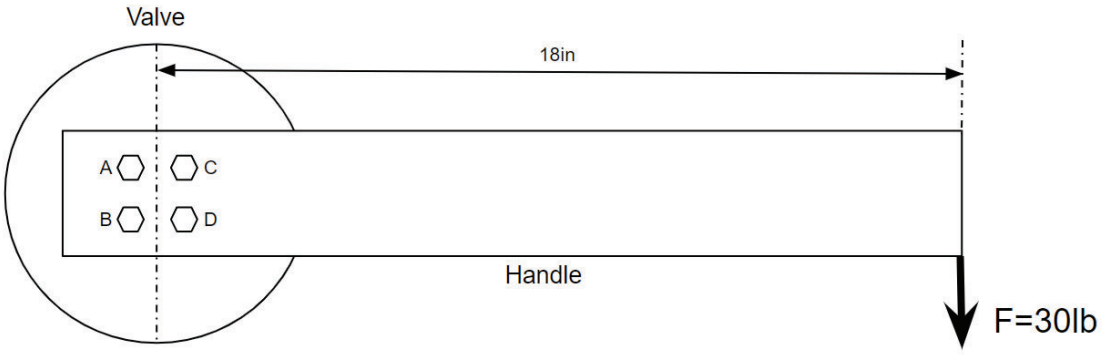
35.10 **The handle of a large manual valve is secured with a square bolt pattern, as shown. The handle is $18in$ long and the force applied to the end of the handle during valve opration is $30lb_f$. The bolts have a nominal diameter of $\frac{1}{4}in$ and a cross-sectional area of $.03in^2$. When the valve is being closed, which statement can be made about the shear stress experienced by the bolts?**



A. Bolts A and B experience higher shear stress than bolts C and D.

B. Bolts C and D experience higher shear stress than bolts A and B.

C. Bolts A and C experience higher shear stress than bolts B and D.

D. Bolts B and D experience higher shear stress than bolts A and C.

This is a qualitative problem, so there is no need to quantify the loads applied to the bolts. Since all bolts have the same diameter and cross-sectional area, the maximum shear stress will be a direct outcome of the resultant force experienced due to the applied load and moment.

Since the applied load is downward, the reaction forces on the bolts from the applied load are all upward.

Since the load is applied a distance away from the bolts, it produces a clockwise moment, generating reaction forces perpendicular to lines drawn through each bolt and the center of the bolt pattern. In othwer words, the forces resulting from the moment are tangent to a circle drawn through all four bolts.

Adding the vectors for the reaction forces from the applied load and the moment, notice the directions of the reaction forces partially offset for bolts A and B. However, the forces are partially additive for bolts C and D. Therefore, bolts C and D have larger resultant reaction forces and more shear stress than bolts A and B.

Answer B