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加速度 $\vec{a}$：$v(t)$，$x(t)$　　$\vec{F} = m\vec{a}$，向量

force：重力．強作用力．弱作用力

圓座標系．直角坐標系

$m_1, m_2 \Rightarrow \vec{F}_{12} = -G\frac{m_1 m_2}{r_{12}^2}\hat{r}_{12}$　→ 單位向量

G：$6.67\times10^{-11}\ [N\cdot m^2/kg^2]$

$m_2 = M_e$ 地球質量　　$F = m\frac{GM}{r^2} = mg$　　$g: 9.8\ m/s^2$

δ：$\int_{-\infty}^{\infty}\delta(x)\,dx = 1$

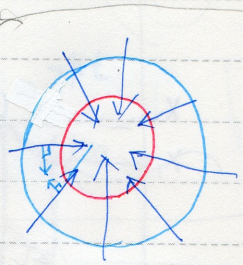
$\delta(x-0)$：$x=0$ 時，$\Rightarrow\infty$

$x\neq0$ 時，$\Rightarrow x=0$

$$\vec{F} = -m\frac{GM}{R^2}\hat{R}$$

$$= m\left(-\frac{GM}{R^2}\hat{R}\right)$$

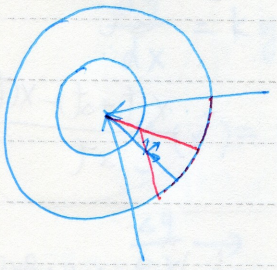
電場！由重力造成！

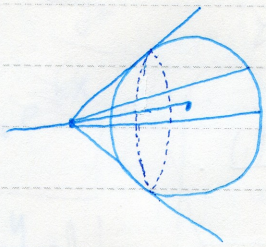


$\oint \vec{E}_g \cdot d\vec{a}$

球表面積 $4\pi r^2$

$= -GM4\pi$（常數！）





$$\oint \vec{E}_g \cdot d\vec{a} = -4\pi G(\Sigma m_i)_{enc}\frac{M}{\frac{4}{3}\pi R^3}$$

$$4\pi r^2 E_g = -4\pi G\left[\frac{4}{3}\pi r^3\right] \Rightarrow \vec{E}_g = \frac{-GM}{R^3}r\hat{r}$$

半 r 的小球

$$\frac{m d^2 r}{dt^2} + -\frac{GMm}{R^3} r = 0$$

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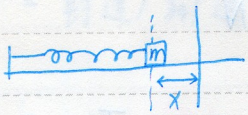
$$\vec{F}_g = m\vec{E}_g = \frac{-GMm}{R^3} r\,\hat{r}$$

$F = -kx$ k：彈性係數

ma 虎克 x：形變量



$$m\frac{d^2x(t)}{dt^2} + kx(t) = 0$$

①多項式 $\frac{d^2 ax^n}{dx^2} = n(n-1)ax^{n-2}$ (V)

②三角函數 $\cos\theta \to -\sin\theta \to \cos\theta$ (V)

$\sin\theta \to \cos\theta \to -\sin\theta$

③指數函數 $\frac{e^{ax}}{dx} = ae^{ax}$ (V)

用 cos $x(t) = A\cos wt$, $\ddot{x}(t) = -w^2 A\cos wt$

$\Rightarrow -mw^2 A\cos wt + kA\cos wt = 0$

$A\cos wt(-mw^2 + k) = 0$

①$A=0$ ⇒不動(X) ②$\cos wt \neq 0$ (X) $=0$

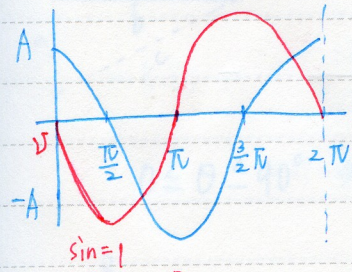
$w = \sqrt{\frac{k}{m}}$

if $wt = 2\pi$ $(x=0)$

$wt = \pi$ $(x=-1)$

$wT = 2\pi$

週期



角頻率 $w = \frac{2\pi}{T} = 2\pi f$

sin=1 平衡點V最大

$v(t) = \frac{dx(t)}{dt} = \frac{d(A\cos\sqrt{\frac{k}{m}}t)}{dt} = -A\sqrt{\frac{k}{m}}\sin\sqrt{\frac{k}{m}}t$

$t=0$ 時 sin=0

速度隨時間的函數

$-A\sqrt{\frac{k}{m}}$ 常數

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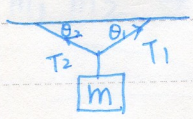
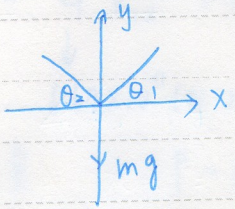
重力 $m\vec{g}$　　正向力 N　　摩擦力 f

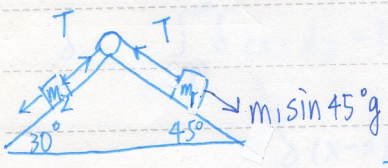
$f_S = \mu_S N$ (靜止)　　$f_K = \mu_K N$

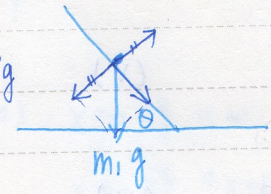




$$\begin{cases} T_1\sin\theta_1 + T_2\sin\theta_2 = mg \\ T_1\cos\theta_1 = T_2\cos\theta_2 \end{cases}$$

(T, m)





$m_1 = 1kg$, $m_2 = 2kg$

① $m_1 g\sin 45° - T = m_1 a$

② $T - m_2 g\sin 30° = -m_2 a$　　(T, a)　　自己算