# DUMKAL COLLEGE

## 2ND SEMESTER INTERNAL EXAMINATION 2026

**Subject: Physics (Major) | Paper: Mechanics**

**Full Marks: 15** **Time: 1 Hour**

**** Answer any three questions. Figures to the right indicate full marks for the respective sub-questions.***

### Question 1

**(a)** Derive the theoretical relation between Young's modulus ($Y$), Modulus of Rigidity ($\eta$), and Poisson's ratio ($\sigma$): **(3 Marks)**
$Y = 2\eta\,(1 + \sigma)$

**(b)** Show that for an isotropic solid, the theoretical limits of Poisson's ratio are $-1 \le \sigma \le 0.5$. **(2 Marks)**

### Question 2

Derive Poiseuille's formula for the rate of steady flow ($V$) of a viscous liquid through a horizontal capillary tube of **(5 Marks)** length $l$ and radius $r$ under a pressure difference $P$, given by $V = \pi P r^4 / (8 \eta l)$. Explicitly state all fundamental assumptions made during the derivation.

### Question 3

**(a)** Derive expressions for the gravitational field intensity ($E$) and gravitational potential ($V$) at a point inside ($r <$ **(3.5 Marks)** $R$) and outside ($r \ge R$) a uniform solid sphere of mass $M$ and radius $R$.

**(b)** Sketch the variation of gravitational field intensity $E(r)$ and gravitational potential $V(r)$ with distance $r$ from **(1.5 Marks)** the center of the solid sphere.

### Question 4

**(a)** Show that in an elastic two-body collision in the Laboratory (L) Frame, if the target particle of mass $m_2$ is **(3.5 Marks)** initially at rest, the maximum scattering angle $\theta_{max}$ of the incident particle of mass $m_1$ (when $m_1 > m_2$) is given by $\theta_{max} = \sin^{-1}(m_2 / m_1)$.

**(b)** Express the relation between the scattering angle in the Laboratory frame ($\theta$) and the Center of Mass frame **(1.5 Marks)** ($\theta^*$).

### Question 5

**(a)** Set up the differential equation for a driven/forced harmonic oscillator subjected to a periodic driving force $F =$ **(1 Mark)** $F_0 \cos(\omega t)$.

**(b)** Find its steady-state solution for displacement $x(t)$. **(2 Marks)**

**(c)** Define Resonance and Quality Factor ($Q$). Derive the relationship showing that $Q = \omega_0 / \Delta\omega$ (the ratio of the **(2 Marks)** resonant frequency to the full width at half maximum of the power resonance curve).