Physics 101.

Lecture 7 Mon. Jan. 19, 2004

Topics : Friction
Drag, Terminal Velocity
Circular Motion

Ref : 6-5. Notes.

Demo : Feather and Hammer
Coffee filters
ball in a ring.

- Friction

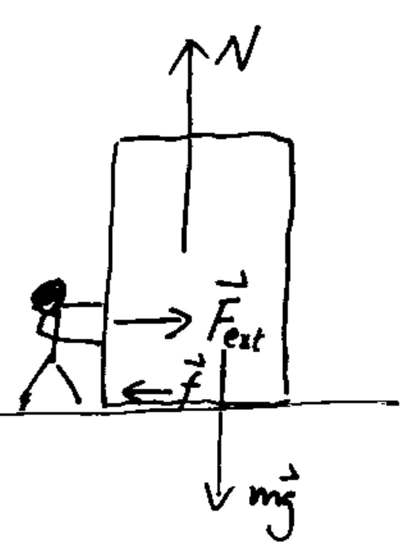
static friction : No relative sliding.

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

Kinetic friction : moving against each other @ surface.

$f = \mu_k N$.

usually, $\mu_s > \mu_k$.



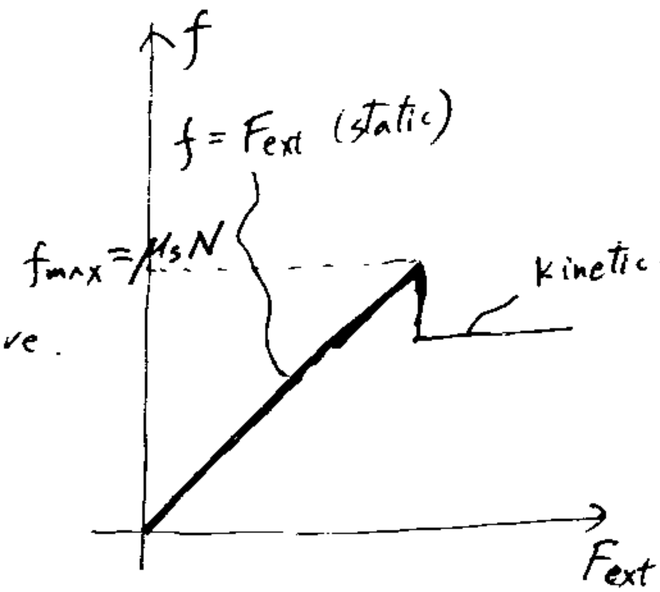
What would happen if F_{ext} increases from zero?

- When F_{ext} is small.

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

  Then, $f = F_{ext}$.

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



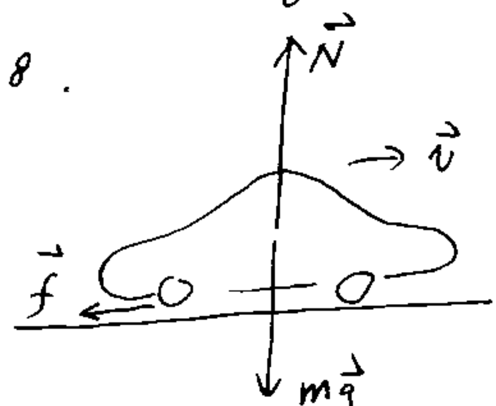
- When $F_{ext} > \mu_s N$

  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: $N = mg$ $\because$ $a_y = 0$).

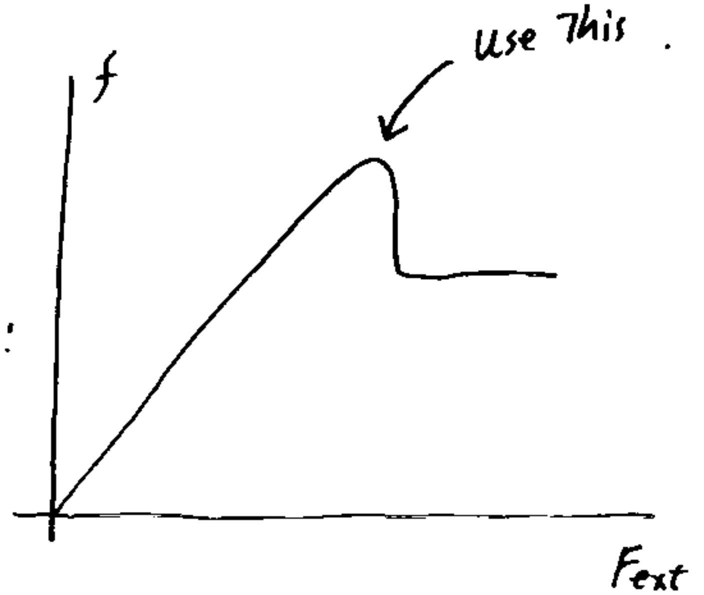
$a = \dfrac{f}{m} = \mu_K g = 0.8 \times 9.8 = 7.8\ \text{m/s}^2 = \text{const}.$

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

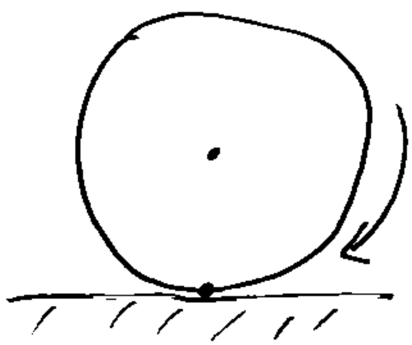
• How do you reduce Δt ?

increase f to f_{max} $\quad (f_{max} = \mu_s N)$

we want the maximum of static friction !



Idea: Let the wheels roll .



rolling — No skidding

i.e., No relative sliding — static friction .

ABS — anti-lock breaking system .

- Drag — when an object moves in a fluid,
  it experiences resistance of the fluid.
  This resistant force is called drag.
  (like friction, but no normal force involved).

e.g: Air resistance.

Demo: Without air, feather and hammer hit the ground at the same time.
(in vacuum, or. on the moon).

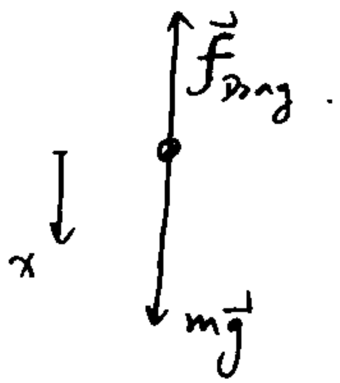
With air. Hammer hits the ground first.

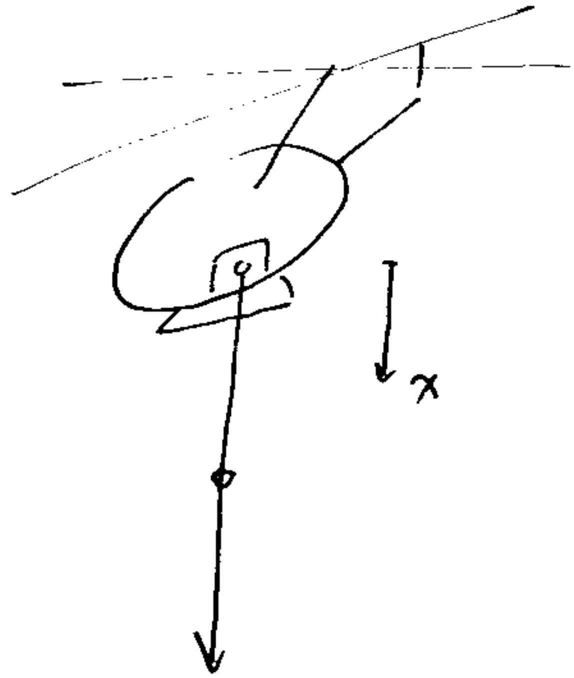
e.g: Riding on a motor cycle:
f_{Drag} increases with v.

(You have to push air away.)
the faster the speed, the more the air you have to push.
the larger the drag force.

- Falling in air — Terminal velocity

Free-Body Diagram.





$$\vec{F} = m\vec{g} + \vec{f}_{Drag} = m\vec{a}.$$

when $t=0$, $v=0$, $f_{Drag}=0$, $a=g$.

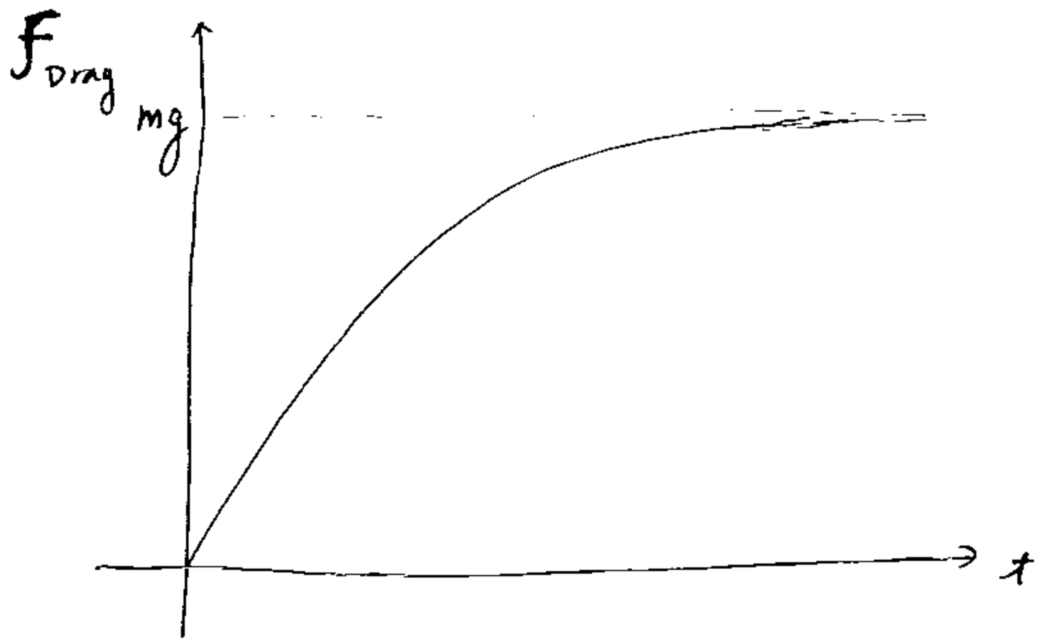
when $t>0$, $v>0$, $f_{Drag}\neq 0$. $a<g$.

$v\uparrow$, $|f_{Drag}|\uparrow$, until $|f_{Drag}| = mg$.

Then $F=0$, $a=0$.

v = constant $\equiv$ terminal velocity

$\therefore$ $\vec{v}$ finally reaches the terminal velocity and then stays constant.



- Relation between f_{Drag} and v :
  - slow motion (No Turbulence). (streamline motion) Lamina motion

$$f_{Drag} = c_1 v . (\propto v.)$$

  - fast motion (with turbulence).

$$f_{Drag} = c_2 v^2 \ (\propto v^2 .)$$

c_1, c_2 — depend on shape, size of the object and the property of the fluid.