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8.01X

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PROBLEM FOR EXPERIMENT FO: FALLING OBJECT

Experiment FO: Solutions

1. My LVPS was set at 6.0 Volts
2. My data for the trials at 3 different distances is

	V cap	V cap	V cap
distance	260 mm	130 mm	65 mm
	0.125	0.091	0.066
	0.132	0.092	0.065
	0.125	0.091	0.064
	0.126	0.091	0.064
	0.125	0.09	0.066
ave	0.1266	0.091	0.065
st dev	0.0030	0.0007	0.0010

3. My data for measuring the time constant $\tau = RC$ is

	(V cap) ₁	(V cap) ₂	time constant τ
	at time $t_1 = 0$	at time $t_2 = 20s$	
	0.24	0.038	10.85
	0.24	0.038	10.85
	0.237	0.039	11.08
ave	0.239	0.0383	10.93
st dev			0.133

where I used
$$\tau \cong \frac{\Delta t}{\ln(V_1/V_2)} = \frac{t_2 - t_1}{\ln(V_1/V_2)}$$
 (1)

4. The average time for each distance is calculated using

$$t = \frac{\bar{z} \bar{V}_{cap}}{V_{LVPS}}$$

average time (s)	0.2306	0.1657	0.1184
distance (mm)	260	130	65

5. The error in the measurement of t for each distance is derived from the product rule applied to the formula

$$t = \frac{\bar{z} \bar{V}_{cap}}{V_{LVPS}}$$

$$\frac{\Delta t}{t} = \left(\left(\frac{\Delta \bar{z}}{\bar{z}} \right)^2 + \left(\frac{\Delta V_{cap}}{\bar{V}_{cap}} \right)^2 \right)^{1/2}$$

$$\text{Thus } \Delta t = t \left(\left(\frac{\Delta \bar{z}}{\bar{z}} \right)^2 + \left(\frac{\Delta V_{cap}}{\bar{V}_{cap}} \right)^2 \right)^{1/2}$$

where $\Delta \bar{z}$ is the standard dev. for \bar{z}
and ΔV_{cap} is the standard dev. for each \bar{V}_{cap}
The results are

distance (mm)	ave time	Δt
0	0	0
65	0.2306	0.0023
130	0.1657	0.0024
260	0.1184	0.0062

By the product rule the error in t^2 is given by

$$\Delta t^2 / \bar{t}^2 = 2 \Delta t / \bar{t}$$

So the error in Δt^2 is

$$\Delta t^2 = (\bar{t})^2 \left(\frac{2 \Delta t}{\bar{t}} \right)$$

The results are given below with

$$\Delta t = .133 \text{ s} \quad \bar{t} = 10.93 \text{ s}$$

distance (mm)	time t^2 (s)	Δt^2 (s ²)	V_{cap} (V)	ΔV_{cap} (V)	\bar{t} (s)
0	0	0	0	0	0
65	0.0140	0.00464	0.1266	0.00305	0.2306
130	0.0275	0.00478	0.091	0.00071	0.1657
260	0.0532	0.01244	0.065	0.0010	0.1184

So the final results of distance vs t^2 are given in the table below

distance (mm)	time t^2 (s ²)
0	0
65	0.0140
130	0.0275
260	0.0532

The results are shown in the graph of t^2 vs distance. Since

$$h = \frac{1}{2} g t^2 \Rightarrow t^2 = \frac{2h}{g}$$

and the slope = $\frac{2}{g}$ so

$$g = \frac{2}{\text{slope}}$$

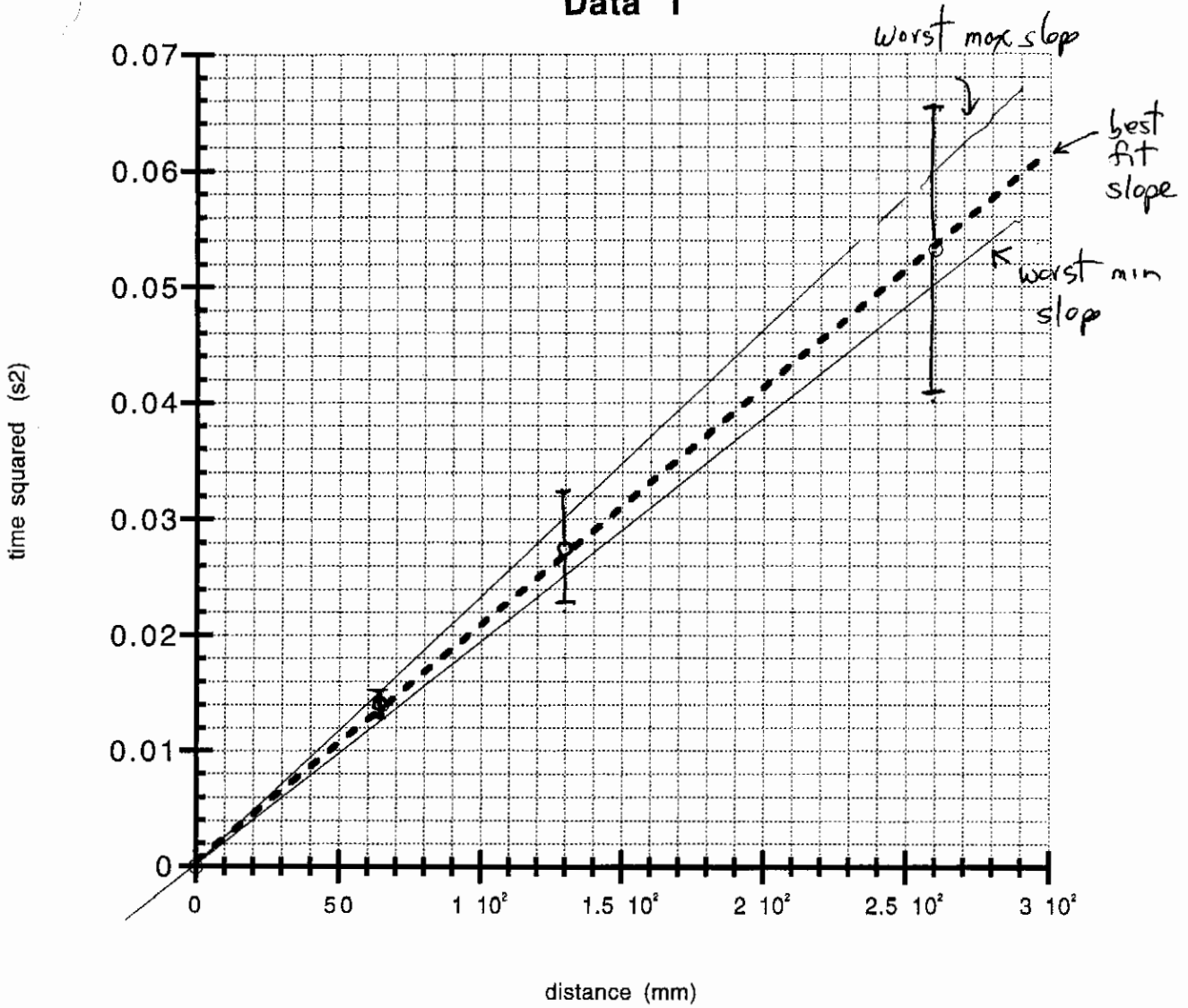
(3)

best fit : $\text{slope} = \frac{g}{2} = 0.000204 \frac{\text{s}^2}{\text{mm}}$

$\bar{g} = 9.80 \text{ m/s}^2$

----- $y = 0.00046 + 0.000204x$ $R = 1$

Data 1



Now the error in the slope due to the uncertainty in the measurements is given by computing the slope with the worst max value

$$\text{slope}_{\text{max}} = \frac{0.06 \text{ s}^2}{260 \text{ mm}} = 2.308 \times 10^{-4} \frac{\text{s}^2}{\text{mm}}$$

corresponding to a value of

$$g_{\text{min}} = \frac{2}{(\text{slope})_{\text{max}}} = 8.67 \text{ m/s}^2$$

The minimum value for the slope

$$(\text{slope})_{\text{min}} = \frac{0.05 \text{ s}^2}{260 \text{ mm}} = 1.923 \times 10^{-4} \frac{\text{s}^2}{\text{mm}}$$

$$g_{\text{max}} = \frac{2}{(\text{slope})_{\text{min}}} = 10.4 \text{ m/s}^2$$

so

$$\bar{g} = 9.80 \frac{\text{m}}{\text{s}^2}$$

$$\Delta g = \pm 1.6 \text{ m/s}^2$$

$$g_{\text{expt}} = 9.80 \text{ m/s}^2 \pm 1.6 \text{ m/s}^2$$

$$\frac{\Delta g}{\bar{g}} = 16\%$$