Joel Herzfeld
Guest teaching for Prof. Jennifer S. Light's "Embodied Education" class at MIT
Thursday 14 Sept 2023

Jennifer S. Light
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STUDENTS WILL UNDERSTAND:
How partnering movements can be connected to physics concepts

STUDENTS WILL BE ABLE TO:
Forge original connections between physics material and partnering movements

BEFORE THE LAB:

--Have students read the two chapters from the online resource Jen found.
https://www.physicsclassroom.com/Physics-Tutorial/Newton-s-Laws

--Clothing announcement about what to wear for acrobatics

--Announcement that partnering is a hands-on activity. Students may be asked to have hands on hips, armpits, thighs. Students can privately opt out beforehand if they don't want to participate, and can also opt out of any specific movement they like day-of.

--Announcement that partnering inevitably entails risk; students can privately opt out beforehand if they don't want to participate

LAB EXERCISE DAY

1. Potentially: A few minutes for preparatory questions about how students think they'll be using the material before we start our warmup.

Guiding Questions for the class:
What forces are at play at this moment? What are their magnitudes and directions?
How do these movements change and adapt to different bodies?

2. Warmup
Break it down step-by-step so students learn what goes into a good circus warmup. (Potential to organize this into a handout for students to take with them.)

3. Spotting technique and physics (general)
--protect the flyer's head
--where to catch a falling body
--how to fall (try not to get in your spotter's way)
--potentially: general physics of spotting (with input from students if possible)

(Students form into groups of 3-4. Ideally, they group with people of similar body size. Switching is allowed, but ideally students will stick to their same group the entire class.)

4. Skills!

Skill template:
1. Demo a skill with only minimal explanation of technique.
2. (Ideally:) Have students analyze the technique, using as much physics language as possible.
3. Fill in the blanks on things students may have missed.
4. Spotting technique (including physics discussions as applicable)
5. STUDENTS GET TO TRY! (groups of 3-4)
6. Students give feedback to each other in neutral language on what worked and what didn't, using as much physics jargon as possible.
7. Maybe each skill comes with a target question or two from the Theory / Application / Critical Thinking document. Remember also the Guiding Questions above.
8. Groups have time to try each trick several times, ideally in different combinations. Each student is encouraged to try each role, according to their comfort level.
9. Remind students that we will have a norm of Awareness, not Avoidance, when it comes to body size. Size is a neutral descriptor that is relevant in physics and circus, and one size isn't better than another! The things we aren't comfortable speaking about become unspeakable.

(If we have access to whiteboards, maybe we can put down step-by-step instructions and technical advice for each skill as we do them. We can also add the Guiding Questions and/or specific trick-oriented questions if there's room.)

While skills are happening, Jen + Joel go from group to group, offering technical and pedagogical advice. Another optional question we might want to give to groups to consider is what strategies we might use to teach these skills / the physics concepts to a classroom of high-schoolers.

Play by ear with how many skills we'll try.

A list of some skills we might include:

COUNTERBALANCE SKILLS
Hand-holding demo
Thigh stands (front and back)
Split lever

Foot flags (for acrobatically experienced groups)
Three-headed dragon (maybe)

WEIGHT-STACKING
Solid Base
Candlestick (for upside-down-experienced people)
Solid base wall (end trick)

5. Ending tableau
A solid-base wall or even maybe a more complex arrangement of students (depending on how it goes) including everyone for a fun group finish.

6. Cooldown
Make sure to explain the elements that go into a good cooldown
(potential for a handout on this subject too)

7. Critical thinking questions / group discussion
Potentially happening even during the cooldown? Give students time to share some things they discovered.Perhaps discuss/relate insights to Guiding Questions or Critical Thinking Questions if possible.
Or:
How would I teach this in high school? What limitations would I face? How might I overcome them?

8. End!
Students can give feedback to the instructors if they like about what worked and what didn't.

Critical thinking questions from Lessons 1 and 2 of:
https://www.physicsclassroom.com/Physics-Tutorial/Newton-s-Laws
Joel Herzberg

THEORY: Newton's first law: Objects in motion stay in motion, and objects at rest stay at rest. "Inertia" is the resistance an object has to a change in its state of motion.
APPLICATION: What's harder: Getting into a position, or holding that position once you've found it? Once you hit a position, it's stable(r). The hard parts are the mounts and dismounts.

THEORY: The more inertia an object has, the more massive it is. A massive object is more resistant to change in its state of motion than a less massive object. Inertia can be redefined as: tendency of an object to resist changes in its velocity.
APPLICATION: A more massive base can more easily absorb the movement of an unstable flyer, whereas a less massive base will need to have more accurate technique to stabilize the same flyer.

THEORY: Forces of equal magnitude in opposite directions balance each other.
APPLICATION: Is a counterbalance an equilibrium? Explain the magnitude and direction of the forces at work in a counterbalance. Critical thinking: Is an acrobalance a true equilibrium? How do constant micro-adjustments play into our understanding of equilibrium?

THEORY: When balanced forces are acting upon an object, that object may be in motion, or it may be at rest, but it will not be accelerating.
APPLICATION: What forces are at play in weight-stacking? Critical thinking: Would you judge weight-stacking to be more or less stable than a counterbalance? Does your answer change after you've tried it?

THEORY: Force stems from interaction between objects. There are two broad categories of forces: Contact forces and forces resulting from action-at-a-distance. We also have specific individual forces that make up these categories, e.g., Applied Force or Normal Force.
APPLICATION: What forces are at play in weight-stacking? In counterbalance?

THEORY: Force is a vector quantity
APPLICATION: How can we guess at the direction and magnitude of the forces in action in a counterbalance? In a weight-stack?

THEORY: A free-body diagram tells us what forces are acting on a body.
APPLICATION: How is a free-body diagram of an individual standing different from a two-person counterbalance?

THEORY: If there is a net force acting on a body, that body is accelerating (or decelerating).
APPLICATION: At what stages of a trick are there net forces acting on bodies? Who generates these forces? How are they balanced?

THEORY: The center of mass of an object or system can be found using vector addition.
APPLICATION: How is the center of mass of a counterbalance different from the centers of mass of the individuals involved? Do we get any surprising results for the location of the center of mass when in counterbalances?

CRITICAL THINKING:
Why is it easier to control a position if the flyer does nothing and leaves the balancing to the base?

CRITICAL THINKING:

A counterbalance is unstable until equilibrium is reached. What forces are at work before equilibrium? What about afterward, during the dismount?

CRITICAL THINKING:
For tricks where a flyer needs to be lifted into position, like a thigh stand, or a lift, what role does momentum play in the trick?

CRITICAL THINKING:
I can make vector diagrams to indicate the forces at work during the stages of mounting and dismounting a skill. In what ways are the vector diagrams of a counterbalance mount similar and different to a weight-stacking skill?