Physics 101

Lecture 6.

Friday, Jan. 16, 2004

Topics: Free-Body Diagram

Friction

Ref: Ch. 5, Ch. 6.

- Newton's 2nd Law of Motion

$\vec{F} = m\vec{a}$. $\vec{F}$ — Net force acting on m.

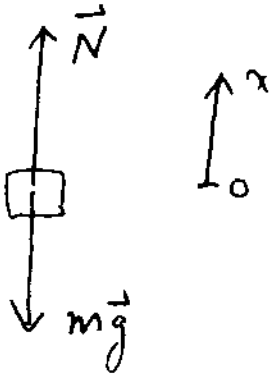
↑ vector sum of all forces.

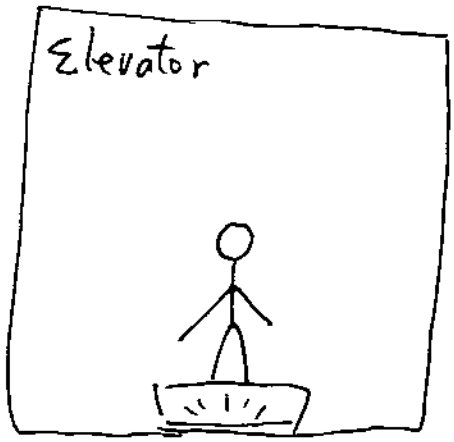
- Free-Body Diagram: 2 for force analysis.

1. Isolate the object
2. Sketch all the forces acting on the object.
3. Set up a coordinate system that is convenient for $\vec{F} = m\vec{a}$.

e.g. How much do you weigh ?

Free-Body Diagram.





What the scale reads is

N = apparent weight.

Newton's Law : $\vec{F} = m\vec{a}$:

$$N - mg = ma \quad .$$

$$N = m(a+g) \quad .$$

when $a = 0$, $N = mg$. (Apparent weight = weight)

when $a > 0$, $N > mg$.

when $a < 0$, $N < mg$.

when $a = -g$, $N = 0$. (Weightless, just like an astronaut in free space.)

$a = -g$ ⇑ Free fall.

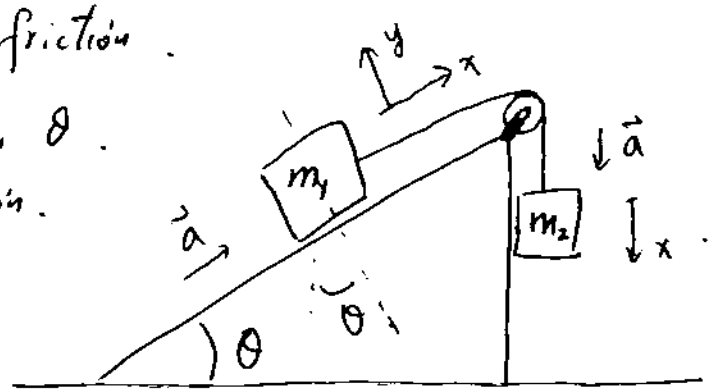
i.e, weightless means $N = 0$.

Not $mg = 0$.

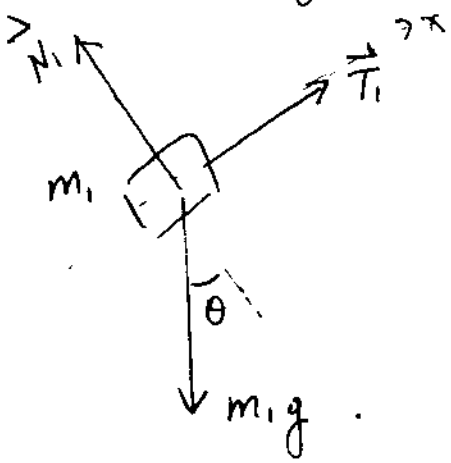
e.g. Assume : No friction.

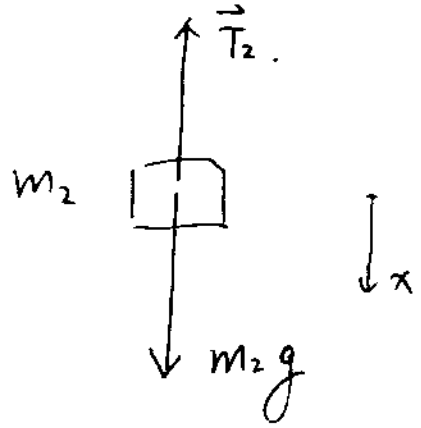
given : m_1, m_2, θ.

want : acceleration.



Free-Body Diagrams.





$$|\vec{T}_1| = |\vec{T}_2| = T. \quad \text{(Since No friction)}.$$

Newton's Law : $\vec{F} = m\vec{a}$.

m_1 : x-component : $T - m_1 g \sin\theta = m_1 a$ ①

y-component : $N_1 - m_1 g \cos\theta = 0$. ②

m_2 : 1-D : $m_2 g - T = m_2 a$ ③.

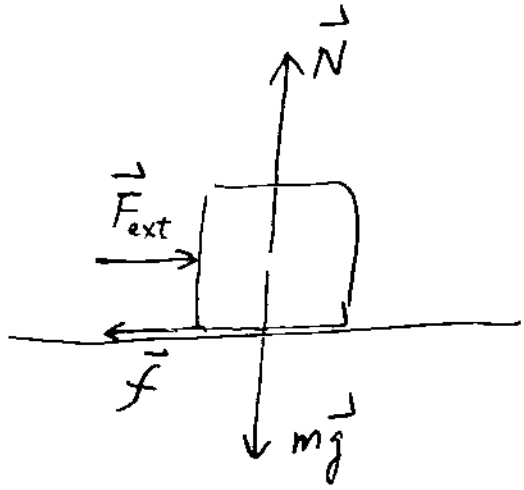
3 equations, 3 unknowns.

We can solve for T, a, and N_1.

① + ③ : $m_2 g - m_1 g \sin\theta = m_1 a + m_2 a$.

$$a = \frac{(m_2 - m_1 \sin\theta) g}{m_1 + m_2}$$

- Frictional force. $\vec{f}$



- Occurs at the surface between two objects.
- Due to molecular interaction between the two objects.
- parallel to the surface.
- Against the relative motion — kinetic friction

  OR. against the tendency of relative motion — static friction.

- Kinetic friction — moving.

$$f = \mu_K \cdot N.$$

μ_K — coefficient of kinetic friction.

- Static friction — NOT Moving.

$$f \leq \mu_s N, \quad f_{max} = \mu_s N.$$

Usually $\mu_s > \mu_K$.