Physics 9 — Friday, August 31, 2018

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- I got online responses from 32/41 of you. If you have trouble, just email me: `ashmansk@hep.upenn.edu`
- This weekend, you have two things to read. (Both are on Canvas, since you may not have books yet.)
- For Monday (no class), read PTFP ch3 ("gravity, force, and space"): you'll learn fun facts about spy satellites, geostationary weather/TV satellites, and GPS.
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- Course web page is `positron.hep.upenn.edu/physics9`
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- Phys 8/9 alum Davis Butner will visit on 9/21 to speak with us about his internships doing architectural acoustics!
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Newton's three laws

- Who remembers the first law? Second? Third?
- How comfortable is everybody with these three laws and what they mean?
- It's worth carefully writing (or at least thinking) words like "BY" and "ON" when discussing forces, so that you don't double-count forces or get the directions reversed.

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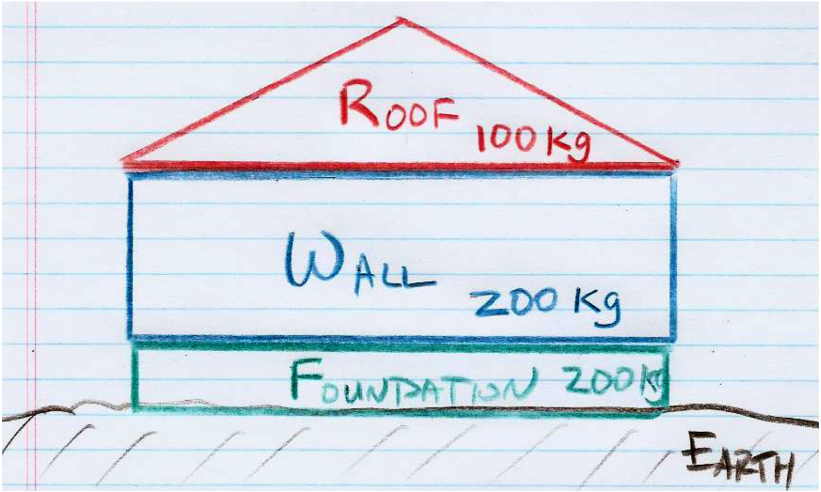
- It's worth carefully writing (or at least thinking) words like "BY" and "ON" when discussing forces, so that you don't double-count forces or get the directions reversed.
- Here is a statement of the third law that I find especially clear: "When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction on the first body."
- Also, for the second law: when you write $\vec{F} = m\vec{a}$ to find the acceleration of object O, it pays to spell things out:

$$\vec{a}_o = \frac{1}{m_o} \sum \vec{F}_{\text{(acting on O)}}$$

- The vector sum of the forces exerted **on** O (not **by** O) determines the acceleration of object O.

A statue (of mass m) is at rest on a table.

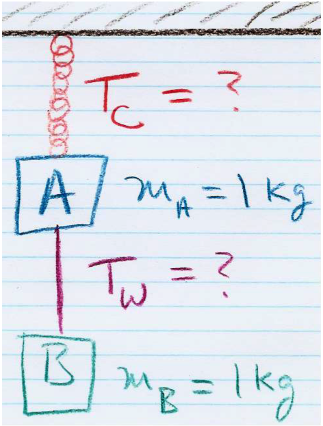
- Is the statue accelerating?
- Name all of the forces acting **on** the statue.
- Is the vector sum of these forces consistent with what we know about the acceleration?
- What other forces must exist, according to the third law?
- Are those other forces relevant for finding the acceleration of the statue?



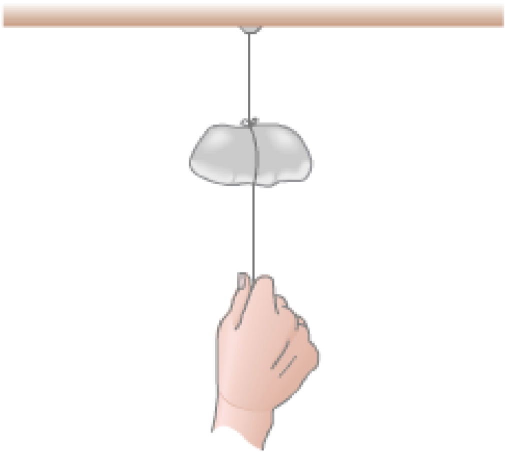
Last fall, we saw how "load tracing," working from top to bottom, lets us solve for forces in a structure. To refresh our memory of drawing Free-Body Diagrams, let's try drawing an FBD first for the Roof, then for the Wall, then for the Foundation. To keep things simple, consider only vertical forces, with lines of action passing through the center of each object. Use $g \approx 10\ \mathrm{N/kg}$ for gravity.

- I use a lightweight chain to suspend block A from the ceiling. Then I use a lightweight wire to suspend block B from the bottom of block A.
- The blocks' masses are $m_A = m_B = 1\ \mathrm{kg}$.
- List all of the forces acting on block A.
- List all of the forces acting on block B.

- What if I make the blocks accelerate upward: $a_y > 0$?
- What if I make the blocks accelerate downward: $a_y < 0$?



A stone hangs by a fine thread from the ceiling, and a section of the same thread dangles from the bottom of the stone (Fig. 4–36). If a person gives a sharp pull on the dangling thread, where is the thread likely to break: below the stone or above it? What if the person gives a slow and steady pull? Explain your answers.



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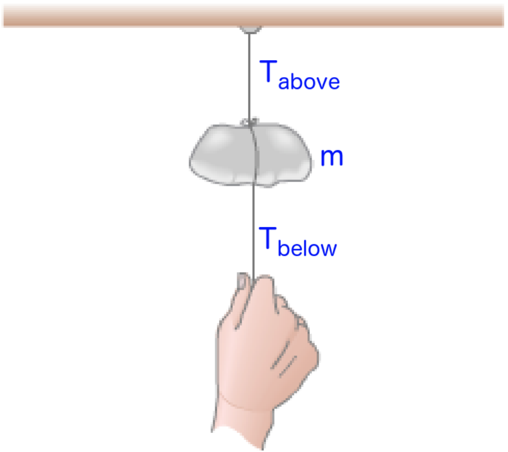

- What force (exerted by what on what) causes a car to accelerate forward when you step on the "accelerator" pedal?
- I stand on the floor and set a demonstration cart into motion by pulling on a tow rope. Why does the cart accelerate? Why do I not accelerate?
- If the acceleration of an object is zero, can I conclude that there are no forces acting on it?
- Only one force acts on an object. (Suppose the force has a magnitude of 1 newton.) Can the object have zero acceleration? Can the object have zero velocity?
- If you walk along a log floating on a lake, why does the log move in the opposite direction?
- The force of gravity on a 2 kg rock is twice as large as that on a 1 kg rock. Why then doesn't the heavier rock fall faster?

- A kid's toy car is at rest on the floor of a moving schoolbus. The schoolbus driver jams on the brakes. The kid sees the car accelerate forward. What coordinate system should she use, if she wants to use Newton's laws to analyze this situation?

We can work through this if we have time left

- You enter an elevator on the ground floor ($y = 0$). You push the button to take you to the top floor. You feel the elevator start to move. Ten seconds later, the elevator stops at the top floor ($y = 20\ \mathrm{m}$).
- Sketch the position (height) vs. time: $y(t)$.
- Sketch the (vertical) velocity vs. time: $v_y(t)$.
- Sketch the (vertical) acceleration vs time: $a_y(t)$.
- What is a reasonable guess for the range of $a_y(t)$ values that you will experience while riding the elevator? (Most architects design buildings to be comfortable for their occupants.)
- Draw a FBD for the passenger when the elevator is (a) at rest, (b) moving at constant velocity, (c) $a_y > 0$, (d) $a_y < 0$.
- What would happen if the largest downward acceleration were $a_y = -12\ \mathrm{m/s^2}$?

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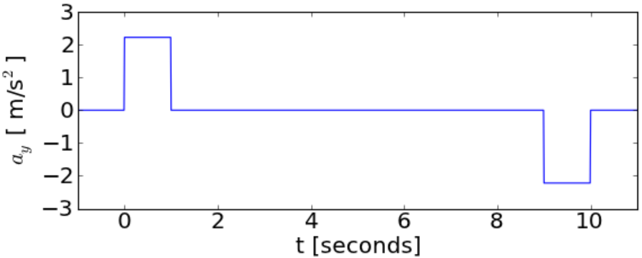

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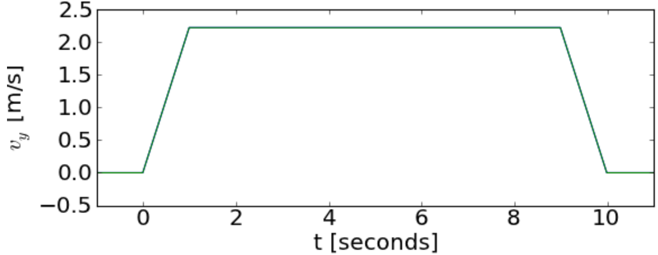
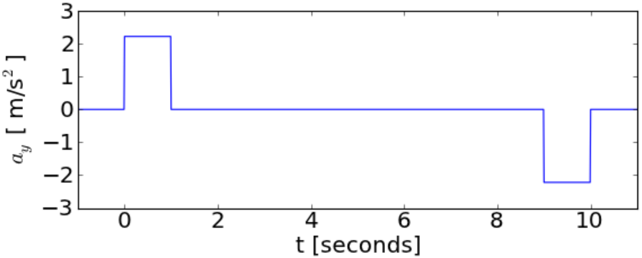


- Sketch the (vertical) acceleration vs time: $a_y(t)$.



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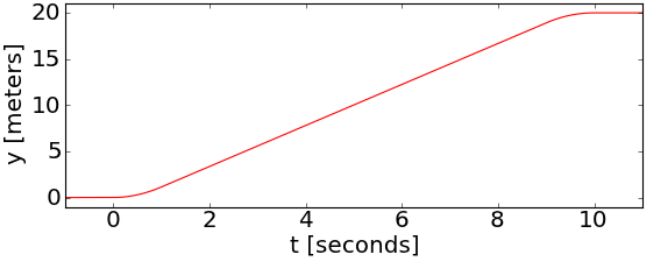
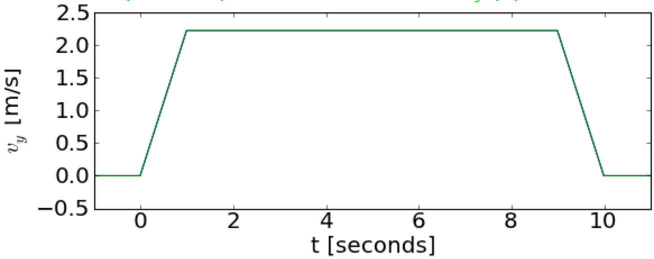
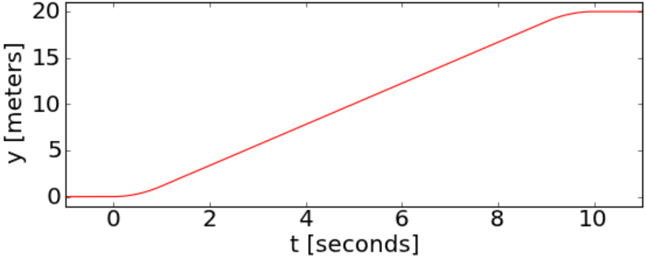


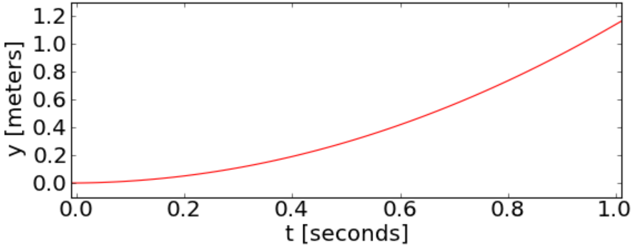
- Sketch the (vertical) velocity vs. time: $v_y(t)$.

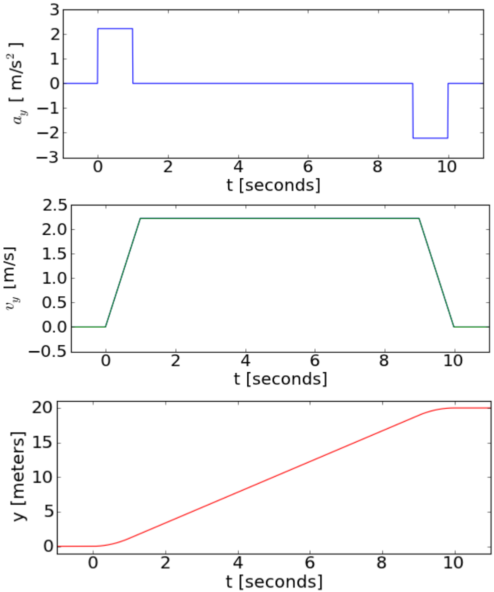


- Sketch the position (height) vs. time: $y(t)$.

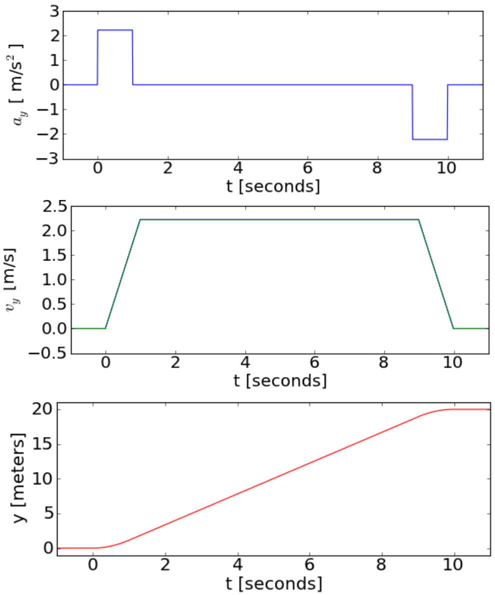


- By the way, if we zoom in on the part of the $y(t)$ graph where the elevator is accelerating upward ($0 < t < 1\ \mathrm{s}$), what mathematical shape does that little segment of $y(t)$ have?

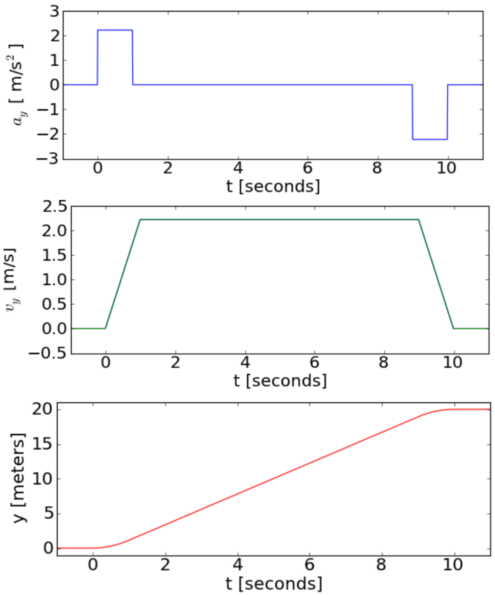




Suppose I am standing on a bathroom scale while I ride the elevator. During what time interval(s) will the scale read my correct weight?



If my actual weight is $mg \approx 700\ \mathrm{N}$ ($m = 70\ \mathrm{kg}$), what will the scale read for $0 < t < 1\ \mathrm{s}$?



If my actual weight is $mg \approx 700\ \mathrm{N}$ ($m = 70\ \mathrm{kg}$), what will the scale read for $9 < t < 10\ \mathrm{s}$?

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- (What does the FBD look like if $a_y = -9.8\ \mathrm{m/s^2}$ exactly?)
- What would happen if the largest downward acceleration were $a_y = -12\ \mathrm{m/s^2}$?

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