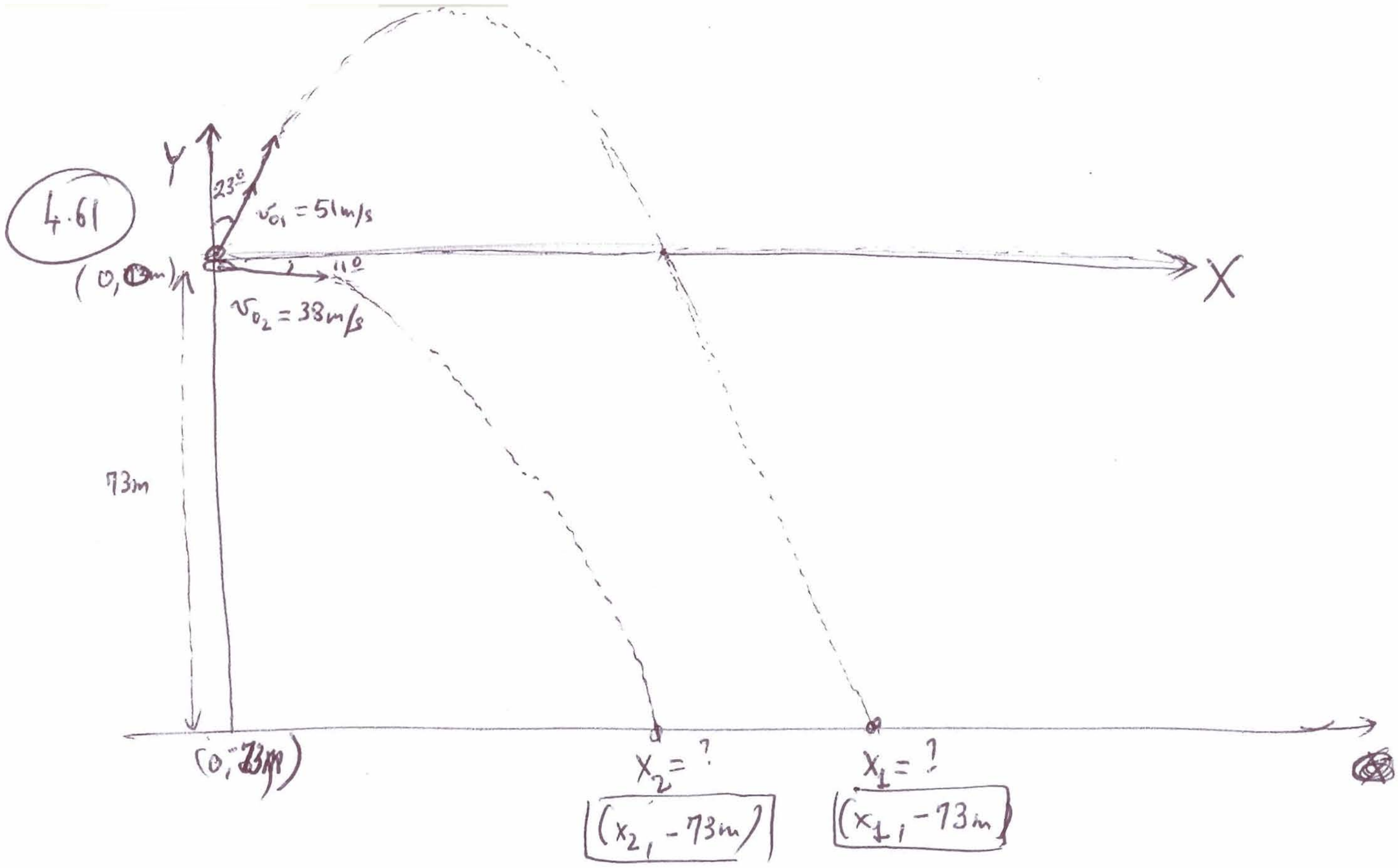


By using non-zero (x_0, y_0) in the derivation of the parabolic trajectory equation from equation II):

$$y - y_0 = (x - x_0)\tan\theta - \frac{g}{2}\frac{(x-x_0)^2}{v_0^2\cos^2\theta}$$

v_0: magn. of initial velocity
θ: angle of initial velocity w.r.t. X-axis.

~~In our problem~~ ($\cancel{x_0 = 0}$ m; $y_0 = 0$ m)

Piece #1:

$$-73 - 0 = (x_1 - 0)\tan 67° - \frac{9.81}{2}\frac{(x_1 - 0)^2}{51^2\cos^2 67}$$

$$0.012\,x_1^2 - 2.35\,x_1 - 73 = 0 \rightarrow x_1 = \frac{2.35 \pm \sqrt{2.35^2 + 3.5}}{0.024}$$

$$x_1 = \frac{2.35 \pm 3}{0.024}$$

$$x_1 = 223\,m.$$

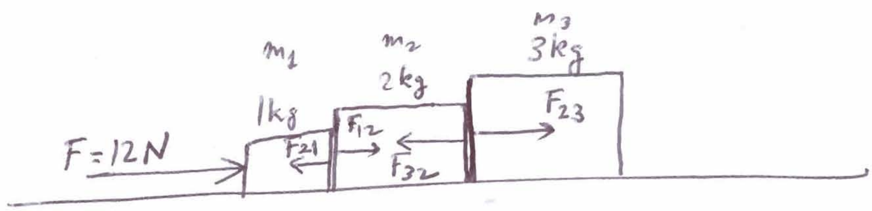
Piece #2:

$$-73 = x_2\tan(-11°) - \frac{9.81}{2}\frac{x_2^2}{38^2\cos^2 11}$$

$$+0.0035\,x_2^2 + 0.19\,x_2 - 73 = 0$$

$$x_2 = \frac{-0.19 \pm 1.03}{0.007} \rightarrow x_2 = 120\,m$$

5-36



What force m_2 exerts on m_3 ?

- The blocks are in contact at all time → they go together with the same acceleration: $a = \dfrac{F}{m_1+m_2+m_3}$

- Net Force exerted on m_3 ? $F_3 = m_3 a = m_3 \dfrac{F}{m_1+m_2+m_3} = \dfrac{3\times 12}{6}$

$= 6N$

From force diagram : $F_{3\,net} = F_{23} = 6N$

What is F_{21} ? (exerted by m_2 on m_1)

Two ways 1) Focus on m_1:

$F_{1net} = F - F_{21} = m_1 a = m_1 \dfrac{F}{m_1+m_2+m_3}$

$F_{21} = F\left(1 - \dfrac{m_1}{m_1+m_2+m_3}\right) = F\dfrac{m_2+m_3}{m_1+m_2+m_3}$

$= 12\dfrac{2+3}{6} = 10N$

1) Focus m_2

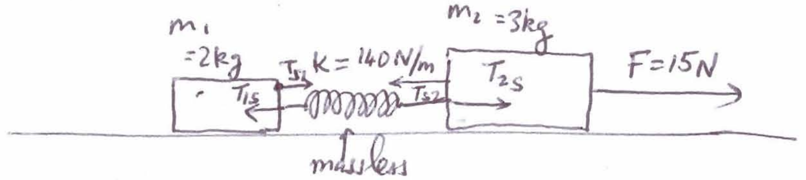
$F_{2net} = F_{12} - F_{32} = m_2 a = m_2 \dfrac{F}{m_1+m_2+m_3}$

F_{32} ↓ 6N

$m_2 \dfrac{F}{m_1+m_2+m_3}$

$\rightarrow F_{12} = F\dfrac{m_2+m_3}{m_1+m_2+m_3} = 10\,N$

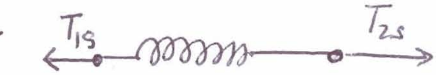
5.61



no friction surface

- System go together at same a
- How much does the spring stretch from its equilibrium length? $F_s = -k\Delta x$

a) ~~Total~~ Net force on the spring T



$$T = T_{2s} - T_{1s} = \underset{\substack{\downarrow \\ 0}}{m_s} a = 0$$

$$\boxed{T_{1s} = T_{2s}} = F_s'$$

b) Focus on m_1: $\quad F_{1net} = \underbrace{T_{s_1}} = m_1 a \rightarrow F_s' = m_1 a$

c) Focus on m_2: $\quad F_{2net} = F - T_{s_2} = m_2 a \rightarrow F - F_s' = m_2 a$

$$\rightarrow F_s' = F - m_2 a = F - \frac{m_2}{m_1} F_s'$$

$$F_s'\left(1 + \frac{m_2}{m_1}\right) = F \Rightarrow F_s' = \frac{F}{1 + \frac{m_2}{m_1}} = \frac{15}{1 + \frac{3}{2}}$$

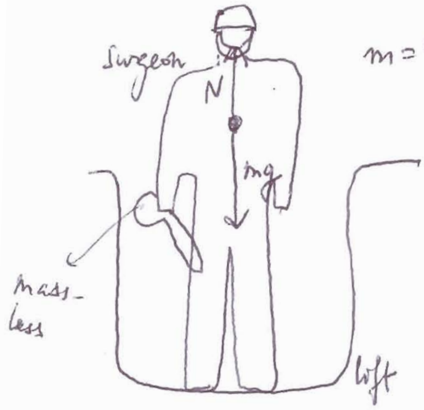
$$= \frac{15}{\frac{5}{2}} = 6N$$

$$\underset{\text{by spring}}{F_s} = -\underset{\text{on spring}}{F_s'} = -6N = -k\Delta x \rightarrow \Delta x = \frac{6}{k} = \frac{6N}{140\frac{N}{m}}$$

$\Delta x = 0.043\ m$ or $4.3\ cm$.

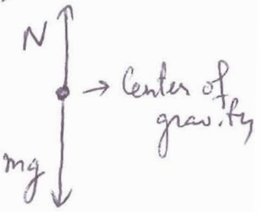
$$a = \frac{F_s'}{m_1} = \frac{6N}{2kg} = 3m/s^2 = \frac{F}{m_1 + m_2} = \frac{15N}{5kg} = 3m/s^2$$

(5.30)



$m = 74\,kg$

Free-body diagram:



N: normal force exerted by lift floor on the surgeon

N?

a) lift bucket at rest $a = 0 = a_{surgeon}$

$$F_{\substack{net\ on \\ surgeon}} = m \cdot a_{surgeon} = 0$$

$$N - mg = 0 \rightarrow N = mg = 74\,kg \times 9.81\,m/s^2 = 726\,N$$

b) bucket upward motion at constant $v = 2.4\,m/s$

$$N = 726\,N \quad (\text{since } a_{surgeon} = 0 \text{ again})$$

c) bucket downward at constant $v = 2.4\,m/s$

$$N = 726\,N \quad (a_{surgeon} = 0 \text{ again})$$

d) bucket acc. upward at $1.7\,m/s^2$?

$$F_{\substack{net\ on \\ surgeon}} = m \cdot 1.7\,m/s^2 = 74 \times 1.7\ N$$

$$N - mg = 74 \times 1.7 \rightarrow N = 74 \times 9.81 + 74 \times 1.7$$
$$= 852\,N$$

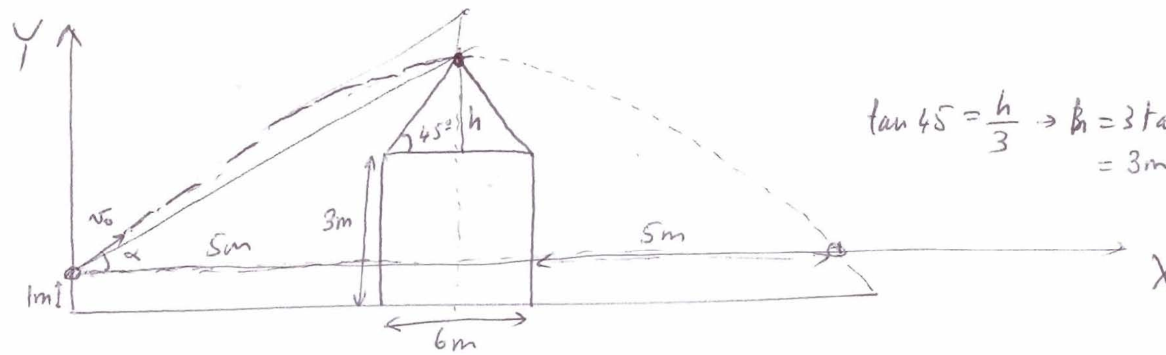
e) bucket acc. downward at $1.7\,m/s^2$

$$F_{\substack{net\ on \\ surgeon}} = 74 \times 1.7\,N$$

$$mg - N = 74 \times 1.7\,N$$

$$N = 74 \times 9.81 - 74 \times 1.7 = 600\,N$$

(4.34)



$\tan 45 = \frac{h}{3} \rightarrow h = 3 \tan 45° = 3m$

What are v_0 & α ?

The problem provide coordinats of max. altitude point (8m, 5m)

$$\boxed{\left(\frac{v_0^2 \sin 2\theta}{2g}, \quad \frac{v_0^2 \sin^2 \theta}{2g} \right)}$$

→ 2 eqs with 2 unknowns (v_0 & θ)

Trigonometry $\begin{cases} \sin 2\theta = 2 \sin\theta \cos\theta \\ \sin^2\theta = 1 - \cos^2\theta \end{cases}$

$$\boxed{\left(\frac{v_0^2 \sin\theta \cos\theta}{g}, \quad \frac{v_0^2 \sqrt{1-\cos^2\theta}\, \sin\theta}{2g} \right)}$$

$$\begin{cases} 8 = \dfrac{v_0^2 \sin\theta \cos\theta}{g} \\ 5 = \dfrac{v_0^2 \left(\sqrt{1-\cos^2\theta}\right) \sin\theta}{2g} \end{cases} \Rightarrow \frac{8}{5} = \frac{2 \cos\theta}{\sqrt{1-\cos^2\theta}}$$

$$\frac{64}{25}(1-\cos^2\theta) = 4\cos^2\theta$$

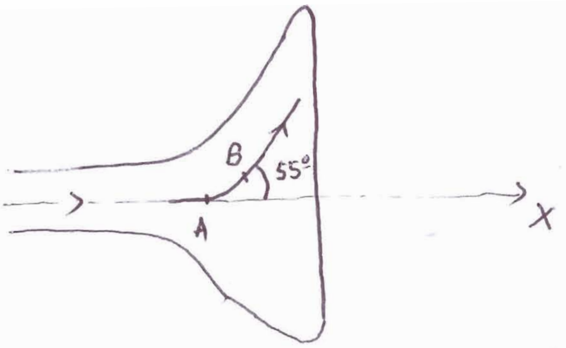
$$\left(4 + \frac{64}{25}\right)\cos^2\theta = \frac{64}{25}$$

$$\cos^2\theta = \frac{64}{25} \cdot \frac{1}{4 + \frac{64}{25}}$$

$$\rightarrow \cos\theta = 0.62 \rightarrow \boxed{\theta = 51.34°}$$

$$v_0 = \sqrt{\frac{8 \times 9.81}{\sin 51.34° \cos 51.34°}} = \boxed{12.6 \text{ m/s}}$$

4.48/



- $R = 4.3\,cm$
- $a = 3.35\times10^{17}\ \frac{m}{s^2}$
- During deflection electrons at constant speed.

How long for electrons to get from A to B?

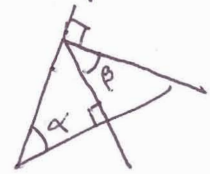
Uniform Circular Motion

a = centripetal acceleration

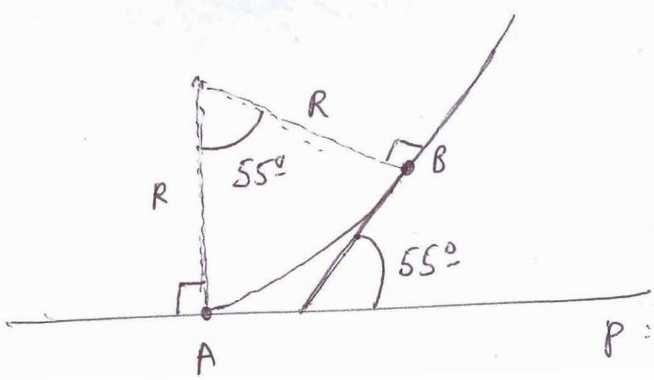
$$a = \frac{v^2}{R} \rightarrow v = \sqrt{aR}$$

$$t_{AB} = \frac{\text{arc } AB}{v} = \frac{\text{arc } AB}{\sqrt{aR}} = \frac{R.\theta_{AB}}{\sqrt{aR}} = \frac{0.043 \times 55\pi}{180\sqrt{3.35\times10^{17}\times0.043}} = 342\times10^{-12}\,s$$

$= 342\,ps$



$\alpha = \beta$



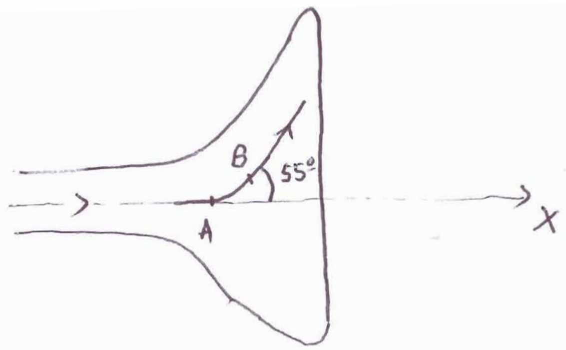
$$\theta_{AB} = 55° \cdot \frac{\pi\,rad}{180°}$$

p : "pico" $= 10^{-12}$

$$v = \sqrt{aR} = 1.2\times10^{8}\ \frac{m}{s}$$

4.34/ Next page

4.48/



- $R = 4.3\,cm$
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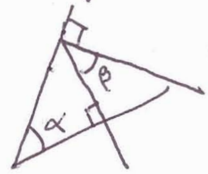
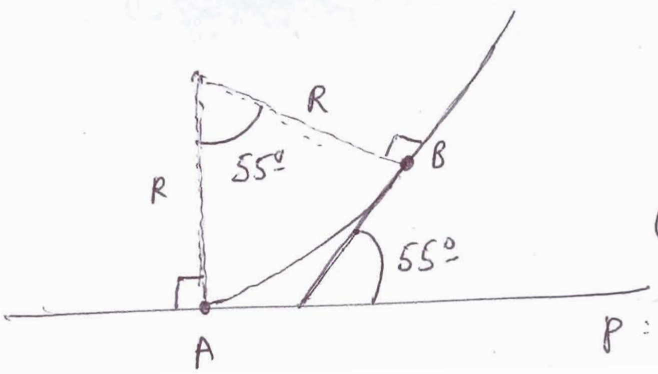
$\alpha = \beta$ $\qquad = 342\,ps$





$$\theta_{AB} = 55° \cdot \frac{\pi\,rad}{180°}$$

p : "pico" $= 10^{-12}$

$$v = \sqrt{aR} = 1.2\times10^{8}\ \frac{m}{s}$$

4.34/ Next page

4.34/ Alternative:

at max altitude point

$$\frac{v_y^2 - v_{oy}^2}{y - y_o} = -2g \rightarrow v_{oy}^2 = 5\times 2\times 9.81$$

$$v_{oy} = \sqrt{98.1} = \boxed{9.905\ m/s}$$

$$\underset{0}{\underset{\downarrow}{v_y}} = v_{oy} - gt \rightarrow t = \frac{v_{oy}}{g} = \frac{9.905}{9.81} = 1.01 s$$

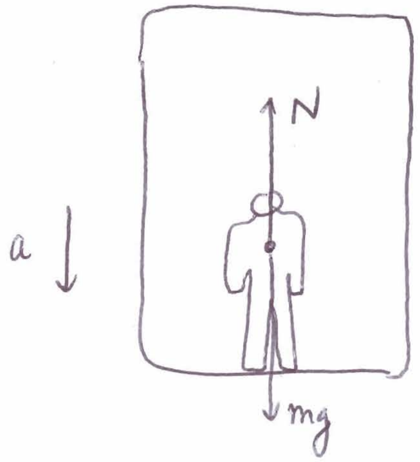
Along x-direction ball will travel 8m during this time at constant speed: $8 = v_{ox}\, t \rightarrow v_{ox} = \frac{8}{t} = \frac{8}{1.01}$

$$\boxed{v_{ox} = 7.92\ m/s}$$

$$\rightarrow \vec{v}_o = (7.92, 9.905) = (12.68, 51.35^{\circ})\ m/s$$

This method is based on kinematic equations (I & II & III) is shorter than starting w/ projectile motion equations (which were derived from kinematic equations)!

5.57/



Free-body diagram

$$F_{net\ on\ person} = ma = mg - N$$

When elevator accelerates downward, assuming person - elevator floor in contact at all time, person accelerates @ same rate:

0 to 9.2 m/s in 2.1 s : $v = v_o + at \rightarrow a = \frac{v - v_o}{t} = \frac{9.2 - 0}{2.1}$

$$a = 4.38\ m/s^2$$

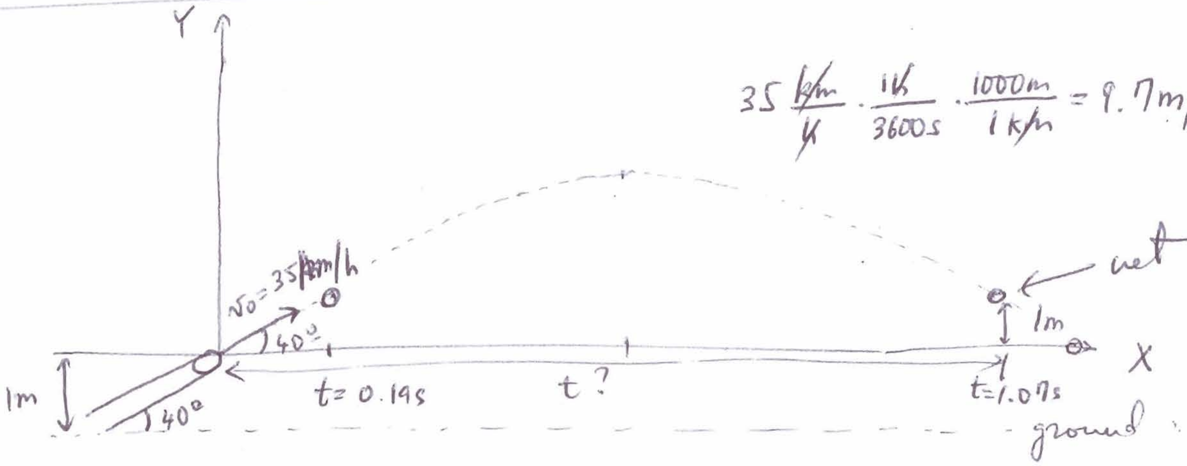
apparent weight: $N = m(g-a)$

compare with actual weight: $\frac{N}{mg} = \frac{\cancel{m}(g-a)}{\cancel{m}g} = 1 - \frac{a}{g}$

$= 1 - \frac{4.38}{9.81} = 0.553$ or 55.3%

4.29

$35 \frac{km}{h} \cdot \frac{1h}{3600s} \cdot \frac{1000m}{1km} = 9.7 m/s$



After leaving cannon, only force on person is gravity →
parabolic projectile motion as shown.

Using kinematic equation. II) $\begin{cases} x = x_0 + v_{0x} t \\ y = y_0 + v_{0y} t - \frac{1}{2} g t^2 \leftarrow \end{cases}$

$y_0 = 0$, $v_{0y} = v_0 \sin 40°$

To get time until net: $\longrightarrow 1m = 0 + \underbrace{v_0 \sin 40°}_{9.7 \sin 40° = 6.2} t - \underbrace{\tfrac{1}{2} 9.81}_{4.9} t^2$

$4.9t^2 - 6.2t + 1 = 0 \Rightarrow t = \frac{6.2 \pm \sqrt{6.2^2 - 4 \times 4.9}}{9.81} = \begin{cases} 1.07s \\ 0.19s \end{cases}$

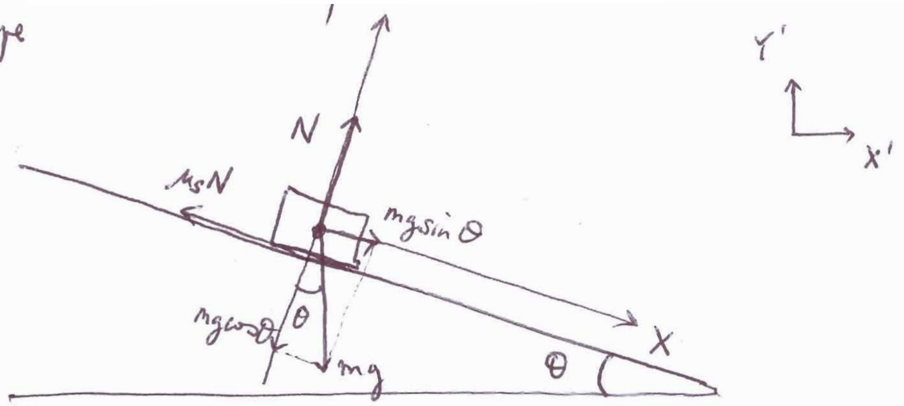
$= \frac{6.2 \pm 4.34}{9.81}$

Positions along x-axis: $x = x_0 + v_{0x} t$ $\begin{cases} \text{at } t = 0.19s & x = 1.41m \\ \text{at } t = 1.07s & x = 7.95m \end{cases}$

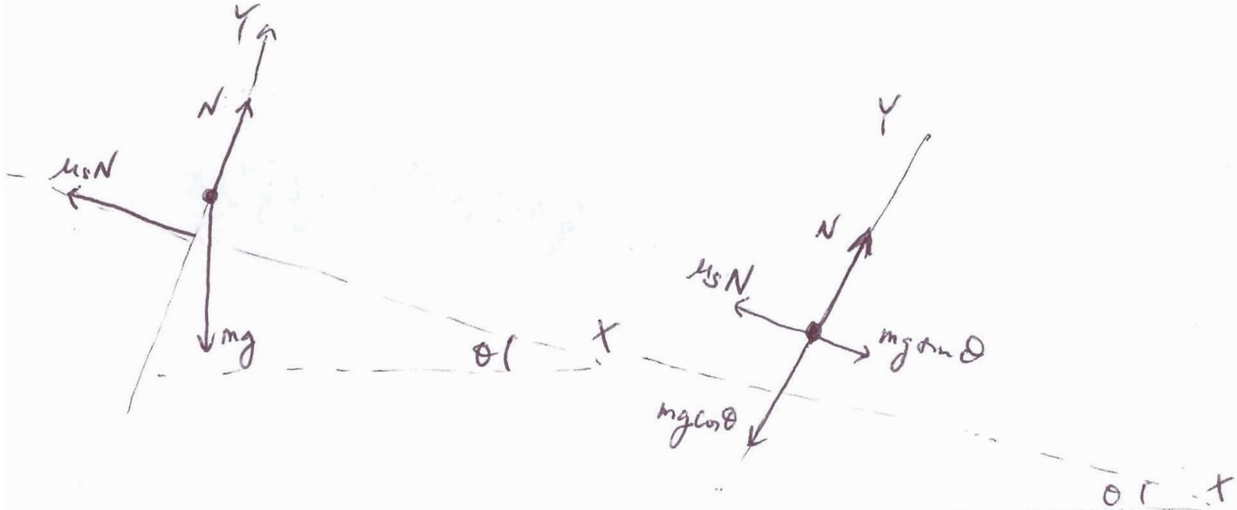
$x_0 = 0$

$v_{0x} = v_0 \cos 40° = 9.7 \times \cos 40° = 7.43$ m/s

1) Slope



N & $\mu_s N$ are along axes ; mg needs decomposition
(since 2 out of 3 forces are along axes, more convenient to use XY than X'Y')



<u>Newton's equation</u>:

$$\vec{F}_{net} = m\vec{a} \begin{cases} F_{x\,net} = mg\sin\theta - \mu_s N = m.a_x = 0 \quad (a_x = 0 \text{ (at rest)}) \\ F_{y\,net} = N - mg\cos\theta = ma_y = 0 \end{cases}$$

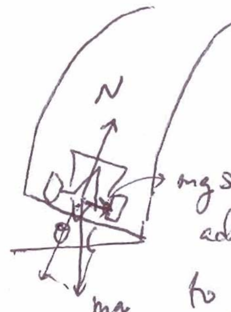
$$N = mg\cos\theta$$

$$\cancel{mg}\sin\theta - \mu_s \cancel{mg}\cos\theta = 0$$

$$\boxed{\mu_s = \tan\theta}$$

2) Curve

$\mu_K N$ provides centripetal acceleration $a = \frac{v^2}{R}$



$mg \sin\theta$ will be added to $\mu_K N$ to provide higher centripetal acceleration.

$$\mu_K N < \frac{mv^2}{R}$$

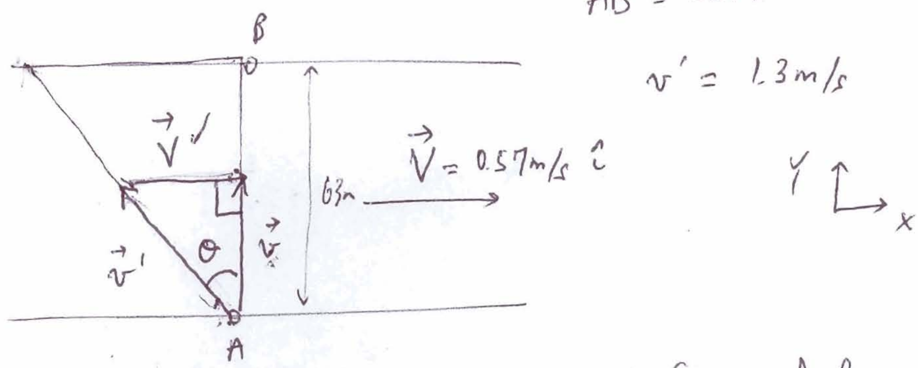
there is a technical limit

4.61 see previous notes.

3.48

$AB = 63m$

$v' = 1.3 m/s$



a) What direction should you head? (to get from A to B)

$$\vec{v} = \vec{v}' + \vec{V}$$

$\vec{v}$: your vel. w.r.t. ground

$\vec{v}'$: your vel. w.r.t. water

$\vec{V}$: vel. of water w.r.t. ground.

→ θ enough to accomodate $\vec{V}$ such that $\vec{v} = \vec{v}' + \vec{V}$ is along AB

$$\sin\theta = \frac{V}{v'} \rightarrow \theta = \sin^{-1}\frac{V}{v'} = \sin^{-1}\frac{0.57}{1.3} = 26^\circ$$

b) How long to cross river? $t = \frac{63m}{v}$

$$v^2 + V^2 = v'^2 \rightarrow v = \sqrt{v'^2 - V^2} = \sqrt{1.3^2 - 0.57^2} = 1.17 m/s$$

$$t = \frac{63m}{1.17\frac{m}{s}} = 53.9s$$