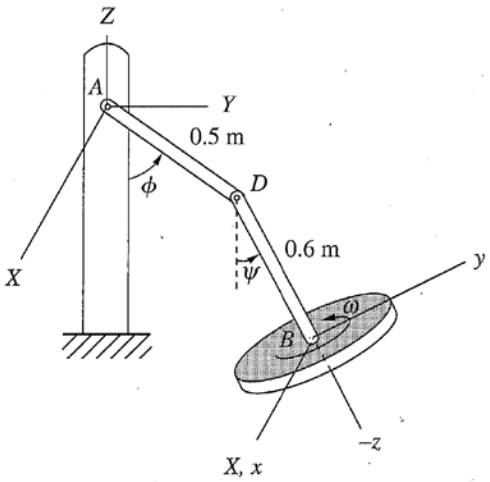
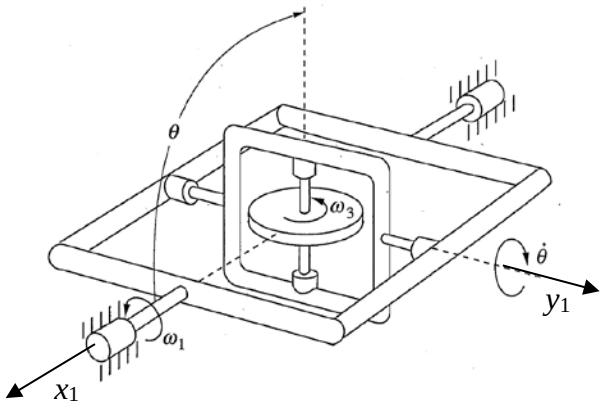
ME EN 534
Homework #2

---

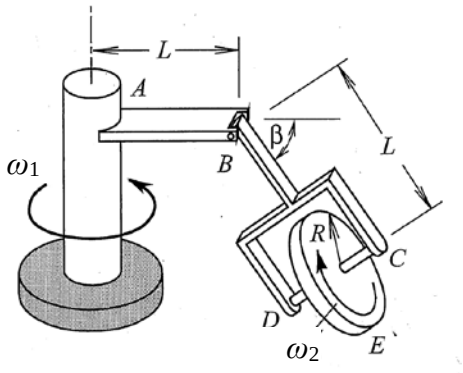
1. The robotic sander shown in the figure has a sanding disk that spins at the constant rate of 1500 rpm. The arms *AD* and *DB*, which are used to position the sander, make angles of ϕ and ψ with the vertical. At the instant shown, their values are $\phi = 90^\circ$, $\psi = 60^\circ$, and they are moving with the constant angular speeds of $\dot{\psi} = -0.3$ rad/s and $\dot{\phi} = 0.2$ rad/s. Find the angular velocity and angular acceleration of the sanding disk in terms of the inertial coordinates.



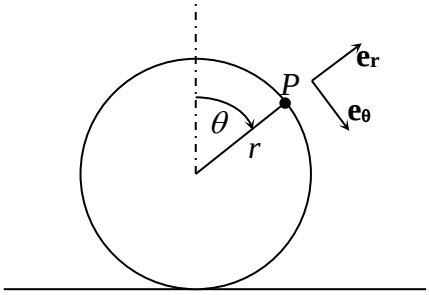
2. The flywheel of the gyroscope shown in the figure has a constant angular speed of $\omega_3 = 5000$ rpm about its axis. The outer gimbal has an angular speed of $\omega_1 = 3$ rad/s, which is decreasing at the rate of 1.8 rad/s^2 relative to an inertial frame. The inner gimbal is at a position such that the angle between the outer gimbal axis and the flywheel axis is $\theta = 75^\circ$, with $\dot{\theta} = 0$, $\ddot{\theta} = 3$ rad/s^2. Find the angular acceleration of the flywheel in terms of the $x_1y_1z_1$ frame, which is attached to the outer gimbal.



3. *E* is a point on a disk that spins about axis *CD* at a constant rate ω_2 as the system rotates about the vertical axis at a constant ω_1. Find the velocity of point *E* at the instant when it is at its lowest point. The joint at *B* is *welded* at an angle β. Express your final result in a frame $x_1y_1z_1$ attached to gimbal *BCD*, with x_1 pointing along the gimbal arm from *B* toward *CD* (parallel to *L* in the figure) and z_1 pointing up and to the right (parallel to *CD*).



4. A vertical wheel of radius *r* rolls without slipping along a straight horizontal line. If its angular speed is given by $\omega = \alpha t$, where α is a constant, solve for the acceleration of a point *P* on its rim, assuming that at $t = 0$ *P* is at the highest point of its path. Express the result in terms of the rotating frame described by $\mathbf{e_r}$ and $\mathbf{e_\theta}$.



ME EN 534
Homework #2

---

5. The plane of the windshield of an automobile is inclined at an angle α from the vertical. The windshield wiper blade is of length l and oscillates according to the equation $\psi = \psi_o \sin\beta t$. Assuming that the auto travels with a constant speed v around a circular path of radius R in a counterclockwise sense (more precisely, the point O' traces out a circle of this radius), solve for the acceleration of the point P at the tip of the wiper. The result should be expressed as a vector in terms of the coordinate frame shown in the figure, which is fixed to the body of the car