





Figures 1, 2, and 3: Rate of mass flow at outlet, internal air pressure, and mass of air and/or water as functions of time at various inlet mass flow rates.

Appendix A: MATLAB Code

%Short program to simulate conditions in air powered water pump

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%22.581 HW#1, Problem 4

clc

%Physical constants

g =9.8; %m/s^2

rhoL =1000; %kg/m^3

PAtm =101325; %Pa

R =287.058; %J/kg K

c\_air =340; %m/s

%Problem ICs

% | A

% \_\_\_|\_\_\_ | H1

% | H3 | V

% |=====| A

% | | | H2

% |\_\_\_\_\_| V

T =293; %K

H1\_0 =0.15; %m

H2\_0 =0.4;

H3\_0 =0.1;

D1 =0.3; %m

D2 =0.02;

D3 =0.02;

mDotL\_0 =0; %kg/s Flow of water through exit

P0 =g\* rhoL\* H1\_0 + PAtm; %Pressure of air in pump

%Inputs

mDotA =0.001; %kg/s Flow of air into pumped port\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Modify Here

del\_t =0.001; %s Timestep for iterative time marching

max\_t =40; %s Maximum time to simulate for

steps =floor(max\_t/del\_t +1);

%Functions defined:

%[mDotL] = Calc\_mDotL(PAir, H1, rhoL, PAtm, D3, g)

%[PDot] = Calc\_PDot(PAir, H3, mDotL, mDotA, rhoL, D1, R, T)

%[p1,p2,p3,p4,p5] = PlotResults(time, data, D1, saved\_H2, saved\_H3, saved\_rhoA, rhoL, saved\_mDotL, saved\_PAir)

%Main loop

%%Initialization

PAir =P0;

H1 =H1\_0;

H2 =H2\_0;

H3 =H3\_0;

mDotL =mDotL\_0;

%Preallocate save structures

step=1;

saved\_mDotL =zeros(steps,1);

saved\_H2=zeros(steps,1);

saved\_H3=zeros(steps,1);

saved\_PAir=zeros(steps,1);

saved\_mDotL(step)=mDotL;

saved\_H2(step)=H2;

saved\_H3(step)=H3;

saved\_PAir(step)=PAir-PAtm;

for t=0:del\_t:max\_t;

step =step+1;

PDot =Calc\_PDot(PAir, H3, mDotL, mDotA, rhoL, D1, R, T);

mDotL =Calc\_mDotL(PAir, H1, rhoL, PAtm, D3, g);

PAir =PAir + PDot\*del\_t; %Pa Calculate new PAir based on rate of change

if H2 %If water hasn't been exhausted

del\_H2 =del\_t\*((-4\* mDotL)/(pi\* D1^2\* rhoL)); %m Calculate change in water height due to water flow out

H2 = max(H2+del\_H2,0);

H1 =H1-del\_H2; %

H3 =H3-del\_H2; %Both H1 and H3 decrease in magnitude by del\_H3

%Save data

saved\_mDotL(step)=mDotL;

saved\_H2(step)=H2;

saved\_H3(step)=H3;

saved\_PAir(step)=PAir-PAtm;

saved\_rhoA =PAir/(R\*T);

else %Plot when empty

PlotResults(0:del\_t:t,1:step-1, D1, saved\_H2, saved\_H3, saved\_rhoA, rhoL, saved\_mDotL, saved\_PAir);

return

end

end

%If sim hasn't run to conclusion, plot what we have

PlotResults(0:del\_t:max\_t+del\_t,1:steps+1, D1, saved\_H2, saved\_H3, saved\_rhoA, rhoL, saved\_mDotL, saved\_PAir);

%For the purposes of printing, function files:

% function [mDotL] = Calc\_mDotL(PAir, H1, rhoL, PAtm, D3, g)

% mDotL = rhoL\*pi\*(D3^2/4)\*sqrt(2\*((PAir-PAtm)/rhoL-g\*H1));

% end

%

% function [PDot] = Calc\_PDot(PAir, H3, mDotL, mDotA, rhoL, D1, R, T)

% PDot = (4/(pi\*D1^2\*H3))\*(mDotA\*R\*T - (PAir\*mDotL/rhoL));

% end

%

% function [p1,p2,p3,p4,p5] = PlotResults(time, data, D1, saved\_H2, saved\_H3, saved\_rhoA, rhoL, saved\_mDotL, saved\_PAir)

% saved\_mL =pi\*(D1^2/4)\*saved\_H2\*rhoL;

% saved\_mA =pi\*(D1^2/4)\*saved\_H3.\*saved\_rhoA;

% saved\_mAL =saved\_mA + saved\_mL;

% p1=subplot(231);plot(time, saved\_mDotL(data));xlabel('time (s)');ylabel('Mass Flow at Outlet (kg/s)');

% p2=subplot(232);plot(time, saved\_PAir(data));xlabel('time (s)');ylabel('Internal Air Pressure(gauge Pa)');

% p3=subplot(234);plot(time, saved\_mA(data));xlabel('time (s)');ylabel('Mass of Air (kg)');

% p4=subplot(235);plot(time, saved\_mL(data));xlabel('time (s)');ylabel('Mass of Water (kg)');

% p5=subplot(236);plot(time, saved\_mAL(data));xlabel('time (s)');ylabel('Mass of Air+Water (kg)');

% end