You are asked to choose a spring and dashpot for the system in the figure below (e.g., a simple dryer). The following properties are given to you

1. The total mass, $M$, is around 200 kg
2. The maximum load (when wet) is 15 kg. The typical unbalanced load ($m$) however, is around 6 kg
3. The effective radius of the unbalance is 75 cm
4. The damping ratio is expected to be between 0.15 and 0.25
5. The most reliable (and inexpensive) motors available operate best at 60 rpm

As the initial (and minimum) goal, you are asked to see if the peak magnitude of the vibration due to the unbalance can be made to stay below 1.5 cm.
PART I:

Q1 Find the expression for the ratio of the force transmitted to the ground to the force due to the unbalance in terms of the damping ratio $\zeta$ and $r = \frac{w}{w_n}$.

D2 Enclosed are two graphs. One is for the expression discussed in Q1, as a function of $r$. The other is the plot of $\frac{M_r}{m_e}$ vs $r$. Decide which graph belongs to which expression. Explain.

Q3 Should the natural frequency of the unit be less than or bigger than the forcing frequency? Why? What is the maximum $r$ that satisfies the main design consideration?

Q4 Choose a value for natural frequency, explain your logic. What is the range of acceptable values for the stiffness $K$? What is the range of acceptable values for the dashpot constant $C$?

Q5 What is the magnitude of the induced forcing function? What is the ratio of this force to the force transmitted to the ground?

PART II:

You are told that this machine is to be operated in a laboratory where vibration sensitive equipment are in use. You are asked to minimize the effects of the vibration on the rest of the equipment by changing the support material (i.e., $K$).

Q6 Suppose that you were asked to reduce the TR below 0.3. How would changes in $K$ affect this new requirement? Do you have to abandon your goal of reducing maximum vibration to 1.5 cm to satisfy this new requirement? If yes, what is the best $X$ you can achieve?

Q7 If you could order material with different effective damping, what would be your choice: material with high damping or low damping? Is there any concern if the motor has low power and takes a long time to reach 60 rpm?