Application of Friction Force in Engineering and Technology
Examples: Automobile brakes, belt drive, wedge, vise/clamp, etc.

Friction Force can be detrimental in engineering and technology
Example: Loss of machine efficiency, overheat, etc.
Friction Force

Situation A  

Situation B

Does the numerical value of friction force depend on the surface area of contact?

Does Situation A or Situation B require a larger force to cause it to move?
Assignment #1:

Answer the above question, explaining the theory upon which your answer is based upon. Design an experiment to verify your theory. Report the results of Assignment #1 in a memorandum to the instructor.

Tools:

You will have the following tools for your experiment:

- Spring scale 1-2,000 g in increments of 50 g
- A brick with a hook attached to the 2” x 4” face
- EXCEL program

Hint: In answering the above question, draw upon your experience in pushing a car off the road when it either ran out of gas or broken down. Is it easier to get the car started moving or keep it going after the wheels have started to roll.
Assignment #2

Conduct the experiment to verify your theory of Assignment #1. Explain how the results of experiment support and dispute your theory. Report the results of the experiment in a laboratory report to the instructor.
Best Practices in Engineering Experimentation:

*Experimental data - Data/Results should be repeatable*

- Make multiple measurements
- Round off insignificant figures
- Find average and standard deviation
1) Mean $\bar{x} = \Sigma x_i / \Sigma i = \Sigma x_i / n$ where $n = \Sigma i =$ number of data points
   (The mean is the average value)

2) Range = $x_{max} - x_{min}$
   (Range measures the spread of the values)

3) Standard Deviation $\sigma = \Sigma (x_i - \bar{x})^2 / (n-1)$
   (Standard Deviation gives a measure of the scatter or error of the measured values about the mean.)

4) Normal Distribution describes a condition in which all measurement errors are random:
   Then there is an approximate
   
   ➢ 65% chance that the next measurement falls within the range $(\bar{x} - \sigma, \bar{x} + \sigma)$
   ➢ 93% chance that the next measurement falls within the range $(\bar{x} - 2\sigma, \bar{x} + 2\sigma)$
   99% chance that the next measurement falls within the range $(\bar{x} - 3\sigma, \bar{x} + 3\sigma)$
Use Excel to Determine Mean and Standard Deviation

1. Create a table listing the data in a column

2. To calculate mean or average of the data, type “=Average(x_1y_1:x_ny_n)” and hit “Enter” where $x_1$, $y_1$ are the column and row, respectively, of the first data point, and $x_n$, $y_n$ are the column and row, respectively, of the last data point.

3. To calculate standard deviation of the data, type “=Stdev (x_1y_1:x_ny_n)” and hit “Enter”
Best Practices in Engineering Experimentation

Format of Laboratory Report

State the question your experiment will answer

State the theory that your answer will be based upon

Describe the procedure to obtain the experimental data

Make and complete a table of measurement

Analyze the data to answer the question stated for the experiment

Conclude and discuss how the collected data support or dispute the theory
Definition of Friction Force

(Worder’s Collegiate Dictionary) – Resistance to relative motion between two bodies in contact

(MICLIMB) – A force that works against motion

(Sophomore-level engineering handbook) – Tangential forces which develop when one attempts to move two surfaces that are in contact with respect to each other

- When on attempts to move two surfaces with respect to each other
- Tangential force at the surfaces that are in contact

There are two types of friction forces:

- Dry friction force refers to force along non-lubricated surfaces.
- Fluid friction refers to lubricated surfaces
For a one-dimensional problem along a horizon surface, dry friction force can be studied in the following manner:

Maximum friction force, \( F_m = \mu_s W \), where \( \mu_s \) is the coefficient of static friction

Kinetic friction force, \( F_k = \mu_k W \), where \( \mu_k \) is the coefficient of kinetic friction

\( F_m > F_k \) and \( \mu_s > \mu_k \). (When you try to push a stalled car off the road, it is hard to get the car push started; once the car begins to move, it is easier to continue to move the car.)
Answer to Assignment #1: The friction force acting to oppose motion does not depend on the surface area of contact but depends on the mass of the object to be moved.
Force is a fundamental concept in engineering science.

A force can be defined as the action of one body on another. The force exerted may be by actual contact, as in the case of a hammer on a nail, or at a distance, as in the case of gravitational forces, magnetic forces, or electrical forces.

A force is characterized by its point of application, its magnitude, and its direction. Therefore, force is a vector (has a magnitude and direction).
The Three Laws of Newton

First Law: For equilibrium (at rest, if initially at rest, or continues original motion at the same speed, if initially in motion), the resultant force must be zero. \( \Sigma F = 0 \).

[Forces are vectors. Therefore, the mathematic operation is vector sum of forces (consider both the magnitude and direction) rather than arithmetic sum (only magnitude)]

Second Law: The acceleration is proportional to the resultant force, if not in equilibrium. \( \Sigma F = ma \), \( m = \text{mass} \), \( a = \text{acceleration} \)

[Since force is a vector, acceleration is also a vector.]

Third Law: Action and reaction forces have the same magnitude, same line of action, but opposite direction.
Units of Force

In the International System of Units (SI Units)
1 Newton = (1 kg)(1 m/sec^2) according to Newton’s 2\textsuperscript{nd} Law (F = ma)

In the U.S. Customary Units,
1 lb\textsubscript{f} = (1 lb\textsubscript{m})(32.2 ft/sec^2)