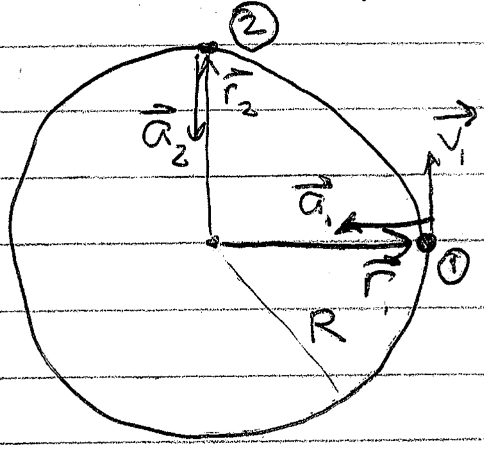
Phys 1402 2017-11-02 Lec 18

Review From Phys-1401 - Circular Motion



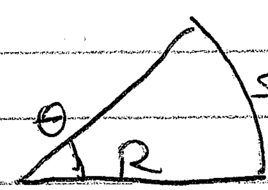
$\vec{r}_1 = R\,\hat{i}$

$\vec{a}_1 = \frac{v^2}{R}(-\hat{i})$

$\vec{r}_2 = R\,\hat{j}$ $\vec{a}_2 = \frac{v^2}{R}(-\hat{j})$

In general: $\vec{a} = -\vec{r}\,\frac{v^2}{R^2}$

In circular motion, $\theta = \frac{s}{R}$



For a full revolution

$$\frac{s}{R} = \frac{2\pi R}{R} = 2\pi$$

At time t: $v = \frac{\Delta s}{\Delta t} = \frac{\text{Dist}}{\text{Time}}$ $s = vt$

If s is prop to time, so is θ.

$$\theta = \underline{\quad\quad} t$$

The x-component of the position is

$$x = R\cos\theta = R\cos(\underline{2\pi f}\, t)$$

The x-component of acceleration is

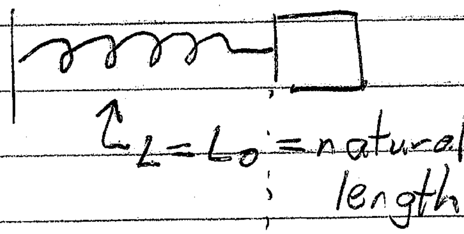
$$a_x = -v^2/R\,\cos\theta = -v^2/R\,\cos(2\pi f t)$$
$$= -v^2/R^2\,(R\cos(2\pi f t))$$

Conclusion: If a particle's position is described by a cos() function, its accel is described by -cos() function.

In this case, $a_x \propto -x$

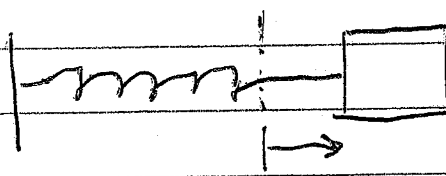
$\propto$ = proportional

A spring creates a force that satisfies this!



m

$F_{spring} = 0$



m

$F_{spring} = -kx$

$L = L_0 + x$

x = stretch of spring

$x = \oplus$

$F_{spring} = \ominus$

k = strength or stiffness of spring

Apply Newton's 2^{nd} Law

x-direction:

$$F_{net} = ma$$
$$-kx = ma$$
$$-\frac{k}{m}x = a$$

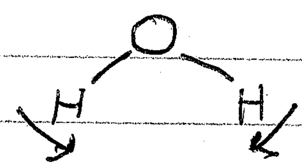
~~Before~~ How does this relate to $\cos(2\pi f t)$?

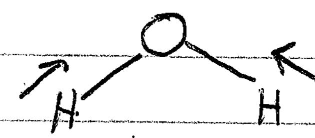
$\cos(2\pi f t)$ satisfies equation if:

$$2\pi f = \sqrt{\frac{k}{m}} \qquad f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

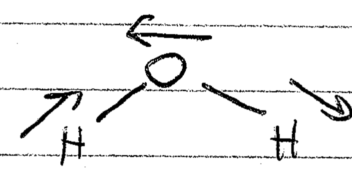
Oscillations:
- Repetitive behavior
- Equilibrium value
- Restoring "Force"
- Inertia - overshoots equilibrium

Examples:
- Mass & Spring
- Diving Board
- Pendulum
- Molecules





"Breathing mode"



frequencies in microwave range

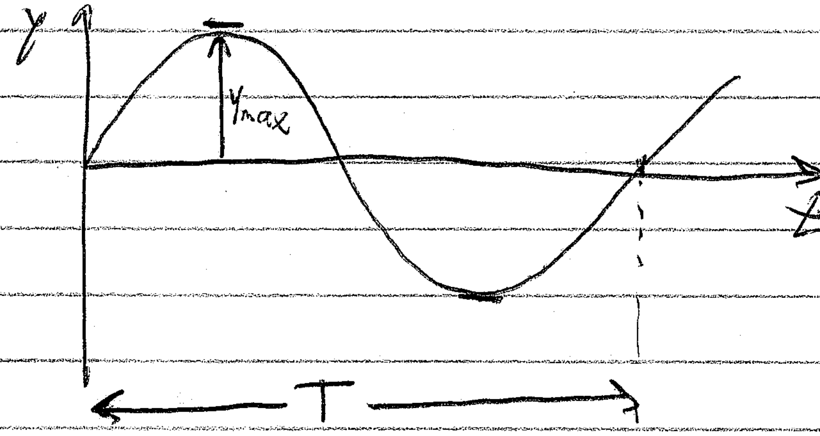
- AC Voltage, Current
- Nuclei in magnetic fields NMR, MRI
- Pieces of Waves

Oscillation graphs

y_{max} = Amplitude

$y=0$ is equilibrium

T = period



$\sin(2\pi f t)$ repeats like $\sin(\Theta)$

$\Delta\Theta = 2\pi$ is one cycle

$\Delta(2\pi f t) = 2\pi$

$2\pi f \Delta t = 2\pi$ $\qquad T = \Delta t$ of one cycle

$fT = 1$

$$f = \frac{1}{T} \qquad T = \frac{1}{f}$$

f is "how fast" the oscillations repeat
T is "how slow" ...

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Let's try to model a car suspension

$F_s = -kx$ Car alone: $F_1 = -kx_1$

w/ cargo: $F_2 = -kx_2$

$$\Delta F = F_2 - F_1 = -kx_2 - (-kx_1)$$
$$= -k(x_2 - x_1)$$
$$\Delta F_s = -k\,\Delta x$$

When a 100 kg person gets in, car sinks <u>1 cm</u>.

$$\Delta F = (100\text{ kg})(9.8\text{ N/kg}) = 980\text{ N}$$
$$k = \frac{980\text{ N}}{0.01\text{ m}} = 98000\text{ N/m}$$

Typical car $m = 2000$ kg

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\sqrt{\frac{98000}{2000}}$$
$$= 1.11\text{ Hz}$$

$$T = \frac{1}{f} = 0.9\text{ s}$$