A14 · Non-Linear Regression

Introduction

Assignment Goals

You will display data on different axes to help determine function type. Then you will linearize the data and determine a linearized model for the data. You will practice converting linearized models to general models. You will then combine all four steps in non-linear regression to find the general model equation for data of an unknown function type.

Successful Completion

This assignment has **5** problems. Problems 1, 2, 3 go with Class A; Problems 4 and 5 go with Class B.

1. Read *Notes Before You Start*, on **Page 1**.
2. Read each problem carefully. You are responsible for following all instructions within each problem.
    a. The deliverables list within each problem contains everything you are expected to submit.
    b. You will need the problem generator **A14_skills.p** for Problem 3. See this link to view instructions.
3. Complete the problems using the problem-specific m-file templates when a template is provided in the assignment download.
4. For any file, replace *template* or *login* in the filename with your Purdue Career Account login.
5. Review your work using the learning objective evidences.
6. When your work is complete, confirm your deliverables are submitted to Gradescope.
    a. Note the three different assignments in Gradescope.
        i. **A14 – Skills Problems**: submit your deliverables for Problem 1. Help link.
        ii. **A14 – Context Problems**: submit your individual deliverables for Problems 2 and 3. Help link.
        iii. **A14 – Team Planning**: submit your team plan for Problems 2 and 3 as a team. Help link.
    b. You can resubmit your work as many times as you want; only the final submission will be graded.
    c. Do **NOT** upload any document not listed in the deliverables. Do not upload temporary versions of m-files (*.m~ or *.asv) – these files will be ignored by Gradescope.
7. Late submissions will be accepted up to 24 hours after the due date and will result in a 25% penalty.

Learning Objectives & Grading

This course uses learning objectives (LOs) to assess your work. You can find a full list of the course LOs here. Review the grading outline at the end of each problem in this assignment to see each problem's LOs.

Notes Before You Start

Helpful MATLAB Commands

Learn about the following built-in MATLAB commands, which might be useful in your solutions:

```
log, log10
```

Problem 1: MATLAB Skills – Scaling

Introduction

This problem focuses on axis scaling. For this problem, you have two x-y data sets in the file **Data_A14Prob1.csv**. Import this data into the script template and then complete the script to generate the required figures.

Submission

Gradescope Assignment	A14 – Skills Problems	Assignment Type	Individual
Deliverables	☐ A14Prob1_scaling_*login*.m ☐ Requested answers Supporting files: ☐ A14Prob1_dataset1_*login*.png ☐ A14Prob1_dataset2_*login*.png ☐ Data_A14Prob1.csv		

Problem

You will practice using log scaling to display data and to use that display to predict what type of mathematical function would best represent the data (exponential, linear, logarithmic, or power). Use Step 1 and 2 of the Non-Linear Regression pre-class video as a reference, if necessary.

Instructions

1. In the provided script template, write the code that will do the following.
    a. Import the data file using an appropriate MATLAB built-in function.
    b. Create 2 figures, one for each data set, where each figure contains a 2x2 subplot grid that follows these expectations:

Scale: Linear X, Linear Y	Scale: Logarithmic X, Linear Y
Scale: Linear X, Logarithmic Y	Scale: Logarithmic X, Logarithmic Y

    c. Format each plot and figure for technical presentation, using short titles for each subplot axis.
        i. Add a title to the subplot grid using the `sgtitle` command. In this grid title, display the data set name and the function type that best describes the data set in the display. A reader of your figure must be able to use the overall title to see which data set is plotted and what function type best describes it.
    d. Programming standards will not be assessed in this problem. Properly name the file.
2. Once your script works properly, run it to generate the two figures. Save each figure as a PNG and name appropriately (see help if needed).
3. In Gradescope:
    a. Use each figure to determine which function type would best represent the data. Select from exponential, linear, logarithmic, or power.
    b. Submit your script, PNG files, and original data set.
4. Save your answers in Gradescope. See this video for help (this is an untimed assignment).

Grading

LOs: PC05, EPS02, MOD01

Point value: 6 points. The partial credit may be more specific than what is in the course LOs and is based on evidences in EPS02, MOD01. If you do not meet the PC05 expectations, you will lose additional credit.

Evidence	Penalty
PC05 (1)	Lose full credit on problem
PC05 (2)	Lose 25% of full credit on problem
PC05 (3)	Lose 10% of full credit on problem
PC05 (4)	Lose 15% of full credit on problem

You will lose full credit if you do not submit the m-file for the problem.

Problem 2: MATLAB Skills – Data Linearization

Introduction

This problem focuses on data linearization. For this problem, you will reuse the two x-y data sets in the file **Data_A14Prob1.csv**. Import this data into a new script template and then complete the problem below.

Submission

Gradescope Assignment	A14 – Skills Problems	Assignment Type	Individual
Deliverables	☐ A14Prob2_linearize_*login*.m ☐ Requested answers Supporting files: ☐ A14Prob2_dataset1_*login*.png ☐ A14Prob2_dataset2_*login*.png ☐ Data_A14Prob1.csv		

Problem

You will practice linearizing data and displaying it along with its linearized model. Use Step 3 of the Non-Linear Regression pre-class video as a reference, if necessary. In Part A, you determined the function type for the two data sets.

Instructions

1. In the provided script template, use your knowledge of the function types to write code that will do the following.
    a. Properly linearize the data for each of the two data sets.
    b. Find the linear model for the linearized data for each specified data set.
    c. Display the following information to the Command Window:
        i. data set name,
        ii. function type (exponential, linear, logarithmic, or power) and
        iii. the linearized model.
    d. Create two figures, one for each data set. For each figure, plot the linear model and the linearized data on the same axes. Format for technical presentation. The title must contain the data set name.
    e. Programming standards will not be assessed in this problem. Do not include comments in your solutions. Properly name the file.
2. Once your script works properly, run it to generate the two figures and the text displays. Save each figure as a PNG and name appropriately (see help if needed).
3. In Gradescope:
    a. Submit your answers and image for each data set.
    b. Submit your m-file and original data set.
4. Save your answers in Gradescope. See this video for help (this is an untimed assignment).

Grading

LOs: PC05, EPS02, MAT03, MOD01

Point value: 6 points. The partial credit may be more specific than what is in the course LOs and is based on evidences in EPS02, MAT03, MOD01. If you do not meet the PC05 expectations, you will lose additional credit.

Evidence	Penalty
PC05 (1)	Lose full credit on problem
PC05 (2)	Lose 25% of full credit on problem
PC05 (3)	Lose 10% of full credit on problem
PC05 (4)	Lose 15% of full credit on problem

You will lose full credit if you do not submit the m-file for the problem.

Problem 3: MATLAB Skills – General Model

Introduction

For this problem, you will practice converting linearized models to general models. Decide which linearized model best fits the data and then convert that model back into its general form. Refer to Step 4 in the Non-Linear Regression online module video for help, if necessary.

Problem Generator Information

If you have questions about how to use the problem generator, review this link that shows step-by-step instructions.

File Name	PUID	Problem Number
A14_skills	Your 8-digit PUID	3

Submission

Gradescope Assignment	A14 – Skills Problems	Assignment Type	Individual
Deliverables	☐ Requested answers, code snippets, and results Supporting files: ☐ A14Prob3_dataset1_*login*.png ☐ A14Prob3_dataset2_*login*.png		

Problem

The problem generator for this problem will generate and display two figures, each with four subplots. In both figures, Plot A shows the original data. Plots B, C, and D show attempted linearization with the corresponding linearized model. Data Set 1 is displayed with blue circles. Data Set 2 is displayed with black diamonds.

Only the run receipt text appears in the Command Window. Everything you need to complete this problem is in this set of instructions and in the two figures generated. Save each figure as a PNG and name appropriately (see help if needed).

Instructions

1. Enter the problem generator function call into the MATLAB Command Window prompt.
2. Use the information displayed in the two figures to complete the following steps. For **each data set** complete Parts A, B, and C:
    a. **Part A**. Select the plot that has the appropriate linearized model that best fits the data. You will select the appropriate plot selection in Gradescope.
    b. **Part B**. Write a MATLAB code snippet that will do the following:
        i. Assign the coefficients from the Part A linear model to variables.
            1. Use variables `M1` and `B1` for the slope and intercept, respectively, for Data Set 1. Use variables `M2` and `B2` for Data Set 2.
        ii. Convert the linearized parameters M and B into the general parameters, m and b.
            1. Name the parameters `m1` and `b1` for Data Set 1 and `m2` and `b2` for Data Set 2.
        iii. Display the function type and the general model equation to the Command Window.
        iv. You will enter your code snippets in Gradescope.

c. **Part C**. Run your code snippet to get the general model with numeric values displayed. You will enter the display in Gradescope.

a. Open Gradescope and complete the fields for each data set.
   - Be sure to include the instruction text with the run receipt with the instruction figures.

b. Save your answers in Gradescope. See this video for help (this is an untimed assignment).

Grading

LOs: PC05, MAT03, MOD01

Point value: 6 points. The partial credit may be more specific than what is in the course LOs and is based on evidences in MAT03, MOD01. If you do not meet the PC05 expectations, you will lose additional credit.

Evidence	Penalty
PC05 (1)	Lose full credit on problem
PC05 (2)	Lose 25% of full credit on problem
PC05 (3)	Lose 25% of full credit on problem
PC05 (4)	Lose 15% of full credit on problem

Problem 4: MATLAB Skills – Model Non-Linear Data

Introduction

Practice non-linear regression steps 1-4.

Submission

Gradescope Assignment	A14 – Skills Problems	Assignment Type	Individual
Deliverables	☐ A14Prob4_*login*.m ☐ Requested answers and results Supporting files: ☐ A14Prob4_figure1_*login*.png ☐ A14Prob4_figure2_*login*.png ☐ A13Prob4_figure3_*login*.png ☐ Data_problem4.csv		

Problem

You have been provided a data set in the file **Data_problem4.csv**. For this problem, you will practice using non-linear regression to find the model for the provided data set. You must write a script that follows the steps below.

1. Create one figure that contains four (4) subplots of the data in this configuration:

Scale: Linear X, Linear Y	Scale: Logarithmic X, Linear Y
Scale: Linear X, Logarithmic Y	Scale: Logarithmic X, Logarithmic Y

   Format each subplot for technical presentation, but use short, concise titles for each subplot axis.

2. Run your script after step 1. Decide which function type is appropriate. Display the function type to the Command Window.
3. Do the data transformation to linearize the data based on the function type determined in Step 2.
4. Display the linearized model to the Command Window.
5. Create a second figure that plots the linearized data and model on the same axes. Format the plot for technical presentation.
6. Identify the function parameters for the function type determined in Step 2.
7. Display the final model with appropriate parameters and form to the Command Window.
8. Create a third figure that plots the original data and the final model on the same axes. Format the plot for technical presentation.

You need to submit an image file for each figure window. From the figure window, select **File > Save As**. Save each figure as a PNG and name appropriately (see help if needed).

After running your script, enter your results in Gradescope:

- Select the most appropriate function type (use your results from Step 2)
- Enter your linearized model (use your displayed results from Step 4)
- Enter your general model (use your displayed results from Step 7)
- Submit PNG files, one for each figure.
- Submit your script.
- Submit the data file.

Grading

LOs: PC05, EPS02, MAT03, MOD01

Point value: 6 points. The partial credit may be more specific than what is in the course LOs and is based on evidences in EPS02, MAT03, MOD01. If you do not meet the PC05 expectations, you will lose additional credit.

Evidence	Penalty
PC05 (1)	Lose full credit on problem
PC05 (2)	Lose 25% of full credit on problem
PC05 (3)	Lose 10% of full credit on problem
PC05 (4)	Lose 15% of full credit on problem

You will lose full credit if you do not submit the m-file for the problem.

Problem 5: Sugar Inversion

Introduction

Combine all the skills you have learned in non-linear regression to model data from a real-life food science context. Produce a script that follows good programming standards and displays information in a professional manner.

Submission

Individual

Gradescope Assignment	A14 – Context Problems	Assignment Type	Individual
Deliverables	☐ A14Prob5_invertSugar_*login*.m Supporting files: ☐ A14Prob5_figure1_*login*.png ☐ A14Prob5_figure2_*login*.png ☐ A14Prob5_figure3_*login*.png ☐ Data_sucroseInversion.csv		

Team Plan

Gradescope Assignment	A14 – Team Planning	Assignment Type	Team
Deliverables	☐ Requested information		

Problem

Cane sugar used in food breaks down in the presence of acid and water. This process is called inversion, where the sucrose in the cane sugar converts into simpler glucose and fructose. Your team designed an experiment where they measured the amount of sucrose in an acidic solution over time. They placed a sucrose solution in an acid solution and measured the concentration of sucrose (the original cane sugar) in the solution over time. They performed the experiment 3 times, recording the concentration every 5 minutes for 60 minutes. The data they collected are in the file **Data_sucroseInversion.csv**. You must model the relationship between sucrose concentration (in molarity, M) and time (minutes).

You must write a script that uses the data to create one model. Your program must do the following:

- Create Figure 1 that displays the original data in a 2x2 grid of subplots to show the data on scaled axes.
    - For this plot, use short titles for each subplot.
- Create Figure 2 that displays the linearized model and linearized data on one set of axes.
- Create Figure 3 that displays the general model and original data on one set of axes.
- Display the general model's function type, the linearized model with coefficients, and the general model with coefficients to the Command Window.

Use professional formatting to display the figures and text, including meaningful variable names in place of x and y.

In the `ANALYSIS` section, copy as comments your text displays to the Command Window and then answer the following questions.

Q1. Justify your model selection using your knowledge of the data.

Q2. Use your model to predict the sucrose concentration at 12 min, 36 min, and 72 min. Use your knowledge of the data to justify your results.

You need to submit an image file for each figure window. From the figure window, select **File > Save As**. Save each figure as a PNG and name appropriately (see help if needed).

Instructions

1. Read through the entire problem statement.
2. **With your teammates**: develop and document a plan to solve this problem.
    a. Understand the expectations of the problem.
    b. Discuss strategies for solving the problem. This can include citing examples from class notes, drawing pictures, outlining a plan using text or pseudocode, etc. **DO NOT SHARE CODING SOLUTIONS.**
    c. Submit your plan to the team assignment in Gradescope
        1. Open the Gradescope assignment for this assignment's team plan (see the submission list at the beginning of this problem).
        2. In the area for this problem:
            a. Enter the names of your teammates who participated in the planning.
            b. Enter a brief description of your team's plan to solve the problem. The plan should be connected to the problem and have at least 2-3 steps. It should not be a detailed explanation of every step necessary to solve the problem.
            c. If you have image files, etc., that you would prefer to share, then you may add them in the *Optional* file submission area.
        3. Save your results.
    d. Add your teammates to the submission. Select 1 team member to submit the plan. **Work together** to make sure it is done correctly.
        1. Click **Submit & View Submission** at the bottom of the assignment
        2. Add all teammates to the group (Gradescope instruction link)
        3. All teammates confirm that you get a submission email and verify that you can see the submission in your Gradescope.
        4. You only need to add teammates one time (regardless of the number of problems in the assignment or the number of resubmissions your team makes).
3. **Individually**:
    a. Complete your m-file and run it to get your results. Answer the analysis questions.
        - The team plan is an initial start on the problem. It may not be completely correct, and you may find flaws in the plan once you start coding. You should make any individual changes that are necessary to obtain the best solution. You will be assessed on your individual solution to the problem.
    b. Cite any peers you worked with in your script header if their help changed how you decided to solve the problem. Make sure you also completed the rest of the script header.
    c. Submit your properly named m-file, data file, and image file to the appropriate problem in the individual Gradescope assignment (see the submission list at the beginning of this problem).
        - Do not submit any other files.

Grading

LOs: PC05, EPS02, EPS01, MOD01, MAT03

Team plan: 1 point

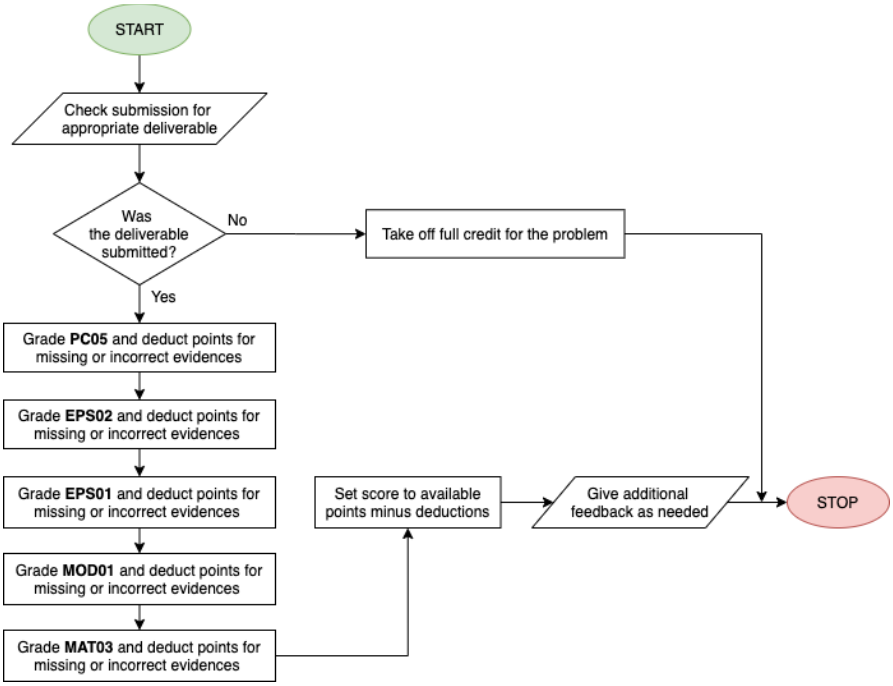
Individual assignment point value: 6 points. Partial credit is possible; see the LO table below for details. You must meet the PC05 expectations. If you do not meet these, you will lose additional credit.

LO Table

	PC05	EPS02	EPS01	MOD01	MAT03
(1)	-100%	0.1	0.4	0	0.2
(2)	-25%	0.2	0.4	0.6	0.1
(3)	-10%	0.4	0.4	0.6	0.1
(4)	-15%	0.1	0.4	0.6	0.1
(5)	0	0.1	0.4	0.6	0
(6)	0	0.1	0	0	0
(7)	0	0.1	0	0	0
(8)	0	0	0	0	0

You will lose full credit if you do not submit the m-file for the problem.

Grading Process



Reference

http://people.uncw.edu/lugo/MCP/DIFF_EQ/deproj/sucrose/sucrose.htm