# II B.Tech I Semester Examinations,MAY 2011 <br> MECHANICS OF FLUIDS <br> Aeronautical Engineering 

Time: 3 hours
Max Marks: 75

## Answer any FIVE Questions

All Questions carry equal marks

1. (a) Describe a formula developed by Darcy for loss of head due to friction for the flow through a pipe.
(b) A pipe carrying water increased in diameter from 40 cm to 100 cm suddenly. The pressure difference in small and bigger sections is measured by using Hg -U-tube which connected to upstream and downstream of the enlarged section immediately. The difference in pressure is equal to 6 cm of Hg . Find out the discharge through the pipe. Take sp.gr. of $\mathrm{Hg}=13.6$.
2. Write the Euler's equation for flow along a stream line and derive Bernoulli?s equation from this equation. What are the assumptions made?
3. A pipe converges uniformly from 0.5 m diameter to 0.25 m over 2.5 m length. The rate of flow changes uniformly from $25 \mathrm{l} / \mathrm{s}$ to $50 \mathrm{l} / \mathrm{s}$ in 40 seconds. Find the total acceleration at the middle of the pipe at $20^{t h}$ second.
4. (a) Explain the concept of stagnation properties.
(b) A supersonic plane flies at $2000 \mathrm{~km} / \mathrm{hr}$ at an altitude of 9 km above sea level in standard atmosphere. If the pressure and density of air at this altitude are stated to be $30 \mathrm{kN} / \mathrm{m}^{2}$ absolute and $0.45 \mathrm{~kg} / \mathrm{m}^{3}$, make calculations for the pressure, temperature and density at the stagnation point on the nose of the plane. Take $\mathrm{R}=287 \mathrm{~J} / \mathrm{kg} \mathrm{K}$ and $\gamma=1.4$.
5. At a certain point in a fluid the shear stress is $0.216 \mathrm{~N} / \mathrm{m}^{2}$ and the velocity gradient $0.267 \mathrm{~s}^{-1}$. If the mass density of the fluid is $1268 \mathrm{~kg} / \mathrm{m}^{\mathbf{3}}$, find the kinematic viscosity of the fluid.
6. (a) What are the practical types of flow?
(b) A 100 mm diameter pipe 1000 m long is used to pump oil of viscosity 0.85 $\mathrm{Ns} / \mathrm{m}^{2}$ and specific gravity 0.92 at the rate of 1200 litres/minute. The first 300 m length of the pipe is laid along the ground sloping upwards at $10^{0}$ to the horizontal and the remaining 700 m length of the pipe is laid on the ground sloping at $15^{0}$ to the horizontal. State whether the flow is laminar or turbulent. Find the pressure required to be developed by the pump and also the power of the driving motor if the efficiency of the pump is $60 \%$. Assume pressure head at the end of the pipe to be atmospheric. $[4+11]$
7. (a) Prove that the momentum thickness and energy thickness for boundary layer flow are given
$\theta=\int_{0}^{\delta} \frac{u}{U}\left[1-\frac{u}{U}\right] d y$ and $\delta^{* *}=\int_{0}^{\delta} \frac{u}{U}\left[1-\frac{u^{2}}{U^{2}}\right] d y$
where U is the free stream velocity.
(b) Water is flowing over a thin smooth plate of length 4.5 m and width 2.5 m at a velocity of $0.9 \mathrm{~m} / \mathrm{s}$. If the boundary layer flow changes from laminar to turbulent at a Reynolds number $5 \times 10^{5}$, find:
i. The distance from the leading edge up to which the boundary layer is laminar
ii. Thickness of the boundary layer at the transition point and
iii. the drag forces on one side of the plate. Take viscosity of water as 0.01 poise.
8. 215 liters of gasoline ( $\mathrm{S}=0.82$ ) flows per second upwards in anfinclined venturimeter fitted to a 300 mm diameter pipe. The venturimeter is inclined at $60^{\circ}$ to the vertical and its 150 mm diameter throat is 1.2 m from the entrance along itslength. Pressure gauges inserted at entrance and throat show pressures of $0.141 \mathrm{~N} / \mathrm{min}$ and 0.077 $\mathrm{N} / \mathrm{mm}^{2}$ respectively. Calculate $\mathrm{C}_{d}$ of the venturimeter. If instead of pressure gauges the entrance and the throat of the venturimeter are connected to the two limbs of a U-tube mercury manometer, find its reading in mm of differential mercury column.

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1. (a) When pipes are connected in series what is the loss of head in the system?
(b) A sudden expansion from a diameter of 250 mm to a diameter of 500 mm is provided in a pipe line. The power lost due to the sudden enlargement is found to be 5 kW . Find the rate of flow in the pipe and the difference of pressure between sections before and after the sudden enlargement.
2. (a) What do you understand by stagnation pressure and stagnation temperature? Prove that they are given by
$T_{o}=T\left[1+\frac{\gamma-1}{2} M^{2}\right]$ and $p_{o}=p\left[1+\frac{\gamma-1}{2} M^{2}\right]$ where $C=\sqrt{\gamma R T}$.
(b) Air flows adiabatically with increasing velocity along the flow direction. At section- $\mathrm{I}, \mathrm{P}_{\mathbf{1}}=275 \mathrm{kN} / \mathrm{m}^{2}$ (ab.), $\mathrm{T}=453 \mathrm{~K}$ and $\mathrm{v}_{1}=150 \mathrm{~m} / \mathrm{s}$. At section-II, air flow just allows the sonic velocity, find the pressure, temperature, velocity and density at section-II. Take $\mathrm{R}=287 \mathrm{Nm} / \mathrm{kg}-\mathrm{K}$.
3. (a) What are the different methods of preventing the separation of boundary layers?
(b) Find the displacement thickness, momentum thickness and energy thickness for the velocity distribution in the boundary layer given by
$\frac{u}{U}=2\left(\frac{y}{\delta}\right)-\left(\frac{y}{\delta}\right)^{2}$
where $\delta=$ boundary layer thickness, U is the free stream velocity. $\quad[5+10]$
4. (a) Obtain an expression for the value of pressure drop in an incompressible, laminar and steady Couette flow such that shear stress at the stationary plate is zero.
(b) Two parallel plates are placed 10 mm apart. The bottom plate is fixed and the top plate is moved at a uniform speed of $1 \mathrm{~m} / \mathrm{s}$. The fluid in the 10 mm space has a viscosity of $0.08 \mathrm{Ns} / \mathrm{m}^{2}$. If the pressure drops from 200 kPa to 100 kPa over a distance of 100 m , determine the velocity distribution and rate of flow.
5. A 120 m long surface vessel is to be tested by a 3 m long model. If the vessel travels at $10 \mathrm{~m} / \mathrm{s}$, at what speed must the model be towed for dynamic similarity between model and prototype? If the drag on the model is 9.5 N , what is the drag force expected on the prototype?
6. (a) Differentiate between the Eulerian and Lagrangian methods of representing fluid flow.
(b) Given the velocity field $\mathrm{V}=\left(6+2 \mathrm{xy}+\mathrm{t}^{2}\right) \mathrm{i}-\left(\mathrm{xy}^{2}+100\right) \mathrm{j}+25 \mathrm{k}$. What is the local acceleration, convective acceleration and total acceleration at (3, 0, $2)$ at time $t=2$ ?
[8+7]
7. Two pipes 0.5 m and 0.25 m in diameter are connected by a smooth transition bend making an angle of $75^{\circ}$ between the two pipes. When a discharge of $0.4 \mathrm{~m}^{3} / \mathrm{s}$ of water is flowing through this bend, the pressure on the U/S larger diameter pipe is 200 kpa . Calculate the force on the bend. Assume the bend to be horizontal. [15]
8. (a) A solid cone of radius R , height h and relative density 0.70 floats in fresh water with its axis vertical and vertex downwards. Determine the minimum value of $R / h$.
(b) Define and explain the terms metacentre and metacentric height.

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[10+5]
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1. (a) What is the cause of vibration of telephone wires in a strong wind blowing across the wire? Under what conditions, could such a vibrations lead to rupture?
(b) What frequency of oscillation may be expected when air of knematic viscosity $15 \mathrm{~mm}^{2} / \mathrm{s}$ flows at $2 \mathrm{~m} / \mathrm{s}$ past a 3 mm diameter telephone wire which is perpendicular to the air stream?
2. The velocity distribution in a circular pipe of radius $R$ is given by
$\frac{\mu}{\mu_{m}}=\left(1-\frac{r}{R}\right)^{n}$ Where u is the velocity at any radial distance r from the axis of the pipe, um is the maximum velocity at the axis of the pipe and n is a constant. Determine the energy correction and momentum correction factors from this flow.
3. 2.57 kg of gas for which theratio of specific heats is 1.35 occupies a volume of 0.15 $\mathrm{m}^{3}$ at 10 bar and 500 K . The gas undergoes expansion to $0.6 \mathrm{~m}^{3}$ and process of expansion may follow any one of the following cases:
(a) Constant pressure,
(b) Constant temperature,
(c) Adiabatic
(d) Polytropic law $\mathrm{pV}^{1.32}=$ const.

For these cases determine:
(a) Final temperature,
(b) Work done and
(c) Heat interchange.
4. (a) With a neat sketch explain the working of
i. pitot tube and
ii. Hot wire anemometer.
(b) Explain how viscosity of a fluid is measured using a viscometer.
5. (a) Prove that for a steady laminar flow between two fixed parallel plates, the velocity distribution across a section is parabolic and that the average velocity is $2 / 3^{\text {rd }}$ of the maximum velocity.
(b) Fluid flows at the rate of 0.5 liter per second per unit width between two infinite parallel plates kept stationary 2 cm distance apart. If the flowing fluid has a mass density $1250 \mathrm{~kg} / \mathrm{m}^{3}$ and dynamic viscosity $0.9 \mathrm{Ns} / \mathrm{m}^{2}$, determine the pressure drop per unit length.
6. (a) Differentiate between hydraulic gradient line and total energy line.
(b) The water surface levels of two reservoirs differ by 12 m . they are connected by a 55 m long pipe. For the first 25 m length the diameter is 120 mm and for the remaining length the diameter is 150 mm . The coefficient of friction of the 120 mm diameter and 150 mm diameter pipes are respectively 0.006 and 0.005 . The junctions with the reservoirs and between the pipes are abrupt. Determine the discharge. If the discharge should be 30 liters per second, what should be the difference of water level in the reservoirs. [4+11]
7. (a) Distinguish between rotational and irrotational flow.
(b) Show that the velocity components given by $u=\frac{2 n x}{t} \mathrm{~V}=-\frac{y}{t}$ and $\mathrm{w}=\mathrm{z} / \mathrm{t}$ represent a possible fluid flow. Mention whether the flow is rotational or not.
8. An opening of 1 m depth and 3 m idth is provided in the vertical side of a large tank. The water surface in the tank is 4 m above the top of the opening. If the opening is closed by a plate which is held in place by 4 bolts placed at the corners, determine the force in each bolt.

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1. A Venturimeter with an entrance diameter of 0.3 m and a throat diameter of 0.2 m is used to measure the volume of gas flowing through a pipe. The discharge coefficient of the meter is 0.96 . Assuming the specific weight of the gas to be constant at $19.62 \mathrm{~N} / \mathrm{m}^{3}$, calculate the volume flowing when the pressure difference between the entrance and the throat is measured as 0.06 m on a water U-tube manometer. [15]
2. (a) What do you mean by momentum correction factor and kinetic energy correction factor?
(b) If the critical velocity of water in a 25 mm diameter pipe is 0.09 metre per second, find the critical velocity of air in a pipe of 300 mm diameter.
Density of water $=1 \mathrm{gm} / \mathrm{cc}$
Density of air $=0.0012$ gm/ec
Viscosity of water $=0.01$ poise
Viscosity of air $=0,00018$ poise
3. (a) Distinguish between
i. Standard and local atmospheric pressure
ii Absolute pressure and gauge pressure
iii. Gauge pressure and vacuum pressure.
(b) Explain, the principle of working og bourdom pressure gauge with a neat sketch.
4. (a) Define the terms stream line, streak line and path line.
(b) Show that the stream function and velocity potential intersect orthogonally.
5. (a) When pipes are connected in parallel, what is the loss of head in the system?
(b) The Reynolds number for a liquid in a pipe of 250 mm diameter is 1800 . Find the Reynolds number in a 150 mm diameter pipe forming an extension of 250 mm diameter pipe.
[5+10]
6. (a) What is sonic velocity? On what factors does it depend?
(b) A supersonic aircraft flies at an altitude of 1.8 km where temperature is $4^{0} \mathrm{C}$. Determine the speed of the aircraft if its sound is heard 4 seconds after its passage over the head of an observer. Take $\mathrm{R}=287 \mathrm{~J} / \mathrm{kg} \mathrm{K}$ and $\gamma=1.4$.
7. (a) How will you find the drag on a flat plate due to laminar and turbulent boundary layers?
(b) For the velocity profile for turbulent boundary layer $\frac{u}{U}=\left(\frac{y}{\delta}\right)^{\frac{1}{7}}$, obtain an expression foe boundary layer thickness, shear stress, drag force on one side of the plate and co-efficient of drag in terms of Reynolds number. Given the shear stress $\left(\boldsymbol{\tau}_{0}\right)$ for turbulent boundary layer as $\tau_{0}=0.0225 \rho U^{2}\left(\frac{\mu}{\rho U \delta}\right)^{\frac{1}{4}} . \quad[4+11]$
8. (a) Describe that each term in the Bernoulli's equation represents the energy per unit weight.
(b) A turbine is set 40 m below the water level of a reservoir and is fed by 60 cm diameter pipe. If short pipe of 45 cm diameter discharges water from the turbine to atmosphere neglecting friction, estimate the power extracted by the turbine when the discharge is $0.8 \mathrm{~m}^{3} / \mathrm{s}$.
$[8+7]$
