Physics 101

Lecture 8

Wed. Jan. 21, 2004

Topics Drag.

Circular Motion

* Impulse
* Work
* Work-Energy theorm

Ref: 6-5.

Demo: Coffee filter, Ball in a ring.

• Drag.

— slow motion (No Turbulence)

$$f_{drag} = c_1 v \quad (\propto v)$$

— fast motion (with Turbulence)

$$f_{drag} = c_2 v^2 \quad (\propto v^2)$$

c_1, c_2 — depends on shape, size of the object and the properties of the fluid.

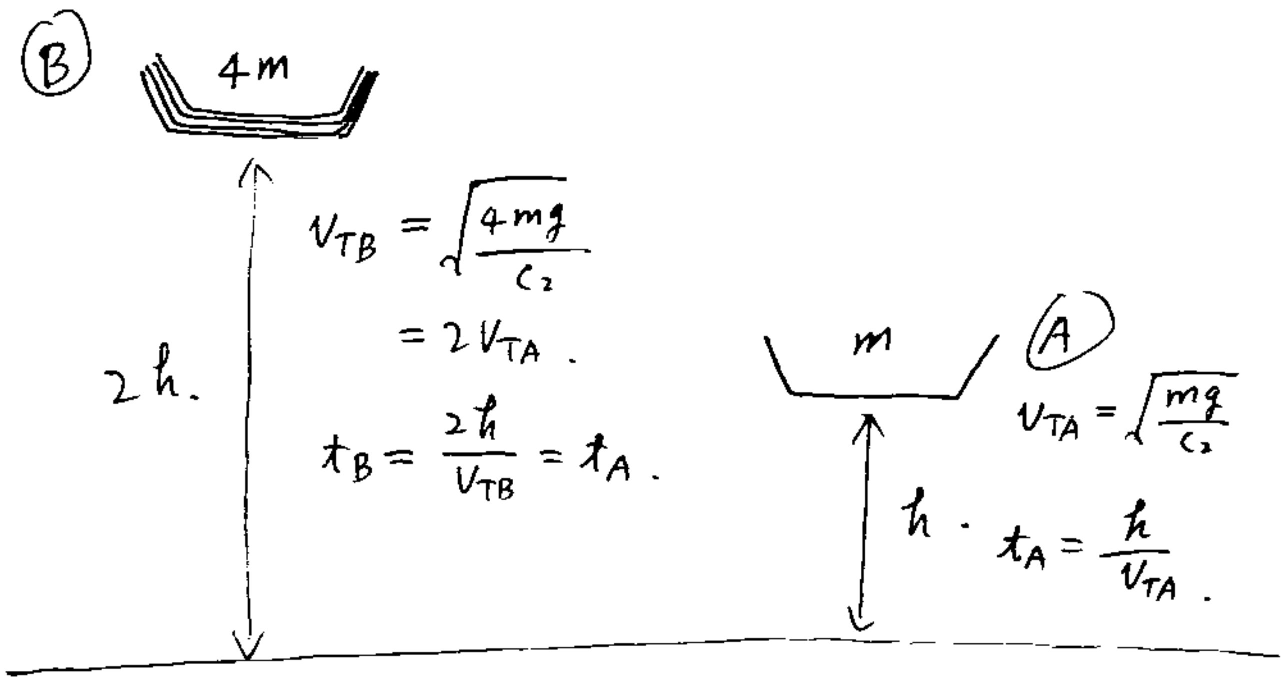
e.g.: Falling of Coffee filters.

The motion is considered as fast because of the Turbulence.

$$f_{Drag} = c_2 v^2$$

$$mg = c_2 v_T^2 \quad \left(\text{when it reaches } v_T,\ a=0,\ F=0. \text{ i.e. } mg = f_{drag}\right)$$

$$v_T = \sqrt{\frac{mg}{c_2}} \propto \sqrt{m}.$$



$$v_{TB} = \sqrt{\frac{4mg}{c_2}} = 2v_{TA}.$$

$$t_B = \frac{2h}{v_{TB}} = t_A.$$

$$v_{TA} = \sqrt{\frac{mg}{c_2}}$$

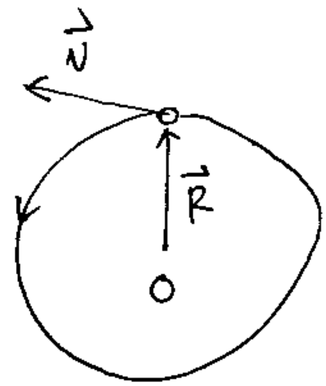
$$t_A = \frac{h}{v_{TA}}.$$

Note: We assume that the Terminal velocity is reached quickly. $\therefore\ t \approx \frac{h}{v_T}$

- Circular Motion

at a constant speed v.

constants:



T — period.

R — Radius.

v — speed.

$f = \frac{1}{T}$ · frequency.

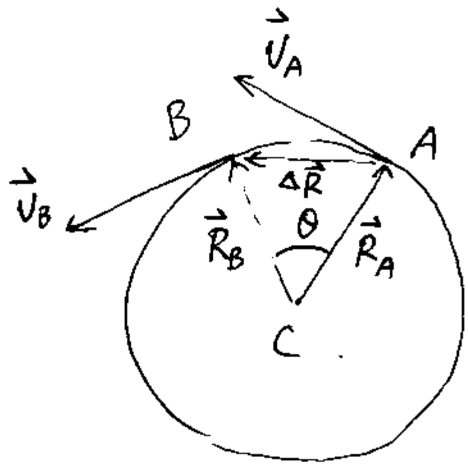
The position of the object is described by vector $\vec{R}$.

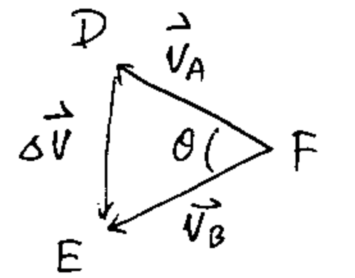
The velocity of the object is $\vec{v}$. The direction of $\vec{v}$ is along the tangential direction.

We need to figure out the acceleration.

idea: $\vec{a} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t}$.

In time interval Δt, the object moves from A to B.





The position is changed from $\vec{R}_A$ to $\vec{R}_B$.

$$\Delta\vec{R} = \vec{R}_B - \vec{R}_A$$

The velocity is changed from $\vec{v}_A$ to $\vec{v}_B$.

$$\Delta\vec{v} = \vec{v}_B - \vec{v}_A .$$

$$\Delta ABC \sim \Delta DEF. \quad (\because \angle\theta = \angle\theta)$$

Thus,
$$\frac{|\Delta\vec{R}|}{R} = \frac{|\Delta\vec{v}|}{v}.$$

$$\lim_{\Delta t \to 0} \left(\frac{1}{\Delta t}\right) \frac{|\Delta\vec{R}|}{R} = \lim_{\Delta t \to 0} \left(\frac{1}{\Delta t}\right) \frac{|\Delta\vec{v}|}{v}.$$

$$\frac{v}{R} = \frac{a}{v}.$$

$\therefore \; a = \dfrac{v^2}{R}.$ — magnitude of acceleration.

The direction of $\vec{a}$: centre-seeking. (centripetal acceleration).