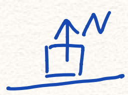
I. Force.

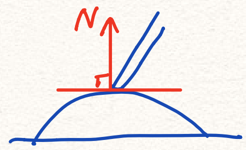
- Force represents **interaction** between two objects or an object and its environment. Interactions (and hence forces) are of material origin.

{ contact force.
{ field force ($-q$ ⊖ $+q$ ⊕).

△ Free-body diagram.

① Normal force





② Frictional force

{ cause : normal force
{ direction : in the opposite direction of $\vec{v}$

③ Tension force

④ Weight

Typical Force Magnitudes

Sun's gravitational force on the earth	3.5×10^{22} N
Thrust of a space shuttle during launch	3.1×10^{7} N
Weight of a large blue whale	1.9×10^{6} N
Maximum pulling force of a locomotive	8.9×10^{5} N
Weight of a 250-lb linebacker	1.1×10^{3} N
Weight of a medium apple	1 N
Weight of smallest insect eggs	2×10^{-6} N
Electric attraction between the proton and the electron in a hydrogen atom	8.2×10^{-8} N
Weight of a very small bacterium	1×10^{-18} N
Weight of a hydrogen atom	1.6×10^{-26} N
Weight of an electron	8.9×10^{-30} N
Gravitational attraction between the proton and the electron in a hydrogen atom	3.6×10^{-47} N

△ Newton's law of Motion

① Newton's First Law

A particle acted upon by zero net force moves with constant velocity.

② Newton's Second Law

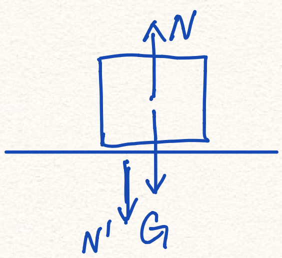
$$\vec{a} = \frac{\vec{F}}{m}$$

Force ↔ motion

③ Newton's third Law

The mutual forces of action and reaction between two bodies are equal in magnitude and opposite in direction.

e.g.



$\vec{N}$ and $\vec{N'}$

not ($\vec{N}$ and $\vec{G}$)

△ Comments

① Must in Inertial FoRs

(And all inertial FoRs are equivalent.)

② $\vec{F} = m\vec{a}$

$\hookrightarrow$ $$\frac{d^2r}{dt^2} = \frac{F(\dot{r}, r, t)}{m} \quad \text{with} \quad v(t_0) = v_0, \quad r(t_0) = r_0$$

An initial Value Problem.

③ Free-Body Diagrams

Be careful about the amplitude and directions

Mind the geometrical relationship.

II. Newton's law's Applications.

A. Particles in equilibrium

$$\sum F = 0 \Rightarrow \begin{cases} \sum F_x = 0 \\ \sum F_y = 0 \\ \sum F_z = 0 \end{cases}$$

① Draw free-body diagram

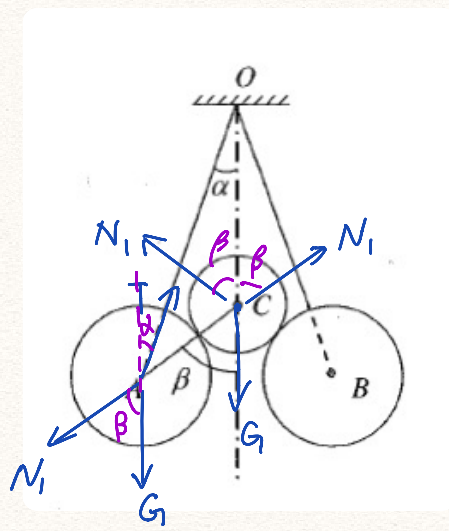
② Start from known force and the "cause" force.

③ Write equations by using geometrical relationship.

7-3　相同的两个匀质光滑球 A 和 B 由两根相同长度的绳悬于固定点 O。两球同时又支持一个等重的匀质光滑球 C，且两根绳不与 C 接触，如图 7-习 3 所示。试求平衡时，绳与竖直线间的夹角 α 和球 A 与球 C 球心连线与竖直线夹角 β 之间应满足的关系。

$$2N_1 \cos\beta = G \quad ①$$

$$\begin{cases} T\sin\alpha = N_1 \sin\beta & ② \\ T\cos\alpha = N_1 \cos\beta + G & ③ \end{cases}$$



①: $N_1 = \dfrac{G}{2\cos\beta}$

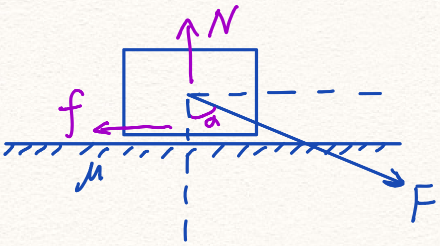
②: $T\sin\alpha = N_1 \cdot \sin\beta = \dfrac{\tan\beta}{2} G$

$T = \dfrac{\tan\beta}{2\sin\alpha} G$

③: $\dfrac{\tan\beta}{2\tan\alpha} G = \dfrac{G}{2} + G = \dfrac{3}{2} G$

$\tan\beta / \tan\alpha = 3$

△ Friction Angle and Self-locking



$$\begin{cases} F\cos\alpha = N & ① \\ f = F\sin\alpha & ② \end{cases}$$

$$F = \frac{N}{\cos\alpha}, \quad f = N\tan\alpha \qquad ④$$

$$f \le \mu N \qquad ③$$

④ → ③ $\quad N\tan\alpha \le \mu N$

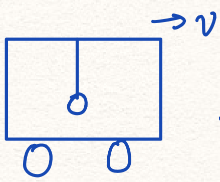
$$\tan\alpha \le \mu.$$

If $\tan\alpha \le \mu$, i.e. $\alpha \le \arctan\mu$, no matter how large F is, the object will not move.

B. Particles in Motion

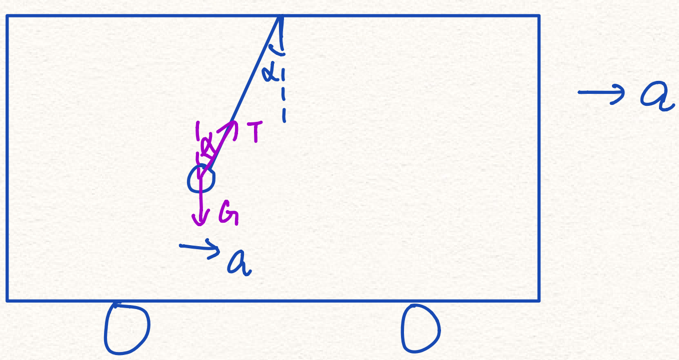
1. Mass m hangs on a massless rope in a car moving with (a) constant velocity $\mathbf{v}$, (b) constant acceleration $\mathbf{a}$ on a horizontal surface. What is the angle the rope forms with the vertical direction

(a)



inertial FoR.

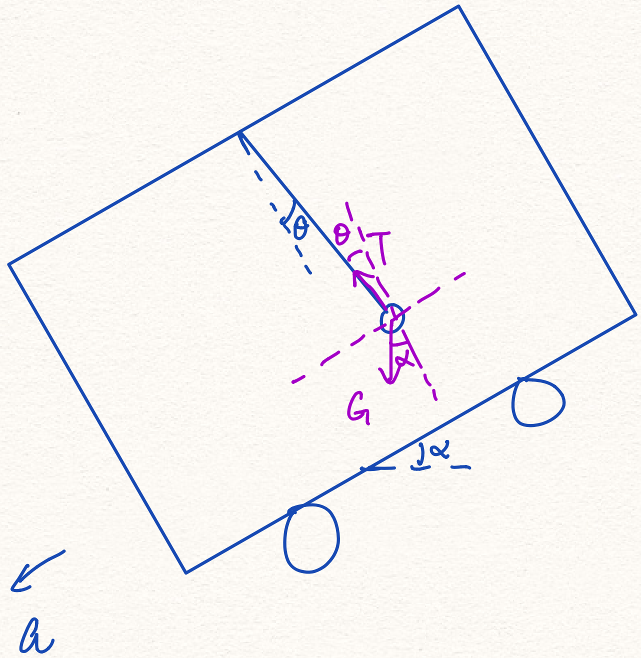
(b).



$$\left.\begin{cases} T\sin\alpha = ma \\ T\cos\alpha = mg \end{cases}\right\} \to \tan\alpha = \frac{a}{g}$$

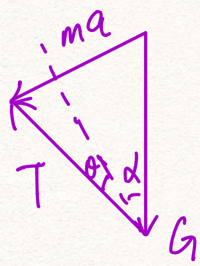
$$\to \alpha = \arctan\left(\frac{a}{g}\right).$$

2. Discuss the previous problem if the car slides (without friction) down a plane inclined at an angle α.



$a = g\sin\alpha$

$$\begin{cases} mg\cos\alpha = T\cos\theta \\ mg\sin\alpha + T\sin\theta = mg\sin\alpha \end{cases}$$



$\vec{G} + \vec{T} = m\vec{a}$

$\Rightarrow \theta = 0$

△ whole method (整体法)

If two objects are in direct contact (or combined together), we use whole method.

Comment : Be careful about critical time point (for sliding).

3-4 两个质量分别为 m_1 和 $m_2(m_2>m_1)$的物体叠放在水平桌面上，另一质量为 m 的物体通过不可伸长细绳及滑轮系统与 m_1 和 m_2 相连，如图 3-习 4 所示。忽略绳与滑轮的质量以及轴承处的摩擦。

1）若 m_1 和 m_2 之间的摩擦系数为 μ，桌面光滑，求 m_1 与 m_2 之间无相对滑动的条件；

① $mg = (m+m_1+m_2)a$

$a = \dfrac{mg}{m+m_1+m_2}$

For m: $mg - 2T = ma \rightarrow T = \dfrac{m_1+m_2}{2}\cdot a$

$= \dfrac{m(m_1+m_2)}{2(m_1+m_2+m)}g > m_1 a$

$f = T - m_1 a = \dfrac{m_2-m_1}{2}a = \dfrac{m(m_2-m_1)g}{2(m_1+m_2+m)}$.

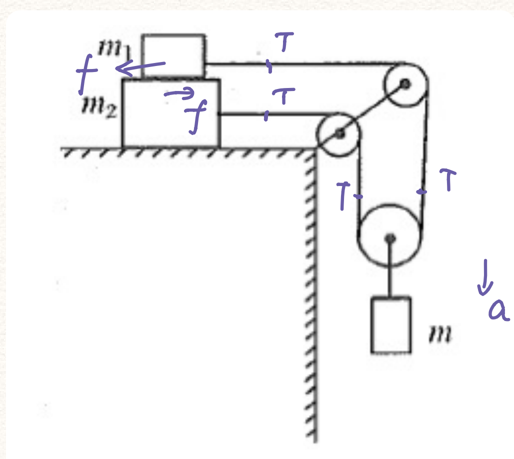


图 3-习 4

$f \le \mu N = \mu m_1 g$

$$\Rightarrow \frac{m(m_2-m_1)}{2(m_1+m_2+m)} \le \mu m_1 \quad , \quad \mu \ge \frac{m(m_2-m_1)}{2m_1(m_1+m_2+m)}$$

△ A Modal : Relative acceleration + Newton's Law.

① List out the acceleration

using relative acceleration (constraint)

② Use free-body diagram to analyze the force

【例题 3-1】 如图 3-例 1(a)所示，ABC 劈质量为 M，高为 h，斜面 AC 倾角为 θ。顶端 A 放一质量为 m 的小物体，自静止下滑，略去各接触面间的摩擦。试求：

1）~~m 从顶端滑到底时，M 的位移~~；

2）m 下滑时，M 对地面的加速度 a_1；

3）m 对 M 的加速度 a_2'；

4）m 对地面的加速度 a_2；

5）m 与 M 间的作用力 N；

6）M 与桌面间的正压力 R。

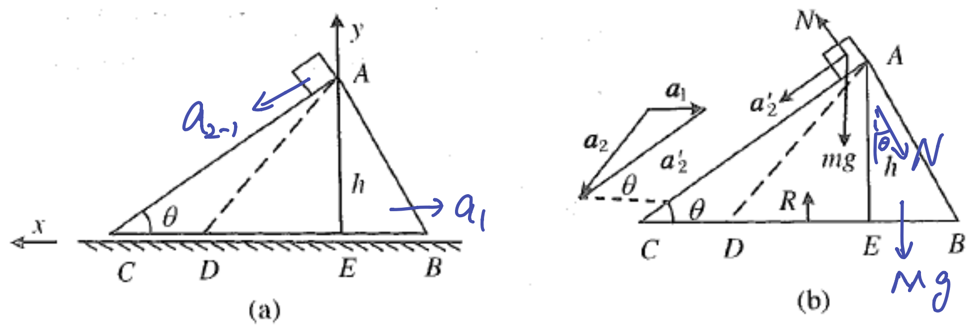
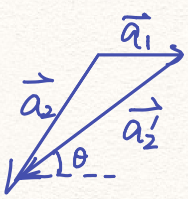


图 3-例 1

① $\vec{a}_{2-1} = \vec{a_2'}$ is parallel to the incline.

$\vec{a_2} = \vec{a_1} + \vec{a_2'}$



$$\begin{cases} a_{2x} = a_2' \cos\theta - a_1 \\ a_{2y} = a_2' \sin\theta \end{cases}$$

$$\begin{cases} N\sin\theta = M a_1 & (1) \\ N\sin\theta = m(a_2'\cos\theta - a_1) & (2) \\ mg - N\cos\theta = m a_2'\sin\theta & (3) \end{cases}$$

$$\Rightarrow \begin{cases} a_1 = \dfrac{mg\sin\theta\cos\theta}{m\sin^2\theta + M} \\ a_2' = \dfrac{(M+m)\sin\theta}{M+m\sin^2\theta}\, g \end{cases}$$

$$N = \frac{mM\cos\theta}{M+m\sin^2\theta}\, g$$

$$\vec{a}_2 = (a_2'\cos\theta - a_1)\hat{i} - a_2'\sin\theta\,\hat{j}$$

$$= \frac{M\sin\theta\cos\theta}{M+m\sin^2\theta}\, g\cdot\hat{i} - \frac{(M+m)\sin^2\theta}{M+m\sin^2\theta}\, g\cdot\hat{j}$$

$$R = Mg + N\cos\theta$$

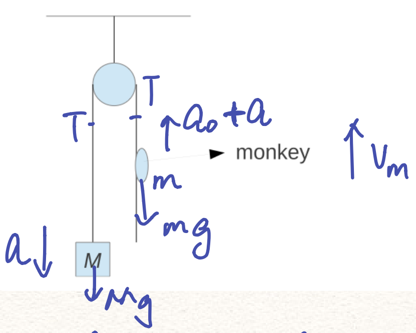
$$= \frac{M(m+M)}{M+m\sin^2\theta}\, g$$

3. A monkey with mass m holds a rope hanging over a frictionless pulley attached to mass M (see figure). Discuss motion of the system if the monkey

(a) does not move with respect to the rope,

(b) climbs up the rope with constant velocity $\mathbf{v}_0$ with respect to the rope,

(c) climbs up the rope with constant acceleration $\mathbf{a}_0$ with respect to the rope.



(a) $$Mg - mg = (M+m)a_0 \rightarrow a = \frac{(M-m)g}{M+m}$$

(b) $$\begin{cases} a_1 = a_0 \\ v_m = a_0 t + v_0 \end{cases}$$

(c) $\begin{cases} Mg - T = Ma & ① \\ T - mg = m(a_0 + a) & ② \end{cases}$

$$① + ② \quad Mg - Ma - mg = m(a_0 + a)$$

$$(M - m)g - ma_0 = (m + M)a$$

$$a = \frac{(M-m)g - ma_0}{m + M}$$

$$v_m = (a + a_0)t$$

△ Initial - Value Problem.

$v(0) = 0 \quad x(0) = 0$

7. Consider fall of an object (mass m) without initial speed. Assuming quadratic air drag find the time dependence of object's velocity and position. Find the terminal speed.

$f = -kv^2$

$$m\frac{dv}{dt} = mg - kv^2 \rightarrow \frac{dv}{dt} = g - \frac{k}{m}v^2$$

Inhomogeneous ODE.

Solutions to Inhomogeneous, Linear Systems Slide 244

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Inhomogeneous Linear Systems

1.10.10. Theorem. The solution of the initial value problem

$$\frac{dx}{dt} = A(t)x + b(t), \qquad x(t_0) = x_0, \qquad (1.10.7)$$

is given by

$$x_{\text{inhom}}(t) = x_{\text{hom}}(t) + x_{\text{part}}(t)$$

where $x_{\text{hom}}(t)$ is the solution of the associated homogeneous initial value problem

$$\frac{dx_{\text{hom}}}{dt} = A(t)x_{\text{hom}}, \qquad x_{\text{hom}}(t_0) = x_0,$$

and

$$x_{\text{part}}(t) = \sum_{k=1}^{n} x^{(k)}(t) \int_{t_0}^{t} \frac{W^{(k)}(s)}{W(s)}\, ds, \qquad (1.10.8)$$

for some fundamental system $(x^{(1)}, \dots, x^{(n)})$.

(Not required)

Question 1. The current definition of the standard meter of length is based on

(1) the distance between the earth's equator and north pole.

(2) the distance between the earth and the sun.

(3) the distance traveled by light in a vacuum.

(4) the length of a particular object kept in France.

(5) the distance traveled by electrons in a copper wire.

Question 2. The value of the dot product of two vectors depends on the particular coordinate system being used.

(1) True

(2) False

Question 3. If $\overline{a}$ and $\overline{b}$ are nonzero vectors for which $\overline{a} \circ \overline{b} = 0$, then it must follow that

(1) $\overline{a} \times \overline{b} = \overline{0}$.

(2) $\overline{a}$ is parallel to $\overline{b}$.

(3) $|\overline{a} \times \overline{b}| = ab$.

(4) $|\overline{a} \times \overline{b}| = 1$.

(5) None of the above.

Question 4. Suppose that two vector quantities $\overline{u}$ and $\overline{v}$ are related as $\overline{u} = T\overline{v}$, where T is a tensor quantity. The vectors $\overline{u}$ and $\overline{v}$ are never parallel.

(1) True

(2) False

Honors Physics -- Online Quiz 2

⚠ 这是一个测验发布版本的预览

已开始: 6月 1 17:46

测验说明

Please answer the following questions.

问题 1

1 分

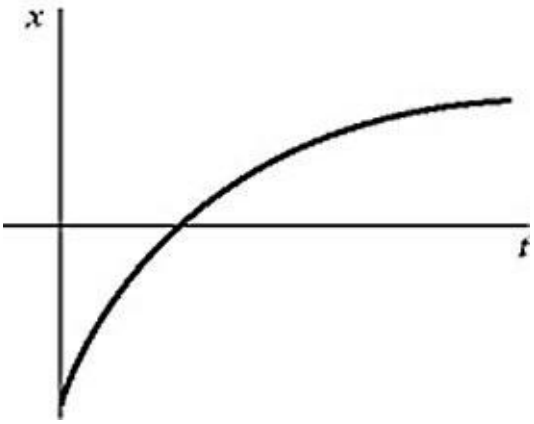
If the acceleration of an object, moving along a straight line, is negative, the object must be slowing down.

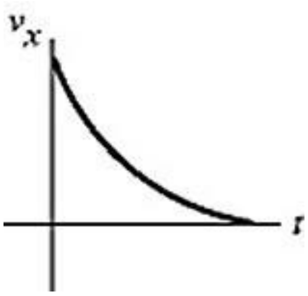
- True
- False

问题 2

1 分

The figure shows the graph of the position x as a function of time for an object moving in the straight line (the *x*-axis). Which of the following graphs best describes the velocity along the *x*-axis as a function of time for this object?



- 

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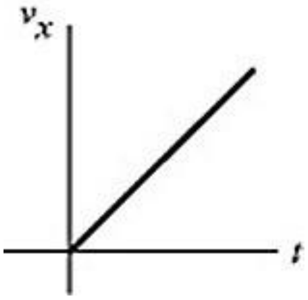
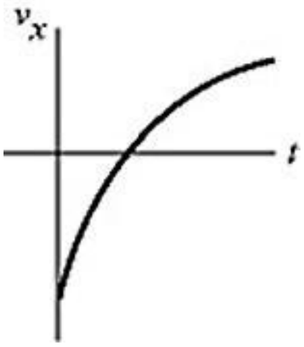
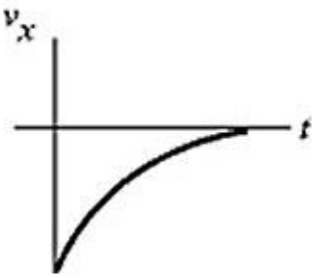
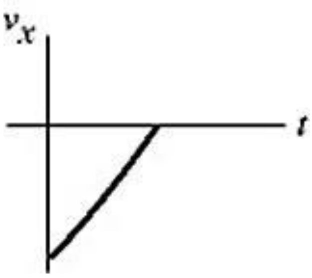


- 

- 

- 

问题 3 **1 分**

Jan and Len throw identical rocks off a tall building at the same time. The ground near the building is flat. Jan throws her rock straight downward. Len throws his rock downward and outward such that the angle between the initial velocity of the rock and the horizon is 30°. Len throws the rock with a speed twice that of Jan's rock. If air resistance is negligible, which rock hits the ground first?

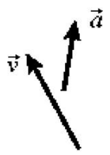
- It is impossible to know from the information given.
- They hit at the same time.

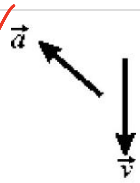
- ◯ Len's rock hits first.
- ◯ Jan's rock hits first.

问题 4

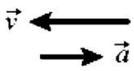
1 分

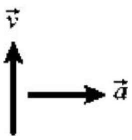
Shown below are the velocity and acceleration vectors for a person in several different types of motion. In which case is the person slowing down and turning to his right?

- ◯ 

- ◯ 

- ◯ 

- ◯ 

- ◯ 

问题 5

1 分

Suppose that a particle moves along a straight line on a plane. The transverse component of the particle's velocity is zero in any polar coordinate system on that plane.

- ◯ True
- ◯ False

在 17:48 保存测验 提交测验