A motor unit, shown in Figure 1, consists of a motor mounted on a baseplate, where the baseplate is represented by a stiffness, K, and a damper, C. The damping ratio for the motor unit (in the X direction) was measured and determined to be $\zeta = 0.06$. The total weight of the motor unit is 890 N, and it has an undamped natural frequency that coincides with a rotor speed of 2300 rpm.

The unit experiences vibrations, X(t), measured from the static equilibrium position, due to an unbalance mass, m_u, on the motor rotor equal to 0.10 kg at an eccentricity, e, equal to 0.20 m. The motor operates at a constant operating speed of 3600 rpm.

Find the following (BOX all answers and SHOW all work or points off):

a. The stiffness of the baseplate, K, in N/m.
b. The damping of the baseplate, C, in N-s/m.
c. The damped natural frequency of the motor unit, ω_d, in rad/sec.
d. The magnitude of the unbalance force, $f_u(t)$, on the motor unit when the motor is rotating at a constant speed of 3600 rpm in N.
e. The Free Body Diagram of the motor unit (Figure 1) in X direction.
f. The Equation of Motion (EOM) in X of the motor unit, with values plugged in for M, K, C, and $f_u(t)$.
g. The steady-state response, X(t), of the motor unit (Figure 1) due to the unbalance force, $f_u(t)$.
h. The *peak-to-peak* amplitude of the steady-state response, X(t), in meters.

You wish to reduce vibrations of the motor unit without shutting it down. You design a vibration absorber and attach a second system, consisting of a stiffness, K_2, and mass, M_2, as shown in Figure 2.

i. For what relationship of K_2, and M_2, does the magnitude of X(t) go to zero at the rotational frequency of 3600 RPM? Assume that the damping, C, of the original system is negligible.

Grading: a – f, h, i: 10 pts each ; g: 20 points

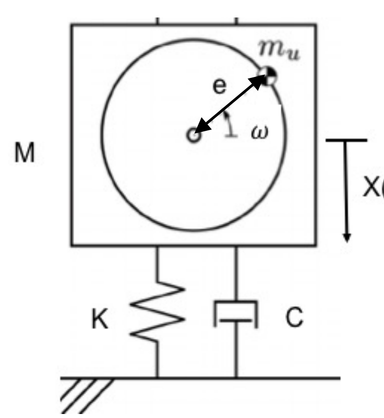

Figure 1: Motor unit

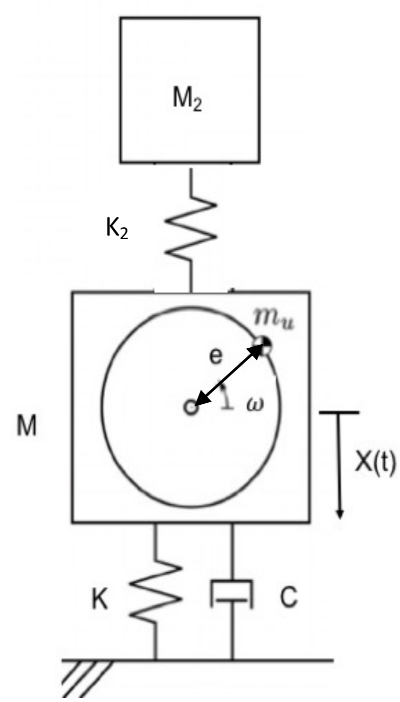

Figure 2: Modified motor unit