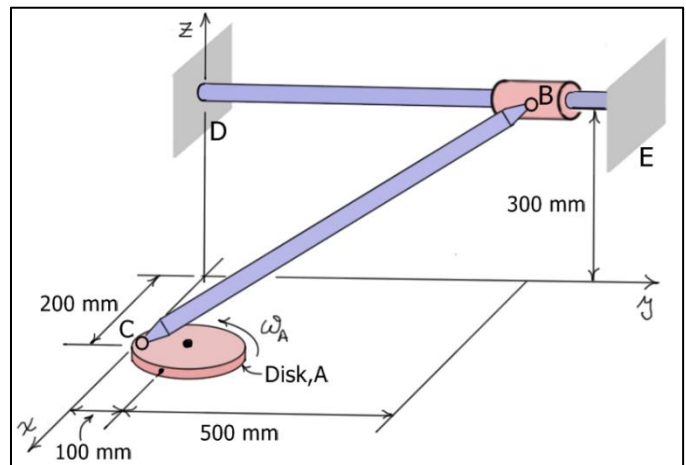


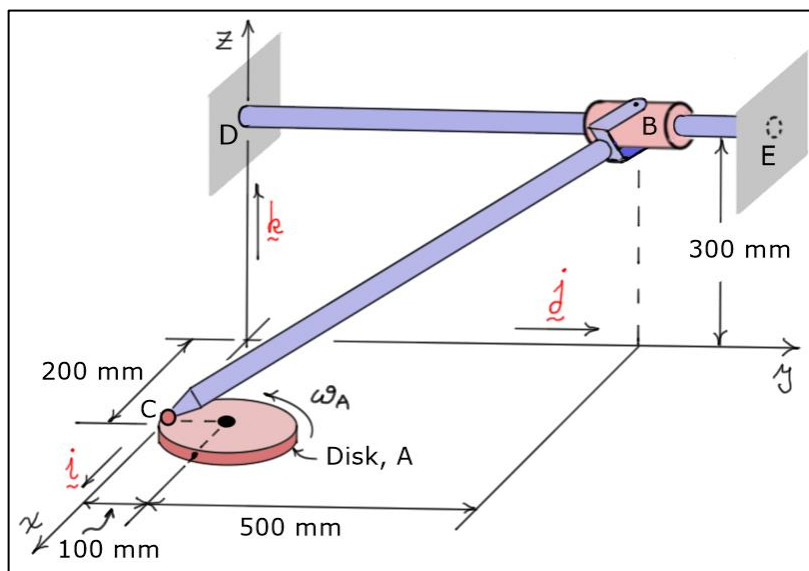
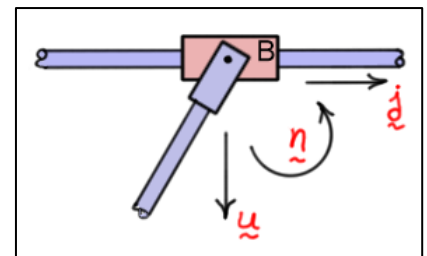
ME 5550 Intermediate Dynamics
Exercises #3

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 ${}^R\omega_A = 10\mathbf{k}$ (rad/sec).



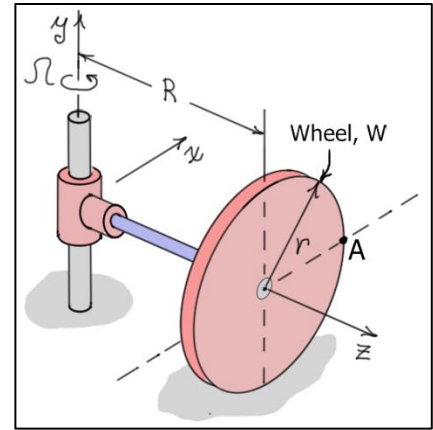
a) If BC is attached to both the disk and the collar with ball-and-socket joints, find ${}^R\omega_{BC}$ and Rv_B . In this case, assume that ${}^R\omega_{BC}$ is **perpendicular** to BC . (Hibbeler, 1995)

b) If the ball-and-socket joint at the collar is replaced with the **two-axis joint** shown at the right, find ${}^R\omega_{BC}$ and Rv_B . In this case, the rod BC rotates relative to collar C about the axis defined by the unit vector \mathbf{n} which is perpendicular to the plane BCD , and the collar translates and rotates about the \mathbf{j} direction. In this case, ${}^R\omega_{BC}$ is **perpendicular** to the vector $\mathbf{u} = \mathbf{j} \times \mathbf{n}$. (Hibbeler, 1995)

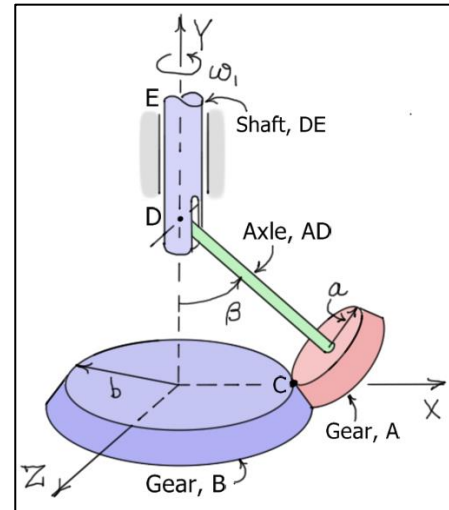


Slider-Crank with Joint of Part (b)

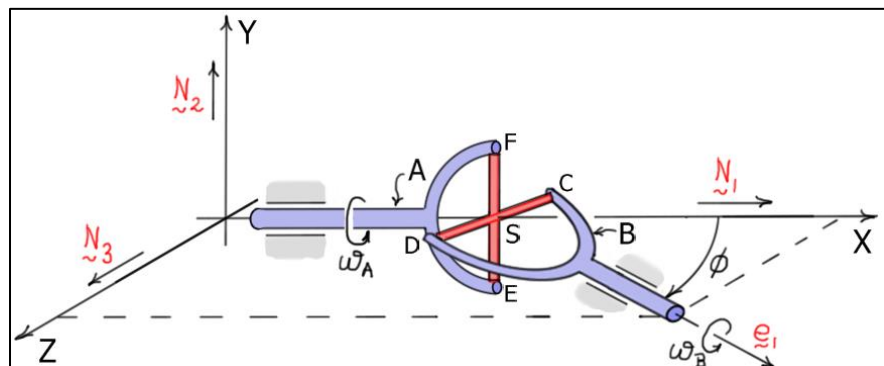
- 2) The system shown consists of a vertical column, a horizontal axle, and a wheel of radius r . The horizontal arm rotates at a **constant** rate Ω , and the wheel (W) rolls without slipping in a circular arc. Find ω_W and α_W the angular velocity and angular acceleration of the wheel relative to a fixed frame, and find v_A and a_A the velocity and acceleration of point A . (Meriam and Kraige, 1992)



- 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 ${}^{AD}\omega_A$ the angular velocity of gear A relative to the axle AD , ${}^R\omega_A$ the angular velocity of gear A , ${}^R\alpha_A$ the angular acceleration of gear A , and a_C the acceleration of tooth C of gear A . (Beer & Johnston, 1977)



- 4) The diagram below depicts a yoke-and-spider **universal joint**. The joint has three members – the **input shaft** A , **output shaft** B , and **spider** S . Shaft A rotates about the X -axis, and shaft B rotates about the e_1 direction which is in the XZ plane and makes an angle of ϕ with the X -axis. **At the instant shown**, spider S rotates **relative** to shaft A about the direction of spider segment EF (represented by unit vector $\underline{n}_{EF} = \underline{n}_2$), and it rotates **relative** to shaft B about the spider segment CD (represented by unit vector $\underline{n}_{CD} = \underline{e}_1 \times \underline{n}_{EF} = \underline{e}_1 \times \underline{n}_2$). **At the instant shown**, find ω_B/ω_A the ratio of the speed of shaft B to the speed of shaft A . Hint: Apply the **summation rule** for angular velocities through the joint using the known directions for the angular velocities and relative angular velocities.



- 5) Referring again to the diagram of the yoke-and-spider *universal joint* of problem (4), let input shaft A rotate through an angle θ . The spider segment EF is now at an angle θ relative to the Y -axis, so $\underline{n}_{EF} = C_\theta \underline{N}_2 + S_\theta \underline{N}_3$. As before, shaft B rotates about the \underline{e}_1 direction, and $\underline{n}_{CD} = \underline{e}_1 \times \underline{n}_{EF}$. Find ω_B/ω_A the ratio of the speed of shaft B to the speed of shaft A as a function of the input shaft angle θ . Hint: Apply the *summation rule* for angular velocities *through the joint* using the known directions for the angular velocities and relative angular velocities.

