Tutorial 4: Mechanics of Continuous Media:

- Elasticity, Hooke's law and elastic constants of isotropic solids and their inter-relation;
- Streamline (Laminar) flow, viscosity, Poiseuille's equation, Bernoulli's equation, Stokes' law and applications.

Q1:

A sphere of radius R moves with velocity $\vec{u}$ in an incompressible, non-viscous ideal fluid. Calculate the pressure distribution over the surface of the sphere. Do you think that a force is necessary to keep the sphere in uniform motion ? *10*

2014

Q2:

Using Poiseuille's formula, show that the volume of a liquid of viscosity coefficient η passing per second through a series of two capillary tubes of lengths l_1 and l_2 having radii r_1 and r_2 is obtained as

$$Q = \frac{\pi p}{8\eta} \Big/ \left[\frac{l_1}{r_1^4} + \frac{l_2}{r_2^4}\right],$$

where p is the effective pressure difference across the series. *15*

2015

Q3:

Define coefficients of viscosity and kinematic viscosity of a fluid. What are Poise and Stokes ? *10*

2015

Q4:

Write down Poiseuille's formula and mention its limitations in analyzing the flow of a liquid through a capillary tube. *10*

2015

Q5:

Show that the Young's modulus Y, modulus of rigidity n and Poisson's ratio σ are related by the equation $Y = 2n(1 + \sigma)$. 10

2016

Q6:

A horizontal pipe of non-uniform bore has water flowing through it such that the velocity of flow is 40 cm/s at a point where the pressure is 2 cm of mercury column. What is the pressure at a point where the velocity of flow is 60 cm/s? (Take, $g = 980\ \text{cm}/\text{s}^2$ and density of water = 1 g/c.c.) 10

2016

Q7:

State and explain Stokes' law. A drop of water of radius 0·01 m is falling through a medium whose density is $1{\cdot}21\ \text{kg/m}^3$ and $\eta = 1{\cdot}8 \times 10^{-5}\ \text{N-s/m}^2$. Find the terminal velocity of the drop of water. 15

2017

Q8:

Two capillary tubes of lengths $2l$ and l with internal radii r and 2r respectively are connected in series. Water flows through them in streamline. If the pressure difference across the first capillary is P, find the pressure difference across the second one. *10*

2018

Q9:

A water drop of radius 0·04 mm is falling through air. If the coefficient of viscosity for air is $1{\cdot}8 \times 10^{-4}$ poise, find its terminal velocity. If 100 such drops coalesce, what will be the new terminal velocity ? *10*

2018

Q10:

(i) रेनॉल्ड्स संख्या तरल गति के अध्ययन में कैसे मदद करती है ?
How does Reynolds number help in the study of fluid motion ?

(ii) एकसमान अनुप्रस्थ परिच्छेद वाली क्षैतिज नली में, 1 km की दूरी के दो बिन्दुओं के बीच के अंतर पर दाब 5 Nm^{-2} गिर जाता है । इन बिन्दुओं पर बहने वाले प्रति 1 किग्रा तेल की गतिज ऊर्जा में परिवर्तन की गणना कीजिए । तेल का घनत्व = 800 kg m^{-3}.
In a horizontal pipeline of uniform area of cross-section, the pressure falls by 5 Nm^{-2} between two points separated by a distance of 1 km. Calculate the change in kinetic energy per kg of oil flowing at these points. Density of oil = 800 kg m^{-3}. *10*

2019

Q11:

A rubber cord 1 mm in diameter and 1 m long is fixed at one end and a weight of 1 kg is attached to the other end. If the Young's modulus of rubber is $0{\cdot}05 \times 10^{11}$ dynes cm^{-2}, then find the period of the vertical oscillations of the weight. *10*

2020

Q12:

A shaft of diameter 8 cm and length 5 m is transmitting power of 8 kW at 300 revolutions per minute. If the coefficient of rigidity of the material of the shaft be 8×10^{11} dynes/cm^2, then calculate the relative shift between the ends of the shaft. *15*

2020

Q13:

A capillary tube having 1·0 mm diameter, 20 cm in length is fitted horizontally to a vessel in which alcohol is kept fully up to the neck. Density of alcohol is 8×10^2 kg/m^3. The depth of the centre of the capillary tube below the surface of alcohol is 40 cm. Find the amount of alcohol that will flow out of the capillary tube in 10 minutes. Coefficient of viscosity of alcohol is 0·0012 Ns/m^2. *10*

2021

Q14:

A light rod of length 100 cm is suspended from the ceiling, horizontally by means of two vertical wires of equal length tied to its ends. One of the wires is made of steel and its cross-section is 0·05 sq. cm and the other is of brass of cross-section 0·1 sq. cm. Find the position along the rod at which a weight may be hung to produce

(i) Equal stresses in both the wires,

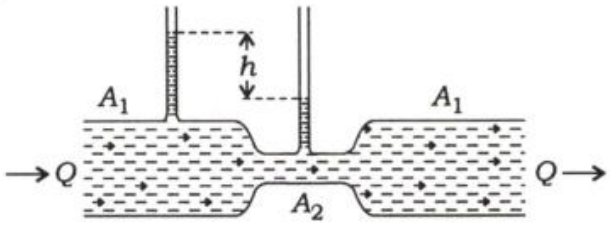
(ii) Equal strain in both the wires.

Young's modulus of elasticity of brass and steel are $1{\cdot}0 \times 10^{11}$ N/m^2 and $2{\cdot}0 \times 10^{11}$ N/m^2 respectively. *15*

2021

Q15:

Consider the diagram below with a water flow rate Q. Derive the expression for Q in terms of the difference in the manometer heights h and the cross-section areas A_1 and A_2 :



15

2022

Q16:

Define streamline flow of a fluid. Using the equation of continuity for an isotropic fluid, find different components of total energy per unit volume. *15*

2023

Q17.

State and explain the Hooke's law of elasticity. Briefly discuss the features of stress-strain diagram for the behaviour of a wire undergoing increasing stress. 10

2024

Q18.

Explain the Poiseuille's equation for the rate of flow of a liquid through a capillary tube. From this, show that if two capillary tubes of radii r_1 and r_2 having lengths l_1 and l_2, respectively, are connected in series, the rate of flow of the liquid is given by

$$Q = \frac{\pi P}{8\eta}\left(\frac{l_1}{r_1^4} + \frac{l_2}{r_2^4}\right)^{-1}$$

where P is the pressure across the arrangement and η is the coefficient of viscosity of the liquid. 10

2024

Q19.

A solid shaft of mass M, length l and radius r is to be replaced by a lighter hollow shaft of the same length l and having the same ratings of τ/θ, where τ is the couple and θ is the angle of twist. Estimate the percentage reduction in mass of the hollow shaft if the outer radius of the shaft is twice the inner radius. Assume the material of the new shaft is same as that of the replaced shaft. *15*

2025