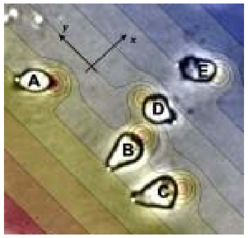
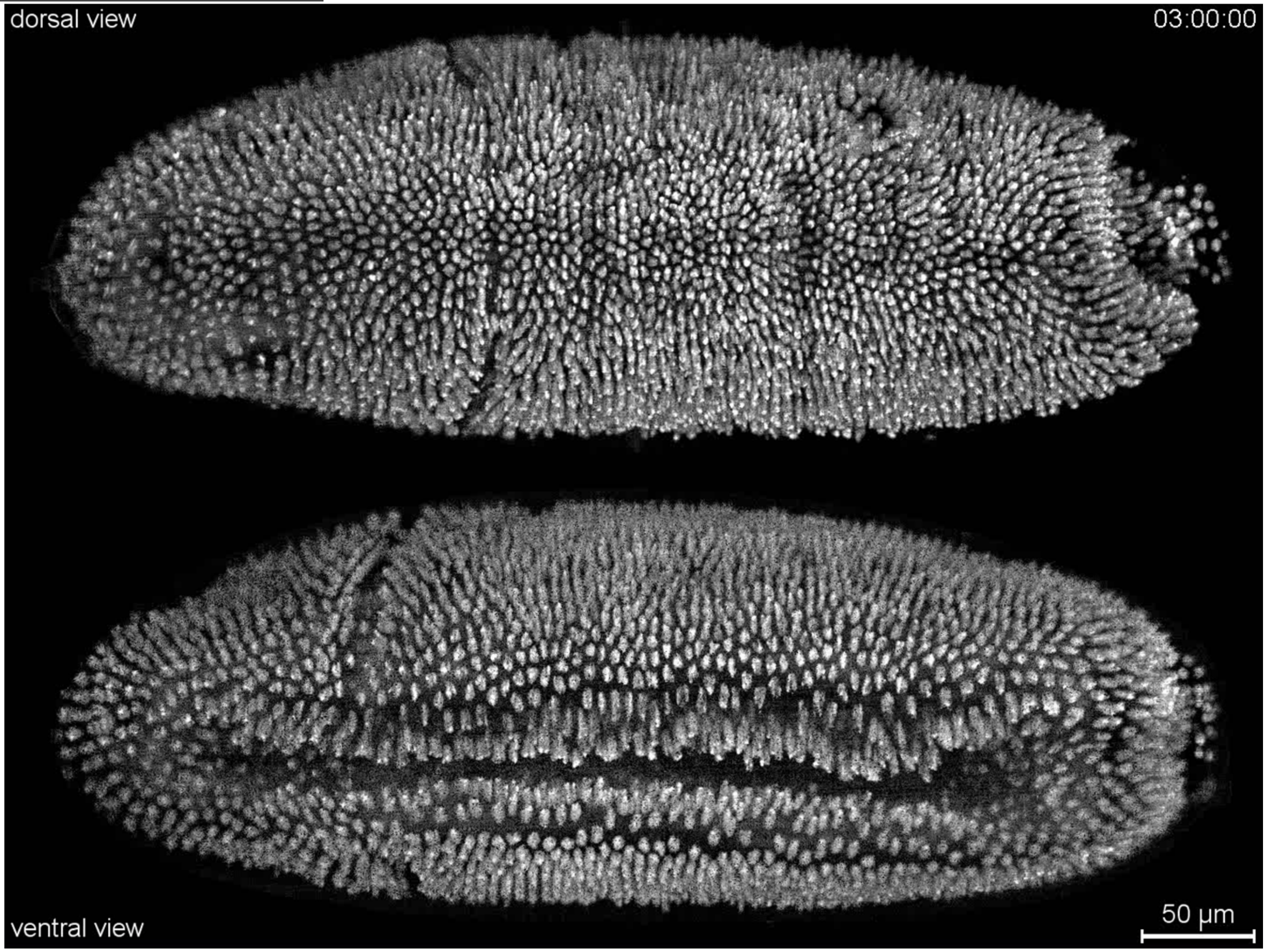
Physics 131- Fundamentals of Physics for Biologists I



Professor: Wolfgang Losert wlosert@umd.edu

http://youtu.be/p7Sl0wMz95w



9/14/2012

-How can we describe motion (Kinematics)

- What is responsible for motion (Dynamics)

Movie of the Day
Drosophilia development
(P. Keller)

Outline

- Using the kinematics equations
- What is responsible for motion (Dynamics)
  - Newton's Laws
    - » **Object egotism**
    - » **Inertia**
    - » **Interactions**
    - » Superposition
    - » **Mass**
    - » Reciprocity

We learned about Kinematics ☑

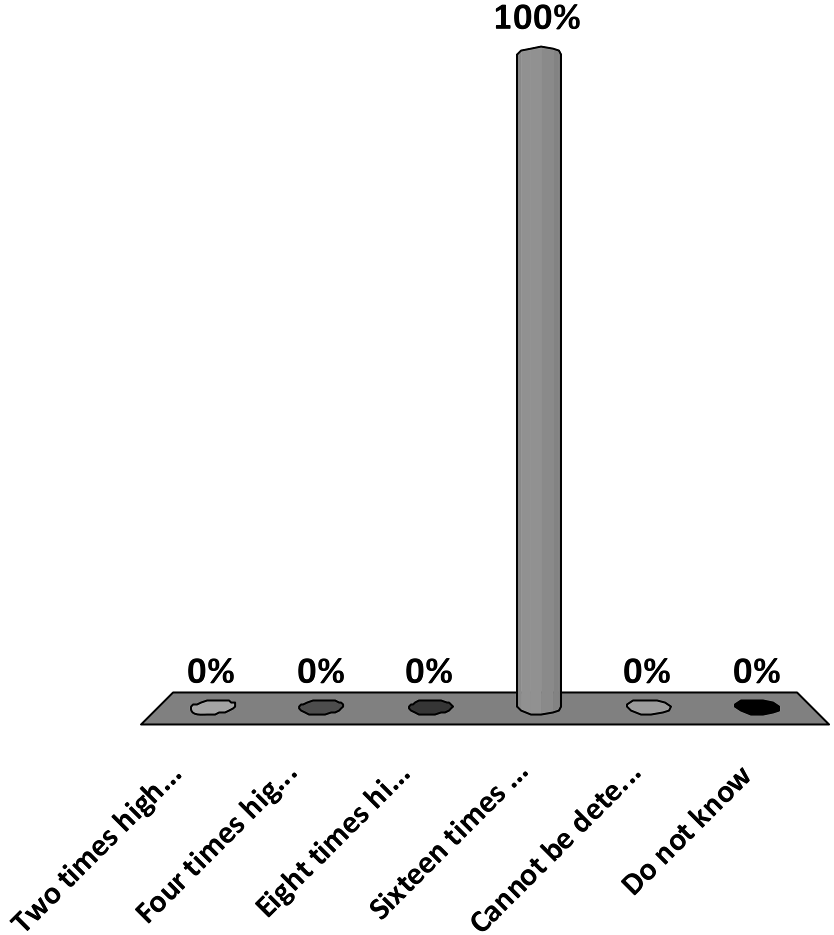
- Position $\hat{r} = x\hat{i} + y\hat{j}$
  (where *x* and *y* are signed lengths)
- Velocity $\langle\vec{v}\rangle = \frac{\Delta\vec{r}}{\Delta t}$ $\quad \vec{v} = \frac{d\vec{r}}{dt}$
- Acceleration $\langle\vec{a}\rangle = \frac{\Delta\vec{v}}{\Delta t}$ $\quad \vec{a} = \frac{d\vec{v}}{dt}$
- Connecting different representations of motion
  - Graphs of Position, Velocity, Acceleration
  - Text
  - Equations

Example: The Black Brant

- http://www.physics.umd.edu/perg/abp/TPProbs/Problems/K/K28.htm

When the rocket is accelerated four times as long, its height after accerleration is

1. Two times higher
2. Four times higher
3. Eight times higher
4. Sixteen times higher
5. Cannot be determined
6. Do not know



Causing Motion

- How do we get something to move?

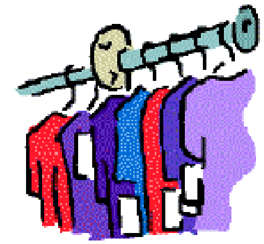
Block on a table

- **Crucial question: What happens to a moving object if nothing acts on it? (or if everything acting on it cancels?)**

Conceptual ideas underlying Newton's Laws

- Objects respond only to influences acting upon them at the instant that those influences act***. (Object egotism)***
- All outside effects on an object being equal, the object maintains its velocity (including direction). The velocity could be zero, which would mean the object is at rest. ***(Inertia)***
- Every change in velocity an object experiences is caused by the object interacting with some other object – **forces**. ***(Interactions)***
- If there are a lot of different objects that are interacting with the object we are considering, the overall result is the same as if we add up all the forces as vectors and produce a single effective force -- the **net force**. ***(Superposition)***
- When one object exerts a force on another, that force is <u>shared</u> over all parts of the structure of the object. ***(Mass)***
- Whenever two objects interact, they exert forces on each other. ***(Reciprocity)***

Coming up with the Laws of Motion



- Redish's Law (from block on table)

$$\mathscr{T} = \Delta x$$

- Newton's Law (from ball on hard floor)

$$\mathscr{T} = \Delta v$$

Newton's law of motion

- As a result of taps

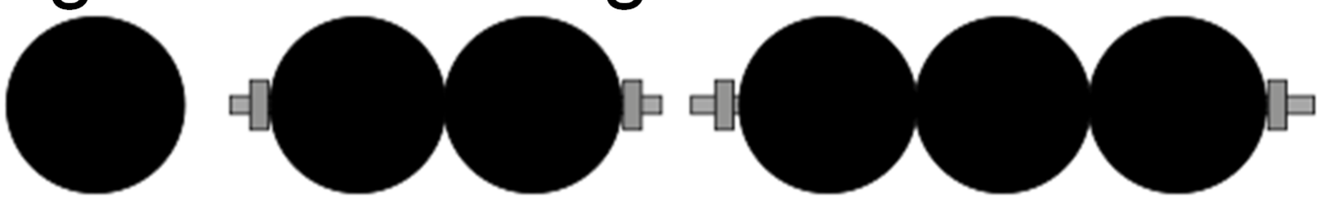
$$\mathscr{T} = \Delta v$$

- Between taps

$$\Delta x = v\,\Delta t$$

Is “tap” the right concept?

- Is a “tap” ($\mathscr{T}$) the right concept?
- Is it really that the same tap causes the same change in velocity for any object, not just the ball? Or does the “tap” also depend on the ball?
- Consider multiple bowling balls ganged together with long bolts.



Impulse

- We expect (and would find if we actually did the experiment) that the effect of a given "hit" with a hammer produces a smaller effect (less Δv) for more bowling balls.
- We therefore replace the "tap" by an "impulse" — something delivered by the hammer to the object.

$$\mathcal{T} = \frac{\mathcal{I}}{m}$$

$\mathcal{I}$ ⟵ **delivered by hammer to object**

m ⟵ **number of bowling balls**

Newton's 2[nd] Law

$$\Delta v = \mathscr{I} / m$$

$$\Delta x = v \Delta t$$

- Where
  - $\mathscr{I}$ is the "impulse" (something delivered to the object by another object touching it)
  - m is the "mass" (a property of the object that says how many bowling balls it is equivalent to)

Taking into account the time duration of the impulse

- If the object that is causing the change of velocity by touching our object doesnt “tap” it but touches it continually, it’s more convenient to extract a time by writing

$$\mathscr{I} = F\Delta t$$

A More Familiar Form

- If the object that is causing the change of velocity by touching our object doesnt “tap” it but touches it continually, it’s more convenient to extract a time by writing

$$\mathscr{I} = F\Delta t$$

- then we get

$$\Delta v = \left(\frac{F}{m}\right)\Delta t \qquad \Delta x = v\,\Delta t \longrightarrow \frac{dv}{dt} = \frac{F}{m} \qquad \frac{dx}{dt} = v \longrightarrow a = F/m$$

A ball that is initially at rest is pushed with a force F for a short time interval. The ball starts rolling and reaches a final speed. To reach the same final speed with a force half as big, the force must be exerted on the cart for a time interval

1. four times as long as
2. twice as long as
3. equal to
4. half as long as
5. a quarter of