Problems Section 5.9 (5.86 through 5.88)

5.86 Reconsider Example 5.2.1, which describes the design of a vibration isolator to protect an electronic module. Recalculate the solution to this example using equation (5.92).

Solution: If data sheets are not available use $G'_\omega = G'/2$. One of many possible designs is given. From the example we have T.R. = 0.5, m = 3 kg and ω = 35 rad/s = 5.57 Hz. From equation (5.92):

$$T.R. = \frac{\sqrt{1+\eta^2}}{\sqrt{\left(1 - r^2 \dfrac{G'}{G'_\omega}\right)^2 + \eta^2}} = 0.5$$

From Table 5.2 for 75°F and frequency of 10 Hz (the closest value listed), the value of E and η are:

$$E = 2.068 \text{ x } 10^7 \text{ N/m}^2 \qquad \text{and} \qquad \eta = 0.21$$

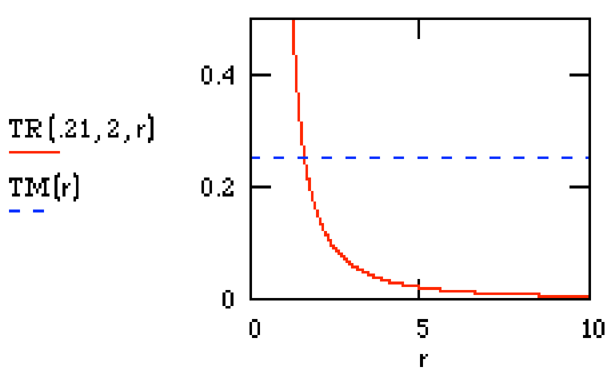
Thus $G' = E/3 = 6.89 \text{ x } 10^9 \text{ N/m}^2$ using the approximation suggested after equation (5.86). They dynamic shear modulus is estimated from plots such as Figure 5.38 to be $G'_\omega = G'/2$. Thus equation 5.92 becomes

$$0.5^2 = \frac{1 + (0.21)^2}{\left(1 - r^2 \dfrac{G'}{G'/2}\right)^2 + (0.21)^2}$$

This is solved numerically in the following Mathcad session:

$$TR(a, b, r) := \frac{\sqrt{1 + a^2}}{\sqrt{\left(1 - b \cdot r^2\right)^2 + a^2}}$$

$$TM(r) := .5^2$$



From the plot, any value of *r* greater then about 2.5 will do the trick. Choosing r = 2.5 yields $\omega_n = \frac{\omega}{3.5} = \frac{35}{3.5} \Rightarrow \sqrt{\frac{k}{m}} = 10 \Rightarrow k = 100(3) = 300$ N/m

5.87 A machine part is driven at 40 Hz at room temperature. The machine has a mass of 100 kg. Use Figure 5.42 to determine an appropriate isolator so that the transmissibility is less than 1.

Solution: Given f = 40 Hz, m = 100 kg or about 220 lbs. and $T.R.$ <1. The maximum static load per mount is 3 lbs. Therefore the system would require a minimum of 73 mounts. Assume then that 75 mounts are used. Thus

$$\frac{220\#}{75} = 2.9\# \text{ per mount}$$

For the isolator, $f_n < 0.5 f = 0.5(40) = 20$ Hz. Therefore the f_n of the isolator must be less then 20 Hz. Referring to the performance characteristics of the table in Figure 5.42 yields 4 possible isolator choices:

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5.88 Make a comparison between the transmissibility ratio of Window 5.1 and that of equation (5.92).

Solution: Comparing equation (5.92) with Window 5.1 yields:

Window 5.1: $$T.R. = \frac{\sqrt{1+(2\zeta r)^2}}{\sqrt{(1-r^2)^2+(2\zeta r)^2}}$$

Equation (5.92): $$T.R. = \frac{\sqrt{1+\eta^2}}{\sqrt{\left(1-r^2\dfrac{G'}{G'_\omega}\right)^2+\eta^2}}$$

Comparing the two equations yields

$$\eta = 2\zeta r \quad \text{and} \quad \frac{G'}{G'_\omega} \approx 1$$