TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL & AUTOMOTIVE ENGINEERING

UNIVERSITY 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

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 question ONE (Compulsory) and any other TWO questions.

Do not write on the question paper.

Question ONE

(a) Discuss blockage corrections in the wind tunnels. **(8 marks)**

(b) Discuss the DDS – suite with emphasis on the analysis phase. **(7 marks)**

(c) In order to undertake predictions of the lift and drag force on a scale model of an aircraft during a section of its operational envelope involving sea level flight at $100ms^{-1}$ where the speed of sound may be taken as 340m/s, it is supposed to utilize a cryogenic wind tunnel with nitrogen at 5 atmospheres of pressure and a temperature and a temperature of -90°C, conditions at which the nitrogen conditions at which the nitrogen density and viscosity may be taken as 7.7 kg/m^3 and $1.2x10^{-5}$ Ns, respectively. The speed of sound in nitrogen at this temperature is 295m/s. Determine the wind tunnel flow velocity, the scale of the model to ensure full dynamic similarity and the ratio of forces on the model and the prototype. **(9 marks)**

(d) Flow through a heat exchanger tube is to be studied by means of a 1/10 scale model. If the heat exchanger normally carries water, determine the ratio of pressure losses between the model and the prototype if;

(i) water is used in the model

(ii) air at normal temperature and pressure is used in the model. **(6 marks)**

Question TWO

Describe an experiment to determine the reduction of drag by inducing turbulence in the boundary layer, providing key equations, experimental results and their analysis. **(20 marks)**

Question THREE

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

(b) Under conditions of zero pressure gradient, the velocity profile in a laminar boundary may be represented by the approximation relation $\frac{u}{u_m} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$ where δ represents the thickness of the boundary layer. Calculate the displacement thickness, δ^* and the momemtum thickness, θ, and energy thickness, when the boundary layer thickness is 0.4mm. **(9 marks)**

An aircraft fuselage has been designed for speeds of 380 km/hr. To estimate power requirements the drag is to be determined. A model of 1/10 is decided on. In order to reduce the effect of compressibility, the model is proposed to be tested at the same speed in a pressurized tunnel. Determine:

i) the pressure required.

ii) the drag on the prototype, if the drag on the model is 100N. **(7 marks)**

Question FOUR

Describe a laboratory experiment for the determination of the coefficient of lift and drag over an airfoil, giving key equations, procedures experimental results and analysis. (**20marks)**

Question FIVE

(a) A 1:40 model of an ocean tanker is dragged through fresh water at 2m/s with a total measured drag of 117.7N. The skin (frictional) drag coefficient, *f,* for model and prototype are 0.3 and 0.02 respectively in the equation $R_f = fAV^2$. The wetted surface area of the model is 25 m^2. Taking the densities for the prototype and the model as 1030kg/m^3 respectively determine

i) The total drag on the prototype;

ii)Power required to drive the prototype **(10marks)**

(b) Discuss and elaborate with diagrams Laser Speckle Velocimetry as an Optical flow visualization technique **(10 marks)**