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E-5338

M.A. / M.Sc. (IIIrd Semester) Examination, 2021

MATHEMATICS

(Fluid Dynamics)

Time Allowed : Three Hours

Maximum Marks : 70

SECTION - A

(Objective Type / Multiple Choice Questions / True or False)

Note : Attempt any ten questions. Each question carries one mark. Choose the correct answer. **10**

Q. 1. (i) Streamlines, path lines and streak lines are virtually identical for :

(a) Uniform flow

(b) Flow of ideal fluids

(c) Steady flow

(d) Non uniform flow

(ii) Existence of velocity potential implies that :

(a) Fluid is in continuum

(b) Fluid is irrotational

(c) Fluid is ideal

(d) Fluid is compressible

(iii) For a continuity equation given $\nabla . \vec{V} = 0$ to be valid, where $\vec{V}$ is the velocity vector, which one of the following is a necessary condition ?

(a) Steady flow

(b) Irrotational flow

(c) Inviscid flow

(d) Incompressible flow

(iv) Bernoulli's equation can be applied between any two points on a stream line for a rotational flow field. (TRUE or FALSE)

(v) Navier Stoke's equation represents the conservation of _____.

(vi) The Reynolds number for an ideal fluid flow is _____.

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(vii) The normal stress is the same in all directions at a point in a fluid, when the fluid is :

(a) Viscous

(b) Non-viscous

(c) Incompressible

(d) Having no motion of one fluid layer relative to the other

(viii) Study of fluid motion without considering the force causing that motion is known as _____.

(ix) The approach of identifying or tracking the individual fluid particle by its position, velocity etc. and describes as a function of time is :

(a) Eulerian approach

(b) Lagrangian approach

(c) Static approach

(d) None of the above

(x) The flow in which velocity of a fluid at a particular fixed point changes with time is _____.

(xi) A velocity field is given by u = –3x, v = 2y and w = z. Is the flow steady :

(a) Yes

(b) No

(c) Cannot say

(xii) A two dimensional flow in x–y plane is irrotational if _____.

SECTION - B

(Very Short Answer Type Questions)

Note : Attempt any five questions. Each question carries 2 marks. Answer the following questions in 2-3 sentences (25-30 words). **10**

Q. 2. (i) Define streamlines and path lines.

(ii) Explain what is meant in hydrodynamics by a stagnation point.

(iii) Explain the Bernoulli's equation.

(iv) Define sources, sinks and doublets.

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(v) State Cauchy-Riemann equation.

(vi) Explain the Magnus effect.

(vii) Define the Reynolds number.

SECTION - C

(Short Answer Type Questions)

Note : Attempt any five questions. Each question carries 4 marks. Answer the following questions (in 250 words). **20**

Q. 3. (i) For a fluid moving in a fine tube of variable section A, prove from the first principles that the equation of continuity is :

$$A\frac{\partial \varrho}{\partial t} + \frac{\partial}{\partial s}(A\,\varrho\,v) = 0$$

where v is the speed at a point P of the fluid and s the length of the tube up to P. What does this become for steady incompressible flow ?

(ii) A long pipe is of length ℓ and has slowly tapering cross-section. It is inclined at angle α to the horizontal and water flows steadily through it from the upper to the lower end. The section at the upper end has twice the radius of the lower end. At the lower end, the water is delivered at atmospheric pressure. If the pressure at the upper end is twice atmospheric find the velocity of delivery ?

(iii) If S is the boundary of a spherical surface lying wholly within the fluid, then show that the mean value of the velocity potential is equal to its value at the centre of the sphere.

(iv) Prove that if $r^n S_n(\theta,\psi)$ is a harmonic function, so also is $r^n S_n(\theta,\psi)$.

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(v) Explain the Karman vortex street.

(vi) Write a notes on the coefficient of viscosity and laminar flow.

(vii) If $\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} = f(x, y)$ at all point (x, y) of a region S in the plane Ox, Oy bounded by a closed curve c and if f is prescribed at each point (x, y) of S and w at each point of c, then show that any solution w = w(x, y) satisfying these conditions is unique.

SECTION - D

(Essay Type Questions)

Note : Attempt any three questions. Each question carries 10 marks. Answer the following questions (in more than 500 words) : **30**

Q. 4. (i) Explain the Euler's equation of motion.

(ii) State and prove the Weiss's sphere theorem.

(iii) Obtain the Navier-Stokes equations of motion of a viscous fluid.

(iv) Establish the usual relation between the stress and rate of strain tensors in an isotropic inviscid compressible fluid.

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