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University of Sargodha

M.A/M.Sc Part- II/Composite, 1st-A/2013

Mathematics: IV-VI(vi)/IX-XI(vi) Fluid Mechanics

Maximum Marks: 100 **Time Allowed: 3 Hours**

Note: **Objective part is compulsory. Attempt any four questions from subjective part.**

Objective Part (Compulsory)

Q. No.1: Give short answers of the following. 20

i. Show that stream function ψ is constant along a stream line.

ii. Which restrictions are used to derive the Bernoulli equation?

iii. Convert 15 lbf / ft^2 into Pascal (Pa).

iv. What is the Archimedes Principle? According to this, which thing will float or sink?

v. Consider $\psi = ax^2 - ay^2, \varphi = 2axy$, prove that the lines of constant ψ and constant φ are orthogonal for this flow field.

vi. Write the Euler's equation in vector form? What happens with this equation if we use irrotational flow?

vii. What is the difference between Fanno line and Raleigh line?

viii. Define the wall shear stress and prove that it depends only on the Reynolds number for laminar flate plate boundary layer.

ix. Find the hydrostatic force on a triangular plate of area $4m^2$ that is submerged 3m in the water.

x. What are the cavitation effects?

Subjective Part (20×4)

Q. No. 2 (a): A wide moving belt moving through a container of a viscous liquid. The belt moves vertically upward with constant velocity V0. Because of viscous effects the belt picks up a film of fluid of thickness h. Gravity tends to make the fluid drain down the belt. Find an expression for velocity by assuming that flow is laminar, steady and fully developed.

(b): If $W^2 = Z^2 - 1$, Prove that stream line for which $\psi = 1$ is $y^2\left(1+x^2\right) = x^2$. Regarding this as a fixed boundary, show that the motion is that of a uniform stream flowing past the boundary.

Q. No. 3(a): Derive Navier Stokes equations for viscous incompressible fluid.

(b): Discuss laminar motion of a fluid over an oscillating porous plate.

Q. No. 4(a): Derive the basic equation of fluid statics. Also deduce the result for an incompressible fluid.

(b): A dam has a parabolic shape $\frac{z}{z_0}=\left(\frac{x}{x_0}\right)^2$ with $x_0=10ft$ and $z_0=24ft$. The fluid is water, $\gamma=62.4lbf/ft^3$, and atmospheric pressure may be omitted. Compute the forces F_H and F_V on the dam and their line of action. The width of dam is 50ft.

Q. No. 5(a): State and prove the theorem of Blasius.

(b): The complex potential for infinite circular cylinder in a uniform stream, with circulation is

$$W=U\left(z+\frac{a^2}{z}\right)+ik\log z,$$

where a is the radius of a long infinite cylinder having velocity U. Find the force exerted by the liquid on unit length of the cylinder and the moment about the origin.

Q. No. 6 (a): Derive the Bernoulli equation for rectangular coordinates.

(b): Determine the velocity field and shear stress for the steady flow of an incompressible Newtonian fluid between two parallel plates, where the flow of the fluid is due to the motion of both lower and upper plates, moving with constant velocities u_1 and u_2 respectively. What will be the velocity field and shear stress when

i. The upper plate is moving with constant velocity u_2 and the lower plate is at rest.
ii. The lower plate is moving with constant velocity u_1 and the upper plate is at rest.

Q. No. 7 (a): Derive momentum integral equation for boundary layer flow in terms of boundary layer thickness.

(b): Consider the two-dimensional laminar boundary layer flow along a flat plate. Assume the velocity profile in the boundary layer is sinusoidal.

$$\frac{u}{U}=\sin\left(\frac{\pi}{2}\frac{y}{\delta}\right).$$

Find expressions for:

i. The rate of growth of δ as a function of x.
ii. The displacement thickness, δ^*, as a function of x.
iii. The total fiction force on a plate of length L and width b.