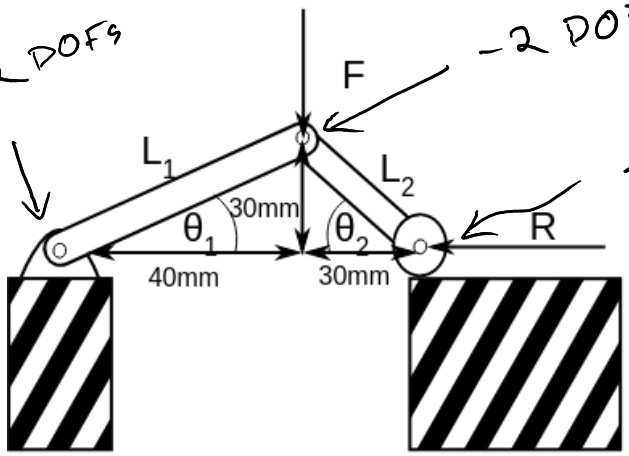
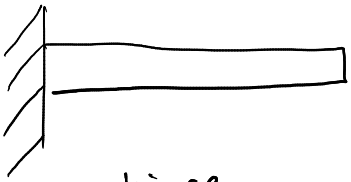


slides on x-axis
-1 DOF

6
-2
-2
-1
1 DOF

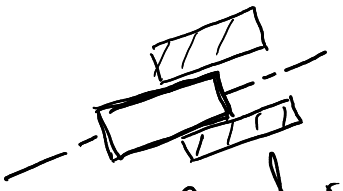
Constraints

Fixed 3 constraints

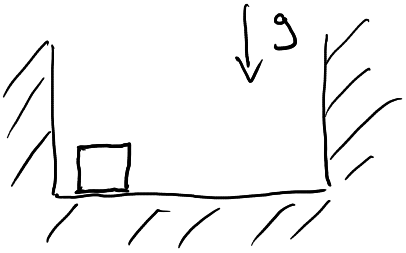


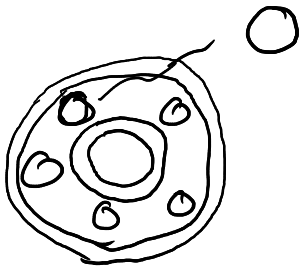
pin or hinge 2 constraints

prismatic constraint

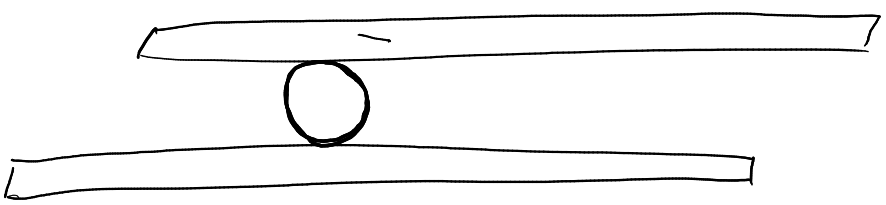


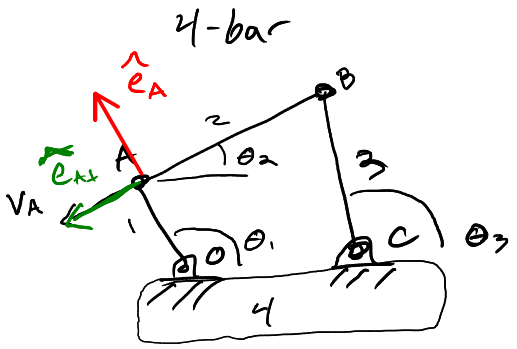
fixed rotation & fixed path





ball bearings → 1 DOF





piston-crank

$l_1 = 0.25\ m,\ l_2 = 1\ m,\ l_3 = 1\ m$

$dx = 1\ m\ and\ dy = 0\ m$

at time, t, link 1 (OA) is rotating at 10 rad/s. The positions of the pins are as follows

$r_0 = 0\hat{i} + 0\hat{j}$ [m]

$r_A = -0.203\hat{i} + 0.1459\hat{j}$ [m]

$r_B = 0.494\hat{i} + 0.863\hat{j}$ [m]

$r_C = 1\hat{i} + 0\hat{j}$ [m]

What are the rotation rates for links 2 and 3 (AB and BC, respectively)

$\dot{\theta}_2$? $\dot{\theta}_3$?

know

$\dot{\theta}_1 = 10\ rad/s$

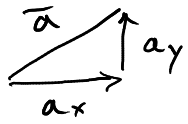
$\bar{r}_A = -0.203\hat{\imath} + 0.1459\hat{\jmath}\ m$

$|\bar{r}_A| = 0.25\ m$

$\bar{V}_A = 2.5\ m/s = l_1\dot{\theta}_1\ m/s$

$\hat{e}_A = \frac{-0.203}{0.25}\hat{\imath} + \frac{0.1459}{0.25}\hat{\jmath}$

$\hat{e}_{A\perp} = \frac{-0.1459}{0.25}\hat{\imath} - \frac{0.203}{0.25}\hat{\jmath}$

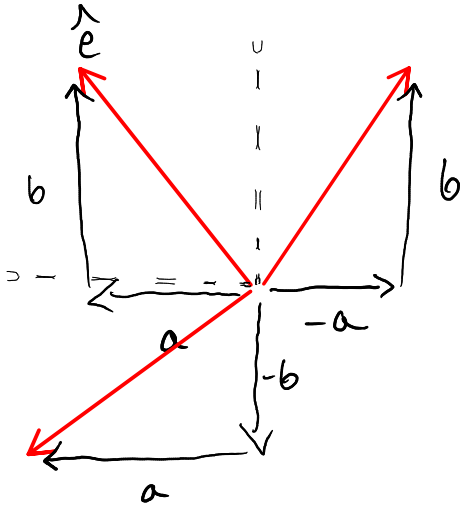


$\cos\theta = \frac{a_x}{|\bar{a}|}$

$\sin\theta = \frac{a_y}{|\bar{a}|}$

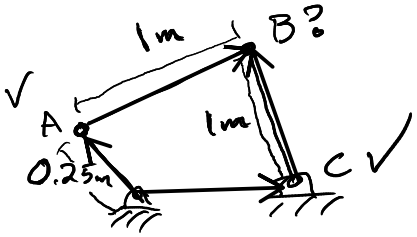
$\hat{e} = \cos\theta\hat{\imath} + \sin\theta\hat{\jmath}$

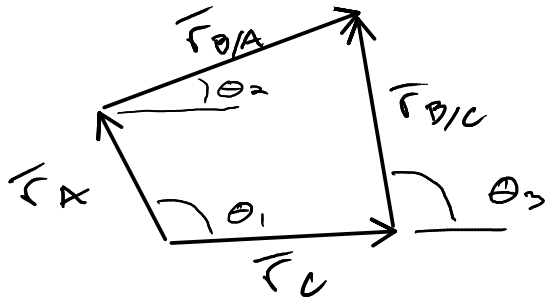
$\hat{e}_\perp = -\sin\theta\hat{\imath} + \cos\theta\hat{\jmath}$



$\bar{V}_A = 2.5\ m/s\left(-\frac{0.1459}{0.25}\hat{\imath} - \frac{0.203}{0.25}\hat{\jmath}\right)$

$\bar{V}_C = 0\hat{\imath} + 0\hat{\jmath}\ m/s$





$$\bar{v}_A = l_1 \dot{\theta}_1 \hat{e}'_A$$

$$\bar{v}_{B/A} = l_2 \dot{\theta}_2 \hat{e}'_{B/A}$$

$$\bar{v}_{B/C} = l_3 \dot{\theta}_3 \hat{e}'_{B/C}$$

$$\frac{d}{dt}\left(\bar{r}_A + \bar{r}_{B/A} = \bar{r}_C + \bar{r}_{B/C}\right)$$

$$\bar{v}_A + \bar{v}_{B/A} = \cancel{\bar{v}_C}^{\,0} + \bar{v}_{B/C}$$

$$\bar{v}_A = 2.5\,\text{m/s}\left(-\frac{0.1459}{0.25}\hat{\imath} - \frac{0.203}{0.25}\hat{\jmath}\right)$$

$$\bar{v}_C = 0\hat{\imath} + 0\hat{\jmath}\ \text{m/s}$$