ELIZADE UNIVERSITY, ILARA-MOKIN, ONDO STATE, NIGERIA

DEPARTMENT OF AUTOMOTIVE ENGINEERING

FIRST SEMESTER EXAMINATIONS

2019/2020 ACADEMIC SESSION

HOD'S SIGNATURE

COURSE: MEE 409 – Heat Transfer II (3 Units)

CLASS: 400 Level Mechanical Engineering

TIME ALLOWED: 3 Hours

INSTRUCTIONS: Answer any **FIVE** questions

Date: February, 2020

Question 1.

(a) Employing a three dimensional flow field, show that

$$\rho\left(\frac{\partial V_x}{\partial t} + V_x\frac{\partial V_x}{\partial x} + V_y\frac{\partial V_x}{\partial y} + V_z\frac{\partial V_x}{\partial z}\right) = -\frac{\partial P}{\partial x} + \left(\frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{zx}}{\partial z}\right) + \rho g$$

(b) Name and state the interpretation of the equation in (a) above.

Question 2.

(a) Given that the pressure acting on a fluid is 360Pa gauge while the temperature and universal gas constant are 45°C and 83141 J/kgK respectively. Determine the density of this fluid if its molecular weight is 36 kg.

(b) The temperature in (a) above is that of acetylene employed for welding at a temperature of 2000 K, a flow rate of 1kg/s and a Nusselt number of 650. Determine the convective heat transfer coefficient, h, of the fluid if the nozzle diameter is 6 mm and the thermal conductivity is 0.0025 W/mK. What is the convective heat transfer of the flame?

Question 3.

(a) A liquid flows under the action of a pressure drop within a horizontal tube. Under laminar flow condition, derive an equation for the velocity profile.

(b) Assuming the radius of a pipe is 10 mm and the pressure gradient in the pipe is 250Pa.m calculate the velocity at the centre of the pipe if the viscosity of the fluid is $15\text{x}10^{-5}$ Pa.s.

Question 4.

(a) A fluid flows down a surface inclined at angle α. If the temperature at the surface is maintained at temperature T_s and the wall surface temperature is at T_w, determine the differential equations for the temperature profiles of the fluid.

(b) The fluid surface temperature at (a) above is 30 °C and the thickness of the fluid on the wall is 6.5 m. Calculate the temperature of the fluid at a depth of 2.5 m from the surface when the wall temperature is 70 °C.

Question 5.

(a) A fluid is placed between two plates one at high temperature above ambient while the other is at room temperature. Employing Navier-Stokes equation compute the velocity distribution of the fluid. Assume a Newtonian fluid at steady state.

(b) Given that the thermal expansibility, β, of a fluid is 1 Unit, the mean density is 1.8kg/m^3, the pipe diameter is 9 m, axial distance is 50 mm and the temperature at ambient wall side is 25 °C, compute the temperature of the hot wall at a bulk velocity of 2.3 m/s. (Take the dynamic viscosity of the fluid as 2.751×10^{-4} Pa.s.}

Question 6.

(a) Define a laminar fluid flow.

(b) Employing a three dimensional flow field, deduce the momentum equation.

Question 7.

(a) The convective heat transfer of water from an internal combustion engine to the radiator is 721.78 kW while the wall temperature of the radiator heat exchanger is 25 °C. The surface area of the exchanger is 35m^2 and the water temperature is 353.15K. Determine the convective heat transfer coefficient of the fluid.

(b) The thermal conductivity of the pipe of the radiator in (b) above is 25W/(m.K) and the total length of the pipe is 150m, compute the Nusselt number of the fluid. If the bulk velocity of the flow in the pipe is 3.4m/s and the viscosity of the water is 13.5×10^{-7}Pa.s with a bulk volume of 70m^3 and inside pipe diameter of 15 cm, determine the Reynolds number of the fluid.

(c) Comment on the state of the fluid in relation to the outcome of the Reynolds number.