Mandatory 3, Lab Practicum Choice 2: Virtual Labs with PHET Physical Science in Motion: Classroom Applications (Fall 2024) Cindy Phillips

The lab I choice was (also at the end of this document)
https://phet.colorado.edu/services/download-servlet?filename=%2Factivities%2F6755%2Fphet-contribution-6755-10903.pdf

Since I am not teaching, nor am I teaching physics, I have decided instead to make modifications to the lab itself, as I found this lab truly uninspired.

My critiques and changes:

- The written directions were correct, but given that there were no screencaps to show what he meant, the instructions would be harder to follow for a student with any special needs. I provided the link directly (which could be replaced with a QR code for a student handout; I will presume the students can access the lab with a device.) I have rewritten the directions with visuals.
- The lab itself should refer to the goals of the lab; it is written on the sim opening page but it is below where most students won't look.
- I have changed all occurrences of "speed" to "velocity." The sim can push the cart in either direction although only positive values are shown; this can be discussed during class reflection
- I have modeled in the first lab a way for students to try to come to conclusions themselves; and with practice in theory they should be able to do that for future and more challenging topics in the rest of the PHET sims.
- I noticed that the lab designer put the last two columns "out of order," meaning the last one has to be determined before the next-to-last one can be determined. I don't know if that was done purposefully but I like the idea that I had to be challenged to determine the last column before the next to last column.
- The original lab gives multiple versions of the same formula with each variable already isolated; I understand that many physics teachers do this to address their students' challenges with math. I am challenging them to do that for themselves.
- I have provided a math and a technology extensions section to integrate other facets of STEM into the lab(s)

<u>How this lab reflects on Physics outcomes</u>
The lab as given was meant to reflect on a large number of concepts related to Newton's laws and the relationship between myriad forces. Unfortunately, most of that lab is just students filling out tables and answering questions. The students are spending more time filling out rows upon rows of data and spend much less time making sense of all the data collected.

I am hoping my redesign gives students a more open-ended way to explore, draw and test their hypotheses, more aligned with student-centered Levels of Inquiry. They are only given the

basics of how the sim works, and the background knowledge to formulate and test hypotheses according to what makes sense in the given scenarios.

I have also composed some ideas on how the labs can be connected to math classes with elements of technology. In this manner, the material is STEM integrated, and the students can make meaning of why someone would want to use math to “code” a spreadsheet in order to do the computations automatically.

Labs on motion

Topics

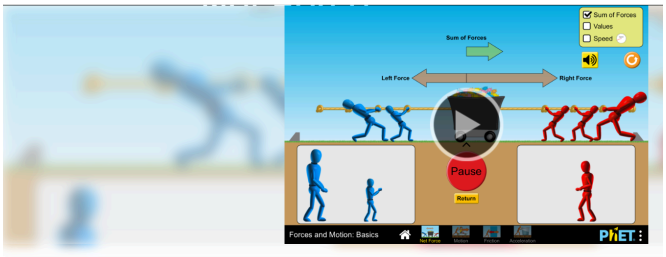
Force, Motion, Friction, Speed, velocity, Newton's First Law

Learning Goals

- Identify when forces are balanced vs unbalanced.
- Determine the sum of forces (net force) on an object with more than one force on it.
- Predict the motion of an object with zero net force.
- Predict the direction of motion given a combination of forces.

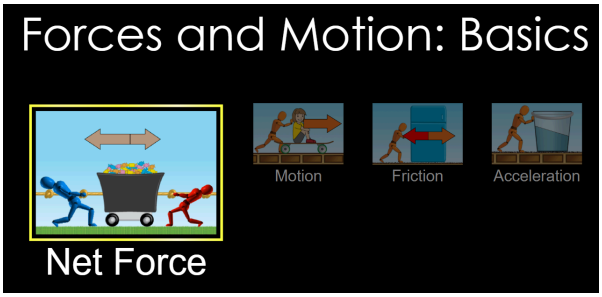
Directions:

Go to the lab called “Forces and Motion: Basics” by clicking this link: https://phet.colorado.edu/en/simulations/forces-and-motion-basics

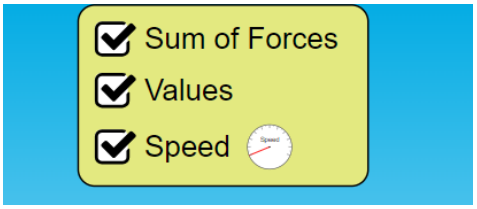


Forces and Motion: Basics

Then click the arrow in the center of the picture and you should see these four choices. First, choose “Net force,” the first option on the left.



On the upper right of the sim, there is a yellow box. Check all of the options as shown here:



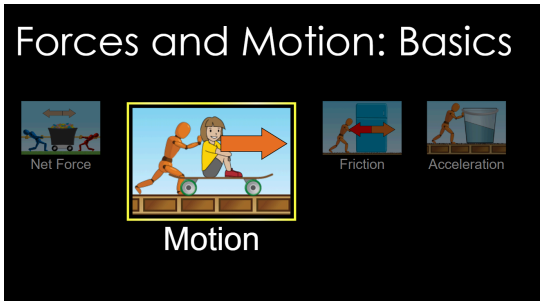
Part I: Net Force Lab

1. Play with the simulation until you seem to have an understanding of what you can control, and how that affects the simulation. Ask me any questions for clarification on what you are allowed to do on the simulation.

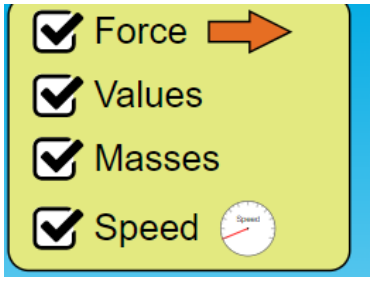
2. The arrows that show up represent the magnitude of forces in either direction. After playing around with the simulation for a while, answer the following questions
    a. What factors affect the **total left force**? What factors affect the **total right forces**? What factors seem to affect the **sum of forces**? Discuss this with your team and make sure your response is as specific as possible. Test out your theories with multiple cases, **including cases where there are no people on either or both sides!**
    b. What factor(s) seem to affect the speed as time passes?
3. Write down any remaining questions you still have about the sum of (net) forces and speed.

Part II: Motion Lab

Go back to the original link, and choose the second box called "motion" instead



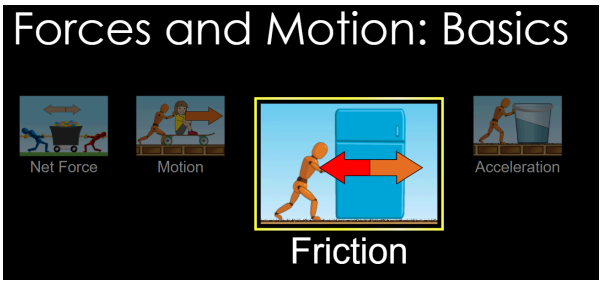
Check off all four options in the yellow box.

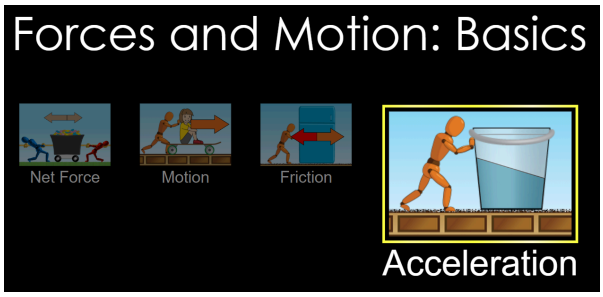


4. Looking at the instructions in Part I of this lab, similarly, play with the simulation to make sure you are clear on what the simulation will allow you to do.
5. Looking at the guided questions I gave you in #2, make a list of questions that this sim is leading you to determine the answers to, and answer those questions! Or, simply make a list of discoveries that the sim leads you to discover. You can write your conclusions in any format.

Part III, IV: Friction Lab and Acceleration Lab

Repeat steps #4 and #5 for the lab on friction and then acceleration.





Name: **Date:**

Student recording sheet: Motion Labs

Type all of your discoveries here, in either paragraphs or a numbered/bulleted list.

Net force
Motion
Friction
Acceleration

Mathematics Extensions

1. In mathematics, and in physics, we say that (Rate)(Time)=Distance or RT=D. In this case, our rate, or rate of change, is the velocity of the object.
   a. Solve this equation for T, meaning, perform necessary mathematical operations to isolate T. Right now, D is isolated.
   b. Do the same, but isolating R.

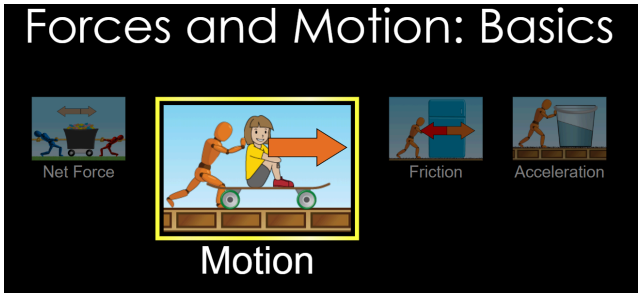
2. Velocity indicates a rate of change of position over time. If v represents the average velocity over a given amount of time, x_0 represents the initial position position of the object along a horizontal number line, x_f represents the final position position of the object along a horizontal number line, and t represents the amount of time that is passed, we can derive the formula $v = \frac{x_f - x_0}{t}$.
   a. The nature of this formula indicates that velocity can take on positive or negative values. Indicate the condition(s) under which velocity will result in a negative value.
   b. Indicate the condition(s) where velocity will take on a value of 0.
   c. Using appropriate mathematical operations, solve the equation for each of the variables x_0, x_f, t.

3. Acceleration is an indication of a rate of change of velocity over time. Look back at the development in the previous set of questions, and invent a formula for acceleration similar to that of velocity. Define each variable you use.

Technology Extension

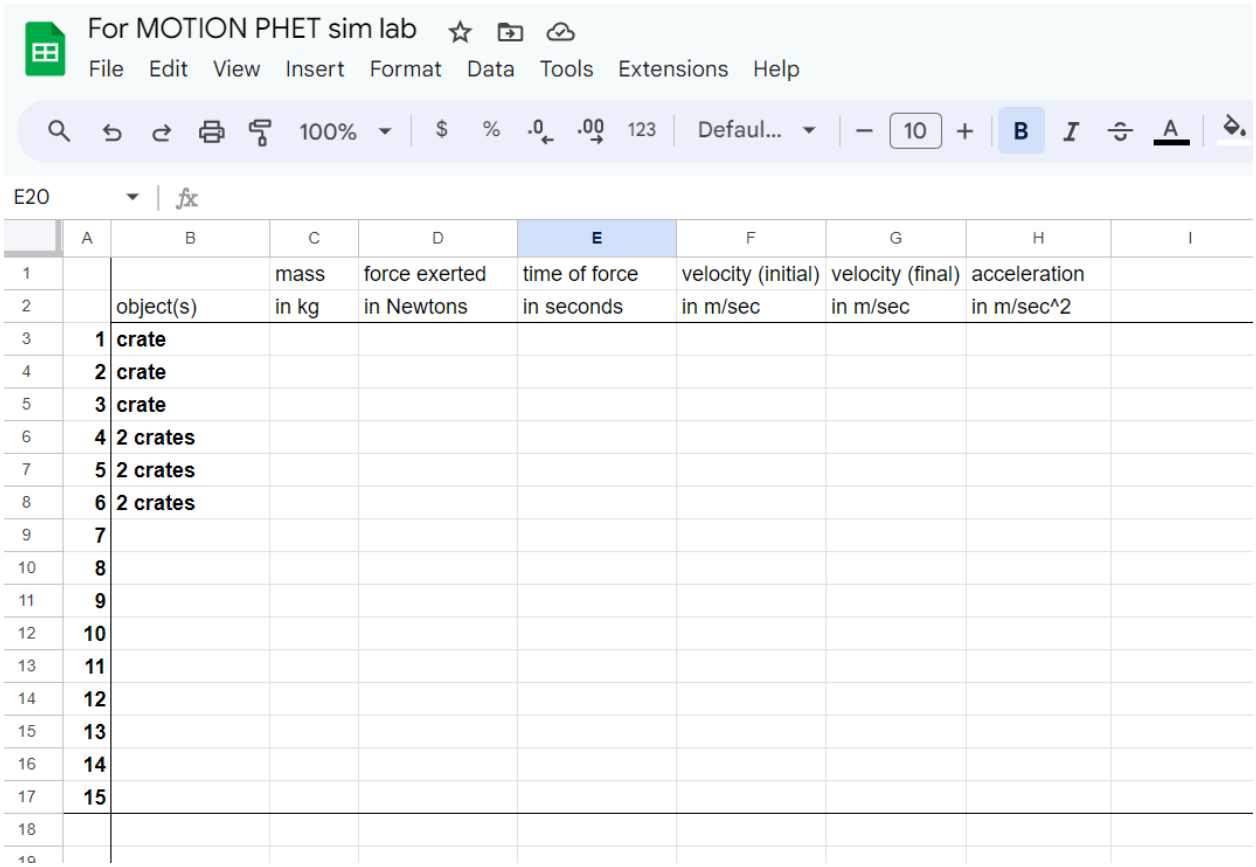
Using Excel, Numbers, or GoogleSheets, create a spreadsheet that looks like this (your teacher may have already provided one for you to use.)

We are going to use your discoveries in the "Motion" lab (below) to populate and program a spreadsheet so the calculations can be performed automatically, given certain conditions.



For the sake of this activity,

Notes to Student:
Columns C, D are independent variables but are controllable through the sim
Columns E, F are independent variables but you have flexibility on what you choose, is not indicated on the sim
Columns G, H are dependent on some of the variables in C-F and you need to determine which and how in order to create a formula!



	A	B	C	D	E	F	G	H	I
1			mass	force exerted	time of force	velocity (initial)	velocity (final)	acceleration	
2		object(s)	in kg	in Newtons	in seconds	in m/sec	in m/sec	in m/sec^2	
3	**1**	**crate**							
4	**2**	**crate**							
5	**3**	**crate**							
6	**4**	**2 crates**							
7	**5**	**2 crates**							
8	**6**	**2 crates**							
9	**7**								
10	**8**								
11	**9**								
12	**10**								
13	**11**								
14	**12**								
15	**13**								
16	**14**								
17	**15**								
18									

1. Fill out a total of 15 situations in Column B of your choosing.
2. Fill out 15 rows of independent variables in columns C-F.
3. Using what you have discovered in the “Mathematics extensions” portion of the lab, find an appropriate formula for columns G, H and use the copy/paste function to copy the formulas down to all 15 cases.
4. Select two cases by random and using what you know from your formulas, determine if you have programmed the spreadsheet correctly. Make adjustments as needed!

Original PHET Lab

Name _____ Period ____ February 7, 2022

Force PhET Simulation

Open PhET.colorado.edu. From the "Simulations" dropdown, select "Forces and Motion: Basics." Select "Net Force." Select "Sum of Forces," "Values," and "Speed" in the box at top, right. Answer the questions and fill in the table.

Speed = $\frac{distance}{time}$ Time = distance ÷ speed Distance = speed × time

Momentum = mass × speed Acceleration = $\frac{final\ speed - begin\ speed}{time}$ Force = mass × acceleration

_____ 1. With what force does the large figure pull?

_____ 2. With what force does the medium-sized figure pull?

_____ 3. With what force does the small figure pull?

_____ 4. What is the sum of the forces when one large figure is pulling against one large red figure?

_____ 5. What is the sum of the forces when one large blue figure is pulling against one large red figure?

_____ 6. What is the sum of the forces when one large blue figure is pulling against the large and the medium red figures? (Give magnitude and direction.)

_____ 7. What is the sum of the forces when one medium blue figure is pulling against the two small red figures? (Give magnitude and direction.)

Motion: Along the bottom of the page, select "Motion." Select "Forces," "Values," "Masses," and "Speed" in the box at top, right.

_____ 8. What is the mass of the wooden crate on the wheeled car on the tracks? (Enter in the table below.)

_____ 9. What is the speed of the wheeled car and one crate if pushed with 50 N of force for five seconds? (Enter in the table below.)

_____ 10. What is the speed of the wheeled car and one crate if pushed with 50 N of force for ten seconds? (Enter in the table below.)

_____ 11. What is the speed of the wheeled car and one crate if pushed with 50 N of force for fifteen seconds? (Enter in the table below.)

_____ 12. What is the speed of the wheeled car and two crates if pushed with 50 N of force for five seconds? (Enter in the table below.)

_____ 13. What is the speed of the wheeled car and two crates if pushed with 50 N of force for ten seconds? (Enter in the table below.)

_____ 14. What is the speed of the wheeled car and two crates if pushed with 50 N of force for fifteen seconds? (Enter in the table below.)

_____ 15. What is the speed of the wheeled car and two crates if pushed with 100 N of force for ten seconds? (Enter in the table below.)

_____ 16. What is the speed of the wheeled car and two crates if pushed with 150 N of force for ten seconds? (Enter in the table below.)

17. What is the speed of the wheeled car and two crates if pushed with 200 N of force for ten seconds? (Enter in the table below.)

18. What is the speed of the wheeled car and two crates if pushed with 250 N of force for ten seconds? (Enter in the table below.)

19. What is the speed of the wheeled car and the refrigerator if pushed with 50 N of force for ten seconds? (Enter in the table below.)

20. What is the speed of the wheeled car and the little girl if pushed with 50 N of force for ten seconds? (Enter in the table below.)

21. What is the speed of the wheeled car and the man if pushed with 50 N of force for ten seconds? (Enter in the table below.)

22. What is the speed of the wheeled car and the trash can if pushed with 50 N of force for ten seconds? (Enter in the table below.)

23. What is the speed of the wheeled car and the unknown wrapped present if pushed with 50 N of force for ten seconds? (Enter in the table below.)

Object	Mass	Force Exerted	Time of Force	$Speed_{begin}$	$Speed_{final}$	Acceleration
Crate		50 N	5 sec			
Crate		50 N	10 sec			
Crate		50 N	15 sec			
2 crates		50 N	5 sec			
2 crates		50 N	10 sec			
2 crates		50 N	15 sec			
2 crates		100 N	10 sec			
2 crates		150 N	10 sec			
2 crates		200 N	10 sec			
2 crates		250 N	10 sec			
Girl		100 N	10 sec			
Man		100 N	10 sec			
Trash can		100 N	10 sec			
Wrapped		100 N	10 sec			

24. Estimate the mass of the unknown wrapped present based upon its acceleration - comparing it to the knowns.

Friction: Along the bottom of the page, select "Friction." Select "Forces," "Sum of Forces," "Values," "Masses," and "Speed" in the box at top, right. Notice the crate no longer has wheels. Leave the friction slider where it starts, in the middle.

Object	Mass	Force Exerted	Force of Friction	Net Force	$Speed_b$	$Speed_f$	Time	$\vec{a}$
Crate		150 N					10 sec	
2 Crates		300 N					10 sec	
Refriger		500 N					10 sec	
Girl		150 N					10 sec	
Man		250 N					10 sec	
Trash		300 N					10 sec	
Unknown		150 N					10 sec	

Acceleration: Along the bottom of the page, select "Acceleration." Select "Forces," "Sum of Forces," "Values," "Masses," "Speed," and "Acceleration." Adjust the friction slider to "None."

Object	Mass	Force Exerted	$Speed_b$	$Speed_f$	Time	$\vec{a}$
Crate		100 N			10 sec	
2 Crates		100 N			10 sec	
Refriger		100 N			10 sec	
Girl		100 N			10 sec	
Man		100 N			10 sec	
Water		100 N			10 sec	