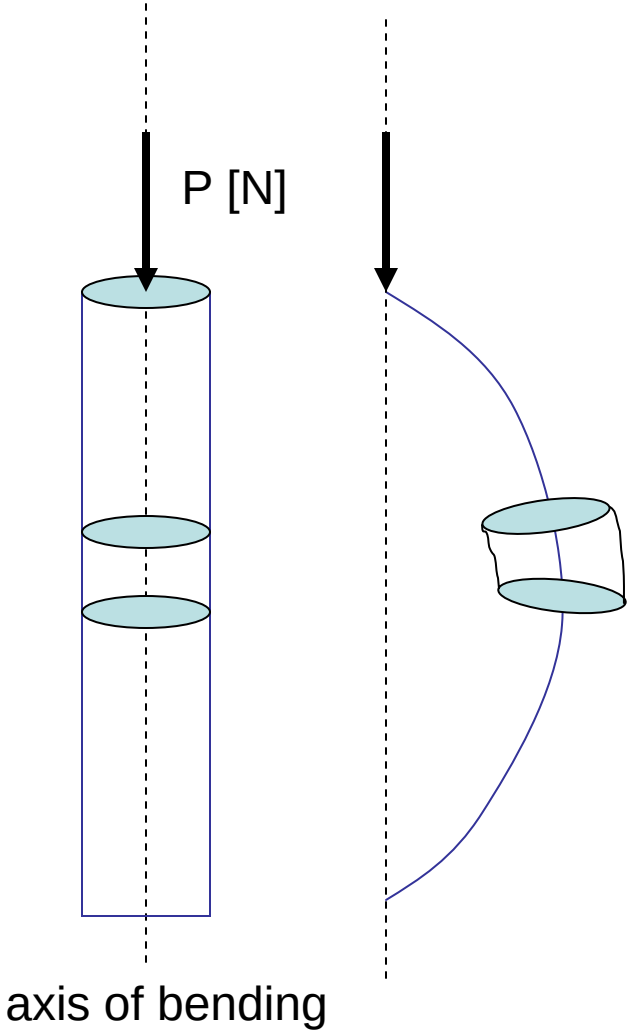
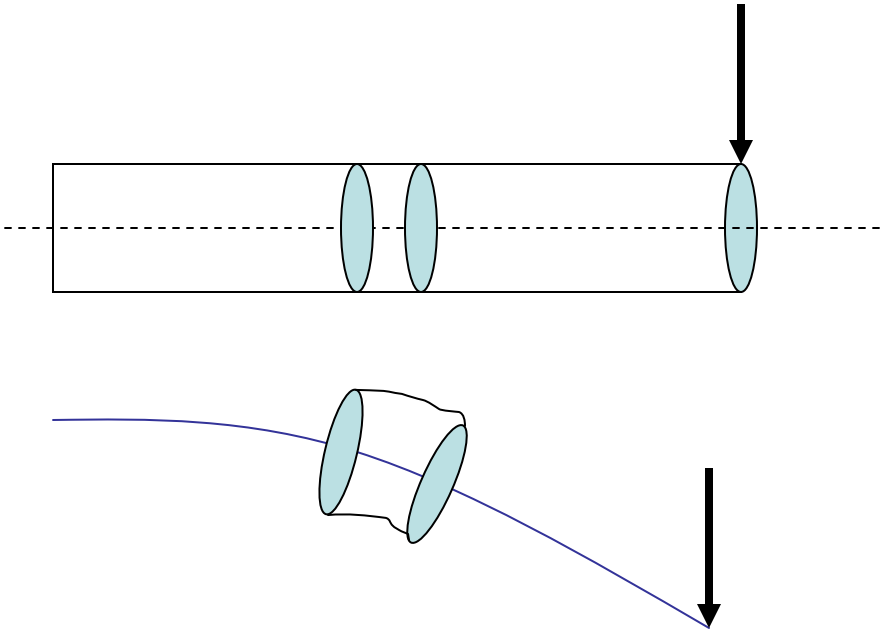
Which cross-section do I choose for moment of inertia, *I* ?

In equilibrium, the beam resists any bending due to applied loads, so we choose the cross-section that is perpendicular to the axis of that intended bending:





What is the moment of inertia …and why are there multiple I_x in Appendix D?

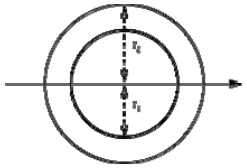
Strictly speaking, we mean the **area moment of inertia**, which relates to the resistance of that area to bending. It is also called the second moment of inertia or the second moment of area about the x-axis, taken over the tiny area dA, where y is the distance from the x-axis to dA:

$$I_x = \int y^2 \, dA$$

Appendix D from Bedford/Liechti in your 3.032 Course Reader (p. 1-28) doesn't annotate this well, and for some cross-sections like a rectangle gives Ix and Ix'. Both are area moments of inertia, but differ depending on whether they assume the x-axis is located along the centroid (x') or located at the bottom of the shape (x).

Neither is "incorrect", but if we assume that the cross-section is made of a homogeneous material, we typically take this moment about the centroid or center of mass. In other words, the I_x' in this appendix are the more standard expressions.

Here is simpler table of centroids and area moments of inertia for solid cross-sections, and also for a hollow cylinder:



$$I_0 = \frac{\pi}{4}\left({r_2}^4 - {r_1}^4\right)$$