Contents

Assumptions and Important Workflow Notes

```
% We will begin by Seperating System Into Control Volumes
%   1) Compression chamber 2)Expansion chamber 3)Piston FBD, and
%    4) annular area
%
% Each system will be iteratively processed using form of Eulers
% I.E one iteration passes, how much flow from one sealed sys to the other
% After taking each iteration into effect, find the total flow,
% compare to removed volume
%
```

Define and Clear Variables

```
% Clear Variables
clc, clear, clear all,;
```

```
Di = 11.25;     % In

%while loop used to analyze varying inside diameters
while Di<12.249;
```

```
Di = Di+.125;    % In
Do = 12.25;     % In
L1 = 13.35;     % In
L2 = 10.95;     % In
syms x;         % In


% Air Properties
gamma = 1.6;        % specific gravity
K1 = 1.4;           % spc heat
R = 40.87;          % Gas constant inlb/molR
MolM = .063845;     % molecular mass lb/mol
u = .00000000263;   % lbf*sec/in2 dynamic viscosity assumed constant
```

Compressed Area CV

Derive from first law Delta U = Q-W assume control volume with no exit, sealed adiabatic rapid compression

```
Apiston = pi*(Di/2)^2;          % In2
V0 = (pi*(Do/2)^2)*((L1-L2)/2); % Initial chamber volume, In3
V1c = V0;                       % Vol of comp chamber before compression
V2c = V0-Apiston*x;             % Vol of comp chamber after compression
P1c = 14.7; % Pressure of initial compression lb/in2

% work of piston is equal to integral pdv (neg for comp)
% W = Fd=int(Pdv) :: W=.5*k*(x^2)=int(Pdv) (note W=fdx)
% Pv^k =C,integrating yeilds W=Fd=(P2V2-P1V1)/(1-k)

Pc = (((-.5*Ks*x*x)*(1-K1))+P1c*V1c)/(V2c); %lb/in
```

Expanded Area CV

Derive from first law Delta U = Q-W assume control volume with no exit, sealed adiabatic rapid expansion

```
Apiston = pi*(Di/2)^2;
V0 = (pi*(Do/2)^2)*((L1-L2)/2);
V1x = V0;
V2x = V0+Apiston*x;
P1x = 14.7;                                % same scenario as compressed

% work of piston is equal to integral pdv (pos for expansion)
% W = Fd=int(Pdv) :: W=.5*k*(x^2)=int(Pdv) (note W=fdx
% Pv^k =C,integrating yeilds W=Fd=(P2V2-P1V1)/(1-k)

Px = (((.5*Ks*x*x)*(1-K1))+P1x*V1x)/(V2x);   % lb/in
```

Annular Area CV

We will use Darcy Weisbach equaions to compute pressure loss and flow rate in equivulant hydrodynamic pipe

```
% calculate Dh hydraulic area
Dh = Do-Di;

% calculate Temperature at entrance T2/T1 = V1/V2^n-1 (ideal, adiabatic)
Tx = 500*((V1x/V2x)^.4);      % 500 is reasonable initial cond in deg R
Tc = 500*((V1c/V2c)^.4);
Tavg = (Tx+Tc)/2;


%calulate ave density in annular pv=mrt=nrt rho=m/v
Achamber = pi*(Do/2)^2;
Aannular = Achamber-Apiston;            % annular area is disc between case and inside piston
Vannular = (Aannular)*L2;               % in3
n=((Px+Pc)/2)*Vannular/(40.87*Tavg);    % mol
m=n*MolM;                               % lb
rho = m/Vannular;                       % lb/in3

%Assume turbulent, roughness e = .025mm.
fd = .0275;
DeltaP = Pc-Px;
Vel2 = sqrt(DeltaP*2*Dh/(fd*L2*rho));       % Darcy Weisbach based on delta Pressure
Vdot = Vel2*Aannular;                       % in3/sec the volume flow rate
```

Compare displaced air volume to escaped volume

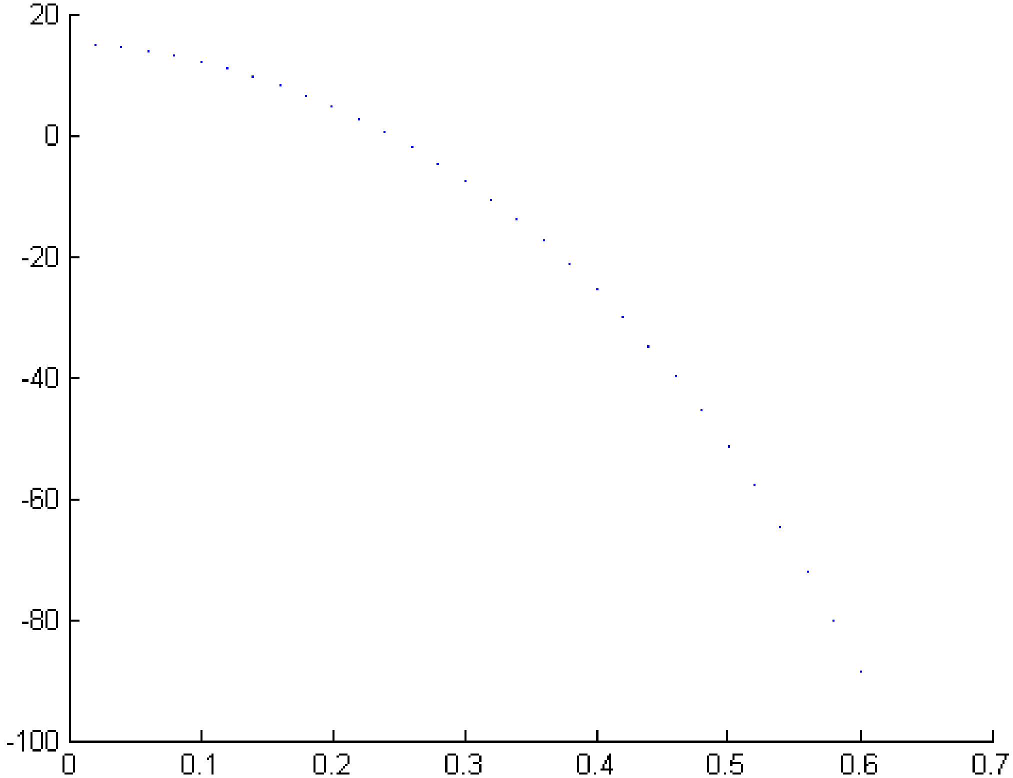
This will find the pressure n plate due to compressed air

```
StrokeTime = x/24;                          % sec, 24 is vel of stroke

Vescape = Vdot*StrokeTime;                  % all velocities in in/sec
Vremoved = Apiston*x;
Vcompressed = Vremoved - Vescape;
Vchamber=Achamber*(((L1-L2)/2))-Vremoved;


n2=.01639706*(Vcompressed+Vchamber)/22.4;   % number moles
Pressure = n2*40.87*Tavg/((Vchamber));      % psi
Force = Pressure / Apiston;                 % lb
```

Compute time iteration for each changing volume flow

```
z=0;

while z<.6

    % we are assaigning the variable sym x some distance value z
    % the will influence each following calculation

    z=z+.02;                                % distances of stroke
    nV2c = subs(V2c,x,z);
    nPc=subs(Pc,x,z);
    nV2x =subs(V2x,x,z);
    nPx =subs(Px,x,z);
    nTx =subs(Tx,x,z);
    nTc=subs(Tc,x,z);
    nTavg=subs(Tavg,x,z);

    nn=subs(n,x,z);
    nm=subs(m,x,z);
    nrho=subs(rho,x,z);

    nDeltaP=subs(DeltaP,x,z);
    nVel2=subs(Vel2,x,z);
    nVdot=subs(Vdot,x,z);
```

```
    nStrokeTime=subs(StrokeTime,x,z);
    nVremoved=subs(Vremoved,x,z);
    nVcompressed=subs(Vcompressed,x,z);
    nVchamber=subs(Vchamber,x,z);
    nn2=subs(n2,x,z);
    nPressure=subs(Pressure,x,z);
    nForce=subs(Force,x,z);

    % set the intitial pressure to the new pressure
    % this changes much of the next calculation, and
    % ultimately the amount of gas not compressed

    P1c=14.7+(nPressure-14.7);
    P1x=14.7-(nPressure-14.7);

    % plot the point
    hold on
    plot(z,nPressure,'-')

end

   % go back and redo process for next diameter
```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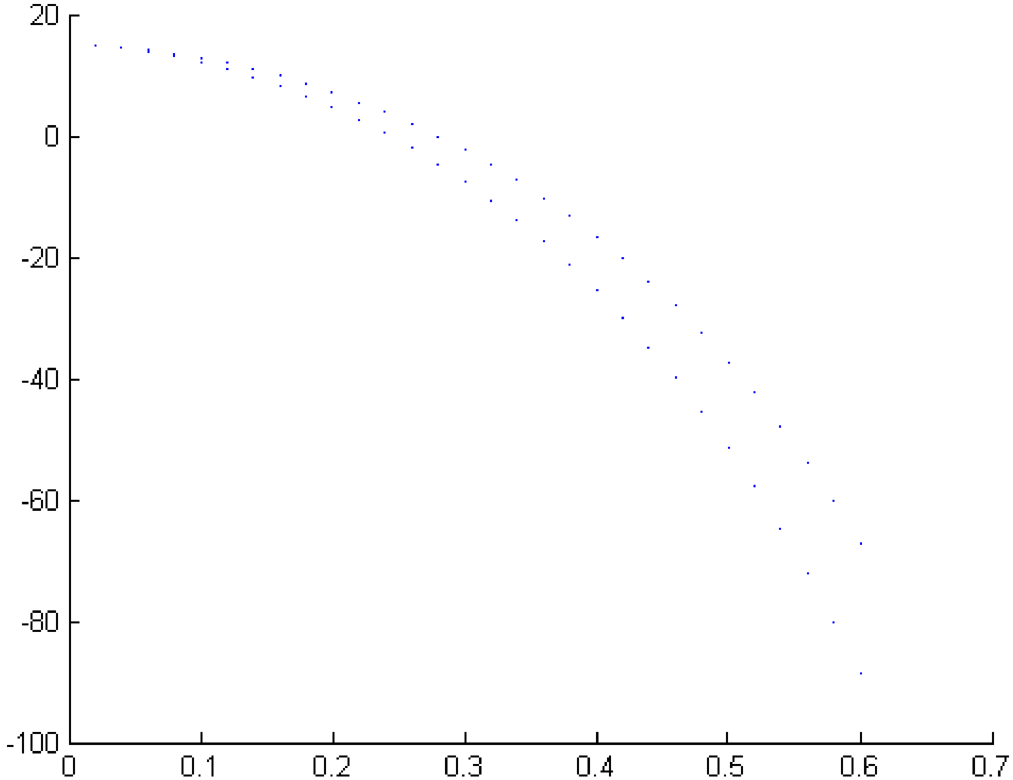
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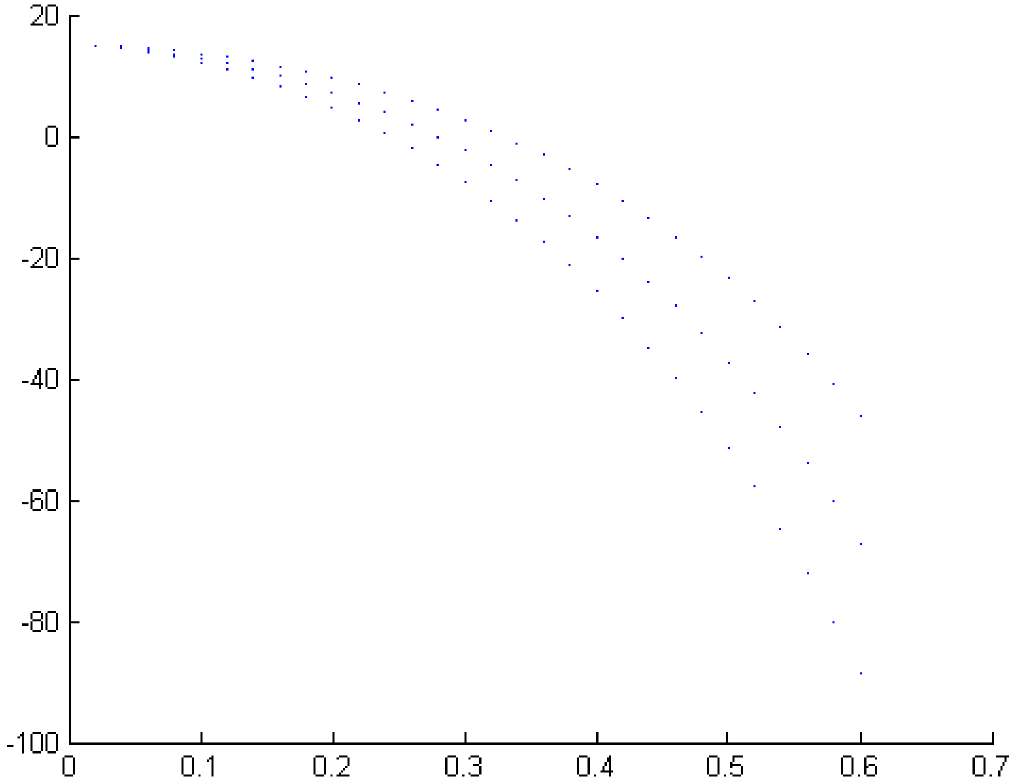

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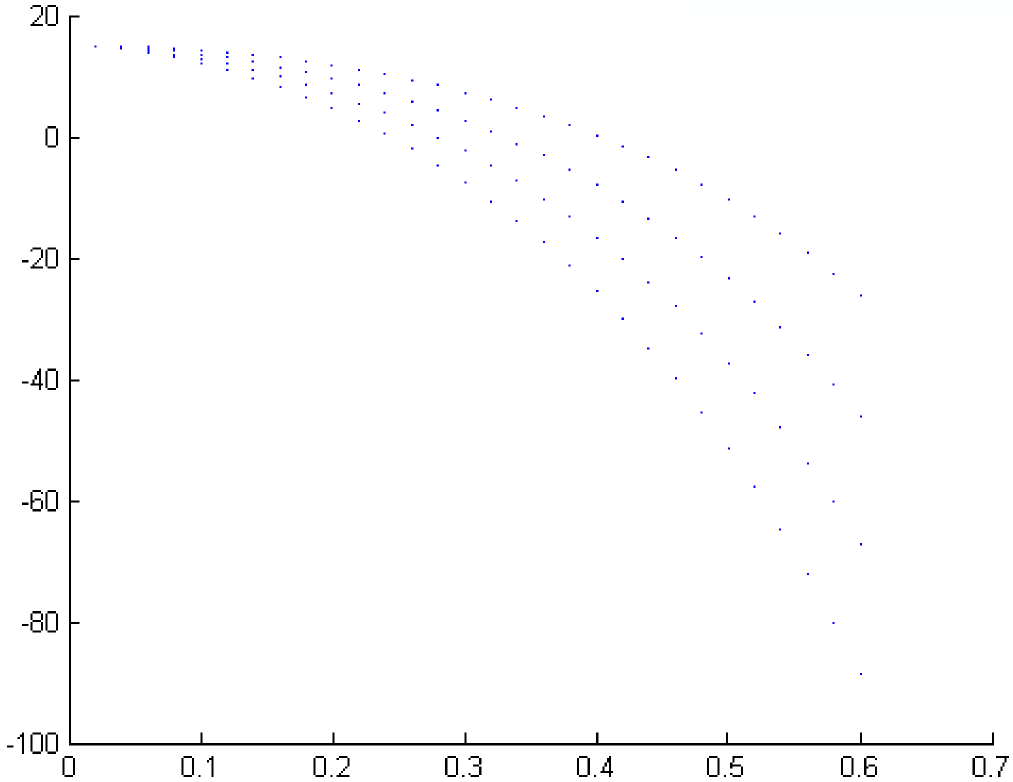
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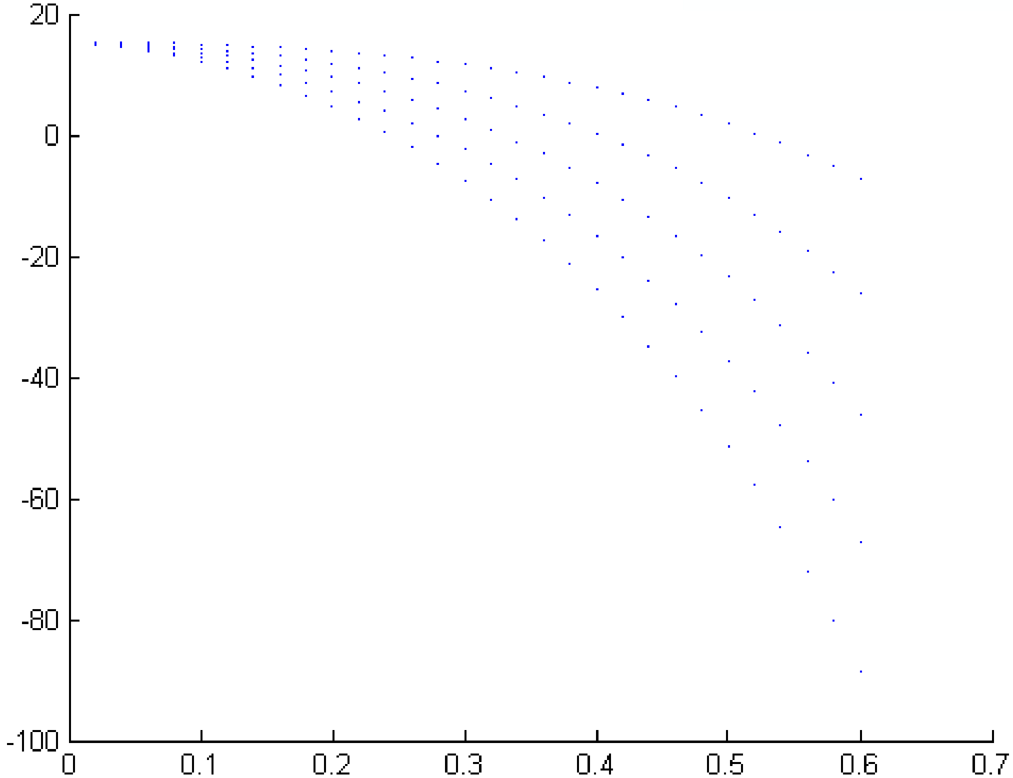
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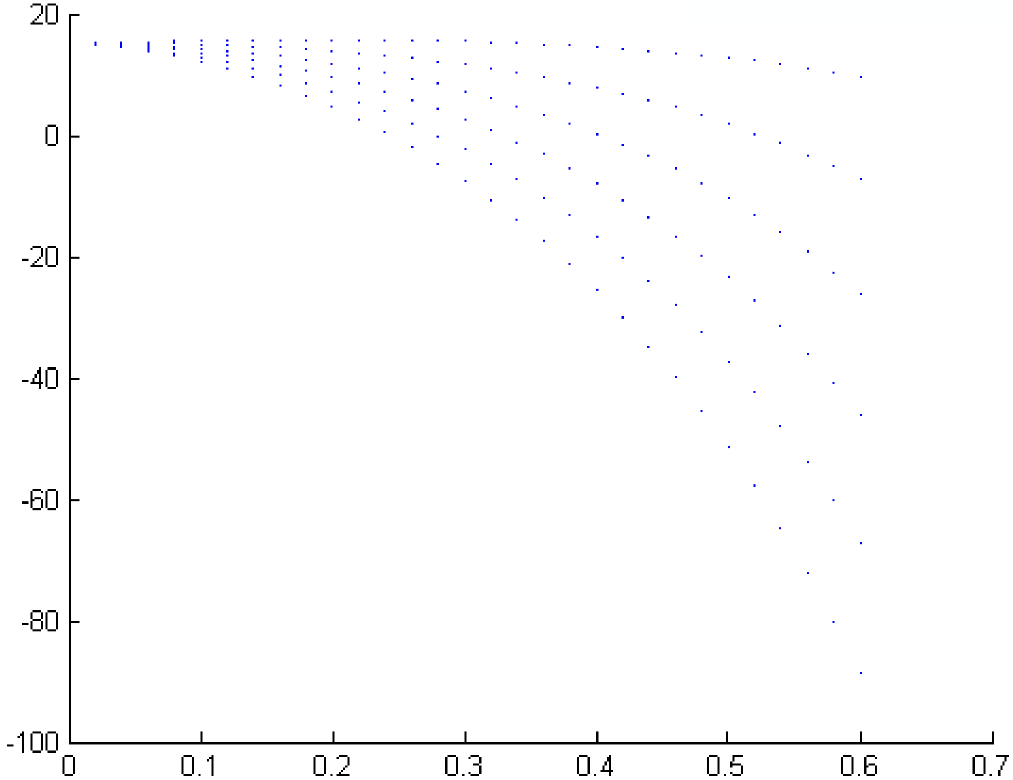
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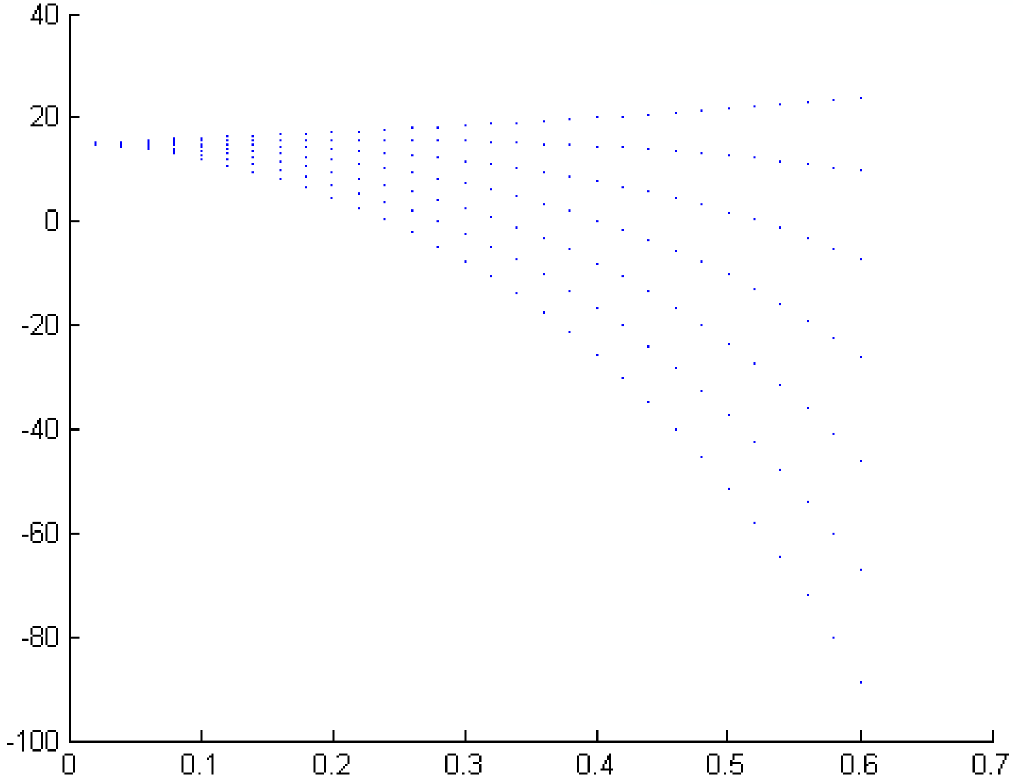
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0.4
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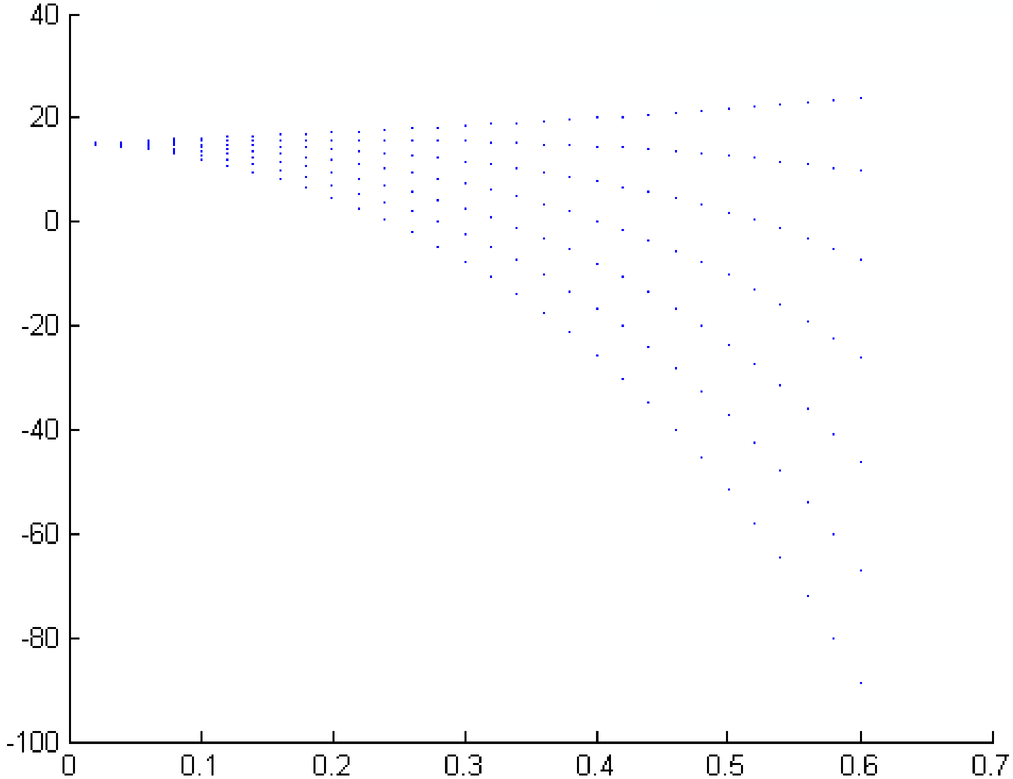
0.7




```
end

   % plot everthing
   plot([0, .6], [14.97, 14.97],'-');
   axis([0,.6,-14,40])
   hold off
```

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