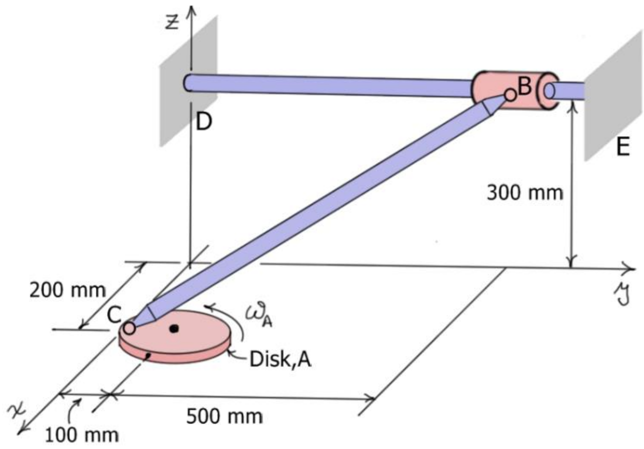
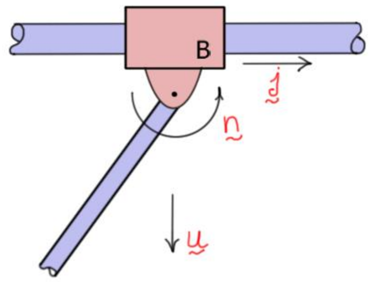
1) The figure shows a three-dimensional slider crank mechanism. The (x, y, z) axes shown represent a fixed reference frame R. At the instant shown, disk A has angular velocity ${}^R\underset{\sim}{\omega}_A = 10\underset{\sim}{k}$ (rad/sec).

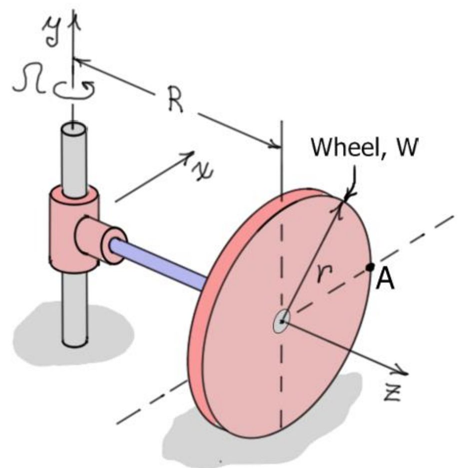


a) If BC is attached to both the disk and the collar with ball-and-socket joints, find ${}^R\underset{\sim}{\omega}_{BC}$ and ${}^R\underset{\sim}{v}_B$. In this case, assume that ${}^R\underset{\sim}{\omega}_{BC}$ is ***perpendicular*** to BC.

b) If the ball-and-socket joint at the collar is replaced with the ***two-axis joint*** shown at the right, find ${}^R\underset{\sim}{\omega}_{BC}$ and ${}^R\underset{\sim}{v}_B$. In this case, the rod BC rotates relative to collar C about the axis defined by the unit vector $\underset{\sim}{n}$ which is perpendicular to the plane BCD, and the collar translates and rotates about the $\underset{\sim}{j}$ direction. In this case, ${}^R\underset{\sim}{\omega}_{BC}$ is ***perpendicular*** to the vector $\underset{\sim}{u} = \underset{\sim}{j} \times \underset{\sim}{n}$.



2) The system shown consists of a vertical column, a horizontal axle, and a wheel of radius r. The horizontal arm rotates at a ***constant*** rate Ω, and the wheel (W) rolls without slipping in a circular arc. Find $\underset{\sim}{\omega}_W$ and $\underset{\sim}{\alpha}_W$ the angular velocity and angular acceleration of the wheel relative to a fixed frame, and find $\underset{\sim}{v}_A$ and $\underset{\sim}{a}_A$ the velocity and acceleration of point A.



3) In the system shown, beveled gear A rolls on beveled gear B. As it rolls on B it spins about the axle AD which is pinned to the vertical shaft DE. If DE rotates at a ***constant*** angular velocity ω_1 (rad/sec), find ${}^{AD}\underset{\sim}{\omega}_A$ the angular velocity of gear A relative to the axle AD, ${}^{R}\underset{\sim}{\omega}_A$ the angular velocity of gear A, ${}^{R}\underset{\sim}{\alpha}_A$ the angular acceleration of gear A, and $\underset{\sim}{a}_C$ the acceleration of tooth C of gear A.