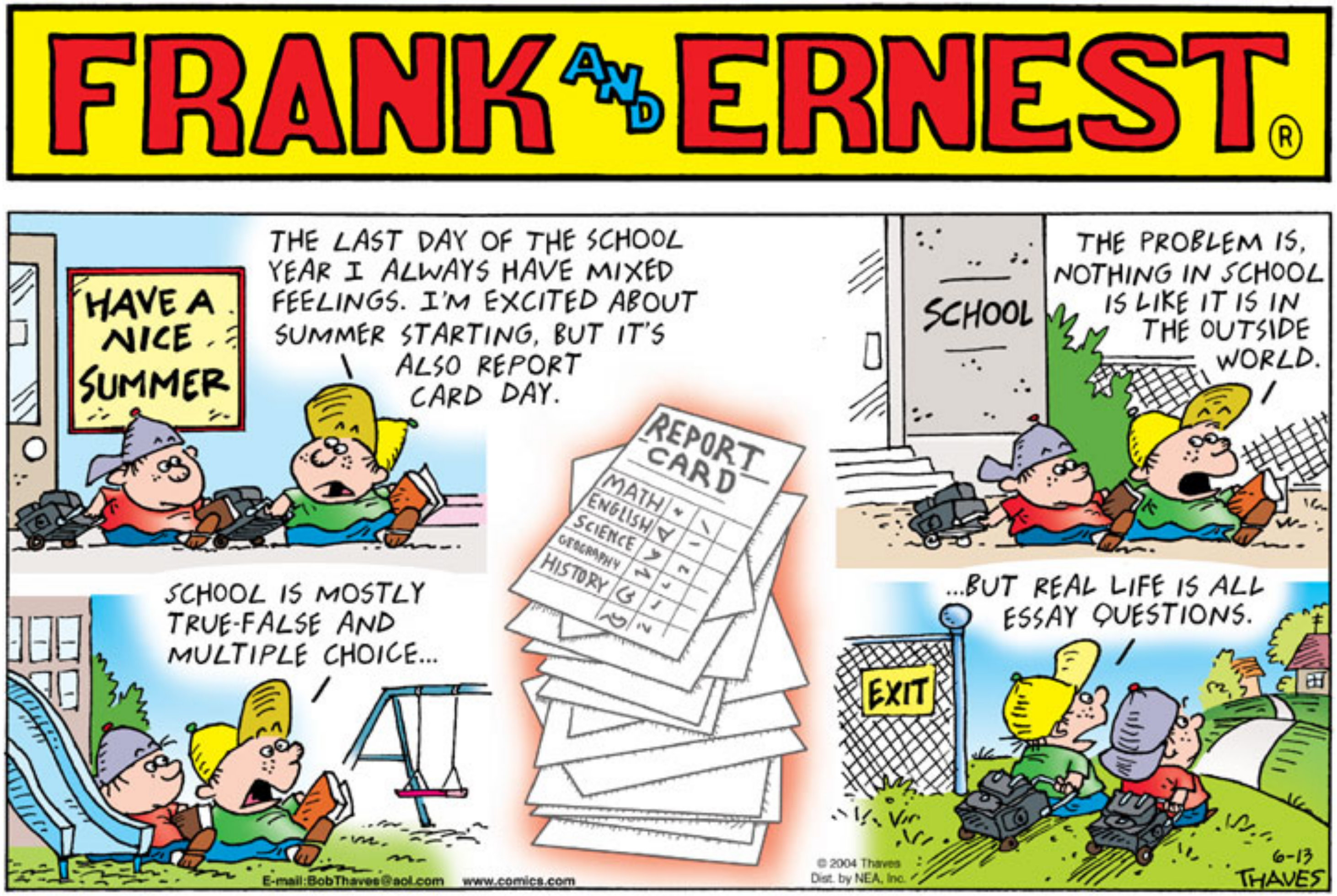
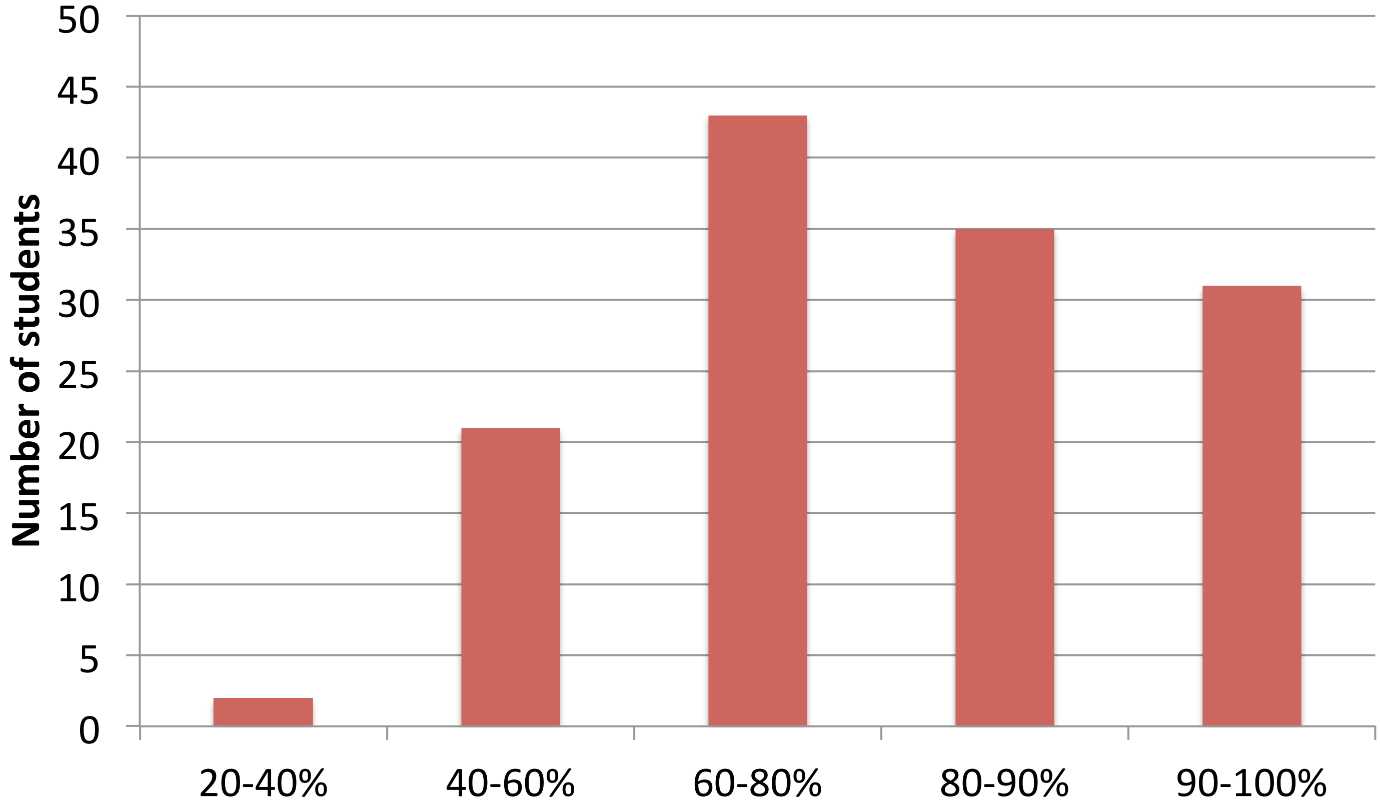
Exams are arranged in alphabetical order by last name



Overall

Average: 76% +/- 17%

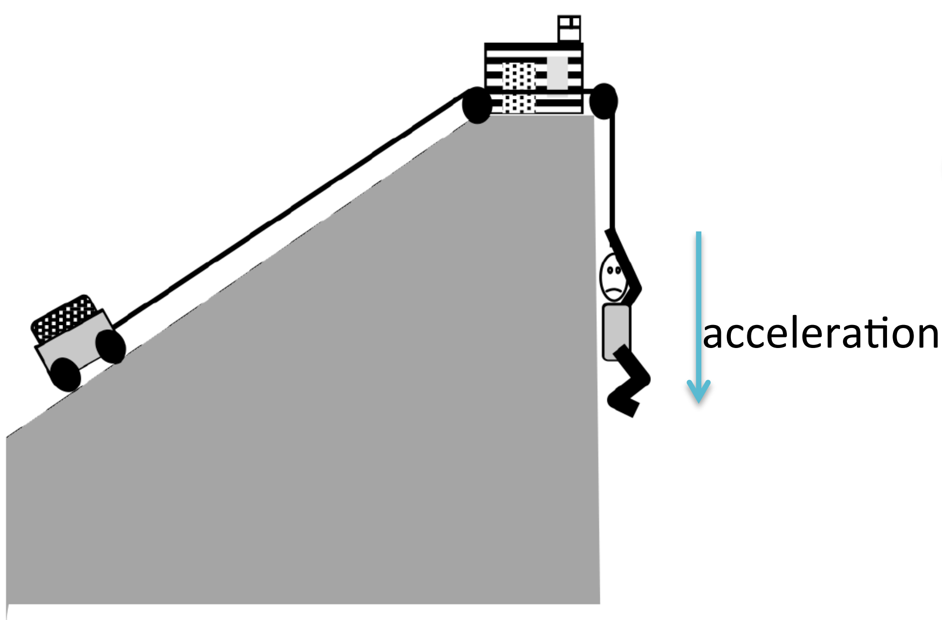


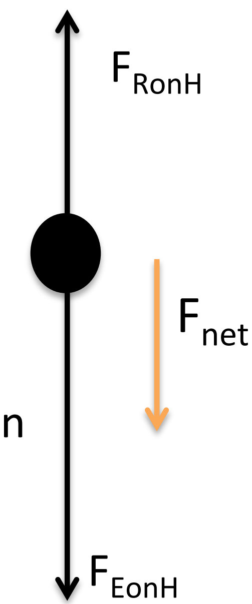
Some Noticings

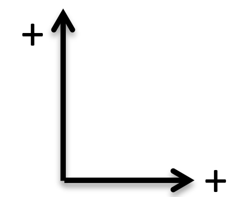
- The Newton's 3rd Law question did not go well at all.
  - So I'm giving everyone a bonus 5 points.
- Some people struggled with time – writing something down for each question is better than getting one or two completely correct
- Practice explaining using math; the two are not incompatible.

Hiker

As the wagon moves with increasing speed up the hill, the hiker moves with increasing downward speed (i.e., the system accelerates). Explain how the magnitude of the force of the rope on the hiker ($F_{R\ on\ H}$) compares to the force that the Earth exerts on the hiker ($F_{E\ on\ H}$) (greater than/equal to/less than).







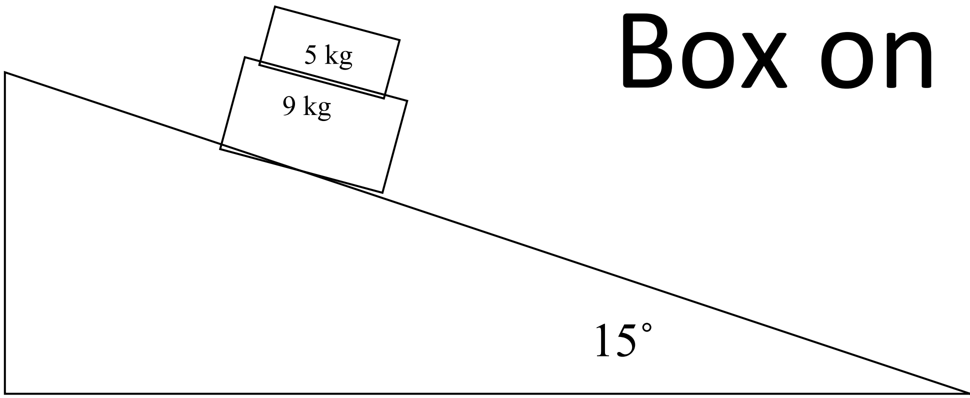
$$F_{net} < 0$$

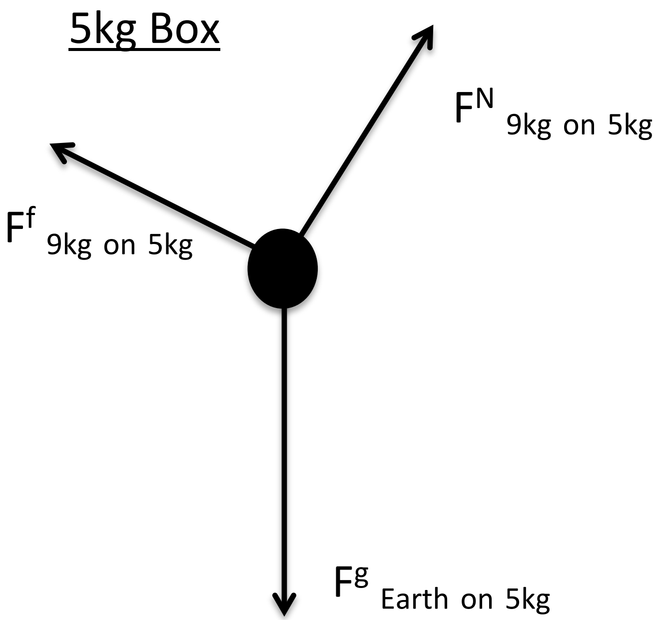
$$F_{net} = F_{RonH} - F_{EonH}$$

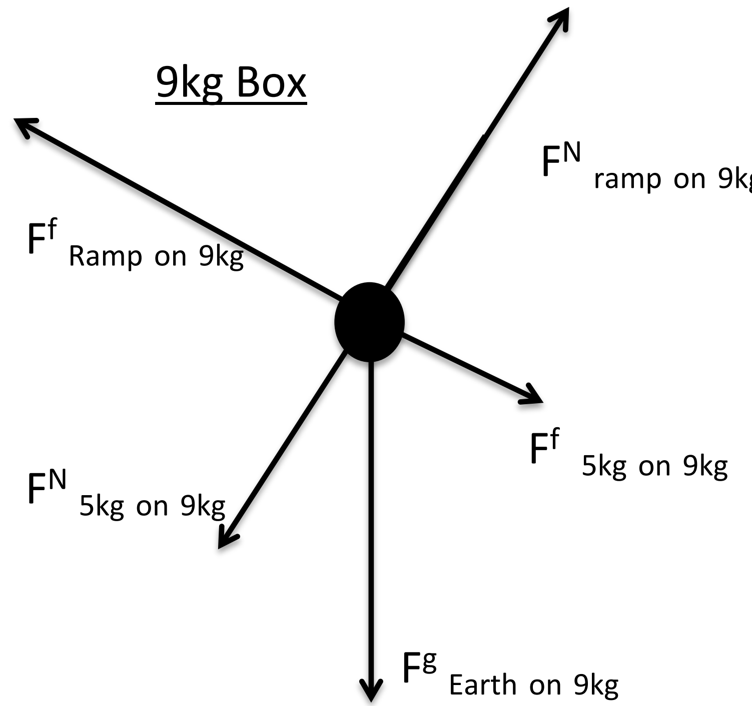
$$F_{RonH} - F_{EonH} < 0$$

$$F_{RonH} < F_{EonH}$$

Box on Box

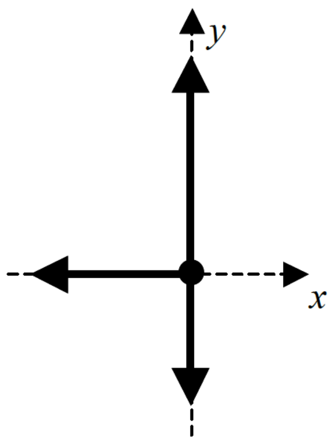

5 kg
9 kg
15°


5kg Box
F^N 9kg on 5kg
F^f 9kg on 5kg
F^g Earth on 5kg


9kg Box
F^N ramp on 9kg
F^f Ramp on 9kg
F^f 5kg on 9kg
F^N 5kg on 9kg
F^g Earth on 9kg

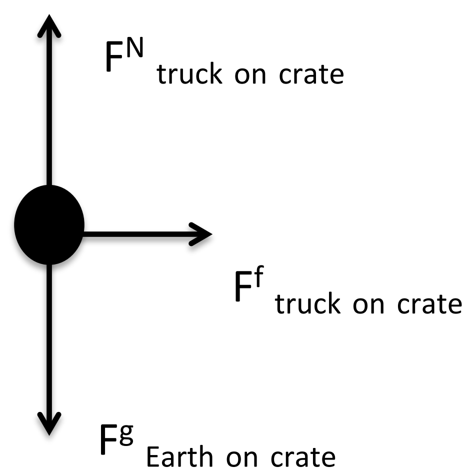
Crate

Truck increasing velocity



In the y-direction, the net force should be 0 because it's not moving up or down

In the x-direction the net force should be in the same direction as the truck's increasing velocity for the crate to move with the truck

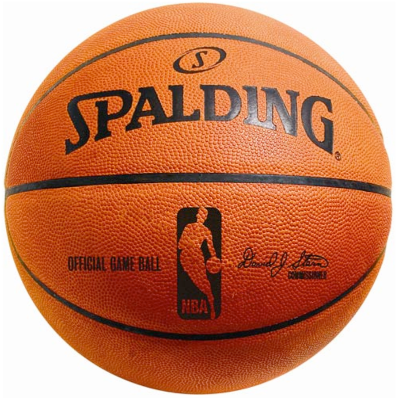


Announcements

- Chapter 8 reading question due on Thursday
  - SKIP section 8.3
- I'll be sending individual messages over the next week with current grade in the class information

You throw a ball vertically upward. Which statement best describes the direction and magnitude of the ball's acceleration while the ball is still moving up?

(ignore air resistance)



A. Upward, constant magnitude
B. Upward, decreasing magnitude
C. Downward, constant magnitude
D. Downward, decreasing magnitude
E. Zero acceleration

Will revisit this question on Wed.
Even split between B & C

Chapter 7
Getting Started & Moving Around: What Makes Motion Change?

Newton's 2nd Law
AKA: "The Momentum Principle"

- Momentum: a vector quantity that depends on both mass and velocity of the object of interest $\vec{p} = m\vec{v}$
- Changes in momentum are achieved by exerting a net force on the system $\overrightarrow{\Delta p} = \overrightarrow{F_{net}} \Delta t$
- If a system experiences a net force it will undergo either:
  - a change in the magnitude of its momentum
  - a change in the direction of its momentum
  - a change in both the magnitude and direction of its momentum

The Momentum Principle

A little girl running to collect plastic eggs in the yard

A linebacker running to tackle the opponent's team

$\Delta \vec{p}_g = 0 - m_g \vec{v}$

$\Delta \vec{p}_{fp} = 0 - m_{fp} \vec{v}$

$m_g < m_{fp}$

$\Delta \vec{p}_g < \Delta \vec{p}_{fp}$

Which direction will $\vec{F}_{net}$ point?

$\Delta \vec{p}/\Delta t = \vec{F}_{net}$

$F_{net\ g} < F_{net\ fp}$

If they are running at similar speeds, the force required to stop the linebacker will be much greater because his mass initial momentum is much greater.

Newton's 2nd Law: Connecting Back to Acceleration

- We define the momentum of an object, A:

$$\vec{p}_A = m_A \vec{v}_A$$

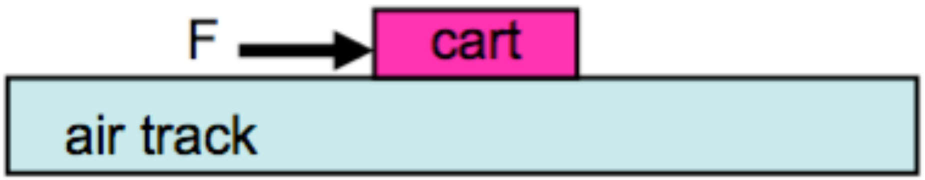
- Our form of the momentum principle can be rewritten

$$\vec{F}_A^{net} = \frac{\Delta \vec{p}_A}{\Delta t} = \frac{\Delta\left(m_A \vec{v}_A\right)}{\Delta t}$$

$$\vec{F}_A^{net} = m_A \frac{\Delta \vec{v}_A}{\Delta t} = m_A \vec{a}_A$$

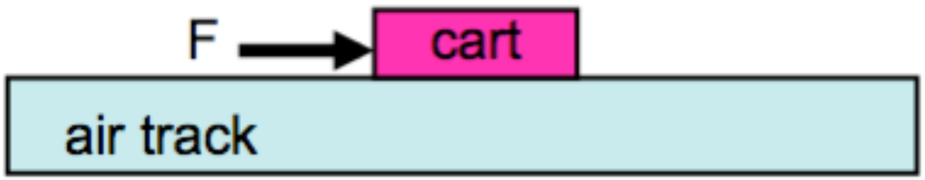
Newton's 2nd Law is a way to quantify the impact of an external force acting on a system for a period of time.

A constant force is exerted on a cart that is initially at rest on a frictionless air track. The force acts for a short time interval and gives the cart a final speed. To reach the same speed using a force that is half as big, the force must be exerted for a time interval that is…



A. Four times as long
B. Twice as long
C. The same length
D. Half as long
E. A quarter as long

A constant force is exerted on a cart that is initially at rest on a frictionless air track. The force acts for a short time interval and gives the cart a final speed. To reach the same speed using a force that is half as big, the force must be exerted for a time interval that is…



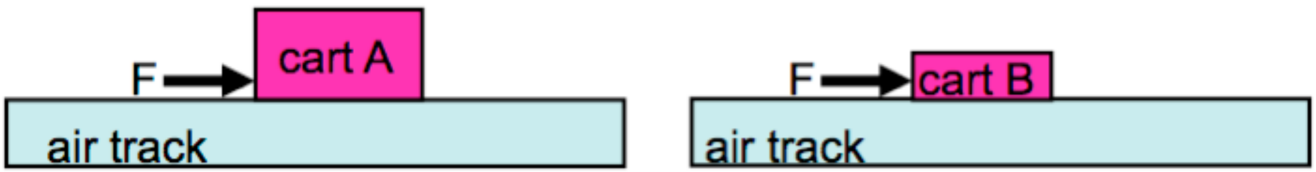
A. Four times as long
B. Twice as long
C. The same length
D. Half as long
E. A quarter as long

$dp = F_{net}\,dt$

$F_{net} = dp/dt$

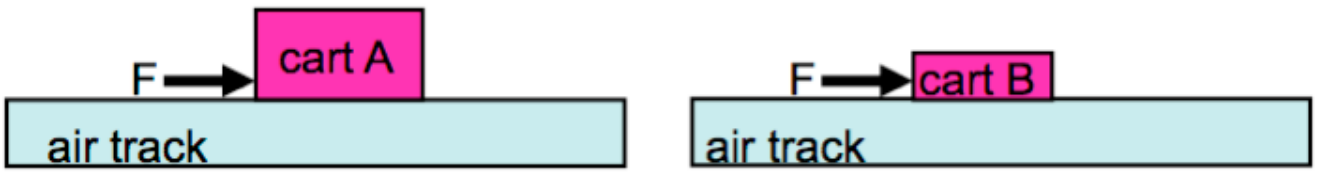
So if F_{net} goes down by ½, dt must increase by 2 to compensate

Two carts - A and B - on frictionless air tracks are initially at rest. Cart A is twice as massive as cart B. Now you exert the same constant force on both carts for 1 second. One second later, the momentum of cart A is...



A. Twice the momentum of cart B
B. The same as the momentum of cart B
C. Half the momentum of cart B
D. Not enough information to determine

Two carts - A and B - on frictionless air tracks are initially at rest. Cart A is twice as massive as cart B. Now you exert the same constant force on both carts for 1 second. One second later, the momentum of cart A is...



A. Twice the momentum of cart B
B. The same as the momentum of cart B
C. Half the momentum of cart B
D. No … mine

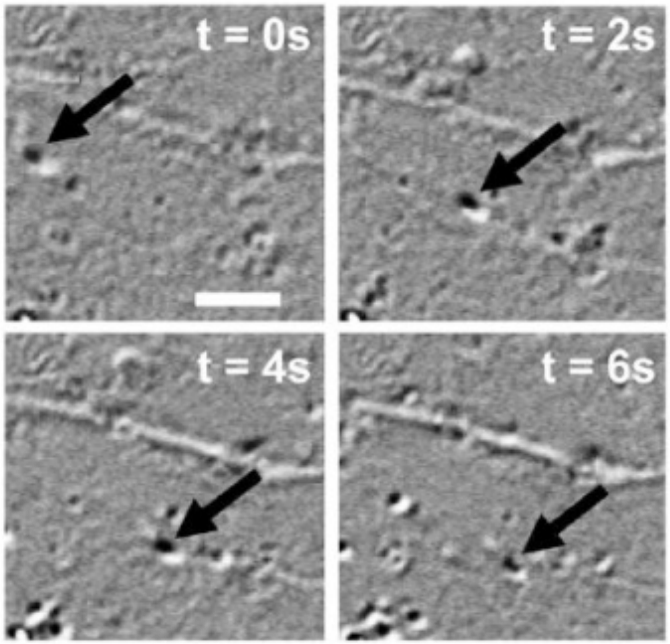
$dp_A = F_{net\text{-}A}\, dt_A$ $\quad$ $dp_B = F_{net\text{-}B}\, dt_B$

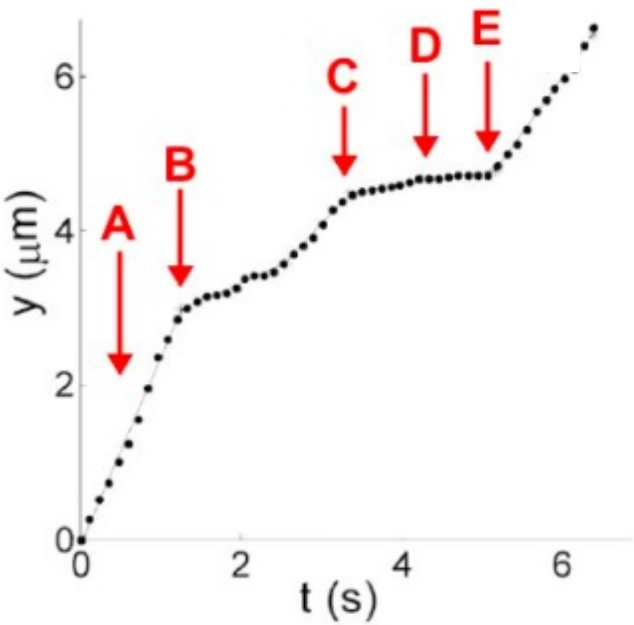
We know $F_{net\text{-}A} = F_{net\text{-}B}$ and $dt_A = dt_B$

Thus $dp_A = dp_B$, but $v_A < v_B$

You are cruising along 496 at 70mph (31 m/s) while trying to adjust your ipod and you go careening into the guard rail, coming to a stop. Luckily you have airbags that compress .5m when impacted. How long would you have for the airbag to slow you down?

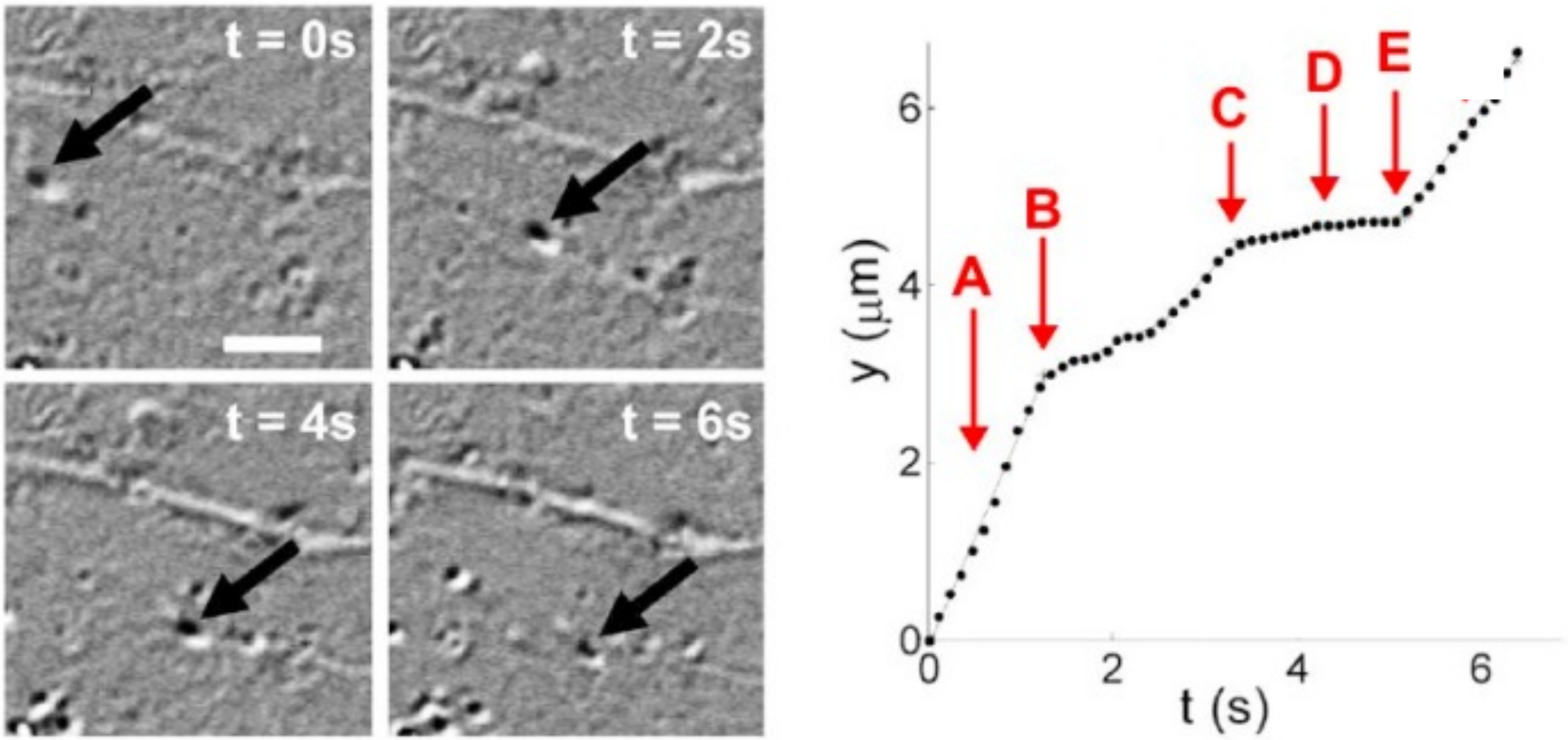
In a study of the forces involved when motor proteins move subcellular structures in cells, Shtridleman et al.* extracted the position of a vesicle using video. Some of the frames are shown in the figure below and a graph of the position of one of the vesicles that moved along a straight line (in a direction they call y) is shown at the right.



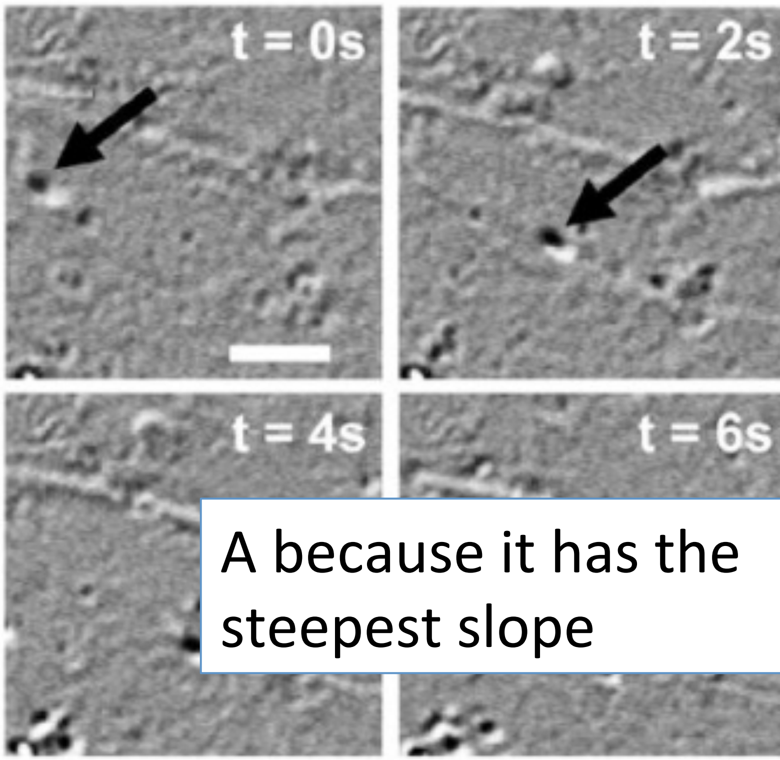


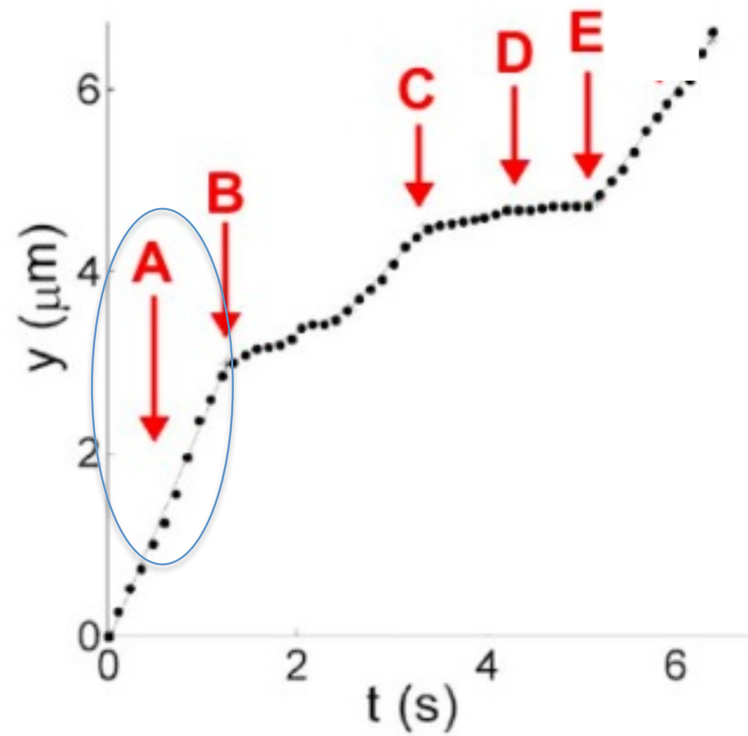
* Force-Velocity Curves of Motor Proteins Cooperating In Vivo, Y. Shtridelman, et al., *Cell Biochem Biophys*. (2008) 52(1): 19–29

Which label on the graph would best describe the instant of time at which the vesicle is moving with the highest speed?



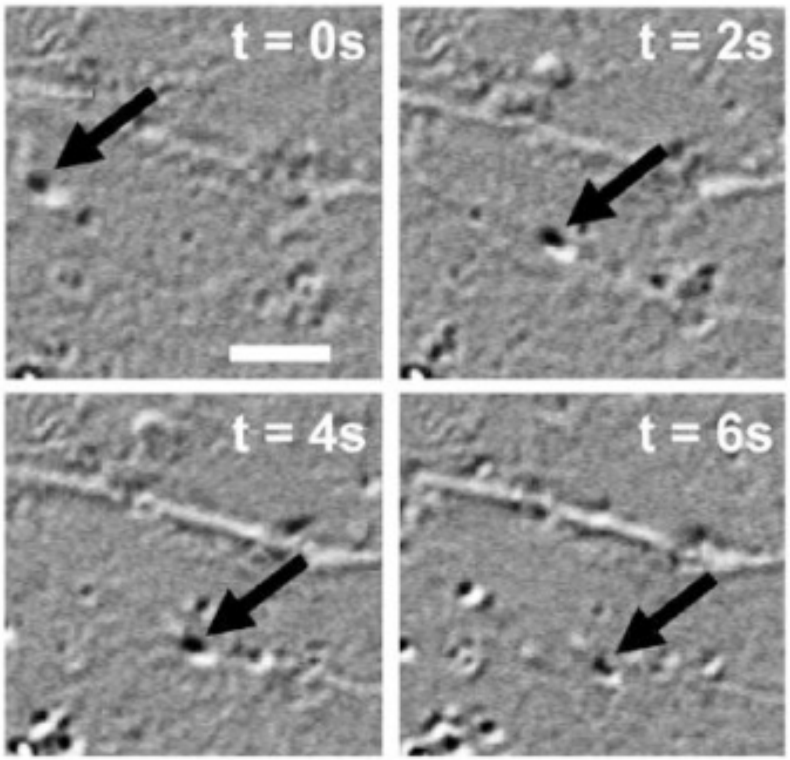
Which label on the graph would best describe the instant of time at which the vesicle is moving with the highest speed?

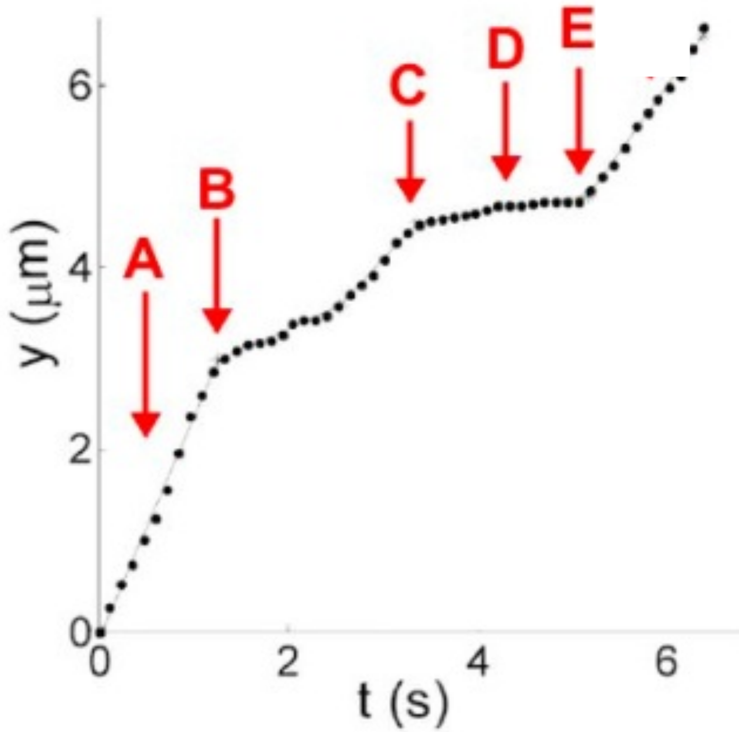




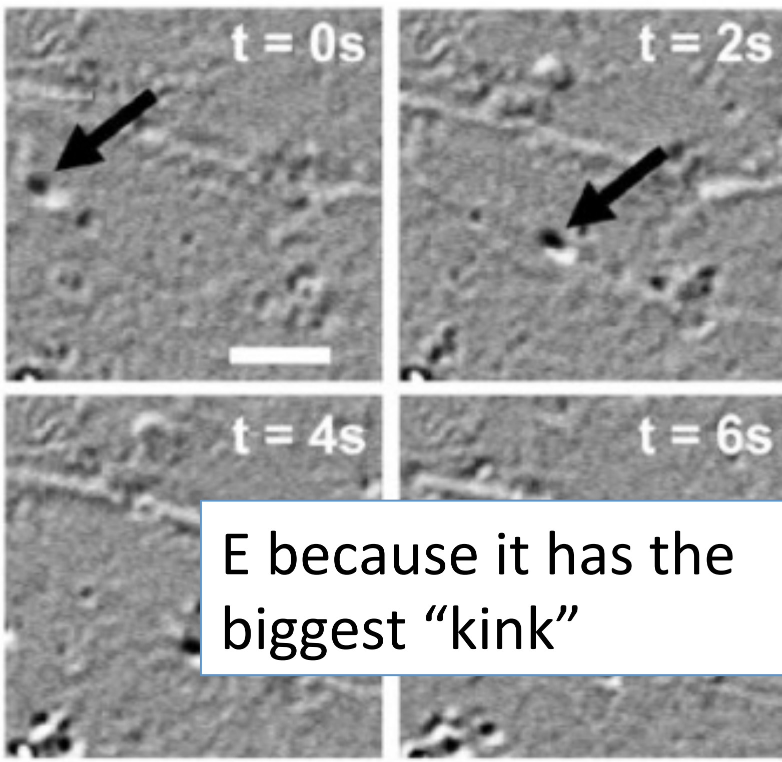
A because it has the steepest slope

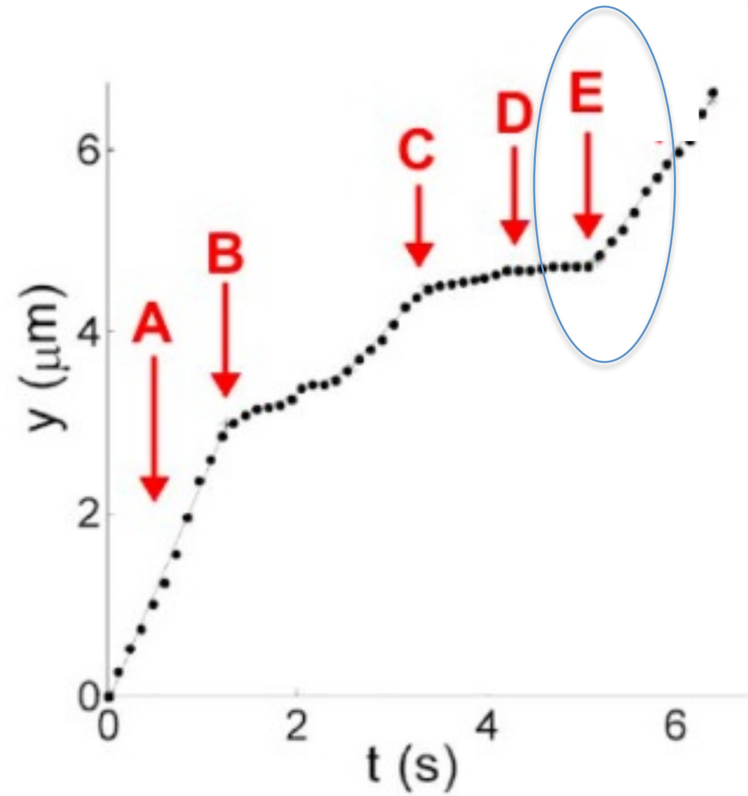
Which label on the graph would best describe the instant of time at which the magnitude of the acceleration is the largest?





Which label on the graph would best describe the instant of time at which the magnitude of the acceleration is the largest?





E because it has the biggest “kink”