Allows the student to use only his own gas table (for regular students and from abroad)
Please do not use a pencil to write.
Assume any missing data from your point of view in the limits of what you studied.
Answer the following questions:-

1st Question (16 Mark) :-

1-1) Air flowing at a Mach number of 0.6 in a 6.25cm^2 pipe is found to be at a pressure of 150 kPa and the flow rate is 0.2 kg/s.

(a) Determine the stagnation temperature of the stream assuming no heat transfer occurs.

(b) Determine the percent reduction in cross-sectional area needed to accelerate the flow to the critical condition assuming that friction and heat transfer in the reducing section of the duct is negligible. **[6 Mark]**

1-2) A stream of air having a stagnation temperature of 38 °C flows through an insulated 100mm diameter cylindrical duct at a rate of 1 kg/s. At a certain station along the duct the static pressure is 41 kPa. Calculate the (a) Mach number, (b) velocity, and (c) stagnation pressure at this station. **[6 Mark]**

1-3) Explain the Pressure wave pattern which produced by a supersonic aeroplane flying at a constant speed.

If it is flying closer to the earth, explain its effect on the earth. **[4 Mark]**

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2nd Question (32 Mark) :-

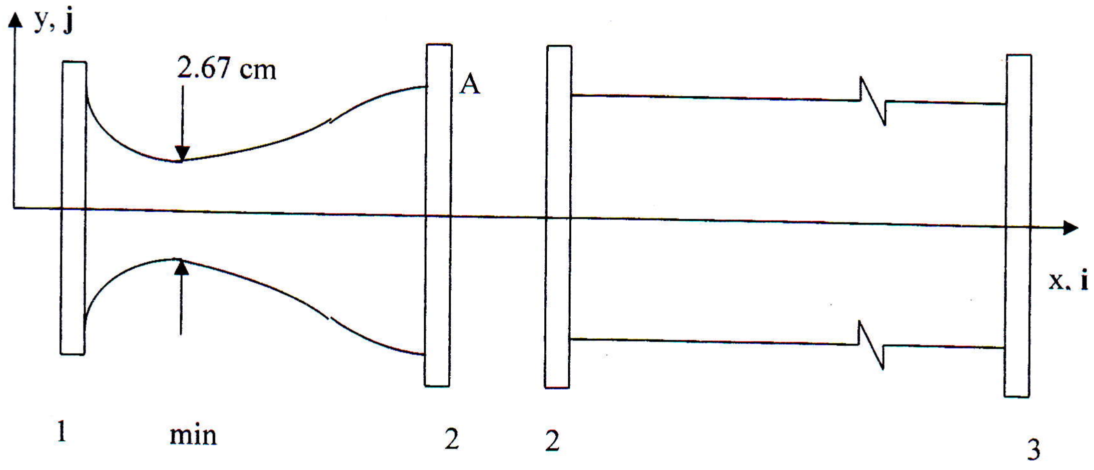
2-1) Put True or False on the Following Statements and Why: **[12 Mark]**

a) "The back pressure at a De-Laval nozzle exit is affected on its performance."

b) "The maximum impulse is obtained at zero exit pressure theoretically."

c) "The Mach number always increases in Fanno flow pipe as one moves downstream"

2-2) Consider the axisymmetric contoured converging-diverging nozzle and the associated circular pipe extension shown in below:



2-2-a) The nozzle alone is attached at station 1 to a large air tank kept at a pressure of 1725 kPa and a temperature of 677K. The nozzle exhausts, at station 2, into the free atmosphere which is at a pressure and temperature of 101 kPa and 300K, respectively. The nozzle is

designed to produce an exit Mach number and pressure of 2.5 and 101 kPA, respectively. Determine the exit diameter, d_2, and the mass flow rate, m, of the nozzle. [4 Mark]

2-2-b) The supply pressure in the air tank is reduced to 182.4 kPa while the temperature remains at 677K. For the nozzle operating alone, a probe measures the stagnation pressure in the exit plane, station 2, to be P_{02}=104.7 kPa, suggesting the presence of a shock in the nozzle. Determine the diameter, d_s, at which the shock is located and the Mach number at the exit plane, M2. [8 Mark]

2-2-c) The circular pipe extension is now connected to the nozzle exit plane and the air tank is again operating at a pressure of 1725 kPa and a temperature of 677K. The purpose of this pipe addition is to reduce the Mach number exhausting into the atmosphere at station 3 to a value of M3=1.5. If the Darcy friction factor (f) is 0.0025, determine the length, L, of pipe needed, in terms of the pipe diameter d2, as well as the exit stagnation pressure P03. [8 Mark]

3rd Question (24 Mark) :-

3-1) What happen if heat addition exceeds the maximum value (in the case of frictionless constant cross-sectional area duct), when the inlet flow condition is subsonic or supersonic? [4 Mark]

3-2) Show the direction of normal stationary shock wave on an h-S diagram (Rayleigh flow case) and state all states on the diagram. [4 Mark]

3-3) A gaseous fuel-air mixture enters a constant area duct with the following conditions: $M_1=2$, $p_1=69$ kPa, and $T_1=166$K. Assuming that the duct is frictionless and that the gas mixture has the properties of air, find:

(a) The maximum heat addition possible, q_{max} [6 Mark]

(b) The stagnation pressure for that case of maximum heat addition, $p_{0,max}$. [2 Mark]

The flow in above problem now encounters a normal shock wave just after entering the duct with the conditions stated. With the same assumptions, find:

(c) The maximum heat addition possible, q_{max}. [6 Mark]

(d) The stagnation pressure for that case of maximum heat addition, $p_{0,max}$. [2 Mark]

4th Question (28 Mark) :-

4-1) How do you determine experimentally the strength and Mach number of the following:-

a) A moving normal shock wave & b) A moving rarefaction wave? [6 Mark]

4-2) Explain what the Prandtl–Meyer function represents. (That is, if someone were to say that ν = 36.8°, what would this mean to you?) [4 Mark]

4-3) Air flowing at Mach 2 is compressed by turning through an angle of 16°. For the strong solution case calculates: [9 Mark]

(i) The shock angle (ii) The Mach number downstream of the shock.

(iii) The maximum deflection angle if the shock remains attached.

4-4) Air at Mach 2.0 and a pressure of 70 KPa flows along a wall which bends away 12° from the direction of the flow. Determine the Mach number and pressure after the bend. [4 Mark]

4-5) Gas at Mach 1.6 enters a straight-walled channel that diverges at an angle of 20°. Determine the two dimensional flow patterns. Assume the fluid is a perfect gas of a constant specific heat ratio 1.4. Neglected boundary layer effects and using Lattice Points Method three points. [5 Mark]

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--THE END--

GOOD LUCK Prof. Dr. Mostafa Nasr & committee

Question	1	2	3	4	5	6	Work &oral exam. through a semester
ILOs	A13, A14,	B3, B5, B13	B3, B13	B3, B5	A13, A14, B3, B5, B13	A14, B3, B5, B13	C12, C13, C15, C16 D4, and D7