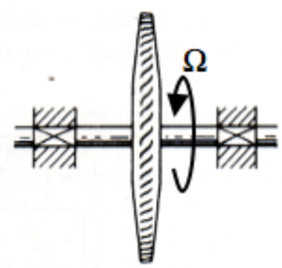
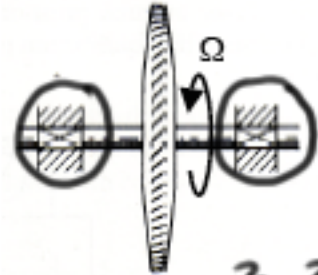
**Example V.1.2**

The rigid rotor of a turbine, having a total mass of $13.6kg$, is known to have a mass imbalance that produces an undesirable level of transmitted force to the environment. It is decided to mount the bearings within compliant supports to reduce this transmitted force. It is felt that a maximum 200 percent force transmissibility is allowable near resonance since, in starting up from rest, the turbine will not operate at that speed for long periods of time. Determine the total damping and stiffness of bearing supports to accomplish a 60 percent transmitted force reduction when the turbine is operating at $6000rpm$. What is the static deformation of these supports under the weight of the rotor?






$$T^2 = \frac{1+4\zeta^2 r^2}{(1-r^2)^2+4\zeta^2 r^2}$$

- Near resonce: $r \approx 1 \Rightarrow$

$$T^2 = \frac{1+4\zeta^2}{4\zeta^2}$$

$$\hookrightarrow \zeta = \frac{1}{2}\frac{1}{\sqrt{T^2-1}}$$

$$T_{allow} = 2$$

$$\hookrightarrow \zeta\big|_{design} = 0.289$$

- Stiffness needed for operation at 6000 rpm:

$$T = 1 - 0.6 = 0.4$$
$$\zeta = 0.289$$
$$\Omega = (6000)\left(\frac{2\pi}{60}\right)\frac{rad}{sec}$$

From Ex #1:

$$r^4 - \left[2 + 4\zeta^2\left(1 - \frac{1}{T^2}\right)\right] r^2 + 1 - \frac{1}{T^2} = 0$$

↳ solve for <u>positive</u> root:

$$r^2 = \_\_\_\_\_\_$$

$$k = \frac{m\Omega^2}{r^2} = \_\_\_\_$$

$$X_{static} = \frac{mg}{k}$$

$$= \_\_\_\_$$

Response amplitude: (inc. k)

$$X = \frac{me\Omega^2/k}{\sqrt{\left[1-\left(\frac{\Omega}{\omega_n}\right)^2\right]^2 + \left[2\zeta\frac{\Omega}{\omega_n}\right]^2}}$$

Vibration isolation design

$\Rightarrow \frac{\Omega}{\omega_n} = \text{fixed} \leftarrow$

If $X$ too large??

(see section 3.3 of text for dynamics of rotating systems)

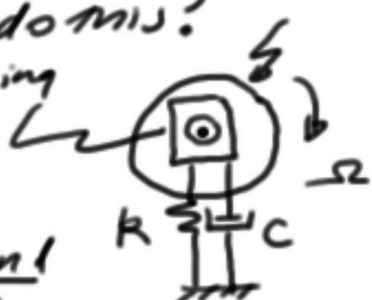
$r$ = constant $\Rightarrow$

$\omega_n$ = unchanged $\Rightarrow$

$\sqrt{\frac{k}{m}}$ = unchanged

↳ Increase $m$ to keep $\omega_n$ = fixed.

How can we do this?




Add massive bearing block and inc. stiffness to keep $\omega_n = \sqrt{\frac{k}{m}}$ fixed