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University Examinations 2013/2014

FIRST YEAR, THIRD TRIMESTER EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE IN APPLIED MATHEMATICS

SMA 3135: FLUID MECHANICS II

DATE: DECEMBER 2013 **TIME: 3HOURS**

INSTRUCTIONS: *Answer questions **one** and any other **two** questions*

QUESTION ONE - (30 MARKS)

a) Define a boundary layer as used in fluid mechanics. (2 Marks)

b) Give two contrasts between natural and artificial channels. (2 Marks)

c) Calculate the shape factor of a velocity distribution of a flat plate given in the laminar boundary layer as $u = U\left(\frac{2y}{\delta} - \frac{y^2}{\delta^2}\right)$. (6 Marks)

d) Define the hydraulics radius (R) hence show that for a circular channel of diameter D carrying a fluid that subtends and angle θ then
$R = \frac{D}{4}\left(1 - \frac{\sin\theta}{\theta}\right)$

e) State the Reynolds's number and its significance in fluid mechanics. (3 Marks)

f) The sides of a trapezoidal channel have equal side slopes making an angle of 45° with the horizontal. The channels base width is 5m, bed slope is 1 in 10,000, normal depth is 4m and n=0.015. compute
   i. The discharge and (5 Marks)
   ii. The mean velocity (2 Marks)

g) State two ways of classifying waves and for each case distinguish between two types of waves. (4 Marks)

QUESTION TWO (20 MARKS)

a) Define the mannings number (n) and state any four factors that affect this number. (5 Marks)

b) A steady, incompressible fluid is bounded by two infinite parallel plates located in the planes $y = -b \; and \; y = b$. The upper plate is impulsively set into motion with a constant velocity U with the lower plate remaining stationary.

i. Formulate an equation of the velocity profiles. (10 Marks)

ii. Give expressions for the discharge per unit width of the plates and, (3 Marks)

iii. the shear stress distribution. (2 Marks)

QUESTION THREE (20 MARKS)

a) What is an "unsteady uniform flow" as used in fluid mechanics. (2 Marks)

b) A model of airduct operating with water produces a pressure drop of $10kN/m^2$ over 10m length. If the scale ration is $^1/_{50}$, the densities and dynamic viscocities of water and air are respectively $\rho_w = 1000kg/m^3$, $\rho_a = 1.2kg/m^3$, $\mu_w = 0.001Pas$ and $\mu_a = 0.00002Pas$ estimate the corresponding drop in 20m long air duct. (9 Marks)

c) define the following numbers and given their significance in fluid mechanics

i. Froude number. (3 Marks)

ii. Prandtl number. (3 Marks)

iii. Grashof number. (3 Marks)

QUESTION FOUR (20 MARKS)

a) Convert the 3 dimensional wave equation $\nabla^2 \emptyset = \frac{1}{c^2}\frac{\partial^2 \phi}{\partial t^2}$ to spherical coordinates (ρ, θ, ψ) and show that if there is spherical symmetry then the equation reduces to $\frac{\partial^2 (\rho \emptyset)}{\partial r^2} = \frac{1}{c^2}\frac{\partial^2 (\rho \emptyset)}{\partial t^2}$. (6 Marks)

b) Express the x component of the following equation in non dimensional from using proper scaling variables.
$\frac{\Delta}{\Delta t} u_i = -\frac{1}{\rho}\frac{\partial p}{\partial x_i} + v\nabla^2 u_i$. (6 Marks)

c) Define the following terms as used in boundary layer theory

i. Thermal boundary layer (2 Marks)

ii. Momentum thickness (2 Marks)

iii. Turbulent boundary layer. (2 Marks)

iv. Shape factor (2 Marks)