Assignment #9: Rocket Propulsion — ME 415

due 12/8/2021 before midnight via Learning Suite — 50 possible points

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9.1 Rocket nozzle sizing. Some parameters for a liquid-fueled rocket engine (not the same as in problem 1) are given below:

γ	ratio of specific heats for combustion gas mixture	1.2
M_w	molecular weight of combustion gas mixture	12 (g/mol)
T_c	combustion temperature	3500 K
P_c	combustion pressure	20 MPa
$\dot{m}_f$	propellant mass flow rate	450 kg/s
	nozzle type	80% bell nozzle
σ_c	max allowable stress in combustion chamber wall	550 MPa

Design the rocket to achieve peak efficiency at an altitude of 12.5 km (shortly after max-Q). Determine/design the following:

- the engine thrust at the design altitude.
- the diameters (3) at the end of the combustion chamber, throat, and exit.
- the lengths (3) of the combustion chamber, the converging, and diverging sections of the nozzle.
- the wall thickness (1) of the combustion chamber assuming a thin-shell cylindrical combustion chamber.
- Draw your nozzle to scale.

Note: These specs correspond to the Space Shuttle Main Engine so you can check some of your numbers (they should be quite close although we are neglecting boundary layer losses and multiphase flow losses).

9.2 Spacecraft maneuver. A spacecraft is in a circular parking orbit of 500 km altitude (above sea level) around the earth. A Hohmann transfer will be initiated to reach a circular target orbit at 15,000 km altitude. If the rocket effective exit velocity is 3,000 m/s, how much fuel must be burned as a fraction of the spacecraft weight to initiate the transfer? (Compute only the first burn into the transfer orbit, the second transfer to the target orbit works similarly)