- Let's first REVIEW ws08 Q1 from last time. (Start from "elevator" reading question: same idea!)
- worksheet: `positron.hep.upenn.edu/p8/files/ws09.pdf`
- 3 calculations, 3 short conceptual force Q's,
  1 more optional/XC calculation
- Atwood hands-on activity: do it either today or Wednesday.
- Before next class meeting, watch my ch09 ("day10") video.

Make a habit of drawing a FBD for object B, then using that FBD to write Newton's second law for object B. (Likewise for system.)

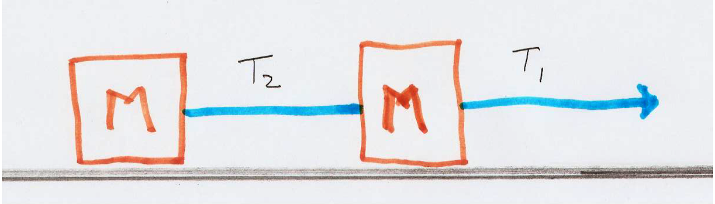
$$m_B\, a_{x,B} = \sum F_{x,ON\,B}$$

$$m_{\rm system}\, a_{x,{\rm system\,CM}} = \sum F_{x,{\rm external\,ON\,system}}$$

$$F_{x,{\rm by\,spring\,ON\,load}} = -k\,(x - x_0)$$

A cable of negligible mass exerts force of same magnitude at both of its ends: that magnitude equals the tension T in the cable.

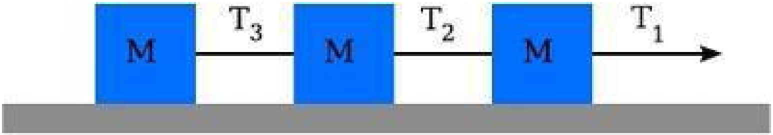
Two blocks of equal mass are pulled to the right by a constant force, which is applied by pulling at the arrow-tip on the right. The blue lines represent two identical sections of rope (which can be considered massless). Both cables are taut, and friction (if any) is the same for both blocks. What is the ratio of T_1 to T_2?



(A) zero: $T_1 = 0$ and $T_2 \neq 0$.
(B) $T_1 = \frac{1}{2} T_2$
(C) $T_1 = T_2$
(D) $T_1 = 2 T_2$
(E) infinite: $T_2 = 0$ and $T_1 \neq 0$.

It's worth drawing an FBD first for the two-mass system, then for the left mass, then for the right mass.

Three blocks of equal mass are pulled to the right by a constant force. The blocks are connected by identical sections of rope (which can be considered massless). All cables are taut, and friction (if any) is the same for all blocks. What is the ratio of T_1 to T_3?



(A) $T_1 = \frac{1}{3} T_3$

(B) $T_1 = \frac{2}{3} T_3$

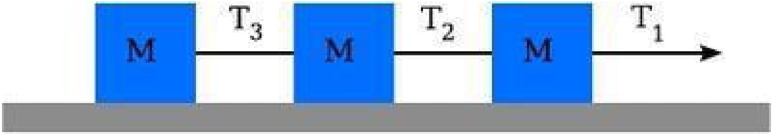
(C) $T_1 = T_3$

(D) $T_1 = \frac{3}{2} T_3$

(E) $T_1 = 2 T_3$

(F) $T_1 = 3 T_3$

Three blocks of equal mass are pulled to the right by a constant force. The blocks are connected by identical sections of rope (which can be considered massless). All cables are taut, and friction (if any) is the same for all blocks. What is the ratio of T_1 to T_2?



(A) $T_1 = \frac{1}{3} T_2$

(B) $T_1 = \frac{2}{3} T_2$

(C) $T_1 = T_2$

(D) $T_1 = \frac{3}{2} T_2$

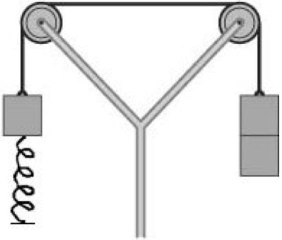
(E) $T_1 = 2 T_2$

(F) $T_1 = 3 T_2$

1. Hands-on activity! We have set up four copies of an Atwood machine at tables 9 and 10. The masses m_1 and m_2 are adjustable in 5 gram ($0.005\,\mathrm{kg}$) increments. Remember that the key result from the video was that the acceleration of the masses, once released, is $a_x = (m_1 - m_2)g/(m_1 + m_2)$. (You'll derive a variant of this result in problem 3.) Tinker with the Atwood machine yourself and try (a) to see qualitatively how a_x depends on the two masses, and then try (b) to measure quantitatively the acceleration a_x for one combination of masses. See if you can get better agreement here than Bill managed to get in the video! The main goal is simply for you to gain some insight by working with your own hands and eyes, but we'll offer a bonus point if you decide to explain clearly how you checked the prediction for a_x against your own measurement.

2*. You want to hang a potted plant from the ceiling of an elevator that has a maximum acceleration of $3.1\,\mathrm{m/s^2}$. (a) If you hang the plant with fishing line that supports a maximum tension of 54 N (ie its tensile strength is 54 N), what is the maximum inertia (ie mass) the plant can have if the line is not to break? (b) What combination(s) of slowing down, speeding up, going up, and going down will cause the most tension? (Explain.)

3*. A modified Atwood machine is shown below. Each of the three blocks has the same inertia m. One end of the vertical spring, which has spring constant k, is attached to the single block, and the other end of the spring is fixed to the floor. The positions of the blocks are adjusted until the spring is at its **relaxed** length. The blocks are then released from rest. What is the acceleration of the two blocks on the right after they have fallen a distance D? (Your answer should be a symbolic expression for a_x, expressed in terms of m, g, k, and D. Be sure to indicate what convenion you use for the meaning of the sign of a_x.)



4*. A red 10.0 kg cart is connected to a green 10.0 kg cart by a relaxed spring of spring constant 30.0 N/m. The green cart is resting against another 10.0 kg cart, this one blue. All are on a low-friction track. You push the red cart to the right, in the direction of the green cart, with a constant force of 15.0 N.

(a) What is the acceleration of the center-of-mass of the three-cart system?

(b) What is the acceleration of each cart the instant you begin to push?

(c) What is the acceleration of each cart when the spring is compressed 0.200 m?

(d) What is the vector sum of forces (sometimes called "the net force," though not in our textbook) on each cart in part (c)?

[For part (c), you can save some time by treating the green+blue carts as a system, since they are (and stay — as long as the spring is pushing, not pulling) in direct contact and thus have equal acceleration.]

More chapter 8 conceptual questions.

5. You are in a stationary elevator, so that the contact force exerted by the floor on you is equal in magnitude to the force of gravity acting on you. When the elevator starts downward, which force changes? What happens to its magnitude?

6. Walking beside a pasture, you and a fellow student see a farmer pulling a mule with a rope and getting nowhere. Your friend says, "The force with which the mule is pulling on the rope has the same magnitude as the force with which the farmer is pulling on the rope, but the two forces point in opposite directions. Because the two forces cancel, the tension in the rope is zero." How do you respond?

7. A delivery person in an elevator is holding a package by a spring-like elastic cord. (Don't ask why.) (a) What happens to the length of the cord when the elevator accelerates upward? Draw the free-body diagram for the package in this case. (b) What happens to the cord's length when the elevator slows to a stop after its ascent? Draw the free-body diagram for the package in this case.

8*. Optional/XC. A tugboat pulls two barges (connected in series, like a train) down a river. The barge connected to the tugboat, carrying coal, has inertia $2.20 \times 10^3\,\mathrm{kg}$. The other barge, carrying pig iron, has inertia $3.30 \times 10^3\,\mathrm{kg}$. The frictional force between the coal barge and the water is $6.50 \times 10^3\,\mathrm{N}$, and that between the pig-iron barge and the water is $9.70 \times 10^3\,\mathrm{N}$. The common acceleration of all three boats is $0.250\,\mathrm{m/s^2}$. Even though the ropes are huge, the gravitational force exerted on them is negligible, as are their inertias. (a) What is the tension in the rope conecting the tugboat to the coal barge? (b) What is the tension in the rope connecting the two barges? (c) Repeat parts (a) and (b) for the case in which the order of the barges is reversed.

Rubric: 4 points per problem: 2 for effort, 2 for correctness.

- 4 points = correct or very nearly correct
- 3 points = minor mistake
- 2 points = major mistake
- 1 point = you haven't convinced us that you put in much effort to try to solve the problem
- 0 points = nothing or very little of substance written down
- For some problems (such as today's hands-on bridge model), it may be unreasonable for us to look for "correctness," so instead all 4 points will be for effort.
- 4 additional overall points for presenting your work clearly, with adequate reasoning. So if n is the number of problems, the total points will usually be $4n + 4$.