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HW 1 - 302

Joshua Oates

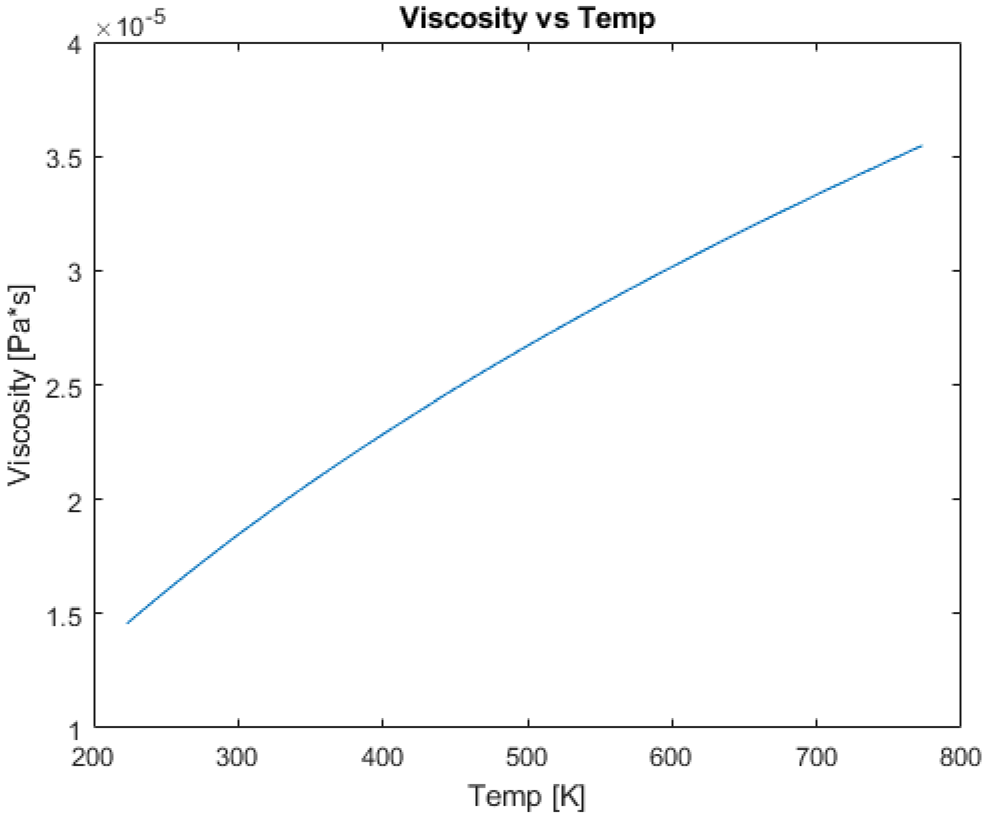
```
close all;
clear all;
clc
```

FF1

```
clear all;
disp("-----FF1-----")


muRef = 1.716e-5;
TRef = 273.15;
S = 110.4;


mu = @(T) muRef*(((T+S).^-1).*(TRef+S)).*(T/TRef).^1.5;

T = -50:1:500;
T=T+TRef;
mu = mu(T);

figure
plot(T,mu);
xlabel("Temp [K]")
ylabel("Viscosity [Pa*s]")
title("Viscosity vs Temp")

disp("Viscosity in a microscopic perspective is essentially the pull of fluid
 particles against each other so that the layers of fluid want to 'stick'
 together and transfer some shear force perpendicularly between layers. From
 a macroscopic perspective, it is essentially the fluids resistance to flowing
 past a surface or itself and represents a fluids ablility to transfer shear
 forces.")
```

```
disp("Cryogenic wind tunnels make use of low temperatures to lower the
 viscosity of the fluid they are testing with. This has the advantage of
 requiring less energy to accellerate the fluid to a high speed.")
disp("assumptions:")
disp("muRef: "+string(muRef)+"[Pa.s]")
disp("TRef: "+string(TRef)+"[K]")
disp("S: "+string(S)+"[K]")
```

```
-----FF1-----
Viscosity in a microscopic perspective is essentially the pull of fluid
 particles against each other so that the layers of fluid want to 'stick'
 together and transfer some shear force perpendicularly between layers. From
 a macroscopic perspective, it is essentially the fluids resistance to flowing
 past a surface or itself and represents a fluids ablility to transfer shear
 forces.
Cryogenic wind tunnels make use of low temperatures to lower the viscosity
 of the fluid they are testing with. This has the advantage of requiring less
 energy to accellerate the fluid to a high speed.
assumptions:
muRef: 1.716e-05[Pa.s]
TRef: 273.15[K]
S: 110.4[K]
```

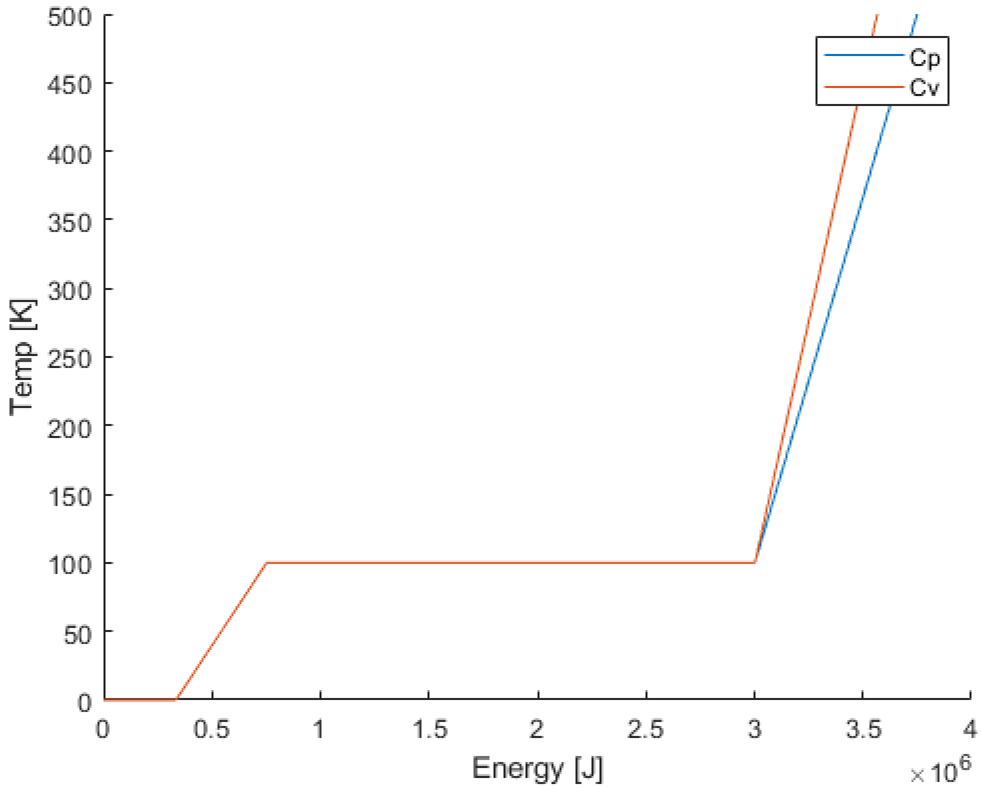


FF2

```
clear all;
```

```
disp("-----FF2-----")
m = 1; % kg
HLF = 334; % heat of latent fusion J/g
HLF = HLF*1000; % J/kg
HLV = 2.25e6; % heat of latent vaporization at 1 atm J/kg
C_water = 4.18; % J/g.K
C_water = C_water*1000; % J/kg.K
Cp_steam = 1.87; % kJ/kg.K
Cp_steam = Cp_steam*1000; % J/kg.K
Cv_steam = 1.4108; % kJ/kg.K
Cv_steam = Cv_steam*1000; % J/kg.K

E_Cp = [0,HLF,HLF+C_water*100,HLF+C_water*100+HLV,HLF+C_water*100+HLV
+Cp_steam*400].*m; % J
E_Cv = [0,HLF,HLF+C_water*100,HLF+C_water*100+HLV,HLF+C_water*100+HLV
+Cv_steam*400].*m;
T = [0,0,100,100,500];

figure
hold on
plot(E_Cp,T)
plot(E_Cv,T)
xlabel("Energy [J]")
ylabel("Temp [K]")
legend("Cp","Cv")


% E_Cp = E_Cp/1000; % KJ
disp("E-tot, Cp: "+string(E_Cp(5))+"[J]")
disp("E-tot, Cv: "+string(E_Cv(5))+"[J]")
disp("assumptions:")
disp("heat of latent fusion: "+string(HLF)+"[J/kg]")
disp("heat of latent vaporization: "+string(HLV)+"[J/kg]")
disp("C_water: "+string(C_water)+"[J/kg.K]")
disp("Cp_steam: "+string(Cp_steam)+"[J/kg.K]")
disp("Cv_steam: "+string(Cv_steam)+"[J/kg.K]")
```

```
-----FF2-----
E-tot, Cp: 3750000[J]
E-tot, Cv: 3566320[J]
assumptions:
heat of latent fusion: 334000[J/kg]
heat of latent vaporization: 2250000[J/kg]
C_water: 4180[J/kg.K]
Cp_steam: 1870[J/kg.K]
Cv_steam: 1410.8[J/kg.K]
```



DA1

```
clear all;
disp("-----DA1-----")
% F c U a rho mu
% L M T
%     [L M T]

M = [[2 1 -2];... %M
     [1 1 -2];... %F
     [1 0 0];...  %c
     [1 0 -1];... %U
     [1 0 -1];... %a
     [-3 1 0];... %rho
     [-1 1 -1]];   %mu

M = M';

pi = joshBuckPiTheory(M,["M","F", "c", "U", "a", "rho", "mu"]);

disp("I found the following pi's algorithmically")
disp("pi 1: "+string(pi(1)))
disp("pi 2: "+string(pi(2)))
disp("pi 3: "+string(pi(3)))
disp("pi 4: "+string(pi(4)))
```

```
disp("The values of pi 1 and pi 2 can be converted into the numbers")

pi(1) = pi(1)^-1; % coeff moment
pi(2) = pi(2)^-1; % mach

disp("pi 1: "+string(pi(1)))
disp("pi 2: "+string(pi(2)))
disp("which are the coeff moment and mach number.")
disp("using all pi's except 2 M and F can be solved. This reduction in number
 of paramenters from 7 to 4 will make testing and modeling much easier for the
 experiementers.")
```

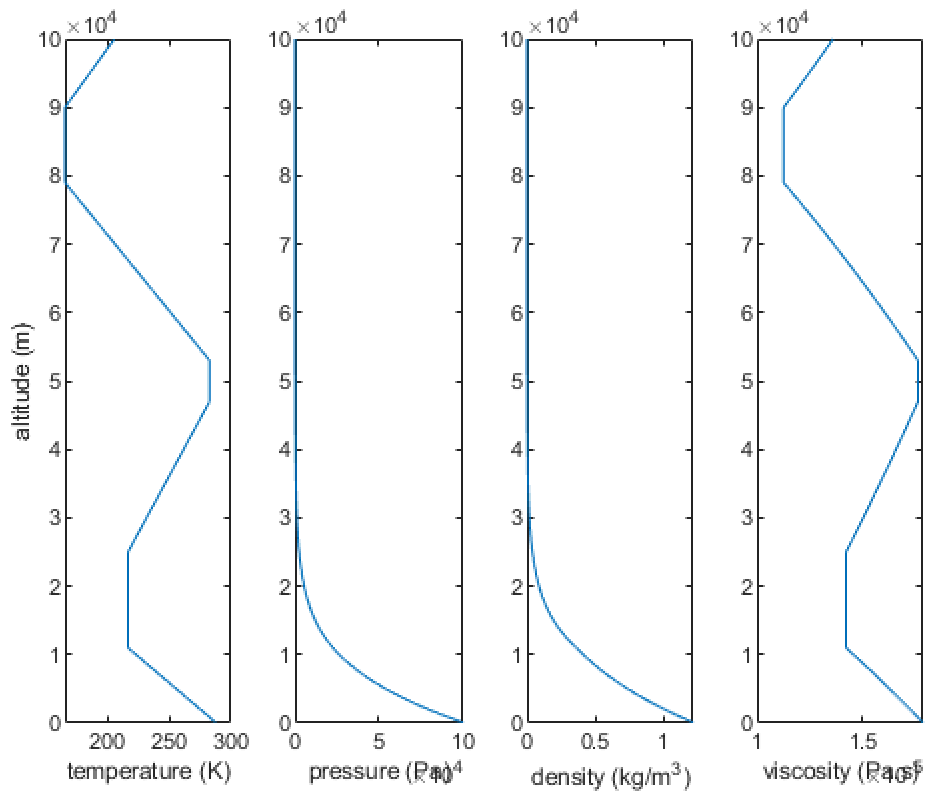
```
-----DA1-----
I found the following pi's algorithmically
pi 1: (F*c)/M
pi 2: a/U
pi 3: (M^2*U^2*rho)/F^3
pi 4: (M*U*mu)/F^2
The values of pi 1 and pi 2 can be converted into the numbers
pi 1: M/(F*c)
pi 2: U/a
which are the coeff moment and mach number.
using all pi's except 2 M and F can be solved. This reduction in number of
 paramenters from 7 to 4 will make testing and modeling much easier for the
 experiementers.
```

FS1

```
clear all;
disp("-----FS1-----")

for i=1:1000 % test iterator for 100 different altitudes
    hM(i)=i*100;
    [TM(i),PM(i),rhoM(i),muM(i)]=stdAtmOatesJoshua(hM(i));
end
figure
hold;
subplot(1,4,1); %set subplot settings
plot(TM,hM); %plot T
ylabel("altitude (m)"); %label altitude
xlabel("temperature (K)"); %label temperature
subplot(1,4,2);
plot(PM,hM);
xlabel("pressure (Pa)");
subplot(1,4,3);
plot(rhoM,hM);
xlabel("density (kg/m^3)");
subplot(1,4,4);
plot(muM,hM);
xlabel("viscosity (Pa.s)");
```

```
disp("We assume that temperatrure is either changing with a constant slope as
 a function of h or that it is not changing between certain altitudes. This
 leads to a peicewise graph of all atmpospheric variables. This appraoch could
 easily be extended to any important altitude but these fomulations will not
 work for long since the stdAtm model is designed only for up to 100km. When
 the air gets very thin, we start to care more about Knudsen number than than
 pressure.")
disp("assumptions:")
disp("stdAtm")
```

```
-----FS1-----
Current plot held
We assume that temperatrure is either changing with a constant slope as a
 function of h or that it is not changing between certain altitudes. This
 leads to a peicewise graph of all atmpospheric variables. This appraoch could
 easily be extended to any important altitude but these fomulations will not
 work for long since the stdAtm model is designed only for up to 100km. When
 the air gets very thin, we start to care more about Knudsen number than than
 pressure.
assumptions:
stdAtm
```



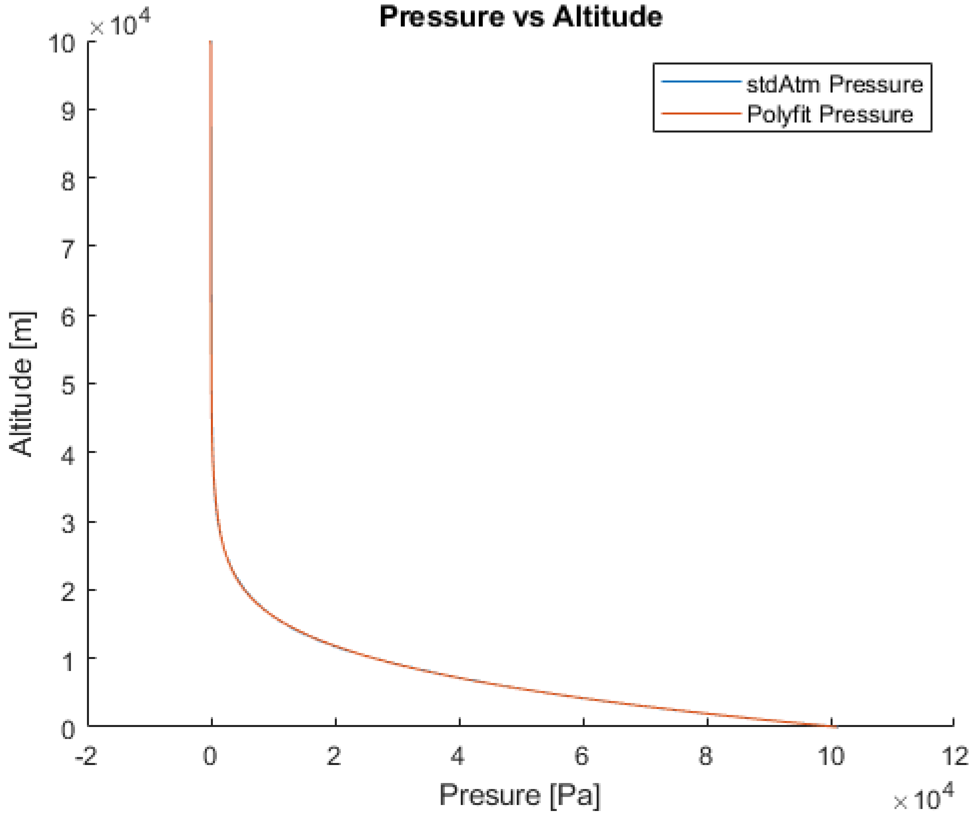
FS2

space elevator

```
clear all;

disp("-----FS2-----")
L = 100; % km
L = L*1000; % m
d = 2; % m
A = L*2; % m^2

degree = 10;
h = 1:L;
for i=1:length(h) % test iterator for 100 different
    % altitudes
    [~,P1(i)]=stdAtmOatesJoshua(h(i));
end

poly = polyfit(h,P1,degree);
P2 = polyval(poly,h);


polyFun1 = @(h) polyval(poly,h);
polyFun2 = @(h) polyval([poly,0],h);

hFun = @(h) h;
polyi = polyint(poly);

F = polyFun2(0) - polyFun2(L);
F = F*2;

Cp = integral(polyFun2,0,L)/integral(polyFun1,0,L);
Cm = L/2;
M = (Cm-Cp)*F;

figure
hold on
plot(P1,h)
plot(P2,h)
xlabel("Presure [Pa]")
ylabel("Altitude [m]")
title("Pressure vs Altitude")
legend("stdAtm Pressure","Polyfit Pressure")

disp("The center of pressure (Cp) is at and altitude of: "+string(Cp)+" m.")
disp("The moment is: "+string(M)+" N.m.")
disp("assumptions:")
disp("stdAtm")
disp("Only evaluate forces on one half of the elevator, if evaluated on both
 side there is no net force or moment.")
```

```
-----FS2-----
Warning: Polynomial is badly conditioned. Add points with distinct X values,
reduce the degree of the polynomial, or try centering and scaling as described
in HELP POLYFIT.
The center of pressure (Cp) is at and altitude of: 6808.868 m.
The moment is: 586255884955.1541 N.m.
```

assumptions:
stdAtm
Only evaluate forces on one half of the elevator, if evaluated on both side there is no net force or moment.



FS3

```
disp("-----FS3-----")
syms P1 P2 P3 V1 V2 h1 h2 theta Pd hm
assume([P1 P2 P3 V1 V2 h1 h2 theta Pd hm],'real')
assumeAlso([P1 P2 P3 V1 V2 h1 h2 theta hm]>0)
assumeAlso(P1 == P2 + P3)
h2 = sind(theta)*hm;
rho_w = 997; % kg/m^3
rho_a = 1.225; % kg/m^3
g = 9.81; % m/s^2
Pd = rho_w*h1*g;
assumeAlso(Pd == P1-P2);

Pd1 = double(subs(Pd,h1,1e-3)); %  Pa
eqn1 = Pd1==rho_a*V1^2/2; % definition of dynamic pressure

V1 = double(solve(eqn1,V1));

Pd2 = Pd1*sind(50);
eqn2 = Pd2==rho_a*V2^2/2;
```

```
V2 = double(solve(eqn2,V2));

disp("Attach line 1 and line 2 to the manometer to find the value of dynamic
 pressure.")
disp("Dynamic Pressure is: "+string(Pd)+ " Pa")
disp("Using the definintion of dynamic pressure, V1 is: "+string(V1)+" m/s")
disp("Using the definintion of dynamic pressure, V2 is: "+string(V2)+" m/s")
disp("The calculated speed is higher because there is an implication that the
 pressure is higher but since this is within the error of the manometer it is
 unreasonable to report a significant difference.")
```

```
-----FS3-----
Attach line 1 and line 2 to the manometer to find the value of dynamic
 pressure.
Dynamic Pressure is: (978057*h1)/100 Pa
Using the definintion of dynamic pressure, V1 is: 3.996 m/s
Using the definintion of dynamic pressure, V2 is: 3.4975 m/s
The calculated speed is higher because there is an implication that the
 pressure is higher but since this is within the error of the manometer it is
 unreasonable to report a significant difference.
```

FM1

```
disp("-----FM1-----")
clear all;
clc

state0 = [100 -11.2]*1000;
tspan = [0 60*60];
options = odeset('RelTol', 1e-8,'AbsTol',1e-8);

[t,y] = ode45(@falling,tspan,state0,options);

figure
plot(abs(y(:,2)),abs(y(:,1)))
ylabel("altitude [m]")
xlabel("speed [m/s]")
title("Altitude vs Velocity")
disp("assumptions:")
disp("stdAtm")
disp("V0 = -11.2 km/s")
disp("y0 = 100 km")
```

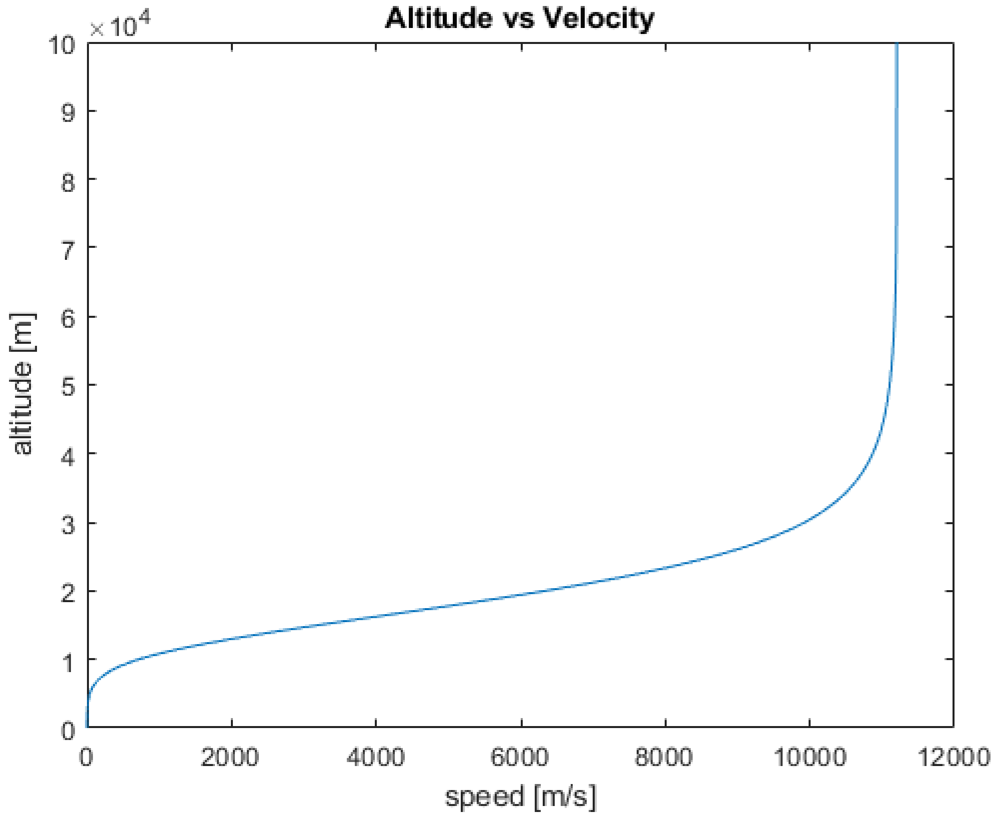
```
-----FM1-----
```

function def

```
function dstate = falling(t,state)
    % disp("here")
    % y = myState(1);
    BC = 4800;%N/m^s
```

```
    g = 9.81;%m/s^2
    y = state(1);
    yd = state(2);
    if y>0
        [~,~,rho] = stdAtmOatesJoshua(y);
    else
        rho = stdAtmOatesJoshua(1);
    end

    ydd=((BC^-1)*((rho*yd^2)/2))*g;
    dstate = [yd;ydd];
end
```

assumptions:
stdAtm
V0 = -11.2 km/s
y0 = 100 km



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