36.10 A $2in$ steel shaft delivers $200ft \cdot lb_f$ of torque. What is the shear stress experienced by the shaft?

A. $200psi$

B. $500psi$

C. $1500psi$

D. $3000psi$

Look up Shear Stress and refer to the section on Torsion since the problem is about delivering torque by turning a shaft. The shear stress, also known as torsion stress, is given by the formula:

$$\tau = \frac{Tr}{J}$$

where T is torque, r is radius, and J is the polar moment of inertia. Torque and radius are given. Search Properties of Various Shapes and scroll to the circular cross-sectional area. The polar moment of inertion for a round shaft is given by the formula below, where a is used for radius. Replace a with r for alignment with the previous equation.

$$J = \frac{\pi a^4}{2} = \frac{\pi r^4}{2}$$

Substitute the expression for J into the equation for τ and simplify.

$$\tau = \frac{Tr}{J} = \frac{Tr}{\frac{\pi r^4}{2}} = \frac{2T}{\pi r^3}$$

Solve for the torsion stress. Change the units to psi.

$$\tau = \frac{2T}{\pi r^3} = \frac{2\left(200ft \cdot lb_f\right)\left(\frac{12in}{ft}\right)}{\pi\left(1in\right)^3} = 1528psi$$

Answer C