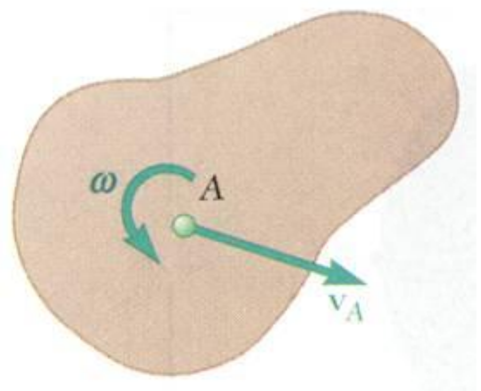
Preview of 15.7- 15.9

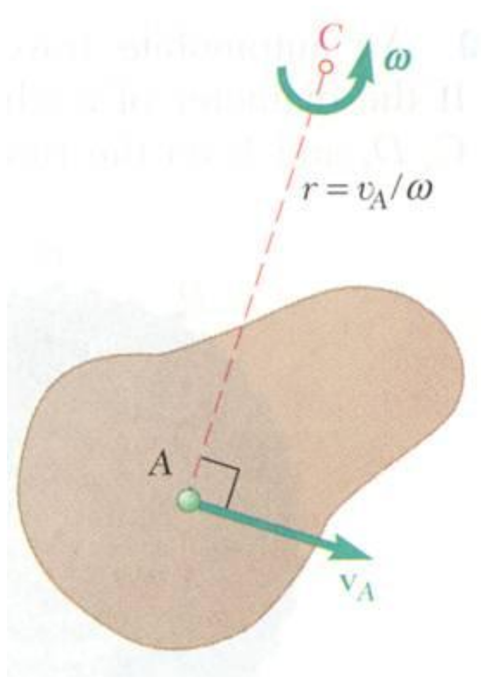
15.7 Instantaneous Center of Rotation in Plane Motion



- Motion of a slab can always be replaced by the translation of an arbitrary point *A* + a rotation about *A* with an angular velocity that is **independent of the choice of *A***.

- Now, Represent the motion with

an instantaneous center of rotation + **angular velocity**.



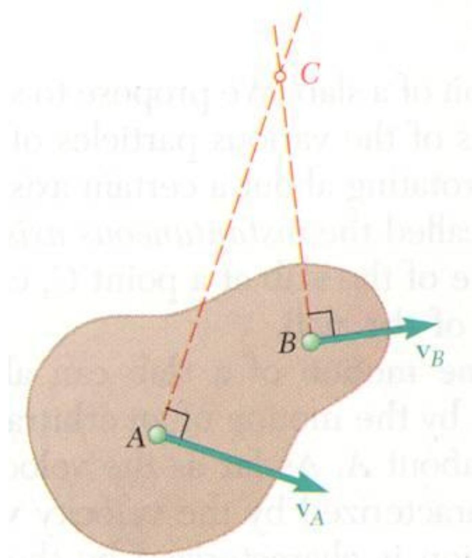
- How do we find the instantaneous center of rotation?

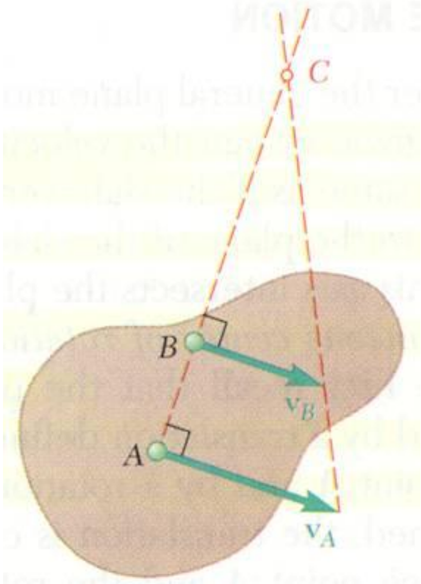
On a line located perpendicular to V_A, distance of

away from point A

- As far as the **velocities** are concerned, the slab seems to rotate about the ***instantaneous center of rotation C.***

15.7 Instantaneous Center of Rotation in Plane Motion





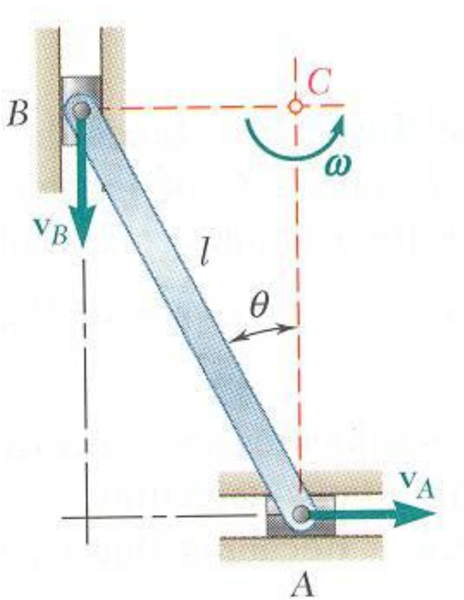
- How do we find the center of rotation when the velocity at two points *A* and *B* are known?

  the instantaneous center of rotation lies at the intersection of the to $\vec{v}_A$ and $\vec{v}_B$

- If the velocity vectors at *A* and *B* are perpendicular to the line *AB*, the instantaneous center of rotation lies at the intersection of the line *AB* with the line joining the of the velocity vectors at *A* and *B*.

- If the velocity magnitudes are equal, the instantaneous center of rotation is at infinity and the angular velocity is

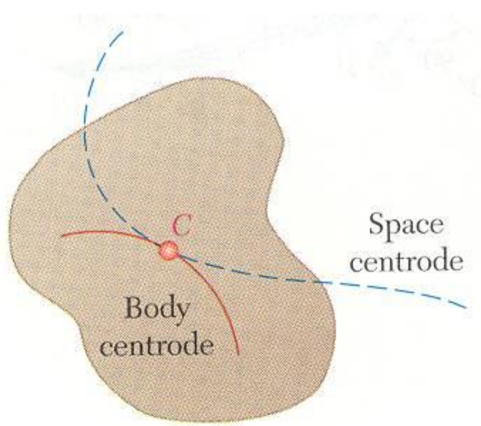
15.7 Instantaneous Center of Rotation in Plane Motion



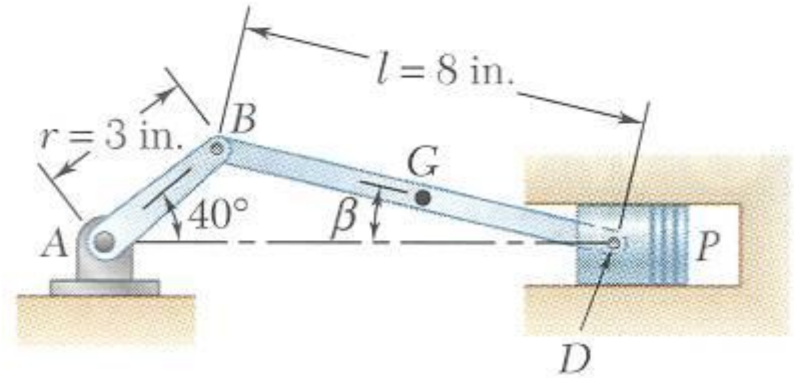
- The instantaneous center of rotation lies at the intersection of the perpendiculars to the velocity vectors through A and B .

$\omega = \square = \square$ $\quad$ $v_B = \square = \square$
$= \square$

- The velocities of all particles on the rod are as if they were rotated about *C*.
- The particle **at the center of rotation** has ☐ velocity.
- The **particle coinciding with the center of rotation** changes with time and the **acceleration** of the particle at the instantaneous center of rotation is ☐
- The **acceleration** of the particles in the slab cannot be determined as if the slab were simply rotating about *C*.
- The trace of the locus of the center of rotation on the body is the **body centrode** and in space is the **space centrode**.



Sample Problem 15.5

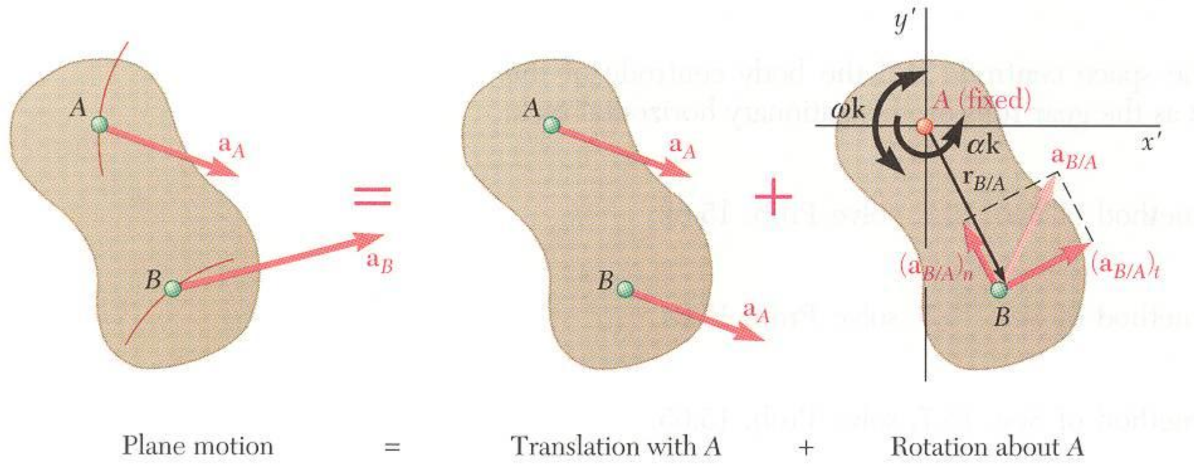


The crank *AB* has a constant clockwise angular velocity of 2000 rpm.

For the crank position indicated, determine *(a)* the angular velocity of the connecting rod *BD*, and *(b)* the velocity of the piston *P*.

Sample Problem 15.5

15.8 Absolute and Relative Acceleration in Plane Motion



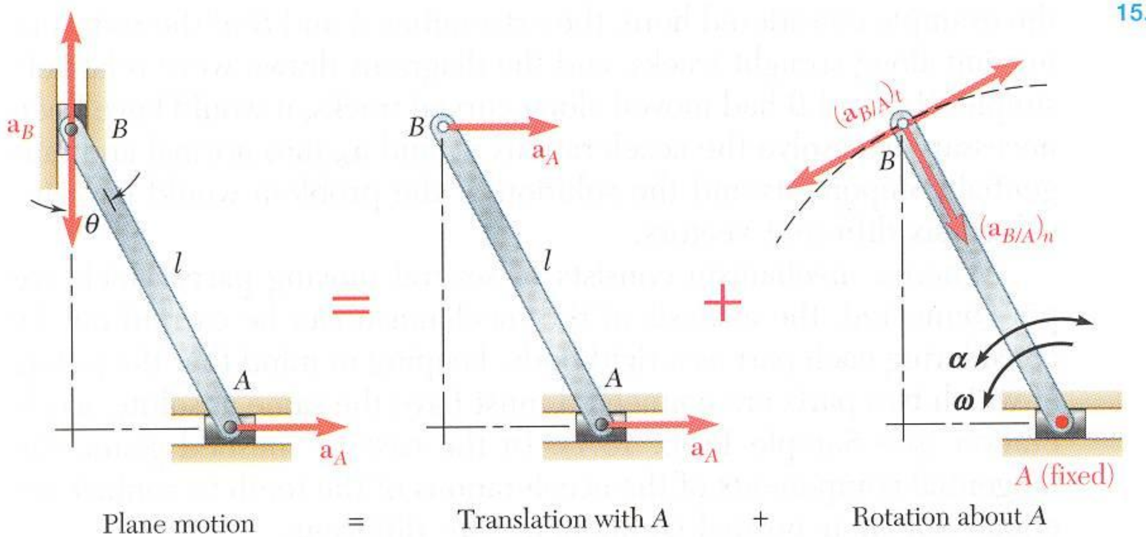
- Absolute acceleration of a particle of the slab,

- Relative acceleration $\vec{a}_{B/A}$ associated with rotation about A includes tangential and normal components,

$$\left(\vec{a}_{B/A}\right)_t = \qquad \left(a_{B/A}\right)_t =$$

$$\left(\vec{a}_{B/A}\right)_n = \qquad \left(a_{B/A}\right)_n =$$

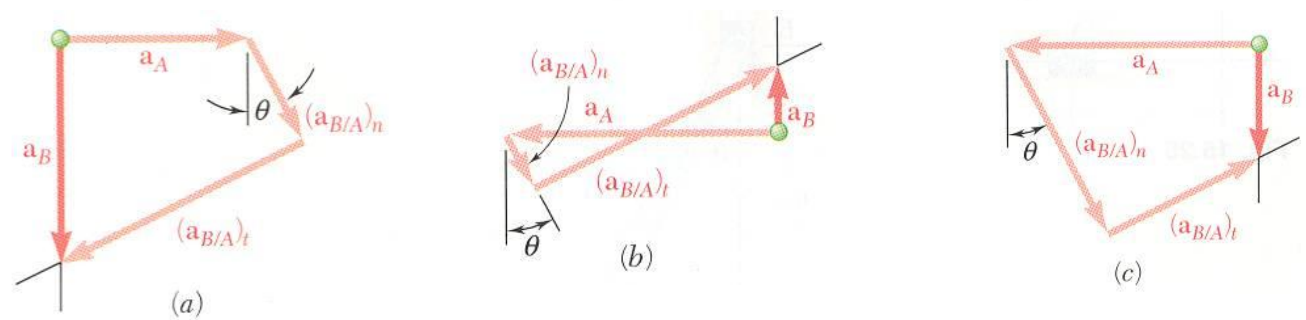
15.8 Absolute and Relative Acceleration in Plane Motion

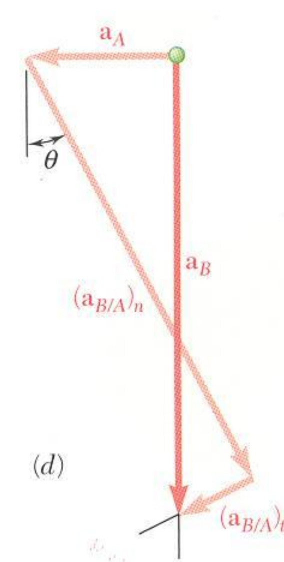


- Given $\vec{a}_A$ and $\vec{v}_A$, determine $\vec{a}_B$ and $\vec{\alpha}$.

$$\vec{a}_B = \vec{a}_A + \vec{a}_{B/A}$$

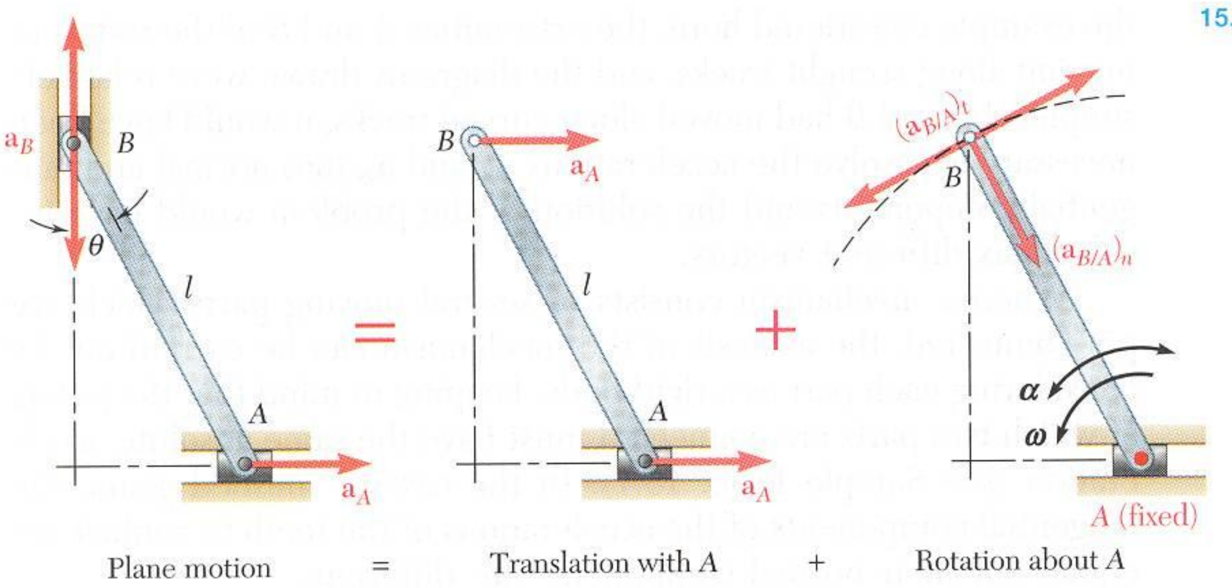
$$=$$

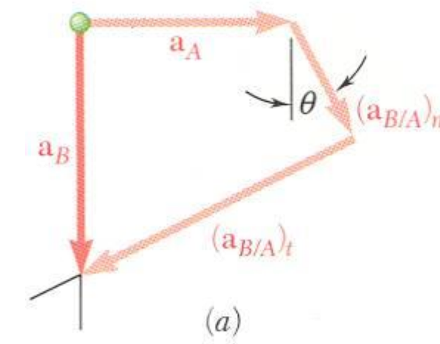




- Vector result depends on sense of $\vec{a}_A$ and the relative magnitudes of a_A and $\left(a_{B/A}\right)_n$
- Must also know angular velocity ω.

15.8 Absolute and Relative Acceleration in Plane Motion





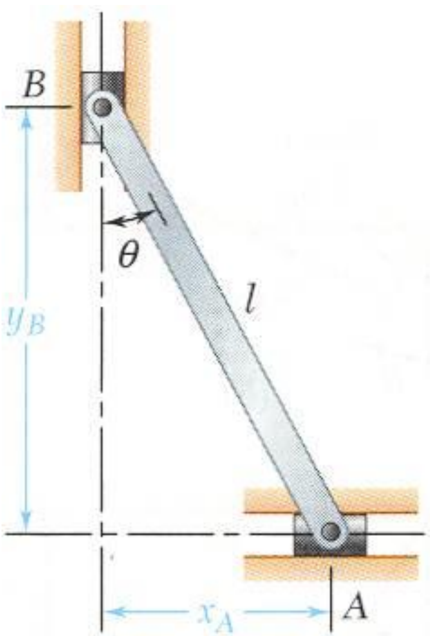
- Write $\vec{a}_B = \vec{a}_A + \vec{a}_{B/A}$ in terms of the two component equations,

  $\overset{+}{\rightarrow}$ x components:

  $+\uparrow$ y components:

- Solve for a_B and α.

15.9 Analysis of Plane Motion in Terms of a Parameter



- In some cases, it is advantageous to determine the absolute velocity and acceleration of a mechanism directly.

$x_A =$ ☐ $\qquad y_B =$ ☐

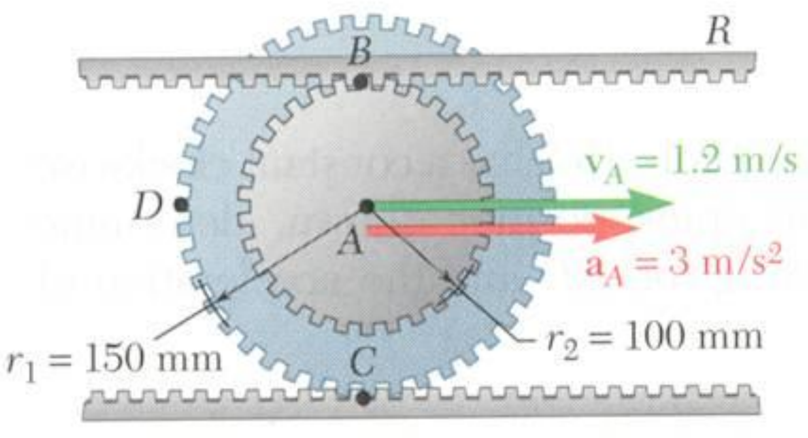
$$v_A = \dot{x}_A = l\dot{\theta}\cos\theta = l\omega\cos\theta$$

$$v_B = \dot{y}_B = -l\dot{\theta}\sin\theta = -l\omega\sin\theta$$

$$a_A = \ddot{x}_A = -l\dot{\theta}^2\sin\theta + l\ddot{\theta}\cos\theta = -l\omega^2\sin\theta + l\alpha\cos\theta$$

$$a_B = \ddot{y}_B = -l\dot{\theta}^2\cos\theta - l\ddot{\theta}\sin\theta = -l\omega^2\cos\theta - l\alpha\sin\theta$$

Sample Problem 15.6

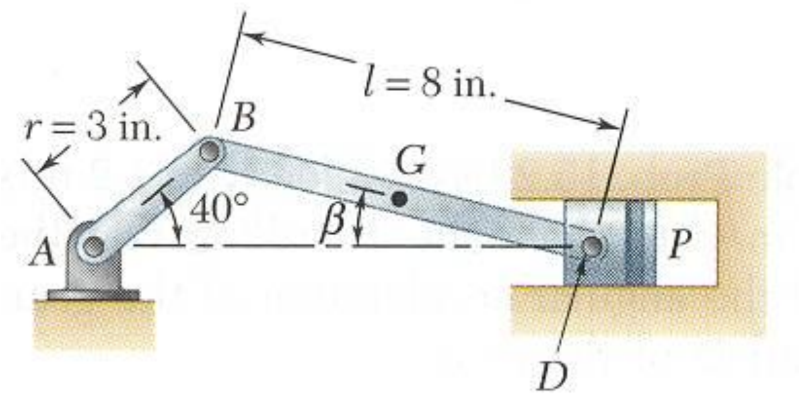


The center of the double gear has a velocity and acceleration to the right of 1.2 m/s and 3 m/s^2, respectively. The lower rack is stationary.

Determine *(a)* the angular acceleration of the gear, and *(b)* the acceleration of points *B*, *C*, and *D*.

Sample Problem 15.6

Sample Problem 15.7

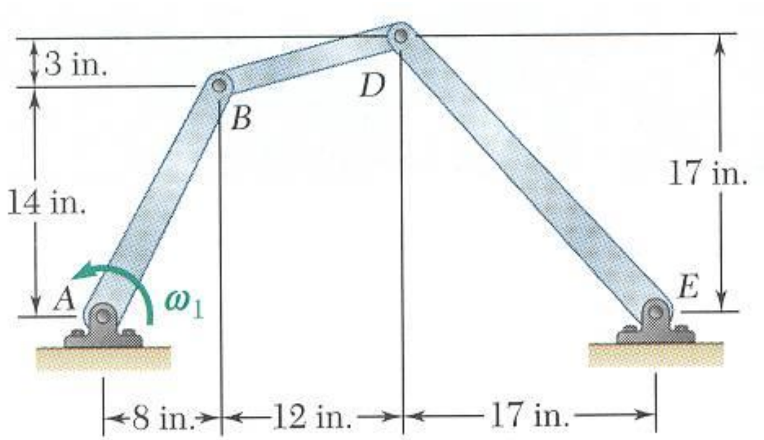


Crank *AG* of the engine system has a constant clockwise angular velocity of 2000 rpm.

For the crank position shown, determine the angular acceleration of the connecting rod *BD* and the acceleration of point *D*.

Sample Problem 15.7

Sample Problem 15.8



In the position shown, crank *AB* has a constant angular velocity ω_1 = 20 rad/s counterclockwise.

Determine the angular velocities and angular accelerations of the connecting rod *BD* and crank *DE*.

Sample Problem 15.8