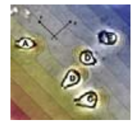
Physics 131- Fundamentals of Physics for Biologists I



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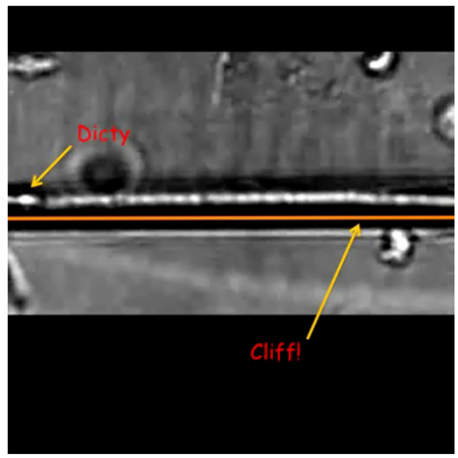
10/3/2012

Midterm review

-How can we describe motion (Kinematics)

- What is responsible for motion (Dynamics)



Movie of the Day **Cells on edge**

- Quiz review
- Midterm Review

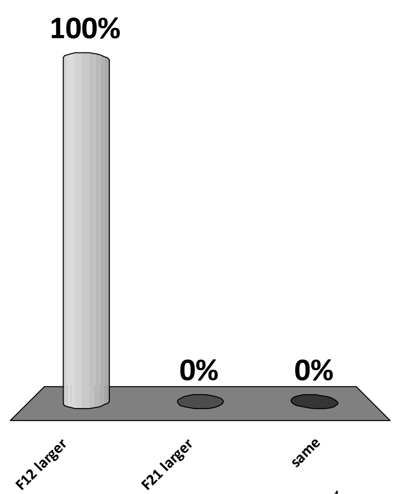
Quiz review

Quiz 4	1	2	3.1	3.2
7	AD	D	BC	B
8	C	D	BC	B
3	AC	AD	ABC	A
5	BC	A	B	B
4	AC	DE	BC	A
8	C	D	BC	B
8	ACD	DE	B	B
10	CD	D	B	B

Correct	**C,D**	**D**	**B**	**B**
Main Incorrect	**A**	**A,E**	**C**	**A**

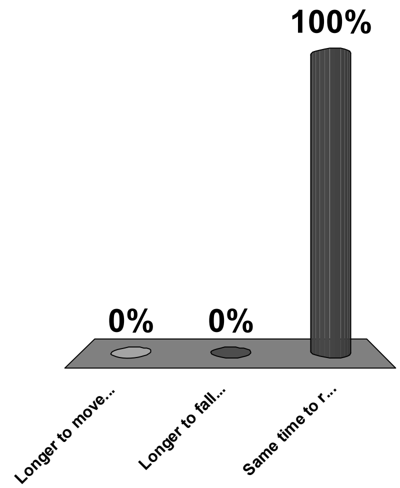
Object accelerates to the right

1. F12 larger
2. F21 larger
3. same



A ball thrown in the air will take

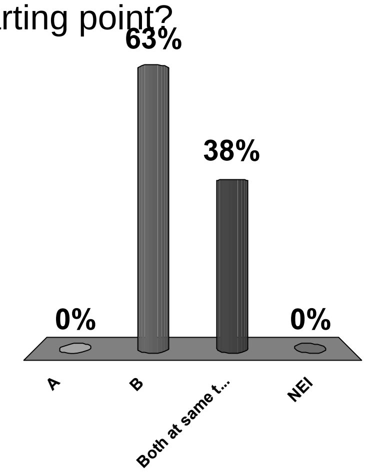
1. Longer to move up then to come down
2. Longer to fall down
3. Same time to reach top as to come back down



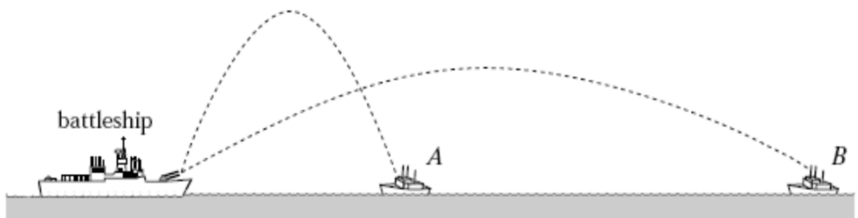
Two dense objects (so air drag can be ignored) are shot straight up at the same time from the same height.

Object A is shot with a speed of 1 m/s, object B with a speed of 2 m/s. Which takes longer to come back to its starting point?

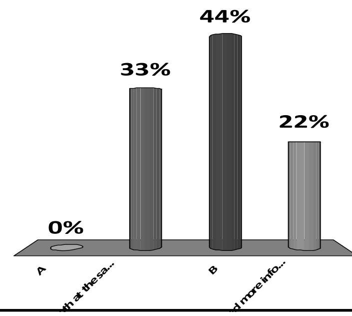
1. A
2. B
3. Both at same time
4. NEI



A battleship simultaneously fires two shells at enemy ships. If the shells follow the parabolic trajectories shown, which ship gets hit first? (from E. Mazur)

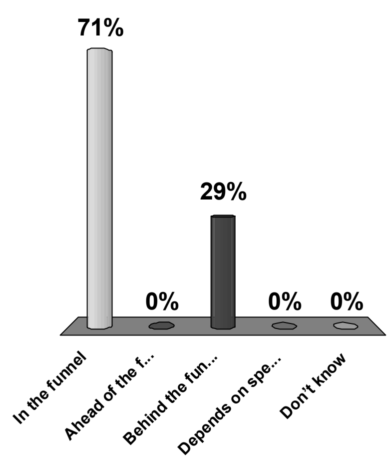


1. *A*
2. both at the same time
3. *B*
4. need more information



The ball on the funnel cart will land

1. In the funnel
2. Ahead of the funnel
3. Behind the funnel
4. Depends on speed of cart
5. Don’t know



REVIEW

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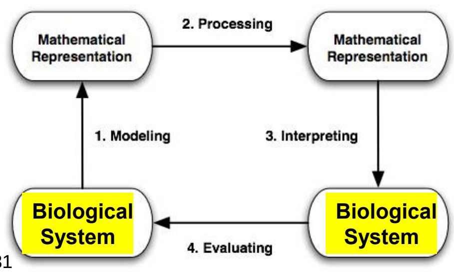
Foothold ideas: Modeling the world with math

- **We use math to model relationships and properties in physical, chemical or biological systems. (1)**
- **Mathematical processing allows us to make predictions (2) from the model that we can interpret (3) for the physical system.**
- **Very non-natural physical systems such as lasers, transistors have been designed via such *"model based extrapolation"*.**
- **In biology, steps 1 and 3 are still very hard**



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Foothold Ideas: Estimation – Quantifying experience

- Use 1-digit arithmetic
- **Do** figure out your estimations by starting with something you can plausibly know and scale up or down
- **Do** check your answer to see if it's reasonable
- **You will learn useful numbers for biology**

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Useful numbers (people)

Numbers	
Number of people on the earth	~7 billion (7×10^9)
Number of people in the USA	~ 300 million (3×10^8)
Number of people in the state of Maryland	~ 5 million (5×10^6)
Number of students in a large state university	~30-40 thousand (3×10^4)

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Useful numbers (distances)

Macro Distances	
Circumference of the earth	~24,000 miles (1000 miles/time zone at the equator)
Radius of the earth*	$2/\pi \times 10^7$ m
Distance across the USA	~3000 miles
Distance across DC	~10 miles

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Foothold Biology Numbers

Numbers that we do NOT know from personal experience but that we need to build an "intuition" for living systems

Bio Scales	
Size of a typical animal cell	**~10-20 microns (10^{-5} m)**
Size of a bacterium, chloroplast, or mitochondrion	**~1 micron (10^{-6} m)**
Size of a medium-sized virus	**~0.1 micron (10^{-7} m)**
Thickness of a cell membrane	**~10nanometer = 0.01 micron (10^{-8} m)**
Number of molecules per μm^3 in a 1 nanomolar solution	1

Foothold ideas: Coordinates in space

- In order to specify the position of something we need a coordinate system.
- The coordinate system includes:
  - Picking an ***origin***
  - Picking perpendicular directions for the axes of the coordinate system
  - Choosing a ***measurement scale***
- Each point in space in then specified by
  - three numbers: the *x*, *y*, and *z* coordinates.
  - a position vector– an arrow drawn showing the displacement from the origin to that position.

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Velocity: Predicting the future position

- Average velocity is defined by

$$\langle \vec{v} \rangle = \frac{\Delta \vec{r}}{\Delta t} = \frac{\text{vector displacement}}{\text{time it took to do it}}$$

Note: an average velocity goes with a time interval.

- Instantaneous velocity is what we get when we consider a very small time interval (compared to times we care about)

$$\vec{v} = \frac{d\vec{r}}{dt}$$

Note: an instantaneous velocity goes with a specific time.

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Foothold ideas: Acceleration

- Average acceleration is defined by

$$\langle \vec{a} \rangle = \frac{\Delta \vec{v}}{\Delta t} = \frac{\text{change in velocity}}{\text{time it took to do it}}$$

Note: an average acceleration goes with a <u>time interval</u>.

- Instantaneous acceleration is what we get when we consider a very small time interval (compared to times we care about)

$$\vec{a} = \frac{d\vec{v}}{dt}$$

Note: an instantaneous acceleration goes with a <u>specific time</u>.

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Newton's Laws

- Newton 0:
  - An object responds to the forces it feels when it feels them.
- Newton 1:
  - An object that feels a net force of 0 keeps moving with the same velocity (which may = 0).
- Newton 2:
  - An object that is acted upon by other objects changes its velocity according to the rule $\vec{a}_A = \vec{F}_A^{net} / m_A$
- Newton 3:
  - When two objects interact the forces they exert on each other are equal and opposite. $\vec{F}_{A\to B}^{type} = -\vec{F}_{B\to A}^{type}$

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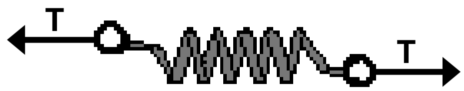
Foothold Idea: Spring Forces

- If you pull on a spring from both sides it changes its length.



$$T = k\Delta L$$

(“ΔL” = stretch or squeeze)

- Tension force T.
- Holds for ALL objects interacting pulled by a spring!

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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 <u>relative motion</u> 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

$$f_{A\to B} \leq f_{A\to B}^{\max} = \mu_{AB}^{static} N_{A\to B}$$

Sliding

$$f_{A\to B} = \mu_{AB}^{kinetic} N_{A\to B}$$

$$\mu_{AB}^{kinetic} \leq \mu_{AB}^{static}$$

- Friction can oppose motion or cause it.

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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.

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

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.

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

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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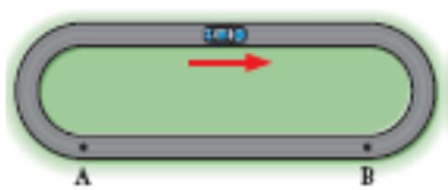
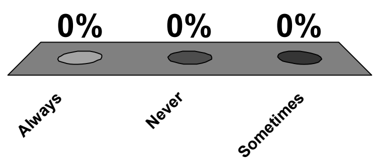
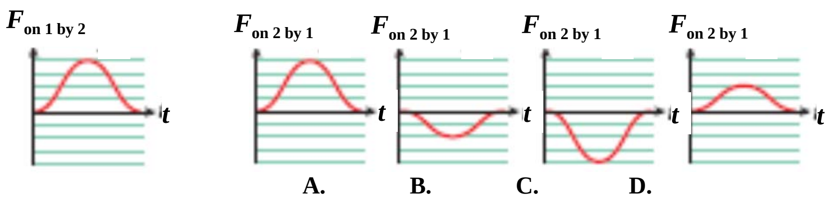
As the car above is driven around the track at constant speed, the net force on the car is______ zero.



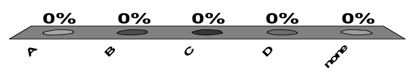
1. Always
2. Never
3. Sometimes



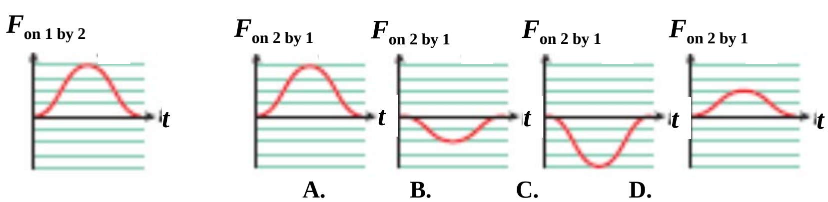
Two objects 1 and 2 are interacting. They are isolated from other objects. Object 2 has twice the mass of object 1. The graph on the left shows the force that 2 exerts on 1, plotted against time. Which of the graphs to the right of it correctly shows the force that 1 exerts on 2?



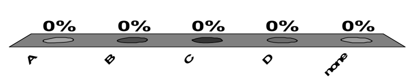
1. A
2. B
3. C
4. D
5. none



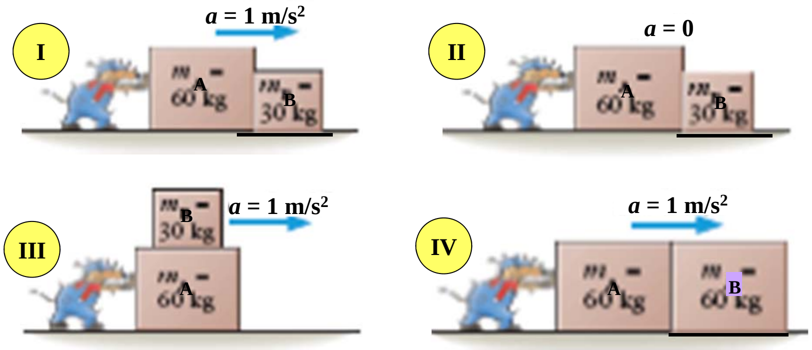
Two objects 1 and 2 are interacting. They are isolated from other objects. Object 2 has twice the mass of object 1. The graph on the left shows the acceleration of object 1, plotted against time. Which of the graphs to the right of it correctly shows the acceleration of object 2?



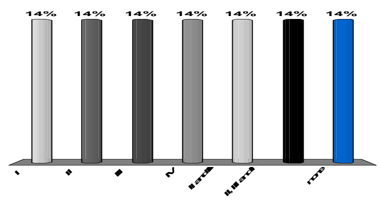
1. A
2. B
3. C
4. D
5. none

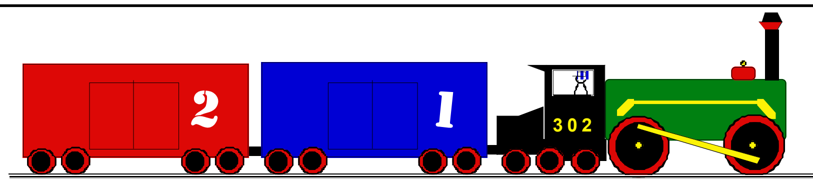


In each of the situations below, a mover pushes two crates along a horizontal surface, and the crates move together with a constant acceleration. Which of these situations are possible only if one or more frictional forces are involved?



1. I
2. II
3. III
4. IV
5. II and III
6. II, III and IV
7. none





The engine above exerts a constant force as it speeds up pulling the two freight cars. Car 1 and its load have a combined mass of 6000 kg; car 2 and its load have a combined mass of 9000 kg. In which pair of quantities below are the two quantities unequal in magnitude?

1. The acceleration of car 1 and the acceleration of car 2
2. The force that the engine exerts on car 1 and the force that car 1 exerts on car 2
3. The force that the car 1 exerts on car 2 and the force that car 2 exerts on car 1
4. The force that the engine exerts on car 1 and the force that car 1 exerts on the engine
5. The normal force that the track exerts on the engine and the engine's weight