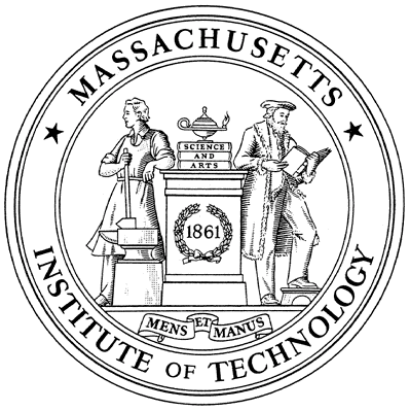


Massachusetts Institute of Technology
Department of Aeronautics and Astronautics
Cambridge, MA 02139

16.01/16.02 Unified Engineering I, II
Fall 2003

Problem Set #1

Name: _____

Due Date: 9/9/03

Problems: U1, T1

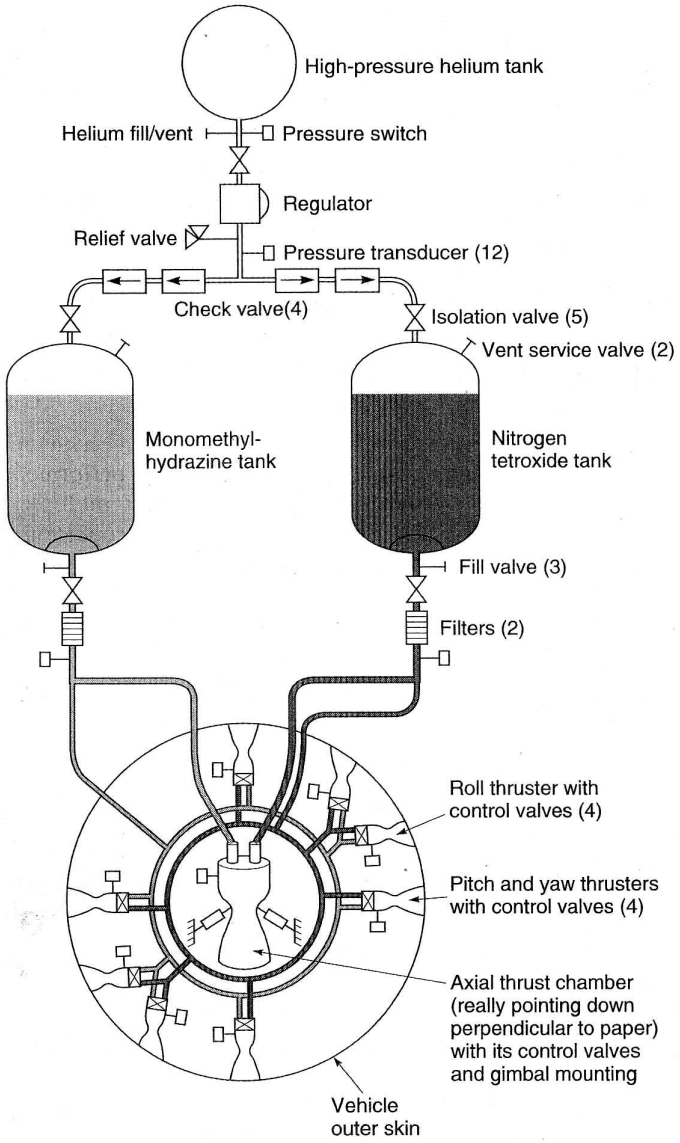
	Time Spent (min)
U1	
T1	
Study Time	

Announcements:

UNIFIED ENGINEERING Fall 2003
Ian A. Waitz

Problem T1. (Unified Thermodynamics)

Below is a schematic diagram of a helium-pressurized, bipropellant rocket engine system (for the fourth stage of the Peacekeeper ballistic missile). Describe the conversions of energy (internal, potential, kinetic and chemical) and exchanges of heat and work for this system and that of the rocket itself. Note at which points in the process heat is transferred to/from the surroundings. (LO#1, LO#2, LO#3)



(Figure from Sutton and Biblarz, Rocket Propulsion Elements, 7th Edition, John Wiley & Sons, Inc., New York, NY, 2001, p 230)

UNIFIED ENGINEERING Fall 2003

Ian A. Waitz

Problem U1. (Range Equation)

a) Assuming steady-level flight and no fuel reserves, estimate the range of a B-777 using the information given in the lecture notes (and/or on Boeing's web page). How well does this compare to the estimates Boeing publishes on their web page?

b) Now assuming that L/D, propulsion system efficiency and final weight are unchanged, estimate the range of a B-777 if the same volume of liquid hydrogen were to be used instead of Jet-A.

c) Derive an equation for the range of a battery-powered aircraft in steady-level flight. Express the range in terms of L/D, propulsion system efficiency, battery mass and heating value, and aircraft weight. Estimate the range of a B-777 if the fuel was taken out and replaced with its equivalent weight in batteries.

"FUEL"	Heating Value (MJ/kg)	Density (kg/m^3)
Jet-A	42.8	800
Liquid Hydrogen	120	70
Batteries	2.5	8000