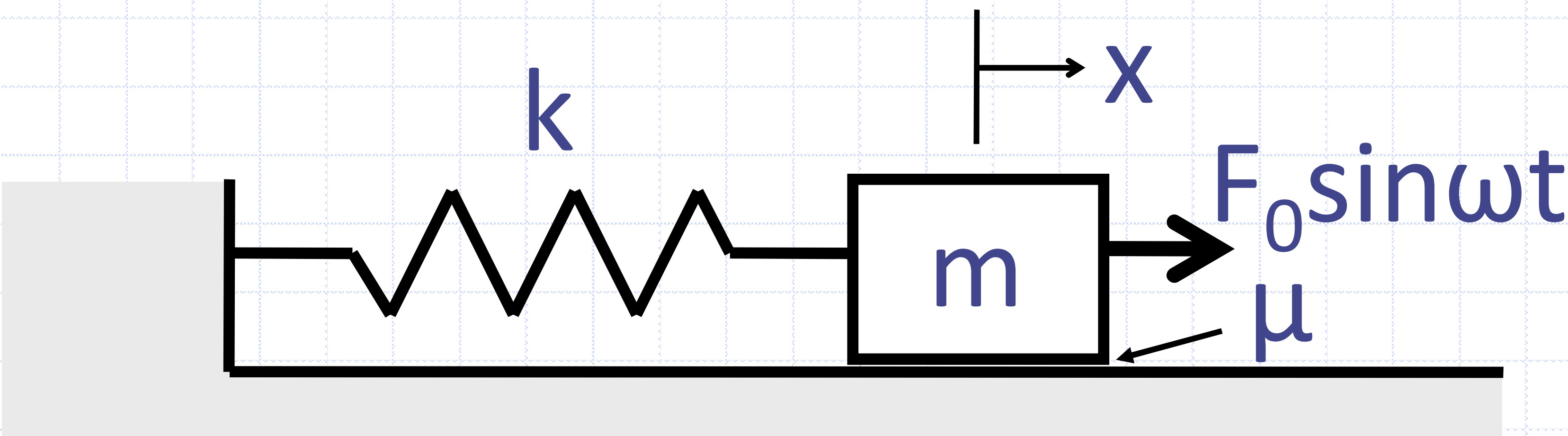
Other Forms of Damping

Section 2.7

Forced Vibration with Coulomb Damping

- A single degree-of-freedom system with mass 100 g, spring stiffness of 10 N/m and a Coulomb damping coefficient of 0.05 is excited by a harmonic force of 0.5 N amplitude at 1 Hz.
- Approximate the displacement amplitude for the vibration of the mass.



Equations of Motion for Vibration Measurement Devices

- Non-Conservative Forces

Type of Force	Source	Amount of Force
Linear viscous damping	Slow fluid	
Air damping	Fast fluid	
Coulomb damping	Sliding friction	
Solid/structural/hysteretic damping	Internal damping	

Coulomb Damping

$$m\ddot{x} + \mu N \operatorname{sgn}(\dot{x}) + kx = F_0 \sin \omega t$$

- Too hard to solve with harmonic excitation term added!
- How about using an approximation? Use a value of c_{eq} in

$$m\ddot{x} + c_{eq}\dot{x} + kx = F_0 \sin \omega t$$

that dissipates the same amount of energy per cycle.

- Considering only the steady-state response, if $F_0 >> \mu N$,

$$c_{eq} = \frac{4\mu N}{\pi \omega X} \quad \text{or} \quad \varsigma_{eq} = \frac{2\mu N}{\pi m \omega_n \omega X}$$

Coulomb Damping

- Substituting into solution:

$$X = \frac{F_0 / k}{\sqrt{\left(1 - r^2\right)^2 + \left(\frac{4\mu N}{\pi k X}\right)^2}}$$

- Solving for X:

$$X = \frac{F_0}{k} \frac{\sqrt{1 - \left(\frac{4\mu N}{\pi F_0}\right)^2}}{\left|1 - r^2\right|} \qquad \theta = \tan^{-1} \frac{4\mu N}{\pi k X \left(1 - r^2\right)} = \tan^{-1} \frac{2\varsigma_{eq} r}{1 - r^2}$$