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Review for Exam II

- Office Hour Today 3:30 PM - 4:30 PM, ME Conf Room
- Exam to Take Place in JEB 104.
- Open book, open notes, calcs welcome.

Coverage is Chapter 16 - Kinematics of a Rigid Body.
Excepting 16.4, 16.6

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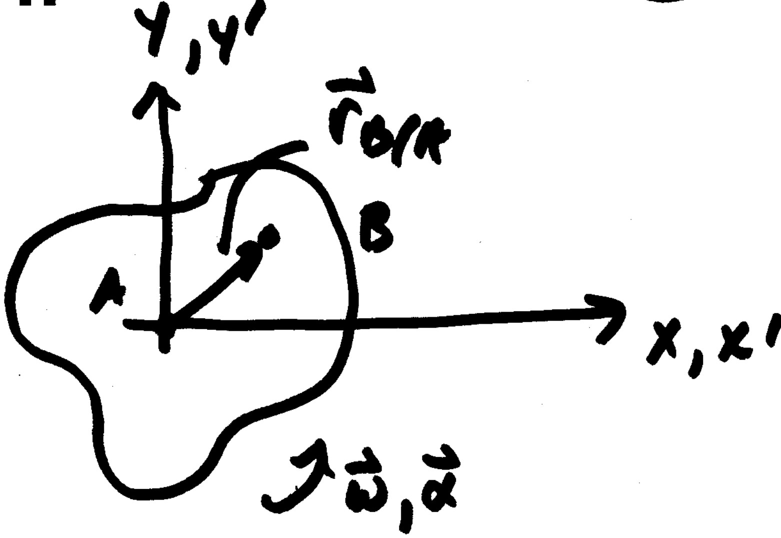
Fixed Axis Rotation about A



$$\vec{v}_B = \cancel{\vec{v}_A}^{\,0} + \vec{\omega} \times \vec{r}_{B/A}$$

$$\vec{a}_B = \cancel{\vec{a}_A}^{\,0} + \vec{\alpha} \times \vec{r}_{B/A} + \vec{\omega} \times (\vec{\omega} \times \vec{r}_{B/A})$$

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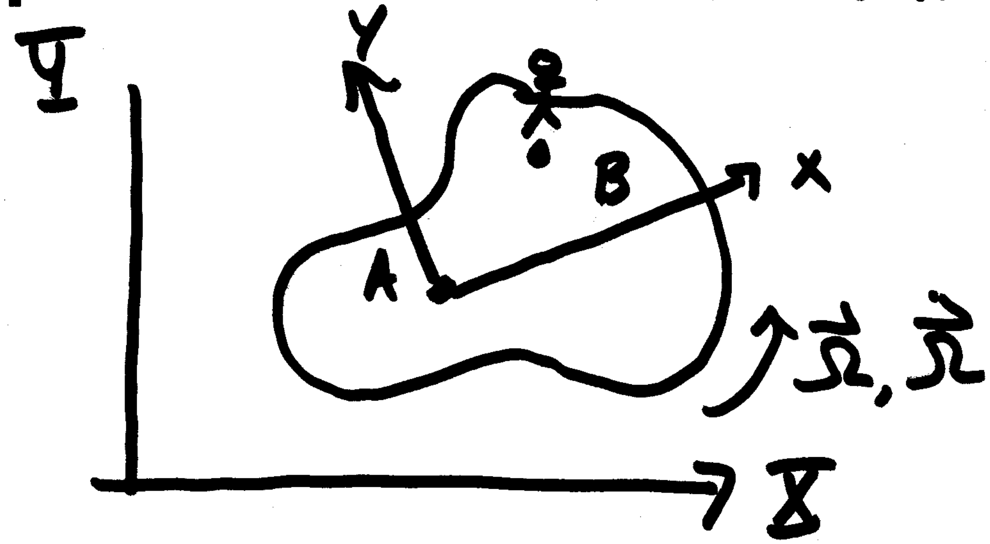
Relative Motion, Rotating Coordinates



XY - Fixed frame

xy - Attached to body, rotates at $\vec{\Omega}$ & $\dot{\vec{\Omega}}$

$$\vec{V}_{\text{person}} = \vec{V}_A + \vec{\Omega} \times \vec{r}_{B/A} + (\vec{V}_{B/A})_{xyz}$$

Text: $\vec{V}_B = \vec{V}_A + \vec{\Omega} \times \vec{r}_{B/A} + (\vec{V}_{B/A})_{xyz}$

$$\vec{a}_{\text{person}} = \vec{a}_A + \vec{\Omega} \times \vec{\Omega} \times \vec{r}_{B/A} + \dot{\vec{\Omega}} \times \vec{r}_{B/A} + 2\vec{\Omega} \times (\vec{V}_{B/A})_{xyz} + (\vec{a}_{B/A})_{xyz}$$

Text $\vec{a}_B = \dots$

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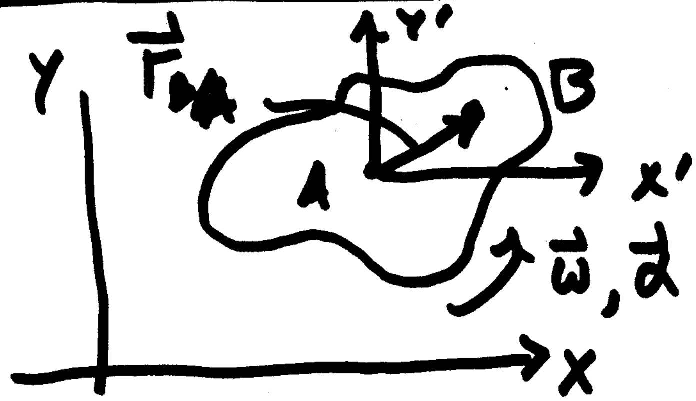
Relative Motion, Translating Coordinates



XY Fixed

X'Y' Translates but does not rotate

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

$$\vec{a}_B = \vec{a}_A + \vec{\alpha} \times \vec{r}_{B/A} + \vec{\omega} \times (\vec{\omega} \times \vec{r}_{B/A})$$

$$= \vec{a}_A + \underbrace{\vec{\alpha} \times \vec{r}_{B/A} - \omega^2 \vec{r}_{B/A}}_{\text{rotational accln}} \qquad \vec{\omega} = \omega \vec{k}$$

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General Problem Solving Procedure

- Write relative velocity and acceleration equation for each part in a system.
- Specify each vector in the relative velocity and acceleration equations. Some vectors will contain unknown <u>magnitudes</u> or directions.
- Equate vector equations at common points.
- From the vector "equations", separate into $\vec{i}, \vec{j}$ components and determine scalar unknowns.

$\vec{\omega} = \omega\vec{k}$

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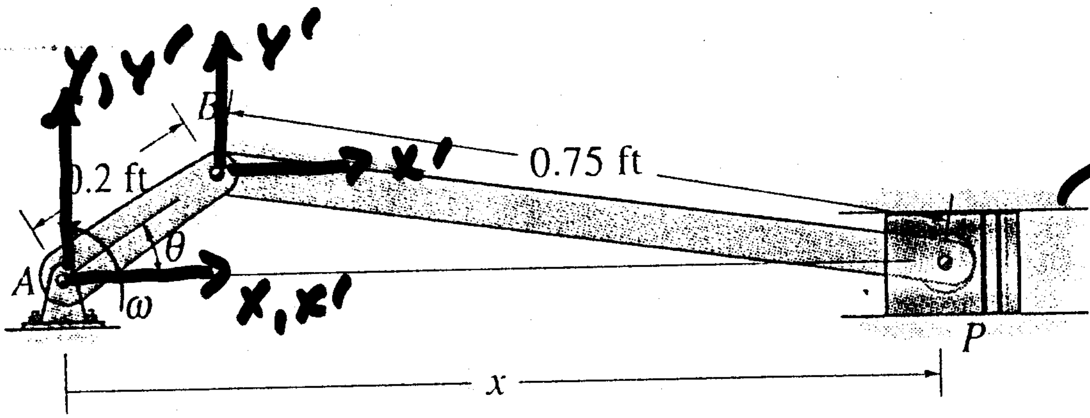


P moves in slot, but slot is fixed

∴ Use relative vel & accln with translating frame

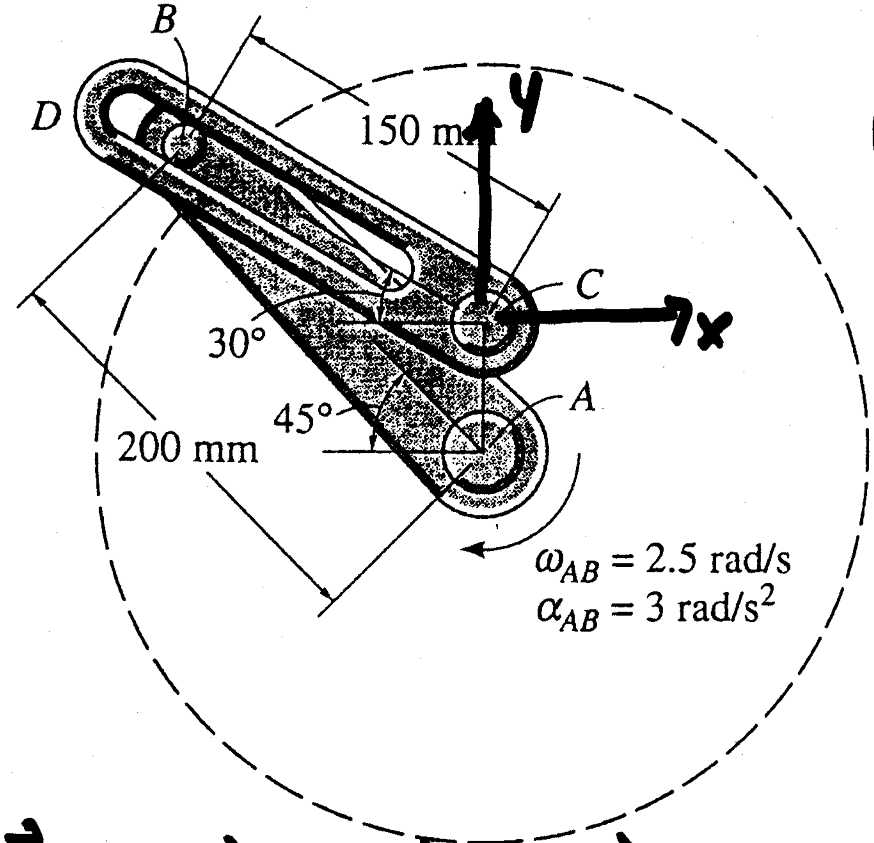
$$\vec{a}_B = \vec{a}_A + \vec{\alpha}_{AB} \times \vec{r}_{B/A} + \vec{\omega}_{AB} \times (\vec{\omega}_{AB} \times \vec{r}_{B/A})$$

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

$$\vec{a}_P = \vec{a}_B + \vec{\alpha}_{BP} \times \vec{r}_{P/B} + \vec{\omega}_{BP} \times (\vec{\omega}_{BP} \times \vec{r}_{P/B})$$

$$\vec{v}_P = \vec{v}_B + \vec{\omega}_{BP} \times \vec{r}_{P/B}$$

↑ Know direction of P in slot, slot fixed (not rotating)



Because B moves in slot on link CD, and slot in link CD rotates, we must use the rotating coord system attached to link CD.

Know the direction of $(\vec{V}_{B/C})_{xyz}$

$$\vec{V}_B = \vec{V}_C + \vec{\Omega}_{CD} \times \vec{r}_{B/C} + (\vec{V}_{B/C})_{xyz}$$

$$\vec{a}_B = \vec{a}_C + \dot{\vec{\Omega}}_{CD} \times \vec{r}_{B/C} + \vec{\Omega}_{CD} \times (\vec{\Omega}_{CD} \times \vec{r}_{B/C}) + 2\vec{\Omega} \times (\vec{V}_{B/C})_{xyz} + (\vec{a}_{B/C})_{xyz}$$

Know direction of $(\vec{a}_{B/C})_{xyz}$

Say we for planar rotation, we always know that the angular velocity and acceln vectors will be in the "z-dir". To specify a vector like this, w use

$$\vec{\Omega} = \Omega \vec{k}$$

$\vec{k}$ ← direction along z axis

Ω ← scalar, how long the vector is, and whether +/−