Conservation of energy:

Total energy at $x = \pm A$ = Total energy at arbitrary x

$$\underbrace{\frac{1}{2} m v_A^2}_{0} + \frac{1}{2} k A^2 = \frac{1}{2} m v^2 + \frac{1}{2} k x^2$$

$$k A^2 = m v^2 + k x^2$$

$$m v^2 = k(A^2 - x^2)$$

$$\boxed{v = \pm\sqrt{\frac{k}{m}(A^2 - x^2)}} \qquad (1)$$

max at $x = 0$

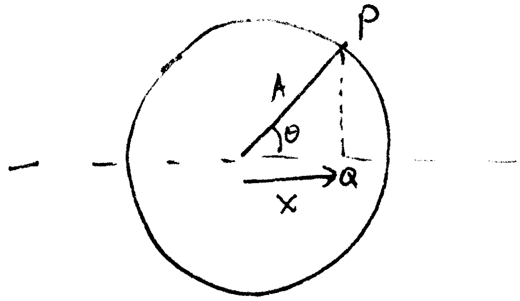
zero at $x = \pm A$

$F = ma$ Newton's law

$F = -kx$ Hooke's law

$$ma = -kx$$

$$\boxed{a = -\frac{kx}{m}} \qquad (2)$$



P rotates at constant angular velocity w

Q is the projection of P onto the x axis

Q undergoes simple harmonic motion

$$x = A\cos\theta$$

$$\theta = wt$$

$$\boxed{x = A\cos wt} \qquad \cos wt = \frac{x}{A}$$

Along x axis, $V = -V_t \cos(90^\circ - \theta)$

$$= -V_t \sin\theta$$

$$= -V_t \sin wt$$

tangential speed for circular motion $\boxed{V_t = wA}$

$$\boxed{V = -wA\sin wt}$$

$$V^2 = w^2A^2\sin^2 wt$$

$$= w^2A^2(1-\cos^2 wt)$$

$$= w^2A^2\left(1-\frac{x^2}{A^2}\right)$$

$$= w_0^2(A^2-x^2)$$

$$V = \pm w_0\sqrt{A^2-x^2}$$

Comparing with (1)

$$\boxed{\omega = \sqrt{\frac{k}{m}}}$$ angular frequency

$$\omega = \frac{\Delta\theta}{\Delta t} = \frac{2\pi}{T} = 2\pi f$$

Point P rotates 2π radians in T seconds.

$$\boxed{f = \frac{\omega}{2\pi}}$$

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

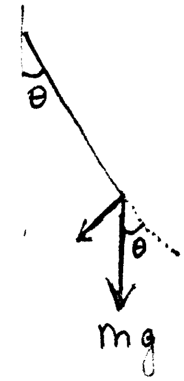
$$T = \frac{1}{f} = 2\pi\sqrt{\frac{m}{k}}$$

Using $F = ma = -kx$

$$a = -\frac{k}{m}x = -\omega^2 x$$

$$\boxed{a = -\omega^2 A \cos\omega t}$$

Simple pendulum



$$F_t = -mg\sin\theta$$

$$\simeq -mg\,\theta$$

$$= -mg\left(\frac{s}{L}\right)$$

$$= -\underbrace{\left(\frac{mg}{L}\right)}_{K_{eff}} s$$

$$T = 2\pi\sqrt{\frac{m}{K_{eff}}}$$

$$= 2\pi\sqrt{\frac{m}{\frac{mg}{L}}}$$

$$\boxed{T = 2\pi\sqrt{\frac{L}{g}}}$$