Palestine Technical University- Kadoorie (PTUK)

Mechanical Engineering Department

12210244: Dynamics

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This is an explanation of the Dynamics course

offered at Palestine Technical University - Kadoorie

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Textbook:

Engineering Mechanics: Dynamics, 7th Edition

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Chapter Five: Plane Kinematics of Rigid Bodies

Section Three: Absolute Motion

5 Chapter Five: Plane Kinematics of Rigid Bodies

5.3 Absolute Motion

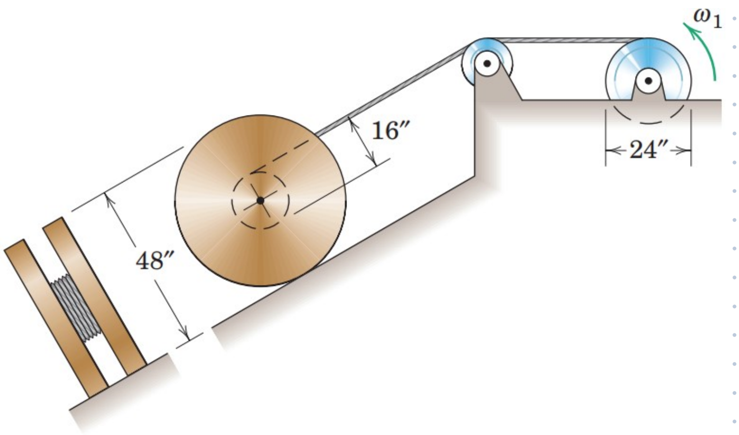
- **Approach:** Absolute-motion analysis is used to describe the plane kinematics of rigid bodies by leveraging geometric relations that define the body's configuration.
- **Process:**
  - Establish geometric relations of the body.
  - Take time derivatives of these relations to obtain velocities and accelerations.
- **Previous Application:** In particle kinematics (Chapter 2), absolute-motion analysis was used for constrained motions of connected particles, focusing on cable lengths without angular quantities.
- **Rigid-Body Motion:** Involves both linear and angular variables, requiring consideration of both linear/angular velocities and accelerations.
- **Consistency:** Ensure consistent mathematical descriptions, e.g., counterclockwise angles correspond to positive angular velocity and acceleration; negative signs indicate clockwise motion.
- **Geometric Description:** The approach is straightforward for simple configurations but may be complex for intricate setups.
- **Relative Motion:** May be preferred for complex configurations, with relative-motion analysis discussed in Chapter 5, starting from section 4.
- **Practical Application:** Includes common situations like the kinematics of a rolling wheel, which is essential for various mechanical systems.

End of Section 5.3

Example 1:

The telephone-cable reel is rolled down the incline by the cable leading from the upper drum and wrapped around the inner hub of the reel. If the upper drum is turned at the constant rate $\omega_1 = 2\ rad/sec$, calculate the time required for the center of the reel to move 100 ft along the incline. No slipping occurs.

ans. $t = 66.67\ sec$

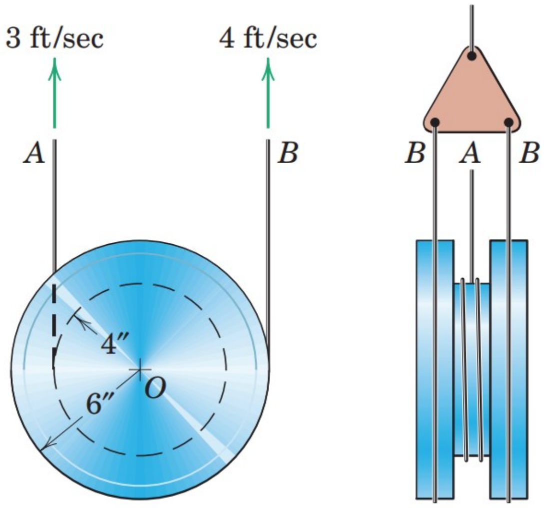


Ans.

Example 2:

The cables at A and B are wrapped securely around the rims and the hub of the integral pulley as shown. If the cables at A and B are given upward velocities of 3 ft/sec and 4 ft/sec, respectively, calculate the velocity of the center O and the angular velocity of the pulley.

ans. $v_o = 3.4\ ft/sec$ $\omega = 1.2\ rad\,\text{sec}$

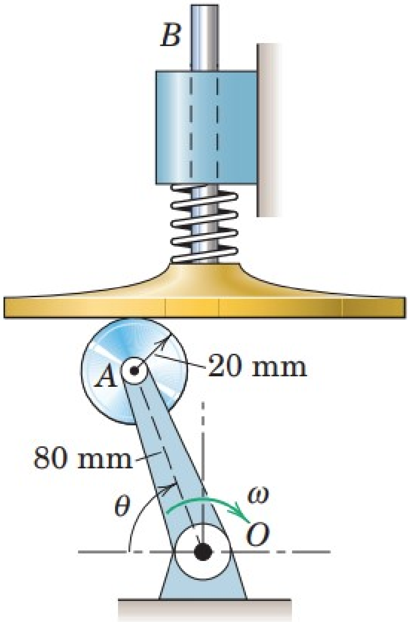


Ans.

Example 3:

Determine the acceleration of the shaft B for $\theta = 60^\circ$ if the crank OA has an angular acceleration $\ddot{\theta} = 8\ rad/sec^2$ and an angular velocity $\dot{\theta} = 4\ rad/sec$ at this position. The spring maintains contact between the roller and the surface of the plunger.

ans. $v_B = 789\ mm/sec\ down$

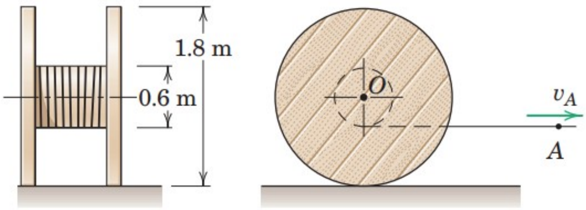


Ans.

Example 4:

The telephone-cable reel rolls without slipping on the horizontal surface. If point A on the cable has a velocity $v_A = 0.8\ m/sec$ to the right, compute the velocity of the center O and the angular velocity of the reel. (Be careful not to make the mistake of assuming that the reel rolls to the left.)

ans. $\omega = 1.3333\ rad/sec$ $v_O = 1.2\ m/sec$



Ans.

Chapter Five: Plane Kinematics of Rigid Bodies

Section Four: Relative Velocity

5 Chapter Five: Plane Kinematics of Rigid Bodies

5.4 Relative Velocity

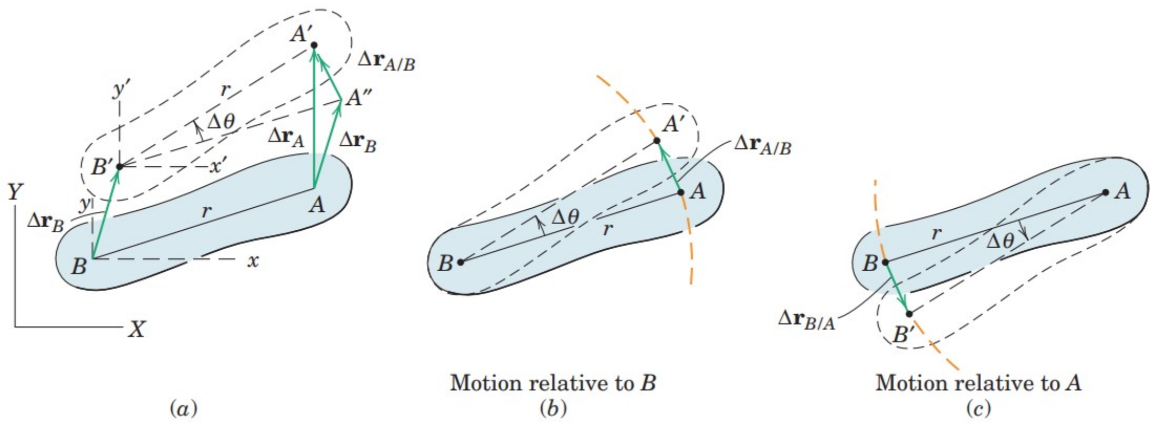


Figure 5/5

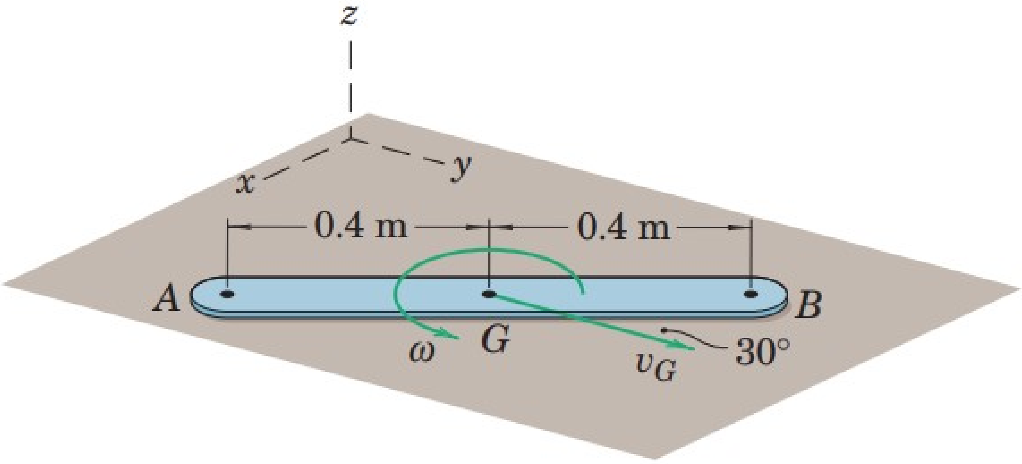
$$\Delta\vec{r}_A = \Delta\vec{r}_B + \Delta\vec{r}_{A/B}$$
$$\Delta\vec{v}_A = \Delta\vec{v}_B + \Delta\vec{v}_{A/B}$$
$$\vec{v}_{A/B} = \vec{\omega} \times \vec{r}_{A/B}$$

End of Section 5.4

Example 1:

Consider a bar AB that moves on a horizontal surface. The mass center of the bar has a velocity $v_G = 2\ m/sec$ directed parallel to the y-axis, and the bar has a counterclockwise angular velocity $\omega = 4\ rad/sec$ (as seen from above). We want to determine the velocity of point B.

$ans.$ $\vec{v}_b = -1.38\hat{i} + 1.2\hat{j}\ m/sec$



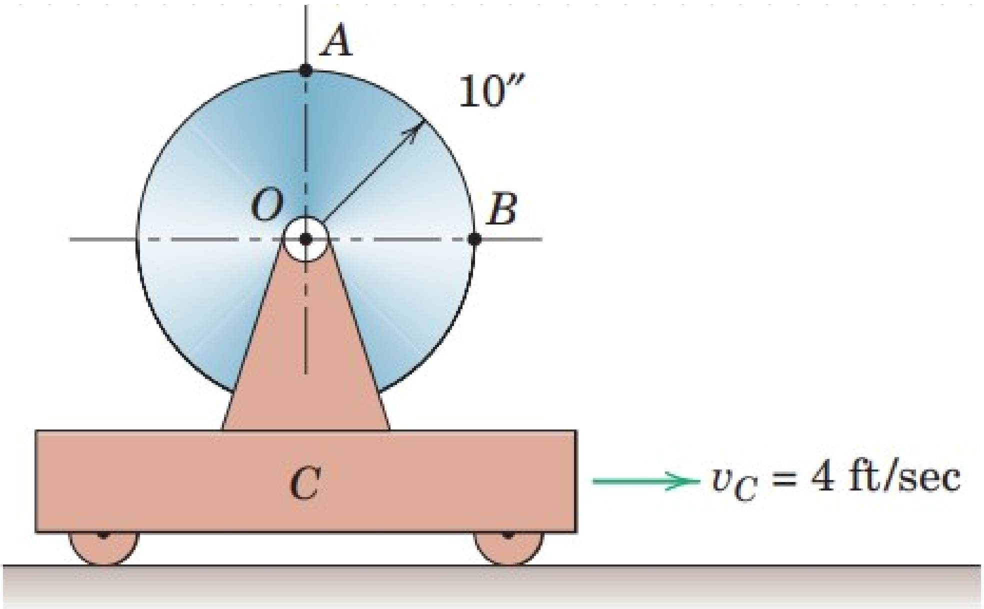
Ans.

Example 1:

The cart has a velocity of 4 ft/sec to the right. Determine the angular speed ω of the wheel so that point A on the top of the rim has the following velocities:

1. A velocity of 4 ft/sec to the left.
2. A velocity of 0 ft/sec.
3. A velocity of 8 ft/sec to the right.

ans. $N = 91.7\ rev/min\ CCW$ $N = 45.8\ rev/min\ CCW$ $N = 45.8\ rev/min\ CW$

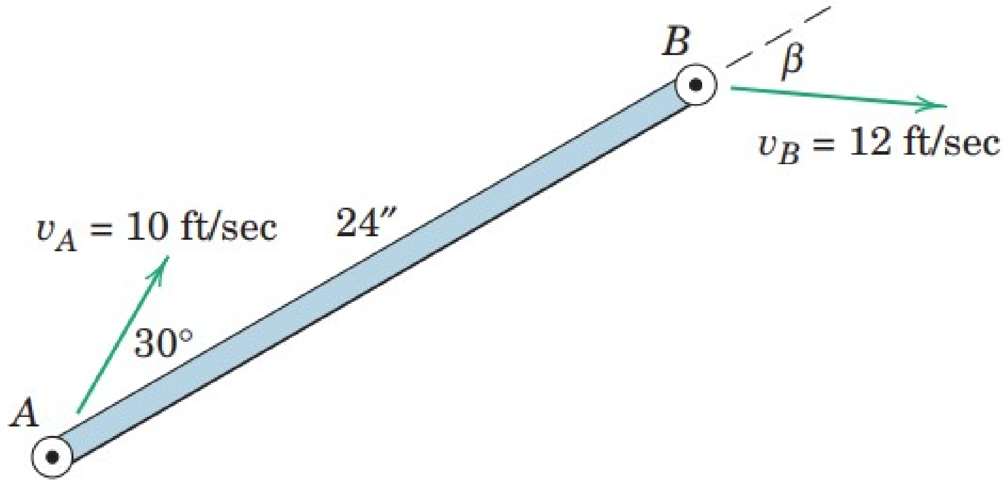


Ans.

Example 2:

End A of the 24 *in.* link has a velocity of 10 ft/sec in the direction shown. At the same instant end B has a velocity whose magnitude is 12 ft/sec as indicated. Find the angular velocity of the link in two ways.

ans. $\omega = 6.685\ rad/sec\ CW$

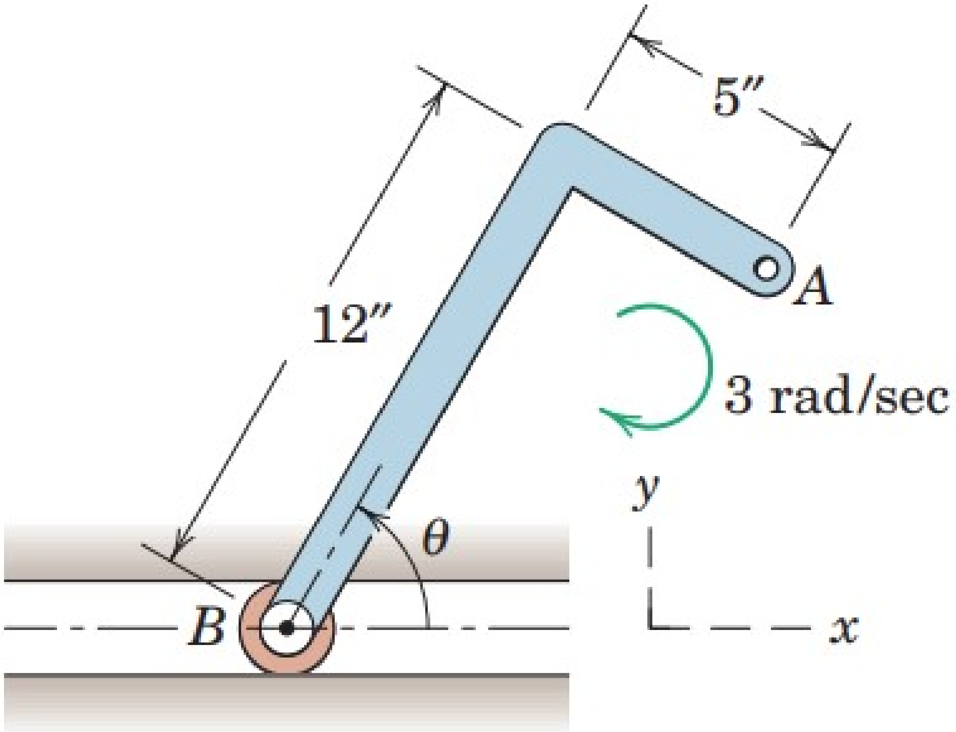


Ans.

Example 3:

The right-angle link AB has a clockwise angular velocity of at the instant when $\theta = 60°$ Express the velocity of A with respect to B in vector notation for this instant

ans. $\vec{v_{A/B}} = 23.7\hat{i} - 31\hat{j}\ m/sec$

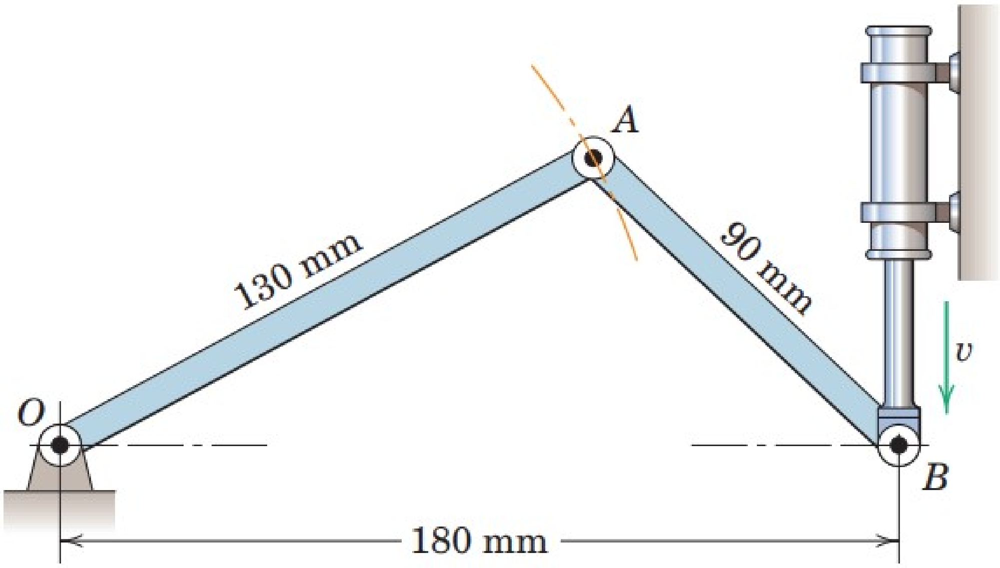


Ans.

Example 4:

For the instant represented point B crosses the horizontal axis through point O with a downward velocity $v = 0.6\ m/sec$ Determine the corresponding value of the angular velocity of link OA.

ans. $\omega = 3.333\ rad/sec\ CW$



Ans.