# TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL & AUTOMOTIVE ENGINEERING

**UNIVERSITY EXAMINATION FOR:**

THE DEGREE IN BACHELOR OF SCINCE IN MECHANICAL ENGINEERING

EMG 2416 : GAS DYNAMICS AND BOUNDARY LAYER THEORY

END OF SEMESTER EXAMINATION

**SERIES:** DECEMBER 2016

**TIME:** 2 HOURS

**DATE:** Pick Date Dec 2016

**Instructions to Candidates**

You should have the following for this examination

*-Answer Booklet, examination pass and student ID*

This paper consists of **FIVE** questions. Attempt any THREE questions.

**Do not write on the question paper.**

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**Question One**

a) Explain the following terms
   i. Turbulent boundary layer
   ii. Laminar sub-layer (4marks)

b) Describe fine the following boundary layer
   i. Boundary layer thickness
   ii. Displacement thickness
   iii. Energy thickness (6 marks)

c) In the boundary layer over the face of a high spillway ,the velocity distribution was observed to have the following form:

$$\frac{u}{U} = \left[\frac{y}{\delta}\right]^{0.22}$$

The free stream velocity U at a certain section was observed to be 30m/s and the boundary layer thickness of 60 mm was estimated from the velocity distribution measured at the section. The discharge passing over the spillway was 6 m/s per metre length of spillway. Calculate

i. The displacement thickness
ii. The energy thickness
iii. The loss of energy up to the section under consideration. (10 marks)

**Question Two**

a) Define the following Terms.
   i. Drag force
   ii. Lift force
   iii. Streamlined body
   iv. Bluff body (6marks)
b) Calculate the diameter of a parachute to be used for dropping an object of mass 100 kg so that maximum terminal velocity of dropping is 5 m/s. The drag co-efficient for parachute which may be treated as hemispherical is 1.3.The density of air is 1.216 kg/$m^3$ (4 marks)
c) A flat plate 1.5mx1.5m moves at 50km/h in stationery air of density 1.15kg\m3.If the co-efficients of .drag and lift are 0.15 and 0.75 respectively Determine
   i. Drag force
   ii. Lift force
   iii. Resultant force
   iv. Power required to keep the plate in motion (8 marks)

**Question Three**

a) Explain the following term related to airfoil
   i. Chold line
   ii. Profile centreline
   iii. Angle of attack
   iv. Camber
   v. Aspect Ratio (5 marks)
b) Experiments were conducted in a wind tunnel with a wind speed of 50km/h on a flat plate of size 2m long and 1 m wide. The density of air is 1.15kg/m3.The coefficient of lift and drag are 0.75 and 0.15 respectively. Calculate
   i. The lift force
   ii. The drag force.
   iii. The resultant force
   iv. Direction of resultant force.
   v. Power exerted by the air on the plate. (10 marks)
c) A spherical steel ball of diameter 40mm and of density 8500kg/m3 is dropped in large mass of water. The co-efficient of drag of the ball in water is given as 0.45. Find
   i. The terminal velocity of the ball in water. If the ball is dropped in air.

ii. The increase in terminal velocity of ball.
(Take the density of air =1.25kg/$m^3$ $C_D$=0.1) (5 marks)

**Question four**

a) Define the following terms of flow which depend on Mach number:
   i. Subsonic flow
   ii. Sonic flow
   iii. Zone of Action
   iv. Zone of silence (6 marks)

b) A gas is flowing through a horizontal pipe at a temperature of 4$^o$C.The diameter of the pipe is 8 cm and at a section 1-1 in this pipe, the pressure is 30,3 N/$cm^2$ (gauge).The diameter of the pipe changes from 8cm to 4 cm at the section 2-2,where pressure is 20.3 N/cm2(gauge).Find the velocities of the gas at these sections assuming an isothermal process .Take R=287.14 Nm/kg K, and atmospheric pressure = 10N/$cm^2$ (8 marks)

c) Find the sonic velocity for the following fluids
   i. Crude oil of sp gravity 0.8 and bulk modulus 153036N/cm2
   ii. Mercury having a bulk modulus of 2648700N/cm2 ( 6marks)

**Question five**

a) What is turbulence? (2 marks)

b) Describe the following types turbulent motions
   i. Wall turbulence.
   ii. Free turbulence.
   iii. Convective turbulence. (3 marks)

c) In a pipe of 360mm diameter having turbulent flow, the centre –line velocity is 7m/s and that at 60 mm from the pipe wall is 6m/s. Calculate the shear friction velocity. (5marks)

d) Calculate the wall shearing stress in a pipe of diameter 100 which carries water .The velocities at the pipe centre and 30 mm from the pipe centre are 2m/s and 1.5m/s respectively. The flow in the pipe is given as turbulent. (6 marks)

e) Water is flowing through a rough pipe of diameter 600mm at the rate of 600 litres/second. The wall roughness is 3 mm. Find the power lost for 1 km length of pipe. (4 marks)