AP Physics - Simple Harmonic Motion - Graphing and Damping

Note Title 11/12/2007

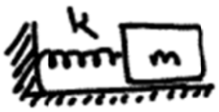
Equations to memorize

Period of a pendulum

$$T_{pend} = 2\pi\sqrt{\frac{l}{g}}$$

l = length of a pendulum
g = acceleration due to gravity

Period of a spring-mass system

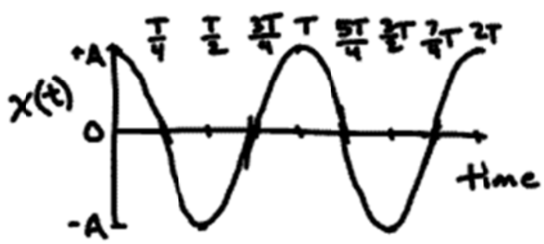


$$T = 2\pi\sqrt{\frac{m}{k}}$$

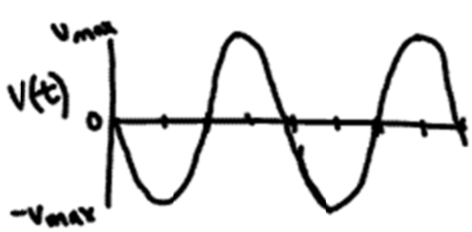
m = mass
k = spring constant

Graphing Motion

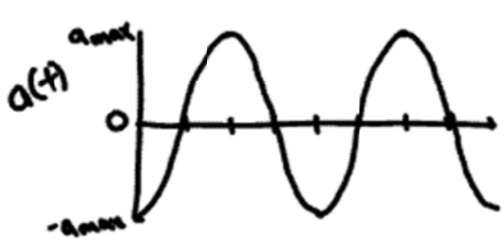
Example: Consider a pendulum.
You hold the pendulum to the right at $+A$, then let go at time $t = 0s$.



$$x(t) = A\cos\left(\frac{2\pi}{T}t\right)$$



$$v(t) = -v_{max}\left(\frac{2\pi}{T}t\right)$$



$$a(t) = -a_{max}\left(\frac{2\pi}{T}t\right)$$

Note that the example above is specific to the initial condition. If we changed the initial condition, for example, by starting the pendulum at $x=0$, but throw it to the right with a velocity $v = v_{max}$, we would use the following equations:

$$x(t) = A\sin\left(\frac{2\pi}{T}t\right)$$

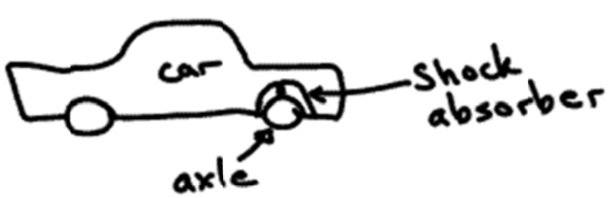
$$v(t) = v_{max}\cos\left(\frac{2\pi}{T}t\right)$$

$$a(t) = -a_{max}\sin\left(\frac{2\pi}{T}t\right)$$

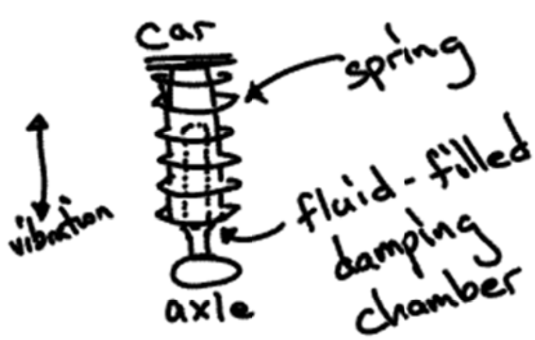
Damping

In real life, friction causes things to stop oscillating. This friction is called "damping".

Example: A car shock absorber



A car's shock absorbers prevent the transmission of jarring bumps from the wheels to the car.



The shock absorber contains a spring to absorb shocks, and a damping chamber to dissipate the kinetic energy.

Damping Conditions

Underdamped - Vibration happens, but amplitude decreases over time

Overdamped - Mass <u>slowly</u> returns to equilibrium, <u>without vibration</u>

Critically Damped - Mass returns <u>rapidly</u> to equilibrium, and does not overshoot or oscillate