Prof. Vashti Sawtelle
Prof. Leanne Doughty

Today:

Finish Resistive Forces

Homework solutions (Ch 3 On-paper and Osteoporosis Q)

Start Ch 6

Irish Phrasebook

Go way outta that – I don't believe you

Announcements

- LON-CAPA homework for Ch 5 due **Wednesday 21st**
- Ch 5 on-paper homework due **Friday 23rd**
  - Paired with Refrigerator Magnet question from LON-CAPA homework
  - Hint: Two variations – in one μ between paper and magnet is greater than μ between paper and fridge; in the other it is reversed
  - Remember to bring attempts to class on Wednesday

- Reading Questions for Ch 7 due **Tuesday 20th**

Foothold ideas: Drag force

- The drag ("Newtonian drag") is a resistive force felt by an object moving through a fluid. It arises because the object is pushing fluid in front of it, bringing it up to the same speed it's going.
- Occurs for objects that are "relatively large" and moving "relatively fast"
- 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.

$$F_{fluid\to object}^{big,fast} = \tfrac{1}{2} C_{fluid} \rho_{fluid} A v^2$$

A tennis ball is released from rest and falls, being accelerated by the force of gravity acting upon it. As its downward speed increases, the upward frictional force resisting its motion also increases. As time goes on, what happens?

A. The ball's downward acceleration remains g
B. The ball's downward acceleration is reduced to a non-zero value
C. The ball's downward acceleration is reduced to zero
D. The ball's downward speed is reduced to zero
E. None of the above

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As the drag force increases, it resists the force from gravity until the point where the net force is 0, meaning the acceleration is also 0.

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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.
- Occurs when objects are "relatively small" moving "relatively slowly"
- The result is a force proportional to the velocity of the object.

$$\vec{F}^{small,slow}_{fluid \to object} = -6\pi\eta R_{object}\vec{v}$$

A paramecium swimming through a fluid is moving at approximately a **constant velocity** as a result of wiggling its cilia. What can you say about the **net force** that is being exerted on it while it is doing this?

A. It is significantly greater than zero
B. It is a little bit greater than zero
C. It is equal to zero
D. It cannot be determined from the information given.

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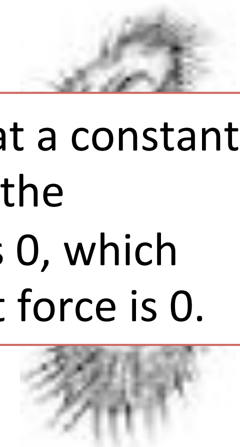

If it’s moving at a constant velocity, then the acceleration is 0, which means the net force is 0.

A paramecium swimming through a fluid is moving at approximately a **constant velocity**
as a result of wiggling its cilia. What can you say about the magnitude of the force that
the paramecium's cilia exert on the water compared to the magnitude of the force the water exerts back on the cilia?

A. $F_{c\rightarrow w}$ is greater than $F_{w\rightarrow c}$
B. $F_{c\rightarrow w} = F_{w\rightarrow c}$
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Newton's 3rd law tells us these forces must be equal in magnitude (and opposite in direction)

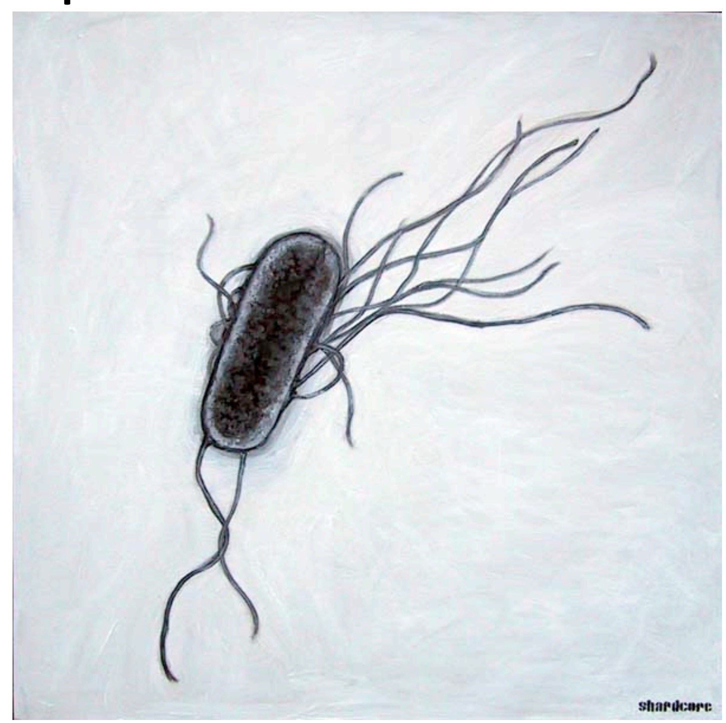
An *E. coli* bacterium is roughly 2 m long and 0.5 m in diameter. *E. coli* bacteria can use their flagella to propel themselves at speeds of up to 0.05 mm/s (around 0.0001 miles per hour) in water, which has a viscosity of =0810−3 Ns/m^2 at room temperature. What can you say about the resistive force on the bacterium as the bacterium speeds up?

A. The resistive force remains constant because the fluid doesn't change.

B. The resistive force increases as the speed increases.

C. The resistive force decreases as the speed increases.

D. None of the above



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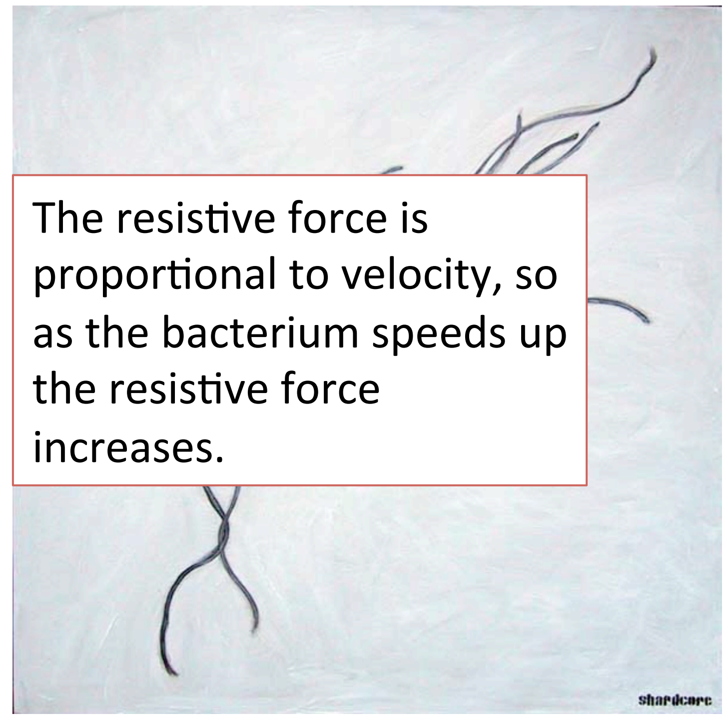

The resistive force is proportional to velocity, so as the bacterium speeds up the resistive force increases.

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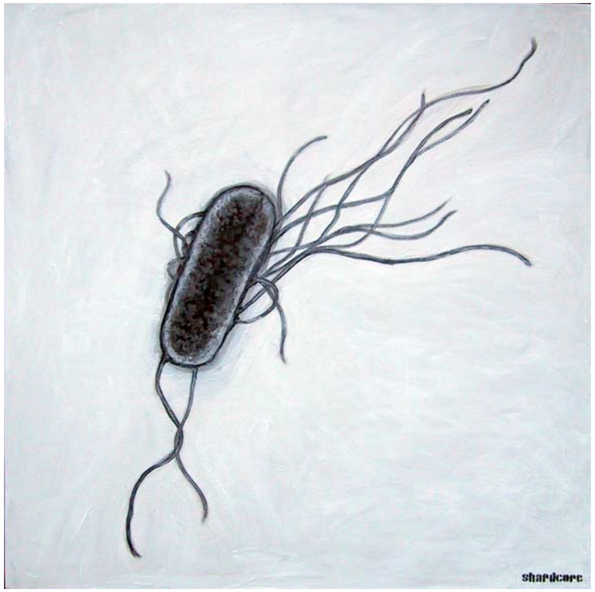
A. The net force is in the direction of motion of the bacterium because it's moving fast.
B. The net force is in the opposite direction of motion because the viscous force increases as it speeds up.
C. The net force is 0 because as the flagella push harder so does the viscous force.
D. None of the above



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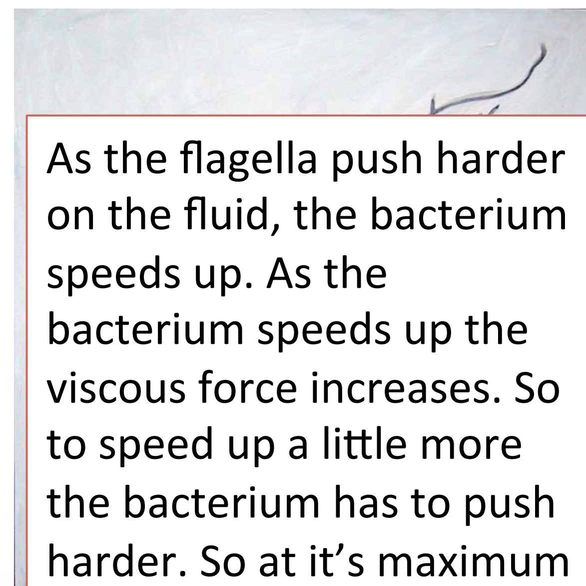
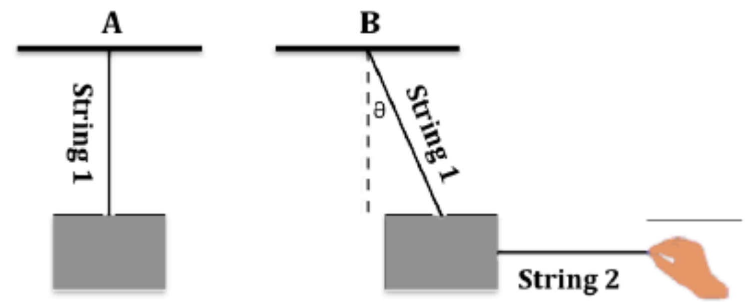


As the flagella push harder on the fluid, the bacterium speeds up. As the bacterium speeds up the viscous force increases. So to speed up a little more the bacterium has to push harder. So at it's maximum speed the forces must sum up to be 0.

A shows a block hanging from a string. You pull the block to the side with another string (shown in **B**).



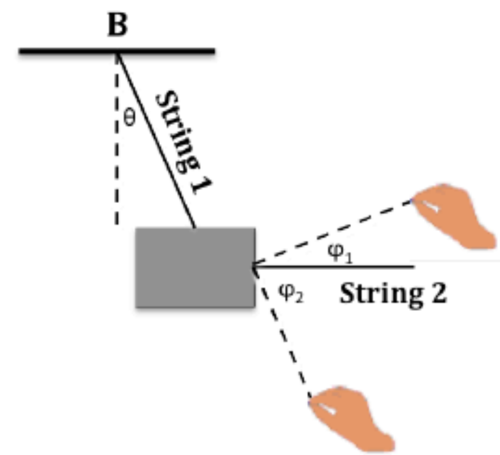
I. Consider the following student statements about the tension in String 1 (T_1) in situations **A** and **B**:

Student 1: *"The tension force due to String 2 in **B** is helping to support the block. Therefore, T_1 in **A** is greater than T_1 in **B**."*

Student 2: *"I think T_1 would be the same in **A** and **B** because the string is the same length and it's acting from the same point"*

Do you agree with either student? Explain your reasoning. (Hint: a free-body diagram will probably help you here.)

II. Suppose now that you pull the block with the same magnitude force but not directly to the right (as shown in the figure at the right.)



a) Draw free-body diagrams that show all the forces acting on the block when you pull to the right in different directions.

b) In what way can you pull on String 2 so that T_1 is *always* bigger than in case **A**?

c) Is there a way of pulling the block so that T_1 is smaller than in case **A**? If it is hard to tell in some cases, tell us what you would need to know in order to say for sure. (Hint: angles θ, φ_1, and φ_2 are variables)