Rod $CD$ is pinned to a frictionless collar $D$ and passes through another frictionless collar $B$. Collar $B$ is welded to the end of lever $AB$. Rod $CD$ and the lever $AB$ are perpendicular to each other.

1. Show that the position of the collar $D$ with respect to pin $A$ is given by
   \[ \mathbf{r}_{AD} = L \mathbf{i} + \left( \frac{d \cos(\theta) + L \cos(\theta) + d \sin(\theta)}{\sin(\theta)} \right) \mathbf{j} \]

2. Use the principal of virtual work to determine the moment $M$ required to hold the system in equilibrium at the position $\theta$ when the force $P$ is applied at the collar. Your answer should be a function of $\theta$, $P$, $d$ and $L$.

3. Repeat the analysis above using the equations of equilibrium (this is a machine problem).

4. Verify your derivation using $\theta = 60^\circ$, $L = 40$ mm, $d = 80$ mm and $P = 150$ N. The moment required for equilibrium is $M = 16$ N.m.