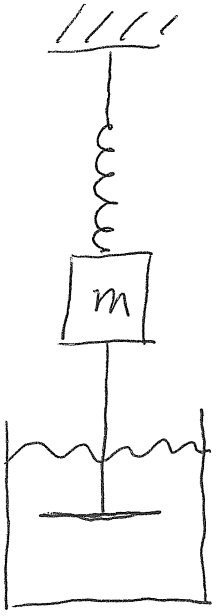
Damping

Any oscillator acted upon by an outside force that reduces oscillation is <u>damped</u>.



As this spring-mass system oscillates the piston movement is resisted by the fluid.

This fluid drag force is called a <u>damping force</u>

* External force transferring energy out of the spring-mass system

With F_g negligible

$$\sum F_{\text{spring-mass}} = F_d + F_s$$

$$F_d = -bv$$

b = damping constant

v = velocity

$$F_s = -kx$$

$$\sum F = -bv + -kx = ma$$

$$0 = ma + bv + kx$$

$$a = \frac{d^2x}{dt^2} \qquad v = \frac{dx}{dt}$$

$$0 = m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx$$

This differential equation has a solution

$$x(t) = x_m e^{-\frac{bt}{2m}} \cos\left(\omega' t + \phi\right)$$

where

$$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$

For small damping effects

$$E(t) \approx \frac{1}{2} k x_m^2 e^{-bt/m}$$