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. The deliverables list contains everything you are expected to submit individually.

Submit Problems 1-4 to the Gradescope online assignment **A14 – Skills Problems**		
Problem	**Type**	**Deliverables**
Problem 1: Axis Scaling	Individual	☐ A14Prob1_scaling_*login*.m ☐ Requested answers ☐ Supporting files: ○ A14Prob1_dataset1_*login*.png ○ A14Prob1_dataset2_*login*.png ○ Data_A14Prob1.csv
Problem 2: Data Linearization	Individual	☐ A14Prob2_linearize_*login*.m ☐ Requested answers ☐ Supporting files: ○ A14Prob2_dataset1_*login*.png ○ A14Prob2_dataset2_*login*.png ○ Data_A14Prob1.csv
Problem 3: General Model	Individual	☐ Requested answers, code snippets, and results ☐ Supporting files: ○ A14Q3_dataset1_*login*.png ○ A14Q3_dataset2_*login*.png
Problem 4: Model Non-Linear Data	Individual	☐ A14Prob4_*login*.m ☐ Supporting files: ○ A14Prob4_figure1_*login*.png ○ A14Prob4_figure2_*login*.png ○ A13Prob4_figure3_*login*.png ○ Data_problem4.cav

Submit Problem 5 to the Gradescope programming assignment **A14 – Context Problems**		
Problem	**Type**	**Deliverables**
Problem 5: Sugar Inversion	Individual	☐ A14Prob5_invertSugar_*login*.m ☐ Supporting files: ○ A14Prob5_figure1_*login*.png ○ A14Prob5_figure2_*login*.png ○ A14Prob5_figure3_*login*.png ○ Data_sucroseInversion.csv

1. Read *Notes Before You Start*, on **Page 2**.
2. Read each problem carefully. You are responsible for following all instructions within each problem.
    a. Problem 5 has a team planning component that you are expected to submit separately from your deliverables. Read the instructions within that problem.
3. Complete the problems using the problem-specific m-file templates provided in the assignment download. Replace *template* in the filename with your Purdue Career Account login
4. When your work is complete, confirm your deliverables and your team plans are submitted to Gradescope.

Learning Objectives & Grading

This course uses learning objectives (LOs) to assess your work. You can find a list of the course LOs on Brightspace (Content > Key Course Info > Learning Objectives). Review the assignment grading for each problem in this assignment, which starts on **Page 10**. This outlines how your work will be graded for each problem.

Notes Before You Start

Helpful MATLAB Commands

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

```
log, log10
```

Gradescope

You will submit all your deliverables to Gradescope for grading. This homework has **two** Gradescope submission assignments for the individual submissions, plus a **third** assignment for the team planning component:

- **A14 – Skills Problems**: submit your deliverables for Problems 1, 2, 3, and 4
- **A14 – Context Problems**: submit your deliverables for Problem 5
- **A14 – Team Planning**: submit your team plan for Problem 5 as a team

Problem Generator File

In the assignment folder, you will see a file named **A14_skills.p**. This is a MATLAB function file that generates problem information for each skill problem in this assignment. Need help using this file? Refer to the *Notes Before You Start* of A04 or A05, or review the A00 Activity from Class 1B to see fully-worked examples.

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.

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, but use short, concise titles for each subplot axis.
    d. 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.
    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. For each data set, use the figure to determine which function type would best represent the data. Select from exponential, linear, logarithmic, or power. Save each figure as a PNG and name appropriately.
3. Submit your work in Gradescope:
    a. Open Gradescope > **A14 – Skills Problems** and find the set of boxes that belong to **Q1** you want to submit. Enter the required information along with your answers. Follow any additional instructions provided.
        - ☐ **Function type**. Select the appropriate function type for each data set.
        - ☐ **Image files**. Submit the PNG image files for each data set.
        - ☐ **Script and data**. Submit your script and provided data file.
    b. When you have entered all the required information for the question, click the **Save Answer** button.

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.

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 PNGs and name appropriately.
3. Submit your work in Gradescope:
    c. Open Gradescope > **A14 – Skills Problems** and find the set of boxes that belong to **Q2** you want to submit. Enter the required information along with your answers. Follow any additional instructions provided.
        - ☐ **Text results**. Submit the text results (includes all information in Step 1.c) for each data set.
        - ☐ **Image files**. Submit the PNG image files for each data set.
        - ☐ **Script and data**. Submit your script and provided data file.
    d. When you have entered all the required information for the question, click the **Save Answer** button.

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

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.

No instruction 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.

Instructions

1. Type this command into the MATLAB Command Window prompt:

   ```
   >> A11_skills(PUID, 1)
   ```

   Remember to replace PUID with your 8-digit Purdue University ID number (leave off the leading 00).
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 to get the general model with numeric values displayed. You will enter the display in Gradescope.
3. Submit your work in Gradescope:
   a. Open Gradescope > **A14 – Skills Problems** and find the set of boxes that belong to **Q3** you want to submit. Enter the required information along with your answer:
      - ☐ **Function call**. Copy the command that you entered at the command prompt to call the function and paste the full command into this box. Be sure your PUID is included.
      - ☐ **Instruction figures**. Submit the two instruction figures.
      - ☐ **Solutions**. Submit your solutions in the appropriate boxes. Follow any additional instructions provided.
   b. When you have entered all the required information for the question, click the **Save Answer** button.

Problem 4: MATLAB Skills – Model Non-Linear Data

Introduction

Practice non-linear regression steps 1-4.

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**. Set the file format to PNG. Name the files using the format given in the assignment instructions.

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.

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.

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 various 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**. Set the file format to **PNG**. Name the files using the format given in the assignment instructions.

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. These 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 **A14 – Team Planning**.

2. In the area for Problem 5:
    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, 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 an email confirming the submission and verify that you can see the submission in your Gradescope.

3. **Individually**:
    a. Complete your script, run it to get your results, and save the figure windows as images.
        - 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 the teammates you worked with in your script header if their help changed how you decided to solve the problem.
        1. Make sure you also completed the rest of the script header.
    c. Submit your properly named files to **A14 – Context Problems** in Gradescope.

Confirm Your Submission

Problems 1 - 4

You should save your progress on each question in a skills problem so that you do not lose your progress. To confirm your answers, click the **Submit & View Submission** button at the bottom of the questions in Gradescope (or select the assignment name from the Gradescope dashboard, if you have already saved your answers and navigated away from the original submission page).

Confirm that your submission for **A14 – Skills Problems** includes

- ☐ The function call and instruction text where applicable, or any data files, etc.
- ☐ The expected deliverables and results;
- ☐ Correct file names for any submitted files, including your Career Account login at the end where required.

You can resubmit your work as many times as you want, but only the final submission will be graded.

Problem 5 – Individual deliverables

Confirm that your submission for **A14 – Context Problems** includes

- ☐ The expected deliverables and results;
  - This includes m-files, data files, and image files for each problem you complete.
- ☐ Correct file names for any submitted files, including your Career Account login at the end where required.

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 and not included in your upload.

You can resubmit your work as many times as you want, but only the final submission will be graded.

Problem 5 – Team plans

Confirm that your submission for **A14 – Team Planning** includes

- ☐ The names of all your teammates who participated in each problem's planning;
- ☐ A brief description of the team's plan for each problem;
- ☐ All team members included in the group submission.

You can resubmit your work as many times as you want, but only the final submission will be graded.

References

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

Assignment Grading

Your work will be graded using the evidences given in the course learning objectives. Familiarize yourself with the LOs and their evidences listed for each problem, which are below. Each non-skill problem's assignment grading has a table and a flowchart. The table outlines what LOs will be used to grade your work and what point values are assigned to each evidence. The flowchart outlines the grading process that a grader will use to assess your work.

Find the list of the course LOs, with evidences, on Brightspace (Content > Key Course Info > Learning Objectives).

Team Planning

Each problem's plan is worth 1 point.

Individual Problems

Problem 1

Problem 1 is worth 4 points. There is partial credit. The partial credit may be more specific than what is in the course LOs and is based on evidences in EPS02, MAT03.

You must meet the PC05 expectations for each question. If you do not meet these, 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 5% of full credit on problem

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

Problem 2

Problem 2 is worth 4 points. There is partial credit. The partial credit may be more specific than what is in the course LOs and is based on evidences in EPS02, MAT03, MOD01.

You must meet the PC05 expectations for each question. If you do not meet these, 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 5% of full credit on problem

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

Problem 3

Problem 3 is worth 4 points. There is partial credit. The partial credit may be more specific than what is in the course LOs and is based on evidences in MAT03, MOD01.

You must meet the PC05 expectations for each question. If you do not meet these, 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 5% of full credit on problem

Problem 4

Problem 4 is worth 4 points. There is partial credit. The partial credit may be more specific than what is in the course LOs and is based on evidences in EPS02, MAT03, MOD01.

You must meet the PC05 expectations for each question. If you do not meet these, 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 5% of full credit on problem

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

Problem 5

LO Table

Note: PC05 evidences are only deductions since you are expected to follow the assignment instructions.

	PC05	EPS02	EPS01	MOD01	MAT03
(1)	-4	0.1	0.2	0	0.1
(2)	-1	0.1	0.2	0.5	0.1
(3)	-1	0.1	0.2	0.5	0.1
(4)	-0.2	0.1	0.2	0.5	0.1
(5)	0	0.1	0.2	0.4	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