Unified Propulsion Quiz
March 18, 2005

Closed Book – no notes other than the equation sheet provided with the exam
Calculators allowed.

- **Put your name on each page of the exam.**
- **Read all questions carefully.**
- **Do all work for each problem on the pages provided.**
- **Show intermediate results.**
- **Explain your work --- don't just write equations.**
- **Partial credit will be given (unless otherwise noted), but only when the intermediate results and explanations are clear.**
- **Please be neat. It will be easier to identify correct or partially correct responses when the response is neat.**
- **Show appropriate units with your final answers.**
- **Box your final answers.**

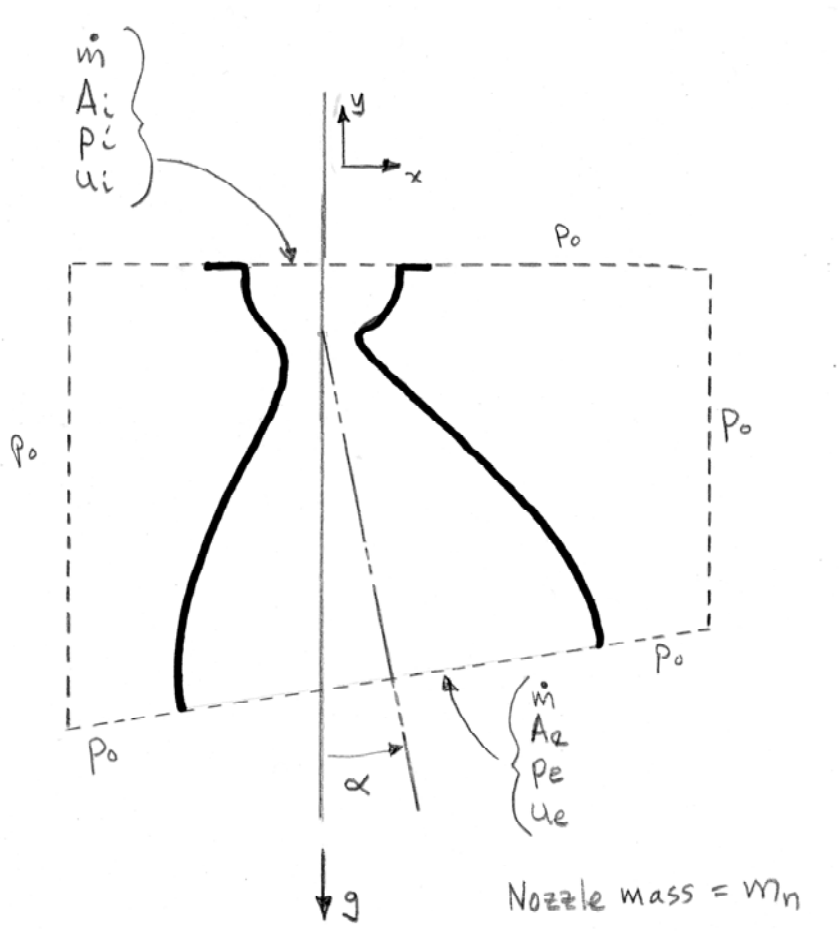
Exam Scoring

#1 (25%)	
#2 (25%)	
#3 (15%)	
#4 (35%)	
Total	

Unified Engineering Propulsion Quiz Number: _____

Spring 2005

1. (25 points, partial credit given, L.O.'s A & B) Below is a schematic of a gimbaled rocket nozzle. Write equations for the x- and y-components of force on the nozzle flange in terms of the parameters given.



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- BLANK PAGE FOR EXTRA WORK -

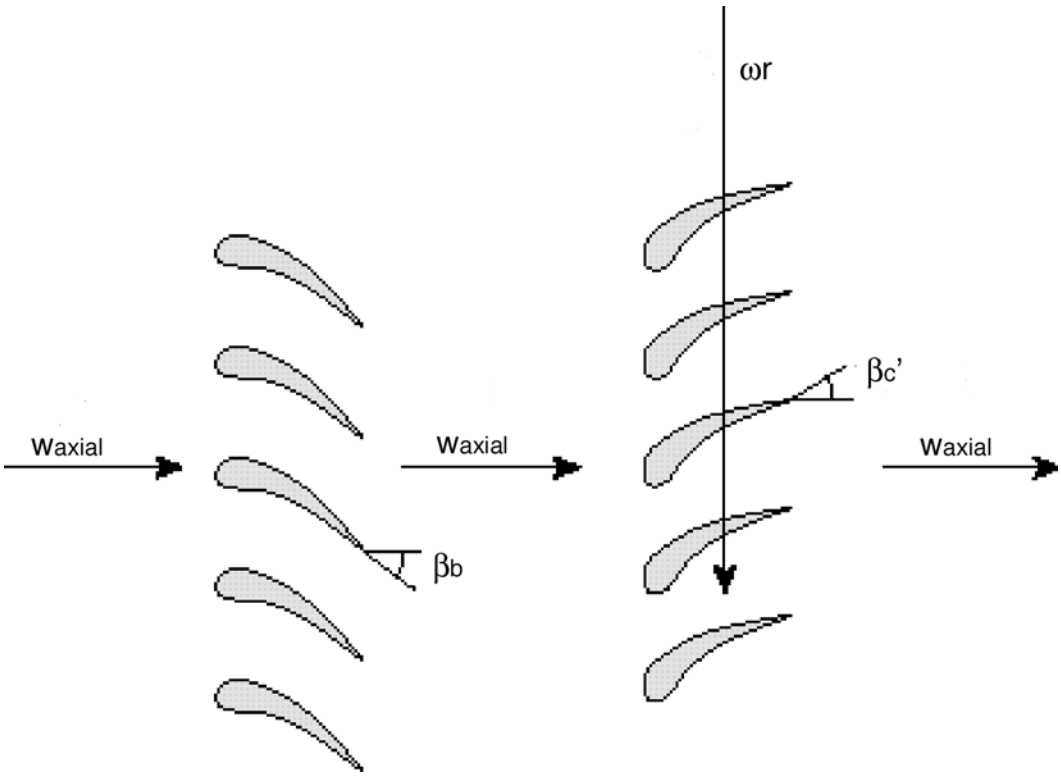
2. (25 points, partial credit given, L.O.'s C, D & F) What are the principal design parameters and constraints for a gas turbine engine? How are these related to the principal figures of merit and to mission performance? In particular, describe how changes in the various design parameters and constraints lead to changes in mission performance.

3. (15 points, partial credit given, L.O.'s C & E)
You are charged with the re-design of a liquid-propellant rocket motor for a deep space application ($p_o = 0$, $g = 0$, drag = 0). You have the option to upgrade the turbopumps and the combustion chamber, allowing a 10% increase combustion chamber temperature. The drawback is increased mass of the propulsion system.

What design trades to you anticipate will be important in making a decision on the attractiveness of this re-design option? Please refer to important equations and physical relationships to substantiate your answer.

4. (35 points, partial credit given, L.O.'s B & G) A set of blade rows is shown.

a) Draw and label the velocity triangles for these blade rows <u>on top of the axial velocity vectors that are given</u> (i.e. show the velocities in the relative and absolute frames).



b) Say in words what the torque is equal to. Write an expression for the torque on the first blade row and draw the direction of the force experienced by the blades in the first row.

c) What happens to the stagnation and static temperatures across the first blade row? Why?

d) Write an expression for the power input or extracted from the flow. Is this a compressor or a turbine?

e) Explain in words how a multistage axial compressor or turbine works.

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