Plan

Projectile Lab - Report and Uncertainty Calcuations

September 17, 2025 9:20 AM

Format: → try to use LaTeX to practice

a) **Muzzle Velocity:**
Data table (times) → Explain why 5 observers
Calculations to find the muzzle velocity (show all work + diagram)

b) **Range:**
Data table (Experimental Range)
Calculations to find theoretical range

Uncertainty:
c) ΔMuzzle Velocity
- Estimate for Uncertainty of Height/Meterstick w/ justification
- Estimate for Uncertainty of Stopwatch w/ justification
- Calculation to find %Δ for the muzzle velocity

ΔRange
d)
- Estimate for Uncertainty in Experimental Range w/ justification
- Estimate for Uncertainty in the 1m launch height
  - Relate to Uncertainty of time
- Calculation to find %Δ for the Theoretical Range

Report all results with uncertainties (in absolute uncertainty)

Crank 3 Calculation & Reported Results

Two Concluding Questions from the Lab Sheet

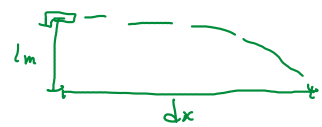
*All values are examples

a) Calculate muzzle velocity

$v_i = ?$
v_f
$a = -9.8\,m/s^2$
$d = -1\,m$
$t = \cancel{x}\ 3.308\,s$

$d = v_i t + \frac{1}{2}at^2$
$v_i = \frac{d - \frac{1}{2}at^2}{t}$
$v_i = \cancel{14}\ m/s$ 15.96 m/s

b) Calculate theoretical Range



x
$v_x = \cancel{14}\ 15.96\ m/s$
$d_x = ?$
$t = 0.4517\,s$

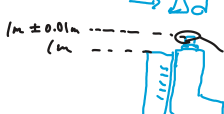
y
$v_{iy} = 0$
v_{fy}
$a_y = -9.8\,m/s^2$
$d_y = -1\,m$
$t = ?$

$d = \cancel{v_i t} + \frac{1}{2}at^2$
$t = \sqrt{\frac{2d}{a}}$
$t = 0.\cancel{4517}\,s$ 0.4518

$d_x = v_x t$ (15.96, 0.4518)
$d_x = \cancel{6.3}\ m$ 7.21
Theoretical Range

c) ΔMuzzle Velocity

→ Δd Estimate ± $\cancel{2}$ cm 1cm (0.01m)



because the tip of the dart rested ---- ---etc.

Δt Estimate ± 0.6s
because my reaction time was measured at 0.300s which effects results when starting and stopping the timer
⇒ find a research
↳ Kosinski (2008)
Auditory SRT
140ms − 160ms
(Auditory and Visual is different)

Is that actually small?

Justify (show another example)

$\%\Delta d = \frac{\cancel{2}\,cm}{100\,cm} = \cancel{2}\%$ 1, 1

My method
$\%\Delta t = \frac{0.6}{3} = 20\%$

very little
$\%\Delta v$
$v = \frac{d - \frac{1}{2}at^2}{t}$

Mr. Westergaard's Method

constants
$\Delta v \approx \frac{\frac{1}{2}at^2}{t} \approx \frac{t^2}{t} \approx \Delta t$

$d = v_i t + \frac{1}{2}at^2$
$v_i = \frac{d - \frac{1}{2}at^2}{t}$ → compare numerator $|d|$ and $|\frac{1}{2}at^2|$

$\frac{|d|}{|\frac{1}{2}at^2|}$ ← How big = $\frac{1}{57.79} \approx 0.0186$ (1.86%) ← very small in the formula
take absolute value to compare values

$v_i \approx \frac{\frac{1}{2}at^2}{t} = \frac{\frac{1}{2}(9.8)t^2}{t} = \frac{4.9t^2}{t} = 4.9t$

∴ $v_i \propto t$
↳ $\%\Delta v_i \approx \%\Delta t$

Justified

d)
Experimental Range
- Identifying where it lands
- Stacking toothpicks

bounce off

Theoretical
$\Delta d = \pm 2$ cm
w/ a reason → Shake

Stacking meter sticks

$\Delta R_{exp} =$

$\%\Delta d = \frac{\Delta d}{d}$

$d_x = v_x \cdot t$ (muzzle velocity)

$\%\Delta t = \frac{1}{2}\%\Delta d$

$t = \sqrt{\frac{2d}{a}}$ constants

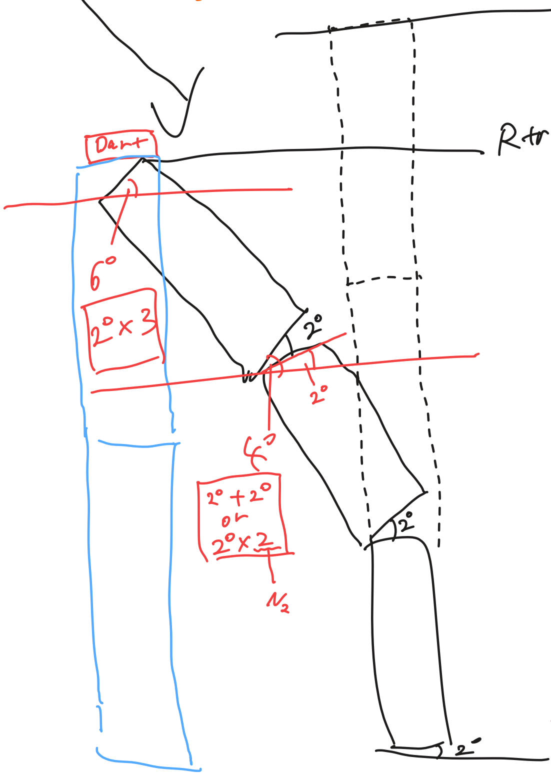
$t \approx d^{\frac{1}{2}}$

$\%\Delta d_x = \%\Delta v_x + \%\Delta t$

Report Results

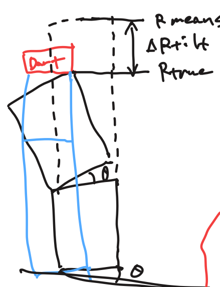
Experimental Range — Data table

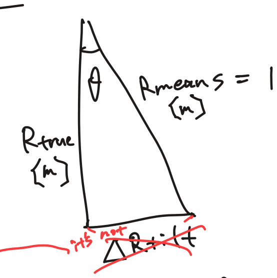
Theoretical Range — part (b)



$R_{means} = \text{Meterstick}_1 + \text{Meterstick}_2 + \dots \text{Meterstick}_n$

$R_{means} = \frac{R_{true}}{\cos\theta}$





$\cos\theta = \frac{R_{true}}{R_{means}}$

$R_{means} = \frac{R_{true}}{\cos\theta}$

$R_{means} = R_{true} \cdot \sec\theta \quad \dots ①$

$\Delta R_{tilt} = R_{means} - R_{true}$

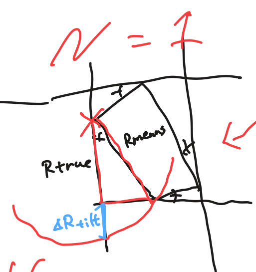
% of ΔR_{tilt} compared to R_{true}

$\frac{\Delta R_{tilt}}{R_{true}} = \frac{R_{means} - R_{true}}{R_{true}} \quad \dots ②$

By ①, ②,

$\frac{\cancel{R_{true}} \cdot \sec\theta - \cancel{R_{true}}}{\cancel{R_{true}}} = \sec\theta - 1$

when only one m stick



when there are several sticks

$\frac{\Delta R_{tilt}}{R_{true}} = \frac{R_{means} - R_{true}}{R_{true}} \quad \dots ③$

N as number of 1m stick $\therefore R_{means} = N$

$R_{true} = \sum_{i=1}^{N} \cos(2i^\circ) \quad \dots ④$ (increment of 2)

$1 \cdot (\cos 2^\circ + \cos 4^\circ + \dots \cos(2N^\circ))$ 1m stick

By ③, ④,

$$\boxed{\%\Delta R_{tilt} = \frac{N - \sum_{i=1}^{N} \cos(2i^\circ)}{\sum_{i=1}^{N} \cos(2i^\circ)}}$$

Stacking meter sticks

⋮

$\Delta R_{exp} =$

$\%\Delta d = \frac{\Delta d}{d}$

muzzle velocity

$d_x = v_x \cdot t$

$\%\Delta t = \frac{1}{2}\%\Delta d$

$t = \sqrt{\frac{2d}{a}}$

constants

$t \approx d^{\frac{1}{2}}$

$\%\Delta d_x = \%\Delta v_x + \%\Delta t$

Report Results

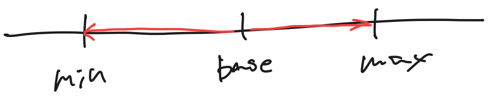
Experimental Range

Data table

Theoretical Range

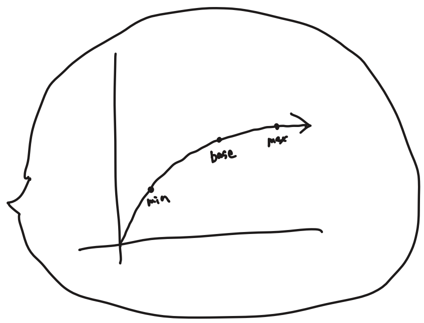
part (b)

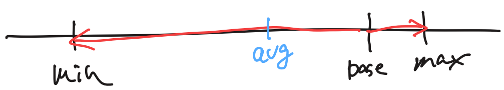
Crank 3 method



base ± difference

what if base is offset?





↳ base ± difference cannot evaluate correctly.

then use avg of min & max

$\frac{min + max}{2} = avg$

↳ I think avg can evaluate correctly because avg takes same amount of difference

$|min - avg|$ or $|max - avg|$

↳ $\frac{max - min}{2}$

$$\boxed{R_{report} = \frac{min + max}{2} \pm \frac{max - min}{2}}$$

x	y
	v_f
$v_i = 15.96\cos\theta$	$v_i = 15.96\sin\theta$
$d = 9.61\,m$	$d = -1\,m$
t $\longleftrightarrow$	t
	$a = -9.8\,m/s^2$
$9.61 = 15.96\cos\theta \cdot t$	$-1 = (15.96\sin\theta)t + \frac{1}{2}(-9.8)t^2$
$t = \frac{9.61}{15.96\cos\theta}$	

$$-1 = \cancel{15.96}\sin\theta \cdot \frac{9.61}{\cancel{15.96}\cos\theta} + \frac{1}{2}(-9.8)\left(\frac{9.61}{15.96\cos\theta}\right)^2$$

$$-1 = 9.61\frac{\sin\theta}{\cos\theta} - 4.9\left(\frac{9.61^2}{15.96^2\cos^2\theta}\right)$$

$$-1 = 9.61\tan\theta - \left(\underbrace{4.9\left[\frac{9.61}{15.96}\right]^2}_{1.78}\right)\sec^2\theta$$

$$-1 = 9.61\tan\theta - 1.78\sec^2\theta$$

$$\sec^2\theta = 1 + \tan^2\theta$$

$$-1 = 9.61\tan\theta - 1.78(1 + \tan^2\theta)$$

$\tan\theta$ as A

$$-1 = 9.61A - 1.78(1 + A^2)$$

$$1.78A^2 - 9.61A + 1.78 - 1 = 0$$

$$A = \frac{9.61 \pm \sqrt{9.61 - 4(1.78)(0.78)}}{2(1.78)}$$

$$\tan\theta = 5.3273,\ 0.08235$$

$$\cancel{\theta = 78.37,\ 46.9}$$