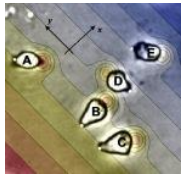
Physics 131-Physics for Biologists I



Professor: Wolfgang Losert
wlosert@umd.edu

Final exam:
Wednesday December 18th
6.30pm-8.30pm

Makeup Midterm

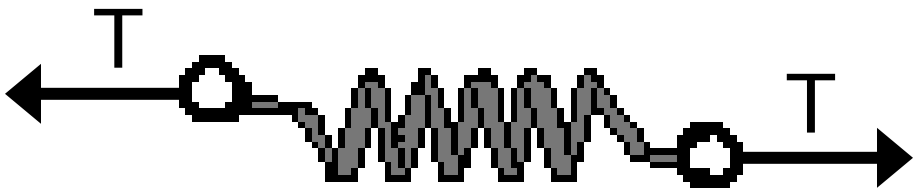
1) YES

Midterm 1

Makeup on Friday! The average grade will be recorded as your midterm grade! The majority of students who take the exam have very low scores on their initial attempt and improve for the makeup, some loose points.

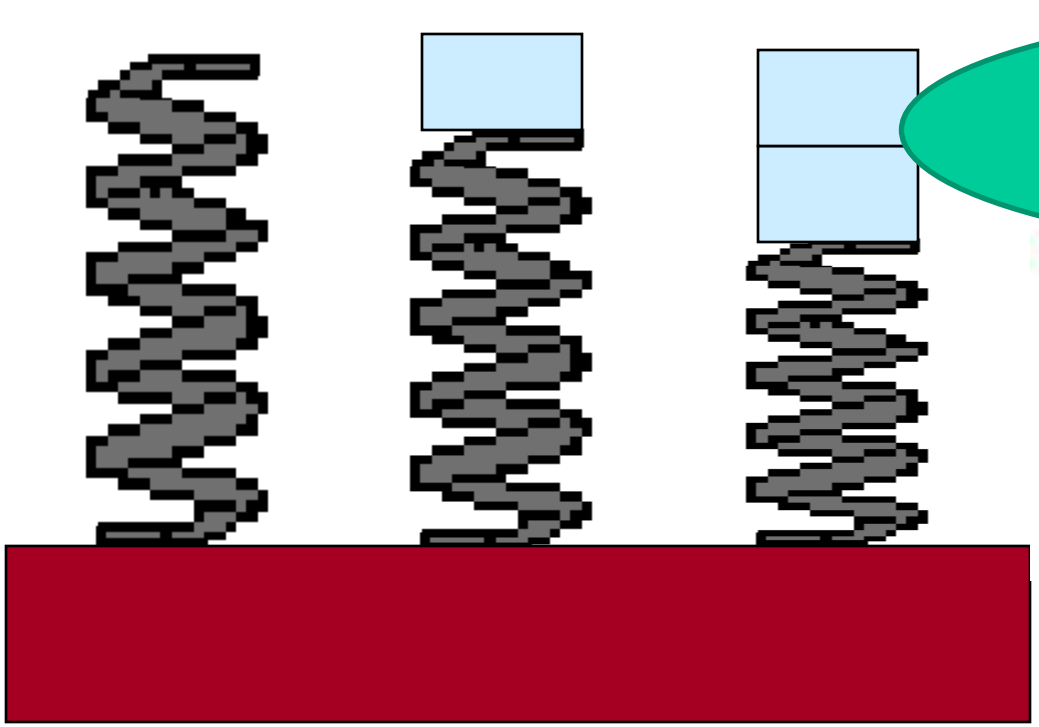
Important: Consider whether you are using the right approach to studying!

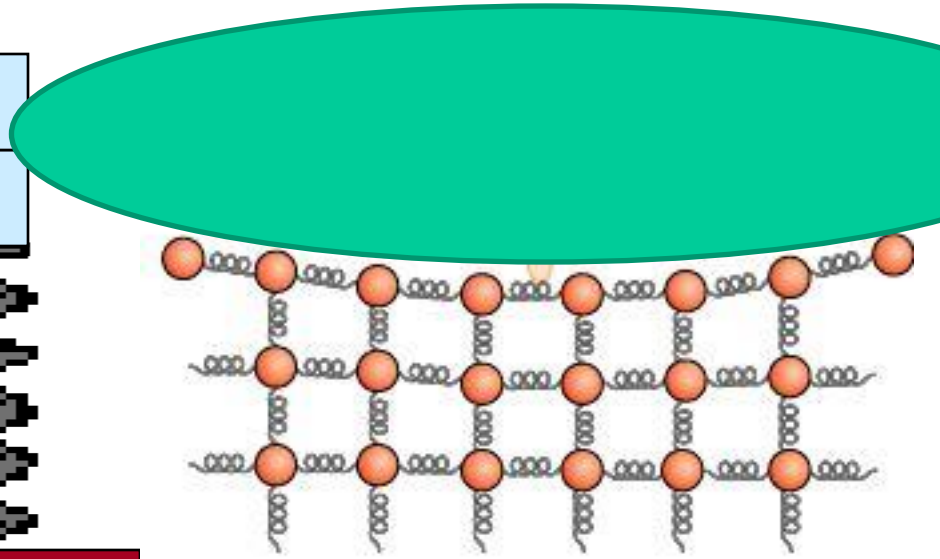
Normal Force works like a network of very stiff springs



$$T = k\Delta L$$

ΔL = stretch or squeeze





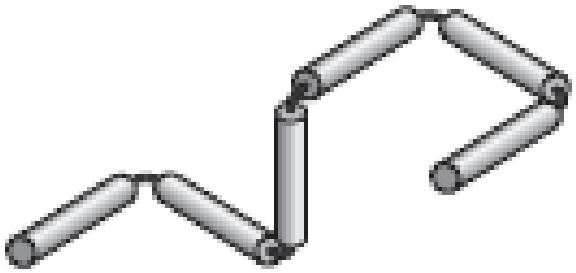
Spring: The resistive force increases with deformation

Show examples of materials or processes that could be modeled as springs in biology

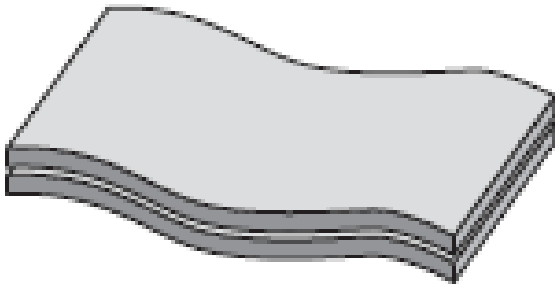
What are the benefits of Spring-like behavior?

(Whiteboard, TA & LA)

Springs in biology

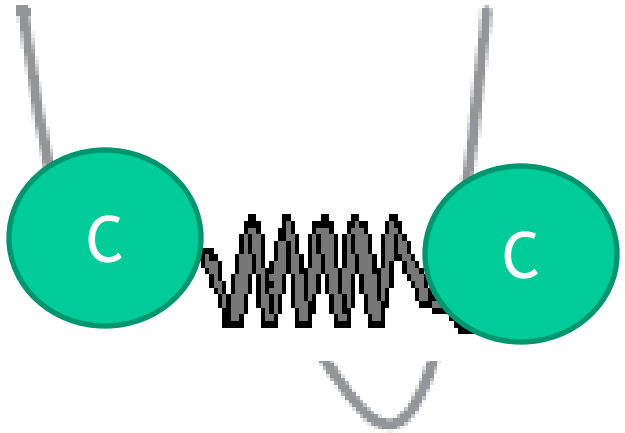


DNA polymer wriggling in solution



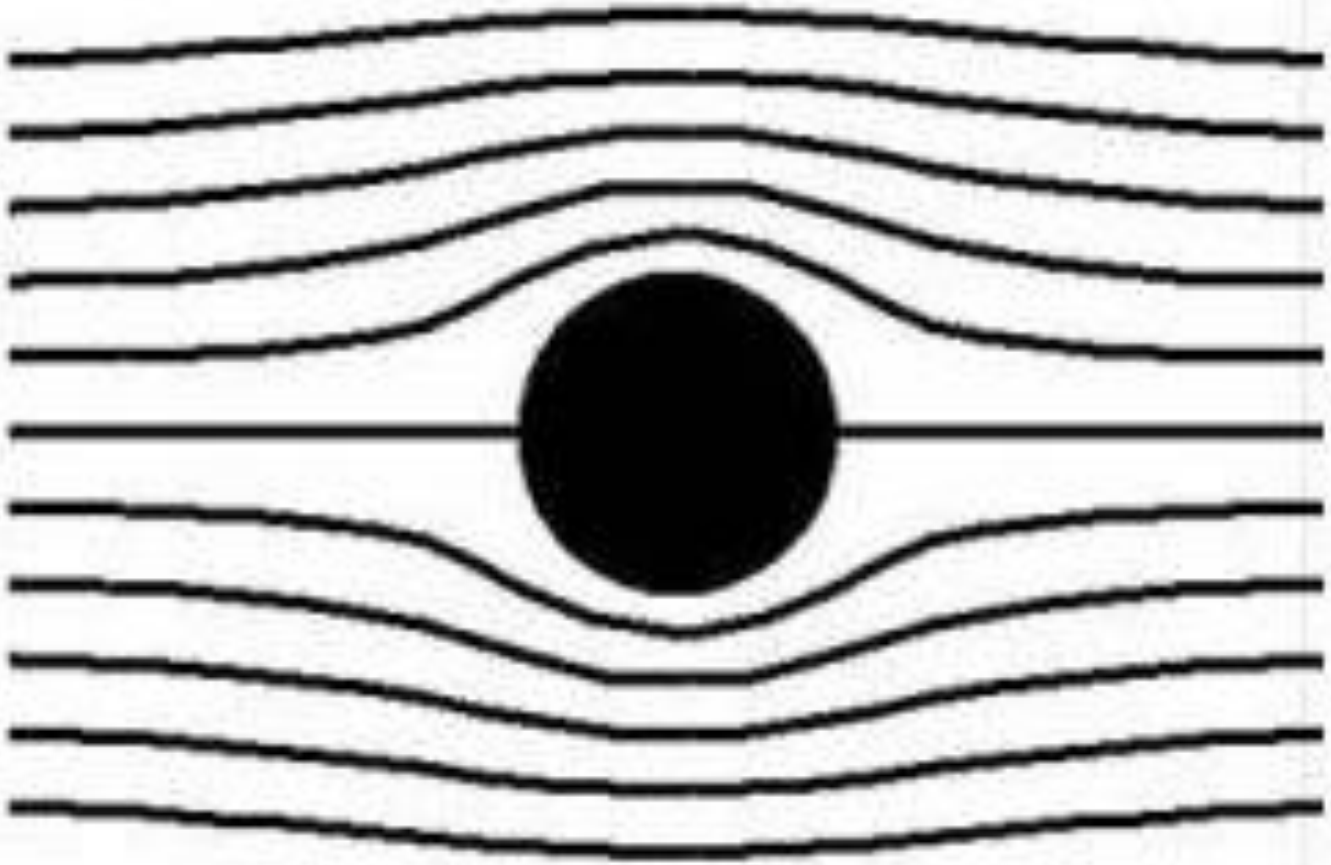
cell membrane fluctuating

flagellum beating on a swimming sperm



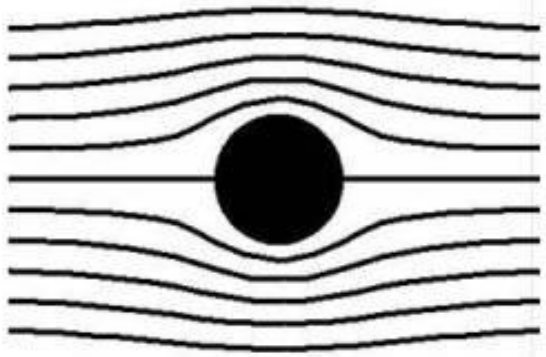
- Connected Atoms in molecules

From: Physical Biology of the Cell, Philips, Kondev, Theriot (2009)

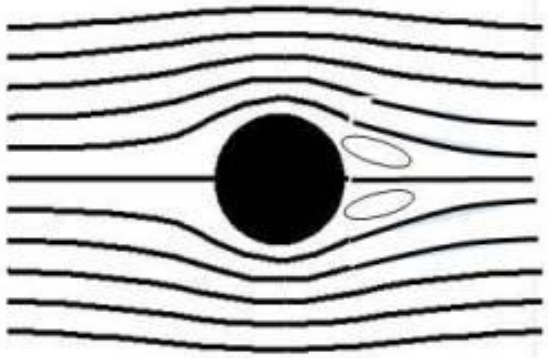


National Aeronautics and Space Administration

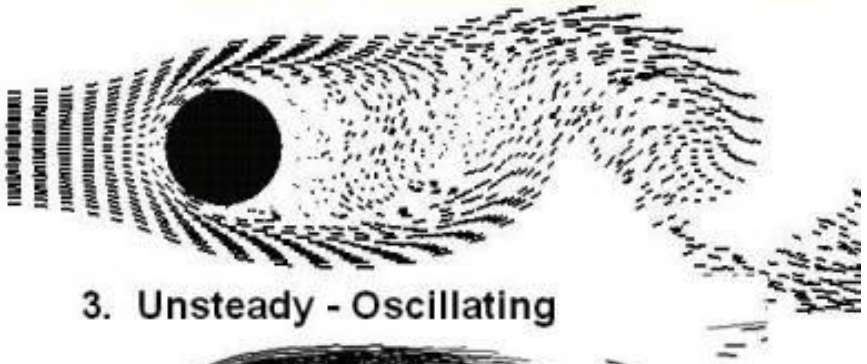
Flow Past a Cylinder



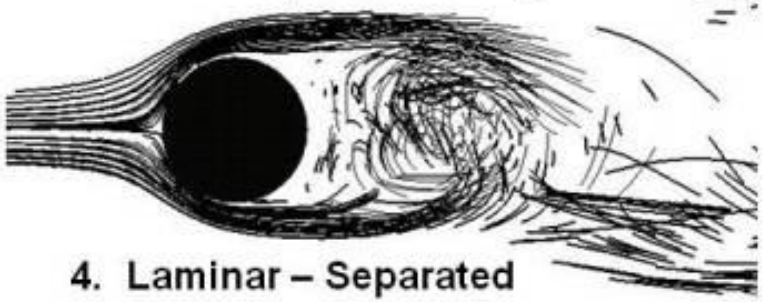
1. Ideal - Flow Attached



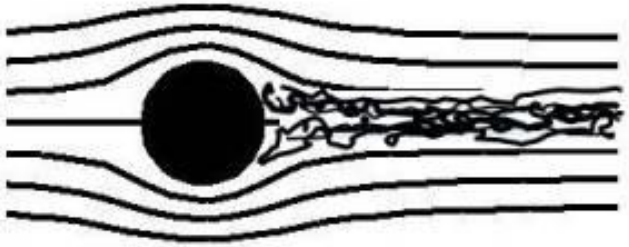
2. Separated - Steady



3. Unsteady - Oscillating



4. Laminar – Separated



5. Turbulent – Separated

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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.

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

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.

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

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

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

Which of the following statements are true:

(Whiteboard, TA & LA)

1) **We always find a velocity at which the two forces are the same magnitude**
2) **For very small objects the viscous force is always larger**
3) **For very high velocity the drag force is always larger**

All statements are true

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).