First Semester M. E. Mech. Engg. (Thermal Engg.) Examination

## FLUUD DYNAMICS

Paper-1 MTE 3
P. Pages: 3

Time : Three Hours
[Max. Marks: 80
Note : (1) Separate answer book must be used for each section in the subject Geology, Engineering material of civil branch and Separate answer book must be used for Section A and B in Pharmacy and Cosmetic Tech.
(2) All question carry marks as indicated.
(3) Answer Three questions from Section $A$ and Three questions from Section B.
(4) Due credit will be given to neatness and adequate dimensions.
(5) Diagrams and Chemical equations should be given wherever necessary.
(6) Assume suitable data wherever necessary.
(7) Illustrate your answer wherever necessary with the help of neat sketches.
(8) Use pen of Blue/Black ink/refill only for writing the answer book.

## SECTION A

1. (a) Derive an expression for the Eulers equation of motion for an ideal fluid in three dimensions.
(b) Define circulation and vorticity. What is the relation between circulation and vorticity?
2. (a) What is a flow net ? What are its limitations and uses ? 6
(b) The velocity components for a fluid flow are $u=a+b y-c z, u=d-b x-e z$, $w=f+c x-e y$ whever $a, b, c, d, c$ and $f$ are arbitrary constants.
(i) Show that it is a possible case of fluid flow.
(ii) Is the fluid flow irrotational ? If not, determine the vorticity and rotation.
3. (a) Explain the following terms as applied to the two dimensional flow of a incompressible fluid.
(i) Source
(ii) sink
(iii) Strength of source
(vi) Doublet and
(v) Strength of doublet
(b) Prove that for a doublet whose axis is horizontal and strength is $\mu$, the velocity potential function is given by

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\begin{equation*}
\phi=-\frac{\mu}{2 \pi} \cdot \frac{\cos \theta}{r} \tag{8}
\end{equation*}
$$

4. (a) A source of strength $+q$ and a sink of strength $-q$ are placed in uniform flow of velocity V . Draw the flow pattern for the resultant flow and obtain the expressions for stream and velocity potential functions.6
(b) A uniform flow of $12 \mathrm{~m} / \mathrm{s}$ is flowing over a doublet of strength $18 \mathrm{~m}^{2} / \mathrm{s}$ The double is in line of the uniform flow, Determine;
(i) Shape of the Rankine oval.
(ii) Radius of the Rankine oval.
(iii) Value of stream line function at Rankine circle and
(iv) Resultant velocity at a point on the Ranking circle at an angle of $30^{\circ}$ from $x$-axis.
5. (a) What is conformal mapping ? Discuss the applications of conformal mapping in aero-dynamics and fluid flow.
(b) Separate the real and imaginary parts for the following transformation.
(i) $\mathrm{w}=\mathrm{kz}{ }^{2}$
(ii) $\mathrm{w}=\frac{\mathrm{k}}{\mathrm{z}^{2}}$
(iii) $w=z+\frac{\mathbf{a}^{2}}{z}$

## SECTION B

6. (a) Name the semiemperical theories of turbulence and explain any one. 7
(b) Derive the Prandtles universal velocity distribution equation for turbulent flow in non dimensional form.
7. (a) A pipe 200 mm diameter conveys water. Measurement indicates that the velocity at the pipe centre and that at a distance 50 mm from the pipe centre are $2.5 \mathrm{~m} / \mathrm{s}$ and $2 \mathrm{~m} / \mathrm{s}$ respectively. The flow in the pipe is turbulent. Calculate the shear velocity and the wall shear stress.
(b) Define Rayleight and Fanno flows. Sketch the Rayleigh line and Fanno line for constant area frictionless flow on $h$-s diagram.
8. (a) How is the strength of shock defined? Show that it is given by
strength of shock $=\frac{2 r}{r+1}\left(M^{2}-1\right)$
(b) A large tank contains air at $284 \mathrm{kN} / \mathrm{m}^{2}$ gauge pressure and $24^{\circ} \mathrm{C}$ temperature. The air flows from the tank to the atmosphere through a convergent nozzle. If the diameter at the outlet of the nozzle is 200 mm , find the maximum flow rate of air.
Take $R=287 \mathrm{~J} / \mathrm{kg} \mathrm{k}, \mathrm{r}=1.4$ and atmospheric pressure $=100 \mathrm{kN} / \mathrm{m}^{2}$.
9. (a) Describe the phenomenon of boundary layer separation when the flow takes place over a curved surface. What are the different methods of controlling boundary layer separation?
(b) If the velocity distribution in laminar boundary layer over a flat plate is assumed to be
$\mathrm{u}=\mathrm{A}+\mathrm{By}+\mathrm{Cy}^{2}+\mathrm{Dy}^{3}$. determine its form using the necessary boundary conditions.
10. (a) A flat plate 0.3 m long and 2 m wide is placed along a $1.2 \mathrm{~m} / \mathrm{s}$ flow of water at $15^{\circ} \mathrm{C}$. Assume the boundary layer on each face is laminar and the velocity profile is linear

$$
\frac{u}{U}=A+B y
$$

Determine the drag force on the plate, taking the viscosity of water as 1.1 $\times 10^{-6} \mathrm{~m}^{2} / \mathrm{s}$ and density $1000 \mathrm{~kg} / \mathrm{m}^{3}$.
(b) Air at standard conditions flows over a flat plate. The free stream speed is $15 \mathrm{~m} / \mathrm{s}$. Find boundary layer thickness and shcar stress $\tau_{o}$ at $\mathrm{x}=1 \mathrm{~m}$ from the leading edge for
(i) Completely laminar flow with parabolic velocity profile and
(ii) Completely turbulent flow with " $1 / 7^{\text {th }}$ power" velocity profile. For air

$$
\begin{align*}
& \mathrm{r}=1.5 \times 10^{-5} \mathrm{~m}^{2} / \mathrm{s} \text { and } \\
& \mathrm{e}=1.23 \mathrm{~kg} / \mathrm{m}^{3} . \tag{6}
\end{align*}
$$

