Physic Ch456

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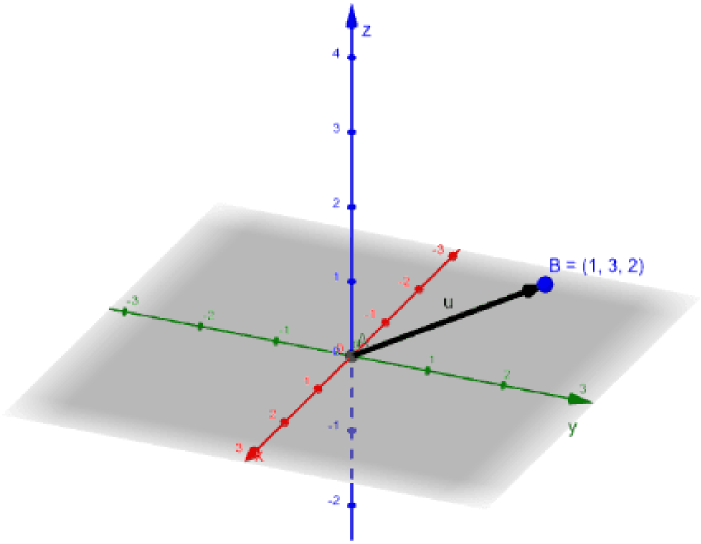
Position vector (位置向量)



$$\vec{r} = x\hat{\mathrm{i}} + y\hat{\mathrm{j}} + z\hat{\mathrm{k}},$$

$$\Delta\vec{r} = \vec{r}_2 - \vec{r}_1.$$

$$\Delta\vec{r} = (x_2 - x_1)\hat{\mathrm{i}} + (y_2 - y_1)\hat{\mathrm{j}} + (z_2 - z_1)\hat{\mathrm{k}},$$

Velocity (速度) Acceleration(加速度)

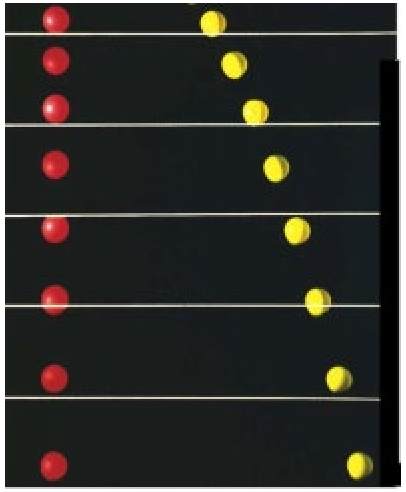
平均速度 : $\vec{v}_{avg} = \frac{\Delta \vec{r}}{\Delta t}.$

瞬時速度 : $\vec{v} = \frac{d\vec{r}}{dt}.$

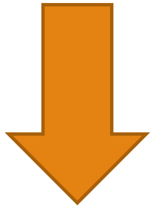
平均加速度: $\vec{a}_{avg} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t} = \frac{\Delta \vec{v}}{\Delta t}.$

瞬時加速度: $\vec{a} = \frac{d\vec{v}}{dt}.$

拋射運動 (Projectile Motion)



1.球在同時間點是等高的
2.唯一不同的只有橫向(x)速度



X方向的速度和y方向的速度是互相獨立的

拋射運動 (Projectile Motion)

高度： $y - y_0 = v_{0y}t - \frac{1}{2}gt^2$

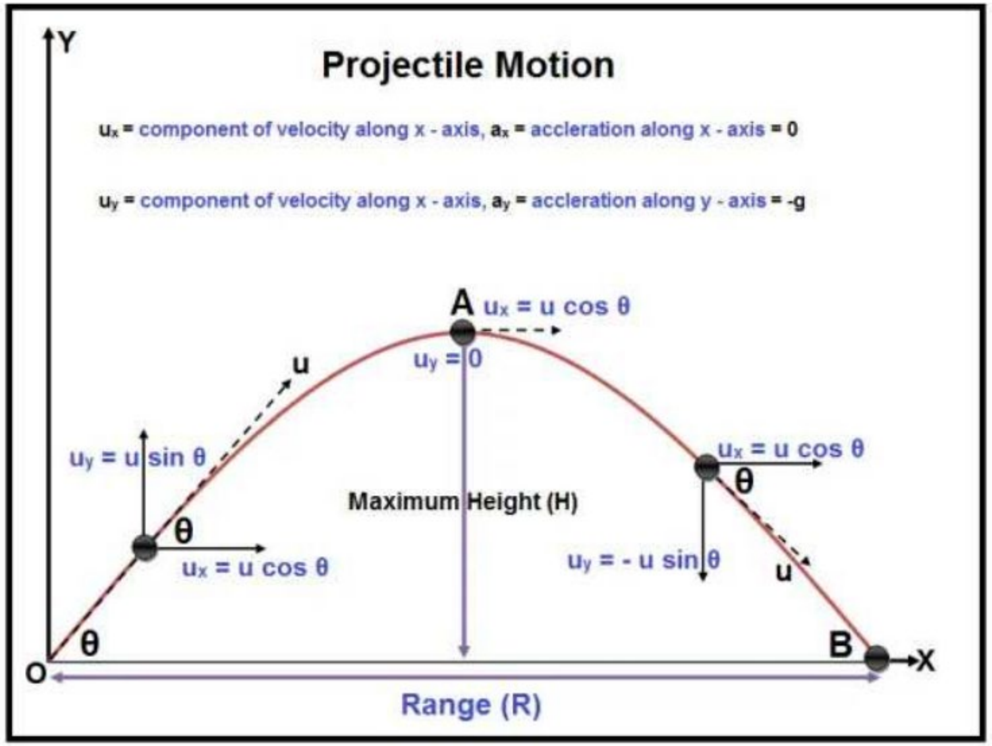
$$= (v_0 \sin \theta_0)t - \frac{1}{2}gt^2$$

高度=y時的速度： $v_y = v_0 \sin \theta_0 - gt$

拋物線中的高度(y)和距離(x)的關係式：

$$y = (\tan \theta_0)x - \frac{gx^2}{2(v_0 \cos \theta_0)^2}$$

總飛行距離(R)： $R = \frac{v_0^2}{g} \sin 2\theta_0$



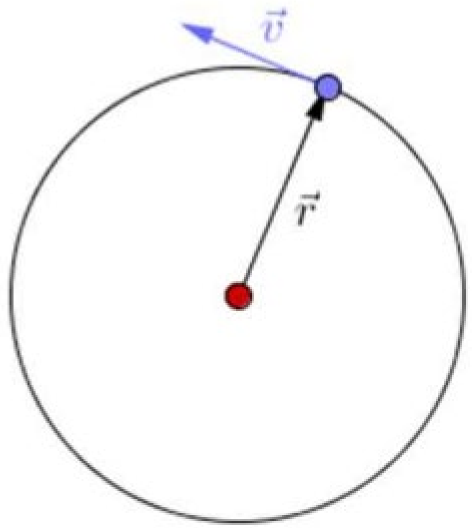
勻速圓周運動 (Uniform Circular Motion)

加速度永遠指向圓心
速率(speed)不變 速度(velocity)一直變

速度和加速度都保持強度(magnitude)不變, 方向(direction)改變

向心加速度 (centripetal acceleration) : $a = \frac{v^2}{r}$

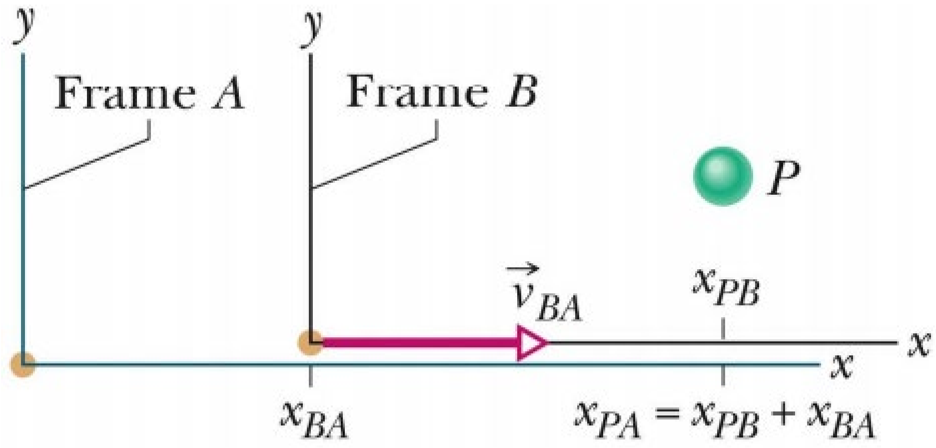
週期 : $T = \frac{2\pi r}{v}$



一維相對運動 (Relative Motion)

在不同的參考係觀察速度 (velocity)和位置 (position)

$\vec{r}_{PA}$ = 在A參考係上觀察P的位置



$$x_{PA} = x_{PB} + x_{BA}.$$

$$\frac{d}{dt}(x_{PA}) = \frac{d}{dt}(x_{PB}) + \frac{d}{dt}(x_{BA})$$

$$v_{PA} = v_{PB} + v_{BA}.$$

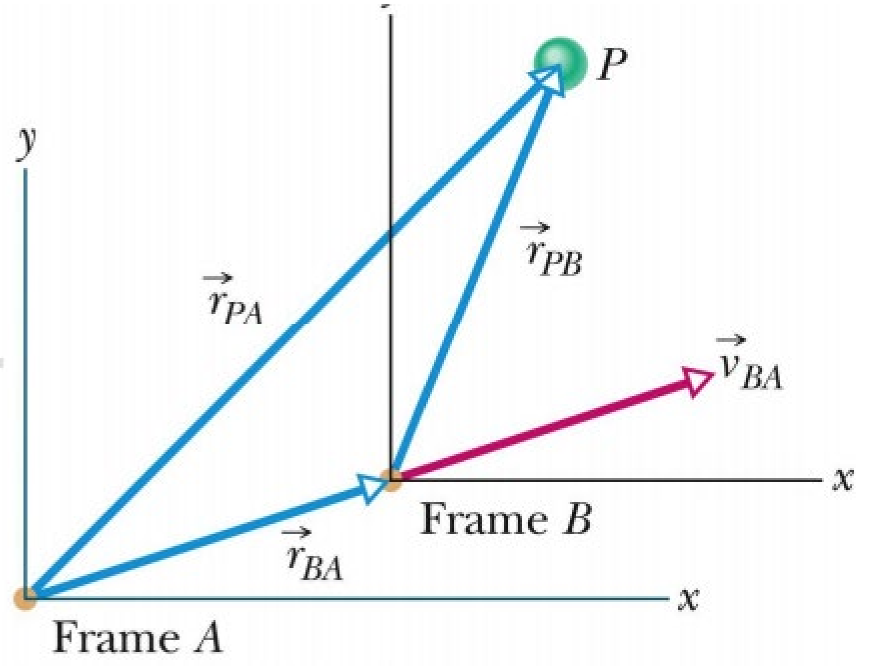
如果是在無加速度參考係內的話 : $a_{PA} = a_{PB}.$

二維相對運動 (Relative Motion)

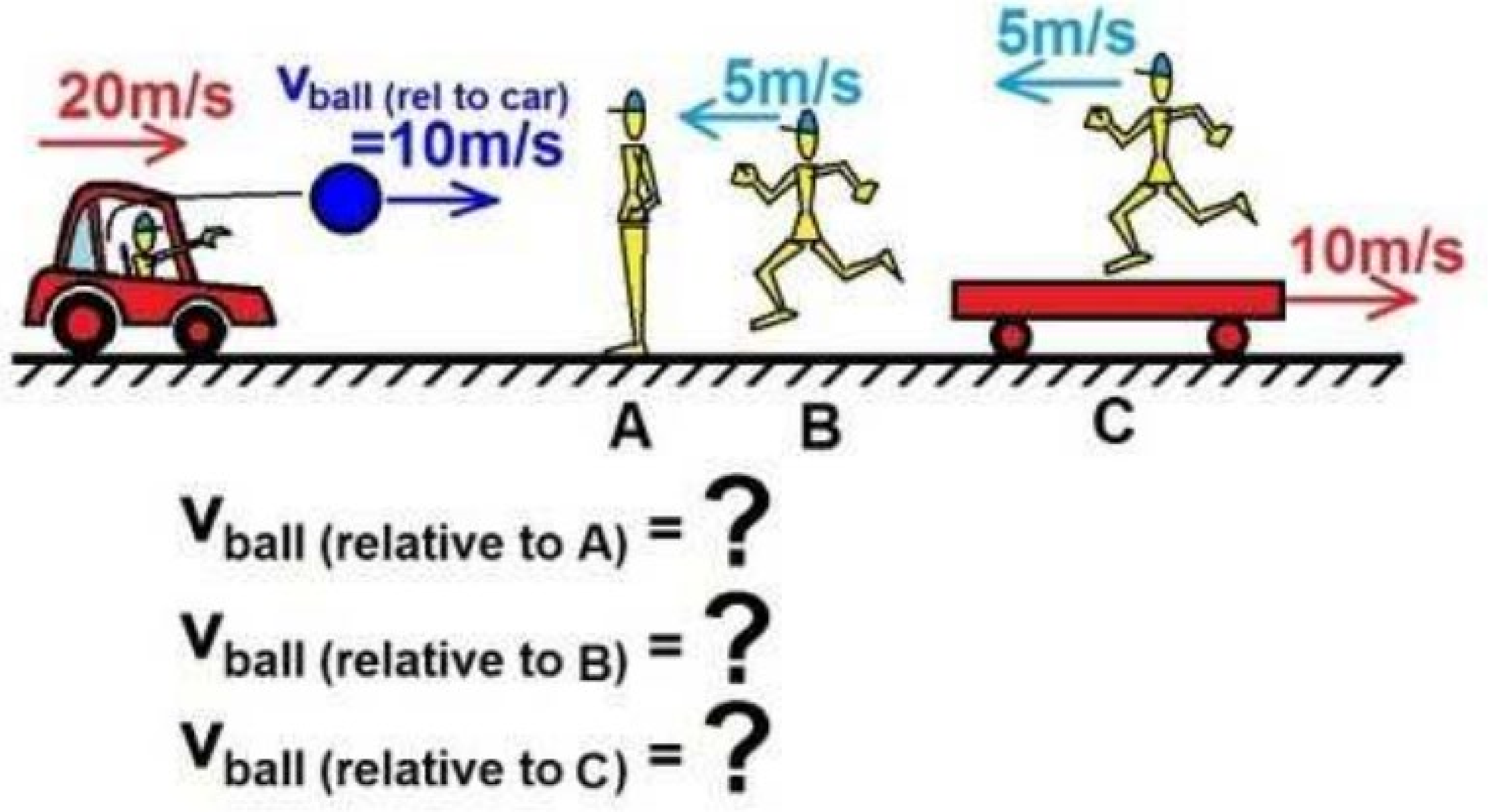
$$\vec{r}_{PA} = \vec{r}_{PB} + \vec{r}_{BA}.$$

$$\vec{v}_{PA} = \vec{v}_{PB} + \vec{v}_{BA}.$$

$$\vec{a}_{PA} = \vec{a}_{PB}.$$



相對運動 (Relative Motion)

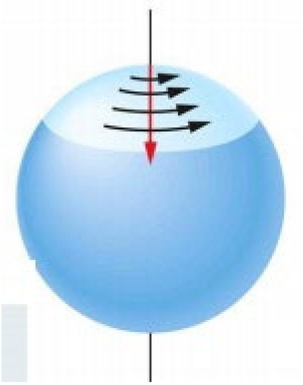


牛頓運動定律 (Newton’s law)

First : 只要對物體作用的合力(淨力)為零, 物體會維持原來的運動狀態繼續運動

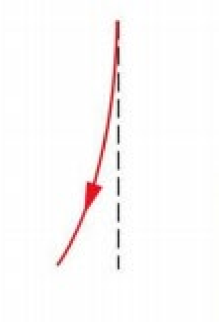
科氏力 :

從宇宙看 :



慣性係 (合力為零)

從地上看 :



非慣性係 (合力不為零)

但通常會假設地球上是慣性係

牛頓運動定律 (Newton’s law)

Second : $\vec{F}_{\text{net}} = m\vec{a}$

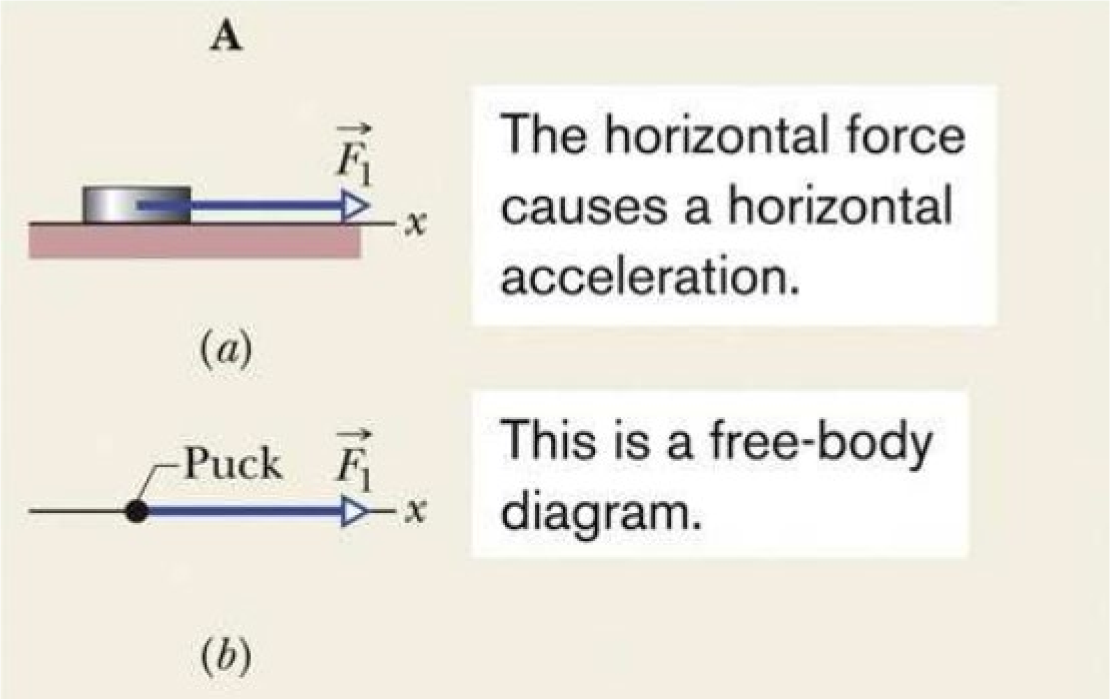
x, y, z 的力互相獨立 : $F_{\text{net},x} = ma_x, \quad F_{\text{net},y} = ma_y, \quad \text{and} \quad F_{\text{net},z} = ma_z.$

力平衡 (Forces in Equilibrium) :

1. 無加速度
2. 合力為零
3. 仍然有受力

FBD(自由體圖)

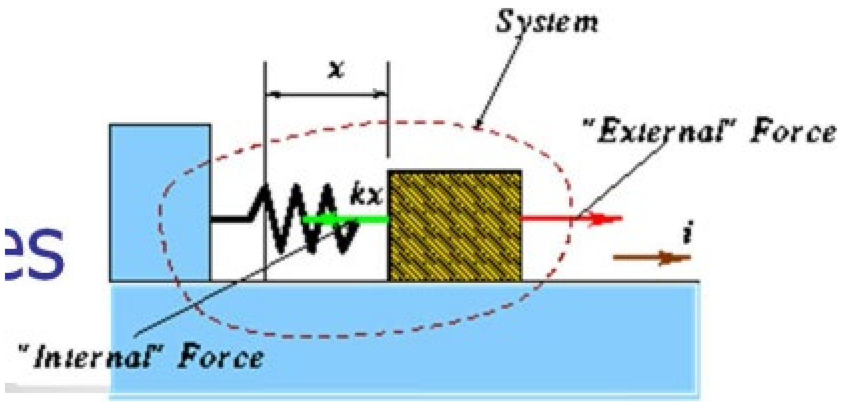
1. 通常用質點來表示物體
2. 用箭頭表示力的向量 (尾端連接物體)
3. 要有座標
4. 加速度不會出現在上面

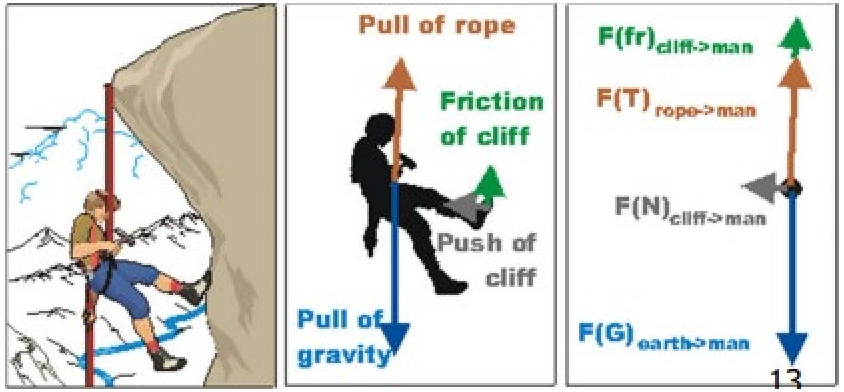


內力和外力

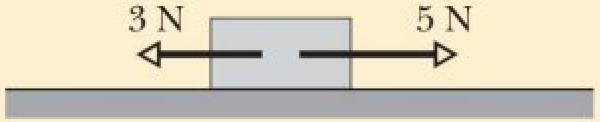
外力 : 系統外施加於系統的力
內力 : 系統內部物體相互施加的力

系統的合力 = 系統的**外力**總和



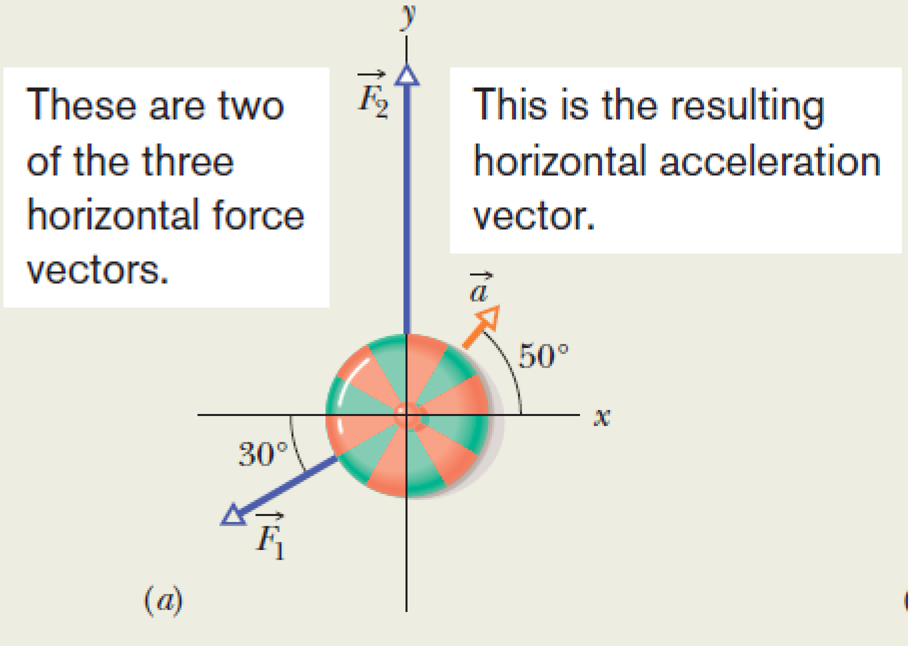


Checkpoint 2



The figure here shows two horizontal forces acting on a block on a frictionless floor. If a third horizontal force $\vec{F}_3$ also acts on the block, what are the magnitude and direction of $\vec{F}_3$ when the block is (a) stationary and (b) moving to the left with a constant speed of 5 m/s?

Here we find a missing force by using the acceleration. In the overhead view of Fig. 5-4a, a 2.0 kg cookie tin is accelerated at 3.0 m/s^2 in the direction shown by $\vec{a}$, over a frictionless horizontal surface. The acceleration is caused by three horizontal forces, only two of which are shown: $\vec{F}_1$ of magnitude 10 N and $\vec{F}_2$ of magnitude 20 N. What is the third force $\vec{F}_3$ in unit-vector notation and in magnitude-angle notation?



重力 (gravitational force)

$F_g = mg.$ 也會作用於靜止的物體

重量 (weight) = $F_g = mg.$

重量 (weight) 只能在無加速度的地方量測

質量 (mass) 不等於 重量 (weight)

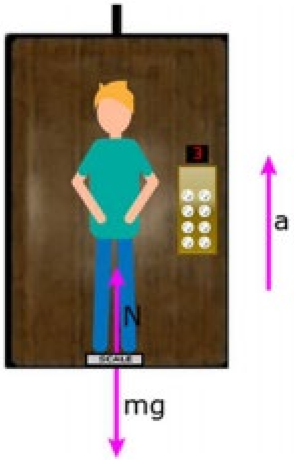
自由落體時的重力是零

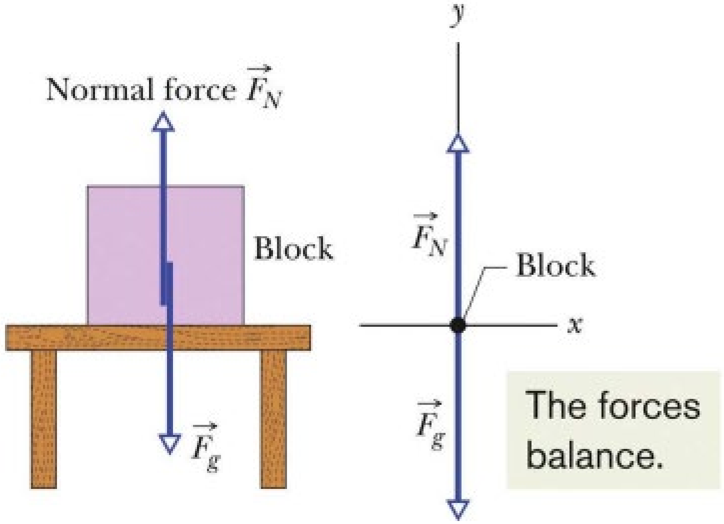
正向力 (Normal Force)

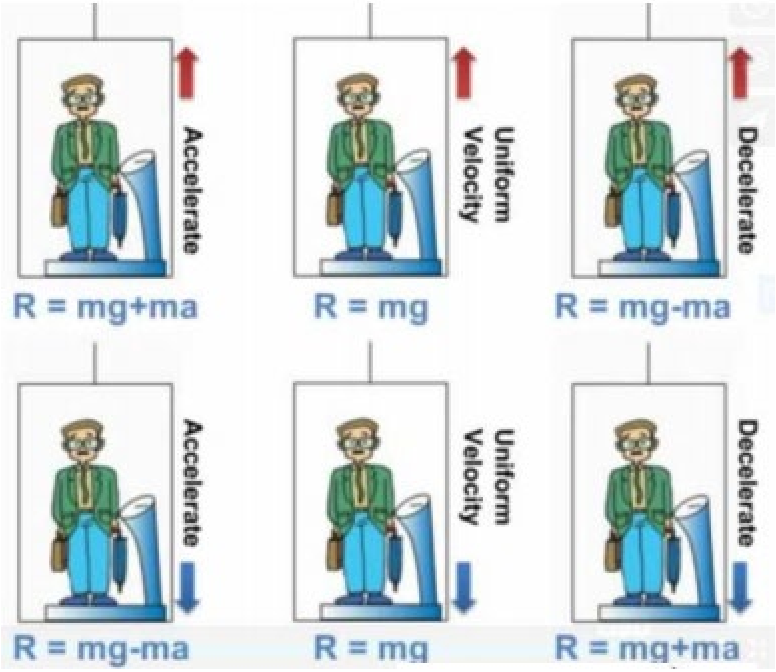
平面對物體施加的力=正向力

假設加速度a向上為正, 則:

$$F_N = mg + ma_y = m(g + a_y)$$





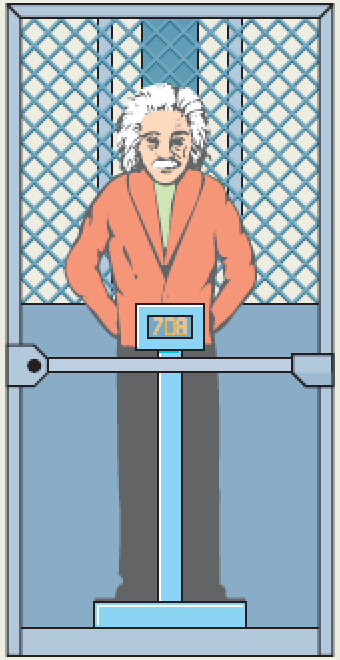


In Fig. 5-17*a*, a passenger of mass $m = 72.2$ kg stands on a platform scale in an elevator cab. We are concerned with the scale readings when the cab is stationary and when it is moving up or down.

(a) Find a general solution for the scale reading, whatever the vertical motion of the cab.

(b) What does the scale read if the cab is stationary or moving upward at a constant 0.50 m/s?

(c) What does the scale read if the cab accelerates upward at 3.20 m/s^2 and downward at 3.20 m/s^2?



(*a*)

(a)

$$F_N = m(g + a) \quad \text{(Answer)}$$

(b)

$$F_N = (72.2 \text{ kg})(9.8 \text{ m/s}^2 + 0) = 708 \text{ N.} \quad \text{(Answer)}$$

(c)

$$F_N = (72.2 \text{ kg})(9.8 \text{ m/s}^2 + 3.20 \text{ m/s}^2) = 939 \text{ N,} \quad \text{(Answer)}$$

$$F_N = (72.2 \text{ kg})(9.8 \text{ m/s}^2 - 3.20 \text{ m/s}^2) = 477 \text{ N.} \quad \text{(Answer)}$$

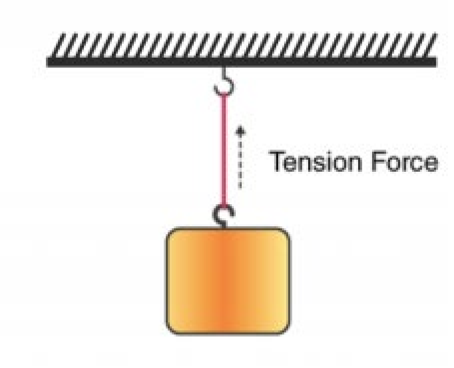
摩擦力 (Frictional Force)

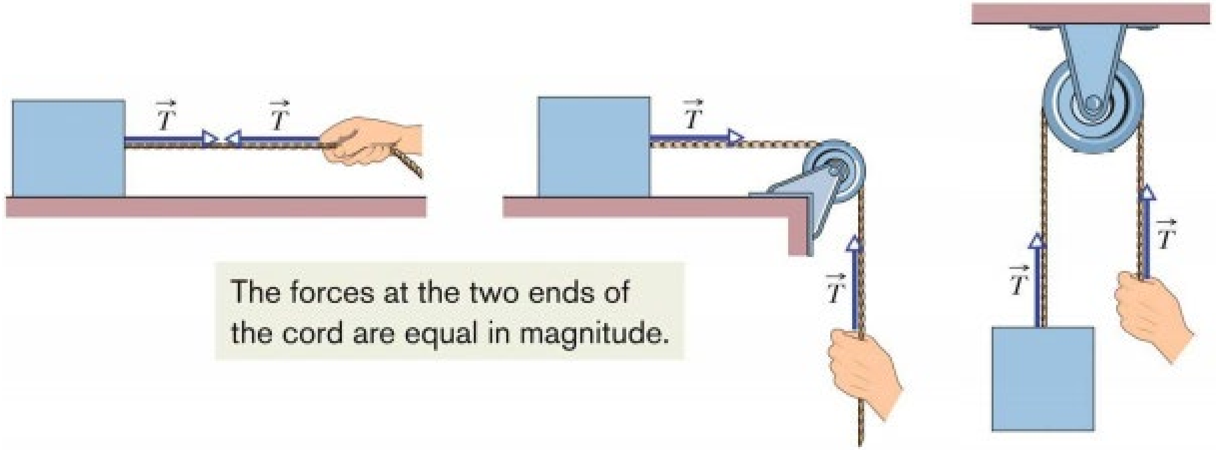
當物體**滑過或試圖滑過**另一個物體時會產生摩擦力

摩擦力方向與滑動或試圖滑動的方向相反

張力 (Tension Force)

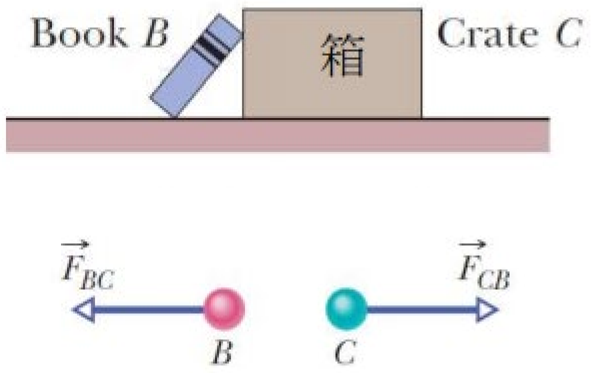
兩物體之間由繃緊的繩子相連
繩子拉兩物體的力都會是T (張力)
無論物體和繩子有沒有加速度或是否有滑輪都成立



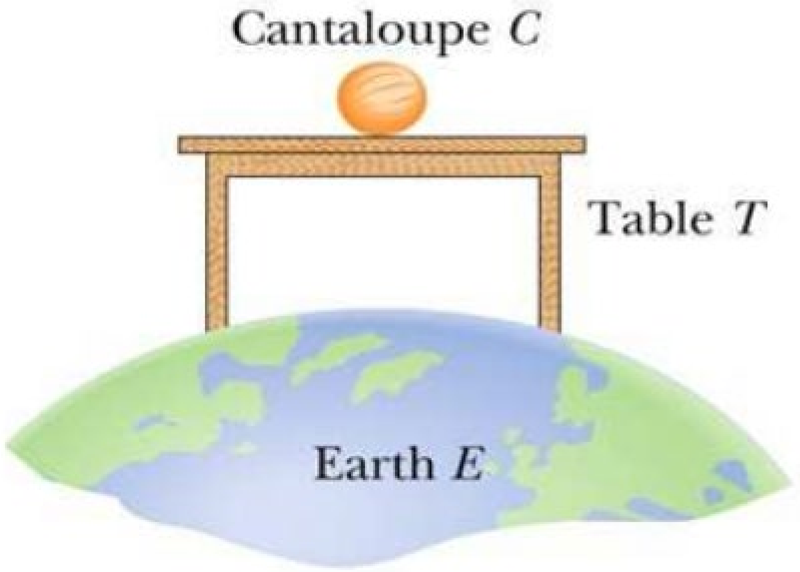


牛頓運動定律 (Newton’s law)

Third : 當兩物體互相影響時, 施加在對方的力和對方對自己施加的力 必定大小相同方向相反



$$\vec{F}_{BC} = -\vec{F}_{CB}$$



$$\vec{F}_{CT} = -\vec{F}_{TC}$$

$$\vec{F}_{CE} = -\vec{F}_{EC}$$

Suppose that the cantaloupe and table of Fig. 5-11 are in an elevator cab that begins to accelerate upward. (a) Do the magnitudes of $\vec{F}_{TC}$ and $\vec{F}_{CT}$ increase, decrease, or stay the same? (b) Are those two forces still equal in magnitude and opposite in direction? (c) Do the magnitudes of $\vec{F}_{CE}$ and $\vec{F}_{EC}$ increase, decrease, or stay the same? (d) Are those two forces still equal in magnitude and opposite in direction?

(a) they increase

(b) yes

(c) they begin to decrease slowly (the gravitational force of Earth decreases with height—negligible in an actual elevator)

(d) yes

Figure 5-12 shows a block S (the *sliding block*) with mass $M = 3.3$ kg. The block is free to move along a horizontal frictionless surface and connected, by a cord that wraps over a frictionless pulley, to a second block H (the *hanging block*), with mass $m = 2.1$ kg. The cord and pulley have negligible masses compared to the blocks (they are "massless"). The hanging block H falls as the sliding block S accelerates to the right. Find (a) the acceleration of block S, (b) the acceleration of block H, and (c) the tension in the cord.

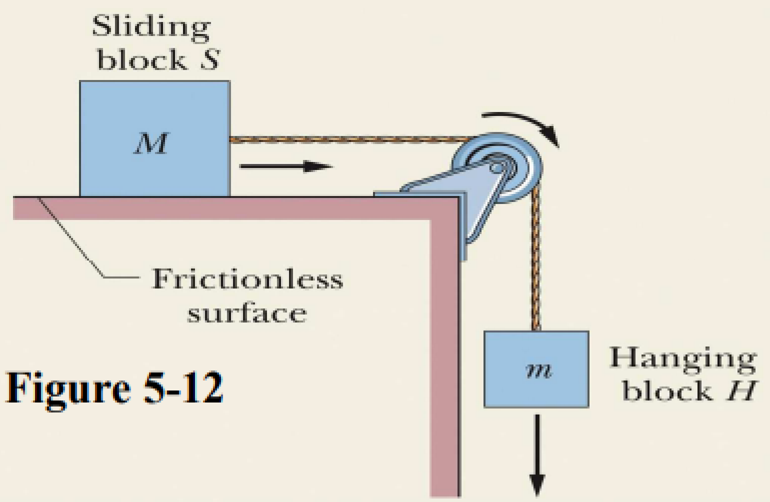
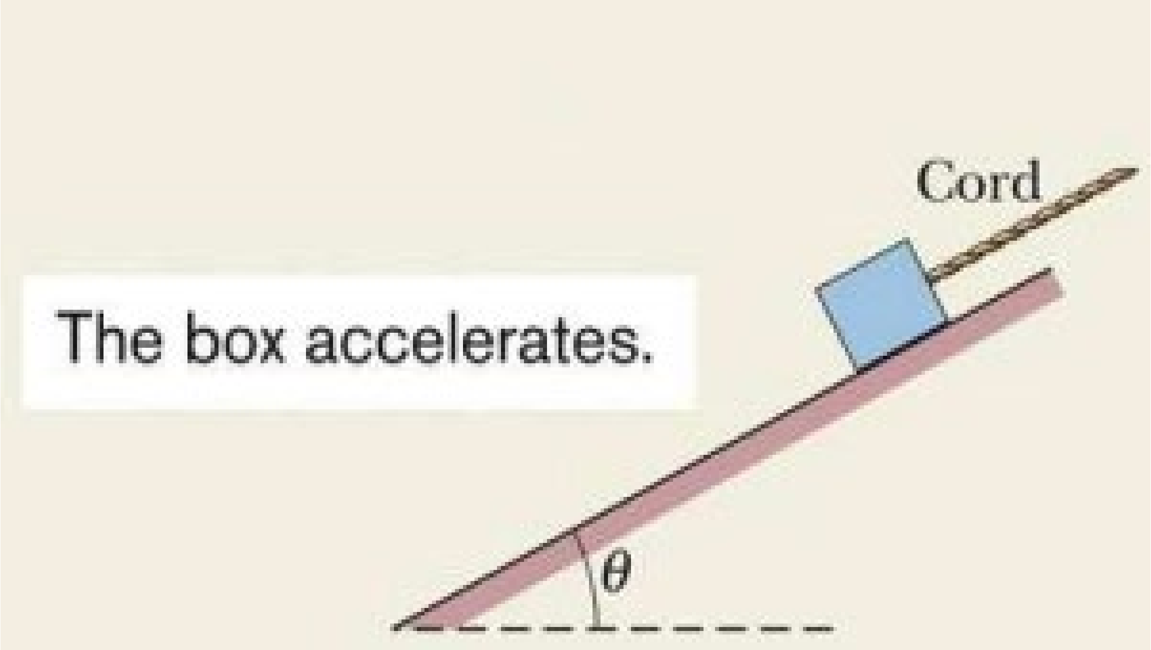
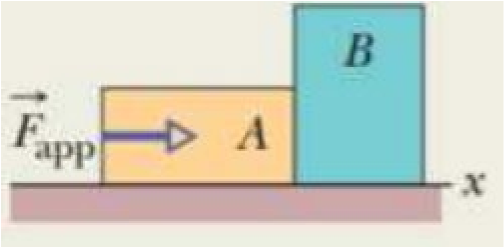
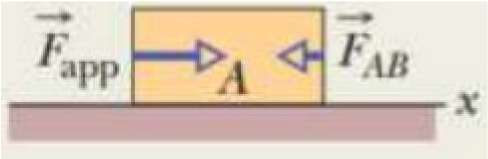
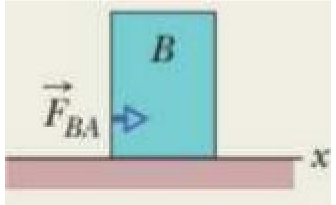


Figure 5-12


The box accelerates.
Cord
θ


$\vec{F}_{app}$
A
B
x


$\vec{F}_{app}$
A
$\vec{F}_{AB}$
x


B
$\vec{F}_{BA}$
x

靜(static)和 動(kinetic)摩擦力

靜摩擦力 :

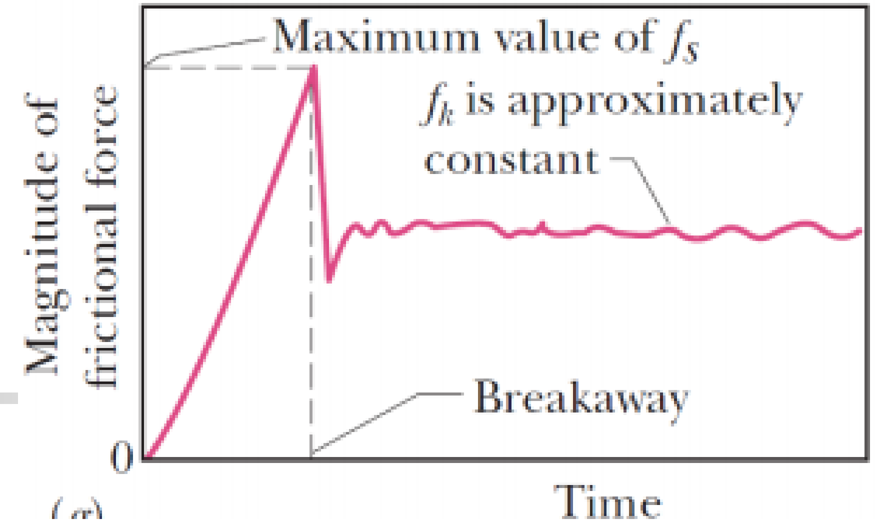
1. 到最大值以前都等於合力F

2. 到最大值為止物體都不會動

動摩擦力 :

1. 有固定值

2. 物體開始動之後才有



靜(static)和 動(kinetic)摩擦力

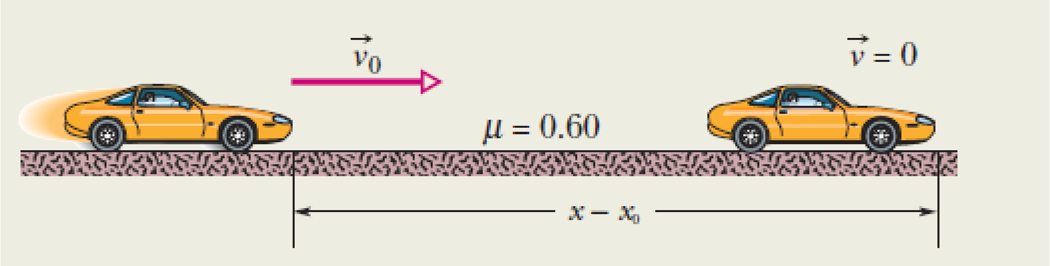
最大靜摩擦力 $f_{s,\max} = \mu_s F_N$

動摩擦力 $f_k = \mu_k F_N$

μ_s μ_k 分別為靜摩擦係數和動摩擦係數
(無單位)

F_N 平面之間的作用力(垂直於平面的正向力)

Set the mass of car is 10kg, $v0$ =10m/s



求煞車距離

阻力 (Drag Force)

物體在流體內運動時受到的力 (摩擦力)

物體落下時的空氣阻力 : $D = \frac{1}{2}C\rho A v^2$

ρ : 空氣密度
C : 阻力係數 (現實中不會是常數)
A : 有效截面積
V : 落下速率

終端速率 : $v_t = \sqrt{\frac{2F_g}{C\rho A}}$

A raindrop with radius $R = 1.5$ mm falls from a cloud that is at height $h = 1200$ m above the ground. The drag coefficient C for the drop is 0.60. Assume that the drop is spherical throughout its fall. The density of water ρ_w is 1000 kg/m^3, and the density of air ρ_a is 1.2 kg/m^3.

(a) As Table 6-1 indicates, the raindrop reaches terminal speed after falling just a few meters. What is the terminal speed?

$$v_t = \sqrt{\frac{2F_g}{C\rho_a A}} = \sqrt{\frac{8\pi R^3 \rho_w g}{3C\rho_a \pi R^2}} = \sqrt{\frac{8R\rho_w g}{3C\rho_a}}$$

$$= \sqrt{\frac{(8)(1.5 \times 10^{-3}\text{ m})(1000\text{ kg/m}^3)(9.8\text{ m/s}^2)}{(3)(0.60)(1.2\text{ kg/m}^3)}}$$

$$= 7.4\text{ m/s} \approx 27\text{ km/h}. \qquad \text{(Answer)}$$

勻速圓周運動 (Uniform Circular Motion)

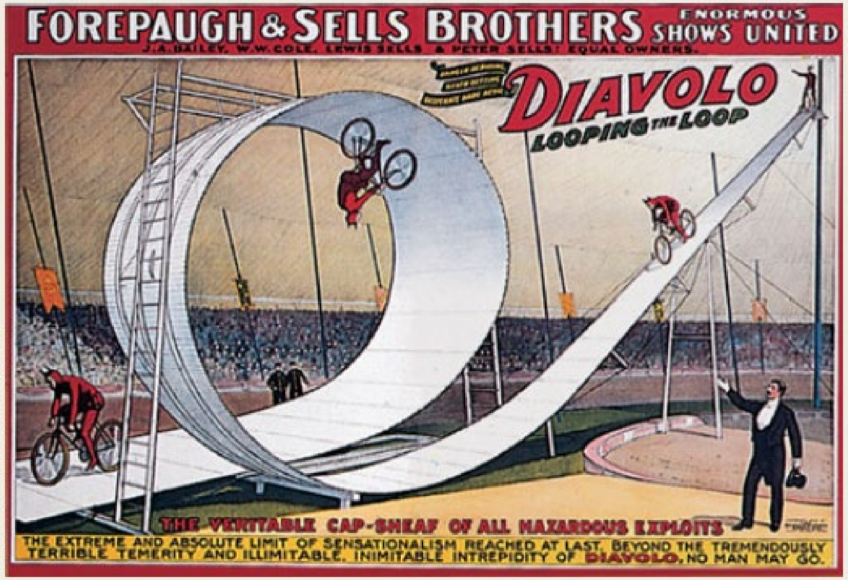
向心力公式：

$$a_c = \frac{v^2}{R} = \omega^2 R$$

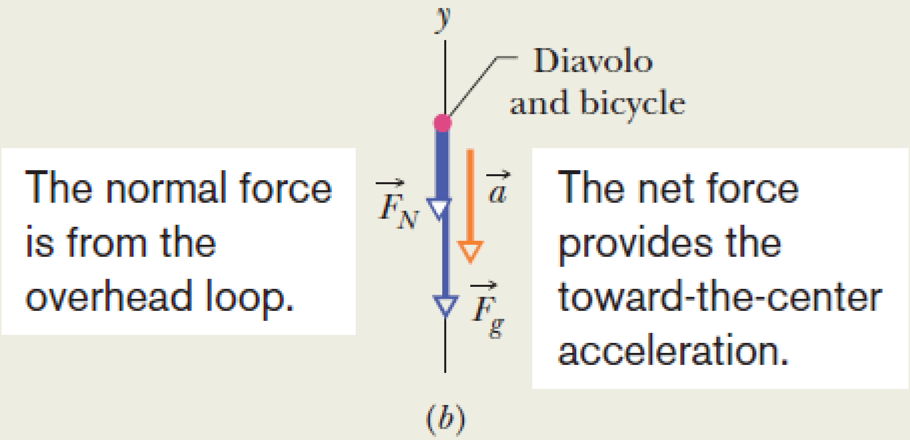
$$T = \frac{2\pi r}{v}$$

In a 1901 circus performance, Allo "Dare Devil" Diavolo introduced the stunt of riding a bicycle in a loop-the-loop (Fig. 6-9*a*). Assuming that the loop is a circle with radius $R = 2.7$ m, what is the least speed v that Diavolo and his bicycle could have at the top of the loop to remain in contact with it there?

Photograph reproduced with permission of Circus World Museum



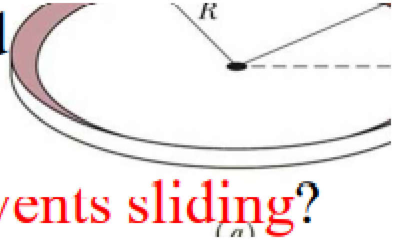
(*a*)



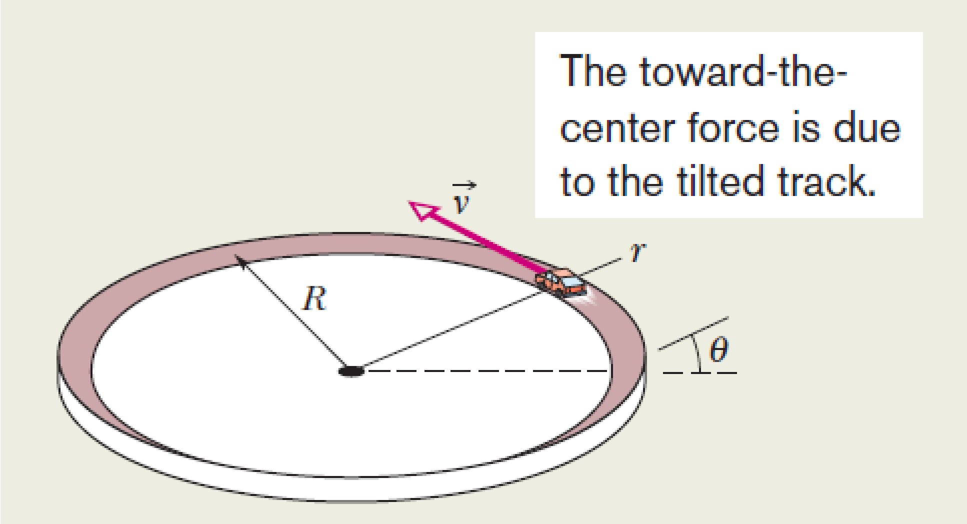
$$-F_N - mg = m\left(-\frac{v^2}{R}\right).$$

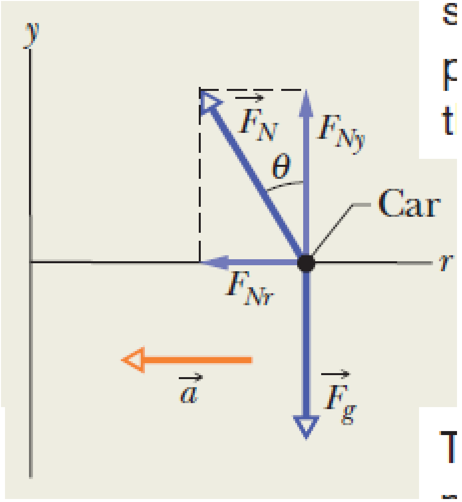
$$v = \sqrt{gR} = \sqrt{(9.8\ \text{m/s}^2)(2.7\ \text{m})}$$
$$= 5.1\ \text{m/s}.$$

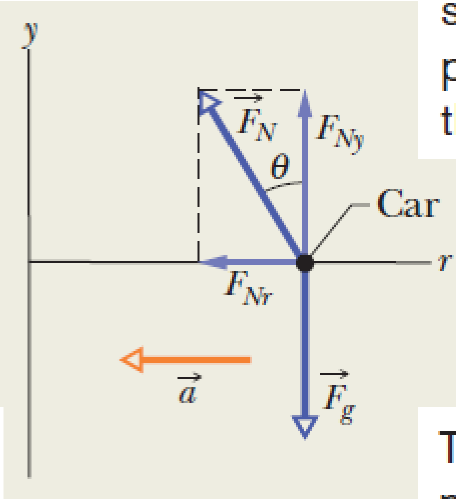
Given: At a constant speed v of 20 m/s, R = 190 m.



Q: What bank angle θ prevents sliding?







$$-F_N \sin \theta = m\left(-\frac{v^2}{R}\right)$$

$$F_N \cos \theta = mg$$

$$\theta = \tan^{-1}\frac{v^2}{gR}$$