Mansoura University
Faculty of Engineering
Mechanical Engineering Dept.
Date: May 2013

Gas dynamics
Third year students
Final Term Exam
Time allowed: 3 Hours

Answer FIVE questions ONLY: (Total marks 110),
Use of gas dynamic Tables are allowed.

Question No. 1 (25 marks)

A. Show that, the speed of sound C is given by;

$$C = \sqrt{\gamma . R . T}$$

B. Schlieren photograph of a bullet in a flight show that at great distance from the bullet, the total included angle of the Mach cone is 57°. The pressure and temperature of the undisturbed air is 101 kPa, and 27°C respectively. Calculate the velocity and Mach number of the bullet.

Question No. 2 (25 marks)

A. Liquid fueled rocket is fired on a test stand. The nozzle of the rocket has an exit diameter of 30 cm. The combustion gases leave the nozzle exit at a velocity of 3500 m/s. and pressure of 100 kPa. The temperature of gases in the combustion chamber is 3000 °K. Find the temperature of gases at nozzle exit, the pressure in the combustion chamber and the thrust developed. Assume that the gases have a specific heat ratio of 1.3 and a molecular weight of 9 and the flow is isentropic though the rocket nozzle.

B. An aircraft is flying at a Mach number of 0.90 at an altitude 10 km. The diffuser at the intake of the engine decreases the air flow Mach number to 0.3 at the inlet of the engine. Find the pressure, and temperature at the inlet of the engine.

Question No. 3 (25 marks)

A. In an air supersonic nozzle, normal shock wave occurs. The pressure ratio across the shock wave is 3.2. Ahead of the shock wave, the pressure is 1.5 atm. and the temperature is 288 K. Find the velocity, pressure, temperature, stagnation pressure, and stagnation temperature behind the shock wave.

B. A blast wave generated by a bomb explosion, is traveling through the air at standard conditions (1 atm., and 27° C) with a speed of 3.2 km/sec. Assuming that the spherical portion of the wave adjacent to the ground as a normal shock wave, estimate the value of the following conditions in the wake of the blast wave

- The pressure and temperature of the disturbed air
- The velocity and Mach number in the wake of the blast wave
- Stagnation pressure and temperature

الامتحان مكون من ستة اسئلة وباقي الاسئلة خلف الورقة

Mansoura University
Faculty of Engineering
Mechanical Engineering Dept.
Date: May 2013

Gas dynamics
Third year students
Final Term Exam
Time allowed: 3 Hours

Question No. 4 (25 marks)

A. A test fighter cruises at a Mach number 2.75 at an altitude of 2 km. The air entering the engine is slowed down to subsonic velocities by passing through two oblique shock waves each of which deflects the flow by an angle of 15o, then followed by a normal shock wave. Following the normal shock wave, the flow is isentropically decelerated to a Mach number of 0.2 before it enters the combustion chamber of the fighter engine. Find the values of air velocity, pressure, and temperature at the inlet to the combustion zone.

B. What would be these values if the initial deceleration had been through a single normal shock wave, compare the drop in stagnation pressure for both cases.

Question No. 5 (25 marks)

A. Air expands from large reservoir, where the pressure and temperature are 20 atm. and 527°C through a nozzle of exit to throat area ratio of 4.0. If the shock wave occurs at nozzle exit what would be the Mach number, velocity, pressure and temperature at exit.

If the nozzle is a shock FREE what would be the Mach number, velocity, pressure and temperature at exit.

B. The intake system of a supersonic air breathing engine has a fixed inlet to throat area ratio supersonic diffuser. It is operating at temperature of 300 K and pressure of 1.0 atm. The inlet and throat cross sectional areas are 0.1 m2 and 0.065 m2 respectively. Determine;

- Mach number at which the diffuser must be over speeded for starting
- Mach number at which the diffuser must be designed and the mass flow rate

---

Question No. 6 (25 marks)

A. Air is flowing through an insulated pipe of 12 m length and 5.2 cm diameter. The friction coefficient of the pipe is f = 0.003. The flow velocity at inlet is 125 m/s, while the pressure and temperature are 1.95 atm. and 300°K respectively. Calculate

- Mach number, flow conditions at the end section of the pipe, and air mass flow rate,
- Change of stagnation pressure, and change of entropy.
- Then, plot the process on a T - s diagram.

B. If the pipe length has been increased to 20 m, what would be inlet Mach number and the mass flow rate.

Good luck and best wishes
Prof. Dr. L. H. Rabie