



ELIZADE UNIVERSITY, ILARA-MOKIN,  
ONDO STATE, NIGERIA

DEPARTMENT OF AUTOMOTIVE ENGINEERING

FIRST SEMESTER EXAMINATIONS

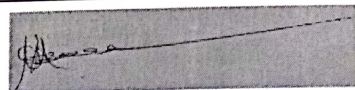
2019/2020 ACADEMIC SESSION

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

CLASS: 400 Level Mechanical Engineering

TIME ALLOWED: 3 Hours

INSTRUCTIONS: Answer any FIVE questions

  
HOD'S SIGNATURE

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  $15 \times 10^{-5}$  Pa.s.

**Question 4.**

(a) A fluid flows down a surface inclined at angle  $\alpha$ . 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,  $\beta$ , of a fluid is 1 Unit, the mean density is  $1.8\text{kg/m}^3$ , the pipe diameter is 9 m, axial distance is 50 mm and the temperature at ambient wall side is  $25\text{ }^\circ\text{C}$ , compute the temperature of the hot wall at a bulk velocity of 2.3 m/s. (Take the dynamic viscosity of the fluid as  $2.751 \times 10^{-4}\text{ Pa.s}$ .)

**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  $25\text{ }^\circ\text{C}$ . The surface area of the exchanger is  $35\text{m}^2$  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  $25\text{W/(m.K)}$  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  $13.5 \times 10^{-7}\text{Pa.s}$  with a bulk volume of  $70\text{m}^3$  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.