Applied Gas Dynamics VTU CBCS Question Paper Set 2018

USN

10AE61

Sixth Semester B.E. Degree Examination, Dec.2015/Jan.2016
Applied Gas Dynamics

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. Use of Shock/Gas tables is permitted.

PART – A

1 a. Derive an expression for area ratio as a function of mach number with usual notation. **(08 Marks)**

b. Air flowing in a duct has a velocity of 300 m/s, pressure 1 bar and temperature 290 K. Taking $\gamma = 1.4$ and $R = 287$ J/kg.K determine
i) stagnation pressure and temperature
ii) velocity of sound in the dynamics and stagnation condition.
iii) stagnation pressure assuming constant density. **(06 Marks)**

c. Air ($c_p = 1.05$ kJ/kg.K, $\gamma = 1.38$) at $P_1 = 3\times10^5$ N/m^2 and $T_1 = 500$ K flows with a velocity of 200 m/s in a 30 cm diameter duct. Calculate (i) Mass flow rate (ii) stagnation temperature (iii) mach number (iv) stagnation pressure values assuming the flow as compressible and incompressible. **(06 Marks)**

2 a. Derive Prandtl-Meyer relation and S.T. $a^* = a_x^* = a_y^*$ **(10 Marks)**

b. The velocity of a normal shock wave moving into stagnant air (P = 1 bar, t = 17°C) is 500 m/s. If the area of cross section of the duct is constant, determine
(i) Pressure (ii) temperature (iii) velocity of air (iv) stagnation temperature (v) Mach number imparted upstream of the wave-front. **(10 Marks)**

3 a. Derive an expression for variation of mach number with duct length for a flow in constant area duct with friction. **(08 Marks)**

b. Air at $P_0 = 10$ bar, $T_0 = 400$ 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 the entry to 1.0 at the exit, determine (i) the length of the pipe and (ii) the mass flow rate. **(12 Marks)**

4 a. Explain Rayleigh curve with the help of a suitable sketch. **(08 Marks)**

b. A combustion chamber in a gas turbine plant receives air at 350 K, 0.55 bar and 75 m/s. The air-fuel ratio is 29 and the calorific value of the fuel is 41.87 MJ/kg. Taking $\gamma = 1.4$ and $R = 0.287$ kJ/kg.K for the gas, determine (i) Initial and final mach number (ii) Final pressure, temperature and velocity of the gas, (iii) Percent stagnation pressure loss in the combustion chamber, (iv) Maximum stagnation temperature attainable. **(12 Marks)**

PART – B

5 a. Derive the general potential equation for three-dimensional flow with usual notation. **(10 Marks)**

b. Derive an expression for pressure co-efficient in three and two dimensional flows. **(10 Marks)**

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

6 a. Explain Von Karman rule for transonic flow with relevant expression. **(08 Marks)**
b. Explain three dimensional flow over bodies (or) Gothert rule. **(06 Marks)**
c. Briefly explain the application of Gothert rule to wings of finite span. **(06 Marks)**

7 a. Explain the methods of characteristics of airfoils in compressible flow. **(08 Marks)**
b. A flat plate is kept at 15° angle of attack to a supersonic stream at mach 2.4 as shown in Fig.Q7(b). Solve the flow field around the plate and determine the inclination of slipstream to the free stream direction using shock-expansion theory. **(12 Marks)**

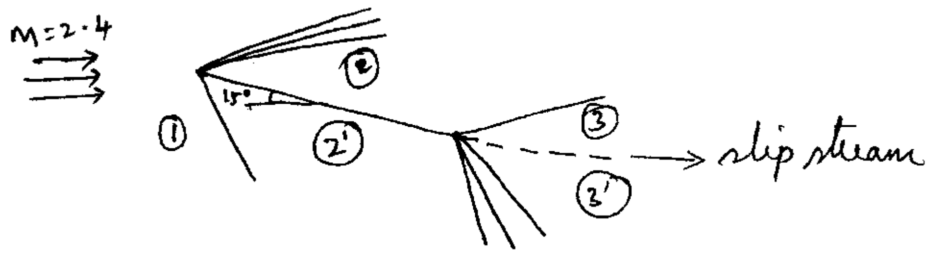

Fig.Q7(b)

8 a. With the help of a neat sketch explain open circuit supersonic tunnel. **(10 Marks)**
b. Explain: (i) Interferometer technique (ii) Orifice meter. **(10 Marks)**

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Sixth Semester B.E. Degree Examination, Dec.2016/Jan.2017
Applied Gas Dynamics

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Gas and shock tables is permitted.***

PART – A

1 a. Derive an expression for area ratio as a function of mach number with usual notation. **(08 Marks)**

b. Air flowing in a duct has velocity of 300m/s, pressure 1 bar and temperature 290K. Taking $\gamma = 1.4$ and R = 287 J/kg – k. Determine :
   i) Stagnation pressure and temperature
   ii) Velocity of sound in the dynamic and stagnation conditions
   iii) Stagnation pressure assuming constant density. **(06 Marks)**

c. Air [$C_p = 1.05$ kJ/kg K, $\gamma = 1.38$) at $P_1 = 3\times10^5$ N/m^2 and $T_1 = 500$K flows with a velocity of 200 m/s in a 30cm diameter duct. Calculate
   i) Mass flow rate
   ii) Stagnation temperature
   iii) Mach number
   iv) Stagnation pressure values.
   Assuming the flow are compressible and incompressible. **(06 Marks)**

2 a. Derive Prandtl Meyer relation and show that $a^* = a_x^* = a_y^*$. **(10 Marks)**

b. The velocity of a normal shock wave moving into stagnant air (p = 1 bar. t = 17°C) is 500m/s. if the area of cross section of duct is constant, determine :
   i) Pressure
   ii) Temperature
   iii) Velocity of air
   iv) Stagnation temperature
   v) Mach number impacted upstream of the wave front. **(10 Marks)**

3 a. Derive an expression for variation of mach number with duct length for a flow in constant area duct with friction. **(08 Marks)**

b. Air at P_0 = 10bar, T_0 = 400K is supplied to a 50mm diameter pipe the friction factor for the pipe surface is 0.002.
   If the mach number changes from 3 at the entry to 1 at the exit, determine.
   i) The length of the pipe and
   ii) The mass flow rate. **(12 Marks)**

4 a. Explain Rayleigh curve with the help of a suitable sketch. **(08 Marks)**

b. A combustion chamber in a gas turbine plant receives air at 350K, 0.55 bar and 75 m/s. The air fuel ratio is 29 and the calorific value of the fuel is 41.87MJ/kg taking $\gamma = 1.4$ and R = 0.287 kJ/kg K for the gas.

Determine :

i) Initial and final mach number

ii) Final pressure, temperature and velocity of the gas

iii) Percent stagnation pressure loss in the combustion chamber

iv) Maximum stagnation temperature attainable. **(12 Marks)**

PART – B

5 a. Derive the general potential equation for three dimensional flow with usual notation. **(10 Marks)**

b. Derive an expression for pressure co-efficient in three and two dimensional flows. **(10 Marks)**

6 a. Explain Von-Karman rule for transonic flow with relevant expression. **(08 Marks)**

b. Explain three dimensional flow over bodies (or) Glauert rule. **(06 Marks)**

c. Briefly explain the application of Glauert rule to wings of finite span. **(06 Marks)**

7 a. Explain the methods of characteristic of airfoils in compressible flow. **(08 Marks)**

b. A flat plate is kept at 15° angle of attack to a supersonic stream at mach 2.4 as shown in Fig. Q7 (b) below. Solve the flow field around the plate and determine the inclination of slip stream to the free stream direction using shock – expansion theory. **(12 Marks)**

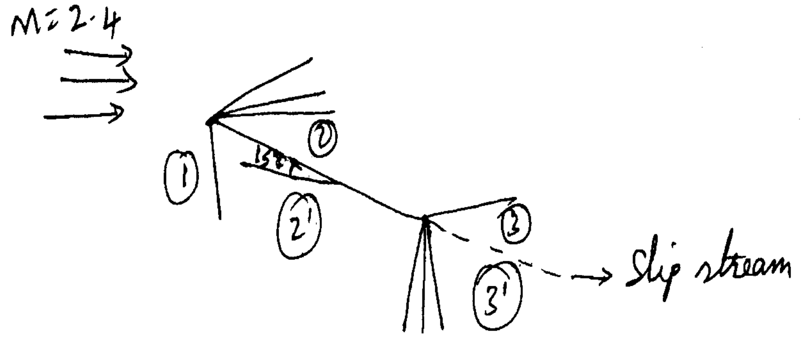

Fig. Q7(b)

8 a. With the help of a neat sketch explain open circuit supersonic tunnel. **(10 Marks)**

b. Explain :

i) Interferometer Technique

ii) Orifice meter. **(10 Marks)**

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Sixth Semester B.E. Degree Examination, Dec.2017/Jan.2018

Applied Gas Dynamics

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Use of thermodynamics table and gas tables are allowed.***

PART – A

1 a. Explain De-Laval nozzle. Derive an expression for area ratio as a function of Mach number for a De-Laval nozzle. **(10 Marks)**

b. A conical diffuser has entry and exit diameters of 15 cm and 30 cm respectively. The pressure, temperature and velocity of air at entry are 0.69 bar, 340 K and 180 m/s respectively. Determine: (i) exit pressure, (ii) exit velocity, (iii) force exerted on diffuser wall. Assume isentropic flow, r = 1.4, c_p = 1 kJ/kgK. **(10 Marks)**

2 a. Derive Prandtl-Meyer relation for normal shock waves with usual notations. **(10 Marks)**

b. A gas (r = 1.4, R = 0.287 kJ/kgK) at a Mach number of 1.8, P = 0.8 bar and T = 373 K passes through a normal shock. Determine its density after the shock. Compare this value in an isentropic compression through the same pressure ratio. Assume for normal shock tables for r = 1.4, at M_x = 1.8, (P_y/P_x) = 3.613, (T_y/T_x) = 1.532. **(10 Marks)**

3 a. Draw a Fanno line and show that $h = h_0 - \frac{1}{2}\left(\frac{G}{\rho}\right)^2$. **(10 Marks)**

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 entry is 0.15, determine:
i) The diameter of duct
ii) Length of duct
iii) Pressure and temperature at the exit
iv) Stagnation pressure loss
v) Verify the exit Mach number through exit velocity and temperature. **(10 Marks)**

4 a. Define Rayleigh flow process and by a suitable graph, explain the Rayleigh curve and its significance and also show that at maximum entropy point, the flow is sonic analytically. **(10 Marks)**

b. The Mach number at the exit of a combustion chamber is 0.9. The ratio of stagnation temperatures at exit and entry is 3.74. If the pressure and temperature of the gas at exit are 2.5 bar and 1000 °C respectively, determine:
i) Mach number, pressure and temperature of the gas at entry
ii) Heat supplied per kg of the fluid
iii) Maximum heat that can be supplied.
Take r = 1.3 and c_p = 1.218 kJ/kgK. **(10 Marks)**

PART – B

5 a. Explain the small perturbation theory and show the linearization of the potential equation. **(10 Marks)**
b. Derive an expression for linearized pressure coefficient. **(10 Marks)**

6 a. Explain Prandtl-Glauert rule for a two dimensional subsonic flow. **(10 Marks)**
b. Discuss the Von-Karman rule for transonic flow. **(10 Marks)**

7 a. Explain the thin aerofoil theory and obtain an expression for the pressure distribution. **(10 Marks)**
b. Discuss the typical aerodynamic characteristics of an aerofoil at low speeds. **(10 Marks)**

8 a. Explain closed circuit supersonic tunnel with relevant sketch. **(10 Marks)**
b. Explain the following with suitable sketch:
i) Hot wire anemometer
ii) Mach Zender Inter ferometer. **(10 Marks)**

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Sixth Semester B.E. Degree Examination, June/July 2014
Applied Gas Dynamics

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. Gas tables and charts are permitted.

PART – A

1 a. Explain De-Laval nozzle. Derive an expression for area ratio as a function of Mach number for a De-Laval nozzle. **(08 Marks)**

b. A ramjet flies at 11km attitude with a flight Mach number of 0.9. In the inlet differences the air is brought to the stagnation condition so that it is stationary just before the combustion chamber. Combustion taken place at constant pressure and a temperature increase of 1500°C results. The combustion products are then ejected through the nozzle.
   i) Calculate the stagnation pressure and temperature.
   ii) What will be the nozzle exit velocity? At inlet $P_\infty = 0.3$ atm, $T_\infty = 213K$, At exit $P_{exit} = 0.3$atm. **(08 Marks)**

c. Explain dynamic head measurement in compressible flow. **(04 Marks)**

2 a. Derive Prandtl-Meyer relation for normal shock waves with usual notations. **(08 Marks)**

b. Air approaches a symmetrical wedge ($\delta = 15°$) at a Mach number of 2.0. Determine for the strong and weak waves i) Wave angle; ii) Pressure ratio; iii) Density ratio; iv) Temperature ratio and v) Downstream Mach number. **(12 Marks)**

3 a. Derive the basic fanno flow equation and find the solution of the basic equation with usual notations. **(08 Marks)**

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 is 0.005. If the Mach number at entry is 0.15. Determine: i) The diameter of the duct; ii) Length of the duct; iii) Pressure and temperature at the exit; iv) stagnation pressure loss and v) Verify the exit Mach number through exit velocity and temperature. **(12 Marks)**

4 a. Show that the maximum heat transfer in a Rayleigh flow is given by

$$Q_{max} = Q^* = \frac{(1-M^2)^2}{2(1+\gamma)M^2} Cp\tau .$$ **(08 Marks)**

b. The Mach number at the exit of a combustion chamber is 0.9. The ratio of stagnation temperature at exit and entry is 3.74. If the pressure and temperature of the gas at exit are 2.5bar and 1000°C respectively. Determine: i) Mach number, pressure and temperature of the gas at entry; ii) the heat supplied per kg of gas and iii) the maximum heat that can be supplied. **(12 Marks)**

PART – B

5 a. Derive an expressional for general potential equation for three dimensional flows. **(10 Marks)**

b. Derive an equation for linearized potential flow equation using small perturbation theory. **(10 Marks)**

6 a. Explain Prandtl-Glauert rule for a two-dimensional subsonic flow. **(10 Marks)**

b. A given profile has at $M\infty = 0.29$ the following lift coefficients:

$C_L = 0.2$ at $\alpha = 3°$

$C_L = -0.1$ at $\alpha = -2°$.

Where α is the angle of attack, plot the relation showing d_{c_L}/d_α Vs M_∞ for the profiles for values of M_∞ upto 10. **(10 Marks)**

7 a. Explain shock wave-boundary layer interaction with relevant sketches. **(10 Marks)**

b. Explain the experimental characteristics of airfoils in compressible flow. **(10 Marks)**

8 a. Explain closed circuit supersonic tunnel with relevant sketch. **(10 Marks)**

b. Write short notes on:

i) Schlieren technique.

ii) Wind tunnel instrumentation and measurement. **(10 Marks)**

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Sixth Semester B.E. Degree Examination, June/July 2015
Applied Gas Dynamics

Time: 3 hrs. Max. Marks:100

Note: ***1.Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. Use of thermodynamics Table and Gas Tables are allowed.

PART – A

1 a. Derive the following relation for a Quasi – ID isentropic flow through variable area duct :

i) $\frac{dA}{A} = -\frac{dV}{V}\left[1 - M^2\right]$

ii) A/A^*

iii) $\frac{m\sqrt{T_0}}{AP_0}$ interms of mach number. **(12 Marks)**

b. Determine the section head indicated by a mercury manometer connected to a wall static pressure located is a Mach 2.0 supersonic tunnel test section, if the stagnation pressure and atmospheric pressure are 3 atm and 760 mm of Hg respectively. treat the flow to be one dimensional and isentropic. **(03 Marks)**

c. Air at a stagnation state of 3.5 MPa and 500°C is expanded isentropically through a level nozzle to a pressure of 0.7 MPa at the nozzle exit. If the mass flow rate through the nozzle is 1.3 kg/s, determine : i) exit Mach number ii) the exit area iii) the throat area. **(05 Marks)**

2 a. A Convergent - Divergent nozzle of exit area 4 cm^2 is to be designed to generate Mach 2.5 air stream. If the nozzle is correctly expanded and discharging is to atmosphere and the stagnation temperature at the entry is 500 K, determine the back pressure required to position a normal shock at the nozzle exit plane. **(08 Marks)**

b. Depict graphically oblique shock chart showing the relation between flow deflection angle (θ), shock wave angle (β) and upstream Mach number (M_1) and write the inference of the chart. **(06 Marks)**

c. Air flow at Mach 4.0 and pressure 10^5 n/m^2 is turned abruptly by a wall into the flow with a truning angle of 20°. The shock is reflected by a another wall which is straight and parallel to the wall from where shock is garneted. Determine the flow properties down stream of reflected shock. **(06 Marks)**

3 a. Atmospheric air at a pressure 1 bar and temperature 300 k is drawn through a frictionless bell – mouth entrance is to a 3 m long tube having 0.05 m diameter. The average friction co-efficient $\bar{f} = 0.005$ for the tube. the system is perfectly insulated :

i) Find the maximum mass flow rate and the range of back pressure that will produce this flow

ii) What is the exit pressure required to produce 90% of the maximum mass flow rate, and what will be the stagnation pressure and velocities at the exit for the mass flow rate . **(10 Marks)**

b. Explain the Fannocurve with suitable graph for three different mass velocities in h – v plane. **(05 Marks)**

c. Air flows through a pipe of 25 mm diameter and 51 m length. The conditions at the pipe exit are $M_2 = 0.8$, $P_2 = 1$ atm and $T_2 = 270$ k. Assuming 1D adiabatic flow, calculate entry Mach number of the flow, if friction co-efficient is 0.005. **(05 Marks)**

4 a. Air at standard sea level condition enters the diffuser having an inlet area of 1 m^3 at Mach 0.6 of and reaches a value of Mach 0.25 at the exit at diffuser. A straight tube is added at the exit of the diffuser where the heat is added until thermal choking occurs. Determine the following : Diffuser exit area ii) pressure and density at exit of diffuser iii) amount of heat added in J/kg iv) stagnation temperature at exit of the tube. **(10 Marks)**

b. Define Rayleigh flow process and by a suitable graph, explain the Rayleigh curve and its significance and also show that at maximum entropy point the flow is sonic analytically. **(10 Marks)**

PART – B

5 a. Derive the governing equation of an inviscid, steady. Compressible flow in non-linear form. **(10 Marks)**

b. Derive an expression for linearized pressure co-efficient. **(05 Marks)**

c. Write a short note on boundary conditions to be considered in perturbation analysis. **(05 Marks)**

6 a. Derive the expressions for aerodynamic co-efficient using Prandtl-Glavert rule compressible and incompressible flows. **(10 Marks)**

b. Obtain an expression relating the aerodynamic characteristics for the actual and transformed bodies using Gotherts rule. **(10 Marks)**

7 a. Explain briefly about the shock wave boundary layer interaction with suitable sketch. **(10 Marks)**

b. Explain the nature of pressure distribution over supersonic airfoils in compressible flow with expressions for different angles of attack. **(10 Marks)**

8 a. Explain the following with suitable sketch :

i) Schlierne technique

ii) Mach zender interferometer **(12 Marks)**

b. Explain in detail about the temperature and velocity measurements in supersonic tunnels. **(08 Marks)**

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Sixth Semester B.E. Degree Examination, June/July 2016
Applied Gas Dynamics

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. Gas Table is allowed in examination. (Gas table compressible Flow Calculation – Sixth Edition S.M. Yahya)

PART – A

1 a. Derive Impulse function for compressible flow problems is

$$\frac{F}{F^*} = \frac{1+\gamma M^2}{M\sqrt{2(1+\gamma)\left(1+\frac{\gamma-1}{2}M^2\right)}}$$ **(10 Marks)**

b. A nozzle in a wind tunnel gives a test section mach number of 2.0 Air enters the nozzle from a large reservoir at 0.69 bar and 310K. The cross sectional area of the throat is 1000cm^2. Determine the following quantities for the tunnel for one dimensional isentropic flow :
i) Pressures, temperatures and velocities of the test section
ii) Area of cross-section of the test section
iii) Mass flow rate
iv) Power required to drive the compressor. **(10 Marks)**

2 a. Show that, the gas velocities before and after the normal shock by using Prandtl-Meyer relationship is expressed by $c_x \cdot c_y = a^{*2}$ $M_x^* \cdot M_y^* = 1$ **(10 Marks)**

b. The velocity of a normal shock wave moving into stagnant air (p = 1.0 bar, t = 17°C) is 500m/sec. if the area of cross-section of the duct is constant deremine
i) pressure ii) temperature iii) velocity of air iv) stagnation temperature and v) the mach number imparted system of the wave front. **(10 Marks)**

3 a. With the help of h-s diagram, show that the gas velocity at the maximum entropy point (F) on the Fanno line is sonic (M =1). **(10 Marks)**

b. Air at P_0 = 10 bar, T_0 = 400 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 the entry to 1.0 at the exit, determine (i) the length of the pipe and (ii) the mass flow rate. **(10 Marks)**

4 a. Show that in Rayleigh Flow, Maximum possible Heat Transfers is equal to

$$Q_{max} = \frac{(1-M^2)^2}{2(1+\gamma)M^2}C_pT_1$$ **(12 Marks)**

b. If the conditions at sonic point are p^*= 1 bar, T^* = 500K. Calculate pressure, temperature and velocity at the maximum enthalpy point. What is the change of entropy between these points? **(08 Marks)**

PART – B

5 a. What do you mean by, the General potential equation for Three – Dimensional flow, also show that $\left(\frac{a}{a_\infty}\right)^2 = 1 - \frac{\gamma - 1}{2} M_\infty^2 \left(\frac{V_x^2 + V_y^2 + V_z^2}{V_\infty^2} - 1\right)$ **(12 Marks)**

b. Derive the basic potential equation for compressible flow in terms of linearized perturbation velocity potential equation. **(08 Marks)**

6 a. Explain Prandtl-Glauest transformation rule for subsonic flow in terms of boundary conditions. **(08 Marks)**

b. How will you define, application of wings to finite span in terms of Gothert Rule? **(06 Marks)**

c. If the value of the pressure coefficient at the maximum velocity location an a profile is – 2.13, determine the critical mach number. **(06 Marks)**

7 a. Define experimental characteristics of airfoils in compressible flow. If cumbered aerofoil at an angle of attack, then explain

i) Kinetic flow condition

ii) At $z \rightarrow \pm\infty$, perturbation velocities are zero as finite. **(12 Marks)**

b. With the help of neat sketch, show nature of pressure distribution profile for symmetrical and unsymmetrical aerofoil's **(08 Marks)**

8 a. How many types of supersonic wind tunnel is there, with the help of diagram explain the working of them? **(12 Marks)**

b. The data of a mach – 2 supersonic wind tunnel is given below :

Pressure in the test section	0.69bar
Area of cross – section of the nozzle threat	1000cm^2
Ambient pressure	1.02bar
Ambient temperature	311K

The air is taken from the atmosphere and compressed continuously in a multistage compressor to the reservoir pressure. That test secion of tunnel directly exhausts into the atmosphere. Determine :

i) Temperature of air in the test section

ii) Mass flow rate of air

iii) Cross – sectional area of the test section

iv) Power required to drive the compressor

Assume reversible flow throughout. **(08 Marks)**

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Sixth Semester B.E. Degree Examination, June/July 2017
Applied Gas Dynamics

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. Use of appropriate gas table permitted.

PART – A

1 a. Define stagnation enthalpy and stagnation pressure. **(04 Marks)**

b. Derive Bernoulli's equation for isentropic flow by assuming perfect gas. **(08 Marks)**

c. A ramjet flies at 11 km altitude with a flight Mach number of 0.9. In the inlet diffuser, the air is brought to the stagnation condition, so that it's stationary just before the combustor. Combustion takes place at constant pressure and a temperature increase of 1500°K results. The combustion products are then ejected through the nozzle. Calculate (i) The stagnation pressure and temperature (ii) Nozzle exit velocity. Assume $P_{\alpha} = P_{exit} = 0.3\,atm$, T_{α}=213°K **(08 Marks)**

2 a. Derive static pressure ratio across the normal shock wave in term of upstream Mach number. Also define strength of a shock wave. **(10 Marks)**

b. The velocity of a normal shock wave moving into stagnant air (P = 1.0 bar, t = 17°C) is 500 m/s. If the area of cross section of the duct is constant. Determine (i) Pressure (ii) Temperature (iii) Velocity of air (iv) Stagnation temperature (v) The mach number imparted upstream of the wave front. **(10 Marks)**

3 a. Derive an expression for static temperature ratio and stagnation pressure ratio of Fanno flow. **(10 Marks)**

b. Air enters a long circular duct (d = 12.5 cm, $\bar{f} = 0.0045$) at a Mach number of 0.5, pressure 3.0 bar and temperature 312°K. If the flow is isothermal throughout the duct. Determine (i) the length of the duct required to change the Mach number to 0.7, (ii) Pressure and temperature of air at M = 0.7 (ii) The length of duct required to attain limiting Mach number (iv) State of air at the limiting Mach number. **(10 Marks)**

4 a. What is Rayleigh flow? Obtain an equation representing Rayleigh curve. Also draw Rayleigh curves on h-s plane. **(10 Marks)**

b. The conditions of a gas in a combustor at the entry are P_1 = 0.343 bar, T_1 = 310°K, C_1 = 60 m/s. Determine the Mach number, pressure, temperature and velocity at the exit if the increase in stagnation enthalpy of the gas between entry and exit is 1172.5 KJ/kg. **(10 Marks)**

PART – B

5 a. Derive the basic potential equation for compressible flow. **(12 Marks)**

b. Derive the expression for pressure coefficient. **(08 Marks)**

6 a. Explain Prandtl-Glauert rule for supersonic flow. (10 Marks)

b. A given profile has at $M_\alpha = 0.29$, the following lift co-efficient:

$C_L = 0.2$ at $\alpha = 3^0$

$C_L = -0.1$ at $\alpha = -2^0$

where α is angle of attack, plot the relation showing $\frac{dC_L}{d\alpha}$ Vs M_α for the profile for values of M_α upto 1.0. (10 Marks)

7 a. Explain the shock expansion theory considering a 2D supersonic flow over an aerofoil. Also show the wave pattern for the flow over a flat plate at an angle of attack. (10 Marks)

b. Explain thin aerofoil theory and obtain an expression for the pressure co-efficient. (10 Marks)

8 a. Explain velocity measurement for (i) incompressible (ii) compressible (iii) supersonic flow. (10 Marks)

b. Write short notes on:

(i) Shock tube.

(ii) Shadow technique. (10 Marks)

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