Seat No.: _____ Enrolment No.______

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E Sem-I Remedial Examination April 2010

Subject code: 712103

Subject Name: Fluid Mechanics & Gas Dynamics

Date: 08 / 04 / 2010 **Time: 12.00 noon – 02.30 pm**

Total Marks: 60

Instructions:

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

Q.1 (a) Derive Euler's momentum equations in Cartesian coordinates system? **06**

(b) What is velocity of sound? From fundamental equation show that velocity of sound is given by $a^2 = (\partial P/\partial \rho)_s$. **06**
Hence obtain the expression of the velocity of sound in perfect gas& explain the effect of molecular weight on it?

Q.2 (a) Explain clearly velocity potential φ and stream function Ψand hence prove Cauchy-Rieman's equation in Cartesian co-ordinates? **06**
In a parallel flow in the positive X-direction, the velocity varies linerly from zero at y = 0 to 120 m/sec at y = 6. Check whether the stream function exists. If so, determine the expression of Ψ. Can the velocity potential φ exist for this flow?

(b) Prove that the function $W=a\,(Z+R^2/Z) + i\,b\log Z$, in which 'a' and 'b' are real constants, represents one type of two-dimensional flow past a cylinder of radius 'R', centered at the origin in z-plane. **06**
Show that, on the surface of the cylinder, the velocity potential φ is given by $\varphi = 2aR\cos\theta - b\theta$, where θ is the polar angle in the flow plane.
Hence, deduce an expression for the flow speeds at point on the surface of the cylinder and thus, show that, two stagnation points coincide if, b = 2aR.

OR

(b) Show that transformation function $W=a\,(Z+R^2/Z)$ transforms into a circle of radius KR in z-plane into an ellipse in the w-plane. From the above transformation explain how *Joukowski* aerofoil section can be obtained? Give two illustrations? **06**

Q.3 (a) With usual notation show that the Maximum mass flow rate through a variable area duct is given by **06**
$M^*max/ A^* = \sqrt{To} /Po \times \sqrt{R/\gamma} = (2/\gamma+1)^{\gamma+1/ 2(\gamma-1)}$
Hence, obtain the expression for area ratio A/A* and in terms of M?

(b) A supersonic wind tunnel nozzle is to be design for M = 2 with a throat section of 0.1 m^2. The supply pressure and temperature at the nozzle, where velocity is negligible, are 0.7 bar and 37^0 C respectively. Assuming isentropic flow throughout the nozzle, determine mass flow rate, area at test section, pressure and temperature and density at the throat as well as test section? **06**

OR

Q.3 (a) Explain what do you understand by doublets? Show that the combine flow field of a uniform flow & a doublet gives the flow around the cylinder, Hence analyze the flow? **06**

(b) Explain Mach No. M*? Obtain its relation in terms of Mach No M? Hence, make a comparison of M and M*? **06**
For adiabatic flow of a perfect gas show that

a) $T/To = 1 - (\gamma-1/ \gamma+1)M^*$ and
b) $(C/ao)^2 = M^2 / (1+ (\gamma-1)/2\, M^2)$
c) Compute the value for γ=1.4 and M=3: What is the value of M*

Q.4 **(a)** What is similitude and model testing? Define conditions for similarity between models and prototype with different similarity? Express types of model studies in brief? **06**

(b) The power developed by hydraulic machine is found to depend on the head h, flow rate Q, density σ, speed N, runner diameter D, and acceleration due to gravity, g. Obtain suitable dimensionless parameter to correlate experimental results. You can adopt MLT set of dimensions. **06**

OR

Q.4 **(a)** Using fundamental equation obtain the Rankine –Hugonout equation for a normal shock? Hence show that a normal shock can not compress the gas to a density more than six times the density on upstream side? Also show that product of upstream and downstream velocity is equal to a square of critical velocity of flow? **06**

(b) A normal shock occurs in the divergent section of a convergent –divergent nozzle. The exit area is 3 times the throat area and the static pressure at exit is 0.4 times the stagnation pressure at the entry. The flow is throughout isentropic except in passing through the shock. Determine **06**

a) The Mach No. at upstream and downstream of shock and at exit section.
b) The ratio of static pressure to a stagnation pressure on upstream of shock
c) The area of x-section of the nozzle at the section where shock occurs in terms of throat area.

Q.5 **(a)** For a flow in a constant area duct in which friction is predominant & heat transfer negligible ,discuss **06**

a) Duct length limitation
b) Chocking due to friction, considering initial velocity as subsonic as well as supersonic.

(b) A convergent –divergent nozzle is attached to a duct of constant cross – sectional area. The duct diameter is 50 cm and the exit of the nozzle is also of the same diameter. The mean coefficient of friction for the duct is 0.003 .Stagnation pressure and Temp. of air at nozzle entry are 15 bar and 600 K. The flow in the entire nozzle is isentropic and adiabatic in the duct. The Mach number at the entry and exit of the duct are 1.8 and 1.0 respectively. Determine **06**

a) the length of pipe
b) Diameter of the nozzle throat.
c) Pressure and temperature at the duct exit.

Further, Determine also the length of the pipe, Pressure and temperature at the duct exit if a normal shock stands at the exit of the nozzle?

OR

Q.5 **(a)** From fundamental equation prove that ,for the flow in constant area duct with heat transfer , **06**

a) $T1/T2 = (M1/M2)^2 (1+ \gamma M_2^2 / 1+ \gamma M_1^2)^2$
b) $C1/C2 = \rho 2/ \rho 1 \ (M1/M2)^2 \ 1+ \gamma M_2^2 / 1+ \gamma M_1^2$
c) $S2\text{-}S1/ R = \text{Ln } M2/M1 \ (M2/M1) (1+ \gamma M_1^2 / 1+ \gamma M_2^2)^{\gamma+1/ (\gamma-1)}$

(b) In a constant area duct ,give in tabulated form the effect of heating and cooling on various parameter like To, M, P,C,T If the initial flow is 1)sub sonic 2)supersonic **06**

Air enters a combustion chamber with a velocity of 10m/s.The pressure and Temp. at entry are 3.0 bar and 50^0 C Respectively. If 502 KJ/Kg of heat is added during the combustion process, find the temperature, pressure, velocity, Mach No., Stagnation pressure & temperature after combustion.

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