Roll No.												

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST - 1

Even Semester: 2018-19 | **Date**: 06 March 2019

Course Code: MEC 308 | **Time**: 1 Hour

Course Name: Compressible Fluid Flow (DE) | **Max Marks**: 40

Programme & Sem: B.Tech (DE) & VI Sem | **Weightage**: 20%

Instructions:

(i) This paper contains total 6 questions. Answer all the questions.

(ii) Explanations, if any, should be brief and in pointed manner. Lengthy answers attract penalty.

(iii) Scientific calculator is allowed. However, exchange of it across the students is not permitted.

(iv) Unless otherwise specified, take for air, R = 0.287 kJ/kg.K, C_p = 1.004 kJ/kg.K and γ = 1.4.

Part A

Answer **all** the Questions. **Each** question carries **four** marks. (3Qx4M=12)

1. Define dynamic viscosity and kinematic viscosity; write down their formulas and units.
2. For a critical Mach number ($M_{critical}$), show that

$$\frac{C^*}{a_o} = \sqrt{\frac{2}{\gamma + 1}}$$

3. Draw the graph between 'a' (velocity of sound) versus 'c' (velocity of fluid) showing various regions of flow.

Part B

Answer **both** the Questions. **Each** question carries **eight** marks. (2Qx8M=16)

4. Carbon dioxide expands isentropically through a nozzle from a pressure of 3 bar to 1 bar. If the initial temperature is 473 K, determine the final temperature, the enthalpy drop and the change the in the internal energy. Take γ = 1.24, R = 0.189 kJ/kg-K.
5. An aircraft is flying at an altitude of 12000 meters (T = 216.65K, p = 0.193 bar) at a Mach number of 0.8. The cross sectional area of the inlet diffuser before LP compressor stage is 0.4 m^2. Determine the mass of air entering the compressor per second, speed of an aircraft, the stagnation temperature and the stagnation pressure of air at the diffuser entry.

Part C

Answer the Question. It carries **twelve** marks. (1Qx12M=12)

6. Derive the relation of conservation of momentum for a flow along x-direction:

$$\sum F_x = \int_{CV} \frac{\partial}{\partial t}(\rho c_x) dV + \int_{out} \rho c_n c_x dA - \int_{in} \rho c_n c_x dA$$

Roll No.											

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST - 2

Even Semester: 2018-19 | **Date**: 16 April 2019

Course Code: MEC 308 | **Time**: 1 Hour

Course Name: Compressible Fluid Flow | **Max Marks**: 40

Program & Sem: B.Tech & VI Sem (DE) | **Weightage**: 20%

Instructions:

(i) This paper contains a total of 6 questions. Answer all the questions.

(ii) Explanations, if any, should be brief and in a pointed manner. Lengthy answers attract penalty.

(iii) A scientific calculator is allowed. However, the exchange of it across the students is not permitted.

(iv) Unless otherwise specified, take for air, R = 0.287 kJ/kg.K, C_p = 1.004 kJ/kg.K and γ = 1.4.

(v) Use of Gas Tables is permitted.

Part A

Answer **all** the Questions. **Each** question carries **four** marks. (3Qx4M=12)

1. What is a shock wave? How do you generate it?
2. A source 'S' is moving with sonic velocity 'u' and create a disturbance that travels at a velocity of 'a'. Draw the movement of these waves with respect to a disturbance at the time (in a second) 1, 2, and 3. Show all necessary points.
3. A turbojet engine takes in 40 kg/s of air and consumes 1 kg/s of fuel. Air enters the engine at a velocity of 300 m/s. Exhaust gases leave the engine at a velocity of 500 m/s. If the pressure at both the entry and exit sections is the same, determine the thrust produced.

Part B

Answer **both** the Questions. **Each** question carries **eight** marks. (2Qx8M=16)

4. Derive the relation:

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

5. How does flow take place in a convergent-divergent nozzle? Also, show the variation of pressure ratio and Mach number along the length of the nozzle.

Part C

Answer the Question. The Question carries **twelve** marks. (1Qx12M=12)

6. Air flows isentropically at the rate of 0.5 kg/s through a convergent-divergent nozzle. At the inlet, the pressure is 680 kPa, the temperatures 295 K, and the area is 6.5 cm^2. If the exit area is 13 cm^2, calculate:
    a. The stagnation pressure and temperature.
    b. The exit Mach number.
    c. The exit pressure and temperature.
    d. The area and the velocity at the throat.

Roll No												

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Even Semester: 2018-19 | **Date**: 23 May 2019

Course Code: MEC 308 | **Time**: 3 Hours

Course Name: Compressible Fluid Flow | **Max Marks**: 80

Program & Sem: MECH & VI SEM | **Weightage**: 40%

Instructions:

(i) This paper contains total 10 questions. Answer all the questions.
(ii) Part A of questions should be solved together. Student should write the full sentences and then provide necessary answer.
(iii) Explanation, if any, should be in brief and in a pointed manner. Lengthy answers attract penalty.
(iv) A scientific calculator is allowed. However, the exchange of it across the students is not permitted.
(v) Unless otherwise specified, take for air, R = 0.287 kJ/kg.K, C_p = 1.005 kJ/kg.K and γ = 1.4.
(vi) Use of Gas tables is permitted.

Part A

Answer **all** the Questions. **Each** question carries **one** mark. (20Qx1M=20M)

1. Answer all the multiple choice questions.

I. Reynolds number is the ratio of inertia force to _____.
a. Elastic force b. Gravity force c. Viscous force d. Compression force

II. Stratosphere contains about _____ of weight of the atmosphere.
a. 25% b. 75% c. 70% d. 30%

III. _____ velocity of a fluid is its velocity at a Mach number of unity.
a. Maximum b. Critical c. Stagnation d. Static

IV. Stagnation temperature is the temperature of the gas when it is adiabatically _____ to zero velocity at zero elevation.
a. Accelerated b. Same c. Decelerated d. Can't say

V. Mass equation in vector form: **(True/False)**

$$\int_{cv} \frac{\partial \rho}{\partial t}\, dV = -\oint_{cs} \rho c dA$$

VI. For a subsonic flow, as area of duct increases, velocity of flow decreases in _____.
a. Nozzle b. Diffuser c. Constant area duct d. None of the above

VII. In supersonic flow, pressure increases with increase in the area of diffuser. **(True/False)**

VIII. When Mach number reaches critical value in convergent nozzle, the pressure ratio P/P_0 reaches _____.

IX. The maximum value of Mach number at the throat region is 1. **(True/False)**

X. Mach angle is written as $\alpha = \sin^{-1}(M)$. **(True/False)**

XI. Strong shocks are created when upstream Mach number is low. **(True/False)**

XII. When wave angle is small, weak shock is created. **(True/False)**

XIII. In oblique shock, tangential velocity component causes _____ in pressure along the shock wave.

a. Increase b. Decrease c. No change d. None of the above

XIV. Normal shock is a special case of oblique shock wave, when a wave angle is _____.

XV. Deflection angle in normal shock wave is _____degree.

XVI. In Fanno flow, flow is frictionless. **(True/False)**

XVII. Following is not the governing equations of Rayleigh flow:

a. Mass Conservation b. Momentum conservation

c. Energy Conservation d. State equations

XVIII. Fanno flow is responsible for heating and cooling of the flow. **(True/False)**

XIX. In Fanno curve, region above F point represents

a. Sonic b. Subsonic c. Supersonic d. Incompressible

XX. Body forces in multidimensional flow is represented by X, Y and X along x, y and z direction respectively. **(True/False)**

Part B

Answer **all** the Questions. **Each** question carries **four** marks. (4Qx4M=16M)

2. Show that $M^{*2} = \frac{\frac{1}{2}(\gamma+1)M^2}{1+\frac{1}{2}(\gamma-1)M^2}$

3. Derive the given relation for one-dimensional isentropic flow. $\frac{A}{A^*} = \frac{1}{M}\left(\frac{2}{\gamma+1}+\frac{\gamma-1}{\gamma+1}M^2\right)^{(\gamma+1)/2(\gamma-1)}$

4. A convergent nozzle has an exit cross-sectional area of 1000 cm^2. Air expands isentropically through the nozzle from constant inlet conditions (p_0 = 5 bar, T_0 = 500 K) to M = 1. Determine the exit velocity and the mass flow rate for the given condition.

5. Why are expansion shocks impossible?

Part C

Answer **all** the Questions. **Each** question carries **eight** marks. (4Qx8M=32M)

6. An aircraft flies at a Mach number of 1.2 at an altitude of 16000 meters (p=103 mbar, T = 216.65 K). The compression in its engines is partly achieved by a normal shock wave standing at the entry of its diffuser. Determine immediately downstream of the shock th Mach Number, the temperature of the air, the pressure of the air, Stagnation pressure loss across the shock, The density of air, and the velocity of air.

7. A supersonic stream of air at M = 3.0 is deflected inwards by 15^0. This generates oblique shock waves. Calculate the following quantities for these waves: Wave angle, downstream Mach number, temperature ratio, static and stagnation ratios.

8. The friction factor for a 25 mm diameter 11.5 m long pipe is 0.004. The conditions of air at entry are P_1 = 2 bar, T_1 = 301 K, M_1 = 0.25. Determine the mass flow rate, the pressure, the temperature, Mach number, and impulse function at the exit. Also, calculate the velocity ratio.

9. The stagnation temperature of the air in a combustion chamber is increased to 3.5 times its initial value. If the air at entry is at 5 bar, 105^0C and a Mach number of 0.25, determine the Mach number, pressure, and temperature at the exit, stagnation pressure ratio, and the heat supplied per kg of air.

Part D

Answer the Question. The question carries **twelve** marks. (1Qx12M=12M)

10. Derive the general three-dimensional form of Euler's Momentum equations of flow in a Cartesian coordinate system.