TECHNICAL UNIVERSITY OF MOMBASA

A Centre of Excellence

Faculty of Applied & Health Sciences

DEPARTMENT OF MATHEMATICS AND PHYSICS

APRIL 2016 SERIES EXAMINATION

UNIT CODE: AMA 4438 UNIT TITLE: APPLICATIONS OF FLUID MECHANICS

MAIN EXAMINATION

TIME ALLOWED: 2HOURS

INSTRUCTIONTO CANDIDATES:

You should have the following for this examination

- Mathematical tables
- Scientific Calculator

This paper consists of **FIVE** questions

Answer question **ONE (COMPULSORY)** and any other **TWO** questions

Maximum marks for each part of a question are as shown

QUESTION ONE (30 MARKS)

a. Find the Laplace transform of $(1 + te^{-t})^3$ (5 marks)

b. The path of flowing water satisfies the equation $xy = (1 + x^2)\frac{dy}{dx}$ and passes through the point (0, 1) on the xy plane. Find the equation of the path through the given point (6 marks)

c. Locate and classify the singular point of the equation

$(x^4 - 2x^3 + x^2)\frac{d^2y}{dx^2} + 2(x-1)\frac{dy}{dx} + x^2y = 0$ (6 marks)

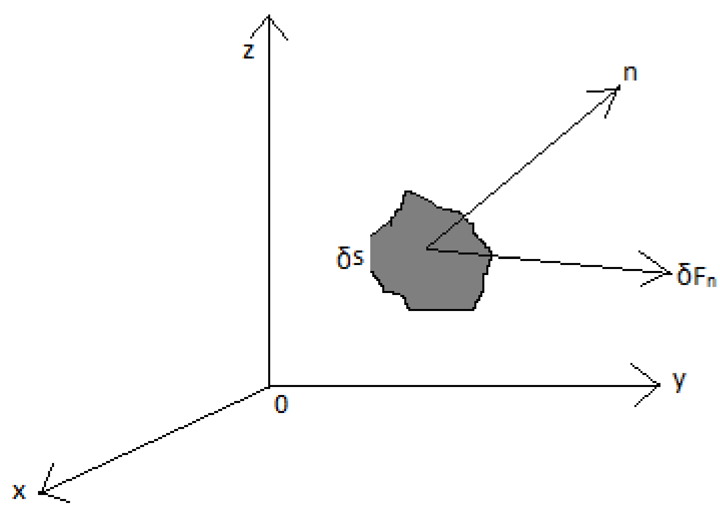
d. A plate having an area of $0.6m^2$ is sliding down an inclined plane at 30^0 to the horizontal with a velocity of 0.36m/s. There is a cushion of fluid 1.8mm thick between the plane and plate. Find the viscosity of the fluid if the weight of the plate is 280N (5 marks)

e. (i) Define a sunspot and state how it occurs (3 marks)

(ii) If the sunspot is in equilibrium, briefly explain that the equation of state holds and the pressure within and outside the sunspot are equal (5 marks)

QUESTION TWO (20 MARKS)

a. Study the figure below and use it to define the terms that follows.



Where δs is a small rigid plane area inserted at a point p in a viscous fluid. The Cartesian coordinates (x, y, z) are a set of fixed axes ox, oy and oz. δF_n is a force exerted by the moving fluid on one side of δs. n Is the unit vector normal at p to δs

i. Normal(direct) stress (2 marks)
ii. Shearing stress (2 marks)
iii. Hydrostatic pressure (2 marks)
iv. The stress matrix (2 marks)

b. Given a cylindrical column of plasma

i. Explain the concept of pinch confinement of the column of plasma, detailing what happens to the magnetic lines of forces when the column is bent.

(6 marks)

ii. Derive the expression for pressure distribution in the column of plasma

(6 marks)

QUESTION THREE (20 MARKS)

a. Using variation principle derive the equation of general form of a function for a steady state quasi one dimensional shallow water, stating the natural conditions

(6 marks)

b. For an adiabatic expansion of a fluid

$c_v \frac{dp}{p} + c_p \frac{dv}{v} = 0$ Where $c_p$and c_v are constants. Given $n = \frac{c_p}{c_v}$ show that $pv^n = constant$ (6 marks)

c. Find the Laplace transform $cosh^3 2t$ (5 marks)

d. Using appropriate conditions, define a finite element

(3 marks)

QUESTION FOUR (20 MARKS)

a. Find an expression for a drag force on a smooth sphere of diameter D, moving with a uniform velocity v in a fluid density ρ and dynamic viscosity μ. (7 marks)

b. Given that the translational equation of motion of equation of motion of a viscous fluid is

$\frac{du}{dt} = X + \frac{1}{\text{þ}}\left(\frac{\partial p_{xx}}{\partial x} + \frac{\partial p_{xy}}{\partial y} + \frac{\partial p_{xz}}{\partial z}\right)$ where

$p_{xx} = -p + 2\mu\left(\frac{du}{dx}\right) + \lambda\Delta$

$p_{yx} = \mu(\frac{dv}{dx} + \frac{du}{dy})$

$p_{zx} = \mu(\frac{du}{dz} + \frac{dw}{dx})$

Derive the Navier stokes equation of motion of a viscous fluid in the vectorial form.

(6 marks)

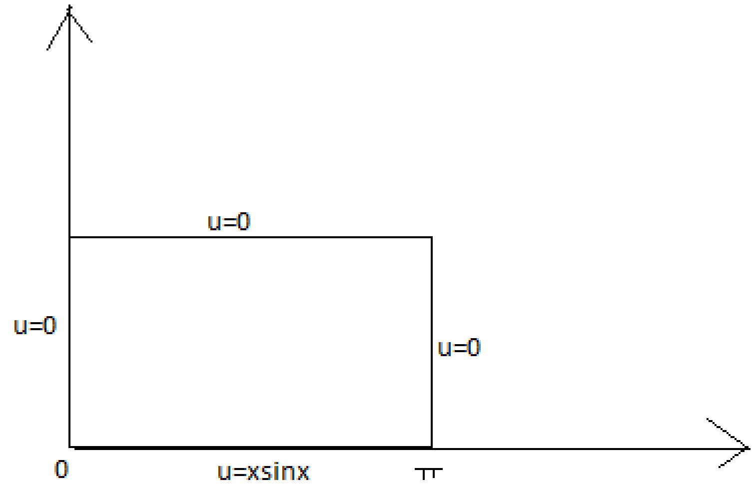
c. List three locations where water can be found in the soil. (3 marks)

d. Determine the particular solution of the equation $\frac{dy}{dx} = 2e^{3t-2\theta}$, given that $t = 0$ when $\theta = 0$ (4 marks)

QUESTION FIVE (20 MARKS)

a. Solve the differential equation below using Laplace transform
$2\frac{d^2y}{dx^2}+5\frac{dy}{dx}-3=0$ Given that when x=o y=4 and $\frac{dy}{dx}=9$ (6 marks)

b. The diagram below shows a rectangular region $0\le x\le\pi,\ 0\le y\le y,$ in which steady temperature distribution $U(x,y)$ is required subject to temperature on the sides $0\le x\le\pi, y=0$ being $u(x,0)=xsinx$ and the temperature on the other three sides being maintained at u=0 (7 marks)



If the domain describes a Laplace equation $\frac{\partial^2u}{\partial x^2}+\frac{\partial^2u}{\partial y^2}=0$. Find its solution

c. (i) define the term magnetohyrodynamics (2 marks)

(ii) Outline the five Maxwell's electromagnetic field equation for a conducting fluid for medium that is in motion, defining every parameter and symbols used in each equation (5 marks)

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