

## AE236: Compressible Fluid Mechanics

### Quiz 4

April 1, 2021

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**Duration: 45 minutes**

**Maximum Marks: 15**

Answer all questions succinctly. All the best!
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1. A convergent-divergent nozzle has an area ratio (always means  $A_e/A_t$ ) of 3.5. At off-design conditions, the exit Mach number is observed to be 0.3. What operating pressure ratio would cause this situation? (2)
2. A supersonic converging-diverging diffuser, is designed to operate at a Mach number of 1.7. To what Mach number should the inlet be accelerated in order to swallow the shock during the start-up? (2)
3. A converging-diverging nozzle with an area ratio of 5.9 is fed by air from a chamber with a stagnation pressure of  $6.8\text{ atm}$ . Exhaust is to the atmosphere at  $1\text{ atm}$ . Show that this nozzle is operating between the second and third critical points. Determine the conditions after the first shock. (2)
4. A de Laval nozzle has to be designed for an exit Mach number of 1.5 with an exit diameter of  $200\text{ mm}$ . Find the required ratio of throat area to exit area. The reservoir conditions are  $p_0 = 1\text{ atm}$ ,  $T_0 = 20^\circ\text{C}$ . Also find the maximum mass flow rate through the nozzle. (2)
5. Air flows through a supersonic wind tunnel having a throat area of  $0.02\text{ m}^2$  and a test section area of  $0.04\text{ m}^2$ . Find the Mach number at the test section. What will be the diffuser throat area, if a normal shock is located at the test section (anywhere)? (2)
6. A Mach 2 convergent-divergent nozzle, run by a settling chamber with air maintained at  $300\text{ K}$ , is discharging to an environment at atmospheric pressure. Determine the settling chamber pressure required to run the nozzle (a) at correctly expanded state, (b) maximum possible overexpansion, and (c) with normal shock at the exit. (d) Determine the settling chamber pressure required to position a normal shock in the divergent part of the nozzle, at the location where the area is 1.5 times the throat area. What will the flow speed be behind the normal shock? (5)