Chapter 2

Planar Rigid Body Kinematics

Homework
Homework 2.A

Given: The pulley shown below freely rotates about point C and interacts with two rubber belts (one horizontal, one vertical). The velocity of point A on the drive belt is measured to be $\vec{v}_A = v_A \hat{i}$, and the acceleration of point B on the load belt is measured to be $\vec{a}_B = a_B \hat{j}$. The belts do not slip.

Find: Determine the velocity and acceleration of point D on the pulley.

Use the following parameters in your analysis: $R = 0.05\, \text{m}$, $r = 0.0125\, \text{m}$, $v_A = 20\, \text{m/s}$ and $a_B = -5\, \text{m/s}^2$. 
Homework 2.B

Given: End A of bar AB is constrained to move along a straight inclined surface. End B of the bar is constrained to move along a straight horizontal surface. End A moves in the direction shown with a speed of \( v_A \) and acceleration \( a_A \). At the position shown, bar AB is horizontal.

Find: For this position:

(a) Determine the angular velocity of bar AB and the velocity of end B. Write your answers as vectors.

(b) Determine the angular acceleration of bar AB and the acceleration of end B. Write your answers as vectors.

Use the following parameters in your analysis: \( \theta = 36.87^\circ \), \( L = 3 \) ft, \( v_A = 20 \) ft/s and \( a_A = 10 \) ft/s\(^2\).
Homework 2.C

Given: The compound wheel assembly shown below is driven by a cable attached to the outer rim of the assembly at point A. The wheel rolls without slip at point B with point C moving to the right with a speed of $v_C$, and the acceleration at point A is given by $\ddot{a} = a_x \hat{i} + a_y \hat{j}$.

Find: Determine the acceleration of the center point C of the pulley.

Use the following parameters in your analysis: $R = 0.1$ m, $r = 0.0125$ m, $\phi = 0^\circ$, $a_x = 8$ m/s$^2$ and $a_y = 3$ m/s$^2$. 
Homework 2.D

**Given:** At the instant shown, the piston has velocity $\vec{v}_A = v_A \hat{i}$.

**Find:** Determine the resulting angular velocity $\vec{\omega}_{BC}$ of the crankshaft.

Use the following parameters in your analysis: $L = 0.06 \text{ m}$, $R = 0.03 \text{ m}$, $\phi = 30^\circ$ and $v_A = -50 \text{ m/s}$.
Homework 2.6

Given: Link OA of the mechanism shown rotates with an angular speed of $\omega_0$. At the position shown, link BC is vertical, and the coordinates of pin A are given by $(x_A, y_A)$.

Find: For this position, determine the angular velocities of links AB and BC. Write your answers as vectors.

Use the following parameters in your analysis: $\omega_0 = 10 \text{ rad/s}$ and $(x_A, y_A) = (-54, 72) \text{ mm}$.
Homework 2.F

**Given:** Link OA rotates at a constant rate of $\omega$. At the instant shown, link OA is aligned with the horizontal line of OC and link AB is vertical.

**Find:** For this position, determine the angular accelerations of links AB and BC. Write your answers as vectors.
Homework 2.G

Consider the four mechanisms shown below. Respond to the questions posed. Feel free to draw directly on these sheets and submit for your homework solution. Use a straight edge when making your drawings.

MECHANISM NO. 1
Link OA is rotating in the clockwise sense. Determine the location of the instant center (IC) of link AB. From the location of this IC, determine the sense of rotation for links AB and BC. Justify your answers in words.
MECHANISM NO. 2
Determine the location of the instant center (IC) of link AD. From the location of this IC, determine the sense of rotation for links AD and DB. Justify your answers in words.
MECHANISM NO. 3
Link OA is rotating in the clockwise sense. Determine the location of the instant center (IC) of link AB. From the location of this IC, determine the sense of rotation for link AB and the sense of translation for the piston. Justify your answers in words.
MECHANISM NO. 4

Racks A and B are moving in the directions shown with the speeds provided. Assume that the gear does not slip on the racks. Determine the location of the instant center (IC) of the gear. From the location of this IC, determine the sense of rotation for the gear. Justify your answers with numbers and words.

\[ v_A = 0.3 \text{ m/s} \]
\[ v_B = 0.1 \text{ m/s} \]
Homework 2.H

This problem has three parts. In each part, you are asked to use the instant center approach in answering the questions related to the problems. In all cases, the figures are drawn to scale. Please use a straight edge when making your drawings.

PART A
In the mechanisms shown below, link OA is rotating in the counterclockwise sense. For the position shown of EACH mechanism:

(a) Determine the location of the instant center for link AB.

(b) Determine the directions of rotation for links AB and BD. Justify your answers in words.

(c) Which is larger: |ω_{OA}| or |ω_{AB}|? Justify your answers in words.
PART B
In the mechanism shown below, link OA is rotating in the counterclockwise sense.

(a) Determine the locations of the instant centers for links AB, BE and EG.

(b) Determine the directions of rotation for links AB, BE and EG. Justify your answers in words.
PART C
Link AB, having a length of $L = 5$ in, is part of a planar mechanism. At the instant shown, the velocities of points A and B are known to be both perpendicular to a line connecting A and B, with $v_B = 3v_A = 30$ in/s. Determine the location of the instant center for link AB.
Homework 2.I

Given: A mechanism is made up of links AB and BC and a wheel pinned to BC at the wheel’s center C. The wheel rolls without slipping on a horizontal surface. Link AB rotates counterclockwise with a constant rate of $\omega_{AB}$. At the instant shown, link AB is vertical.

Find: For this position:

(a) Determine the angular velocity of link BC and the wheel. Write your answers as vectors.
(b) Determine the angular acceleration of link BC and the wheel. Write your answers as vectors.

Use the following parameters in your analysis: $r = 0.5$ m, $L = 2$ m, $d = 1$ m and $\omega_{AB} = 3$ rad/s. You may solve the problem using the Method of Instant Centers and/or by adopting a vector approach.
Homework 2.J

Given: The mechanism shown below is made up of links OA and AB, along with the slider at B. The slider is constrained to move in the horizontal direction. Link OA is moving with a constant clockwise rotation rate of $\omega_{OA}$. At the position shown, B is directly below O.

Find: For position shown:

(a) Determine the angular velocity link AB and the velocity of the slider. Write your answers as vectors.

(b) Determine the angular acceleration link AB and the acceleration of the slider. Write your answers as vectors.

Use the following parameters in your analysis: $\omega_{OA} = 4 \text{ rad/s}$ and $L = 5 \text{ cm}$.