Name		LA ( )

B. Results and data analysis (42 pts)

Part I. Measurements of the initial velocity, time-of-flight and horizontal travelling distance of the projectile (21 pts)

Table 1

Vertical distance = 0.878 m ± 0.0005 Angle of inclination = 58° ± 0.5°

Trial	Initial velocity (ms^{-1})	Time-of-flight (s)	Horizontal distance (m)
1	4.01	0.874	2.006 ± 0.0005
2	4.06	0.892	1.986 ± 0.001
3	3.87	0.865	1.859 ± 0.0015
4	4.00	0.878	2.011 ± 0.001
5	4.06	0.893	1.983 ± 0.0015
Average	4.00	0.880	1.969
Standard error	0.0311	0.00481	0.02507

Part II. Study of the effect of different angles of inclination (21 pts)

Table 2

Vertical distance = 0.878 m ± 0.0005 Angle of inclination = 35° ± 0.5°

Trial	Initial velocity (ms^{-1})	Time-of-flight (s)	Horizontal distance (m)
1	4.07	0.714	2.390 ± 0.0015
2	4.09	0.724	2.414 ± 0.0015
3	4.00	0.702	2.328 ± 0.001
4	4.09	0.724	2.404 ± 0.0015
5	4.09	0.725	2.409 ± 0.0015
Average	4.07	0.718	2.389
Standard error	0.0156	0.00396	0.01410

TA signature: Zhang Wei

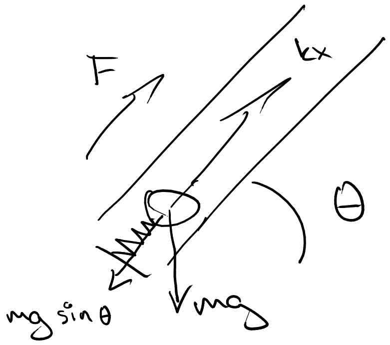
C. Answer the following questions after the experiment (8 pts each)

4. Compare the difference between the two initial velocities for different angles of inclination. According to the concept discussed in Section III: "Discussion of Errors in Lab Write-Ups" on page "Error analysis – 4/9" in the lab manual, does the magnitude of the initial velocity change with the angle of inclination?

Assuming that the measuring device can measure the initial velocity with an error $< 0.01 \text{ ms}^{-1}$, we see that the discrepancy in the v_0 values in parts I and II is 0.07 ms^{-1}, whereas the sum of uncertainties is $\approx 0.02 \text{ ms}^{-1}$. This means that the velocity does change depending on θ, and we can even explain it physically.

$$F = kx - mg \sin\theta$$

$$\theta_1 < \theta_2 \Rightarrow F_1 > F_2 \Rightarrow v_{0_1} > v_{0_2}$$



5. Using Eq. (4) with the known values of the angle of inclination, θ, the mean value of the initial velocity of the ball, v_0, and the measured vertical height of the Projectile Launcher above the floor, y_0, in Part I, calculate the time-of-flight of the ball. There are two solutions, which one represents the correct time-of-flight? What is the significance of the other time value?

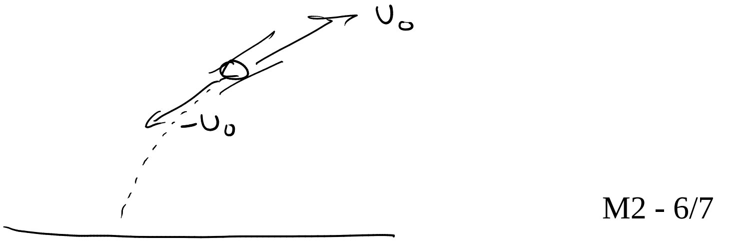
$$y = y_0 + (v_0 \sin\theta)t - \frac{1}{2}gt^2$$

$$y = 0.878 + 4.00 \cdot \sin(58°) \cdot t - \frac{1}{2}gt^2 = 0$$

$$t_1 = 0.892\text{s}, \quad t_2 = -0.201\text{ s}$$

correct one, since the other is negative

The other time value shows how much time it would take the ball to fall in the other direction, had it been launched with velocity $-v_0$!



6. Calculate the percent error between the value that you calculated in Question 5 and the measured average value. What physical mechanisms (or reasons) might be involved in the difference among the measured five values of the time-of-flight?

$$err = \frac{|t_1 - t_{av}|}{t_{av}} \cdot 100\% = 1.36\%$$

The 5 measured times are different primarily due to slightly different initial velocities, which in turn, may result from mechanical imperfections. The measurement of the times themselves may bear errors.

7. Calculate the horizontal distance using the measured time-of-flight, the initial velocity and the angle of inclination given in Table 2. Calculate the percent error between the calculated horizontal distance and the measured average distance in Table 2.

$$x = v_0 \cos\theta \cdot t \qquad x_f = v_0 \cos\theta \cdot t_{av} = 4.07 \cdot \cos(35^\circ) \cdot 0.718 =$$
$$= 2.394 \text{ m}$$

$$\frac{|x_f - x_{av}|}{x_{av}} = \frac{2.394 - 2.389}{2.389} = 0.002 = 0.2\%$$

8. Suggest how to change the velocity of the ball in order to shoot over much larger distances, say ~100 meters.

From equations (3) and (4) it can be derived that the optimal angle θ is 45°, since that would maximize $v_0 \cos\theta \cdot t_f$. Apart from that, the magnitude of v_0 should be increased to reach further distances.