WAVES INTRODUCTION

Examples of Waves

- Water surface waves – think of ripples on a pond. → "wave fronts" spread out as circles on the surface → 2-D waves.

3-D waves.
- Sound → caused by oscillating air pressure, above & below ambient pressure
- Light: Electromagnetic Wave with freq ~ 10^{14} Hz → our eyes can detect this

—

November 8, 2004

PHYS 138 - Waves Quarter, Lecture 1

Chapter 12 – Oscillatory Motion, Sections 12.1 -12.3

- ~~Intro to Jason Harlow~~
- Hooke's Law for Springs
- Motion of a mass on a spring
- Simple Harmonic Motion

a.k.a. "Simple Harmonic Motion"

S.H.M.

We observe: Restoring forces lead to oscillation

Example: A mass, m, sits on a frictionless table. It is attached to a spring, whose other end is attached to the wall. Hookes Law describes restoring force:

$$F = -kx$$

$x = 0$ is equilibrium point of mass.

$k =$ <u>positive</u> constant $[N/m]$

Describe motion of the mass:

$x = f(t)$ ← "f of t" "function of time"

Use <u>Newton's 2nd Law</u>: $\underbrace{\Sigma F} = ma$

Assume Net force, ΣF is force provided by spring.

$$\Sigma F = F = -kx$$

$$ma = -kx$$

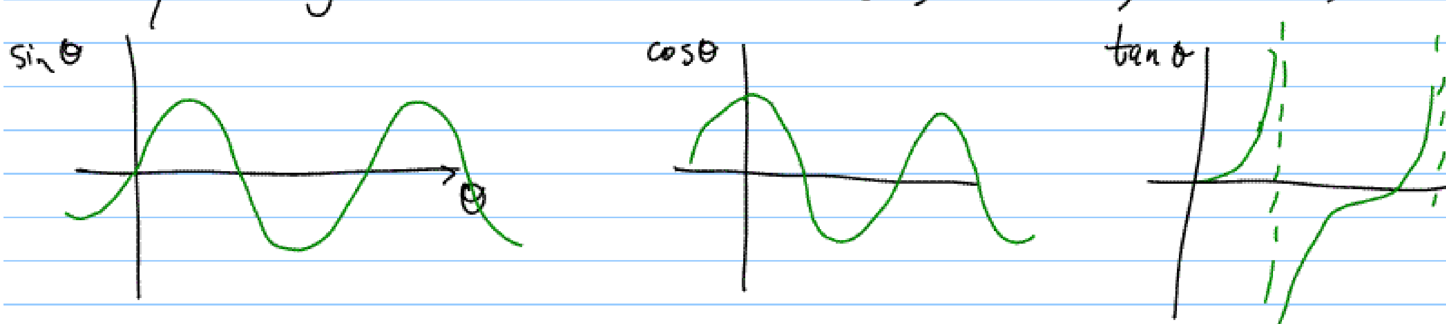
$$a = \boxed{\frac{d^2x}{dt^2} = -\frac{k}{m}x} \qquad (1)$$

How do you solve (1)? "Trial Solution Method"

<u>Guess</u> a solution, see if it works.

Hint comes from our observations: the solution should oscillate.

Try trig functions: $\sin(\theta)$, $\cos(\theta)$, $\tan(\theta)$



$\tan(\theta)$ is no good, because it equals ∞

when $\theta = \pi/2$, sin & cos could work.

TRIG REVIEW:

$$\frac{d}{d\theta}\sin\theta = \cos\theta$$

$$\frac{d}{d\theta}\cos\theta = -\sin\theta$$

By calculus rules: $\frac{d}{d\theta}\left(A\cos(B\theta + C) + D\right)$

A, B, C, D constants. $= -AB\sin(B\theta + C)$

Back to mass on spring:

try: $\boxed{x = A\cos(\omega t + \phi)}$

does it work? $\frac{dx}{dt} = -A\omega\sin(\omega t + \phi)$

$$\frac{d}{dt}\left(\frac{dx}{dt}\right) = \boxed{\frac{d^2x}{dt^2} = -A\omega^2\cos(\omega t + \phi)}$$

Eq(1): $\frac{d^2x}{dt^2} = -\frac{k}{m}x$

$$\cancel{-A}\omega^2\cancel{\cos(\omega t+\phi)} = -\frac{k}{m}\left(\cancel{A}\cancel{\cos(\omega t + \phi)}\right)$$

→ Can be true for all time.

Solve for constants:

$$-\omega^2 = -k/m$$

$\boxed{\omega = \sqrt{k/m}}$ ← set by force constant & mass

↑ "Angular Frequency" of motion

[rad/s]

A, ϕ are "arbitrary" → set by initial conditions.

S.H.M. solution: $\boxed{x = A\cos(\omega t + \phi)}$

Period: $\boxed{T = \frac{2\pi}{\omega}}$

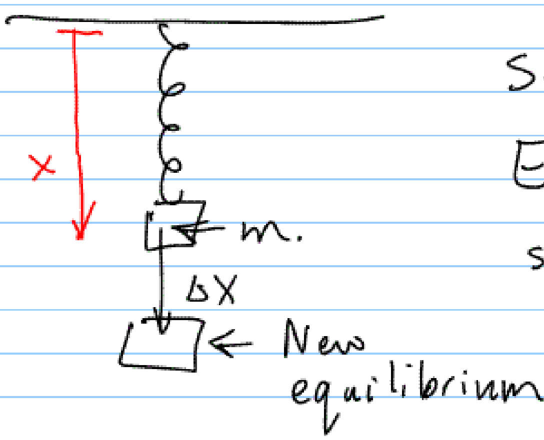
$a = -A\omega^2 \cos(\omega t +$

QUIZ RESULTS:

1. 1%
2. 90%
3. 1%
4. 2%
5. 5%

Class gets an A!

Vertical Hanging Mass on spring.



Solution is S.H.M.!!

Equilibrium position is below spring's natural equilibrium

$k\Delta x = mg$

$$\boxed{\Delta x = \frac{mg}{k}}$$

Again $x = A\cos(\omega t + \phi)$

(define $x = 0$ new equilibrium)