Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

ME Semester –I Examination Feb. - 2012

Subject code: 711103N **Date: 17/02/2012**
Subject Name: Fluid Mechanics & Gas Dynamics
Time: 10.30 am – 01.00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Show that the upper and lower branches of Fanno curve represent subsonic and supersonic flows respectively. Prove that at maximum entropy point Mach number is unity and all processes approach this point. **07**

(b) A circular duct passes 8.25 kg/s of air at an exit Mach number of 0.5. The entry pressure and temperature are 3.45 bar and 38°C respectively and the coefficient of friction 0.005. If the Mach number at the entry is 0.15, determine (i) the diameter of the duct (ii) length of the duct (iii) pressure and temperature at the exit. **07**

Q.2 **(a)** Draw Rayleigh lines on h-s and p-v planes for two different values of the mass flux. Show that the slope of the Rayleigh line on the p-v plane is **07**

$$\left(\frac{dp}{dv}\right)_R = -\rho^2 c^2$$

(b) Air is heated in the constant area duct. The initial conditions are 0.3 MPa and 15°C. The initial Mach number is 0.2. The final stagnation temperature is 897°C. What are the final stagnation pressure and Mach number? **07**

OR

(b) For a Rayleigh flow obtain an expression for the value of maximum possible heat transfer in terms of Mach number. **07**

Q.3 **(a)** Explain the phenomenon of chocking in isentropic flow. Prove that for a chocked flow of air through a varying area passage, the pressure at the minimum cross sectional area is $0.528P_0$ where P_0 is the stagnation pressure. **07**

(b) Air flowing in a duct has a stagnation temperature of 227°C and a stagnation pressure of 7 bar. How large must be the cross sectional area at a section where the pressure is 2 bar in order to allow 1.5 kg/s of air to pass through. Assume isentropic flow. **07**

OR

Q.3 **(a)** The pressure, temperature and Mach number at the entry of a flow passage are 2.45 bar, 26.5°C and 1.4 bar respectively. If the exit Mach number is 2.5 determine for adiabatic flow of a perfect gas $(\gamma = 1.3, R = 0.469 \text{ kJ/kgK})$ **07**

(i) Stagnation temperature at exit
(ii) Temperature and velocity of gas at exit
(iii) The flow rate per unit area of inlet cross section

(b) Assuming perfect gas derive the energy equation of adiabatic flow in the following form: **07**

$$\frac{\gamma}{\gamma-1}\frac{p}{\rho}+\frac{1}{2}c^2=\frac{\gamma}{\gamma-1}\frac{p_0}{\rho_0}$$

Q.4 **(a)** If the value of impulse function across the normal shock is constant, show that the ratio of static pressure across the normal shock is given by **07**

$$\frac{p_x}{p_y}=\frac{2\gamma}{\gamma+1}M_x^2-\frac{\gamma-1}{\gamma+1}$$

(b) A compression shock occurs in a divergent air flow passage. On the upstream side of the shock, the velocity of air is 400 m/s and the pressure and temperature are 0.2 Mpa and 35°C respectively. Determine (i) Mach number and air velocity on the downstream side of the shock (ii) change in entropy per unit mass of air as a result of shock. **07**

OR

Q.4 **(a)** Explain the following: (i) Mach angle (ii) Mach cone (iii) Mach wave (iv) Zone of action (v) Zone of silence (v) stagnation pressure (vi) critical velocity **07**

(b) Explain briefly what is meant by impulse function. Derive the expression for non dimensional impulse function in the following form **07**

$$\frac{F}{F^*}=\frac{1+\gamma M^2}{M\left[2(\gamma+1)\left(1+\frac{\gamma-1}{2}M^2\right)\right]^{\frac{1}{2}}}$$

Q.5 **(a)** Explain the different types of hydraulic similarities that must exist between a prototype and its model. **07**

(b) A partially submerged body is towed in water. The resistance R to its motion depends on the density ρ, the viscosity μ of water, length L of the body, velocity V of the body and acceleration due to gravity g. Show that the resistance to the motion can be expressed in the form **07**

$$R=\rho L^2V^2\phi\left[\left(\frac{\mu}{\rho VL}\right)\left(\frac{Lg}{V^2}\right)\right]$$

OR

Q.5 **(a)** Define stream function (ψ) and potential function (ϕ) for free vortex flow and with usual notation show that **07**

$$\psi=\left(-\frac{\Gamma}{2\pi}\right)\log_e r \;\;\&\;\; \phi=\frac{\Gamma}{2\pi}\varphi$$

(b) If the circulation developed on an airfoil is equal to $\pi CU\sin\alpha$ then prove that coefficient of lift for airfoil is given by $C_L=2\pi\sin\alpha$ where α is angle of attack. **07**

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