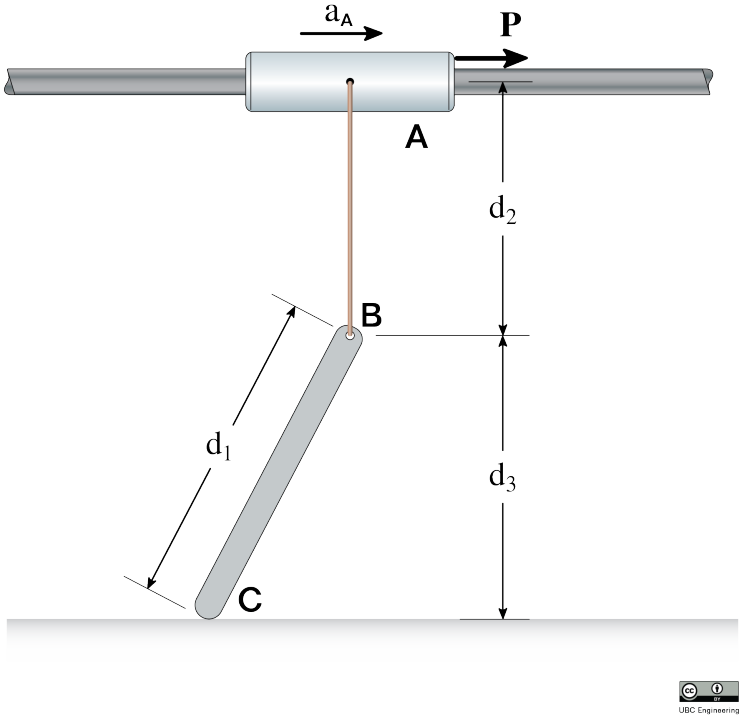
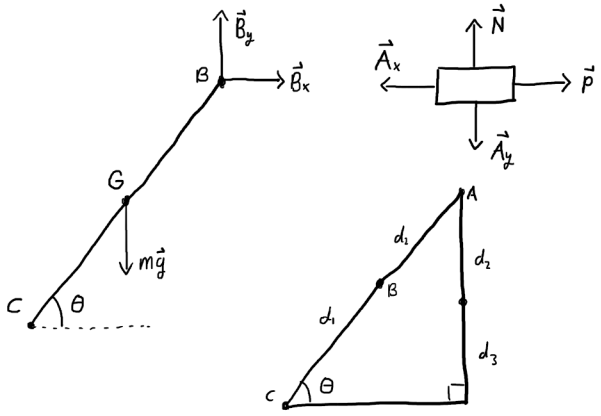
22-R-KIN-TW-11



A rod of mass 16 kg with uniform density is connected to a collar by a rope of negligible mass, as shown. If a constant force P is applied to the collar, for what value P will the rod experience lift-off (no normal force from the ground) when the system is in equilibrium?
Take $d_1 = 3$ m, $d_2 = 2$ m, $d_3 = 2$ m, and use $g = 9.81$ m/s^2. (Assume that there is no friction acting on the slider)

Solution:



Note that because the system is in equilibrium, there will be no net acceleration. The rope must also be in line with the rod in order for it just experience lift-off.

$$F_y : mg = B_y$$

$$
\begin{aligned}
M_G : \frac{d_1}{2} B_y \cos\theta &= \frac{d_1}{2} B_x \sin\theta \\
B_x &= \frac{B_y}{\tan\theta} \\
B_x &= -A_x = P \\
P &= \frac{mg}{\tan\theta} \\
\tan\theta &= \frac{d_2 + d_3}{\sqrt{(d_1 + d_2)^2 - (d_2 + d_3)^2}} = \frac{4}{3} \\
P &= \frac{3}{4}(16)(9.81) = 117.72 \text{ N}
\end{aligned}
$$