_y = \cancel{v_{iy}}^{0}\Delta t + \frac{1}{2} a_y \Delta t^2$

$1.5m = \frac{1}{2}(9.80)\Delta t^2$

$\Delta t = \sqrt{\frac{2(1.5)}{9.80}} = 0.553 s$

Now solve for v_x:

$v_x = \frac{\Delta d_x}{\Delta t} = \frac{16m}{0.553 s} = 28.9 m/s \simeq 29 m/s$

34] S-swimmer w-water b-bank

④

$V_{sw} = 0.80\,m/s$

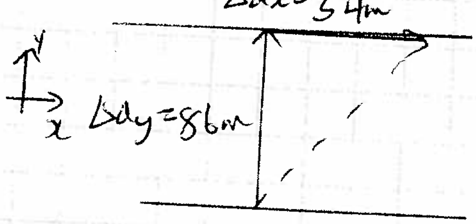
$\Delta d_y = 86\,m$

$\Delta d_x = 54\,m.$

$\vec{V}_{wb} = ?$

$\vec{V}_{sb} = ?$

a)



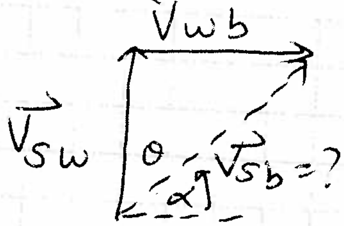
Solve for time:

$\Delta d_y = V_{sw} \cdot \Delta t$

$\Delta t = \dfrac{\Delta d_y}{V_{sw}} = \dfrac{86\,m}{0.80\,m/s} = 107.5\,s$

$\therefore V_{wb} = \dfrac{\Delta d_x}{\Delta t} = \dfrac{54\,m}{107.5\,s} = 0.5023\,m/s \approx 0.50\,m/s$

b)



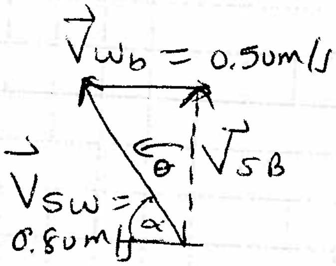
$\vec{V}_{sb} = \vec{V}_{sw} + \vec{V}_{wb}$

$V_{sb} = \sqrt{0.502^2 + 0.80^2} = 0.94\,m/s$

$\theta = \tan^{-1}\left(\dfrac{0.502}{0.80}\right) = 32^\circ$ or $\alpha = 90 - 32^\circ = 58^\circ$

$\therefore \vec{V}_{sb} = 0.94\,m/s$ [58° from near shore downstream]

c)

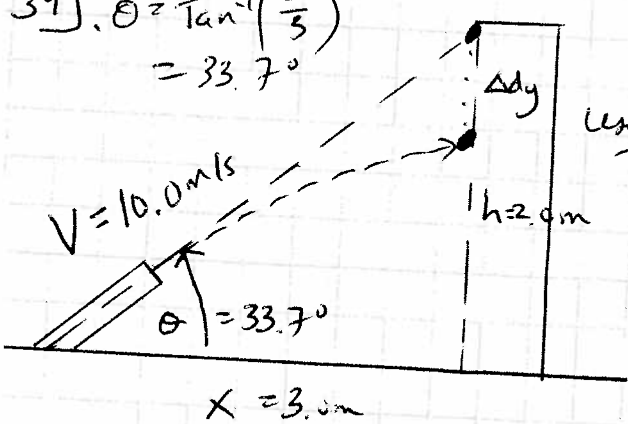


$\theta = ?$ $\theta = \tan^{-1}\left(\dfrac{0.502}{0.80}\right) = 32^\circ$

OR $\alpha = 90 - 32^\circ = 58^\circ$

$\therefore \alpha = 58^\circ$ from nearby upstream shore

39] $\theta = \tan^{-1}\left(\dfrac{2}{3}\right) = 33.7^\circ$



Let $h = 2.0\,m$ $V = 10.0\,m/s$

$X = 3.0\,m$

↑ up = +

use horizontal component to find time for dart to reach monkey:

$V_x = V\cos 33.7^\circ = 10.0\cos 33.7^\circ = 8.32\,m/s$

$\Delta t = \dfrac{\Delta d_x}{V_x} = \dfrac{3.0\,m}{8.32\,m/s} = 0.3606\,s$

39 continued

Find height of dart at time $\Delta t = 0.3606s$

$$\Delta d_{y\,dart} = v_{iy}\Delta t + \frac{1}{2}a_y\Delta t^2$$
$$=(10.0)(\sin 33.7)(0.3606s) + \frac{1}{2}(-9.80)(0.3606s)^2$$
$$= 1.3635m$$
$$\simeq 1.36m$$

Find height of monkey at time $\Delta t = 0.3606s$.

$$\Delta d_{y\,monkey} = 2.0m - \Delta d_{fall}$$
$$= 2.0m - \frac{1}{2}a_y\Delta t^2$$
$$= 2.0m - \frac{1}{2}(9.80)(0.3606)^2$$
$$= 1.363m$$
$$\simeq 1.36m$$

$\therefore$ at time $\Delta t = 0.361s$, the dart has reached the horizontal location of the monkey and both the monkey and the dart are at the same height.

$$\Delta d_{y\,dart} = \Delta d_{y\,monkey} = 1.36m.$$

$\therefore$ the monkey is hit by the dart!

50 * This is a SIN challenge question. This would not be on the test. See me later to work on the solution if you like!! ☺

Chapter 3 Review

1.) Centripetal acceleration is an instantaneous acceleration. It represents the instantaneous change in direction as an object undergoes uniform circular motion.

2.)

all points are at different radii but rotating at the same rate.

$$V_1 = \frac{2\pi r'}{T} \qquad V_2 = \frac{2\pi r2}{T}$$

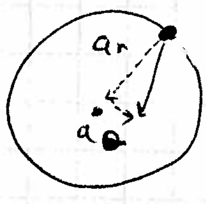
$$a_{c_1} = \frac{V_1^2}{r_1} = \frac{\left(\frac{2\pi r_1}{T}\right)^2}{r_1} \qquad \text{Similarly } a_{c_2} = \frac{2\pi r_2}{T^2}$$

$$= \frac{2\pi r_1^2}{T^2 \cancel{r_1}} =$$

$$= \frac{2\pi r_1}{T^2}$$

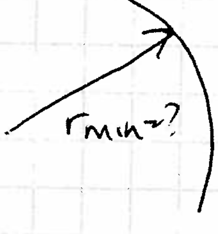
Since the period is consistent, points at larger radii experience greater centripetal acceleration.

3.)



If the speed of the particle is changing then some component of the net acceleration must be directed tangentially. Thus the acceleration has both a radial (a_r) component and a tangential a_θ component.

4.)



$V = 25 m/s$

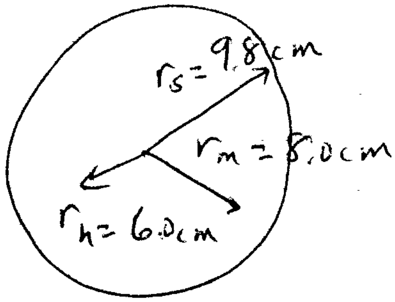
$a_{max} = 4.4 m/s^2$

$$a_{max} = \frac{V^2}{r_{min}}$$

$$r_{min} = \frac{V^2}{a_{max}} = \frac{(25 m/s)^2}{(4.4 m/s^2)} = 142 m$$

$$\approx 1.4 \times 10^2 m$$

5)



$T_{\text{second hand}} = 60.0\,s$; $r_s = 4.8\text{cm}$

$$\therefore a_{c_s} = \frac{4\pi^2 r_s}{T_s^2} = \frac{4\pi^2(9.8\text{cm})}{(60.0)^2} = 0.107\,\text{cm}/s^2$$
$$\simeq 0.11\,\text{cm}/s^2$$

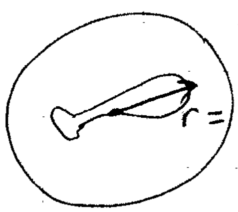
$T_{\text{minute hand}} = 60.0\,\text{min} = 3.600 \times 10^3 s$

$$a_{c\,min} = \frac{4\pi^2 r_{min}}{T_{min}^2} = \frac{4\pi^2(8.0\text{cm})}{(3.600\times10^3 s)^2} = 2.44\times10^{-5}\,\frac{\text{cm}}{s^2}$$

$T_{\text{hour hand}} = 12.0\,h = 43200\,s = 4.32\times10^4 s$

$$a_{c_h} = \frac{4\pi^2 r_h}{T_h^2} = \frac{4\pi^2(6.0\,\text{cm})}{(4.32\times10^4 s)^2} = 1.26\times10^{-7} s$$
$$\simeq 1.3\times10^{-7} s$$

6)



$r = 16\,\text{cm}$
$= 0.16\text{m}$

$a_c = 0.22\,\text{m}/s^2$

$T = ?$

$$a_c = \frac{4\pi^2 r}{T^2}$$

$$T = \sqrt{\frac{4\pi^2 r}{a_c}} = \sqrt{\frac{4\pi^2(0.16\text{m})}{(0.22\,\text{m}/s^2)}}$$
$$= 5.4\,s$$