KATHMANDU UNIVERSITY
End Semester Examination [C]
November, 2018

Marks scored:

Level : B.Sc.
Year : II

Course : PHYS 202
Semester: I

Exam Roll No.: Time: 30 mins. F.M. : 20

Registration No: Date NOV 15 2018

SECTION "A"
[15 Q.×1=15 marks]

Choose and tick the most appropriate answer. The symbols have their usual meanings.

1. The flow in a river during the period of heavy rainfall is
[a] steady, non-uniform and three-dimensional.
[b] steady, uniform and two-dimensional.
[c] unsteady, uniform and three-dimensional.
[d] unsteady, non-uniform and three-dimensional.

2. Velocity for a two dimensional flow field is given by $\vec{V} = (3+2xy+4t^2)\hat{i} + (xy^2+3t)\hat{j}$ .The velocity at a point $(1,2)$ after 2 sec is
[a] 2.508 units [b] 25.08 units [c] 186.03 units [d] 20.58 units

3. A tank has a hole at its bottom. The time needed to empty the tank from level h_1 to h_2 will be proportional to
[a] $h_1 - h_2$ [b] $\sqrt{h_1} - \sqrt{h_2}$ [c] $h_1 + h_2]$ [d] $\sqrt{h_1} + \sqrt{h_2}$

4. Oil flows through a 25 mm diameter orifice under a head of 5.5 m at a rate of 3 L/s. If the coefficient of velocity is 0.925, the value for coefficient of contraction will be
[a] 0,588 [b] 5.88 [c] 6.37 [d] 0.637

5. Two capillary tubes of same radii but different lengths l_1 and l_2 are connected in parallel. The equivalent length of single tube having same flow rate is
[a] $l_1 + l_2$ [b] $l_1 l_2$ [c] $\frac{l_1 l_2}{l_1+l_2}$ [d] $\frac{l_1+l_2}{l_1 l_2}$

6. When subjected to shear force, a fluid
[a] deforms continuously no matter how small is the shear stress may be.
[b] deforms continuously only for large shear stress.
[c] undergoes static deformation.
[d] deforms continuously only for small shear stress.

7. The velocity potential Φ at any point for a two-dimensional, steady, irrotational flow is given by $\Phi = K\theta$. This equation represents a
[a] Vortex [b] sink [c] source [d] doublet

8. The continuity equation in polar form is
[a] $\frac{1}{r}\frac{\partial u}{\partial \theta} + \frac{1}{r}\frac{\partial}{\partial r}(v)$ [b] $\frac{1}{r}\frac{\partial(ru)}{\partial r} + \frac{1}{r}\frac{\partial v}{\partial \theta}$ [c] $\frac{1}{r}\frac{\partial u}{\partial \theta} + \frac{1}{r}\frac{\partial}{\partial r}(rv)$ [d] $\frac{\partial u}{\partial r} + \frac{1}{r}\frac{\partial}{\partial \theta}(rv)$

9. If two-dimensional stream function for a flow is $\psi = 9 + 6x - 4y + 7xy$, then the velocity potential is

[a] $(4x+6y) - \frac{7}{2}(x^2 - y^2)$

[b] $(4x+6y) - \frac{7}{2}(x^2 + y^2)$

[c] $6y + \frac{7}{2}(x^2 + y^2)$

[d] $6y + \frac{7}{2}y^2$

10. In Couette flow with zero pressure gradient, the shear stress 'τ' at the boundary is given by

[a] $\tau = \frac{U_\infty h}{\mu}$ [b] $\tau = \frac{U_\infty \mu}{h}$ [c] $\tau = \frac{h}{\mu}$ [d] $\tau = \frac{\mu h}{U_\infty}$

11. Very low Reynolds number (i.e. $R_e \ll 1$) renders the

[a] inertial terms significantly higher than the viscous terms.

[b] viscous terms significantly higher than the inertial terms.

[c] equal viscous terms and inertial terms.

[d] flow between parallel channels.

12. Navier-Stoke's equations are approximated to boundary layer equation when

[a] $\frac{\partial(x)}{x} \ll 1$ [b] $\frac{\partial(x)}{x} \gg 1$ [c] $\frac{\partial(x)}{x} = 1$ [d] $\frac{\partial(x)}{x} = 0$

13. The velocity profile for flow over flat plate is

[a] $\frac{u}{U_\infty} = \frac{3y}{2\delta} - \frac{1}{3}\left(\frac{y}{\delta}\right)^3$

[b] $\frac{u}{U_\infty} = \frac{3y}{2\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)$

[c] $\frac{u}{U_\infty} = \frac{2y}{3\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$

[d] $\frac{u}{U_\infty} = \frac{3y}{2\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^2$

14. A smooth flat plate 2.0 m wide and 2.5 m long is towed in oil ($\nu = 10^{-4}\ m^2/s$) at velocity of 1.5 m/s along its length. The skin friction coefficient at the trailing edge of the plate is:

[a] 4.849×10^{-3} [b] 4.849×10^{3} [c] 3.335×10^{3} [d] 3.335×10^{-3}

15. A boundary layer developed along the flow, the pressure decreases along the downstream direction. The boundary layer thickness would

[a] increase gradually along the flow

[b] remains constant

[c] increase rapidly along the flow

[d] tend to decrease along the flow

Fill in the blanks:

16. A venturimeter is used for measuring...............................

17. The condition of "No Slip" at the rigid boundaries is applicable to flow of ....fluid.

18. For force vertex flow the velocity is given by $u = \omega r$ and verticity is ....

19. The ratio of displacement thickness and momentum thickness (δ_1 / δ_2) for third degree velocity profile in a laminar boundary layer along a flat plate is equal to ....

20. The distance between the point of instability and fully turbulent condition is known as ....

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SECTION "B"
[5 Q.×4=20 marks]

1. Show that the velocity profile for the flow of liquid across a pipe is parabolic. Also estimate the flow rate of the liquid.

2. Define turbulent flow. Discuss the kinematically different condition existing below and above the critical Reynolds number.

3. Obtain the Bernoulli's equation for irrotational flow of fluid.

OR

Show that head loss due to sudden expansion is $h_L = \frac{(v_1 - v_2)^2}{2g}$.

4. For flow over flat plate, the third degree velocity profile is given by $\frac{u}{U_\alpha} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$.

Estimate the thickness of boundary layer.

5. Air flows through a circular pipe of 1 cm diameter at an average velocity of 2 m/s. Assuming that the flow takes place at room temperature, calculate the pressure drop over a length of 5 m. The viscosity of air is $\mu = 1.983 \times 10^{-5}$ kg/ms.

OR

The velocity field in a fluid medium is given by $\bar{V} = 3xy^2\hat{i} + 2xy\hat{j} + (2zy + 3t)\hat{k}$. Find the magnitudes and direction of (i) translational velocity (ii) rotational velocity and (iii) acceleration at (1, 2, 1) at time $t = 3$.

SECTION "C"
[5 Q.×7=35 marks]

6. Estimate the energy change in the radial direction when a body of fluid is constrained to follow the curved paths where in the centrifugal body force comes into play. Show that the total energy input causes the rise in pressure and kinetic energy at the impeller outlet for forced vortex.

7. Derive Euler's equation of motion for an ideal fluid and establish this equation in stream line coordinate system as well.

OR

Discuss the analogy between liquid flow through pipe and current flow through wire. Calculate the rate of flow through capillaries when they are connected in series and parallel.

8. Define stream function (ψ) and velocity potential function (ϕ). Establish the relation between them in both Cartesian and polar co-ordinates system for two dimensional flow of fluid.
9. Derive Navier-Stokes equation for two dimensional viscous flows. Estimate the velocity profile for Couette flow.

10. Show that $\boxed{\psi = \Lambda\, r^{\pi/\alpha} \sin(\pi\theta/\alpha)}$ satisfies Laplace equation. Derive the potential function for the corresponding irrotational flow. Generate and sketch the flow net when $\alpha = \frac{\pi}{2}$. For what value of α, the given stream function may represent an uniform flow.

OR

A smooth flat plate 1.5 m long, 30 cm wide is placed in a stream of air at 8 m/s.
Calculate:

(i) Thickness of the boundary layer and displacement thickness at the edge of the plate.
(ii) Skin friction drag force and the average value of 'C_f'.
(iii) Momentum thickness at the edge of the plate
Assume laminar flow and a third degree velocity profile in the boundary layer.
[For air, $\rho = 1.2\ \text{kg/m}^3$, $\mu = 15\times10^{-6}\text{m}^2/\text{s}$]