A top-loading washing machine executes the spin cycle at 4 rotations per second. The mass of the drum is 10 kg and it has a diameter of 0.6 m. The stiffness and damping coefficient of the mount are 379 N/m and 37.7 N·s/m respectively. If the mass of the clothes is 5 kg, what is the worst case possible for:

- vibration amplitude?
- transmitted force?

\[ m = 10 + 5 = 15 \text{ kg} \] (includes unbalance mass)

\[ m_b = 5 \text{ kg} \]

\[ e = \frac{0.6}{2} = 0.3 \text{ m} \] (in the worst case all the clothes are in the same place on one side)

\[ \omega = 4 \times 2\pi = 25.13 \text{ rad/s} \]

\[ k = 379 \text{ N/m} \]

\[ c = 37.7 \text{ N·s/m} \]

\[ \omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{379}{15}} = 5.03 \text{ rad/s} \]

\[ r = \frac{\omega}{\omega_n} = \frac{25.13}{5.03} = 5.00 \]

\[ \xi = \frac{c}{2\sqrt{km}} = \frac{37.7}{2 \times 379 \times 15} = 0.25 \]

\[ X = \frac{m_b e}{m} \frac{r^2}{\sqrt{1 - r^2}^2 + 2^2 r^2} = \frac{(5 \times 0.3)}{15} \frac{5.00^2}{\sqrt{(1 - 5^2) + (2 \times 0.25 \times 5)^2}} \]

\[ X = 0.104 \text{ m} \]

\[ F_t = X \sqrt{k^2 + (c\omega)^2} = 0.104 \sqrt{379^2 + (37.7 \times 25.13)^2} \]

\[ F_t = 106 \text{ N} \]
Problem 2.51

Given: Lathe

Find: \( X \)

Sol'n: \[ r = \frac{\omega}{\omega_n} = \frac{188.50}{47.124} = 4 \]

\[ X = \frac{m o e}{m} \frac{r^2}{\sqrt{(1-r^2)^2 + (2\varphi r)^2}} = \frac{(5)(0.1)}{(50)} \frac{4^2}{\sqrt{(1-4^2)^2 + (2(0.06)(4))^2}} = 0.011 m \]

\[ X = 1.1 cm \]

Problem 2.52

Given: \( \omega \) varies

at \( r = 1 \), \( X = 0.010 m \)

as \( r \to \infty \), \( X \to 0.001 m \)

Find: \( s \)

Sol'n: At \( r \to \infty \)

\[ \frac{m X}{m o e} \to 1 \quad \therefore \quad \frac{m o e}{m} \to X = 0.001 \]

At \( r = 1 \)

\[ X = \frac{m o e}{m} \frac{r^2}{\sqrt{(1-r^2)^2 + (2\varphi r)^2}} \]

\[ 0.01 = 0.001 \frac{12r^2}{\sqrt{(1-0.01)(2(0.06)(1))^2}} \]

\[ 0.01 = 0.001 \frac{1}{2 \varphi} \quad \therefore \quad \varphi = 0.05 \]

Homework 2.53