MECE 340 VIBRATIONS

40 EXAM 2 Practice Questions

Name: ______________________ You are allowed 2 sheets of notes.

1. A single-degree-of-freedom system with mass 0.1 kg, spring stiffness of 10 N/m and a Coulomb damping force of 0.1 N is excited by a harmonic force of 1 N amplitude at 1 Hz.
   - Approximate the amplitude of vibration of the mass.
   - After the harmonic force is turned off, approximately how long will the vibrations continue?
   - After the harmonic force is turned off, will the frequency of the vibration stay the same, increase, or decrease?

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2. To effectively isolate engine vibration from an automobile's structure, the stiffness and damping coefficient of the engine mounts should be as small as possible. Design an engine mount for an engine having a mass of 200 kg that vibrates with a harmonic force of 10 N amplitude (assume constant for all engine speeds) by answering the following two questions:
    - What is the smallest stiffness that can be used if the vibration amplitude must be less than 5 mm as $\omega \rightarrow 0$?
    - What is the smallest damping coefficient that can be used if the vibration amplitude must be less than 20 mm at resonance?

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3. A vehicle weighing 1000 kg, with a suspension having an overall stiffness of 100 000 N/m and damping coefficient of 5000 N·s/m travels over a rough rode (approximated as a sine wave with 50 mm amplitude (100 mm bottom-to-top) and distance of 0.25 m between successive peaks).
   - What is the amplitude of the vehicle vibration when the vehicle travels at 15 km/hr and at 100 km/hr?
   - Why would the vibration amplitude be higher at 15 km/hr than 100 km/hr?

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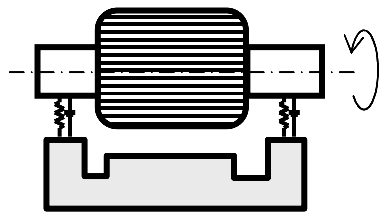
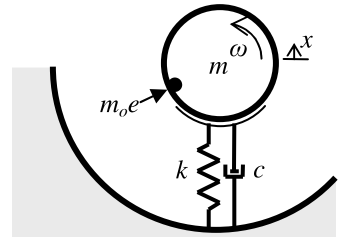
4. The rotor of a portable generator spins at 3600 RPM. The mass of the rotor, including all rotating components (shaft and rotor windings) is 10 kg. The rotor has an unbalance of $m_o e = 7 \times 10^{-4}$ kg-m. The oil bearings provide a total effective stiffness of 40 kN/m and damping of 60 N·s/m.
   - What is the amplitude of the vibration?
   - What is the amplitude of the transmitted force?





Only consider vertical motion about the equilibrium position.

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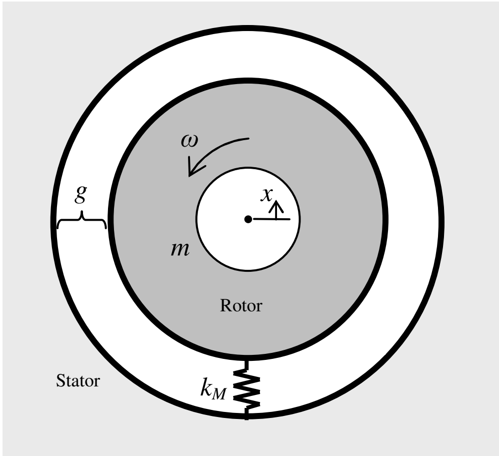
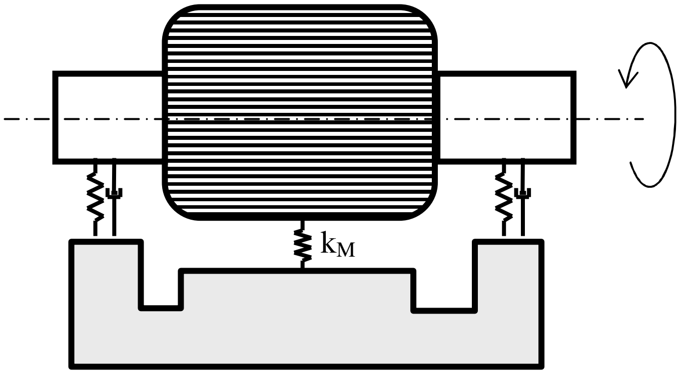
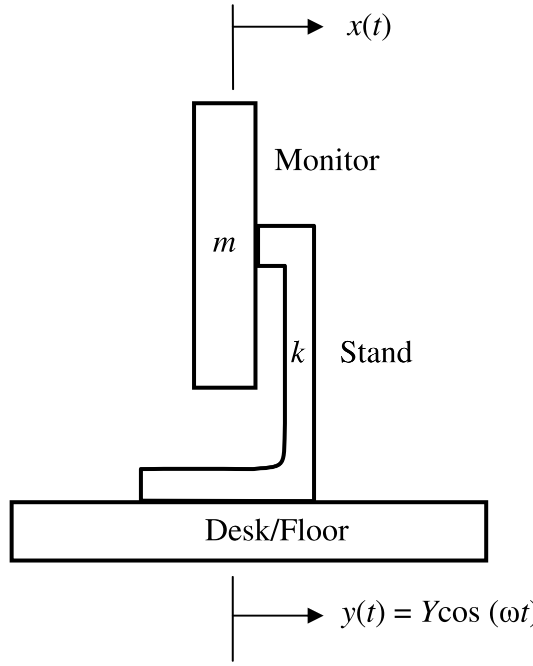
5. The generator from Question 4 also has a magnetic pull that, when the rotor moves to one side, will try to pull it even closer. When the rotor is centered in the stator, for small displacements the magnetic pull can be represented by a negative stiffness of $k_M = -\frac{160}{g}$, where g is the nominal designed size of the air gap (in m) between the rotor and the stator. What is the smallest air gap that the designer can specify if the system is to be stable? Assume that static deflections due to gravity are negligible.





6. A heavy LCD computer monitor, having a mass of 8.5 kg is supported by a very light-weight stand having a (cantilever) stiffness of 755 N/m and effective damping of $\varsigma = 0.15$. The monitor sits on a desk on an upper floor of a building close to a railway track. Vibrations created by passing trains cause the floor to sway (vibrate horizontally) at a frequency of 1.5 Hz, which also causes the monitor to sway. Since the desk is very rigid, the base of the stand, the desk, and the floor all move together as given by $y(t)$. If the monitor's vibration **with respect to the floor** (i.e., $x(t)$-$y(t)$) has an amplitude of 10 mm, what is:
   - the amplitude of vibration of the floor?
   - the phase difference between the floor vibration and the monitor vibration?



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Question 6 cont'd.