Some additional instant center examples

ME 274 – Spring 2022

cmk

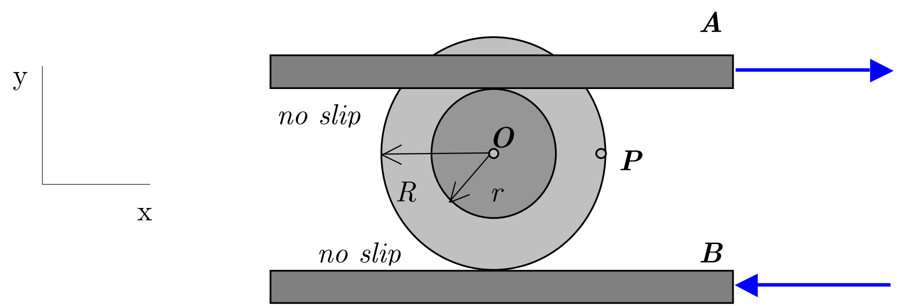
Contained here are some selected kinematics problems from Section 2.A of the lecture book. These examples were not originally written as instant center problems, but rather as problems on which vector methods were to be used; however, we can always use the instant center approach to get some qualitative checks on your results from analysis.

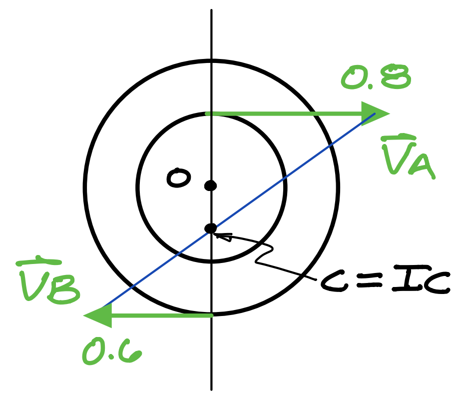
Carefully study these problem solutions. Let me know if you have any questions.

Example 2.A.4

Given: Rack A moves to the right with a speed of v_A and an acceleration of a_A. Rack B moves to the left with a constant speed of v_B. Assume $v_A = 0.8$ m/s, $a_A = 2$ m/s^2, $v_B = 0.6$ m/s, $r = 0.1$ m and $R = 0.16$ m.

Find: Determine:
(a) The velocity of point P on the outer rim of the gear; and
(b) The acceleration of point P on the outer rim of the gear.

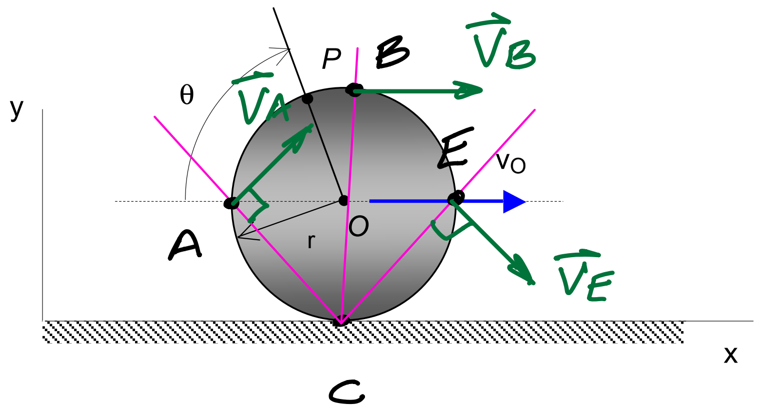




Example 2.A.5

Given: A wheel rolls without slipping on a rough horizontal surface. At one instant, when $\theta = 90°$, the center of the wheel O is moving to the right with a speed of $v_O = 5$ ft/s with this speed decreasing at a rate of 3 ft/s^2.

Find: Determine the acceleration of point P on the circumference of the wheel at this instant, if $r = 2$ ft. Make a sketch of this acceleration vector at P.



- C = IC (zero velocity on body)
- $\vec{V}_A \perp \overline{AC}$

  $\vec{V}_B \perp \overline{BC}$

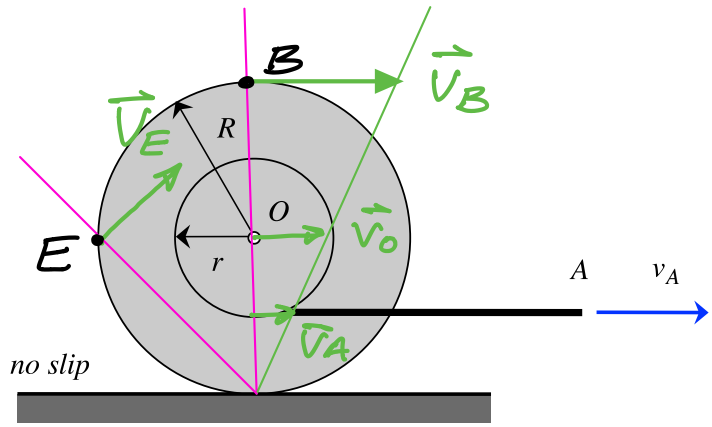
  $\vec{V}_E \perp EC$
- $$\left.\begin{aligned} V_A &= \overline{AC}\,\omega \\ V_B &= \overline{BC}\,\omega \\ V_E &= \overline{EC}\,\omega \\ V_O &= \overline{OC}\,\omega \end{aligned}\right\} \qquad V_B > V_A = V_E > V_O$$

Example 2.A.6

Given: A cable is wrapped around the inner radius of a spool. End A of the cable is moving to the right with a speed of v_A. The spool is able to roll without slipping on a rough horizontal surface.

Find: Determine:
(a) The velocity of the center O of the spool; and
(b) The angular velocity of the spool.

Use the following parameters in your analysis: $v_A = 2$ m/s, $r = 0.4$ m and $R = 0.8$ m. Also, be sure to express your answers as vectors.



$C = IC$ (since $V_C = 0$ for no slip)

- $\vec{V}_O \perp \overline{OC}$
  $\vec{V}_B \perp \overline{BC}$
  $\vec{V}_E \perp \overline{EC}$
- $V_B > V_E > V_O > V_A$ (based on distance from point to the IC)

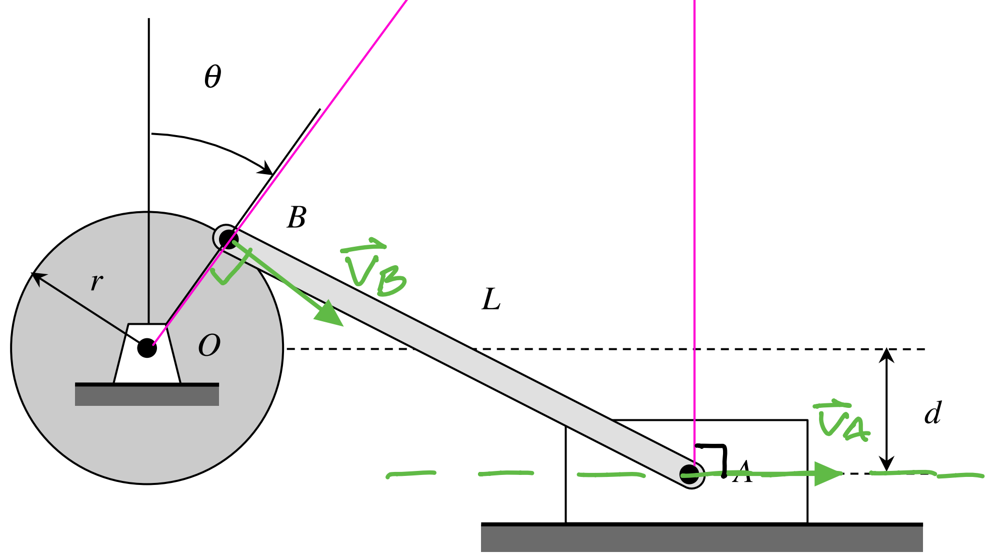
Example 2.A.8

$C = IC_{AB}$

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.



- $V_B = r\dot{\theta}$
- $\left.\begin{aligned} V_B &= \overline{BC}\,\omega_{AB} \\ V_A &= \overline{AC}\,\omega_{AB} \end{aligned}\right\} \Rightarrow \dfrac{V_B}{V_A} = \dfrac{\overline{BC}}{\overline{AC}} \Rightarrow V_B = \dfrac{\overline{BC}}{\overline{AC}} V_A$

$\therefore$ If $\overline{BC} > \overline{AC} \Rightarrow V_B > V_A$

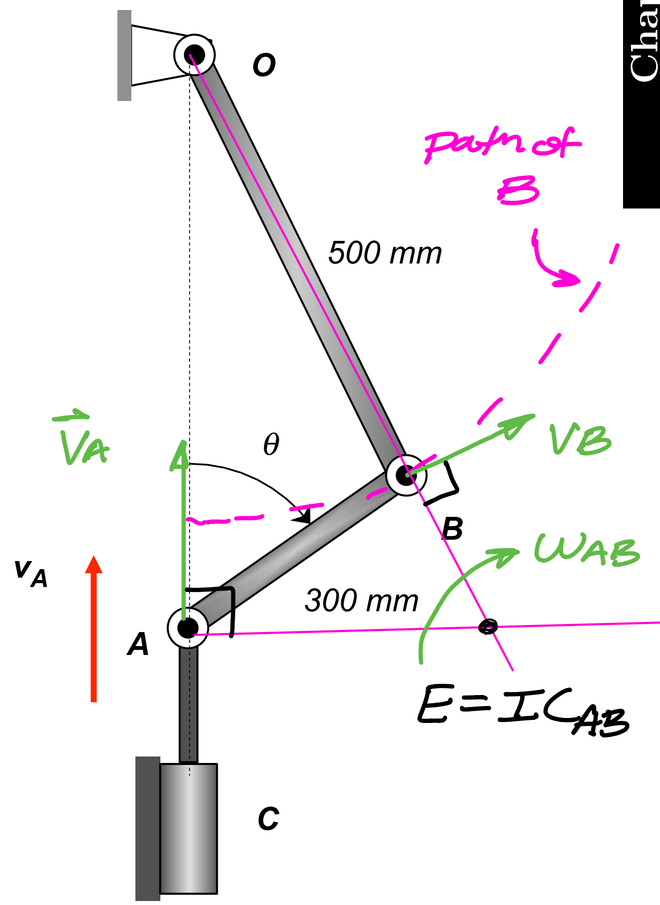
If $\overline{BC} < \overline{AC} \Rightarrow V_B < V_A$

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.

- $E = IC_{AB}$ is @ intersection of $\perp$ to $\vec{V}_A$ w/ $\perp$ to $\vec{V}_B$
- Since A is moving upward and AB rotating about $E \Rightarrow \omega_{AB} = CW$
- $V_A > V_B$ since $\overline{AE} > \overline{BE}$ for this position

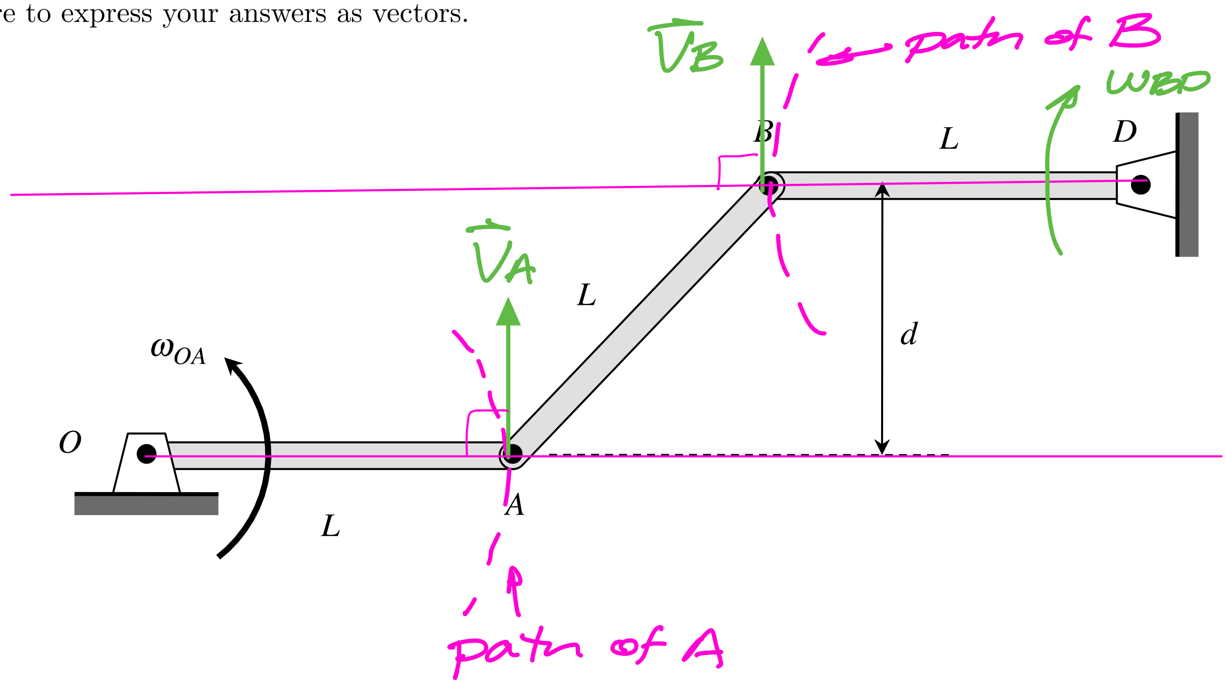


Example 2.A.10

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.



Since ⊥'s to $\vec{V}_A$ & $\vec{V}_B$ intersect at ∞, $\Rightarrow$

$\omega_{AB} = 0 \Rightarrow \vec{V}_A = \vec{V}_B$

$\Rightarrow \vec{\omega}_{BD} = -\vec{\omega}_{OA}$