AAE 334: Aerodynamics

HW8: Compressible Isentropic Relation & Pitot Tube

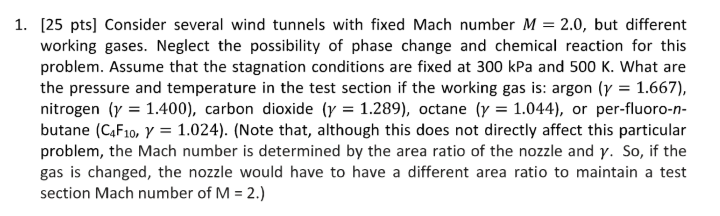
Dr. Blaisdell

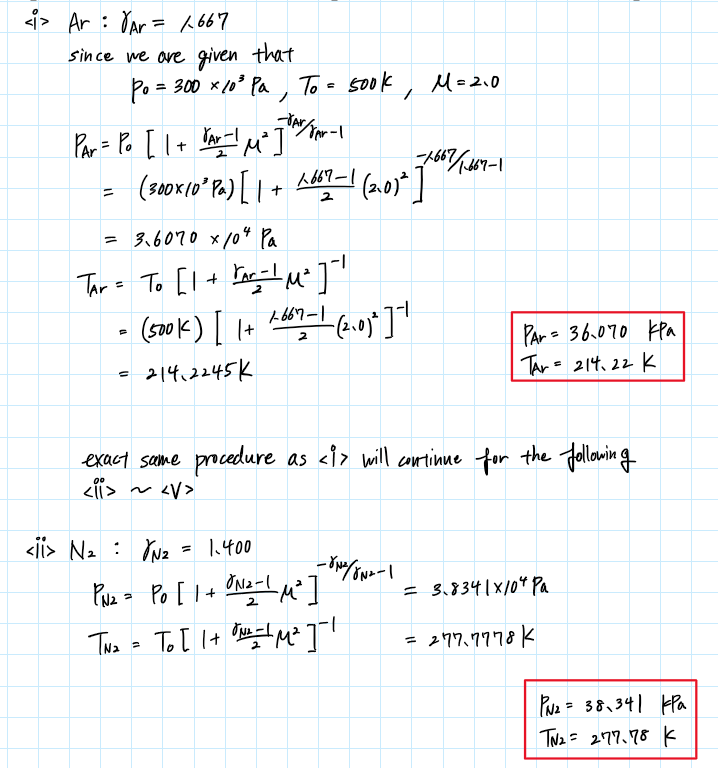
School of Aeronautical & Astronautical Engineering

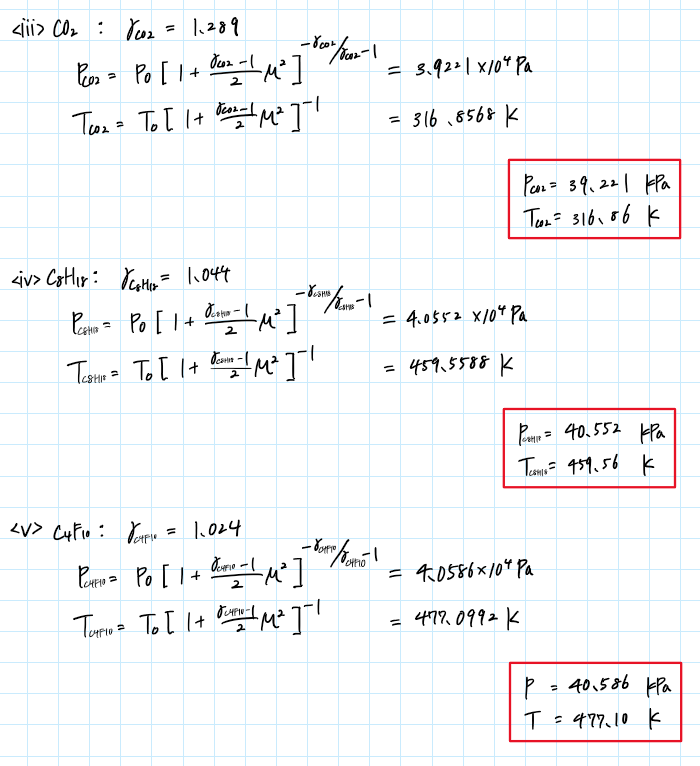
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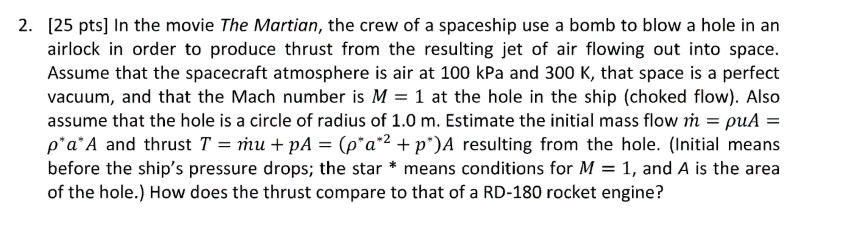
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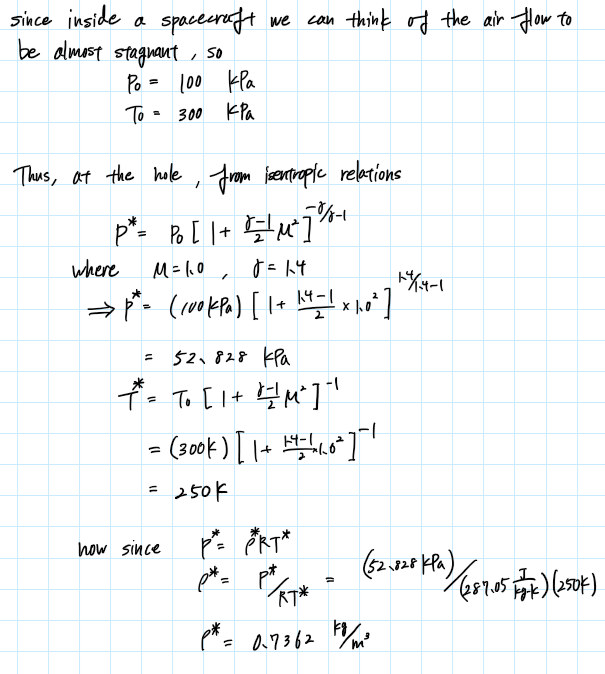
Friday March 27th 2020

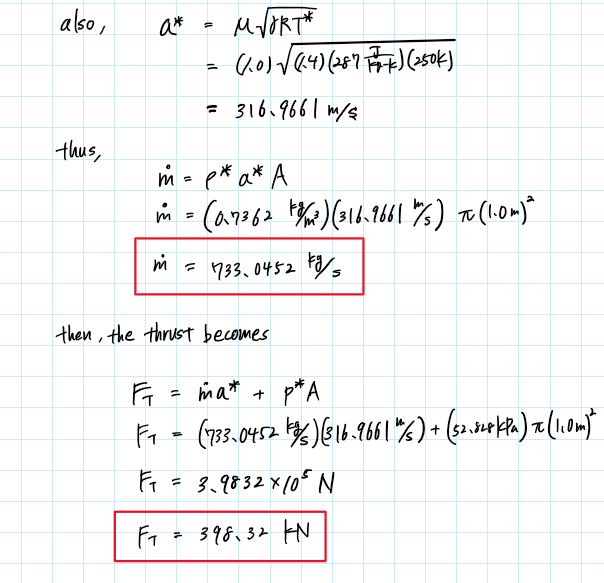


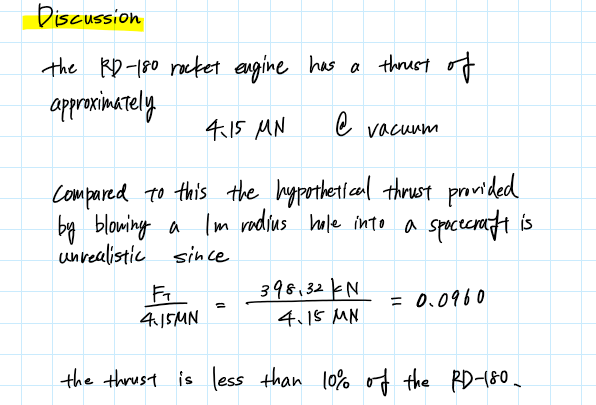


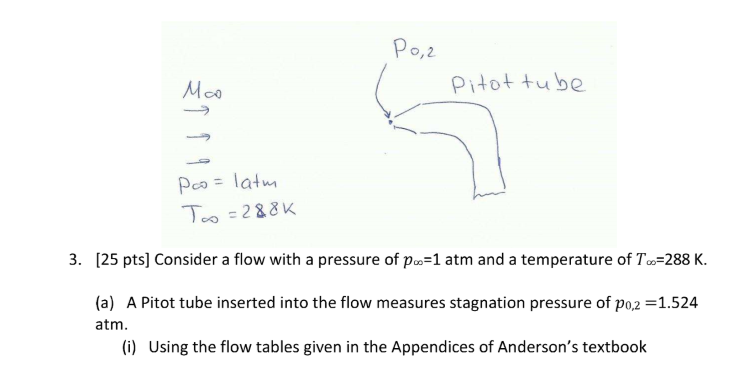
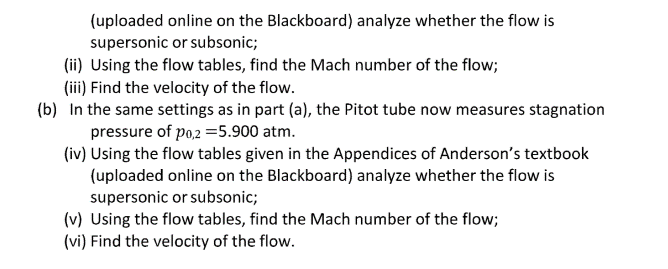


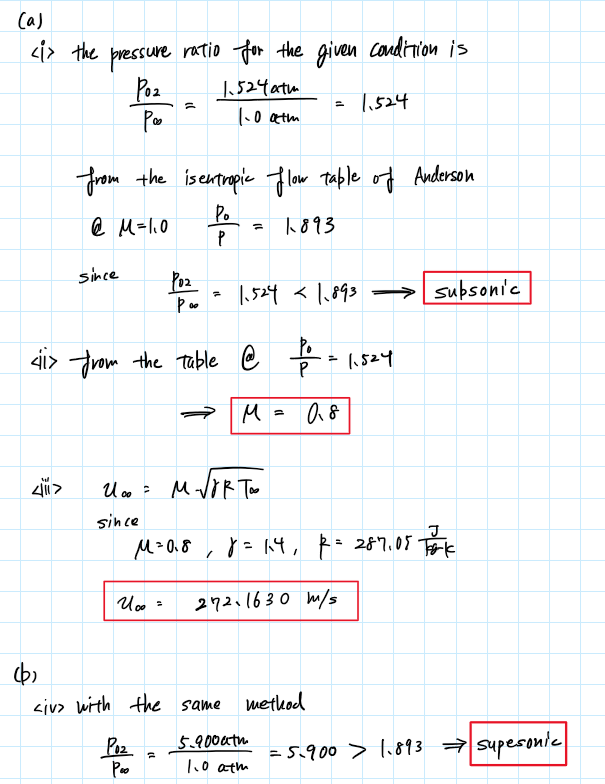


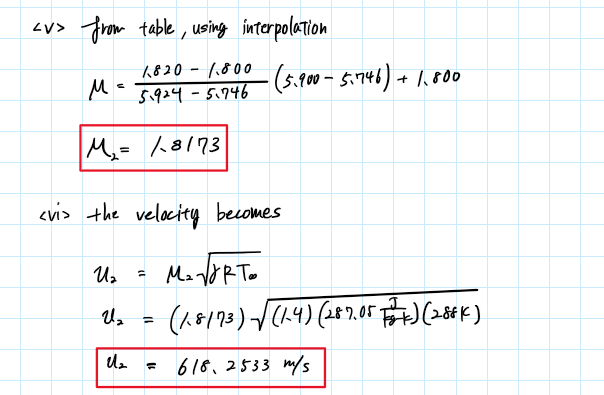


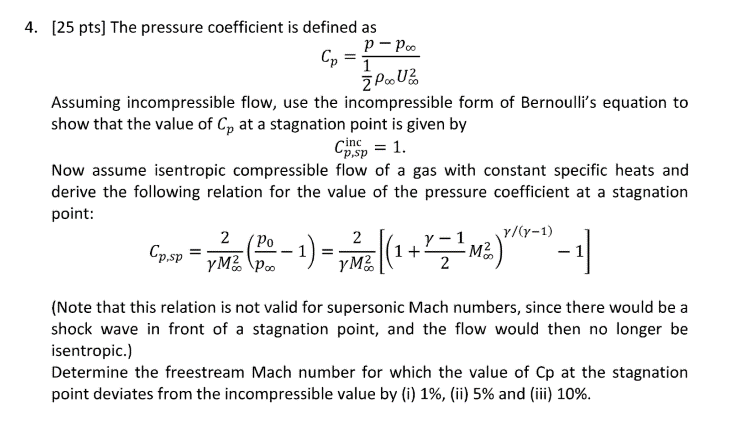


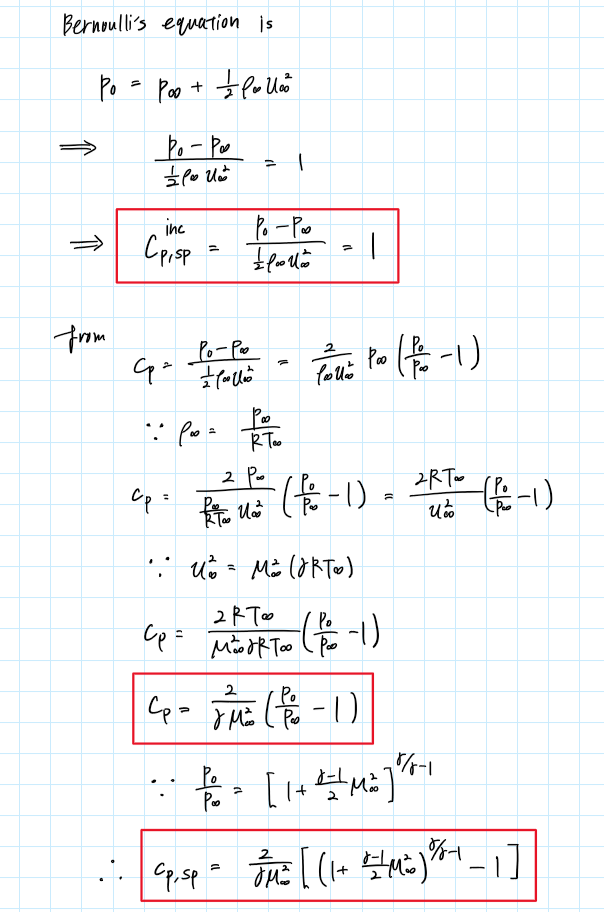


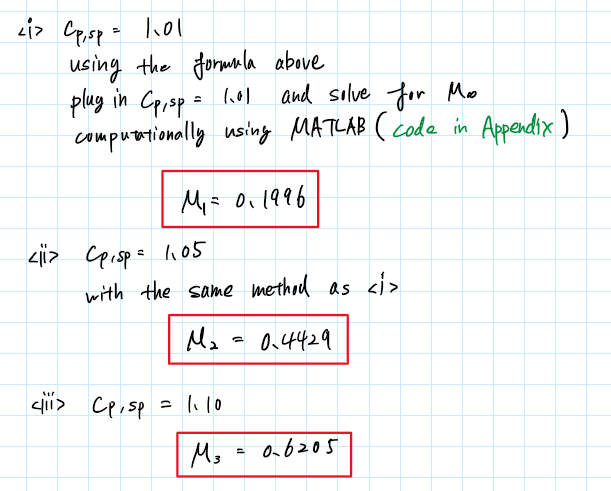
 











Appendix

**AAE334 HW8 MATLAB**

clear all; close all; clc;

**P1**

P0 = 300e3; % stagnation pressure [Pa]

T0 = 500; % stagnation temperature [K]

M = 2.0; % Mach number

% Argon

gamma\_Ar = 1.667;

P\_Ar = p\_from\_M\_and\_gamma(P0,M,gamma\_Ar,'static')

T\_Ar = T\_from\_M\_and\_gamma(T0,M,gamma\_Ar,'static')

% Nitrogen

gamma\_N2 = 1.400;

P\_Ar = p\_from\_M\_and\_gamma(P0,M,gamma\_N2,'static')

T\_Ar = T\_from\_M\_and\_gamma(T0,M,gamma\_N2,'static')

% Carbon Dioxide

gamma\_CO2 = 1.289;

P\_Ar = p\_from\_M\_and\_gamma(P0,M,gamma\_CO2,'static')

T\_Ar = T\_from\_M\_and\_gamma(T0,M,gamma\_CO2,'static')

% Octane

gamma\_C8H18 = 1.044;

P\_Ar = p\_from\_M\_and\_gamma(P0,M,gamma\_C8H18,'static')

T\_Ar = T\_from\_M\_and\_gamma(T0,M,gamma\_C8H18,'static')

% Per-fluoro-n-butane

gamma\_C4F10 = 1.024;

P\_Ar = p\_from\_M\_and\_gamma(P0,M,gamma\_C4F10,'static')

T\_Ar = T\_from\_M\_and\_gamma(T0,M,gamma\_C4F10,'static')

**P2**

P0 = 100e3; % stagnation pressure [Pa]

T0 = 300; % stagnation temperature [K]

M = 1.0; % Mach number

gamma = 1.4; % heat capacity ratio

R = 287.05; % gas constant [J/kg/K]

A = pi\*1.0^2; % hole area [m2]

P = p\_from\_M\_and\_gamma(P0,M,gamma,'static') % static pressure at hole

T = T\_from\_M\_and\_gamma(T0,M,gamma,'static') % static temperature at hole

rho = P/R/T % static density at hole

u = M\*sqrt(gamma\*R\*T) % velocity at hole

m\_dot = rho\*u\*A % mass flow at hole

Ft = m\_dot\*u + P\*A % thrust at hole [N]

% Compare to RD-180 rocket engine

rat = Ft/4.15e6

**P3**

P02 = 1.524; % [atm]

P = 1; % [atm]

T = 288; % [K]

M = 0.8;

% <iii>

u = M\*sqrt(gamma\*R\*T)

% <v>

M2 = two\_point\_interpolate(5.9,5.746,5.924,1.8,1.82)

% <vi>

u2 = M2\*sqrt(gamma\*R\*T)

**P4**

% Cp = 1.01

M1 = calc\_M\_from\_Cp(1.01)

% Cp = 1.05

M2 = calc\_M\_from\_Cp(1.05)

% Cp = 1.10

M3 = calc\_M\_from\_Cp(1.10)

**FUNCTION**

function M = calc\_M\_from\_Cp(Cp)

gamma = 1.4;

syms M

a1 = 2/gamma/M^2;

a2 = (1 + (gamma - 1)/2\*M^2)^(gamma/(gamma - 1));

eqn = Cp == a1\*(a2 - 1);

M = double(solve(eqn,M));

M = M(M==real(M) & real(M)>0);

end

function y = two\_point\_interpolate(x,x\_low,x\_high,y\_low,y\_high)

slope = (y\_high - y\_low) / (x\_high - x\_low);

y = slope \* (x - x\_low) + y\_low;

end

function T2 = T\_from\_M\_and\_gamma(T1, M, gamma, type)

if type == "stagnation"

T2 = T1 \* (1 + (gamma - 1) / 2 \* M^2);

elseif type == "static"

T2 = T1 / (1 + (gamma - 1) / 2 \* M^2);

else

disp("Error. Incorrect type. Type can only be 'stagnation' or 'static'.")

end

end

function p2 = p\_from\_M\_and\_gamma(p1, M, gamma, type)

if type == "stagnation"

p2 = p1 \* (1 + (gamma - 1) / 2 \* M^2)^(gamma/(gamma - 1));

elseif type == "static"

p2 = p1 / (1 + (gamma - 1) / 2 \* M^2)^(gamma/(gamma - 1));

else

disp("Error. Incorrect type. Type can only be 'stagnation' or 'static'.")

end

end