TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL & AUTOMOTIVE ENGINEERING

UNIVERSITY SPECIAL/SUPPLEMENTARY EXAMINATION FOR:

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMG 2407: WIND TUNNEL EXPERIMENTAL TECHNIQUES

END OF SEMESTER EXAMINATION

SERIES: DECEMBER 2016

TIME: 2 HOURS

DATE: Pick Date Dec 2016

<u>**Instructions to Candidates**</u>
You should have the following for this examination
  -*Answer Booklet, examination pass, pocket calculator and student ID*
This paper consists of **FIVE** questions. Attempt question **ONE** (**Compulsory**) and any other **TWO** questions.
Do not write on the question paper.

Question ONE

(a) Using clearly labeled schematic diagrams, show the nature of flow in a sub-sonic and supersonic wind tunnel indicating the changes in Mach pressure and velocity in different section of the wind tunnel.   **(4 marks)**

(b) Oil with a free stream velocity of 5.0 m/s flows over a thin plate 2.25m wide and 3 m long. Given

$\rho = 860\,kg/m^3$, $v = 10^{-5}m/s$, $v = \dfrac{\mu}{\rho}$ Determine :

i) the boundary layer thickness and the shear stress at mid length

ii) the total double-sided resistance of the plate   **(7 marks)**

(c)) Tabulate any 6 flow visualization techniques used in flight, their primary use and test point description. **(12 marks)**

(d) In a test in a wind tunnel on 1:16 scale model of a bus at an air speed of 35m/s, the drag on the model was measured as 10.7N. If the width and frontal area of the prototype was 2.44m and 7.8m^2:

i) Estimate the aerodynamic drag force on the bus at 100km/hr.

ii) The total power required.

Conditions of air in the wind tunnel are the same as at the operating conditions of the bus. Assume coefficient of drag remains constant above Reynolds number 10^5 $\sqrt{}=1.006 \times 10^{-6}m^2/s$ **(7 marks)**

Question TWO

Describe an experiment to determine the pressure distribution around a circular cylinder in cross flow, providing key equations, experimental results and their analysis.   **(20 marks)**

Question THREE

(a) Discuss Froude's Number, stating its symbol significance and field of application.   **(4 marks)**

(b) Assuming a velocity distribution $\dfrac{u}{U_m} = 2\left(\dfrac{y}{\delta}\right) - 2\left(\dfrac{y}{\delta}\right)^3 + \left(\dfrac{y}{\delta}\right)^4$ in laminar boundary layer, determine the boundary layer thickness and the shear stress for a smooth flat plate   **(9 marks)**

(c) To ascertain the flow characteristics of the spillway of a dam, 1/20 geometric scale model is to be used. The spillway is 40m long and carries 300m³/s at flood condition. Determine

i) the flow rate required to test the model

ii) the time scale for the model, viscous and surface tension effects may be neglected.   **(7 marks)**

Question FOUR

Describe a laboratory experiment for the determination of the boundary layer over a flat plate, giving key equations, procedures experimental results and analysis.   (**20marks**)

Question FIVE

(a) Discuss the beneficial practical applications of modeling in the engineering field.   **(4marks)**

(b) A water tunnel operates with a velocity of 3m/s at the test section and power required was 3.75kW. If the tunnel is to operate with air, determine for similitude the flow velocity and the power required. Given
$\rho_a = 1.25 kg/m^3$, $v_{air} = 14.8 \times 10^{-6} m^2/s$, $v_{water} = 1.14 \times 10^{-6} m^2/s$ **(6 marks)**

c) Discuss and elaborate with diagrams Interferometry as a flow visualization technique.   **(10 marks)**