MAE 343. Intermediate Mechanics

Chapter 3: Statics
Reactions and Internal Forces in Mechanical Components

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The Lug Wrench (assumed clamped at the bolt head)

Calculate Internal Forces at A, then at O

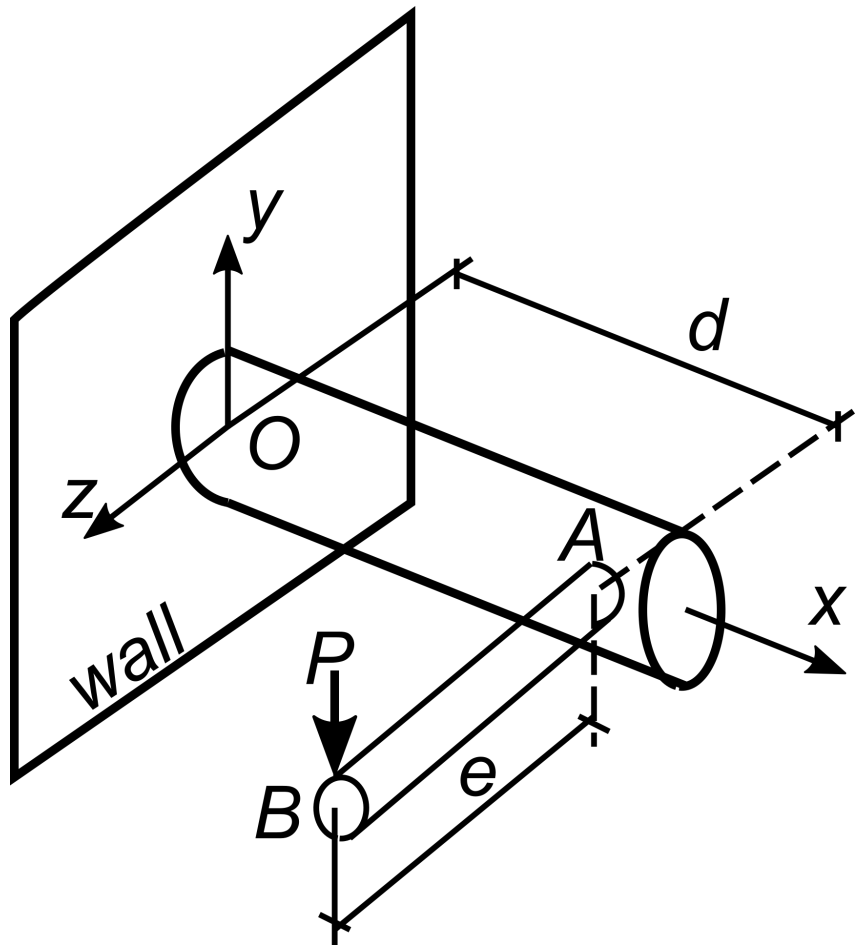
In 3D, we have:

$$\sum F_x = 0, \sum M_x = 0$$

$$\sum F_y = 0, \sum M_y = 0$$

$$\sum F_z = 0, \sum M_z = 0$$

but seldom we use them all at once. Rather we decompose the problem into 2D sub-problems.



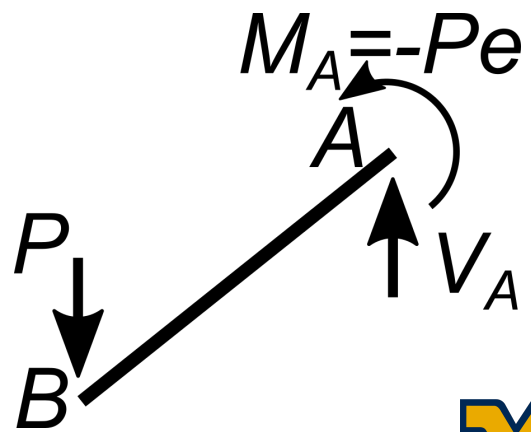
At A with P=10

We start with segment AB, and assume is fixed at A, as if segment OA is ∞-strong. So we do a Free Body Diagram (FBD) for segment AB, and eliminate OA from consideration.
You can choose any orientation you want for V_A and M_A but in anticipation of shear/bending diagrams, I choose for you.
We assume that rod AB can sustain any load without failure, so the load, and resulting moment, are transferred from B to A, no problem.

$$V_A - P = 0 : V_A = P = 10$$

$$M_A + Pe = 0 : M_A = -Pe = -10e$$

Internal forces V_A, M_A, are like reactions supplied by the part that we eliminated from the FBD. Those forces are coming from OA, not applied to OA.

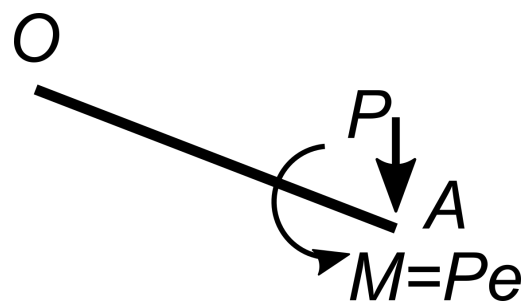


Transfer the forces from B to A

To calculate the internal forces at O (same as reactions) we make a FBD of OA, eliminate AB, then "transfer" P from B to A, and "add" a moment Pe.

Rod OA feels the load P, opposite of V_A, and moment Pe, opposite of $-Pe$.

When we "transfer" P from B to A, we must add a moment because forces are not free vectors, but moments are free vectors. The "transferred" forces and moments are minus the internal forces because the act on different FBDs. OA is loaded with minus the internal forces on AB.



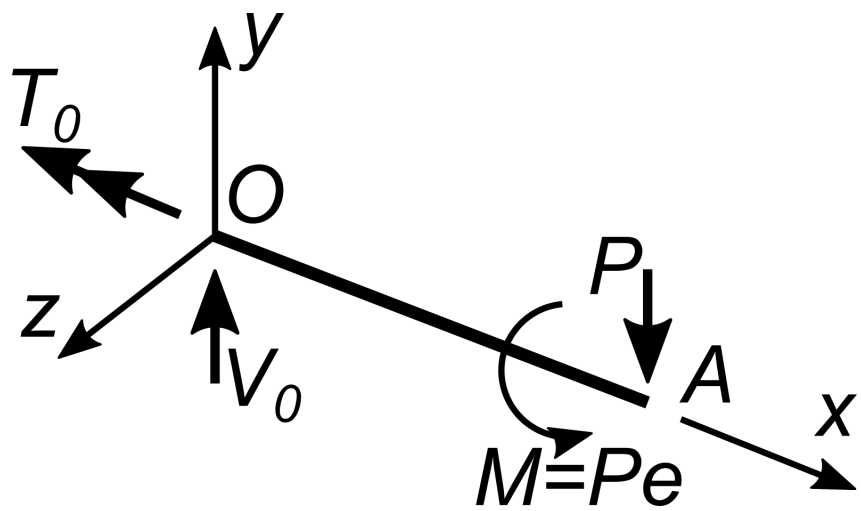
At O, calculate reactions

Now we apply P and the resulting moment Pe to segment OA. Then, use the same procedure we used before to calculate the reactions at O, or internal forces anywhere along the length.

$$V_0 - P = 0 : V_0 = P$$

$$-T_0 + Pe = 0 : T_0 = Pe$$

The moment $M = Pe$ applied at A is called "torque" because it points along the rod, opposite to the double-headed arrow T_0,but it is still a moment with units [lbf.in] or [N.m].



Summary and Conclusions

- Rarely we use 6 eqns. with 6 unknowns.
- Instead, we solve one segment at a time, transferring the load to the next segment.
- At a given point, the sign of the internal force reverses when we change our point of view.
- Moments are free to "move" but forces are not.
- A moment is often added when a load is "transferred" to another point.
- Homework is on WebWork
- Next lecture: Reticulated Structures
- THANK YOU