# Assignment 10: Data Analytics –Regression

This assignment includes (2) problems.

**Purpose of this assignment**

Engineers use **regression** to make **evidence-based decisions**. Understanding the process and limitations of these tools helps drive better decisions.

This assignment demonstrates the application of regression in engineering design and analysis. You will learn to appropriately create mathematical models of a system and measure the relationship between variables, and to use that relationship to make predictions.

**Relevant Course Resources**:

| | |
|---|---|
| Pre-Class Videos | • Data Analytics – Slope and Intercept<br>• Data Analytics – Regression |
| Lecture Slides | • Taum Sauk Project: Regression<br>• Taum Sauk Project: Slope, Pressure Head, & Volumetric Flowrate |

**Organizing Your Work**

Pay attention to how you format and organize your work in Excel.

In general,

1. Complete all of your work on the Excel answer sheet provided **ENGR131_ A10_StudentAnswerSheet.xlsx**.
2. Answer all questions with complete sentences by explicitly referring back to your calculations.

**Submission Instructions:**

1. Re-name your answer sheet as, **ENGR131_A10_*yourlogin*.xlsx**, where *yourlogin* is your *Purdue Career Account* login.
2. Save your files to your **Purdue Career Account** (This is your Purdue storage space. For more information see https://www.itap.purdue.edu/connections/careeraccount)
3. Submit your work through the designated **Brightspace Assignment Drop box at** https://purdue.brightspace.com

# Assignment 10: Data Analytics –Regression

## Problem 1 FRICTION FORCE AND NORMAL FORCE

Goal

Cylinder liner friction force test results have been collected. Your tasks are to:

1. In your Excel file, there is a worksheet tab called **Problem 1,** which contains the data. Answer the following questions.
   a. What type of data have been generated by the test and are summarized in Table 1?
   b. What type of chart will best represent the data?
2. Create the chart you recommended in Question 1b. Show both data sets on one chart. Format the chart for technical presentation.
   a. Determine the coefficient of friction, μ, for each of the two materials. Remember the equation for the force of friction.
   b. How accurate is your coefficient of friction? How do you know? (*Hint: what is the strength of the correlation?*)
   c. If you were on the engineering team, which of the two materials (A or B) would you recommend as the final choice for the cylinder liner? Why?

## Background/Technical Content:

Friction is defined as the force that resists relative motion between two bodies in contact. The Coulomb model for the force of friction (static or kinetic) is:

$$F_f = \mu * F_N$$

Where:

$F_f$ is the force of friction
$\mu$ is the coefficient of friction
$F_N$ is the normal force

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The simple Coulomb model of friction assumes three important laws:

a. Amonton's first law of friction

**The magnitude of the friction forces is independent of the area of contact**

b. Amonton's second law of friction

**The magnitude of the friction force is proportional to the magnitude of the normal force.**

c. Coulomb's law of friction

**The kinetic friction is independent of the sliding velocity.**

A team of materials engineers at an engine manufacturer are evaluating new materials for use as cylinder liners. A cylinder liner is a cylindrical part that is fitted into an engine block, forming a cylinder. Cylinder liners must have excellent sliding surfaces (low friction) to minimize galling, wear on the liner and the piston, and to lessen the consumption of lubricant [2].

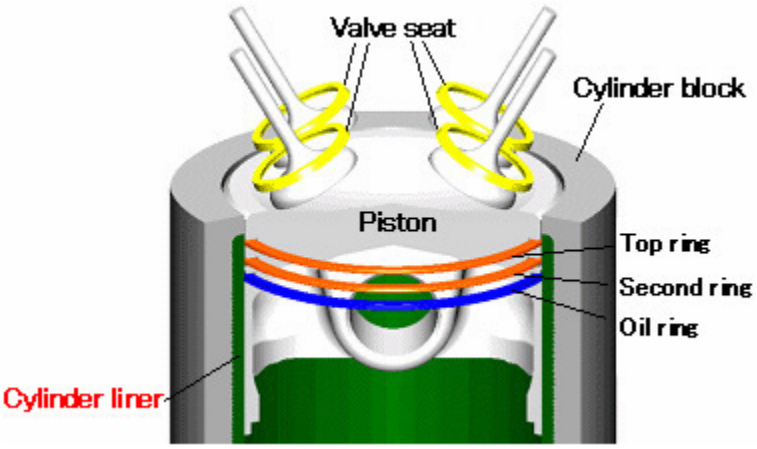


Figure 1: Cross section of a cylinder liner [2]

The team subjected two different liner materials to a series of tests. Different masses of blocks were slid along the liner at a constant velocity. The resulting maximum static friction force was measured. Their results are summarized in Table 1:

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| Normal Force (N) | Max Static Friction Material A (N) | Max Static Friction Material B (N) |
|---|---|---|
| 0 | 0 | 0 |
| 5 | 1.4 | 1.7 |
| 10 | 2.5 | 2.9 |
| 15 | 3.1 | 3.9 |
| 20 | 4.2 | 6.1 |
| 25 | 4.8 | 6.5 |
| 30 | 5.7 | 7.8 |
| 40 | 7.5 | 10.6 |
| 50 | 8.8 | 12.1 |
| 60 | 10.8 | 14.4 |

Table 1: Normal force and resulting static friction for two test materials

**Organizing Your Work**:

| **Inputs**: | **Charts:** | **Outputs:** |
|---|---|---|
| Table 1: Trial data | Scatter plot of both test results | **2a)**<br>**2b)**<br>**2c)** |
| | Use Excel create the scatter plots and show the trendline and equations. | Answer all questions with complete sentences (in 2-3 sentences) AND by explicitly referring back to your calculations and data. |

### *References*

[1] https://physics.stackexchange.com/questions/154443/why-is-the-equation-for-friction-so-simple

[2] http://www.tpr.co.jp/tp_e/products/cylinderliners/about.html

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## Problem 2 SPEAKER WIRE RESISTANCE

Goal

Tests were run on three different wires to determine, by the resistance, which one is best suited for a speaker wire application. Your tasks are to:

1. In the same Excel file as you used for Problems 1, there is a worksheet tab called **Problem 2** that contains the test data. Generate a scatter plot that contains the data from all three wires in one plot. Format the plot for technical presentation. It will be helpful to increase the size of the plot to allow for best interpretation of the three lines.
2. Insert trendlines for each of the three data sets. Display the equation and r-squared value of each line.
3. Answer the following questions:
   a. Which of the three wires has the most resistivity?
   b. If the length of wire 2 are 0.05 m and 1m, what are the resistances? Use the trendline equation.

## Background/Technical Content:

An electrical engineer has been asked to test three different types of wire to determine which will work best as inner conductors in a speaker cable (see Figure 2). These speaker cables connect power amplifiers and speaker systems. Speaker cable wires are required to carry high levels of current; for example an 8-ohm speaker and a 100-watt amplifier will require between 0.5 and 3 amperes using US voltages (Pro Co Sound, 2014).

Since resistance limits the current flowing through the wire and therefore the amplification, the electrical engineer must analyze the different types of wire to determine which will work best in this application.

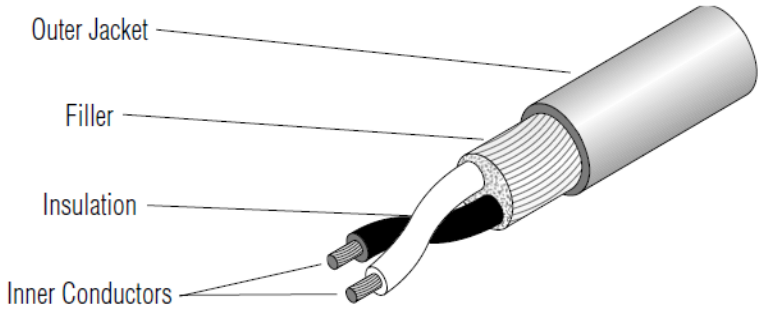


**Figure 2. Main Parts of a Speaker Cable**[1]

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During the test, the electrical engineer measured the resistance (ohms) of three different wires. The three wires tested, wires 1, 2, and 3, were made from different materials and had different lengths, but all had the same cross-sectional area. The data from the tests are contained in the **Problem 2** tab of the Excel file.

The resistance of a wire ($R$ [Ω]) is a function of the wire dimensions ($A$ = cross-sectional area, $L$ = length) and material ($\rho$ = resistivity) according to the relationship

$$R = \frac{\rho L}{A}$$

The engineer performed the test using a 0.2 cm diameter wire.

References:

[1] Main Parts of a Speaker Cable [Online Image] (n.d.) Retrieved February 11, 2014, from http://www.procosound.com/download/whitepapers/Understanding%20Speaker%20Cables.pdf

(This problem is modified from Cardella, M.E., Diefes-Dux, H.A., Dux, D., Hoffmann, S.R., & Pawley, A. (2012). *Ideas to innovation* (3rd ed.). M.E. Cardella, C.E. Nyquist, M.W. Ohland, & A.V. Epps. (Eds.). Boston, MA: Pearson Learning Solutions)

**Organizing Your Work**:

| **Inputs**: | **Charts:** | **Outputs:** |
|---|---|---|
| Table 2: Trial data | Scatter plot of results of all three tests | **3a)**<br>**3b)** |
| | Use Excel create the scatter plots and show the trendline and equations. | Answer all questions with complete sentences (in 2-3 sentences) AND by explicitly referring back to your calculations and data. |

# Assignment 10: Data Analytics –Regression

| **Problem 1*: Friction Force and Normal Force*** | |
|---|---|
| **Learning Objectives**<br>Your work will be graded on demonstration of proficiency of the following learning objectives: | **Did you address this?** |
| **SQ01** – Use accurate, scientific, mathematical, and/or technical concepts, units, and/or data in solutions. | |
| **DV02** – Select appropriate graphical representation of dataset based on data characteristics such as numerical (discrete or continuous) or categorical (ordinal or nominal) | |
| **DV05** – Prepare a chart for technical presentation with proper formatting, including title, axes labels, appropriately scaled axes, units and appropriate markers | |
| **DV09** – Given independent and dependent variables, interpret or predict the performance of a solution. | |
| **DV11 -** Given two numeric variables with data, calculate the strength of the correlation and interpret the finding in terms of $R^2$. | |
| **EB03 -** Clearly articulate reasons for answers with explicit reference to data to justify decisions or to evaluate alternative solutions | |
| **PC05** - Fully address all parts of assignment by following instructions and completing all work | |

| **Problem 2*: Speaker Wire Resistance*** | |
|---|---|
| **Learning Objectives**<br>Your work will be graded on demonstration of proficiency of the following learning objectives: | **Did you address this?** |
| **SQ01** – Use accurate, scientific, mathematical, and/or technical concepts, units, and/or data in solutions. | |
| **DV02** – Select appropriate graphical representation of dataset based on data characteristics such as numerical (discrete or continuous) or categorical (ordinal or nominal) | |
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