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 [redacted]?

$m = 10 + 5 = 15\ kg$ ← m includes unbalance mass

$m_o = 5\ kg$

$e = \frac{0.6}{2} = 0.3\ m$ ← In the worst case all the clothes are in the same place on one side.

$\omega = 4 \times 2\pi = 25.13\ rad/s$

$k = 379\ N/m$

$c = 37.7\ \frac{Ns}{m}$

$\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{379}{15}} = 5.03\ rad/s$

10

$r = \frac{\omega}{\omega_n} = \frac{25.13}{5.03} = 5.00$

$\zeta = \frac{c}{2\sqrt{km}} = \frac{37.7}{2\sqrt{379 \times 15}} = 0.25$

$$X = \frac{m_o e}{m} \frac{r^2}{\sqrt{(1-r^2)^2 + (2\zeta r)^2}} = \frac{(5)(0.3)}{15} \frac{5.00^2}{\sqrt{(1-5^2)^2 + (2 \times 0.25 \times 5)^2}}$$

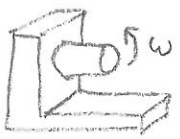
$$\boxed{X = 0.104\ m}$$

$$F_T = X\sqrt{k^2 + (c\omega)^2} = 0.104\sqrt{379^2 + (37.7 \times 25.13)^2}$$

$$\boxed{F_T = 106\ N}$$

Problem 2.~~51~~ 61

Given: Lathe



$m = 50\ kg$

$m_o = 5\ kg$

$e = 0.1\ m$

$\zeta = 0.06$

$\omega_n = 2\pi \cdot 7.5 = 47.124\ rad/s$

$\omega = 2\pi \cdot 30 = 188.50\ rad/s$

Find: X

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

$$X = \frac{m_o e}{m} \frac{r^2}{\sqrt{(1-r^2)^2 + (2\zeta r)^2}} = \frac{(5)(0.1)}{(50)} \frac{4^2}{\sqrt{(1-4^2)^2 + (2(0.06)(4))^2}} = 0.011\ m$$

$$\boxed{X = 1.1\ cm}$$

Problem 2.~~52~~ 62

Given:

ω varies

at $r = 1$, $X = 0.010\ m$

as $r \to \infty$, $X \to 0.001\ m$

Find: ζ

Sol'n: At $r \to \infty$

$$\frac{mX}{m_o e} \to 1 \quad \therefore \quad \frac{m_o e}{m} \to X = 0.001$$

At $r = 1$

$$X = \frac{m_o e}{m} \frac{r^2}{\sqrt{(1-r^2)^2 + (2\zeta r)^2}}$$

$$0.01 = 0.001 \frac{1^2}{\sqrt{(1-1^2)^2 + (2\zeta(1))^2}}$$

$$0.01 = 0.001 \frac{1}{2\zeta} \quad \therefore \quad \boxed{\zeta = 0.05}$$

Homework 2.~~53~~ 63