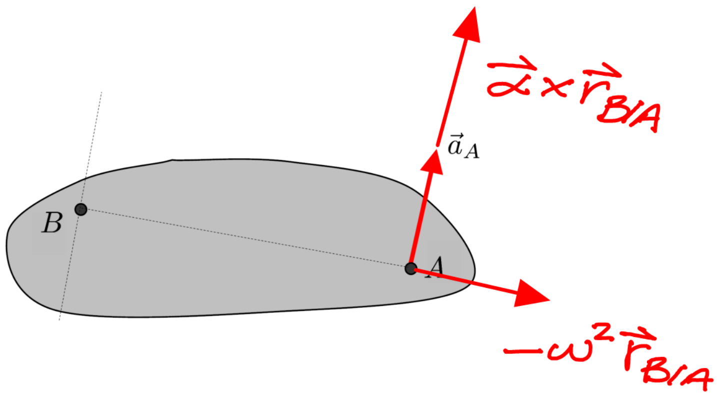
Question C2.1

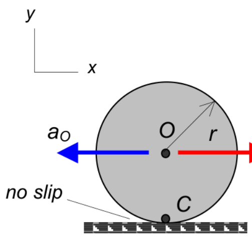
The rigid body shown below has a counterclockwise angular velocity ω and a clockwise angular acceleration α. The direction of the acceleration of point A, $\vec{a}_A$, is shown in the figure with $\vec{a}_A$ being perpendicular to line AB. Make a sketch showing the direction of the acceleration vector for point B. This sketch does not need to be accurate; simply show its direction relative to the lines in the figure, where these two lines are perpendicular and parallel to $\vec{a}_A$.



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

Question C2.2

A sphere of radius r rolls without slipping to the right on a rough, horizontal surface. The center of the sphere, O, has a speed of v_O, with this speed decreasing at a rate of a_O.



Circle the figure below that most accurately represents the direction of the acceleration of the contact point C.

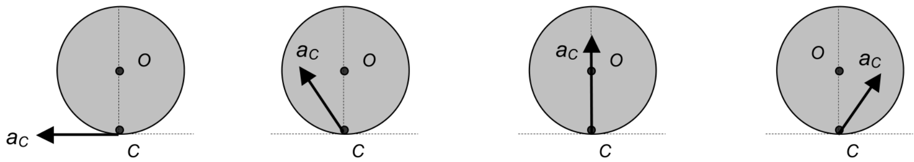


Figure A **Figure B** **Figure C** **Figure D**

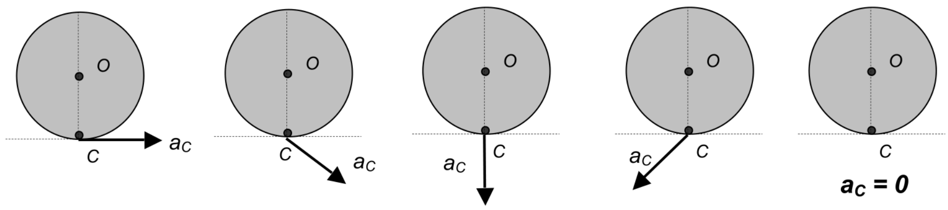


Figure E **Figure F** **Figure G** **Figure H** **Figure I**

$$\vec{a}_c = \vec{a}_0 + \vec{\alpha} \times \vec{r}_{c/0} - \omega^2 \vec{r}_{c/0}$$

$$= a_0 \hat{\imath} + (\alpha \hat{k}) \times (-r\hat{\jmath}) - \omega^2(-r\hat{\jmath})$$

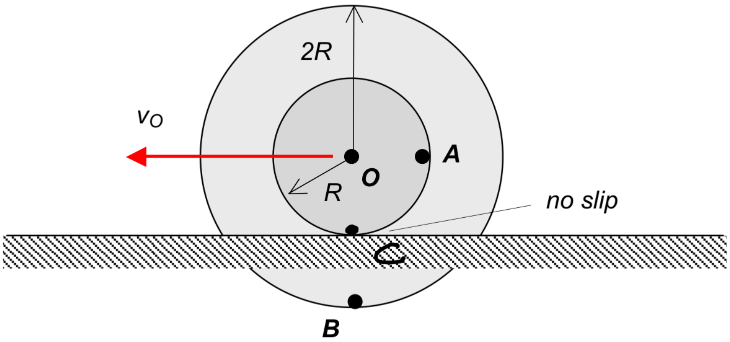
$$= \underbrace{(a_0 + r\alpha)}_{a_{cx}} \hat{\imath} + \underbrace{r\omega^2}_{a_{cy}} \hat{\jmath}$$

Question C2.3

A stepped drum has inner and outer radii of R and $2R$, respectively. The drum rolls to the left with its center O having a constant speed of v_O, as shown below. Point A and B lie on the inner and outer radii, respectively, of the drum. At the instant shown, A is directly to the right of O, and B is directly below O. For this position:

(a) Make a sketch of the velocity vectors for A and B.

(b) Make a sketch of the acceleration vectors for A and B.



C = no slip point ⇒ C = IC of drum ⇒

$\vec{V}_A \perp \overline{AC}$

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

V_O = constant ⇒ $\vec{a}_O = 0$ & $\vec{\alpha} = \vec{0}$ ⇒

$$\begin{cases} \vec{a}_A = \cancelto{0}{\vec{a}_O} + \cancelto{0}{\vec{\alpha}} \times \vec{r}_{A/O} - \omega^2 \vec{r}_{A/O} \\ \vec{a}_B = \cancelto{0}{\vec{a}_O} + \cancelto{0}{\vec{\alpha}} \times \vec{r}_{B/O} - \omega^2 \vec{r}_{B/O} \end{cases}$$

Question C2.4

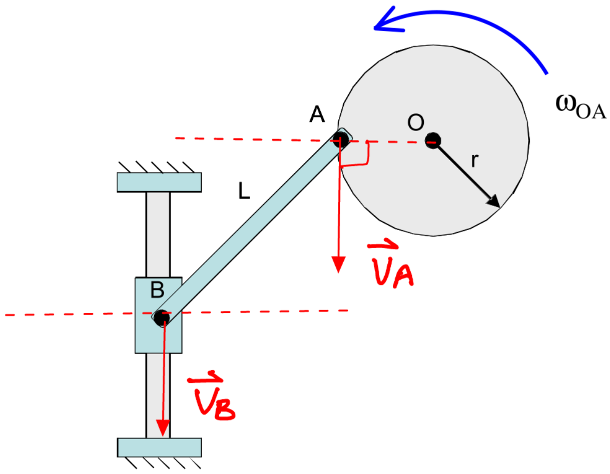
Collar B is free to move vertically, and the rigid disk is free to rotate about point O. Collar B and point A on the disk are connected by a rigid link. At the instant shown, point A on the disk is on the same horizontal line as point O. At this instant, the angular velocity of AB is:

(a) counterclockwise

(b) zero

(c) clockwise

(d) indeterminate without known values for L, r and ω_{OA}



$\vec{V}_B \parallel \vec{V}_A \Rightarrow IC_{AB}$ @ ∞

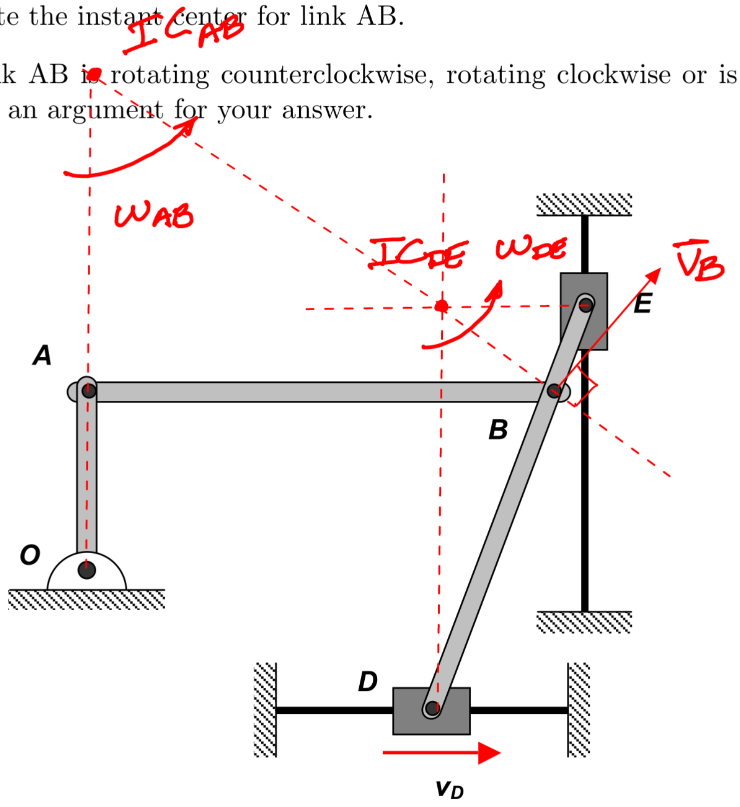
Question C2.5

A mechanism is made up of links OA, AB and DE. Pins D and E on link DE are constrained to move along straight guides. Link OA is pinned to ground at O and pinned to link AB at A. Link AB is also pinned to link DE at point B. Pin D moves to the right with a speed of v_D. For the position shown:

(a) Accurately locate the instant center for link DE.

(b) Accurately locate the instant center for link AB.

(c) Determine if link AB is rotating counterclockwise, rotating clockwise or is instantaneously at rest. Provide an argument for your answer.



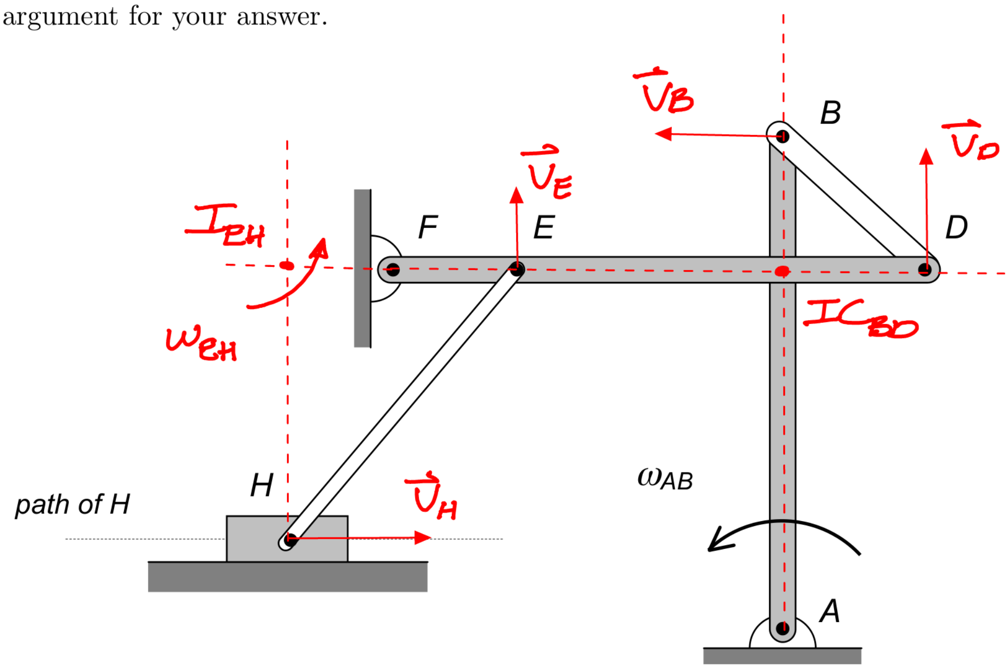
Question C2.6

The mechanism shown below is made up of links AB, BD, DF and EH. Links AB and DF are pinned to ground at pins A and F, respectively. Link EH is pinned to link DF at E. Pin H is constrained to move along a straight, horizontal path. Link AB is rotating counterclockwise, as shown.

(a) Accurately locate the instant center for link BD.

(b) Accurately locate the instant center for link EH.

(c) What is the direction of motion for pin H (left, right or instantaneously stationary)? Provide an argument for your answer.



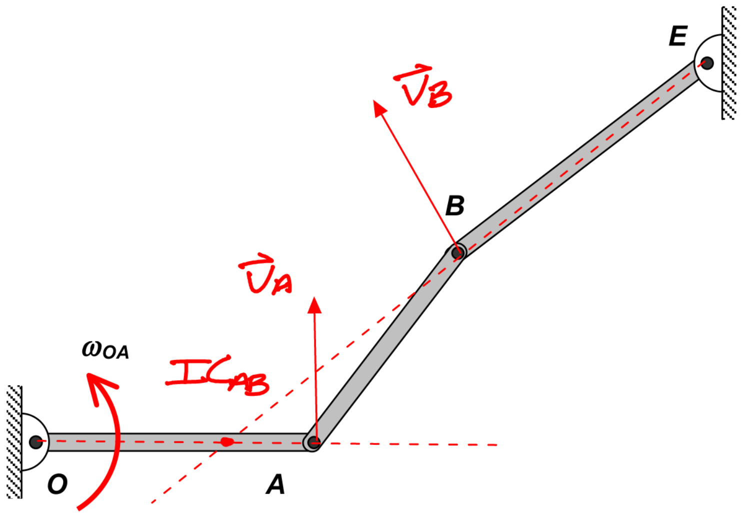
Chapter 2

Question C2.7
The mechanism shown below is made up on rigid links OA, AB and BE. Link OA is rotating in the counterclockwise direction with an angular speed of ω_{OA}.

(a) Accurately locate the instant center for link AB.

(b) Is AB rotating clockwise, rotating counterclockwise or instantaneously stationary? Justify your answer.

(c) Is BE rotating clockwise, rotating counterclockwise or instantaneously stationary? Justify your answer.

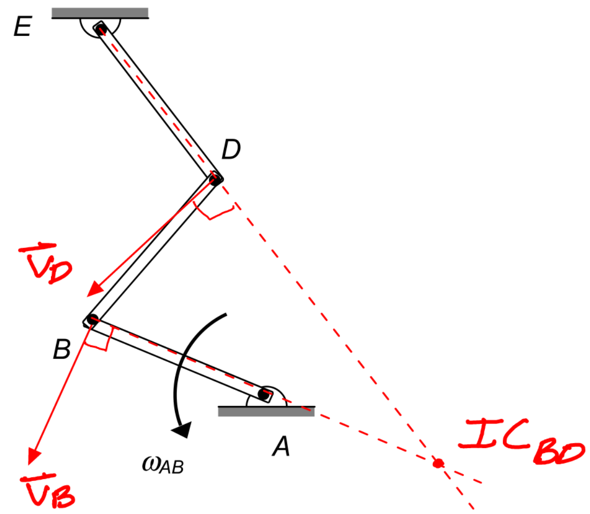


Question C2.8
The mechanism shown below is made up on rigid links AB, BD and DE. Link AB is rotating in the counterclockwise direction with an angular speed of ω_{AB}.

(a) Accurately locate the instant center for link BD.

(b) Is BD rotating clockwise, rotating counterclockwise or instantaneously stationary? Justify your answer.

(c) Is DE rotating clockwise, rotating counterclockwise or instantaneously stationary? Justify your answer.



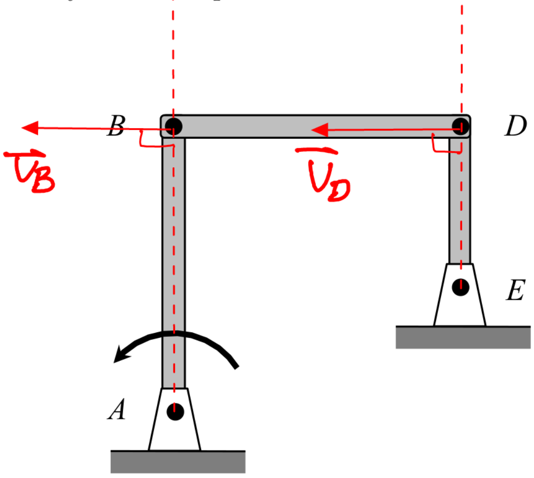
Question C2.9

Link AB of the mechanism shown below is rotating counterclockwise when at the configuration shown (when AB and DE are vertical, and BD is horizontal). At this configuration (circle the correct answer):

(a) Link BD is rotating counterclockwise

(b) Link BD is rotating clockwise

(c) Link BD instantaneously has zero speed



Question C2.10
A scaled drawing of a rigid disk is shown below highlighting two points A and B on the disk. The velocity of A, v_A, is shown on the disk as well as the path of point B. Circle the response below that most accurately describes the speeds v_A and v_B:

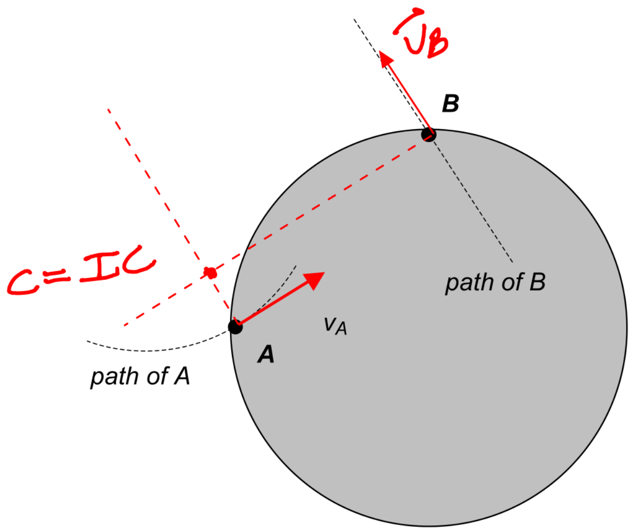
(a) $v_B = 0$

(b) $0 < v_B < v_A$

(c) $v_B = v_A > 0$

(d) $v_B > v_A > 0$

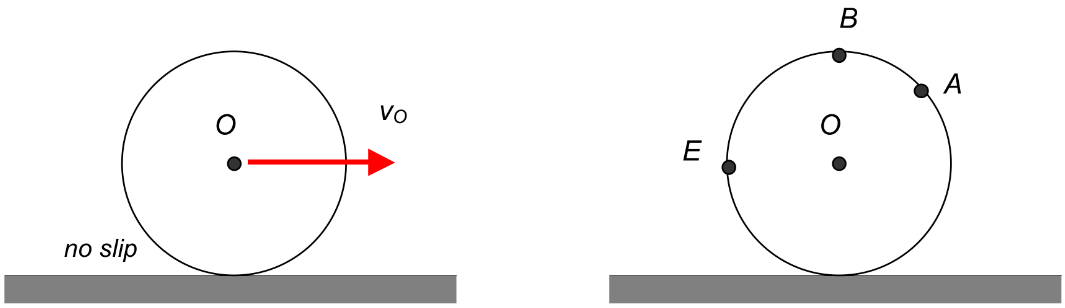
(e) Additional information is needed to answer this question.



From figure: $\overline{BC} > \overline{AC}$

Question C2.11

A wheel rolls without slipping with its center O having a constant speed of v_O. In the figure below, sketch the directions for the acceleration vectors for points A, B and E on the wheel.

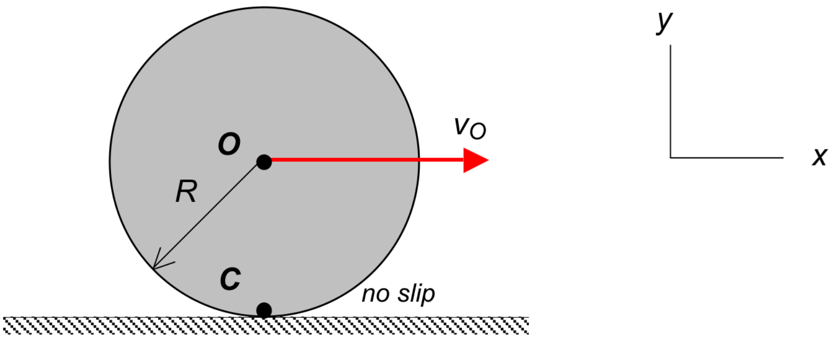


Since V_O = constant $\Rightarrow \vec{a}_O = \vec{0}$ & $\vec{\alpha} = \vec{0} \Rightarrow$

$$\vec{a}_A = \cancelto{0}{\vec{a}_O} + \cancelto{0}{\vec{\alpha}} \times \vec{r}_{A/O} - \omega^2 \vec{r}_{A/O}$$

Question C2.12

A wheel having an outer radius of R rolls without slipping with its center moving to the right with a constant speed v_O. Without looking back at the lecture notes, derive an expression for the acceleration vector for point C.



$V_O = \text{constant} \Rightarrow \vec{a}_O = \vec{0}$ & $\vec{\alpha} = \vec{0} \Rightarrow$

$\vec{a}_C = \cancel{\vec{a}_O}^{\,0} + \cancel{\vec{\alpha}}^{\,0} \times \vec{r}_{C/O} - \omega^2 \vec{r}_{C/O} = -\omega^2 \vec{r}_{C/O}$

Question C2.13

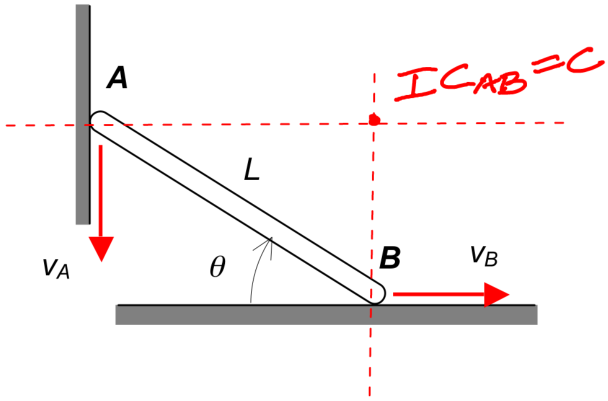
Ends A and B of a thin bar slide on vertical and horizontal surfaces, respectively. At the position shown, $\theta < 45°$. For this position, circle the answer below that most accurately describes the relative sizes of the speeds v_A and v_B:

(a) $v_A > v_B$

(b) $v_A = v_B$

(c) $v_A < v_B$

(d) Additional information is needed to answer this question.



Note $\overline{AC} > \overline{BC}$

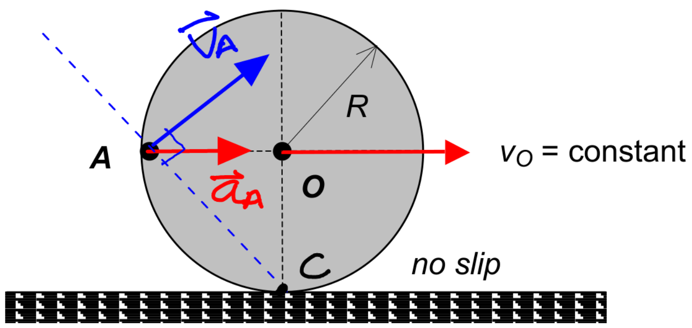
Question C2.14
A wheel rolls without slipping as its center O moves to the right with a constant speed of v_0. Point A is on the circumference of the wheel. At the instant shown, A is located directly to the left of O. At this instant (circle the correct answer):

(a) The speed of A is decreasing.

(b) The speed of A is constant.

(c) The speed of A is increasing.

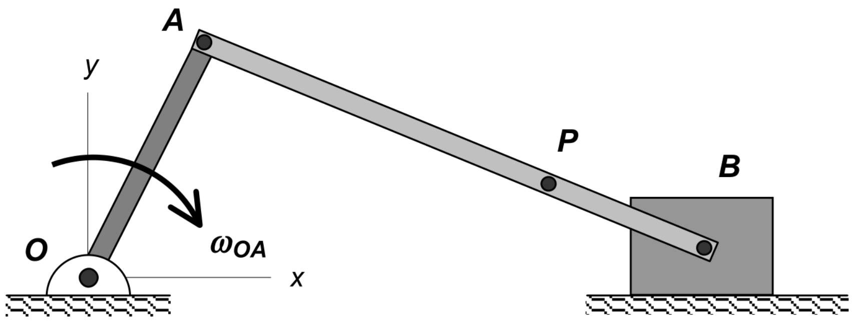
(d) Numerical values for v_O and the radius R of the wheel are needed to answer this question.



- V_0 = constant $\Rightarrow \vec{a}_0 = \vec{0}$ & $\vec{\alpha} = 0 \Rightarrow$
  $\vec{a}_A = \cancel{\vec{a}_0}^{\,0} + \cancel{\vec{\alpha}}^{\,0} \times \vec{r}_{A/O} - \omega^2 \vec{r}_{A/O}$
- Since $C = IC$, $\vec{V}_C \perp \overline{OC}$

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: $\vec{v}_P = \left(20\hat{\imath} - 4\hat{\jmath}\right)$ 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.



$$\dot{v}_P = \vec{a}_P \cdot \hat{e}_t = \frac{\vec{a}_P \cdot \vec{v}_P}{|\vec{v}_P|}$$

$$|\vec{a}_P|^2 = \dot{v}^2 + \left(\frac{v_P^2}{\rho_P}\right)^2 \Rightarrow \rho_P = \frac{v_P^2}{\sqrt{|\vec{a}_P|^2 - \dot{v}_P^2}}$$