ME 274 Lecture 8

Rigid Body Kinematics – Long problems

Eugenio “Henny” Frias-Miranda

1/30/26

Housekeeping/Announcements

1. **HW 6 & 7 due tonight!!**
2. ME2206 & Tutorial Room – Office hours location.
3. HWs the day that they are assigned, will be posted at 8 AM (used to be 4PM).

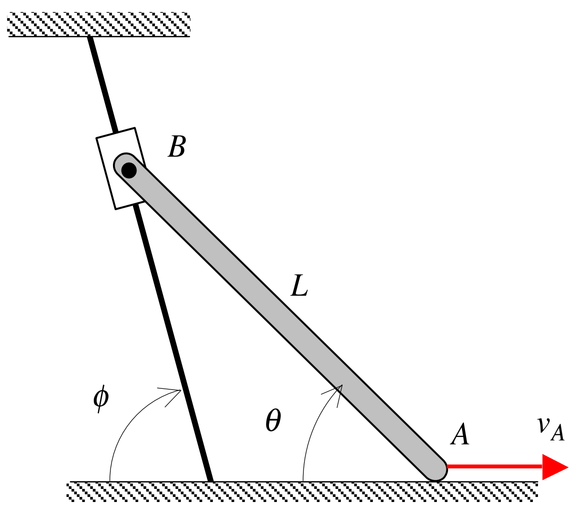
1:30-2:30, MWF
(ME 2206)

***Reminder for Henny to wear a mic during the lecture.

Homework H2.C HW help!

Given: Thin bar AB (having a length of L) moves in a way that ends A and B slide along straight, fixed guides as shown in the figure. End A has a constant speed of v_A to the right as the bar moves.

Find: Determine the velocity and acceleration of end B.



Use the following parameters in your analysis: $L = 2$ ft, $v_A = 4$ ft/s, $\theta = 36.87°$ and $\phi = 45°$.

Same as 2.A.7 except

1/29/26 error | fix

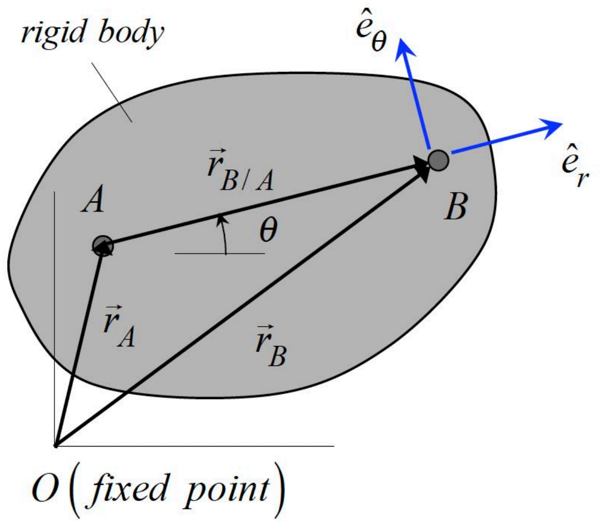
~~$\vec{v}_B = v_B(-\sin\phi\,\hat{i} + \cos\phi\,\hat{j})$~~

~~$\vec{a}_B = \dot{v}_B(-\sin\phi\,\hat{i} + \cos\phi\,\hat{j})$~~

$$\vec{v}_B = v_B(\cos\phi\,\hat{i} - \sin\phi\,\hat{j})$$

$$\vec{a}_B = \dot{v}_B(\cos\phi\,\hat{i} - \sin\phi\,\hat{j})$$

Rigid Body Kinematics



1. A rigid body is an object where the **distance between any two points on the object remains fixed,** regardless of the motion of the object.

o Key Observations: Same ω & α for any point on the rigid body

2. Velocity and acceleration equations for ***planar motion of a rigid body:***

$$\vec{v}_B = \vec{v}_A + \vec{\omega} \times \vec{r}_{B/A}$$

$$\vec{a}_B = \vec{a}_A + \vec{\omega} \times \left[\vec{\omega} \times \vec{r}_{B/A}\right] + \vec{\alpha} \times \vec{r}_{B/A}$$

When in the same plane… :

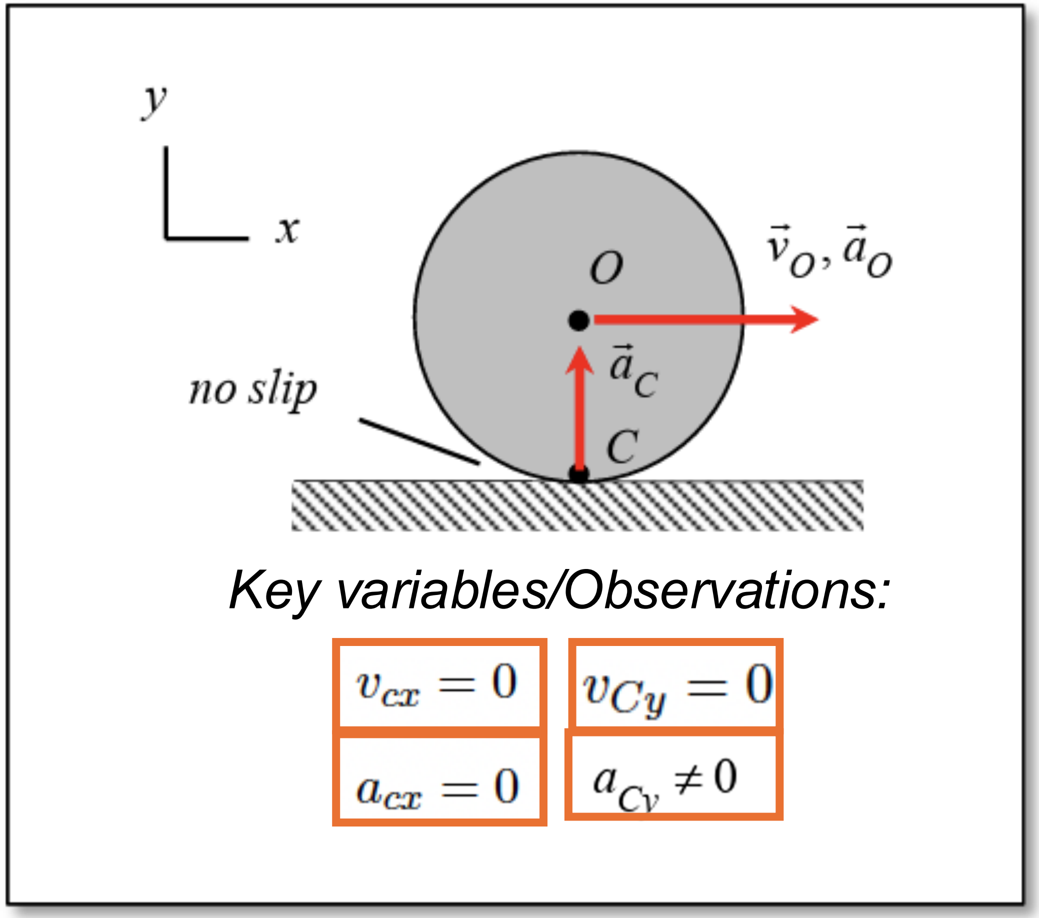
$$\vec{a}_B = \vec{a}_A + \vec{\alpha} \times \vec{r}_{B/A} - \omega^2 \vec{r}_{B/A}.$$

[pg. 85 content]

Last Lecture… Rolling without slipping

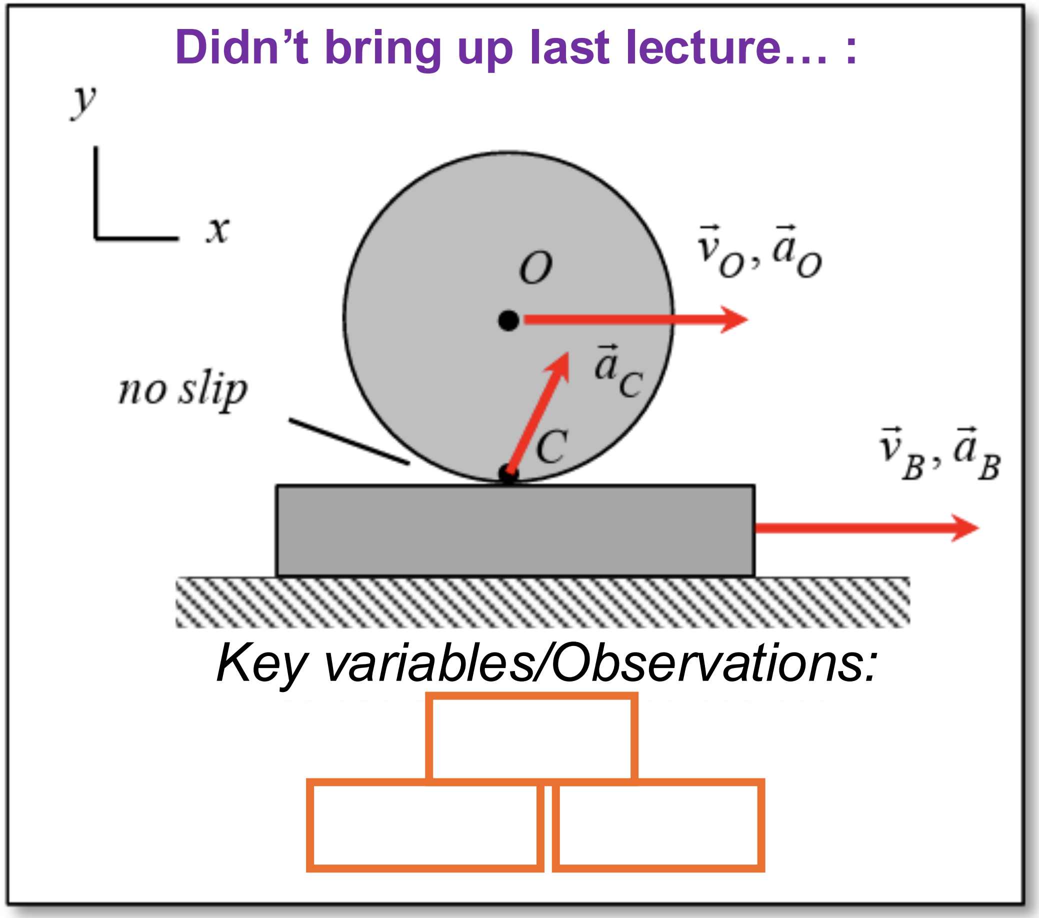
- As the wheel moves, it is assumed that **sufficient friction** acts between the wheel and surface that the contact point C **does not slip.**

rolling on fixed surface



[pg. 91-92 content]

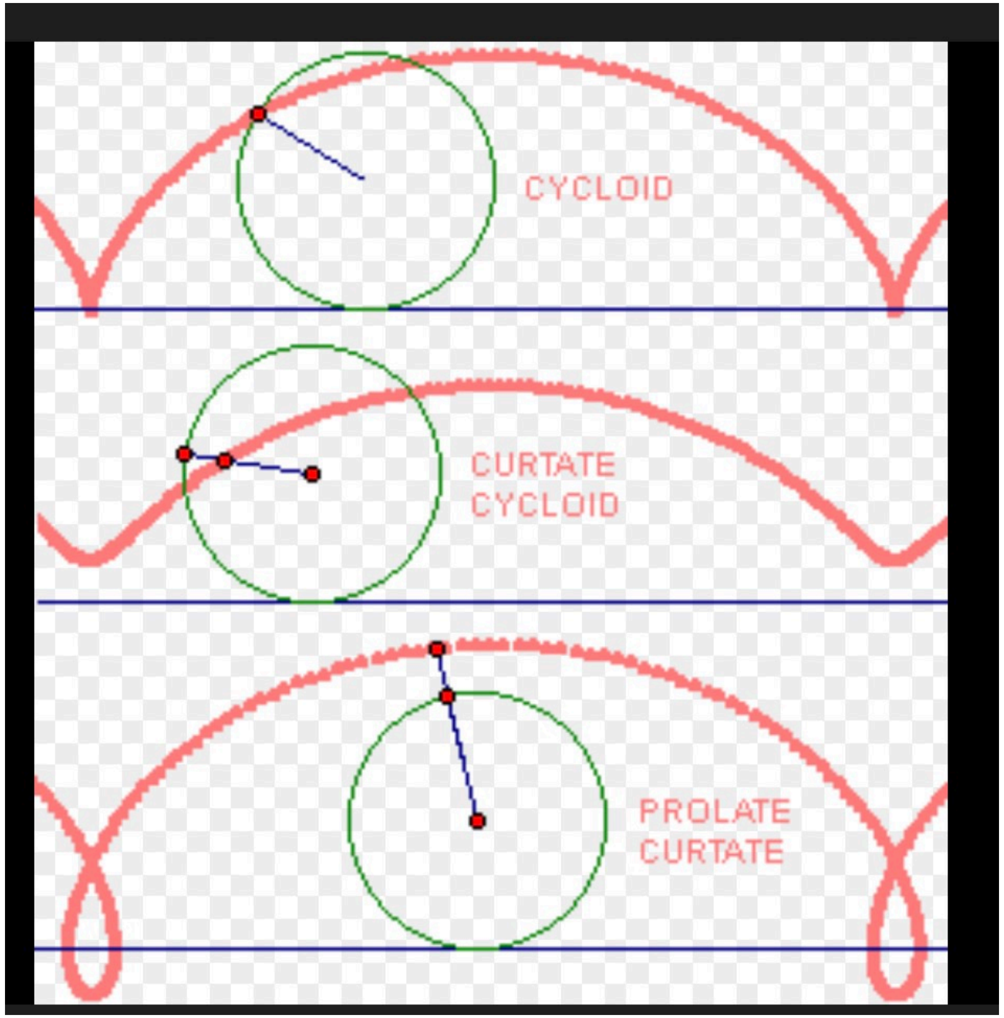
rolling on moving surface

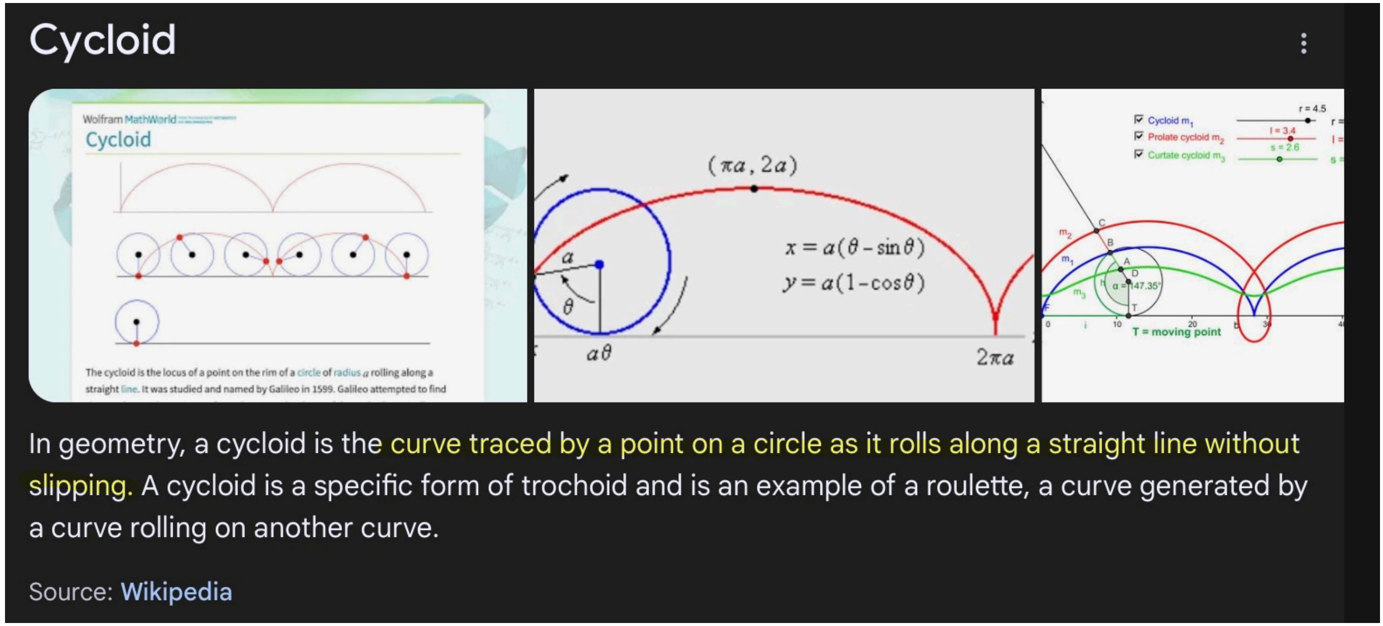


[pg. 92 content. bottom]

Visualizing Mechanics: (Video from last lecture)

↳ names of the paths traced by LEDs



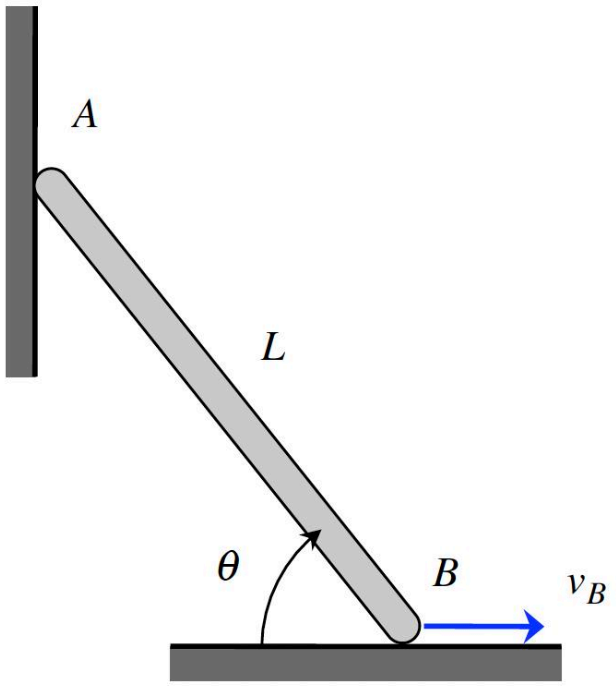


Example 2.A.7

Given: End B of the link moves to the right with a constant speed v_B.

Find: Determine:
(a) The angular velocity of link AB; and
(b) The angular acceleration of link AB.

Use the following parameters in your analysis: $v_B = 3$ m/s, $L = 0.5$ m and $\theta = 36.87°$. Also, be sure to express your answers as vectors.



[pg. 99]

Example 2.A.7 p. 99

Given: End B of the link moves to the right with a constant speed v_B.

Find: Determine:

(a) The angular velocity of link AB; and ω_{AB} ?

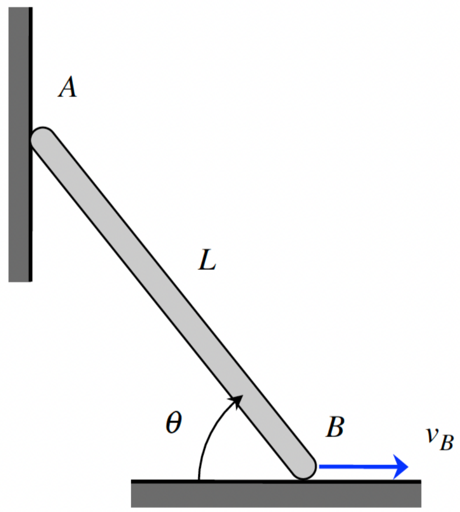
(b) The angular acceleration of link AB. α_{AB} ?

Use the following parameters in your analysis: $v_B = 3$ m/s, $L = 0.5$ m and $\theta = 36.87°$. Also, be sure to express your answers as vectors.

$v_B = 3$ m/s $\quad a_B = 0$

$L = 0.5$ m

$\theta = 36.87°$



Example 2.A.8

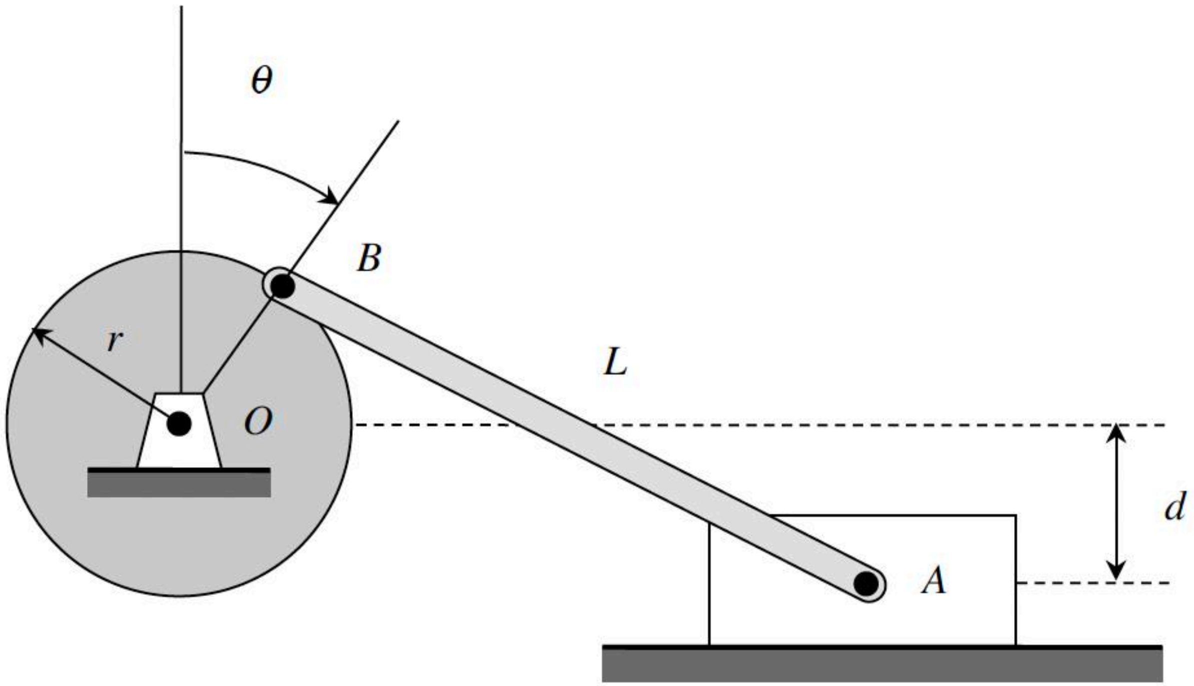
Given: A flywheel rotates in the clockwise sense with a constant angular speed $\dot{\theta}$ about a shaft passing through its center O. The flywheel is connected to a piston A through connecting rod BA. The piston is constrained to slide along a horizontal surface.

Find: Determine:

(a) The acceleration of piston A; and

(b) The angular acceleration of connecting rod arm BA.

Use the following parameters in your analysis: $\dot{\theta} = 10$ rad/s, $\theta = 90°$, $r = 0.1$ m, $d = 0.2$ m and $L = 0.45$ m.



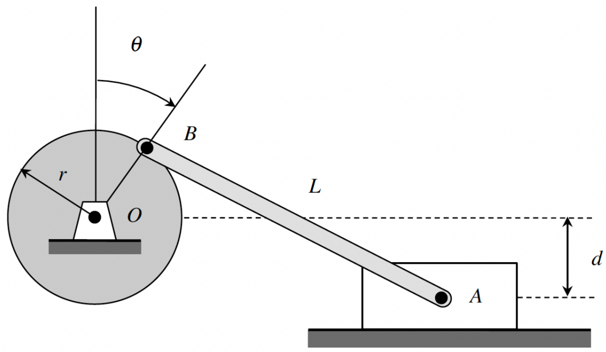
[pg. 100]

Example 2.A.8 P.100

Given: A flywheel rotates in the clockwise sense with a constant angular speed $\dot{\theta}$ about a shaft passing through its center O. The flywheel is connected to a piston A through connecting rod BA. The piston is constrained to slide along a horizontal surface.

Find: Determine:
(a) The acceleration of piston A; and
(b) The angular acceleration of connecting rod arm BA.

Use the following parameters in your analysis: $\dot{\theta} = 10$ rad/s, $\theta = 90°$, $r = 0.1$ m, $d = 0.2$ m and $L = 0.45$ m.

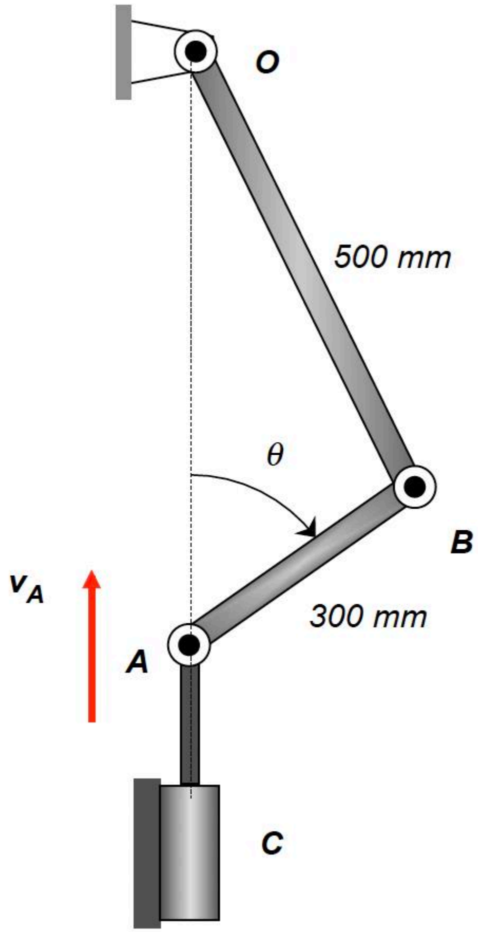


Example 2.A.9

Given: The piston rod of the hydraulic cylinder C imparts a constant acceleration to pin A of $a_A = 0.1$ m/s^2 (downward). At the instant when $\theta = 90°$, the speed of A is known to be $v_A = 0.4$ m/s (upward).

Find: Determine, at this instant:

(a) The angular velocity of link AB;
(b) The angular velocity of link OB;
(c) The angular acceleration of link AB; and
(d) The angular acceleration of links OB.



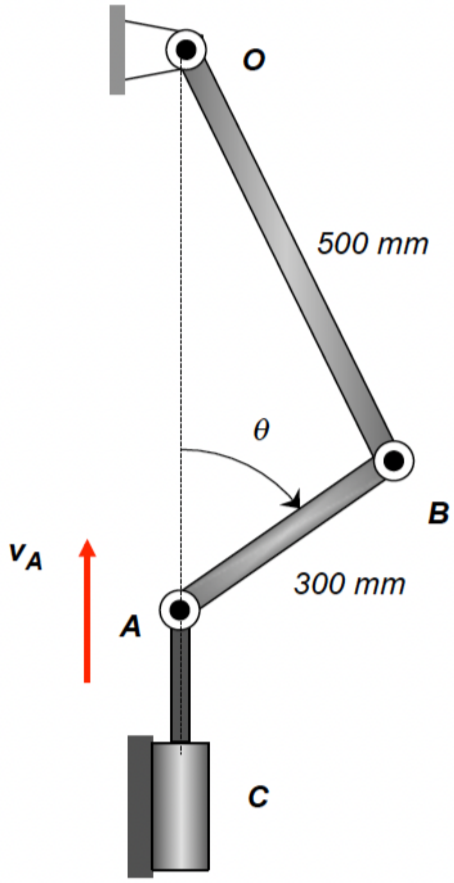
[pg. 101]

Example 2.A.9 p.101

Given: The piston rod of the hydraulic cylinder C imparts a constant acceleration to pin A of $a_A = 0.1$ m/s^2 (downward). At the instant when $\theta = 90°$, the speed of A is known to be $v_A = 0.4$ m/s (upward).

Find: Determine, at this instant:

(a) The angular velocity of link AB;
(b) The angular velocity of link OB;
(c) The angular acceleration of link AB; and
(d) The angular acceleration of links OB.



Example 2.A.10

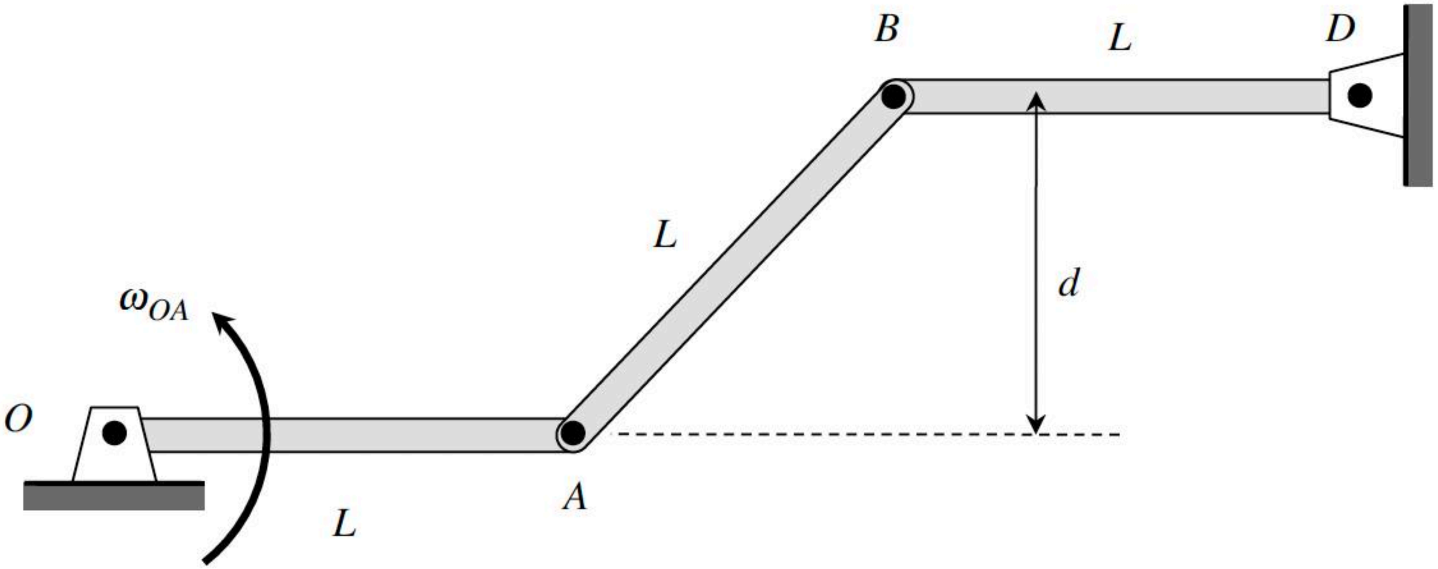
Given: At the instant shown, link OA rotates counterclockwise about pin O with a constant angular speed of ω_{OA}. At the instant shown, links OA and BD are horizontal.

Find: Determine at this instant:

(a) The angular acceleration of link AB; and

(b) The angular acceleration of link BD.

Use the following parameters in your analysis: $\omega_{OA} = 3$ rad/s, $L = 0.5$ m and $d = 0.4$ m. Also, be sure to express your answers as vectors.



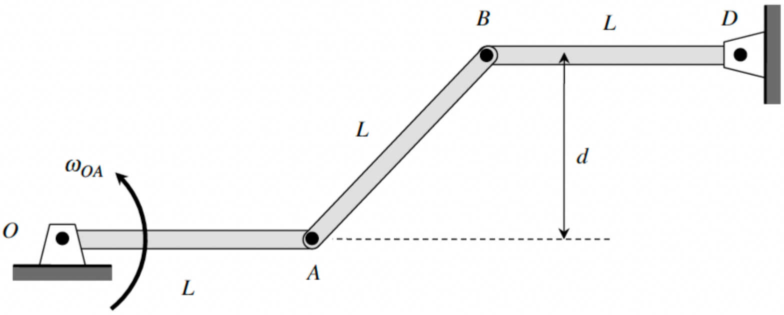
[pg. 102]

Example 2.A.10 P.102

Given: At the instant shown, link OA rotates counterclockwise about pin O with a constant angular speed of ω_{OA}. At the instant shown, links OA and BD are horizontal.

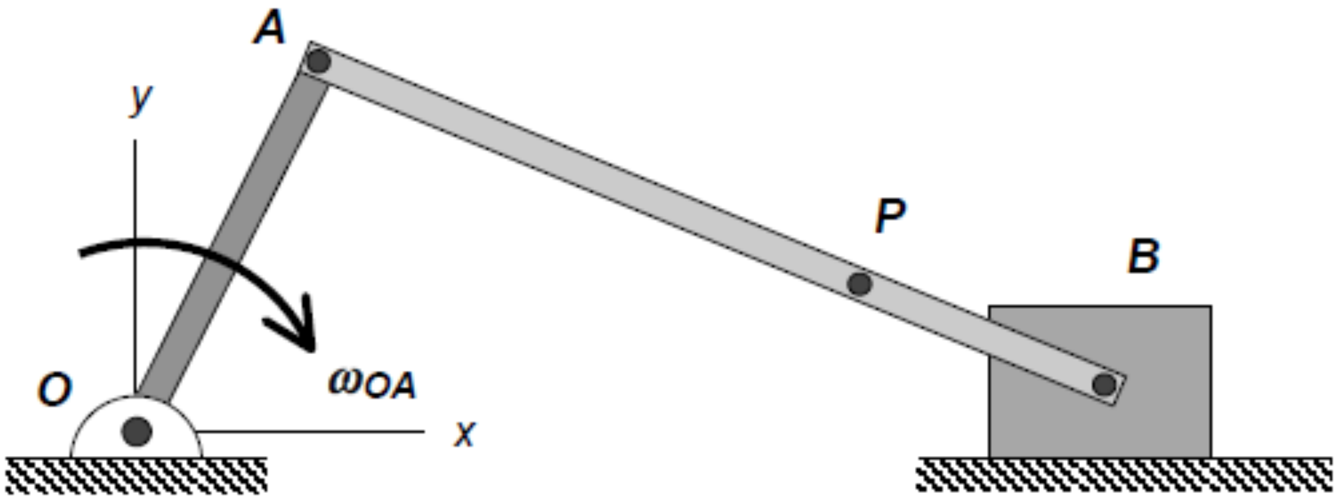
Find: Determine at this instant:
(a) The angular acceleration of link AB; and α_{AB} ?
(b) The angular acceleration of link BD. α_{BD} ?

Use the following parameters in your analysis: $\omega_{OA} = 3$ rad/s, $L = 0.5$ m and $d = 0.4$ m. Also, be sure to express your answers as vectors.



Question C2.15

The mechanism shown below is made up of links OA and AB. At the instant shown, link OA is rotating in the clockwise direction with the velocity and acceleration of point P on link AB known to be: $\vec{v}_P = \left(20\hat{i} - 4\hat{j}\right)$ m/s and $\vec{a}_P = \left(-10\hat{i} - 5\hat{j}\right)$ m/s^2. For this position, determine the rate of change of speed for P and the radius of curvature for the path of P.



[pg. 140]

Question C2.15 p.140

The mechanism shown below is made up of links OA and AB. At the instant shown, link OA is rotating in the clockwise direction with the velocity and acceleration of point P on link AB known to be: $\vec{v}_P = \left(20\hat{\imath} - 4\hat{\jmath}\right)$ m/s and $\vec{a}_P = \left(-10\hat{\imath} - 5\hat{\jmath}\right)$ m/s^2. For this position, determine the rate of change of speed for P and the radius of curvature for the path of P.

(a) $\dot{v}$?

(b) ρ ?