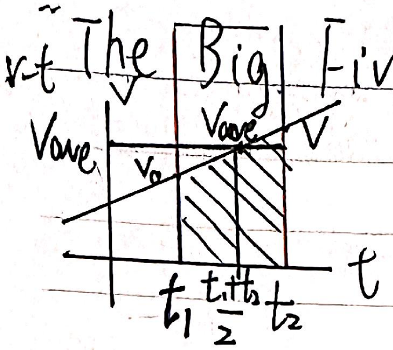
"The Big Five"



① $V_{ave} = \frac{V_0+V}{2}$

② $\Delta X = V_0\Delta t + \frac{1}{2}a(\Delta t)^2$ V

③ $\Delta X = V\Delta t - \frac{1}{2}a(\Delta t)^2$ V_0

④ $V = V_0 + a\Delta t$ ΔX

⑤ $2a\Delta X = V^2 - V_0^2$ t

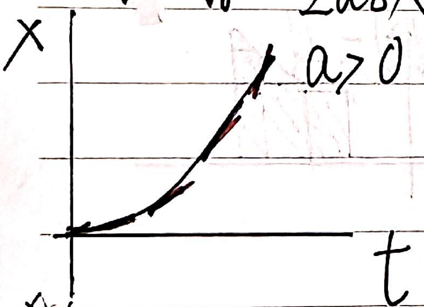
$\underset{F}{\underline{ma}}\,\Delta X = m\frac{1}{2}V^2 - m\frac{1}{2}V_0^2$

$V_{ave} = \frac{V+V_0}{2}$ $t = \frac{\Delta V}{a} = \frac{V-V_0}{a}$

$V_{ave}\cdot t = \Delta X$

$\frac{V+V_0}{2}\cdot\frac{V-V_0}{a} = \Delta X$

$V^2 - V_0^2 = 2a\Delta X$

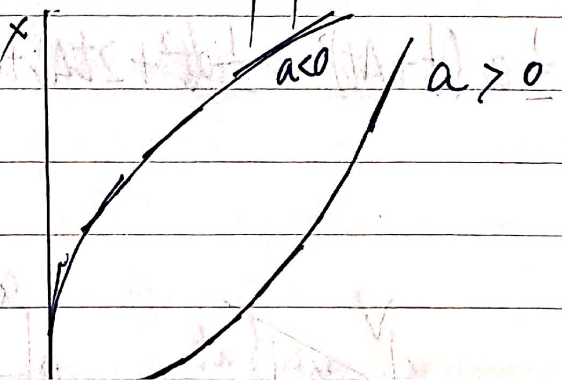


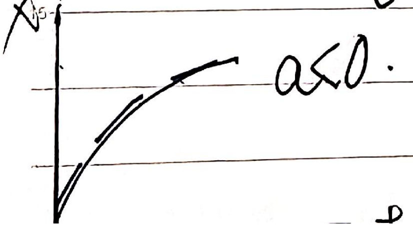
X.t图中

斜率⇒V.

斜率↑⇒a↑

a⇒斜率变化量ΔV



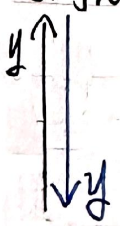


5. Free fall

a. $g = 9.8\,m/s^2 = \frac{W}{m}$ $\quad$ $\downarrow g$ (m)

b. local gravity mg.

c. free fall with initial velocity

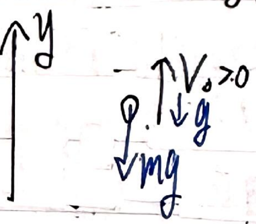


$\downarrow mg$ $\quad$ $a = \frac{F}{m} = -g$
$= +g$

以向下为正：$V_0 = 0$ $\quad v = gt$. $\quad y = \frac{1}{2}gt^2$.

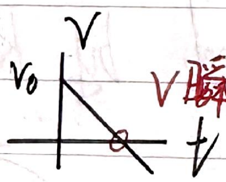
向上 $\quad v = -gt \quad y = -\frac{1}{2}gt^2$

向上抛：



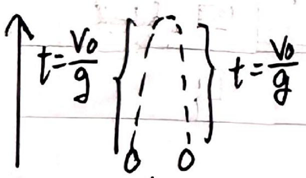
$a = -g$

$v = V_0 - gt$

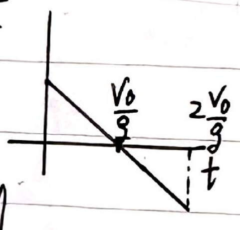


V瞬间为0 达到最高点 $t = \frac{V_0}{g}$

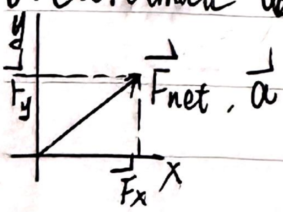
$y = y_0 + V_0 t - \frac{1}{2}gt^2$. $\quad y_0 = 0$



$\Delta t = 2\frac{V_0}{g}$



6. Coordinate decomposition



$\vec{F} = m\vec{a}$

$\vec{F_x} + \vec{F_y} = m\vec{a_x} + m\vec{a_y}$

$0 = \underbrace{\vec{F_x} - m\vec{a_x}}_{x} = \underbrace{m\vec{a_y} - \vec{F_y}}_{y}$ / $\underbrace{(\vec{F_x} - m\vec{a_x})}_{x} + \underbrace{(\vec{F_y} - m\vec{a_y})}_{y} = 0$

$$\begin{cases} F_x = ma_x \\ F_y = ma_y \end{cases}$$

自由落体

$$\begin{cases} V_t = gt \\ h = \frac{1}{2}gt^2 \\ V_t^2 = 2gh \end{cases}$$

竖直上抛

$$\begin{cases} V_t = -gt \\ h = V_0 t - \frac{1}{2}gt^2 \\ V_t^2 - V_0^2 = -2gh \end{cases}$$

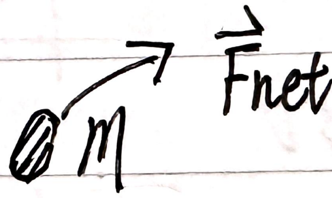
3. Newton's 2^{nd} law

a. Inertia

Inertial mass : m

b. 2^{nd} law

$\vec{F}_{net} = 0 \Longleftrightarrow \vec{a} = 0$



$\vec{F}_{net} \propto m\vec{a}$ $\quad\quad \vec{F} = m\vec{a}$

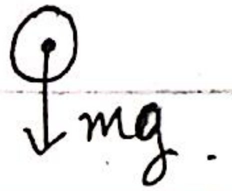
$\vec{a} \propto \frac{\vec{F}_{net}}{m}$ $\quad\quad \vec{a} = \frac{\vec{F}}{m}$

$\vec{a}(\vec{F}_{net}, m)$

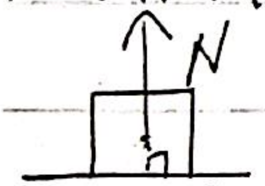
$\vec{F}_{net} = m\vec{a}$

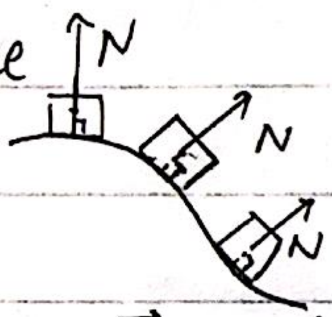
Toy Model Forces

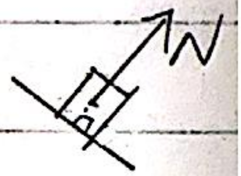
a. Gravity



b. Normal Force

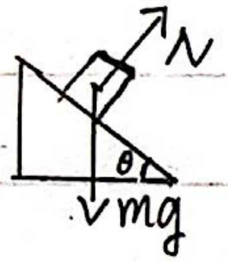




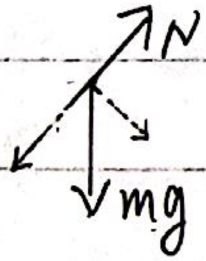


Prependicular. $\vec{N} \perp$ surface.

e.g.
rest.



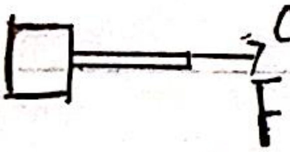
$\Rightarrow$



$\boxed{\text{Only}}$ 2 Forces : N and mg

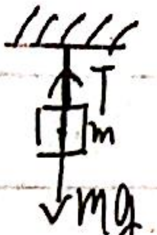
$0 = ma_y = N - mg\cos\theta \Rightarrow N = mg\cos\theta$.

c. Tension (pulling force)



cable/rope/string ...

(tension in the rope).



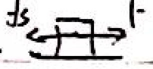
d. Friction (passive) (tangential)

$\vec{F}_{net} = m\vec{a}$

i. Kinematic friction μN

$f_k = \mu N$ μ: coefficient of friction

ii. Static friction 受力分析

$f_s = F$ (pull)/(push)... e.g. 

$a=0$
$v=0$

$f_s \leq f_K \Rightarrow f_s \leq \mu N$

when $f_s = f_K = \mu N$, $f_s \propto N$

e. Drag

$f = \beta v$

e.g.

$a = \frac{mg - \beta v}{m}$

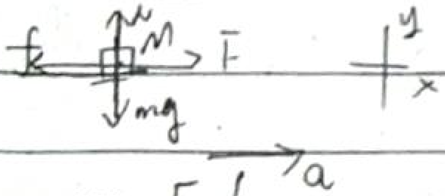
$= g - \frac{\beta}{m} v$

$\Rightarrow$ when $a = 0$, Terminal speed: $V_{terminal} = \frac{mg}{\beta}$

$(g - \frac{\beta}{m} v = 0)$

Mechanics.

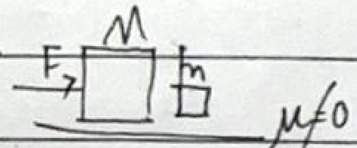
a. Horizontal Surface.



$$\begin{cases} ma = F - f \\ 0 = N - mg \\ f = \mu mg \end{cases}$$

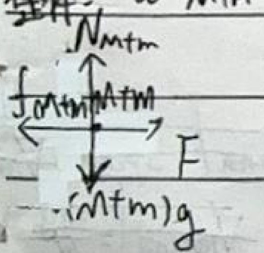
$a = \frac{F_{net}}{m} = \frac{F-f}{m} = \frac{F}{m} - \mu g$

e.g.

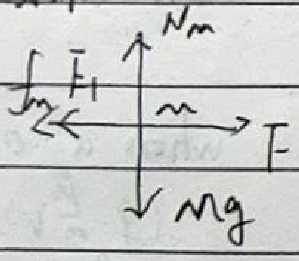


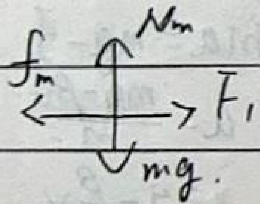
$(M+m)a = F$

整体： $a = \frac{F}{M+m}$



分拆：





$$\begin{cases} ma = F_1 - f_m = F_1 - \mu mg \\ Ma = F - F_1 - f_m = F - F_1 - \mu Mg. \end{cases} \Rightarrow (M+m)a = F - \mu(M+m)g$$

$a = \frac{F}{M+m} - \mu g.$

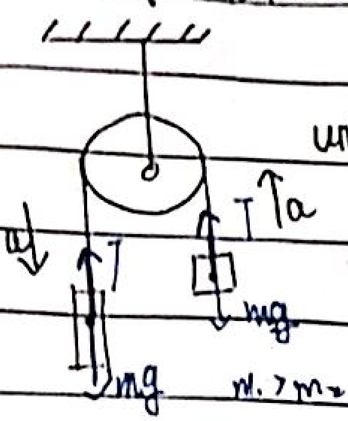
$F_1 = ma + \mu mg = m(a + \mu g)$

$= \frac{m}{M+m} F.$

$\mu = 0$ " F_{net_2} " $= F - F_1 = \frac{M}{M+m} F$

b. Atwood Machine

T与T internal forces



unstretchable cable

$$\begin{cases} m_2 a = T - m_2 g \\ m_1 a = m_1 g - T \end{cases}$$

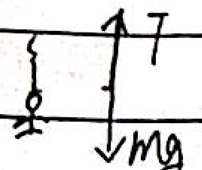
$$(m_1+m_2)a = (m_1-m_2)g$$

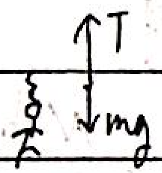
$$a = \frac{m_1-m_2}{m_1+m_2} g$$

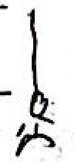
$$T = m_1(g-a)$$
$$= m_1\left(g - \frac{m_1-m_2}{m_1+m_2} g\right)$$
$$= m_1 g\left(\frac{2m_2}{m_1+m_2}\right) = 2\frac{m_1 m_2}{m_1+m_2} g$$

c. Apparent Weight

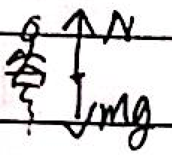
i. $a<g$





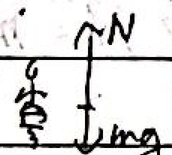


$a=0$



$N=mg$ $T=mg$

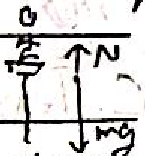
$a\uparrow$



$T-mg=ma$

$N-mg=ma$

$a\downarrow$

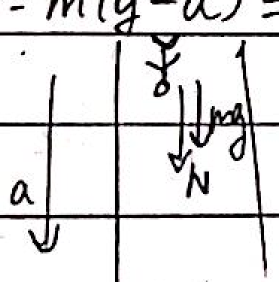


$mg-N=ma$

ii. $a=g$.

N or $T = m(g-a)=0$.

iii. $a>g$

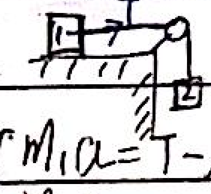


$a=2g$

$N+mg=ma$.

d. Another Atwood Machine

e.g.



$$\begin{cases} m_1 a = T - \mu m g \\ m_2 a = m_2 g - T \end{cases} \Rightarrow (m_1+m_2)a = (m_2-\mu m_1)g$$

$$a = \frac{m_2-\mu m_1}{m_1+m_2} g \qquad \cancel{T = m_2(g-a)}$$