Due: 5 Sep 2007

EA429
Assignment 2

1. Plot propulsive efficiency, dimensionless thrust ($T/\dot{m}C$) and power ($P/\frac{1}{2}\dot{m}C^2$) for the rocket and air breather as a function of the speed ratio ($0 < V_1/C < 1$). Compare the air breather and rocket by plotting them together on the same graph.

2. Find propulsive efficiency for the following two engines (from N. Cumpsty):
   a. An RB211 (Rolls-Royce Turbofan) at 31,000 ft, flight Mach number is 0.85 and approximate jet velocity is 390 m/sec.
   b. An Olympus 593 (Concorde) at 51,000 ft (p_{inf} = 11.0 kPa, T_{inf} = 216.7 K), flight Mach number 2.0 and an approximate jet velocity of 1009 m/sec.

3. Do problems 2, 3, 6, 9, 10 from Chapter 2 of Handout Notes.

4. Work problems 2.17 or 2.18 from Philips (your S&C text) – let's make sure somebody works both!

5. Given a commercial airliner with a range of 6000 miles using 200 tons of JP4 fuel, estimate the range of the aircraft burning either gaseous or liquid hydrogen at (from Hill & Peterson)
   a. The same mass of hydrogen as JP4,
   b. The same volume of hydrogen as JP4

The dry mass of the aircraft is 800 tons. The fuel properties are as follows:

Fuel	Density (kg/m3)	Heating Value (kJ/kg)
JP4	800.0	45,000
H_2 (gaseous, S.T.P.)	0.0824	120,900
H_2 (liquid at 1 atm)	70.8	120,900

6. The idling engines of a landing turbojet produce forward thrust when operating in a normal manner, but they can produce reverse thrust if the jet is properly deflected. Suppose that while the aircraft rolls down the runway at 150 km/hour the idling engine consumes 50 kg/sec and produces exhaust velocity of 150 m/sec (from Hill & Peterson).
   a. What is the forward thrust of the engines?
   b. What are the magnitude and direction of the (i.e. forward or reverse) if the exhaust is deflected 90 degrees without affecting the mass flow?
   c. What are the magnitude and direction of the thrust as above after the plane has come to a stop, with 90 degree exhaust deflection and airflow of 40 kg/sec?

7. A rocket has a thrust of 8896 N and propellant consumption of 3.867 kg/sec. The vehicle flies at a velocity of 400 m/sec and the propellant specific energy content (heat of combustion) is 16.9 megajoule/kg (from Sutton). Find the following:
   a. Effective exhaust velocity (2300 m/sec)
   b. Kinetic energy of the jet for 1 kg of fuel (2.64 MJ)
   c. Internal energy (38.3%)
   d. Propulsive efficiency (33.7%)
   e. Overall efficiency (13.3%)
   f. Specific impulse (234.7 sec) and specific propellant consumption (0.00426 sec^{-1})