M.E. MECHANICAL ENGINEERING 1st YEAR 2nd SEM EXAM 2025

CONTACT MECHANICS

Time: Three hours Full Marks: 100

Missing data, if any, may be assumed.

Answer any **five** questions.

1. a) Consider the contact between a rigid plane and a thin elastic spherical cap which is bound to another rigid plane. Use uniaxial deformation approximation to determine the qualitative relation between contact force and depth of penetration.
   b) A rigid sphere is in contact with an elastic half-space. Estimate qualitatively the contact force in terms of penetration depth for both elastic and plastic deformation of the half-space. 10+10

2. Determine the force-displacement dependence, the effective modulus of elasticity, and the shear stress distribution in a contact plane for a thin, round, elastomer sheet with a radius R and thickness h, assuming that the material is incompressible. Consider two cases: (a) the sheet sticks to both rigid planes (b) the sheet sticks to one surface and slides without friction on the other. 10+10

3. a) Explain Hertz contact problem. For this, derive the expressions for contact force and contact radius.
   b) A steel railway wheel with a 400 mm radius rolls on a steel rail with a cross radius of 300 mm. The load on the wheel is 4.5 kN. Find the maximum contact stress and contact area. Take E = 210 GPa and Poisson's ratio = 0.3 for steel.
   10+10

4. a) Explain Greenwood-Williamson model of contact of rough surfaces. State its limitations.

b) An elastic ball of dia 60 mm is allowed to fall from a height h on a steel plate. This produces a contact impression of 20 micron dia. Assume all deformation are elastic. Find the maximum contact pressure if the ball is dropped from a height of 3h. Take E = 210 GPa and Poisson's ratio = 0.3 for steel.

10+10

5. a) Draw and explain the load-displacement relation for contacting solids following JKR adhesive contact. Derive JKR equation for contact load and contact radius.

b) In a milling mill, two rolls are 500 mm dia and 80 mm dia respectively and their axial length is 1 m. The maximum load between the rolls is 2 MN. Find the maximum contact pressure. Take E = 200 GPa and Poisson's ratio = 0.3.

10+10

6. a) What is depth sensing indentation? Draw and explain typical load-displacement curve in depth sensing indentation.

b) Explain how unloading curve can be used to determine the combined elastic modulus. 10+10

7. Write short notes on:

a) Asperity interaction

b) Plastic asperity concept model

c) Kogut-Etsion elastic-plastic contact

d) Indentation size effect 5 x 4