



## Unit on Force and Motion: March 18<sup>th</sup>

### Transition to the next Puzzling Phenomenon: Forces at Work in Simple Machines



#### To understand the language in these commentaries...

It is important to have read our Discourse Primer, found at:

[http://tools4teachingscience.org/tools/discourse\\_tools/primer.html](http://tools4teachingscience.org/tools/discourse_tools/primer.html)

The commentaries also draw upon the language of our Discourse Tools, which should also be reviewed first:

[http://tools4teachingscience.org/tools/discourse\\_tools/index.html](http://tools4teachingscience.org/tools/discourse_tools/index.html)



#### As you watch this video episode...

Keep track of where you are by noting the time codes in the left-hand column. In the right-hand column are important features of the classroom discourse.

In one or more of the time segments, we ask you to do more than follow along—we leave the discourse commentary section blank. Here we ask you to listen closely to the video and fill in the commentary yourself.

The teacher's commentary for these sections can be found at the end of the document. Compare what you heard with what the teacher noted.

#### Summary of Episodes:

1. How the two units are connected – helping students see engineering as an extension of physics-for-physics'-sake.
2. Demonstration of the ropes/sticks pulley system.
3. Small group exploration & beginning explanations of the ropes/sticks pulley systems.

Time points	Commentary
0:00 → 3:42  Transition from doing physics-for-its-own-sake to doing applied physics (engineering) tasks.	<ol style="list-style-type: none"> <li>1. Connecting the physics we've been doing to the ways in which you might apply those ideas – such as in engineering.</li> <li>2. Showing cartoon of the little monkey lifting the big elephant with a pretend system of pulleys.</li> <li>3. Raising the idea that a “pulley” does not need to contain a wheel – a pulley could also be made from ropes + sticks or just from ropes with knots or carabineers.</li> </ol>
3:43 → 8:20  Demonstrating the ropes + sticks pulley system with Jadyn, Yael, and Hilina.  Setting up the intellectual work that students should be doing while experimenting with the rope/stick pulley	<p><b>Important ideas/language I heard:</b> 6:50 – Samson: “Jadyn doesn't look like he's pulling very hard.” (students are starting to make observations &amp; comparisons between the different people pulling) ... Students will have more opportunities to make these observations in the next episode so I'm not taking much time to discuss ideas/observations right now.</p> <p><b>Important moves:</b> Trial #1 – I position Hilina (the tiniest person) as “the muscles” of the group so we can later talk about how a smaller person might be able to use pulley systems to move heavy objects.  Trial #2 – I have the same group of three students switch positions so that</p>

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system.

they are able to feel the differences in the forces exerted at each spot. You can't understand these differences until you feel them for yourself.

7:20 – Framing the Upcoming Activity –

Before having all of the students try out the sticks and ropes, I frame the activity by highlighting some of the things that I'd like the kids to pay attention to and some of the question that I'd like them to be thinking about.

1. Who is having to pull really hard and who is having an easier time pulling?
  - a. Trade jobs so that you can talk to each other about what it felt like at each position.
2. Why is it possible that one person has to pull really hard and another person doesn't have to pull as hard?

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8:20 → end

Small groups of students try out the sticks/ropes pulley systems and start making observations about how hard or easy it felt to pull the system at each position.

**Important ideas/language I heard:**

9:00 – Destiny: “Are you man enough, Bradley? Do you have the muscles? ‘Cause I’m not moving anywhere.” – In her own way, Destiny is making an observation about the differences between the force that she is exerting & the force that Bradley is exerting.

In response to my press for explanation:

10:18 – Shawna: “Maybe it’s because this side is the same side as the puller” ... then Liliana adds an idea about “this rope being the first one” by which she means that the “first” segment of rope pulls directly on the opposite stick exerting “more direct force” in her mental model of the system. Then, Amy suggests a “what if” that can be immediately tested with the ropes/sticks set-up. She wants to add another loop and pull from Shawna’s side. It’s not clear what Amy’s unspoken hypothesis is at this point, but it is something that we can test out. If I could do this piece of discourse over again, I would like to get Amy to say aloud whatever it is that she is thinking about that prompted her to propose this little experiment. I ask Liliana about her theory, but I don't ask Amy about her ideas.

**Questions I use to help kids say more (you fill in below, then check your observations against teacher commentary at end of this document)**

**Press for Explanation:**

***Section starting at 13:03 – Probing into Liliana’s Theory about More Direct Force –***

13:03 “What do you guys think about Liliana’s theory ...”

Here I’m getting the group to elaborate on and comment on Liliana’s original

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idea that the segment of rope held by the puller is exerting “more direct force” and is therefore responsible for pulling the opposite stick with greater force.

13:25 “What if there were no loops at all ...”

Following up on Liliana’s idea about “more direct force” and Shawna’s idea that the force of the puller “gets to the stick first”, I propose a simplified scenario where there are no loops – essentially no pulley, JUST “direct force” – in order to see how the girls’ model will change.

→ Liliana maintains that Amy “will win” because Amy is pulling on a rope while Liliana is pulling on a stick attached to the rope.

13:50 “What if it was just like that ...”

Following up on Liliana’s assertion, I slip the rope off of the stick and hand just the rope to Liliana. I’m creating the simplest pulling phenomenon possible – two people pulling in opposite directions on a rope – in order to push the girls to talk more about their ideas of “most direct force” and “force getting there first.” In Model-Based Inquiry, this is a kind of rule-of-thumb: after examining a complex scenario, help students think about one segment or one, simplified condition in order to start building their model.

→ Liliana responds to this scenario with a good prediction: “Then it would matter who was pulling harder.” I can now start helping Liliana build on this premise.

14:02 “So then why does looping it around ...”

Pushing students to theorize about why wrapping the rope around the sticks makes it pull differently than just pulling the rope like a tug-of-war.

We see the girls have the classic response to being “pressed” – they stammer a little and struggle to piece together some ideas. But, importantly, you can also tell that they are accustomed to this kind of press so they don’t get overly uncomfortable. It takes a LONG time to create this kind of comfort zone.

→ 14:35ish – Liliana suggests that friction between the rope and the sticks somehow INCREASES the force felt by the people holding the sticks. I play “devil’s advocate” and question her about her ideas.

15:15 – Here I notice that the girls have run out of ideas or have at least started feeling the pressure of my pressing so I back off and table their ideas until our next class session. I think a key part of creating a classroom culture that is full of “pressing” is that you also have to know when to let students off of the hook before they start to feel crushed.

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END OF LESSON

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Teacher's  
commentary from  
8:20 → end

**Questions I use to help kids say more:**

9:40 – “So where do you guys feel like it’s the hardest to hold it?” ... “What about at this position?” ... “And when you’re the ‘puller’ do you feel like you have to do a lot of work?” ... “So do you all agree ...” Here I am using some questions to help the students agree publicly on their observations about the differences in pulling forces felt at each location in the system.

10:08 – “So now your next job is to try to figure out WHY that is. What’s going on with the ropes ...” Here I am pushing students to begin to think about possible explanations – involving the ropes (i.e., forces) – for the differences that they felt at each position in the system.

**Press for Explanation:**

10:08 – “So now your next job is to try to figure out WHY that is. What’s going on with the ropes ...” Here I am pushing students to begin to think about possible explanations – involving the ropes (i.e., forces) – for the differences that they felt at each position in the system.

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