Group Work 12.A.2 Solution

A)

In this problem, the word pivot is included to tip you off that you should start by balancing the torques! In these problems it is generally a good move to select the pivot point as the axis of rotation! Carrying this out gives:

$$\Sigma\tau = T(1m)\sin(60^\circ) - F(2m)\sin(90^\circ) = I(0) \tag{1}$$

Rearranging this equation gives:

$$T = \frac{F(2m)}{(1m)cos(60^\circ)} = \frac{(2)(500N)(2m)}{\sqrt{3}(1m)} = 1155N \tag{2}$$

B)

To find the x- and y-components of the force from the pivot, we sum the forces in the x- and y-directions. Beginning with the x-direction, we find:

$$\Sigma F_x = P_x - T + F\cos(30^\circ) = m(0). \tag{3}$$

After rearranging, this becomes:

$$P_x = T - F\cos(30^\circ) = 1155N - (500N)\left(\frac{\sqrt{3}}{2}\right) = 722N. \tag{4}$$

By the same logic, we see:

$$\Sigma F_y = P_y - F\sin(30^\circ) = m(0), \tag{5}$$

which produces:

$$P_y = F\sin(30^\circ) = 500N(0.5) = 250N. \tag{6}$$

C)

We will begin this part of the problem by using Young's Modulus to find the tension necessary to stretch the wire $0.001m$. Young's Modulus is defined as:

$$Y = \frac{\frac{F}{A}}{\frac{\Delta L}{L}}, \tag{7}$$

or equivalently—and hopefully slightly less busily—as:

$$Y = \frac{(F)(L)}{(A)(\Delta L)}. \tag{8}$$

Now, we can rearrange this to be:

$$F = \frac{(Y)(A)(\Delta L)}{L}. \tag{9}$$

At this point, we realize we may realize that we are not given the length of the wire. Luckily, though, some quick trigonometry can solve this. Namely:

$$\sin(30°) = \frac{L}{1m} \implies L = 0.5m. \tag{10}$$

Now we plug values into equation 9, giving:

$$F = \frac{\left(20 * 10^{10} \frac{N}{m^2}\right)(0.0005m^2)(0.001m)}{0.5m} = 200,000N \tag{11}$$

Now, that we know the tension, we once again do torque balancing:

$$\Sigma\tau = T\sin(60°)(1m) - F\sin(90°)(2m) = T(0). \tag{12}$$

Rearranging this equation gives:

$$F = \frac{T\sin(60°)(1m)}{2m} = \frac{\sqrt{3}}{2}\frac{(200,000n)(1m)}{2m} = 86600N \tag{13}$$