

GUJARAT TECHNOLOGICAL UNIVERSITY
M. E. - SEMESTER – I • EXAMINATION – WINTER • 2014

Subject code: 711103N**Date: 03-12-2014****Subject Name: Fluid Mechanics and 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.
4. Use of Gas Table is permissible

- Q.1 (a)** What is the difference between Bernoulli's equation and steady flow energy equation? Derive the energy equation in the following form **07**

$$\frac{\gamma}{\gamma-1} \left(\frac{p_0}{\rho_0} \right) \left(\frac{p}{p_0} \right)^{(\gamma-1)/\gamma} + \frac{1}{2} c^2 = \frac{\gamma}{\gamma-1} \left(\frac{p_0}{\rho_0} \right)$$

- (b)** Air ($\gamma = 1.4$, $R = 287.43 \text{ J/kgK}$) enters a straight axisymmetric duct at 300 K, 3.45 bar and 150 m/s and leaves it at 277 K, 2.058 bar and 2602 m/s. The area of cross section at entry is 500 cm^2 . Assuming adiabatic flow, determine **07**
- | | |
|----------------------------|------------------------------------|
| (i) Stagnation temperature | (iii) maximum velocity |
| (ii) Mass flow rate | (iv) area of cross section at exit |

- Q.2 (a)** Explain the behavior of flow in a convergent divergent nozzle when it is operated at (i) design pressure ratio (ii) pressure ratio higher than the design value (iii) pressure ratio lower than the design value. **07**

- (b)** A nozzle in a wind tunnel gives a test section. Air with a Mach number of 2.0 enters the nozzle from a large reservoir at 0.69 bar and 310 K. The cross sectional area of the throat is 1000 cm^2 . Determine the following quantities for the tunnel for one dimensional isentropic flow. **07**
- (i) Pressures, temperatures and velocities at the throat and test sections
 - (ii) Area of cross section of the test section

OR

- (b)** Explain briefly what is meant by impulse function. Derive **07**

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

- Q.3 (a)** Show that the stagnation pressure ratio across a normal shock is given by **07**

$$\frac{p_{0x}}{p_{0y}} = \left\{ \frac{\frac{\gamma+1}{2} M_x^2}{1 + \frac{\gamma-1}{2} M_x^2} \right\} \times \left(\frac{2\gamma}{\gamma+1} M_x^2 - \frac{\gamma-1}{\gamma+1} \right)^{-1/(\gamma-1)}$$

- (b)** The state of a gas ($\gamma = 1.3$, $R = 0.469 \text{ kJ/kgK}$) upstream of the normal shock wave is given by the following data: **07**
 $M_x = 2.5$, $p_x = 2 \text{ bar}$, $T_x = 275 \text{ K}$
 Calculate the Mach number, pressure, temperature and velocity of the gas downstream of the shock.

OR

- Q.3 (a)** Explain uniform flow with source and sink. Obtain expressions for stream and velocity potential function. **07**

- (b) A uniform flow of 12 m/s is flowing over a doublet of strength $18 \text{ m}^2/\text{s}$. The doublet is in the line of uniform flow. Determine: 07
1. Shape of Rankine oval
 2. Radius of the Rankine circle
 3. Value of stream line function at Rankine circle
 4. Resultant velocity at a point on the Rankine circle at an angle of 30° from x-axis
 5. Value of maximum velocity on the Rankine circle and location of the point where velocity is maximum.
- Q.4 (a)** Show that the coefficient of lift for a rotating cylinder placed in a uniform flow is given by 07
- $$C_L = \frac{\Gamma}{RU}$$
- where Γ =Circulation, R= Radius of cylinder, U = Free stream velocity
- (b) A sub-marine which may suppose to approximate a cylinder 4 m in diameter and 20 m long travels submerged at 1.3 m/s in sea water. Find the drag exerted on it if the drag coefficient for Reynold number greater than 10^5 may be taken as 0.75. The density of sea water 1035 kg/m^3 and kinematic viscosity as $0.015 \text{ cm}^2/\text{s}$. 07
- OR**
- Q.4 (a)** Discuss the effect of friction on compressible flow through a constant area duct and explain the phenomena of choking. 07
- (b) Air at $p_0 = 10 \text{ bar}$, $T_0 = 400 \text{ K}$ is supplied to a 50 mm diameter pipe. The friction factor for the pipe surface is 0.002. If the Mach number changes from 3.0 at entry to 1.0 at exit, determine 07
1. The length of the pipe
 2. The mass flow rate
- Q.5 (a)** What are the methods of dimensional analysis? Describe Rayleigh method for dimensional analysis. 07
- (b) Water is flowing through a pipe of diameter 30 cm at a velocity of 4 m/s. Find the velocity of oil flowing in another pipe of diameter of 10 cm, if the condition of dynamic similarity is satisfied between the two pipes. The viscosity of water and oil is given as 0.01 poise and 0.025 poise. The specific gravity of oil = 0.8 07
- OR**
- Q.5 (a)** Prove that the Mach number at the maximum enthalpy point and maximum entropy point on the Rayleigh line are $1/\sqrt{\gamma}$ and 1.0 respectively. 07
- (b) Air at Mach number 1.5, pressure 300 kN/m^2 and temperature 288 K is brought to sonic velocity in friction less constant area duct through which heat transfer occurs. Determine the final pressure, final temperature and heat added during the process. 07
