2024 A2

TORSION & FASTENERS

L1 Part 1: 160 lbf in

L1 Part 2: 50 inches

Torque is a rotational or twisting force dependent on the linear force applied and the distance to the center of rotation. In this case, the force is 20 lbf, and the distance to the center of rotation is 8 inches. Multiplying these two values gives you Torque.

$$Torque = Force * Distance\ to\ Center\ of\ Rotation$$
$$Torque = (20\ lbf) * (8\ inches) = \mathbf{160\ lbf\ in}$$

Increasing Torque can be done by increasing the force you put on a wrench (pushing harder), or, you can use a longer tool to increase the torque, even with the same input force. In this case, we will be using the same force with a longer tool to increase torque.

$$Torque = Force * Distance\ to\ Center\ of\ Rotation$$
$$(1{,}000\ lbf\ in) = (20\ lbf) * (r\ inches)$$

In this case, by rearranging the equation we can solve for the length of tool needed, r.

$$\frac{(1{,}000\ lbf\ in)}{(20\ lbf)} = (\boldsymbol{r}) = \mathbf{50\ inches}$$

L2 Part 1: 138.56 lbf in

L2 Part 2: 69.075°

The force tangent to the tool is what transmits torque. When applying a force at an angle it is important to solve for what amount of that force is being applied in the direction perpendicular to the wrench. We can find the perpendicular force applied using trigonometry equations provided. We are provided with the resultant force 'c'.

$$\cos(A) = \frac{b}{c}$$

$$\cos(30°) = \frac{b}{20lbf}$$

$$20 * \cos(30) = b = 17.32lbf$$

Plugging the newfound tangential force to the original Torque equation will yield the Torque transmitted on the bolt.

$$T = Fr$$

$$T = (17.32\ lbf) * (8\ inches) = \mathbf{138.56\ lbf\ in}$$

The second part of the problem is the same, only solved in reverse. Divide the transmitted torque by the distance to the center of rotation, this will show what the target tangential force is. Then using $'arccos'\ or\ cos^{-1}$ you can solve for the target angle.

$$T = Fr \rightarrow \frac{T}{r} = F$$

$$\frac{(500\ lbf\ in)}{(14\ inches)} = 35.714\ lbf$$

$$\cos(A) = \frac{b}{c} = \frac{(35.714\ lbf)}{(100\ lbf)} = 0.357$$

$$\cos(A) = 0.357$$

$$\cos(0.357)^{-1} = \mathbf{69.075°}$$