AAE 339: Aerospace Propulsion

HW 8: Introduction to Rocket Propulsion

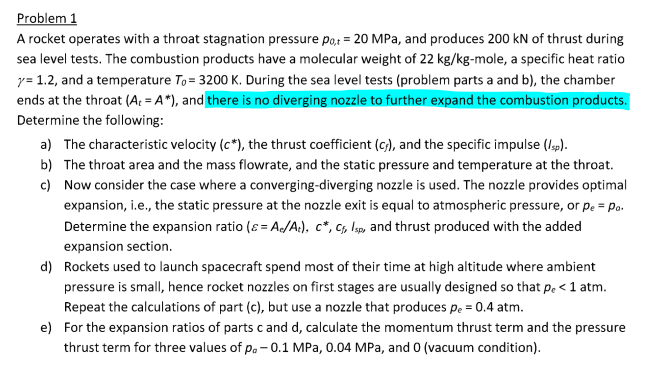
Dr. Anderson

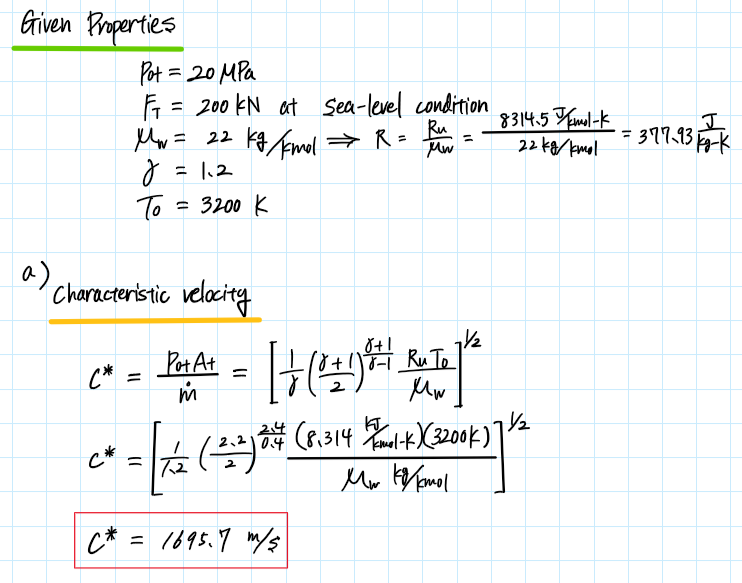
School of Aeronautical and Astronautical

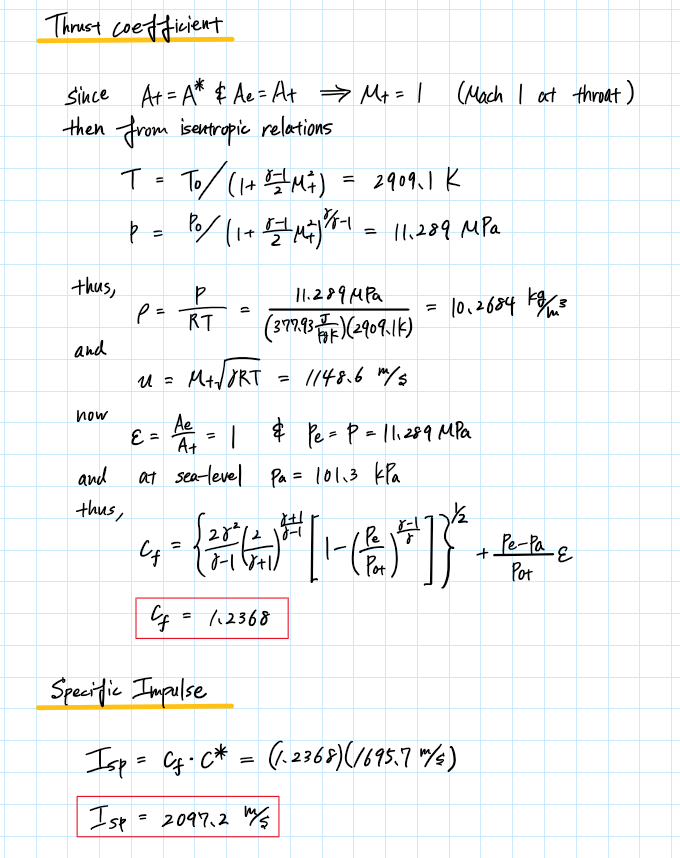
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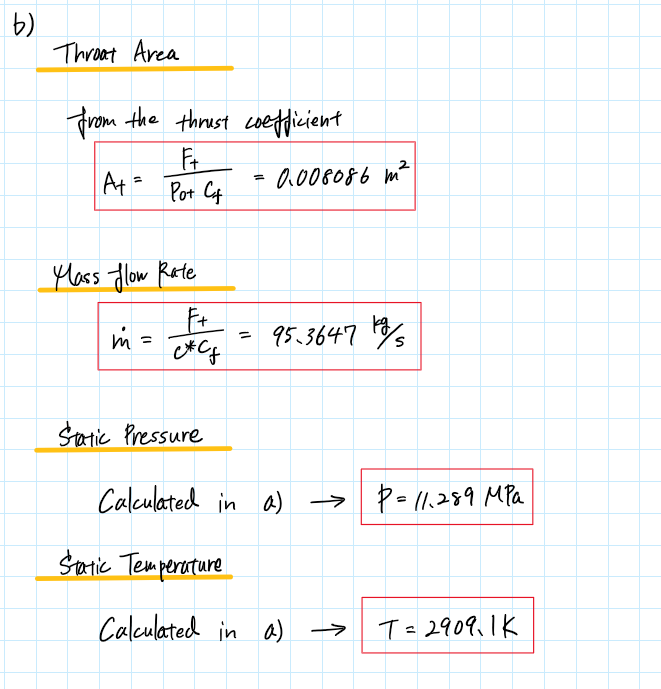
Tomoki Koike

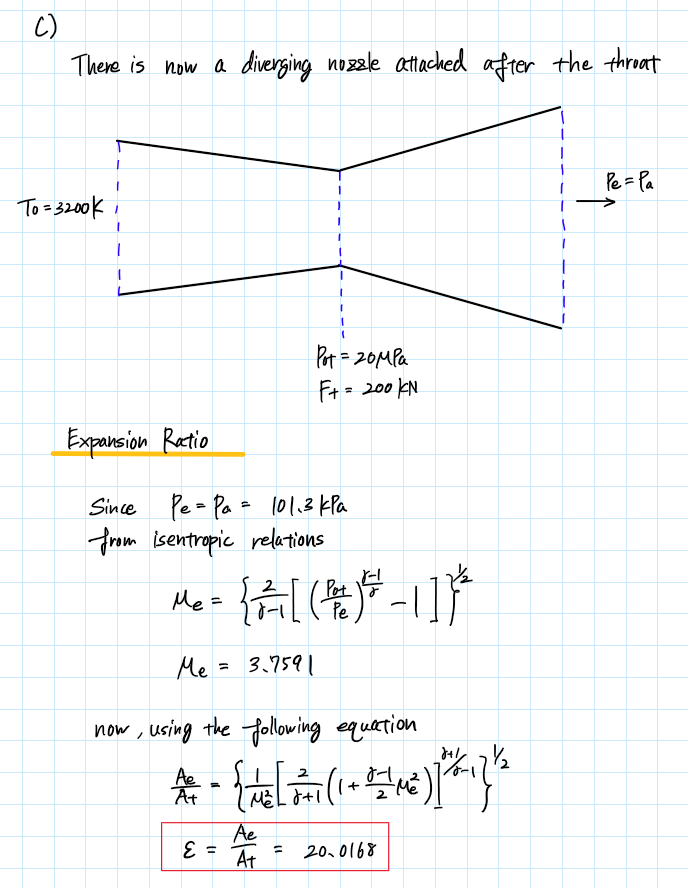
Friday April 10th, 2020

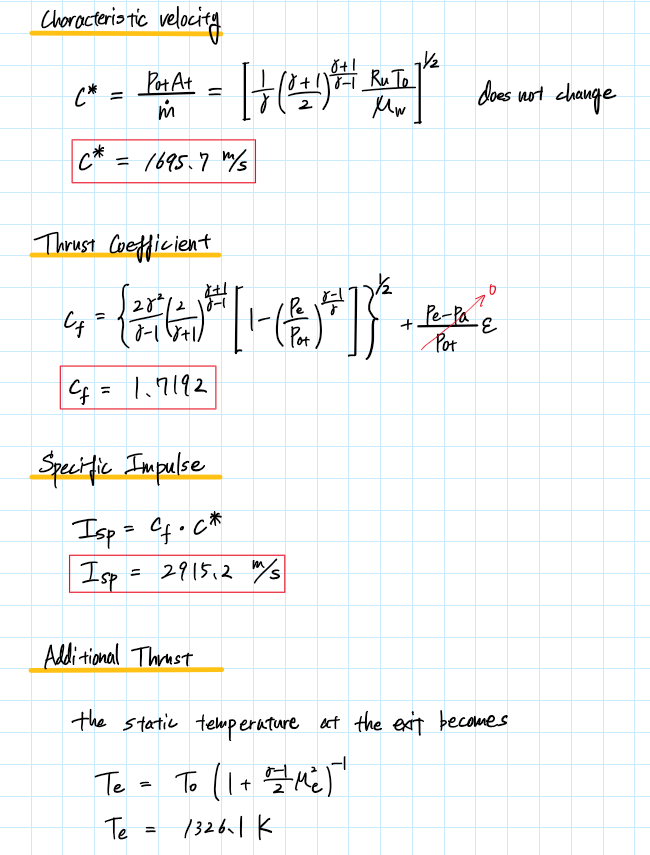


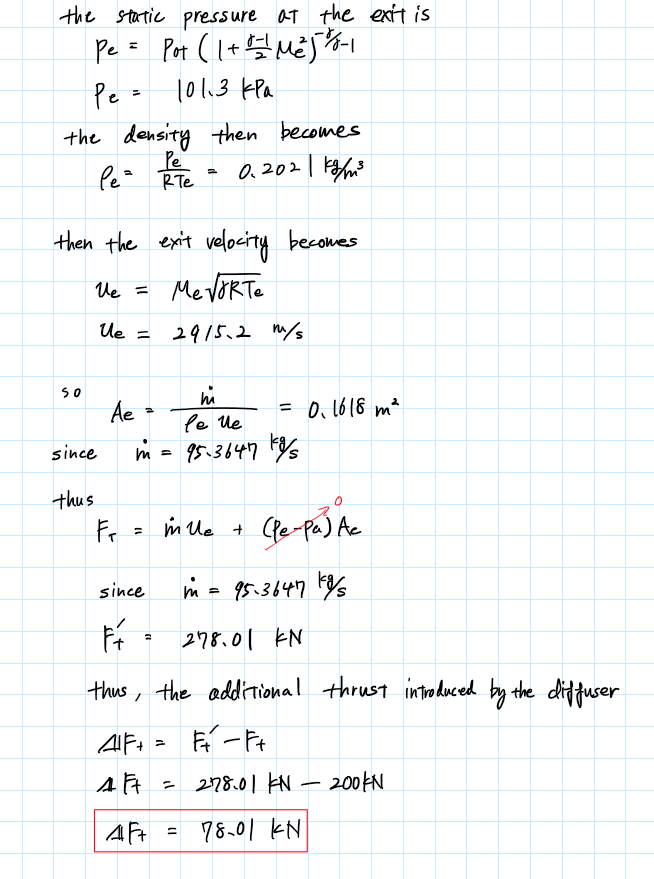


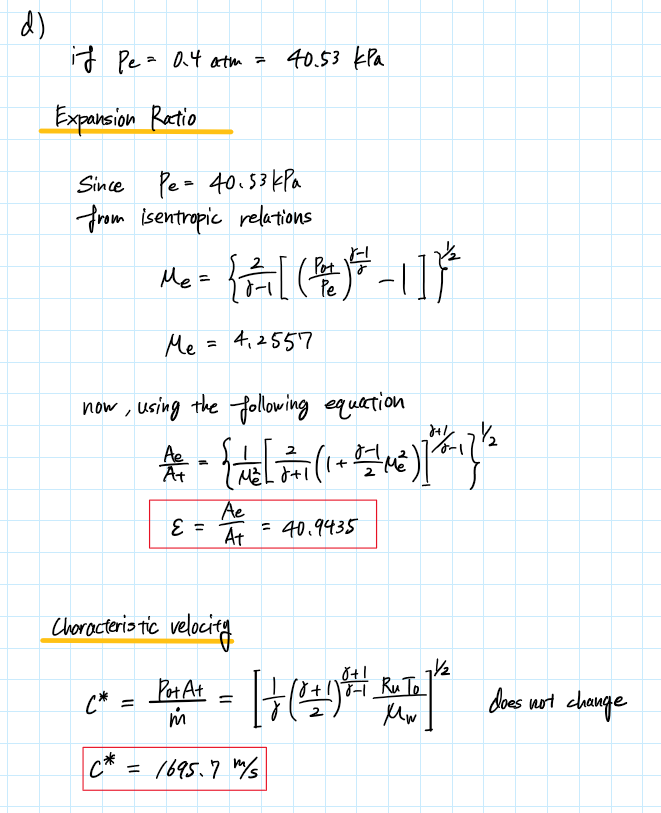


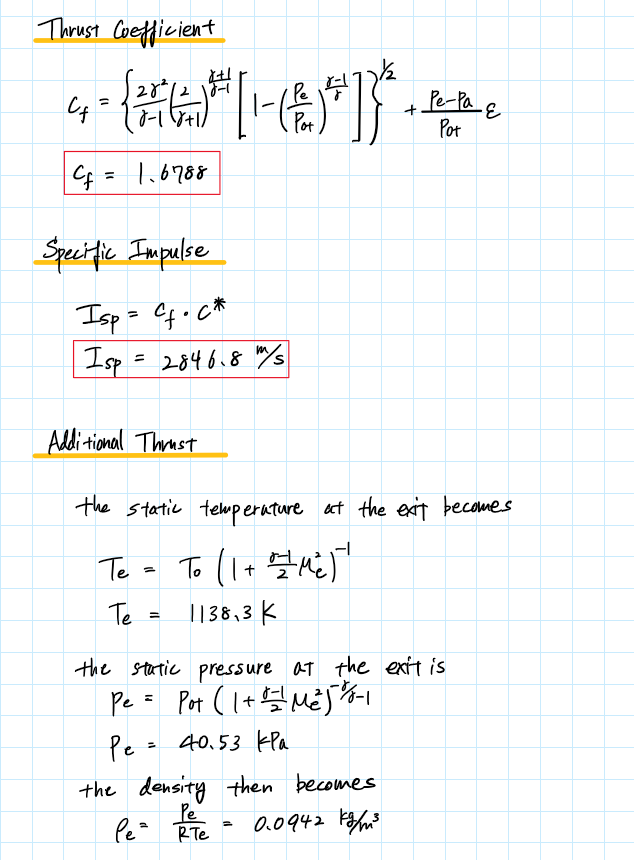


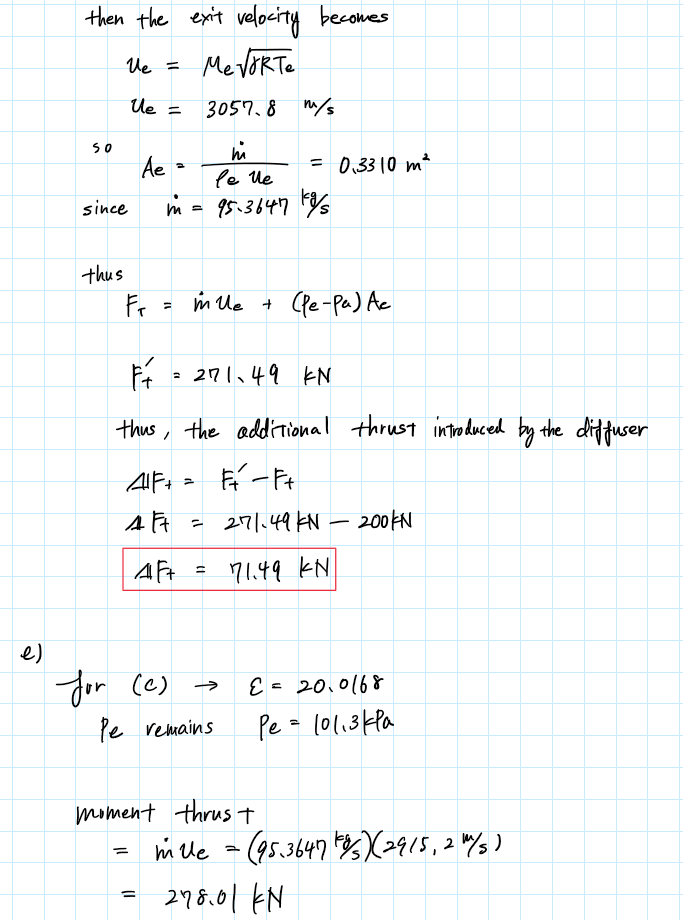


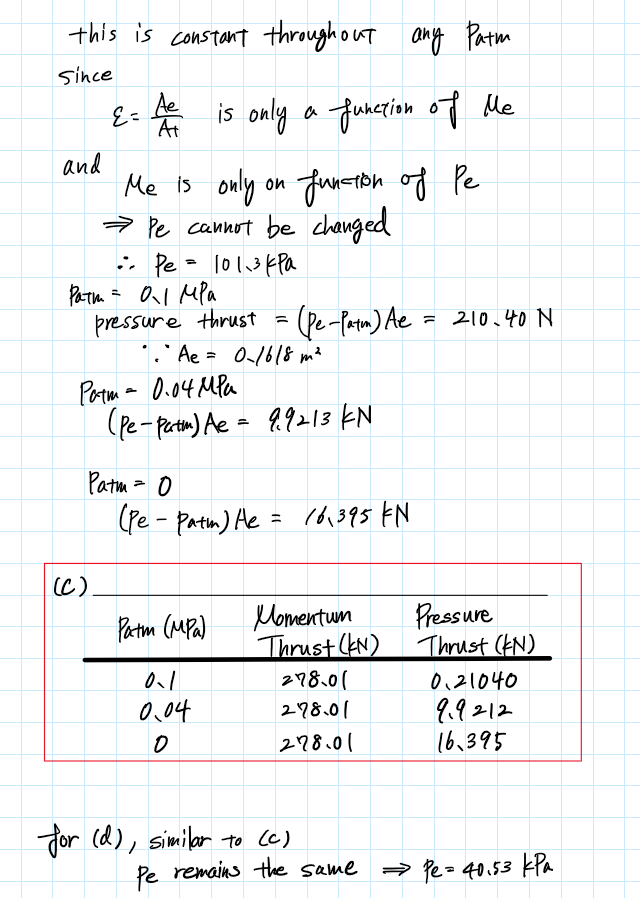


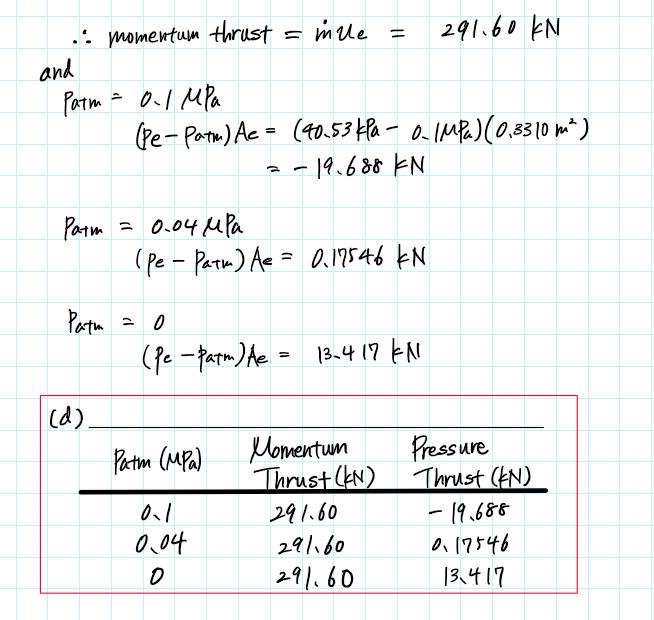


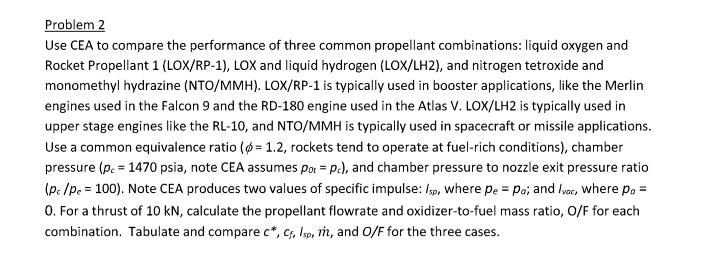


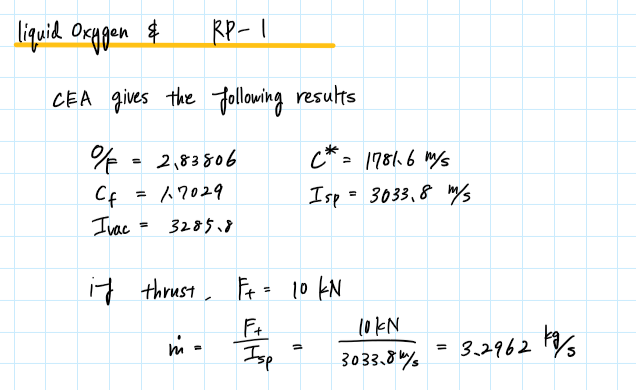


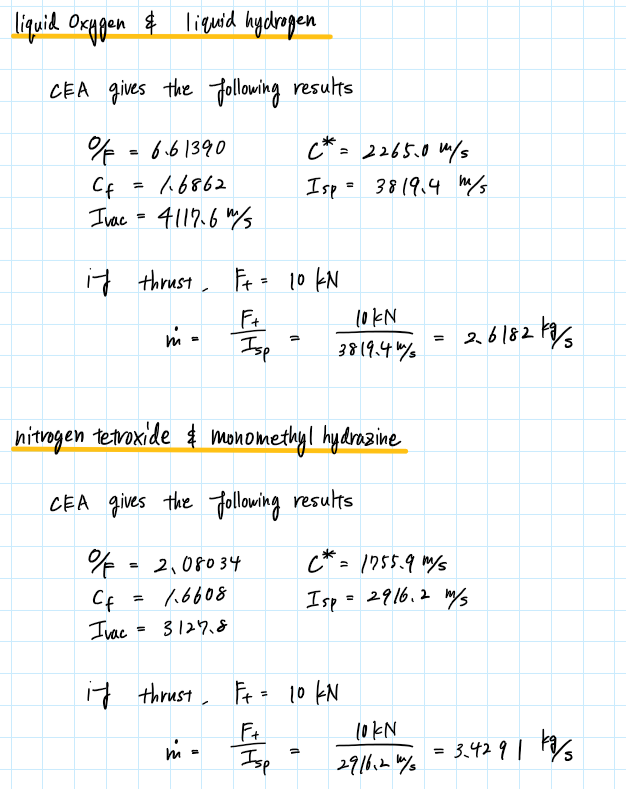


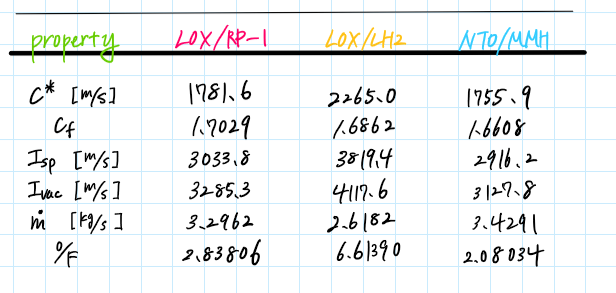


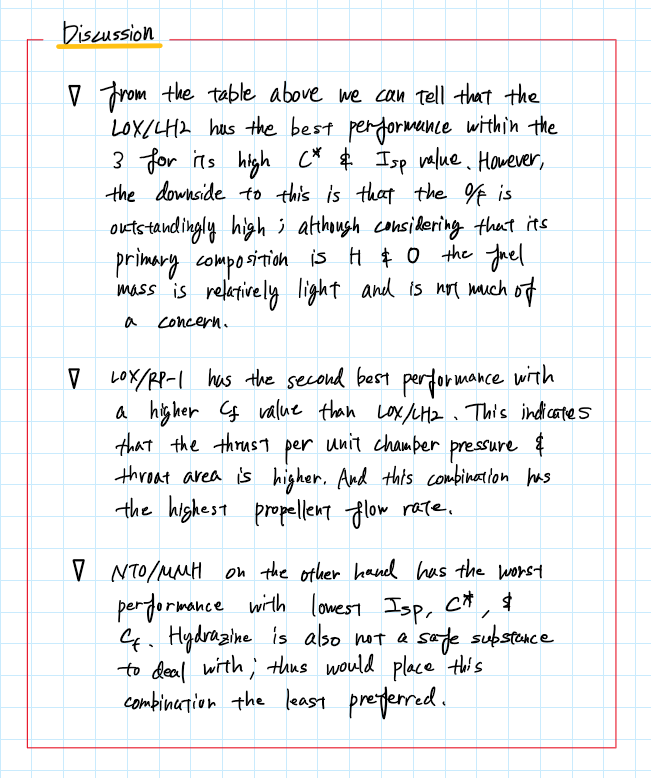












Appendix

## **AAE 339 HW 8**

close all; clear all; clc;

### P1

### a)

% Define the given properties

P0t = 20e6; % throat stagnation pressure [Pa]

Ft = 200e3; % thrust [N] @ sea-level conditions

Mw = 22; % molecular weight of the product gas [kg/kmol]

gamma = 1.2; % specific hear ratio

T0 = 3200; % temperature at the chamber [K]

Ru = 8314.5; % universal gas constant [J/kmol-K]

R = Ru/Mw; % specific gas constant [J/kg-K]

Patm = 101.3e3; % atmospheric pressure [Pa]

% Characteristic velocity

a1 = 1/gamma\*((gamma + 1)/2)^((gamma + 1)/(gamma - 1)); % intermediate var 1

a2 = R\*T0; % intermediate var 2

c\_star = sqrt(a1\*a2)

% Specific thrust

Mt = 1.0;

T = T\_from\_M\_and\_gamma(T0,Mt,gamma,"static")

P = p\_from\_M\_and\_gamma(P0t,Mt,gamma,"static")

rho = P/R/T

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

epsilon = 1.0;

a1 = 2\*gamma^2/(gamma - 1); % intermediate var 1

a2 = (2/(gamma + 1))^((gamma + 1)/(gamma - 1)); % intermediate var 2

a3 = 1 - (P/P0t)^((gamma - 1)/gamma); % intermediate var 3

a4 = (P - Patm)/P0t\*epsilon; % intermediate var 4

cf = sqrt(a1\*a2\*a3) + a4

% Specific impulse

Isp = cf\*c\_star

### b)

% Throat area

At = Ft/P0t/cf

% Mass flow rate

m\_dot = Ft/c\_star/cf

### c)

% Calculate the exit Mach number

Pe = Patm;

a1 = 2/(gamma - 1); % intermediate var 1

a2 = (P0t/Pe)^((gamma - 1)/gamma) - 1

Me = sqrt(a1\*a2)

% Expansion ratio

a1 = 2/(gamma + 1); % intermediate var 1

a2 = (1 + (gamma - 1)/2\*Me^2); % intermediate var 2

a3 = (gamma + 1)/(gamma - 1); % intermediate var 3

epsilon = sqrt(1/Me^2\*(a1\*a2)^(a3))

% Thrust coefficient

a1 = 2\*gamma^2/(gamma - 1); % intermediate var 1

a2 = (2/(gamma + 1))^((gamma + 1)/(gamma - 1)); % intermediate var 2

a3 = 1 - (Pe/P0t)^((gamma - 1)/gamma); % intermediate var 3

a4 = (Pe - Patm)/P0t\*epsilon; % intermediate var 4

cf = sqrt(a1\*a2\*a3) + a4

% Specific impulse

Isp = cf\*c\_star

% Additional thrust

Te = T\_from\_M\_and\_gamma(T0,Me,gamma,"static")

Pe = p\_from\_M\_and\_gamma(P0t,Me,gamma,"static")

rho\_e = Pe/R/Te

ue = Me\*sqrt(gamma\*R\*Te)

Ae = m\_dot/rho\_e/ue

Ft\_new = m\_dot\*ue + (Pe - Patm)\*Ae

delta\_Ft = Ft\_new - Ft

% PROBELM (e)

Patm = 0.1e6;

M\_thrust = m\_dot\*ue

P\_thrust = (Pe - Patm)\*Ae

Patm = 0.04e6;

M\_thrust = m\_dot\*ue

P\_thrust = (Pe - Patm)\*Ae

Patm = 0;

M\_thrust = m\_dot\*ue

P\_thrust = (Pe - Patm)\*Ae

### d)

% Calculate the exit Mach number

Pe = 40.53e3;

a1 = 2/(gamma - 1); % intermediate var 1

a2 = (P0t/Pe)^((gamma - 1)/gamma) - 1; % intermediate var 2

Me = sqrt(a1\*a2)

% Expansion ratio

a1 = 2/(gamma + 1); % intermediate var 1

a2 = (1 + (gamma - 1)/2\*Me^2); % intermediate var 2

a3 = (gamma + 1)/(gamma - 1); % intermediate var 3

epsilon = sqrt(1/Me^2\*(a1\*a2)^(a3))

% Thrust coefficient

a1 = 2\*gamma^2/(gamma - 1); % intermediate var 1

a2 = (2/(gamma + 1))^((gamma + 1)/(gamma - 1)); % intermediate var 2

a3 = 1 - (Pe/P0t)^((gamma - 1)/gamma); % intermediate var 3

a4 = (Pe - Patm)/P0t\*epsilon; % intermediate var 4

cf = sqrt(a1\*a2\*a3) + a4

% Specific impulse

Isp = cf\*c\_star

% Additional thrust

Te = T\_from\_M\_and\_gamma(T0,Me,gamma,"static")

Pe = p\_from\_M\_and\_gamma(P0t,Me,gamma,"static")

rho\_e = Pe/R/Te

ue = Me\*sqrt(gamma\*R\*Te)

Ae = m\_dot/rho\_e/ue

Ft\_new = m\_dot\*ue + (Pe - Patm)\*Ae

delta\_Ft = Ft\_new - Ft

% PROBELM (e)

Patm = 0.1e6;

M\_thrust = m\_dot\*ue

P\_thrust = (Pe - Patm)\*Ae

Patm = 0.04e6;

M\_thrust = m\_dot\*ue

P\_thrust = (Pe - Patm)\*Ae

Patm = 0;

M\_thrust = m\_dot\*ue

P\_thrust = (Pe - Patm)\*Ae

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