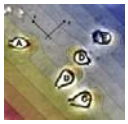
Physics 131- Fundamentals of Physics for Biologists I



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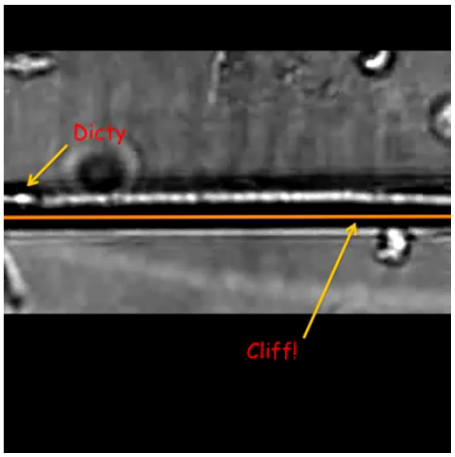
10/1/2012

-How can we describe motion (Kinematics)

- What is responsible for motion (Dynamics)

Movie of the Day
Cells on edge



Outline

- Quiz
- Exam Fri
- Forces
  - Resistive forces
    - » Friction force
    - » Viscous force
    - » Drag force
  - Gravity in 2D

Foothold Ideas: Friction

- Friction is our name for the interaction between two touching surfaces that is parallel to the surface.
- It acts to oppose the relative motion of the surfaces. That is, it acts as if the two surfaces are sticking together a bit.
- Normal forces adjust themselves in response to external forces. So does friction – up to a point.

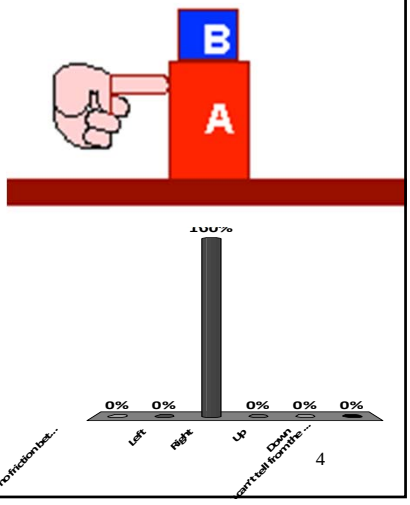
Static *Sliding*

$$f_{A\to B} \le f^{\max}_{A\to B} = \mu^{static}_{AB} N_{A\to B} \qquad f_{A\to B} = \mu^{kinetic}_{AB} N_{A\to B} \qquad \mu^{kinetic}_{AB} \le \mu^{static}_{AB}$$

- Friction can oppose motion or cause it.

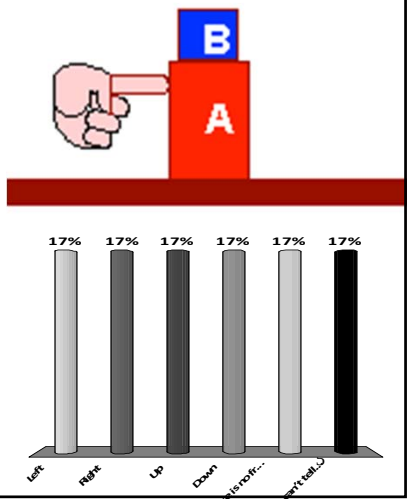
Suppose I start pushing a box along a table that has a box sitting on top of it. The boxes slowly start moving and the top one doesn't slip. If there is a friction force exerted by box A on box B, in what direction does it point?

1. There is no friction between the boxes.
2. Left
3. Right
4. Up
5. Down
6. You can't tell from the information given.



I continue pushing and the boxes move at constant velocity with box B still staying on top of box A. The friction force A exerts on B points to

1. Left
2. Right
3. Up
4. Down
5. There is no friction between the boxes.
6. You can't tell from the information given.



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Foothold ideas: Viscosity

- Viscosity is a resistive force that an object feels when it moves through a fluid as a result of the fluid sticking to the object's surface. This layer of fluid tries to slide over the next layer of fluid and the friction between the speeds that layer up and so on.
- The result is a force proportional to the velocity of the object.

$$\vec{F}^{viscous}_{fluid \to object} = -6\pi\mu R_{object}\vec{v}$$

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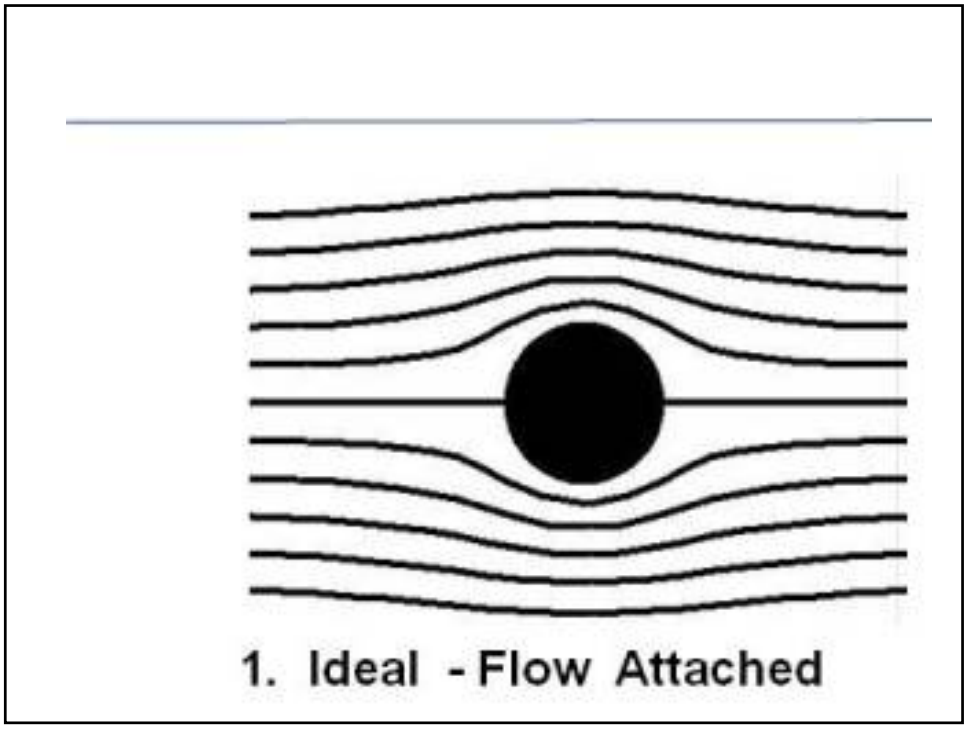
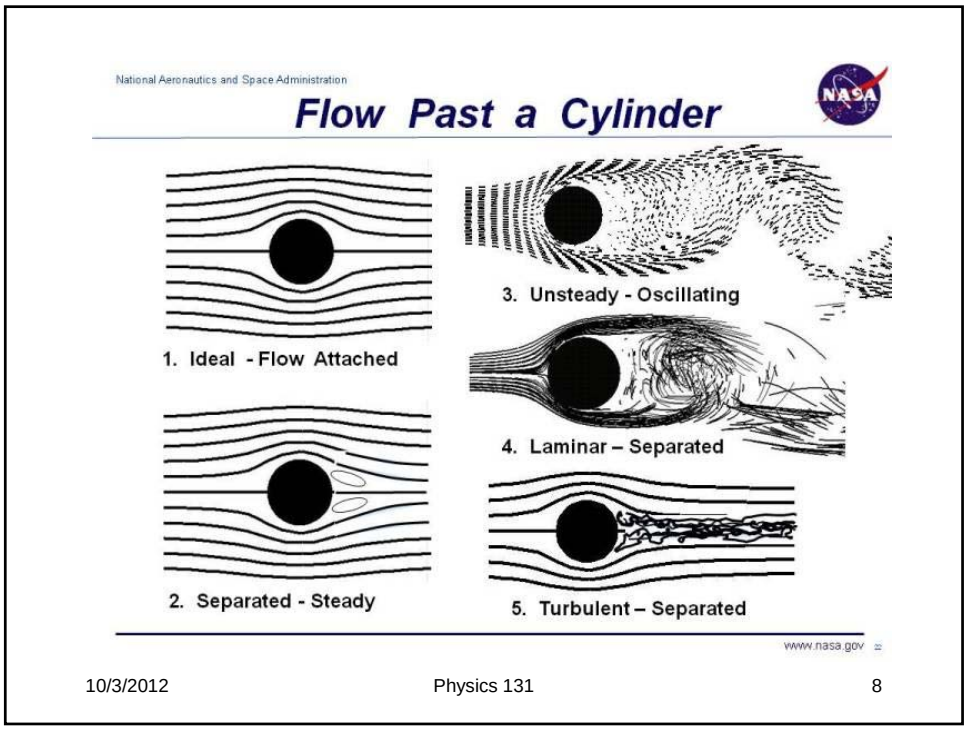

1. Ideal - Flow Attached


National Aeronautics and Space Administration
Flow Past a Cylinder
1. Ideal - Flow Attached
2. Separated - Steady
3. Unsteady - Oscillating
4. Laminar – Separated
5. Turbulent – Separated
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Foothold ideas: inertial Drag force

- The drag (inertial force) is a resistive force felt by an object moving through a fluid. It arises because the object is pushing fluid with it, bringing it up to the same speed it's going.
- The result is a force proportional to the density of the fluid, the area of the object, and the square of the object's velocity.

$$F^{drag}_{fluid \to object} = Cd_{fluid} A_{object} v^2$$

Reynolds' Number

- Generally, for an object moving in a fluid both drag and viscosity are present. However, often, one is much more important.
- The ratio of the two forces (inertial force / viscosity) is called the Reynolds' Number (leaving out a few dimensionless constants)

$$\mathrm{Re} = \frac{dvR}{\mu}$$

  - For small objects (v, R small) the resistive forces are generally dominated by viscosity;
  - For larger objects (v, R large) tend to be dominated by inertial forces (drag).

Foothold Ideas: Gravity

- Every object (near the surface of the earth) feels a downward pull proportional to its mass:

$$\vec{W}_{E\to m} = m\vec{g}$$

where $\vec{g}$ is referred to as *the gravitational field.*

- This is a pForce even though nothing touching the object is responsible for it.
- The gravitational field has the same magnitude for all objects irrespective of their motion and at all points.
- The gravitational field always points down.
- It is measured to be $g \approx 9.8$ N/kg

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A ball is shot sideways by a spring at the same time a ball is dropped. Which ball will hit the ground first?

1. The one shot?
2. The one dropped?
3. Both the same?