**Class problems # 2 (7th February, 2020)**

1. For an ideal ramjet engine with un-chocked nozzle, prove that the thermal efficiency is expressed by



Hint: use the following approximations



1. A single-spool turbojet engine (without an after burner) is running on ground (M=0). Prove that for an ideal process and un-choked nozzle, the pressure ratio of the turbine (πt) is related to the pressure ratio of the compressor (πc) by the relation:



Where πt=Po4/Po5, Ta and To4 are the ambient and maximum temperatures, respectively. Assume that the fuel-to-air ratio is negligible and the work consumed by the compressor is equal to the work developed by the turbine. γc= γ in compressor (cold gas), γh= γ in turbine and nozzle (hot gas), CPc= Cp of fluid in compressor (cold gas), CPh= Cp of fluid in turbine and nozzle (hot gas).

1. It is required to calculate and plot (**no hand plot**) the momentum drag as well as momentum, pressure, gross and net thrusts versus the flight speed for a turbojet engine powering an air-craft flying at 9 Km (*Ta*= 229.74K, *Pa*=30.8KPa) and having the following characteristics: *Ai*=0.235 m2, *Ae*=0.25 m2, *f*=0.02. *Pe*=200 KPa, *Ue*=600 m/s. The flight speed varies from 500 to 6000 Km/h. Two cases are to be considered:
2. The air mass flow rate is constant and equal to 40 Kg/s irrespective of the variation of the flight.
3. The mass flow rate varies with the flight speed.