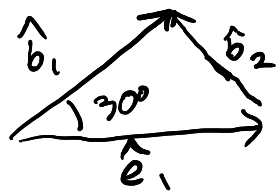
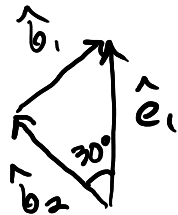


$$\vec{r}_P = 2.3 \hat{e}_1 + 3.1 \hat{e}_2 [\text{m}] = \underline{x_b} \hat{b}_1 + \underline{y_b} \hat{b}_2$$



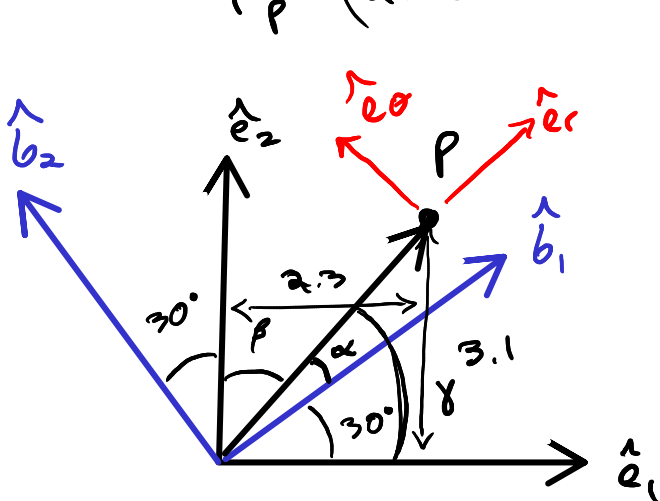
$$\hat{e}_1 = \cos \theta \hat{b}_1 - \sin \theta \hat{b}_2$$



$$\hat{e}_2 = \sin \theta \hat{b}_1 + \cos \theta \hat{b}_2$$

$$\begin{aligned} \vec{r}_P &= 2.3 [\cos 30^\circ \hat{b}_1 - \sin 30^\circ \hat{b}_2] \\ &+ 3.1 [\sin 30^\circ \hat{b}_1 + \cos 30^\circ \hat{b}_2] \end{aligned}$$

$$\vec{r}_P = (2.3 \cos 30^\circ + 3.1 \sin 30^\circ) \hat{b}_1 + (3.1 \cos 30^\circ - 2.3 \sin 30^\circ) \hat{b}_2$$



$$\vec{r}_P = 2.3 \hat{e}_1 + 3.1 \hat{e}_2 = \boxed{r \hat{e}_r}$$

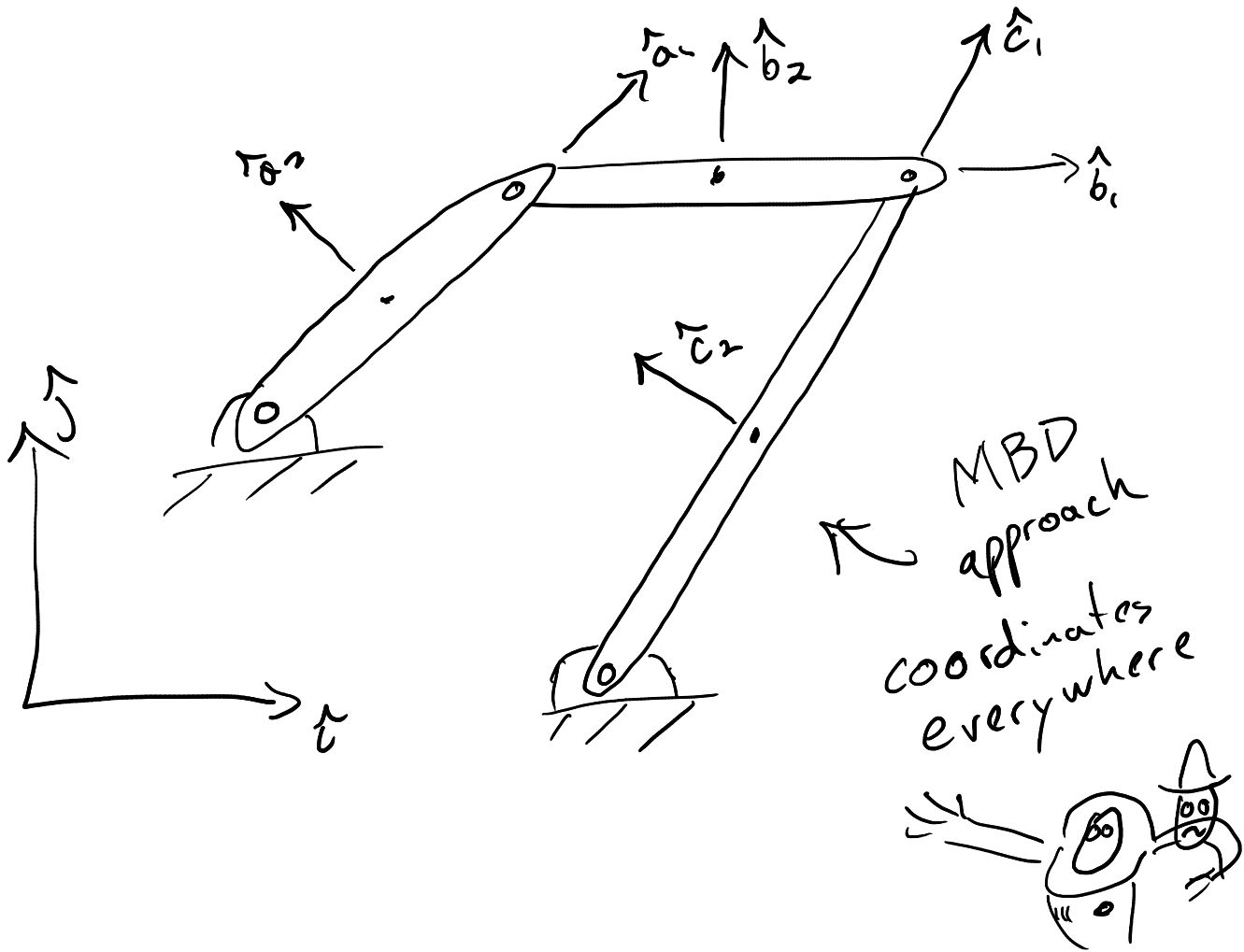
$$r = \sqrt{2.3^2 + 3.1^2}$$

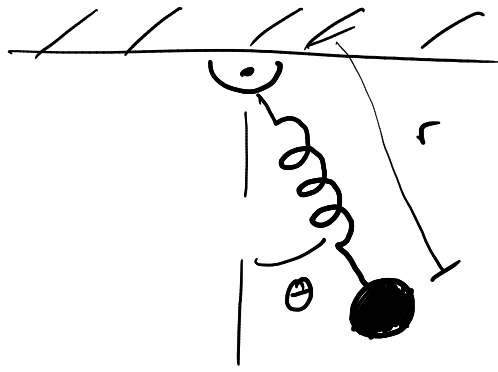
$$\text{in } \hat{e}_1 - \hat{e}_2 \rightarrow (r, \gamma)$$

$$\hat{b}_1, \hat{b}_2 \rightarrow (r, \alpha)$$

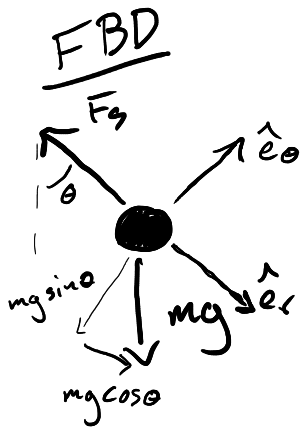
$$\tan \gamma = \frac{3.1}{2.3}$$

$$\vec{r} = 2.3 \hat{e}_1 + 3.1 \hat{e}_2 = r \hat{e}_r = \sqrt{2.3^2 + 3.1^2} \left( \underbrace{\frac{2.3}{r}}_{\cos \gamma} \hat{e}_1 + \underbrace{\frac{3.1}{r}}_{\sin \gamma} \hat{e}_2 \right)$$





2 DOFs  
=  
x 2 eqns



$$\sum \vec{F} = m\vec{a}$$

$$\hookrightarrow \vec{F} \cdot \hat{e}_r = m a_r$$

$$\vec{F} \cdot \hat{e}_\theta = m a_\theta$$

$$\hat{e}_r \Rightarrow -k(r-l_0) + mg \cos \theta = m(\overbrace{\ddot{r}}^{a_r} - r\dot{\theta}^2)$$

$$\hat{e}_\theta \Rightarrow -mg \sin \theta = m(\underbrace{r\ddot{\theta} + 2\dot{r}\dot{\theta}}_{a_\theta})$$