Optimizing Range and Height of a Projectile using Matlab

S. Ahmadi and K. Bulusu

Problem Statement:

The problem considered is about idealized projectile motion, without any air drag, indicated in the figure with a dashed line. A gun is being test fired in a firing range to estimate the distance a cannon ball travel or in other words, estimate it's range (R). The initial velocity of the cannon is v_o, which is shot at angle θ.

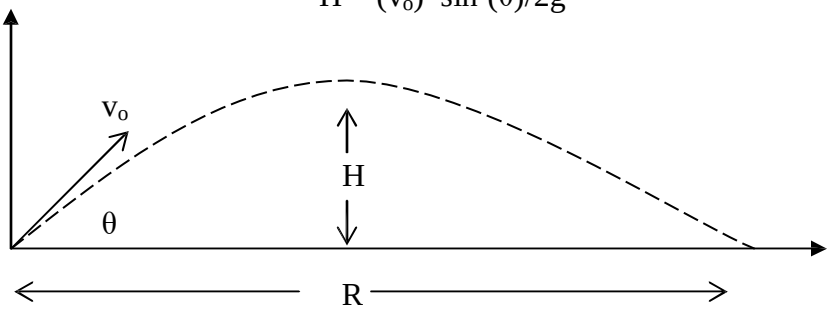
The range (R) is a function of initial velocity of the cannon (v_o) and the angle at which it is shot (θ), with the following relation:

$$R = (v_o)^2 \sin(2\theta)/g$$

Where 'g'is the acceleration due to gravity = 9.8 m/s.

The height the cannon reaches (H) is also a function of initial velocity of the cannon (v_o) and the angle at which it is shot (θ) with the following relation:

$$H = (v_o)^2 \sin^2(\theta)/2g$$



MATLAB Project:

Write a matlab script with the following requirements:

1. Vary the angle θ between 10 degrees and 90 degrees in steps of 2 degrees and calculate the range (R) for an initial velocity of the cannon (v_o = 5 m/s)

(note: is matlab using degrees or radians? Check help to find out.)

```
1 -    theta = 10: 2 : 90;
2 -    R = (25* sind(2.*(theta))./9.8;
3 -    A=max(R)
4 -    B=min(R)
```

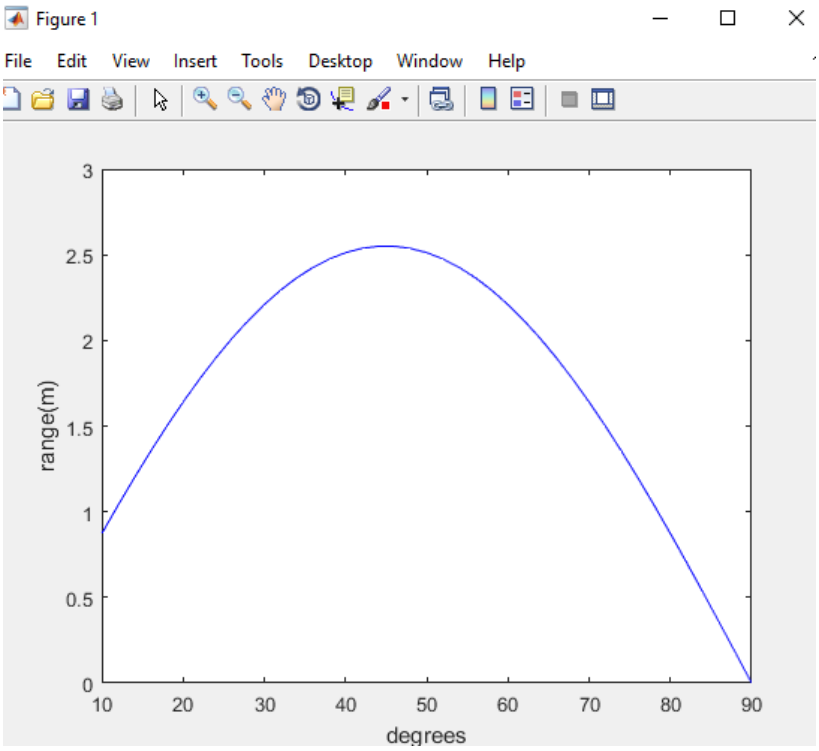
Command Window

New to MATLAB? See resources for Getting Started.

```
>> Untitled

A =

    2.5495


B =

     0
```

2. Plot R vs. θ for $v_o = 5$ *(indicate units on axis or legend)*

```
1 -    theta = 10: 2 : 90;
2 -    R = (25* sind(2.*(theta))./9.8;
3 -    A=max(R)
4 -    B=min(R)
5 -    plot(theta, R, 'b')
6 -    xlabel("degrees")
7 -    ylabel ("range(m)")
```



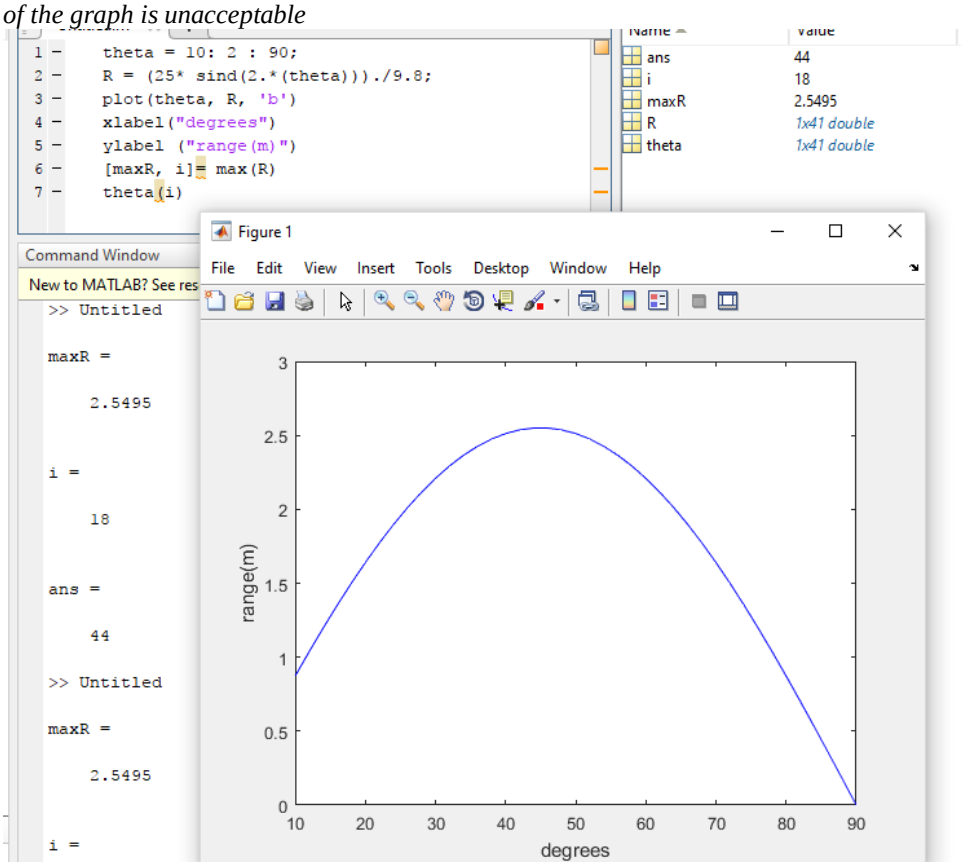
3. Find the maximum range (R) from the data generated.

```
Untitled.m
1 -    theta = 10: 2 : 90;
2 -    R = (25* sind(2.*(theta))./9.8;
3      %A=max(R)
4      %B=min(R)
5 -    plot(theta, R, 'b')
6 -    xlabel("degrees")
7 -    ylabel ("range(m)")
8 -    [maxR, theta]= max(R)
```

```
Command Window
New to MATLAB? See resources for Getting Started.

>> Untitled

maxR =

    2.5495


theta =

    18
```

4. Find the value of (θ) –in degrees-- that yields the maximum value of (R).

Note: for questions 3 & 4, matlab commands must be used to obtain these values, reading the value off of the graph is unacceptable



5. Repeat questions 1-4 by calculating H and plot H vs. θ for v_o = 5m/s

1)

```
1 -     theta = 10: 2 : 90;
2 -     theta
3 -     H = (25* (sind(theta).^2))./19.6;
```

Command Window

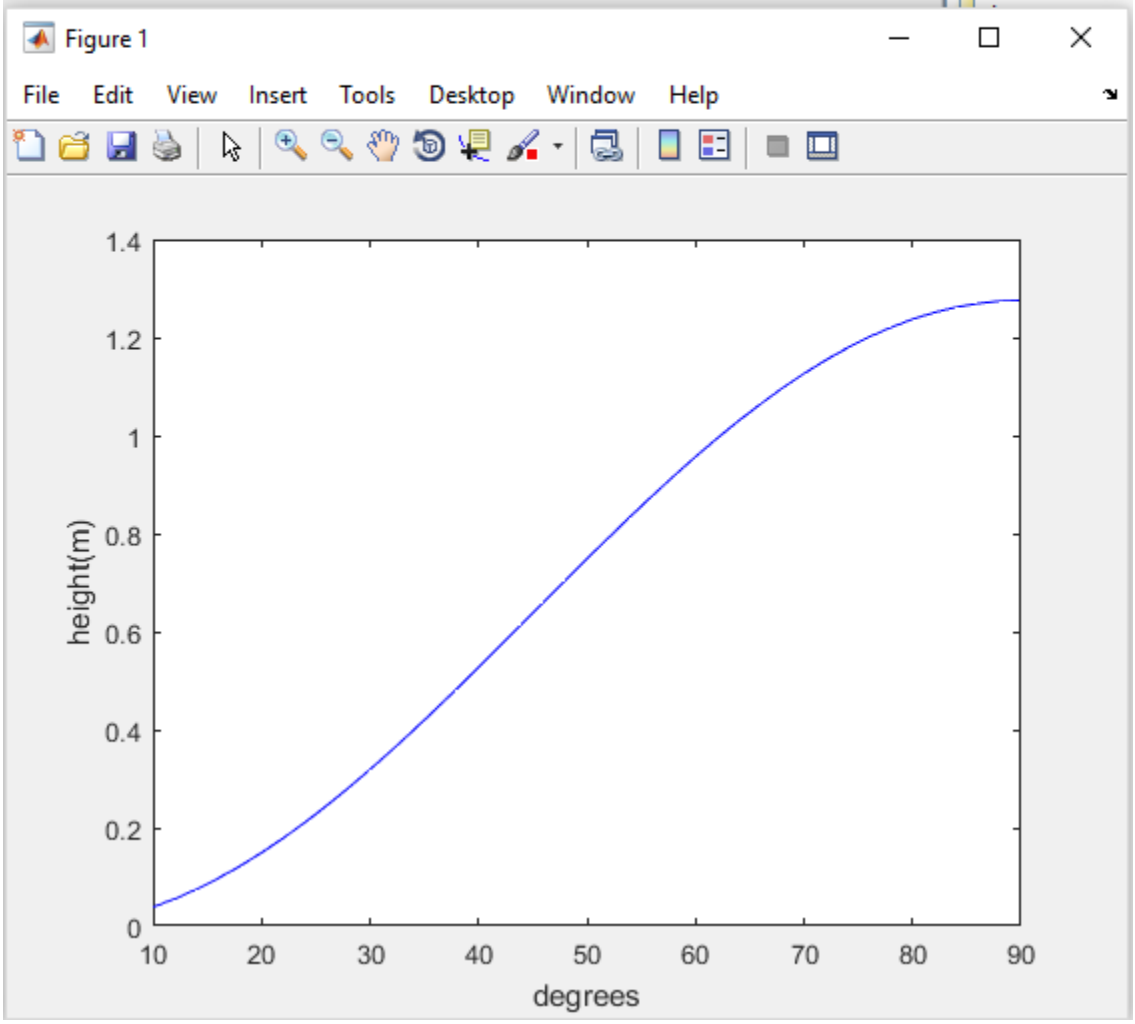
New to MATLAB? See resources for Getting Started.

```
>> Untitled

theta =

  Columns 1 through 8

    10    12    14    16    18    20    22    24

  Columns 9 through 16

    26    28    30    32    34    36    38    40

  Columns 17 through 24

    42    44    46    48    50    52    54    56

  Columns 25 through 32

    58    60    62    64    66    68    70    72

  Columns 33 through 40

    74    76    78    80    82    84    86    88

  Column 41

    90
```

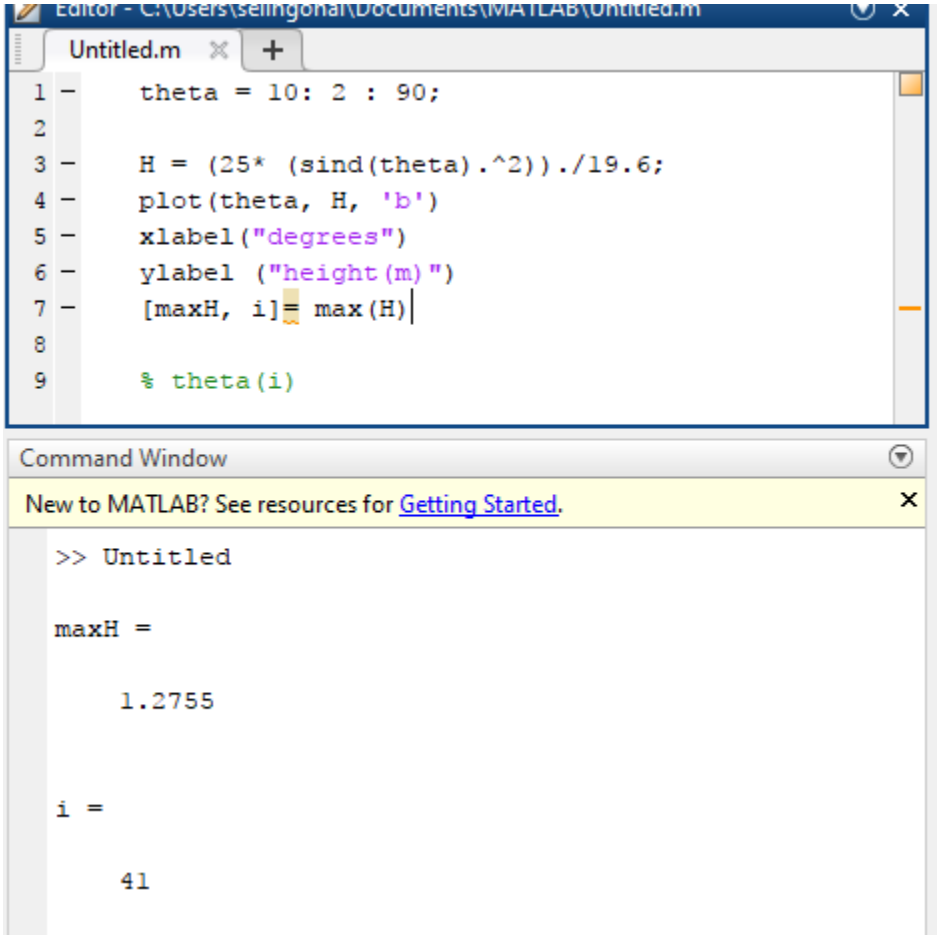
2)

```
theta = 10: 2 : 90;

H = (25* (sind(theta).^2))./19.6;
plot(theta, H, 'b')
xlabel("degrees")
ylabel ("height(m)")
```

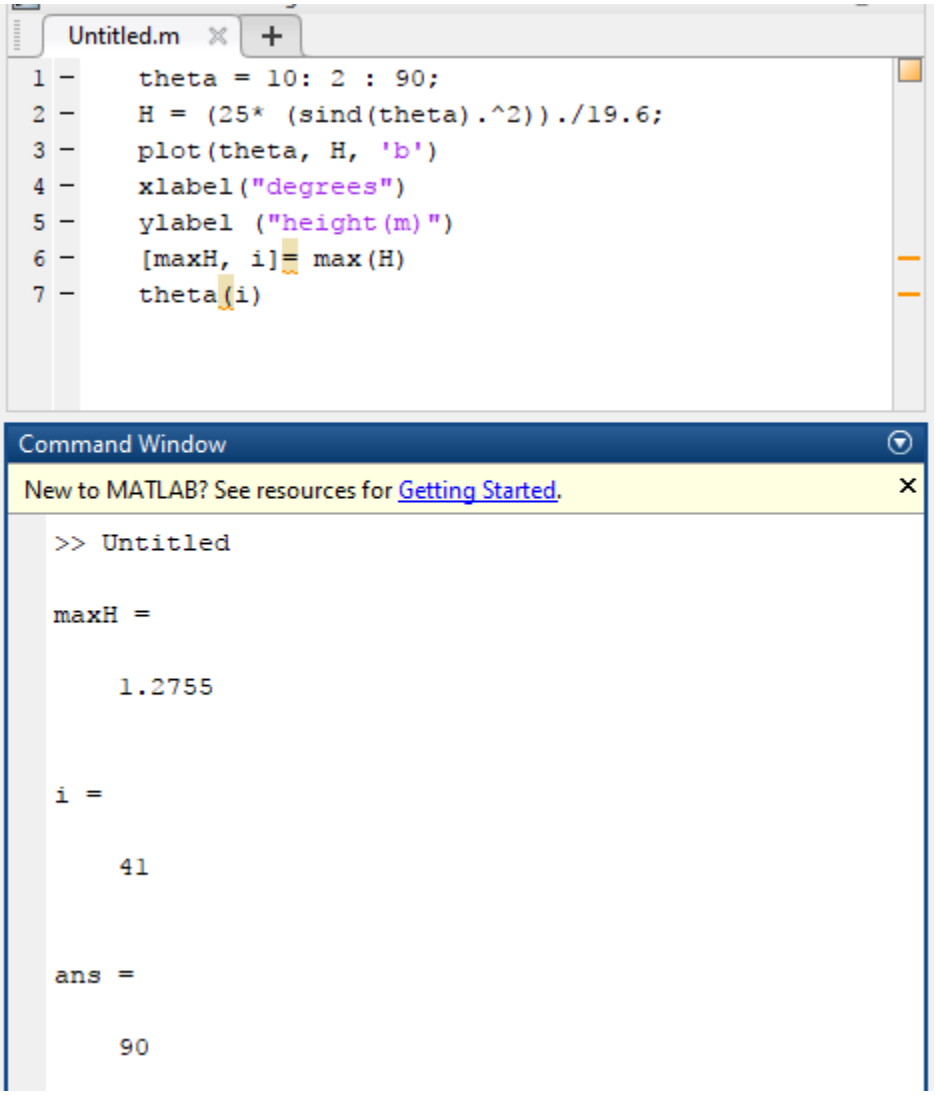
ans
H
i
maxH
maxR
R



3)


Editor - C:\Users\selingonal\Documents\MATLAB\Untitled.m
Untitled.m
1 theta = 10: 2 : 90;
2
3 H = (25* (sind(theta).^2))./19.6;
4 plot(theta, H, 'b')
5 xlabel("degrees")
6 ylabel ("height(m)")
7 [maxH, i]= max(H)
8
9 % theta(i)
Command Window
New to MATLAB? See resources for Getting Started.
>> Untitled
maxH =
1.2755
i =
41

4)


Untitled.m
1 theta = 10: 2 : 90;
2 H = (25* (sind(theta).^2))./19.6;
3 plot(theta, H, 'b')
4 xlabel("degrees")
5 ylabel ("height(m)")
6 [maxH, i]= max(H)
7 theta(i)
Command Window
New to MATLAB? See resources for Getting Started.
>> Untitled
maxH =
1.2755
i =
41
ans =
90

Optimizing Power Transfer to a Load Using Matlab

S. Ahmadi, T. Tag and T. Farmer

Problem Description

The aim of this task is to calculate the maximum power transferred from a fixed supply, to a load.
To put this requirement into perspective, *given a fixed supply, i.e. an electrical outlet, what is the maximum load you can connect to it in order to obtain the maximum power transfer from the supply to the load.*

As shown in the Figure below, the supply can be represented by two components, a voltage source, denoted by V_S, and a supply resistance, denoted by R_S. The load being applied can be simplified to its equivalent total resistance, R_L. By continually varying this load, and calculating the corresponding power at each value, the load that results in maximum power can be obtained.

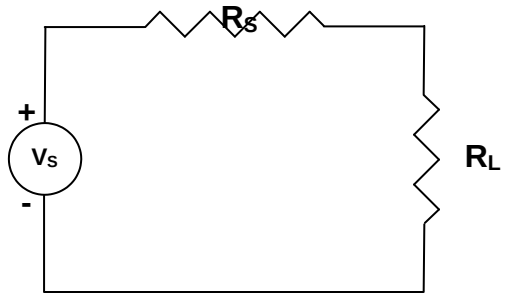


Figure 1: Circuit under test.

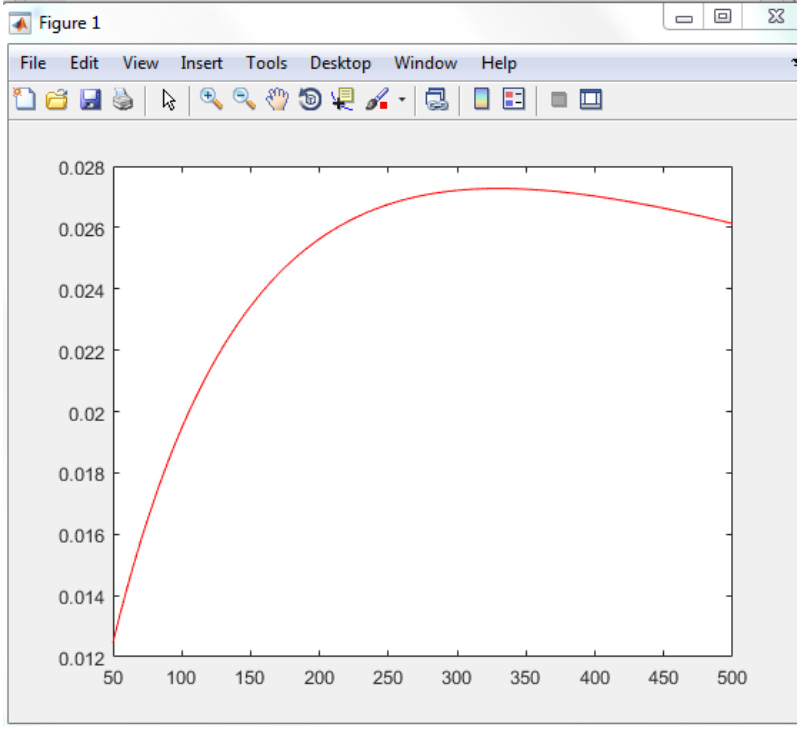
In order to be able to solve this sort of problem the following equation can be used:

$$\text{Power} = \left(\frac{Vs}{Rs \quad R_L} \right)^2 * R_L$$

Using MATLAB, carry out the following:

1) Given a supply, with V_S = 6V and R_S = 330Ω, vary the load resistance, R_L, between 50Ω and 500Ω in increments of 5Ω, and plot Power P vs R_L. From this graph, extract the value of R_L which gives maximum power.
(HINT: we do not want max(P), we want the RL that causes the max(P).
NOTE: you cannot use the graph to determine the value of RL, you must use matlab commands to find it)

```
1 -    Rl = 50 : 5 : 500;
2 -    Vs = 6;
3 -    Rs = 330;
4 -    P = (((Vs)./(Rs + Rl)).^2).*Rl;
5 -    plot(Rl, P , 'r')
```




```
1 -    Rl = 50 : 5 : 500;
2 -    Vs = 6;
3 -    Rs = 330;
4 -    P = (((Vs)./(Rs + Rl)).^2).*Rl;
5 -    plot(Rl, P , 'r')
6 -    [maxP, i] = max(P)
7 -    Rl(i)
```

Command Window

New to MATLAB? See resources for Getting Started.

```
>> Untitled

maxP =

    0.0273


i =

    57


ans =

   330
```

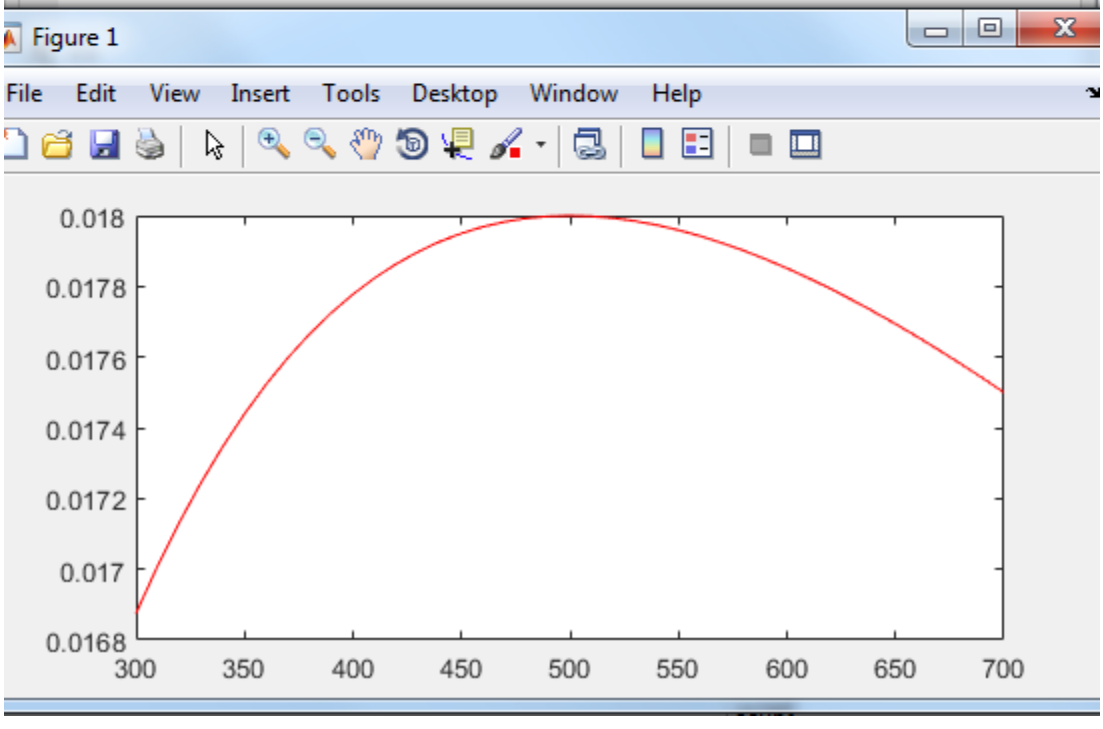
2) Again plot Power P vs R_L, but this time use supply values: V_S = 6V, R_S = 500Ω. Vary R_L, in increments of 10Ω, between 300Ω and 700Ω. Extract the value of the load resistance, R_L, such that maximum power is obtained.
(HINT: we do not want max(P), we want the RL that causes the max(P).
NOTE: you cannot use the graph to determine the value of RL, you must use matlab commands to find it)

```
1 -     Rl = 300 : 10 : 700;
2 -     Vs = 6;
3 -     Rs = 500;
4 -     P = (((Vs)./(Rs + Rl)).^2).*Rl;
5 -     plot(Rl, P , 'r')
6 -     [maxP, i] = max(P)
7 -     Rl(i)
```

Command Window

New to MATLAB? See resources for Getting Started.

```
>> Untitled

maxP =

    0.0180


i =

    21


ans =

   500
```



3) From your results, what is the relationship, if any, between the supply resistance, and the load resistance, in order to obtain maximum power?

- As Rs increased, the max power decreased and the load resistance required to get the maximum power increased.

Deriving the Equation:

The two main equations that are used are Ohms Law, and the power equation:

Ohms Law: $V = IR$
Power Equation: $P = IV = I^2R$.

where V = Voltage
I = Current
R = Resistance

First we must calculate the current running through the circuit of ***Figure 1***. Therefore, using Ohms Law, and the rule of resistances in series, we get:

$$I = \left(\frac{Vs}{Rs \quad R_L} \right)$$

Substituting this into our power equation, we get:

$$P = \left(\frac{Vs}{Rs \quad R_L} \right)^2 * R$$

The R at the end of this equation represents the resistance of the load that we are connecting to our circuit, i.e. R_L. By substituting into the above equation accordingly:

$$P = \left(\frac{Vs}{Rs \quad R_L} \right)^2 * R_L$$

Optimizing Volume of a Box Using Matlab

S. Ahmadi, O. Turkcu and P. Shang

You are given a piece of paper with length 50cm and width 20 cm. You are expected to fold this paper into a topless box after cutting the corners of the paper as shown in Fig.1. Find the dimensions of the box giving the maximum volume using MATLAB.

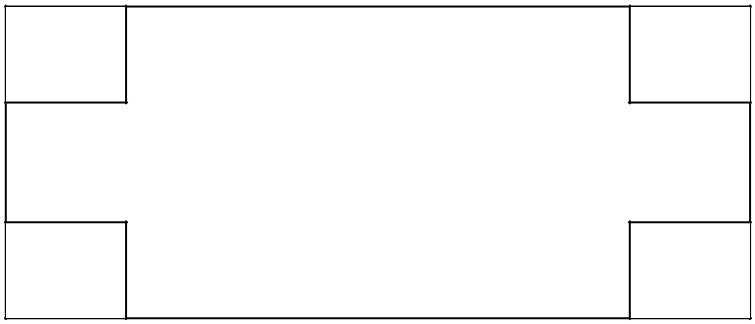


Fig. 1

1- Find a formula for the volume (V) of the box as a function of one variable (x)
   a. $V = (50 - 2x)\ (20 - 2x)^* x$
2- Use Matlab, evaluate the Volume function, V(x), for the entire *practical* values of x function.

a.

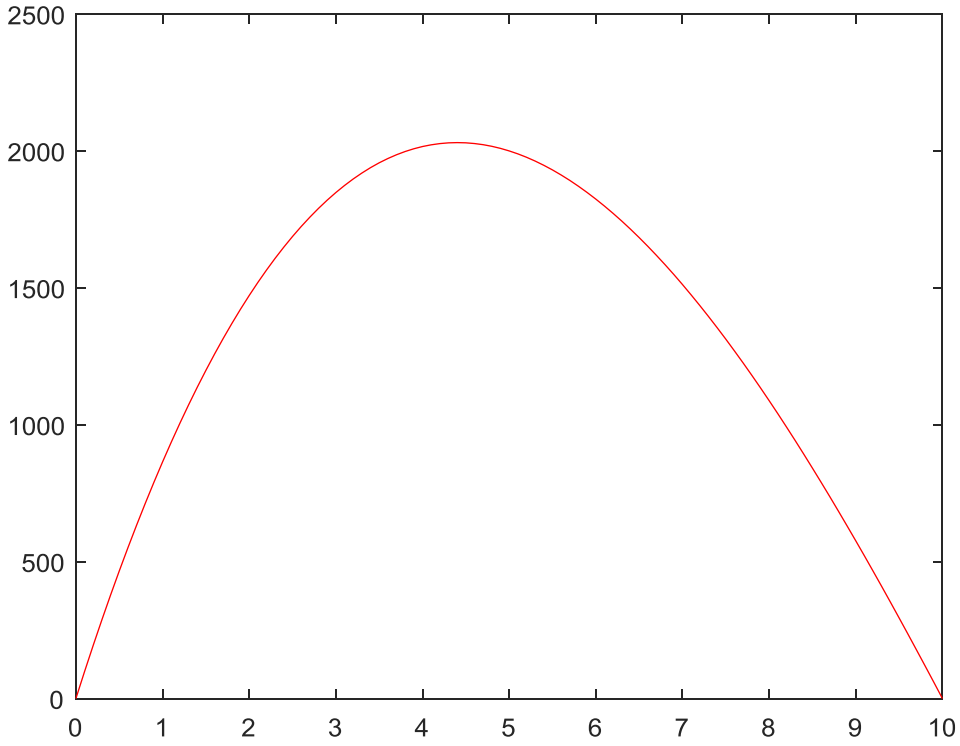
```
1 -    x= 0: 0.1 : 10;
2 -    V = (50 - (2.*x)).* (20 - (2.*x)).* x;
```

Command Window

New to MATLAB? See resources for Getting Started.

```
V =

 1.0e+03 *

Columns 1 through 6

       0    0.0986    0.1944    0.2875    0.3779    0.4655

Columns 7 through 12

  0.5505    0.6328    0.7124    0.7895    0.8640    0.9359

Columns 13 through 18

  1.0053    1.0722    1.1366    1.1985    1.2580    1.3151

Columns 19 through 24

  1.3697    1.4220    1.4720    1.5196    1.5650    1.6081

Columns 25 through 30

  1.6489    1.6875    1.7239    1.7581    1.7902    1.8202

Columns 31 through 36

  1.8480    1.8738    1.8975    1.9191    1.9388    1.9565

Columns 37 through 42

  1.9722    1.9860    1.9979    2.0079    2.0160    2.0223

Columns 43 through 48

  2.0268    2.0294    2.0303    2.0295    2.0269    2.0227

Columns 49 through 54

  2.0168    2.0092    2.0000    1.9892    1.9768    1.9629
```

3- Use Matlab, plot Volume, V, versus x--using date obtain in part 2



4- Using part 2 and 3, what is the maximum volume of the box?

```
1 -     x= 0: 0.1 : 10;
2 -     V = (50 - (2.*x)).* (20 - (2.*x)).* x;
3 -     plot(x, V, 'r')
4 -     maxV = max(V);
5 -     maxV
```

Command Window

New to MATLAB? See resources for Getting Started.

```
>> Untitled

maxV =

    2.0303e+03
```

5- Find the dimensions of the box with maximum volume (length, width, height).

```
1 -    x= 0: 0.1 : 10;
2 -    V = (50 - (2.*x)).* (20 - (2.*x)).* x;
3 -    plot(x, V, 'r')
4 -    maxV = max(V);
5 -    [maxV, i] = max(V);
6 -    x(i)
```

Command Window

New to MATLAB? See resources for Getting Started.

```
>> Untitled

ans =

    4.4000
```

Note: For questions 4 & 5, you must use matlab code, you cannot determine the values from the graph.

(Include equations, MATLAB code, etc)