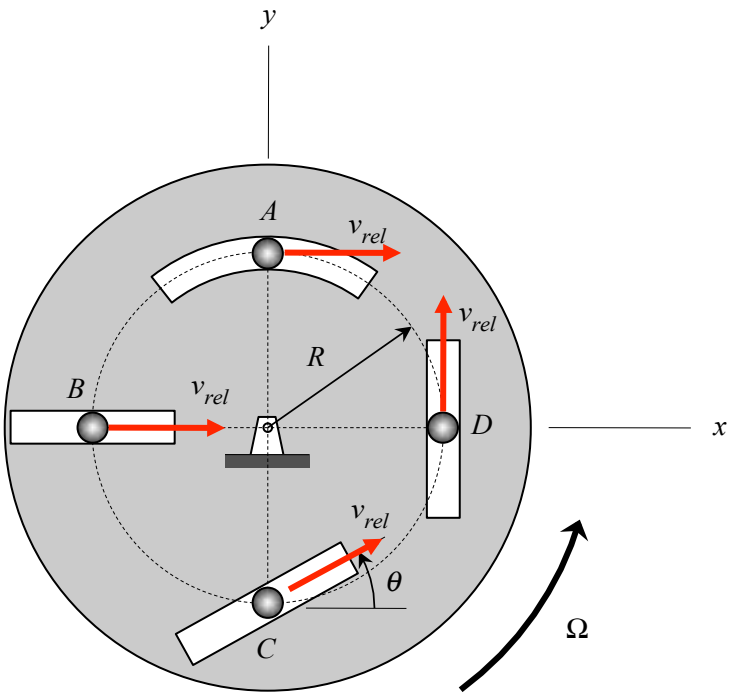
Chapter 3

Moving Reference Frame Kinematics Homework

Homework H.3.A

Given: The disk shown is rotating about its center with a constant rotation rate of Ω. Four slots have been cut into the disk, and a particle in each slot has a constant speed of v_{rel} relative to the disk. Each particle is at a distance of R from the center of the disk.

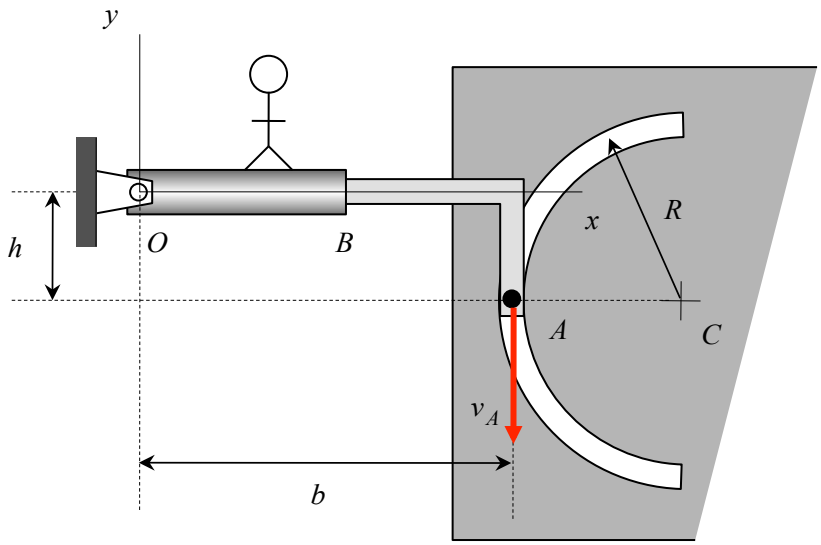
Find: Determine the velocity and acceleration of each particle in the disk. Write your answers as vectors.



Homework H.3.B

Given: An L-shaped telescoping arm is pinned to ground at point O. End A of the arm is constrained to move within a stationary circular slot with a constant speed of v_A. At the instant shown, the arm is oriented horizontally with end A located immediately to the left of the center C of the circular slot. A set of xyz axes are attached to section OB of the telescoping arm, with an observer also attached to this section of the arm.

Find: Determine the angular velocity and angular acceleration of the arm. Write your answers as vectors.



Homework H.3.C

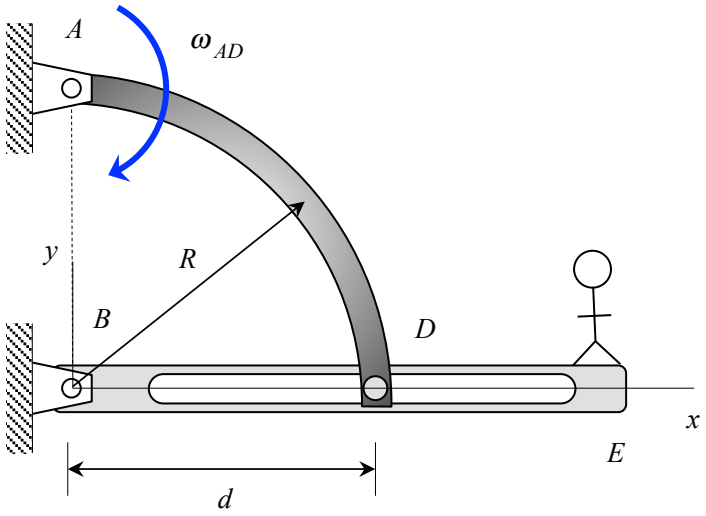
Given: Arm AD is made from a quarter circular arc bar of radius R and is pinned to fixed ground at end A. Slotted arm BE is pinned to fixed ground at end B with pin B located directly below pin A, as shown. A pin at end D of the curved arm is allowed to slide within the slot of arm BE. At the position shown, arm BE is horizontal, and arm AD is rotating CW with a constant rate of ω_{AD}.

Find: For this position,

(a) Determine the angular velocity of arm BE and the value of $\dot{d}$.

(b) Determine the angular acceleration of arm BE and the value of $\ddot{d}$.

HINT: Use an observer attached to the slotted arm BE, and relate the kinematics of points B and D through the moving reference frame kinematics equations.



Homework H.3.D

Given: A guide rod is able to control the angular position of the L-shaped arm BOE through its end A moving vertically and through the slot cut into section OE of the arm. In turn, arm BOE controls the horizontal position of slider C through end B being constrained to move within the slot in slider C. For a particular task of this mechanism, end A of the guide rod is moving upward with a constant speed v_A. Our goal is to determine the velocity and acceleration of slider C.

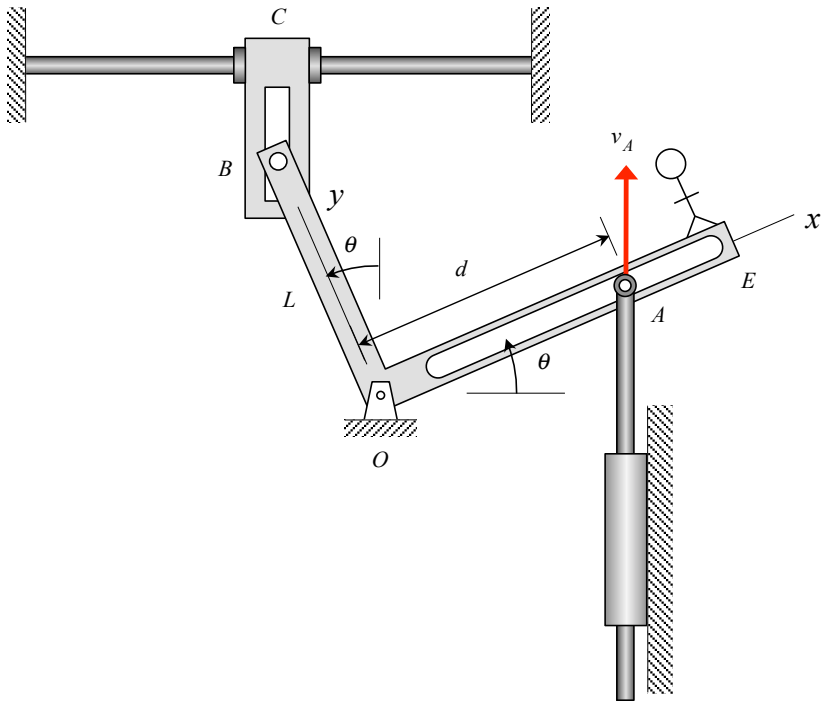
Find: For this problem:

(a) Determine the angular velocity and angular acceleration of arm BOE.

(b) Determine the velocity and acceleration of pin B on BOE.

(c) Determine the velocity and acceleration of slider C.

HINT: Consider using an observer attached to the slotted arm BOE.

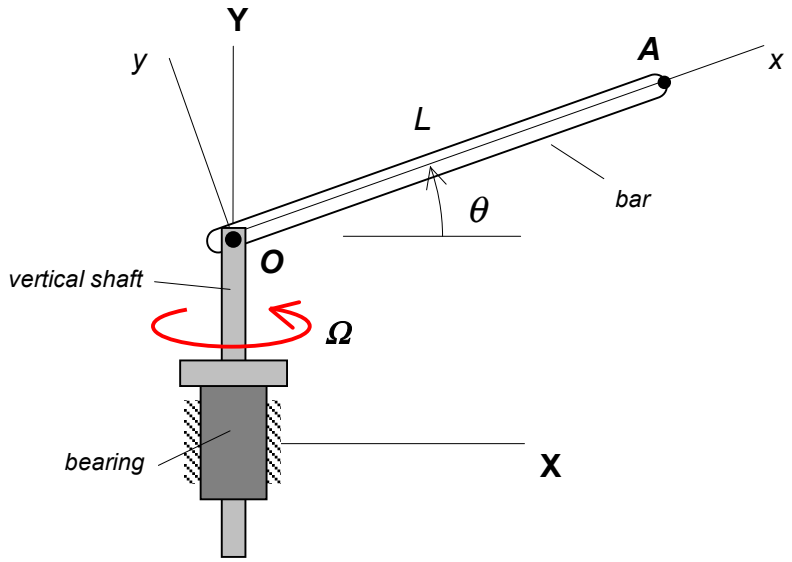


Use the following parameters in your analysis: $v_A = 20$ ft/s, $\theta = 30°$, $L = 2$ ft and $d = 1.5$ ft.

Homework H.3.E

Given: A shaft rotates about a fixed vertical axis at a constant rate of Ω, as shown below. A straight bar OA, having a length of L, is pinned to point O on the shaft, with O being on the rotation axis of the shaft. At the instant when $\theta = 0°$, bar OA is being raised at a rate of $\dot{\theta}$ from the horizontal plane, with this rate changing at a rate of $\ddot{\theta}$. A set of xyz coordinate axes is attached to bar OA with its origin at O. A second set of coordinate axes, XYZ, are fixed to ground. At the instant when $\theta = 0°$, the xyz and XYZ axes are aligned with each other.

Find: For the instant when $\theta = 0°$, determine the angular velocity and angular acceleration of bar OA.



Use the following parameters in your analysis: $\Omega = 5$ rad/s, $\dot{\theta} = 4$ rad/s, $\ddot{\theta} = -3$ rad/s^2 and $L = 2$ m.

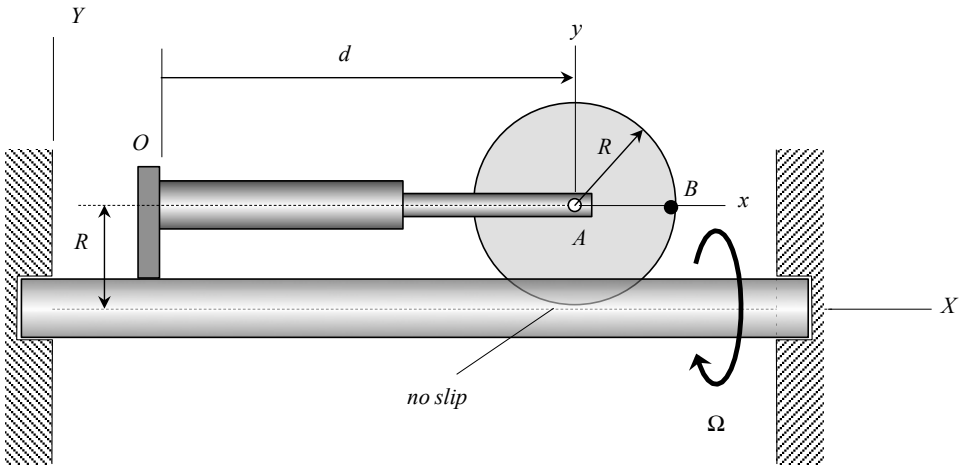
Homework H.3.F

Given: A shaft is rotating at a constant rate of Ω about a fixed axis. A disk of radius R is able to roll without slipping in a slot that is cut longitudinally into the shaft. The position of the disk's center A is controlled by an hydraulic cylinder that is extending at a constant rate of $\dot{d}$. Consider a set of coordinate axes xyz that are attached to the disk, and a set of coordinate axes XYZ that are fixed in space.

Find: For this problem,

(a) determine the angular velocity and angular acceleration of the disk.

(b) determine the acceleration of point B on the perimeter of the disk at a time when B is immediately to the right of A, as shown in the figure.



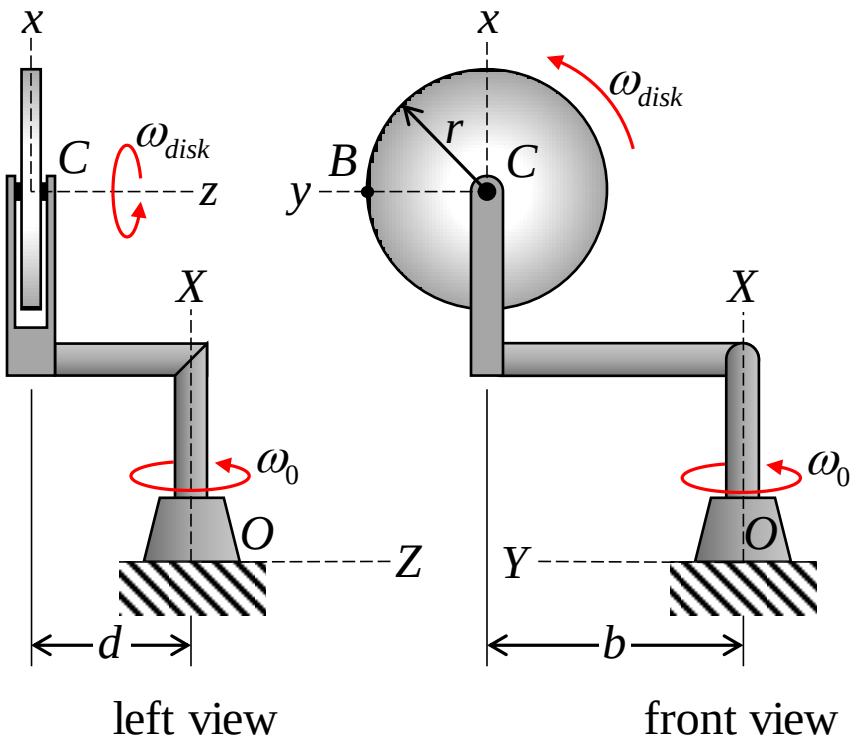
Homework H.3.G

Given: The yoke shown below rotates about a fixed axis with a constant rate of ω_0. A disk, of radius r, rotates about its center C at a constant rate of ω_{disk} relative to yoke. The XYZ coordinate system is fixed with the X-axis aligned with the fixed rotation axis of the yoke. The xyz coordinate system is attached to the disk with the z-axis aligned with the rotation axis of the disk for all time. For the position shown below, the xyz axes are aligned with the XYZ axes.

Find: For the position shown:

(a) Determine the angular velocity and angular acceleration of the disk. Write your answers as vectors in terms of their xyz components.

(b) Determine the acceleration of point B of the disk. Write your answer as a vector in terms of its xyz components.



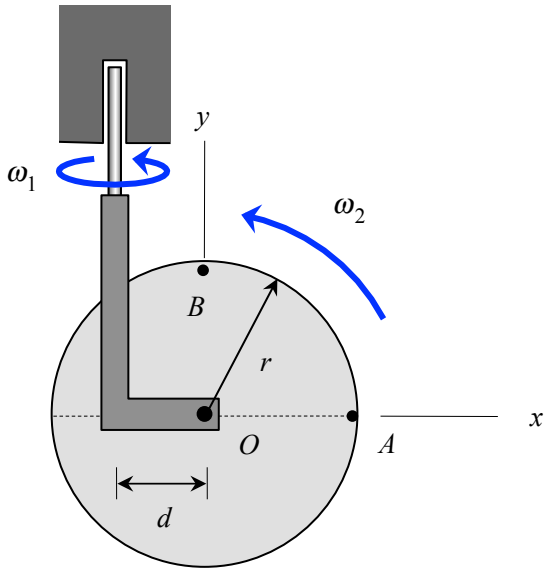
Use the following parameters in your analysis: $\omega_0 = 3$ rad/s, $\omega_{disk} = 2$ rad/s, $d = 0.5$ m, $b = 1.5$ m and $r = 0.25$ m.

Homework H.3.H

Given: A caster wheel is supported by an L-shaped bracket. The bracket is rotating about a fixed vertical axis with a constant rate of ω_1. The wheel rotates with respect to the bracket with a constant rate of ω_2.

Find: For this problem, determine:

1. The angular velocity and angular acceleration of the wheel. Write your answers as vectors.
2. The acceleration of point A on the wheel at the instant shown when A is immediately to the right of the center O of the wheel.
3. The acceleration of point B on the wheel at the instant shown when B is immediately above the center O of the wheel.



Use the following parameters in your analysis: $\omega_1 = 2$ rad/s, $\omega_2 = 5$ rad/s, $r = 200$ mm and $d = 100$ mm.

Homework H.3.I

Given: Particle P travels in a tube with $\dot{R} = constant$. The tube is being raised at a constant rate of $\dot{\theta}$. In addition, the tube is attached to a vertical shaft which is rotating about the fixed Y axis with a constant rate of ω. An observer is attached to the tube with the xyz axes also attached to the tube with its origin at point O.

Find: For the position shown, determine:

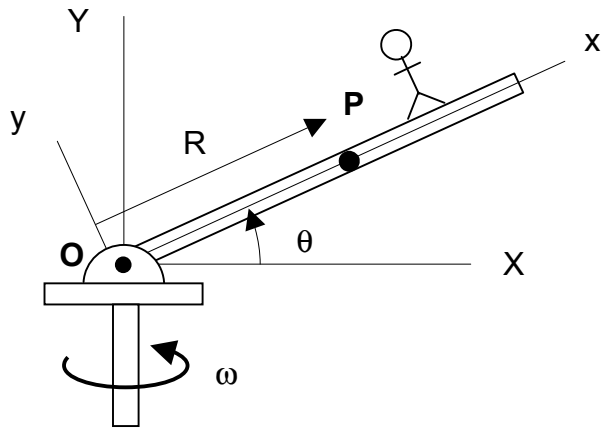
(a) The angular velocity vector of the observer.

(b) The angular acceleration vector of the observer.

(c) The velocity of point P as seen by the observer.

(d) The acceleration of point P as seen by the observer.

(e) The acceleration of point P using the above results.

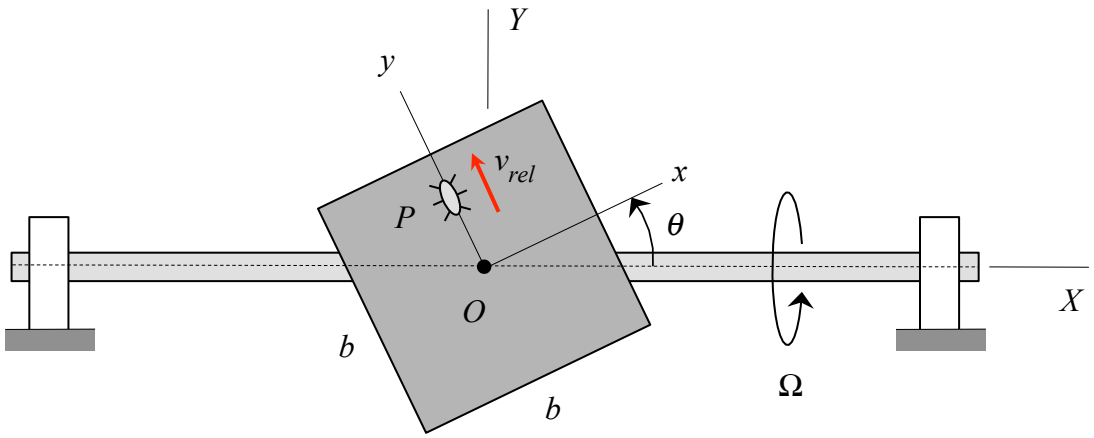


Use the following parameters in your analysis: $R = 5$ ft, $\theta = 36.87°$, $\dot{R} = 6$ ft/s, $\dot{\theta} = 3$ rad/s and $\omega = 4$ rad/s.

Homework H.3.J

Given: A shaft is rotating about the fixed X-axis at a constant rate of Ω. A square plate is pinned at its center O to the centerline of the shaft and is rotating relative to the shaft about O at a constant rate of $\dot{\theta}$. A set of xyz axes are attached to the plate with its origin at O. An insect on the plate is walking along the y-axis with a constant speed of v_{rel} relative to the plate.

Find: Determine the velocity and acceleration of the insect when the insect has reached the edge of the plate. The insect reaches the edge of the plate when $\theta = 0°$.



Use the following parameters in your analysis: $b = 6$ in, $v_{rel} = 12$ in/s, $\Omega = 3$ rad/s and $\dot{\theta} = 5$ rad/s.