Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. IST Semester–Remedial Examination – July- 2011

Subject code: 712103N

Subject Name: Fluid Mechanics & Gas Dynamics

Date:11/07/2011 **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.**
4. **Use of gas tables is permitted.**

Q.1 (a) The force F acting on a propeller of an aircraft depends upon the forward speed of the aircraft U, the density of air ρ, the viscosity of air μ, diameter of the propeller D and the speed of rotation of the propeller in revolutions per minute N. Derive non dimensional functional relationship between variables using Buckingham Π theorem. **07**

(b) What is similitude and model testing? Explain geometric, kinematic and dynamic similarity. **07**

Q.2 (a) Explain clearly velocity potential Φ and stream function ψ for two dimensional incompressible potential flow and hence prove Cauchy - Riemann's equation in Cartesian coordinates. **07**

(b) Show that transformation function $W = a(Z+ R^2/Z)$ transforms a circle of radius KR in z- plane into an ellipse in the W plane. 'a' is the real constant. **07**

OR

(b) Define the following model laws and give their fields of applications. **07**
(i) Reynolds number (ii) Froude Number (iii) Euler Number (iv) Mach Number (v) Weber Number

Q.3 (a) From the theory of propagation of infinitesimal pressure wave in a medium derive that velocity of sound is given by $a^2 = (\partial p/\partial \rho)s$ **07**

(b) Define the following terms for an aerofoil with figure. **07**
(i) Drag force (ii) Lift Force (iii) Angle of attack (iv) Performance an aerofoil with different angles of attack

OR

Q.3 (a) Derive Euler's equation and Bernoulli's equation for one dimensional incompressible flow. **07**

(b) Derive x-direction momentum equation in Cartesian coordinates system. **07**

Q.4 (a) Explain the performance of convergent divergent nozzle with variation of back pressure. Draw the graphs of effects of variation of back pressure ratio on throat pressure ratio, exit pressure ratio and mass flow parameter. **07**

(b) Derive the relation $\frac{dA}{A} = \frac{dp}{\rho c^2}\left(1 - M^2\right)$ for a one – dimensional isentropic flow. Explain the effect of inlet supersonic and subsonic flow conditions on outlet pressure and velocity in convergent passage **07**

OR

Q.4 (a) A pitot tube traveling in super sonic wind tunnel gives value of 16 kPa and 70 kPa for the static pressure upstream of the normal shock and the stagnation pressure at the mouth of the tube respectively. After the normal shock, the fluid stream decelerates isentropically to the total pressure at the mouth of the pitot tube. Estimate the Mach number of the tunnel. If the stagnation temperature is 300ºC, calculate the static temperature and total (stagnation) pressure upstream and downstream of the tube. Take $\gamma = 1.4$. Use table given below. **07**

Mx	My	p_y/p_x	T_y/T_x	p_{oy}/p_{ox}	p_{oy}/p_x
1.72	0.635	3.285	1.473	0.847	4.315
1.74	0.631	3.336	1.487	0.839	4.443

(b) Derive Rankine – Hugoniot equation relation for a normal shock wave as below form: **07**

$$\frac{p_y}{p_x} = \frac{\frac{\gamma+1}{\gamma-1}\frac{\rho_y}{\rho_x} - 1}{\frac{\gamma+1}{\gamma-1} - \frac{\rho_y}{\rho_x}}$$

Q.5 (a) For the of Fanno curves (flow in a constant area duct with friction without heat transfer), discuss the variation in flow parameters such as pressure, temperature, total temperature, total pressure, density, velocity, Mach Number when flow approaches towards maximum entropy condition on subsonic and supersonic branches of the curve. **05**

(b) A circular duct passes 8.25 kg/s of air at an exit Mach number of 0.5. The entry static pressure and static temperature are 3.45 bar and 38 ºC respectively and the coefficient of friction 0.005. If the Mach number at entry is 0.15,determine (i) The diameter of the duct (b) length of the duct (c) pressure and temperature at the exit. Take $\gamma = 1.4$. Use the table given below. **09**

M	p / p*	T / T*	p_0 / p_0*	c / c*	$4f'L_{max}$ / D
0.15	7.319	1.1945	3.928	0.164	28.354
0.50	2.138	1.1430	1.340	0.534	1.0690

OR

Q.5 (a) For the of Rayleigh curve (flow in a constant area duct without friction with heat transfer), discuss the variation in flow parameters such as pressure, temperature, total temperature, total pressure, density, velocity, Mach Number when flow approaches towards maximum entropy condition on subsonic and supersonic branches of the curve. **05**

(b) The Mach number at the exit of a combustion chamber is 0.9. The ratio of stagnation temperature at exit to entry is 3.74. If the pressure and temperature of the gas at exit are 2.5 bar and 1000ºC respectively determine (a) Mach number, pressure and temperature of the gas at entry (b) the heat supplied per kg of gas (c) the maximum heat can be supplied. Take $\gamma = 1.3$ and Cp = 1.218 kJ / kg K. Use the table given below. **09**

M	p / p*	p_0 / p_0*	T / T*	T_o / T_o*	c / c*
0.90	1.120	1.005	1.017	0.991	0.907
0.26	2.114	1.205	0.302	0.265	0.143

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