IDE 110 – Summer 2006 Quiz 9 **Name:**_____

A motor delivers 120 kW at 1900 rpm to a gear box that reduces the speed to 300 rpm to drive a crusher. If the maximum shearing stress in the shafts (G = 80 GPa) is not to exceed 70 MPa and the angle of twist in a 3-m length is not to exceed 0.075 rad, determine the minimum permissible diameter for each of the two shafts.

Show steps clearly, include units, and box the final answer.

$P = 120{,}000 \ \frac{N\cdot m}{s}$

Motor to Gear Box

$\omega = 1900\left(\frac{2\pi}{60}\right)\frac{rad}{s} = 198.97 \ \frac{rad}{s}$

$T = \frac{P}{\omega} = 603.11 \ N\cdot m$

$\tau = \dfrac{603.11\left(\frac{d}{2}\right)}{\frac{\pi}{32}d^4} = 70(10^6) \Rightarrow d \geq 35.27 mm$

$\phi = \dfrac{603.11\,(3)}{(80\times10^9)\left(\frac{\pi}{32}d^4\right)} = 0.075 \Rightarrow \boxed{d \geq 41.86 mm}$

Gear Box to Crusher

$\omega = 300\left(\frac{2\pi}{60}\right) = 31.42 \ \frac{rad}{s}$

$T = \frac{P}{\omega} = 3819.72 \ N\cdot m$

$\tau = \dfrac{3819.72\left(d/2\right)}{\frac{\pi}{32}d^4} = 70(10^6) \Rightarrow d \geq 65.26 mm$

$\phi = \dfrac{3819.72\,(3)}{(80\times10^9)\left(\frac{\pi}{32}d^4\right)} = 0.075 \Rightarrow \boxed{d \geq 66.41 \ mm}$