Phys. 101.

Lecture 7.

Friday, Jan. 17, 2003.

Topics Covered: Free-Body Diagram.

Friction.

Ref: ch. 5, ch. 6.

- Free-Body Diagram.

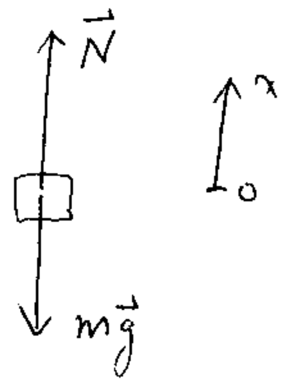
1. Isolate the object.

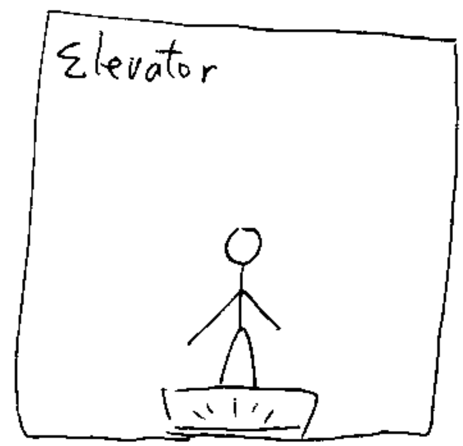
2. Sketch all the forces acting on the object.

3. Set up a coordinate system that's 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: $\vec{F} = m\vec{a}$:

$$N - mg = ma$$

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

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.)

Free fall.

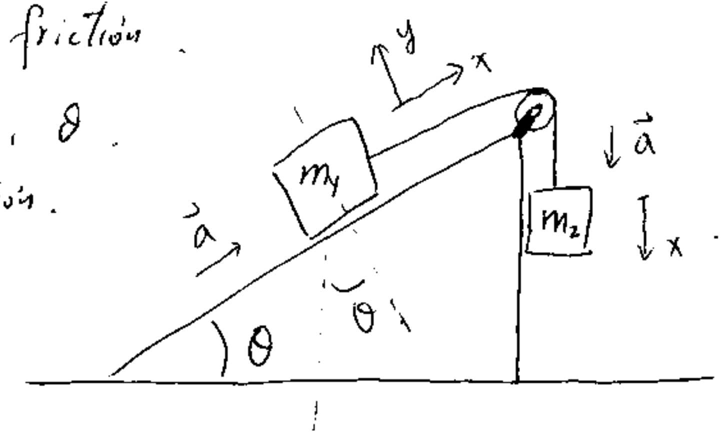
i.e, weightless means $N = 0$.

Not $mg = 0$.

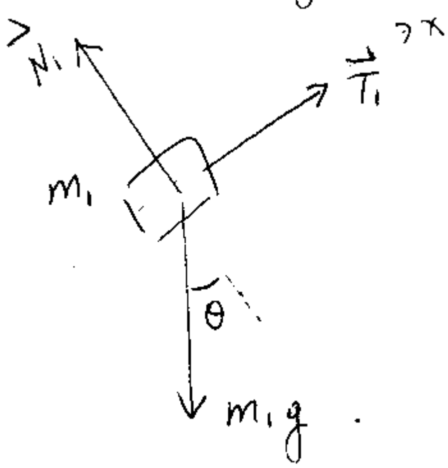
e.g. Assume: No friction.

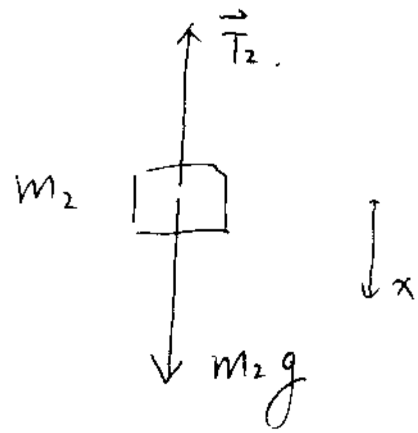
given: m_1, m_2, θ.

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

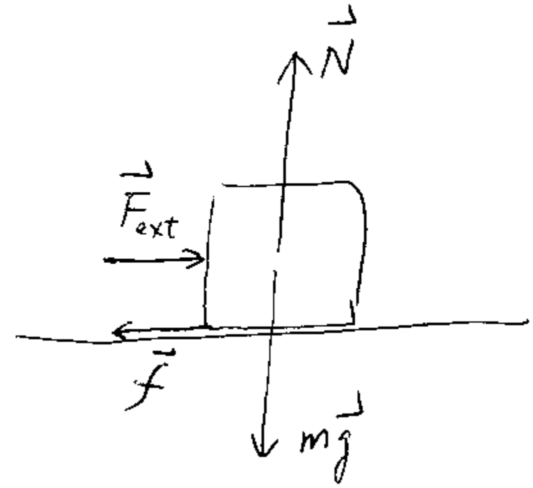
y-component: $N_1 - m_1 g \cos\theta = 0$. ②

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.

- 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 $\mu_s > \mu_K$.

- When F_{ext} is small,

  i.e., $F_{ext} \leq \mu_s N$

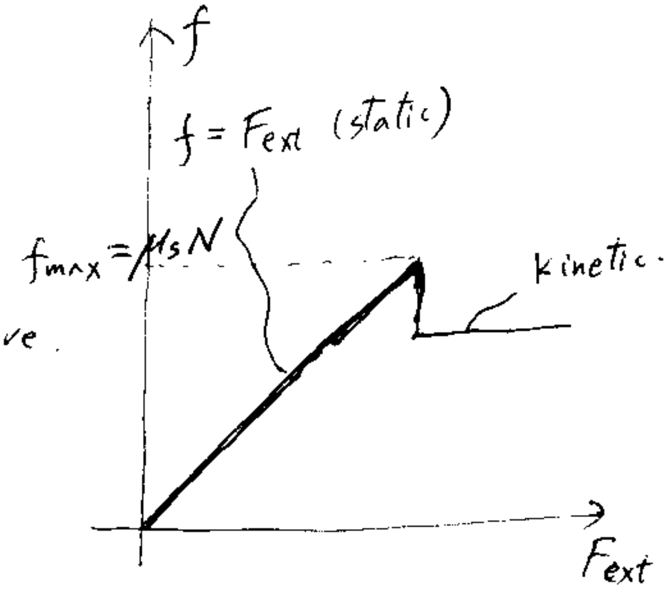
  Then, $f = F_{ext}$.

  $F = ma = 0$, object not move.

- When. $F_{ext} > \mu_s N$

  Object will move.

  $f = \mu_K \cdot N$ (kinetic friction)

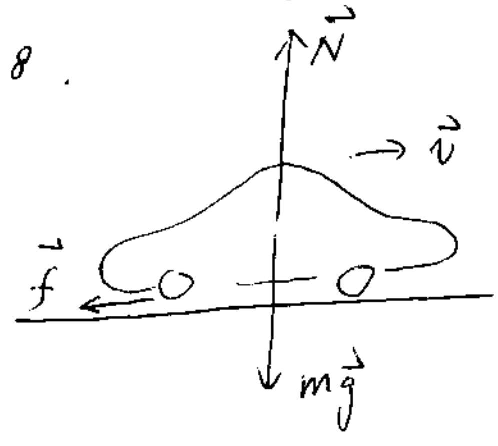


e.g: Friction between the road and Tires of a car.

$\mu_s = 1.0$, $\mu_K = 0.8$.

If the car is moving at 100 Km/h.
how long does it take to stop?

$V_0 = 100 \text{ Km/h} = 28 \text{ m/s}$.



Assume wheels are not rolling. (The car skids).

$f = \mu_K N = \mu_K \cdot mg$ (Note: $N = mg \because a_y = 0$).

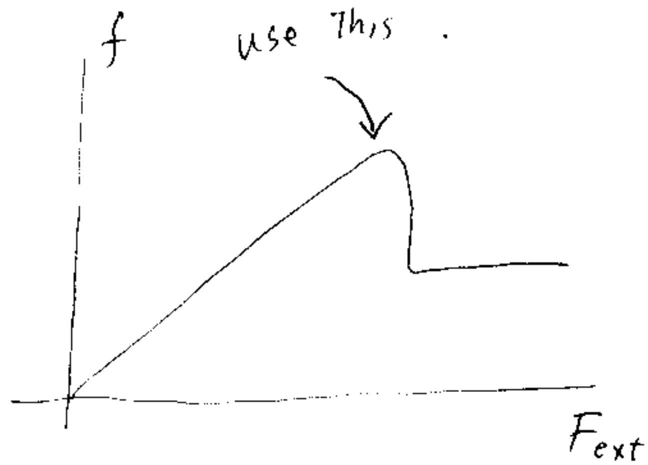
$a = \frac{f}{m} = \mu_K g = 0.8 \times 9.8 = 7.8 \text{ m/s}^2 = \text{const}.$

$\Delta t = \frac{\Delta V}{a} = \frac{28 \text{ m/s}}{7.8 \text{ m/s}^2} = 3.6 \text{ s}.$

- How Do you reduce Δt?

increase f To f_{max} $(f_{max} = \mu_s N)$.

i.e, we want the maximum of static friction.



Idea: Let the wheels roll!

ABS — anti-lock breaking system.