

EGR 111

Trig Functions

The purpose of this lab is to use MATLAB to demonstrate the use of trig functions by analyzing the movement of a piston. This exercise is adopted from Example 1.6-1 in *Introduction to MATLAB for Engineers*, third edition by William J. Palm III.

New MATLAB Commands: `comments %`, `asin`, `cos`, `sin`, `grid`, `whos`

1. The MATLAB Workspace

In the previous lesson, we encountered the MATLAB Workspace, which is a panel on the right side of the MATLAB window. Enter the following commands in the Command Window:

```
x = 7;  
y = 1:10;  
z = y';
```

You will see these three variables appear in the Workspace. You can also view the same information with the `whos` command :

```
whos
```

Notice that the number 7, stored as variable “x”, is stored with 8 bytes (a byte is 8 bits where each bit is a 1 or 0). A typical computer has enough memory to store very large matrices with hundreds of millions of elements.

At times, you may want to delete all of the variables in the MATLAB Workspace in order to start again “from scratch.” This can be done with the `clear` command:

```
clear
```

Try it. Then verify that all of the variables have been cleared. It is good practice to start script files with the `clear` command to avoid inadvertently writing a script file that relies on variables that have been previously defined in the workspace instead of in the script file. However, when you submit your homework solutions to MATLAB Grader, do NOT use the `clear` command because it can interfere with the program that grades your program.

2. Comments

It is good practice to place notes in your programs to explain how the program works. These notes are called comments. Comments are ignored by MATLAB, and are only there to make it easier for a person (including you) to understand how the program works. Any text on a line after the percent character `%` is a comment and is ignored by MATLAB. Consider for example the following line:

```
A = pi/4; % angle in radians
```

MATLAB performs the command “`A = pi/4;`”, but ignores the rest of the line.

3. Background: Piston Motion

Figure 1 below shows a piston, connecting rod, and crank for an internal combustion engine. When the sparkplug fires inside the cylinder, the gasoline in the cylinder explodes and pushes the piston down. This causes the connecting rod to turn the crank, which causes the crankshaft to rotate. There is an animation of a piston at <http://www.youtube.com/watch?v=ep1NhANcCL4>.

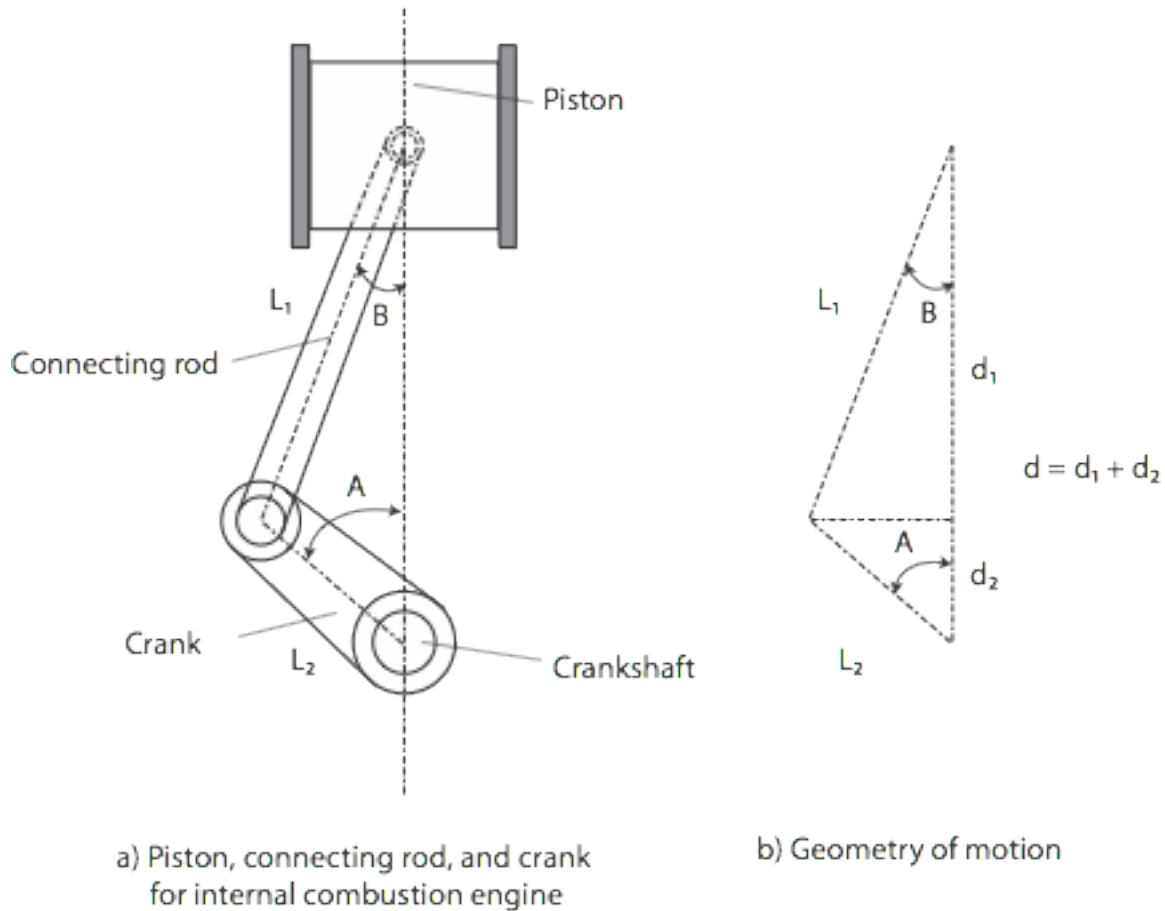


Figure 1: Geometry of a Piston

The goal of this lab is to develop a MATLAB program which computes and plots the distance d as a function of the angle A for given values of lengths L_1 and L_2 .

From Figure1b, the distance d may be calculated as follows:

$$d = d_1 + d_2 \quad (1)$$

$$d = L_1 \cos B + L_2 \cos A \quad (2)$$

$$(3)$$

To compute d based on the values of L_1 and L_2 , use the law of sines:

$$\frac{\sin A}{L_1} = \frac{\sin B}{L_2} \quad (4)$$

Solve this for B .

$$\sin B = \frac{L_2 \sin A}{L_1} \quad (5)$$

$$B = \sin^{-1} \left(\frac{L_2 \sin A}{L_1} \right) \quad (6)$$

Equations (2) and (6) form the basis of the MATLAB program that will plot d versus A for given values of lengths L_1 and L_2 . Because the mechanism's motion is symmetrical about $A = 0$, consider only angles in the range $0^\circ \leq A \leq 180^\circ$.

The MATLAB trigonometric functions used in this experiment assume that the angles are radians. MATLAB also has a separate set of functions that are set up for angles in degrees, but let's use the radian-based functions for this experiment because part of what we are practicing is converting angles between degrees and radians.

Exercise 1: Create a script file to that will plot d versus A for $L_1 = 1$ ft and $L_2 = 0.5$ ft. Because the mechanism's motion is symmetrical about $A = 0$, consider only angles in the range $0^\circ \leq A \leq 180^\circ$.

- Use the `clear` command to clear any existing variables from the workspace.
- Define a variable `L1` that stores your value for L_1 .
- Define a variable `L2` that stores your value for L_2 .
- Define a vector `A_d` that steps from 0 to 180 in steps of 0.5 degrees.
- Convert the values in `A_d` from degrees to radians, and store the result in a vector called `A_r`. Note that the angle in radians = (angle in degrees) * pi / 180.
- Using equation (6), solve for B for all values of `A_r`.
- Using equation (2), solve for d for all values of B and `A_r`.
- Create a plot of d versus `A_d` with the angle d on the horizontal axis. Be sure to label the axes with the variable and the units, and title the plot. Also, turn on the grid in your plot.
- Use the semicolon ";" to suppress unnecessary screen output whenever possible.
- Add comments "%" in your file to make it more understandable.

Checkpoint 1: Show the instructor your script file and plot from Exercise 1.