KATHMANDU UNIVERSITY
End Semester Examination
March/April, 2017

Marks Scored:

Level: B.Sc.
Year : II

Course : PHYS 202
Semester: I

Exam Roll No. :
Registration No:

Time: 30 mins.

F. M. : 20
Date MAR 3 0 2017

SECTION "A"

[15Q × 1 = 15 marks]

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

1. A block of base area 20 cm^2, weight 100 N slides down a 20^0 inclined plane over an oil film of thickness 1 mm, $\mu = 500$ poise. The steady state velocity of the block, assuming linear velocity profile in the oil film and Newtonian characteristics, is
[a] 34.2 m/s [b] 0.342 m/s [c] 3.42 m/s [d] 342 m/s

2. The flow has diverging straight streamlines. If the flow is steady, the flow
[a] is a uniform flow with local acceleration.
[b] has a convective normal acceleration.
[c] has convective tangential acceleration.
[d] has convective normal as well as tangential acceleration.

3. If a tank discharges water from an orifice under variable head 'h', the water surface will be lowered at constant velocity, the surface area varies as
[a] $\sqrt{h}$ [b] $\frac{1}{\sqrt{h}}$ [c] $\frac{1}{h}$ [d] h

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. The concept of continuum in fluid flow assumes that the characteristics length of the flow is
[a] smaller than the mean free path of the molecules.
[b] larger than the mean free path of the molecules
[c] larger than the dimensions of the suspended particles.
[d] larger than the wavelength of the sound in the medium.

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. Lines of constant potential function 'ϕ'
[a] are parallel streamlines
[b] are parallel to streamlines.
[c] are normal to the streamlines.
[d] can never intersect each other.

8. The velocity potential for a two-dimensional flow field is given by $\phi = (x^2-y^2)+3xy$. The corresponding stream function is
[a] $2xy-3/2(x^2+y^2)$ [b] $3/2(x^2-y^2)-2xy$ [c] $2xy+3/2(x^2-y^2)$ [d] $2xy-3/2(x^2-y^2)$

9. 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] $\frac{\partial u}{\partial r}+\frac{1}{r}\frac{\partial}{\partial \theta}(rv)$

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

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

11. In a laminar flow between two parallel plates with a separation of 6 mm, the central line velocity is 1.8 m/s. The velocity at a distance of 1 mm from the boundary is

[a] 0.15 m/s [b] 1.0 m/s [c] 0.55 m/s [d] 0.75 m/s

12. The apparent modulus of normal stress in an incompressible Newtonian fluid is equal to

[a] P [b] –P [c] μ [d] 2μ

13. A laminar boundary layer has a velocity distribution given by $\frac{u}{U_\alpha}=\frac{y}{\delta}$. The displacement thickness δ_1 for this boundary layer is

[a] δ [b] $\frac{\delta}{4}$ [c] $\frac{\delta}{2}$ [d] $\frac{\delta}{8}$

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. The Laminar sub-layer exists

[a] only in laminar boundary layer.

[b] only in smooth turbulent boundary layer.

[c] only in rough fully developed turbulent boundary layers.

[d] in all turbulent boundary layer.

16. The Bernoulli's equation for a particular flow is $\frac{P}{\rho}+\frac{v^2}{2}+gZ=C$. If the constant of integration 'C' is same at any place of flow field, then the flow is ....

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

18. The circumferential velocity $u=\frac{\Lambda}{2\pi r}$ for vortex flow becomes infinity at $r=0$. This indicates the existence of ....at the origin.

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 flat plate flow becomes turbulent at the location where $\frac{U_\alpha x}{\nu}$ is equal to ....

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F. M. : 55

SECTION "B"

[5Q × 4 = 20 marks]

Attempt *ALL* questions.

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. Setup the equation of motion for the forces acting on the boundaries of the control volume.

   OR

   Discuss the order of magnitude analysis as suggested by Prandtl. From this analysis also discuss the laminar to turbulent transition for external flow of the fluid.

3. Show that Bernoulli's equation being an equation of conservation of energy, can also be obtained by purely thermodynamic approach.

   OR

   Define circulation for two dimensional flow of an ideal fluid. Show that the circulation for two dimensional irrotational flow is zero.

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 $\mu = 1.983\times10^{-5}$ 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"

[5Q × 7 = 35 marks]

Attempt *ALL* questions.

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 in three dimensional flow of an ideal fluid. Show that the Euler's equation takes the form $\rho V\frac{dV}{dS} = -\frac{dp}{ds} - \rho g\frac{dz}{ds}$ when the three velocity components in the x, y and z direction are conversed to one in the direction of tangent.

   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. Show that Navier-Stoke's equation expressing the momentum change and the continuity equation for conservation of mass together constitutes the equation of motion of the fluid element. Establish equation for velocity profile for the flow of fluid through parallel channel.

10. 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, $\rho = 1.2\ kg/m^3$, $\mu = 15\times10^{-6} m^2/s$]

OR

A source of strength 10 m^2/s is located at point A (-1, 0) and a sink of strength 20 m^2/s is located at point B (1, 0) as shown in figure below. Find the resultant velocity and stream function at point P (2, 2).