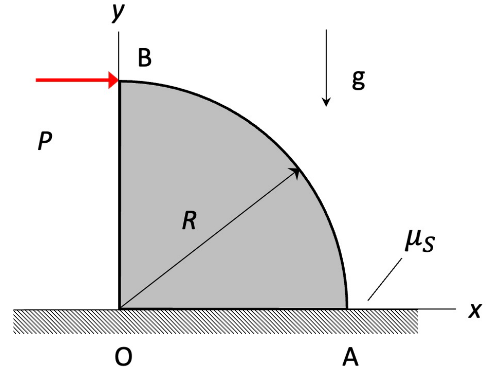
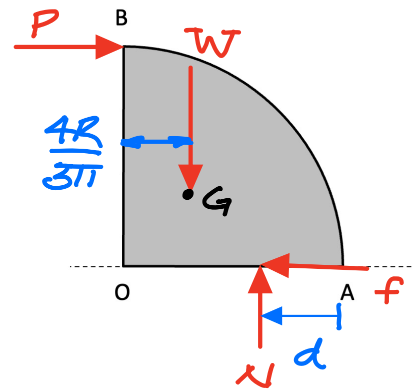
Quiz No. 6 **Name** SOLUTION

ME 270 – Summer 2024 – Prague

Given: A homogeneous quarter-circle block (with a radius of R and a weight of W) is supported by a rough, horizontal floor, as shown, with the coefficient of static friction between the block and the floor being μ_S. A horizontal force P is applied to the block at corner B.



Find: Following the four steps below, you are asked to determine the maximum force P that can be applied to the block without having the block move by either tipping or slipping.



Step 1 – FBD: Using the figure provided, draw the free body diagram of the block for a ***general*** state of equilibrium (that is, without an assumption of either tipping or slipping).

Step 2 – Equilibrium: Write down the equilibrium equations for your FBD.

(1) $\sum F_x = P - f = 0$

(2) $\sum F_y = N - W = 0 \Rightarrow N = W$

(3) $\sum M_A = -Nd + W\left(R - \frac{4R}{3\pi}\right) - PR = 0$

Step 3 – Solvability: Count the number equations and the number of unknowns.

3 eqns / 4 unknowns (P, f, N, d)

Step 4 – Solve: Determine the maximum value of P for the block to remain in equilibrium. Is the block in a state of tipping or slipping at that value of P? ***BONUS***:

- If the block is in a state of impending tipping, what is the value of friction on the block?
- If the block is in a state of impending slipping, what is the location of the normal force on the block from the floor?

- Assume tipping (about point A):

(4a) $d = 0$; $f \neq \mu_s N$

(3) & (4a) $\Rightarrow P_{tip} = W\left(1 - \frac{4}{3\pi}\right) = 0.576W$

- Assume slipping

(4b) $f = \mu_s N$; $d \neq 0$

(1), (2) & (4b) $\Longrightarrow P_{slip} = \mu_s W = 0.4W$

Choose the smaller of the two $\Longrightarrow P_{max} = 0.4W$ (slipping)

For this: $d = \dfrac{WR\left(1 - \frac{4}{3\pi}\right) - P_{max}R}{W} = R\left[1 - \frac{4}{3\pi} - \frac{P_{max}}{W}\right]$

$= 0.176R$