

ENED 1090: Engineering Models I
Homework Assignment #3

Due: Week of September 23rd at the beginning of your Recitation Section

Instructions:

1. In addition to this HW3 document, you will also need the two excel files posted with HW3: ProjectileData.xlsx and HydrogenPeroxide.xlsx. Put both of these files in your current MATLAB directory.
2. **Show your work! Make sure you include MATLAB commands.**
3. It is fine to work with other students, but what you turn in must be your own work - not something copied from someone else.
4. Submit an electronic copy of your work to your *individual section* of Blackboard – go to the Assignments Folder and look for Homework #3.

Problem 1: Curve Fitting – Trajectory of Projectile

The excel file, ProjectileData, has three columns of data: time, distance, and height. Import each of these columns into MATLAB using either xlsread or the Import Data tool. The variable distance represents measurements of the x-position (horizontal position) of the projectile over time and the variable height represents measurements of the y-position (vertical position) of the projectile over time.

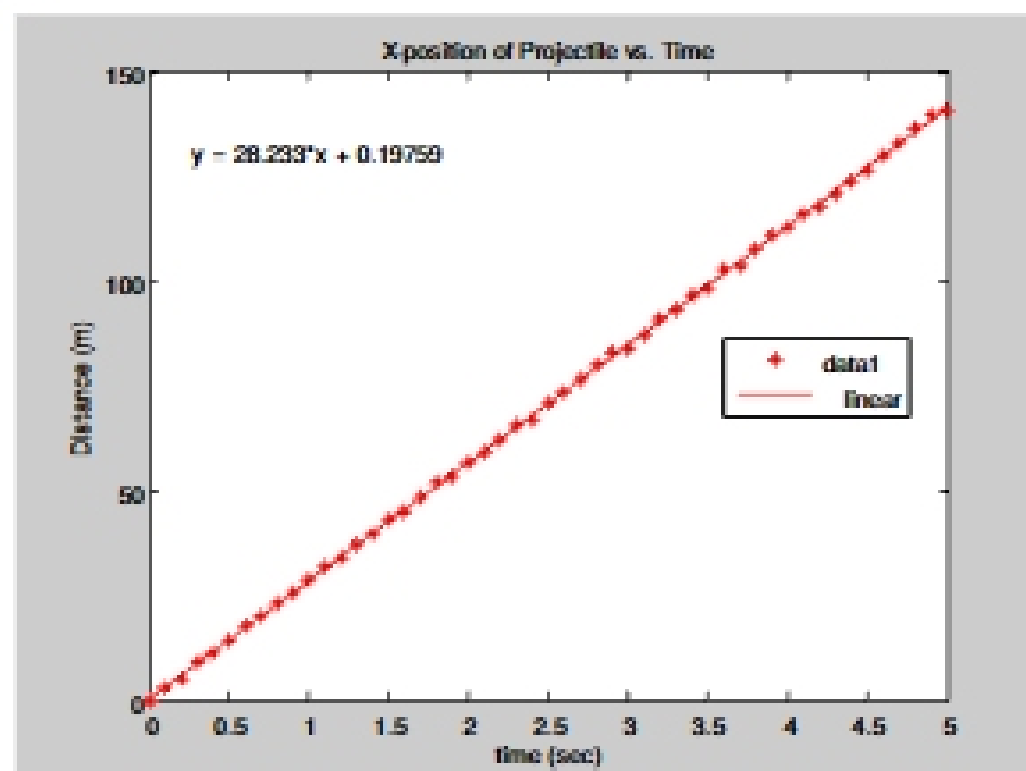
The equations for the x and y position of a projectile launched at an angle of θ (rad or degrees) with an initial velocity of V_0 (m/s) are:

$$x_{\text{position}} = [V_0 \cos(\theta)]t$$

$$y_{\text{position}} = -\frac{1}{2}gt^2 + [V_0 \sin(\theta)]t + y_0 \quad \text{Note: } g = 9.81 \text{ m/s}^2$$

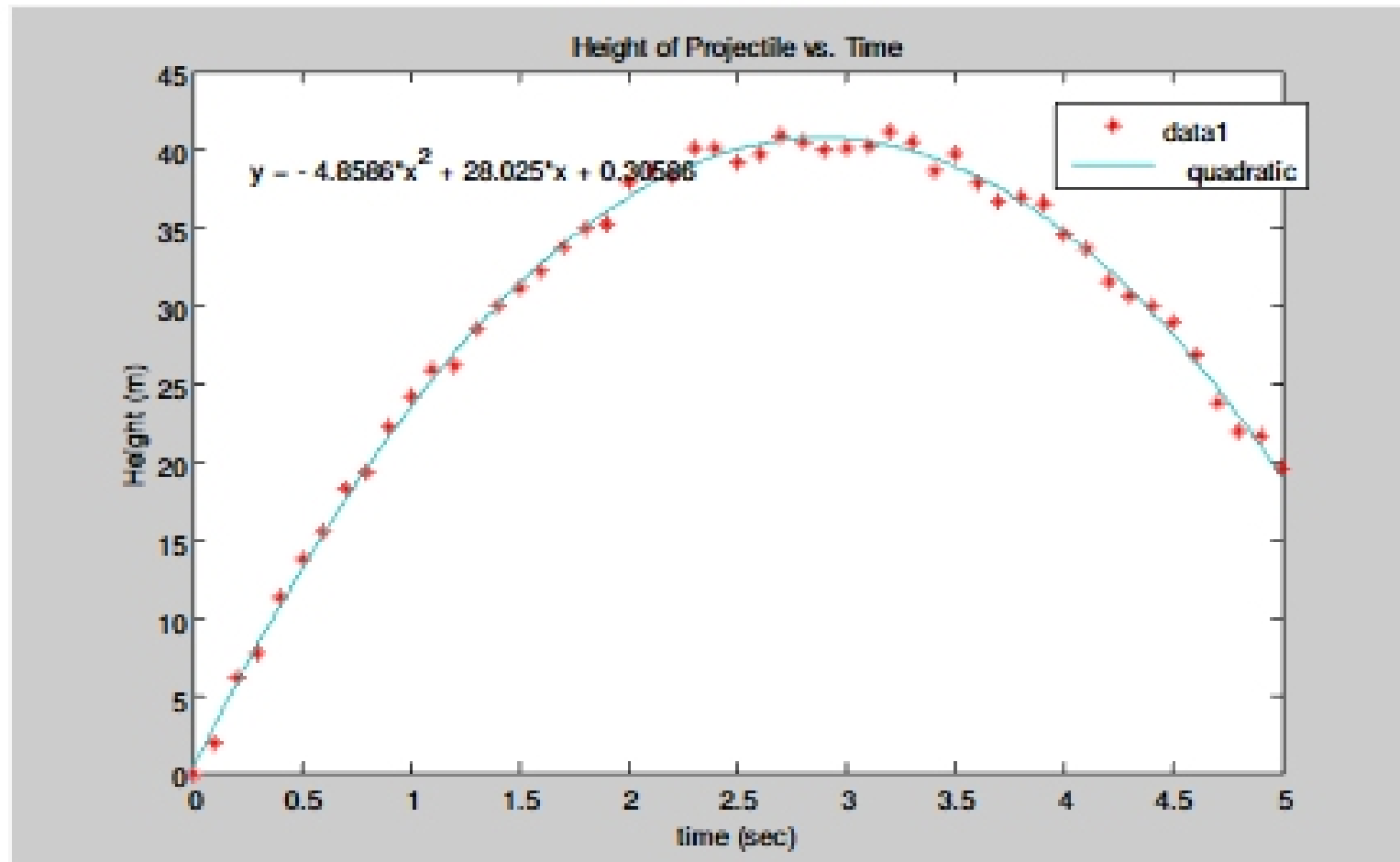
- (a) Plot **time** on the x-axis and **distance** on the y-axis. Add axis labels (with units) and a title to your plot. We know that the x-position of the projectile increases linearly with time. So use the curve fitting tool to fit a 1st order polynomial (line) to the distance data. Display the equation for the fitted polynomial on your graph with 5 significant digits. Then copy and paste your plot in the space below.

MATLAB PLOT:



- (b) Plot **time** on the x-axis and **height** on the y-axis. Add axis labels (with units) and a title to your plot. We know the height of the projectile follows a parabolic (2nd order) curve. So use the curve fitting tool to fit a 2nd order polynomial (quadratic) to the height data. Display the equation for the fitted polynomial on your graph with 5 significant digits. Then copy and paste your plot in the space below.

MATLAB PLOT:



- (c) Look at the numerical coefficient for the squared term in the fitted polynomial for the **height** data. Theoretically, this coefficient should be equal to $-1/2 \cdot g$. How close is it? Calculate a percent error using the following formula with $-1/2 \cdot g$ as actual value:

$$\%Error = \frac{Estimated - Actual}{Actual}$$

Show Calculations:

EDU>> (-4.8586-(-0.5*9.81))/(0.5*9.81)*100

% Error = 0.95%

- (d) The numerical coefficient for the linear term in the fitted polynomial for **height** should be approximately $V_0 \sin(\theta)$ and the numerical coefficient for the linear term in the fitted polynomial for **distance** should be approximately $V_0 \cos(\theta)$. Enter the values below then solve for the initial velocity, V_0 , and the launch angle, θ .

$V_0 \sin(\theta) =$ 28.025

$$V_0 \cos(\theta) = \underline{28.23}$$

$$\theta = \underline{44.79^\circ} \text{ (include units)}$$

$$V_0 = \underline{39.78 \text{ m/s}} \text{ (include units)}$$

Show Calculations:

$$V_0 \sin(\theta) / (V_0 \cos(\theta)) = \tan(\theta) = 28.025 / 28.233 = 0.9926$$

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>> atand(0.9926)
ans = 44.79
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$$V_0 = 28.025 / \sin(44.7872) = 39.78$$

Problem 2: Curve Fitting – Decomposition of Hydrogen Peroxide – Estimating Reaction Rates from Experimental Data

First order chemical reactions can be modeled using exponential functions. Hydrogen Peroxide (H_2O_2) decomposes as a 1st order reaction into water and oxygen gas:



The concentration of hydrogen peroxide decreases exponentially according to the following equation:

$$C(t) = C_0 e^{-kt}$$

$C(t)$ = Concentration at time t (M or mols/L)

C_0 = Initial Concentration (M)

k = Reaction rate (s^{-1})

In lab, we investigated the decomposition of hydrogen peroxide in air which was a very slow reaction. It decomposes much, much faster in the presence of a catalyst such as Iodide (I⁻).

The HydrogenPeroxide.xlsx file has the results of five experiments measuring the concentration of hydrogen peroxide using an Iodide catalyst at 5 different temperatures. We will use curve fitting to estimate the reaction rate, k , for each of these five temperatures.

If we take the natural log of the concentration equation, we have:

$$\ln(C(t)) = -kt + \ln(C_0)$$

- For each of the five temperatures, plot **time** on the x-axis and **ln(C(t))** on the y-axis. Create five separate plots. **Remember, in MATLAB ln(C) is log(C)!**