I. Answer the following questions:

i. What is the center of percussion when a rigid body in plane motion? Also define its location mathematically (8%)

ii. What is the impending condition for a block on a rough plane, and try to define the coefficient of static friction (9%)

iii. To define the wrench for a three-dimensional forces system. Also illustrate a three-dimensional forces system must be replaced by a wrench (9%).

iv. When a circular cylinder is rolling without slipping on a smooth surface. To describe both of its space and body centrode (8%).

II. Spherical particle 1 has a velocity $v_1 = 6$m/s in the direction shown and collides with spherical particle 2 of equal mass and diameter and initially at rest. If the coefficient of restitution for these conditions is $e = 0.6$, determine the resulting motion of each particle following impact (16%).

III. For a rigid body motion relative to rotating axes, derive the relation of relative accelerations of a particle A to a particle B can be written as:

$$\mathbf{a}_A = \mathbf{a}_B + \dot{\omega}\times\mathbf{r} + \omega\times(\omega\times\mathbf{r}) + 2\omega\times\mathbf{v}_{rel} + \mathbf{a}_{rel} \quad (10\ \%)$$

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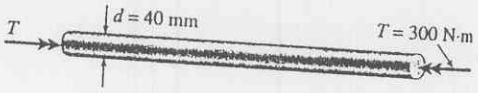
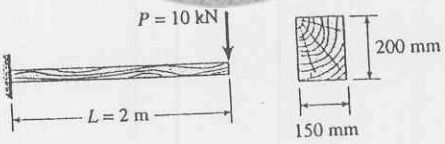
IV. A steel aluminum bar ($G = 27$ Gpa) of diameter $d = 40$ mm is subjected to torques $T = 300$ N-m acting in the direction shown in the figure. Determine the maximum shear, tensile, and compressive stresses and the corresponding maximum strains in the bar(20%)



V. A cantilever beam of length $L = 2$ m supports a load $P = 10$ kN (see figure). The beam is made of wood with cross-sectional dimensions 150 mm x 200 mm. Calculate the shear stresses due to the load P at points located 25 mm, 50 mm, 75 mm, and 100 mm from the top surface of the beam.(20%)



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