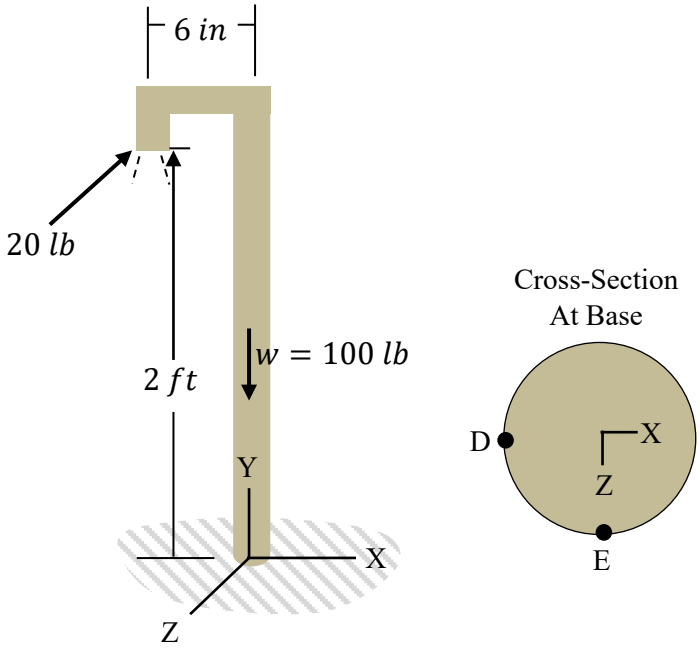
Q1 (10 Points): A standing lamp is subject to a force 20 lb in the –z direction shown below. The lamp is composed of a column of weight $= 100\ lb$, and radius $r = 1\ in$.

(a) Determine the state of stress at the location D, and draw the stress element.
(b) Determine the state of stress at the location E, and draw the stress element.



Solution:

1. Bending stress due to the $20\ lb$ load:

$$|M_x| = (20lb) \times (24in) = 480lb - in$$

$$\sigma_{y,E} = \frac{32|M_x|}{\pi d^3} = \frac{32 \times 480}{\pi(2)^3} = 611.15\ psi \qquad \text{(tensile)}$$

$$\sigma_{y,D} = 0 \qquad \text{(on neutral plane)}$$

2. Torsional shear stress due to the $20\ lb$ load:

$$\left|M_y\right| = (20lb) \times (6in) = 120lb - in$$

$$\tau_{xy,E} = \tau_{yz,D} = -\frac{16\left|M_y\right|}{\pi d^3} = -\frac{16 \times 120}{\pi(2)^3} = -76.39\ psi$$

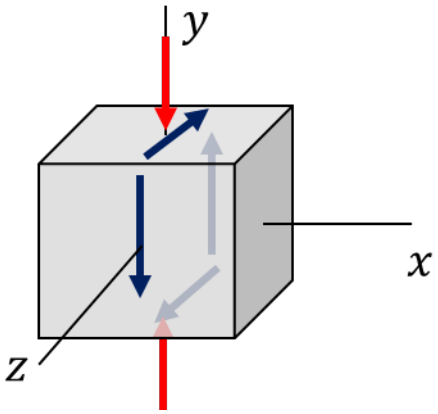
3. Shear stress due to the $20\ lb$ load:

$$\tau_{xy,E} = 0 \qquad \text{(on neutral plane)}$$

$$\tau_{yz,D} = -\frac{4(V)}{3A} = -\frac{16(20)}{3\pi d^2} = -\frac{16(20)}{3\pi(2)^2} = -8.49\ psi$$

4. Axial stress due to $100\ lb$ weight:

$$\sigma_{y,E} = \sigma_{y,D} = -\frac{100}{(\pi d^2)/4} = -31.83\ psi$$

At D,	At E,
$\sigma_{y,D} = -31.83\ psi$ $\tau_{yz,D} = -76.39 - 8.49 = -84.88\ psi$ 	$\sigma_{y,D} = 611.15 - 31.83\ psi = 579.32\ psi$ $\tau_{xy,E} = -76.39 psi$