Virtual Laboratory

Topic 5 – FORCES and SIMPLE MACHINES

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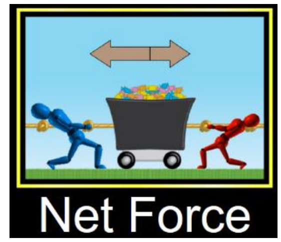
Name	Section #	Date	Topic #

GETTING STARTED: Google **PHET Forces and Motion: Basics**

NOTE: Sum of Forces = Net Force



A. TUG OF WAR: (Notice 4 choices on the page. Select Net Force.)

Make sure all of the boxes in the upper right-hand corner are checked.

1. Create a scenario on the rope in which the forces are **BALANCED** by clicking on and dragging the men to the rope positions. Click on the Go button.

   a) What is the **NET FORCE** on the cart?______________________________
   Explain how Newton's First Law applies to the **<u>cart</u>** this situation.
   ____

Comparing the Red Team's Force to the Blue Team's force: (circle the appropriate answer)

b) The direction and strength of the RED force is: **RIGHT** or **LEFT** and **SMALLER** or **LARGER or EQUAL**?

a) The direction and strength of the BLUE force is: **RIGHT** or **LEFT** and **SMALLER** or **LARGER or EQUAL**?

b) The NET force is in which direction? **RIGHT** or **LEFT** **or** **Not applicable**

2. Click **the orange reset button.** Create a scenario on the rope pull in which the forces are **UNBALANCED**. Click on the Go button.

   a) What is the **NET FORCE** on the cart? ____
   b) Describe how Newton's First Law applies <u>to the cart</u> in this scenario.
   ____

   c) Does Newton's second apply **to the cart** in this scenario?
   ____

   Explain why or why not. ____

Comparing the Red Team's Force to the Blue Team's force: (circle the appropriate answer)

a) The direction and strength of the RED force is: RIGHT or LEFT and SMALLER or LARGER or EQUAL?

b) The direction and strength of the BLUE force is: RIGHT or LEFT and SMALLER or LARGER or EQUAL?

c) The NET force is in which direction? RIGHT or LEFT or Not applicable

d) Explain how Newton's Third Law applies to the cart in both situations.

e) ____

B. MOTION: Click on the Motion Icon. Play around with the simulation so that you know how to use it. You can click on the objects below the track and drag them to the skate board. Change the applied force by typing the amount in the white box below the Applied Force slide or sliding the slider. Make sure that all of the boxes in the upper right-hand corner are checked (Force, Value, Masses, Speed) *There is **no** **FRICTION** in this scenario.

1. Place the refrigerator on the skateboard. **Calculate** the acceleration of the Skateboard/Refrigerator if a PUSH force of 100 N is applied to it, __________________, (Don't forget the units!) Will the Skateboard/Refrigerator continue accelerating if the PUSH force is removed? (highlight the answer) **YES** or **NO**

2. Apply a **PUSH** force of approximately 100 N, Click the play button. Once the skateboard is moving remove the **PUSH** by changing the force to 0 quickly. Answer the following questions. *You might need to do this a couple of times to get the feel of removing the force without stopping the skateboard.* ***All of your answers below** are based on the situation where you have stopped pushing the skateboard.*

3. What happens to the **SPEED** of the Skateboard/Refrigerator when there is no longer a Push force? (Highlight the appropriate answer.) **Increase** **Decrease** **Stays the Same** **Zero**

4. Are the forces acting on the Skateboard/Refrigerator **BALANCED** or **UNBALANCED**?

5. What are the horizontal **FORCES** acting on the Skateboard/Refrigerator?

6. Will the Skateboard/Refrigerator ever stop moving? **Yes** or **No** Why or why not? **EXPLAIN using the appropriate Newton's Laws**!

7. Reset the simulation and click all of the boxes again. Place the refrigerator on the skateboard and **APPLY** a force of approximately 100 N. This time **DO NOT** remove the **PUSH** force from the refrigerator/skateboard. Answer the following questions.

8. What happens to the **SPEED** of the Skateboard/Refrigerator when the **FORCE** is continuously applied? (Highlight the appropriate answer.) **Increase** **Decrease** **Stays the Same** **Zero**

9. Are the forces acting on the Skateboard/Refrigerator **BALANCED** or **UNBALANCED**?

10. Will the Skateboard/Refrigerator speed ever stop changing? **YES** or **NO** Why or why not? **EXPLAIN using the appropriate Newton's Laws**!

C. FRICTION: Click on the **FRICTION** Icon at the bottom of the simulation. Play around with the simulation so that you know how to use it. Make sure that all of the boxes in the upper right-hand corner are checked (Forces, Sum of Forces, Values, Masses, Speed). Notice you can control the amount of friction using the slider bar labeled Friction in the box on the upper right. Leave it in the middle to start with. Drag a 50 kg box to the track. Apply a **PUSH** force of 100 N to the box (type 100 into the box). Press the Play button. Notice the play button is going but the box is not moving. Notice the direction of the force arrows for the **PUSH** (applied force) and the Friction force. Now begin to slide the Friction bar to the left very slowly. Observe. Then move the Friction bar to the right very slowly. Observe. (Hold mouse button in to continuously apply force or click on arrow to hold force.)

Circle the appropriate answers below:

a) How does the presence of **FRICTION** affect the movement of the objects in the simulation?
The object: **SPEEDS UP** **SLOWS DOWN** **IT'S NOT AFFECTED**

b) **BEFORE** the object starts moving, what do you notice about the **FRICTION FORCE** and the applied **PUSH FORCE?**
Are the forces **BALANCED** **or** **UNBALANCED**

c) **AFTER** the object starts moving**,** what do you notice about the **FRICTION FORCE** and the applied **PUSH FORCE?**
Are the forces **BALANCED** **or** **UNBALANCED?**

d) Place a 50 kg box on the ground. Slide the Friction slider to approximately ¼ from the left (this equals around 50 N of friction). How much **Applied FORCE** is required to just put the box in **MOTION**? _______________ Newtons. What is the **NET FORCE** acting on the box? __________________

e) Keep the previous friction setting and place the 2nd 50 kg box on top of the 1st. **PREDICT** how much **FORCE** will be required to just put the boxes in **MOTION.**____**Newtons**

Now try it using the simulator.

f) What was the **ACTUAL FORCE REQUIRED**? _______________________________________Newtons

g) Can you use this to **PREDICT** how much force is required to just move the **REFRIGERATOR**?

h) **PREDICTION**______________________**ACTUAL**_____________________ **(Don't forget units!)**

i) **This is Not required - CHALLENGE:** Determine the **MASS** of the PRESENT? Mass = _________________kg.

j) **EXPLAIN** how you got your answer. ___

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FORCES and SIMPLE MACHINES

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Friction

A. A. How much static friction force is there between wood and 4 other surfaces?

Obtain the multi surface friction board and place it near the end of the table. You will need to place a heavy weight (found in the kit) on it to prevent sliding. Cut a piece of string approximately 60 cm long. Make a loop at each end of the string. Place one end of the loop on the hook of a wood block. Place the other end of the loop over the edge or pulley connected to the edge of the table. Place the block on one of the surfaces. Begin by hanging a 10 gram mass from the loop that is dangling. Does it cause the block to slide? Determine the maximum amount of weight that can be hung from the string without causing the block to slide. **This hanging weight is equal to the static force of friction between the block and surface it is on.** (Remember weight is a force.) (Look for DATA PATTERNS)

How to calculate weight: weight = hanging mass (in kg) x 9.8 m/s^2.
Example: What does a 33.32 gram mass weigh? First convert from grams to kg.
Mass = 33.32 grams = 0 .03332 kg. **weight = 0.0332 x 9.8 = 0.33 N.**

Perform the experiment again but this time place a mass (as indicated on the table below) on the wood block.

Mass of wood block ___________grams = ____________kg. Weight of wood block = ________N

(x-axis) Weight of wood block + weight of additional mass (N)		**(y-axis)** **Cardboard /wood** Hanging weight plus chain (N)	**(y-axis)** **Sandpaper/wood** Hanging weight plus chain (N)	**(y-axis)** **Rubber/wood** Hanging weight plus chain (N)	**(y-axis)** **Cork/Wood** Hanging weight plus chain (N)
	Frictional force (N) No additional mass on wood block.				
	Frictional force (N) +20 grams on wood block				
	Frictional force (N) +40 grams on wood block				
	Frictional force (N) +60 grams on wood block				
	Frictional force (N) +80 grams on wood block				
	Frictional force (N) + 100 grams on wood block				

Important Note: Be careful when hanging the masses to avoid jerking the block.

1. Make 4 plots of Frictional Force (y axis) vs (weight of block + additional weight) (x axis) on one graph. Answer the following questions based on your graph.

2. Which surface pair exhibited the greatest frictional force? Explain why. (How do you know from your graph?)

   ____

3. Does placing additional weight on the wood block change the amount of frictional force between the block and the surface it is on? Explain why or why not. (How do you know from your graph?)

   ____

B. Kinetic friction (Use wood blocks or flat masses for race.)

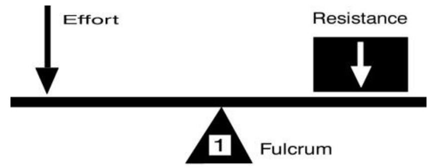
Place the board on the table with equal metal weights on the 4 different surfaces. The results are better if you use the flatter brass 10 g or 20 g masses or 4 like coins. Slowly lift the board from the starting position end. The weights will begin to slide as it is raised. Once they begin sliding you are observing kinetic friction (friction when one surface slides against another surface).

4. Which surface has the greatest amount of kinetic friction? How do you know based on what you observed? Make sure not to confuse static friction with kinetic friction!!!!!

5. Which surface has the least amount of kinetic friction? How do you know based on what you observed? Make sure not to confuse static friction with kinetic friction!!!!!

6. How does the force of static friction compare with the force of kinetic friction? (Compare the surface pair with the greatest static friction with the surface pair that has the greatest kinetic friction etc….) Discuss the results.

PRE-LAB PREP Complete all of the following tables and answer the questions.

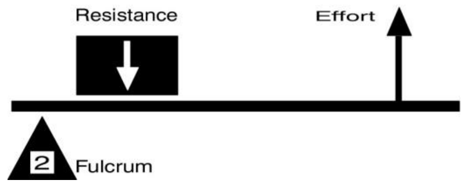


Part A - Lever

Section 1: 1st Class Levers

	Trial 1	Trial 2	Trial 3
1. Distance (meters) a. Resistance Placement	0.100	0.100	0.200
b. Resistance Distance D_R	.0051	.0111	.0100
c. Effort Placement	0.050	0.100	0.050
d. Effort Distance D_E	0.010	0.020	0.020
2. Force (Newton's) a. Resistance R	5.0	5.0	5.0
b. Effort E	2.4	2.5	2.5
3. Ideal Mechanical Advantage $IMA = D_E / D_R$			
4. Ideal Effort (Newton) $IE = R / IMA$			
5. Actual Mechanical Advantage $AMA = R / E$			
6. Error (between E and IE)			
7. %Error for E and IE where IE is the theoretical value			

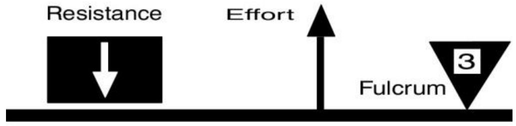
1. Explain any difference between the ideal Mechanical Advantage and the Actual Mechanical Advantage? Why should they be the same?



Section 2: 2nd Class Levers

	Trial 1	Trial 2	Trial 3
1. Distance (meters) a. Resistance Placement	0.050	0.050	0.100
b. Resistance Distance D_R	.0071	.0100	.0101
c. Effort Placement	0.100	0.150	0.150
d. Effort Distance D_E	0.020	0.030	0.030
2. Force (Newton's) a. Resistance R	5.0	5.0	5.0
b. Effort E	1.7	1.7	1.7
3. Ideal Mechanical Advantage $IMA = D_E / D_R$			
4. Ideal Effort (Newton) $IE = R / IMA$			
5. Actual Mechanical Advantage $AMA = R / E$			
6. Error (between E and IE)			
7. %Error for E and IE where IE is the theoretical value			

1. Explain any difference between the Ideal Mechanical Advantage and the Actual Mechanical Advantage? Why should they be the same?

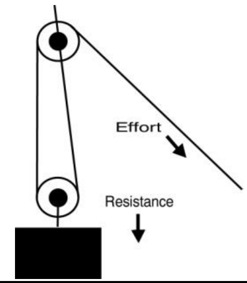


Section 3: 3rd Class Levers

	Trial 1	Trial 2	Trial 3
1. Distance (meters) a. Resistance Placement	0.200	0.200	0.300
b. Resistance Distance D_R	0.003	.0051	.0050
c. Effort Placement	0.050	0.100	0.100
d. Effort Distance D_E	0.010	0.020	0.020
2. Force (Newton's) a. Resistance R	5.0	5.0	5.0
b. Effort E	1.2	1.2	1.3
3. Ideal Mechanical Advantage $IMA = D_E / D_R$			
4. Ideal Effort (Newton) $IE = R / IMA$			
5. Actual Mechanical Advantage $AMA = R / E$			
6. Error (between E and IE)			
7. %Error for E and IE where IE is the theoretical value			

1. Explain any difference between the Ideal Mechanical Advantage and the Actual Mechanical Advantage? Why should they be the same?

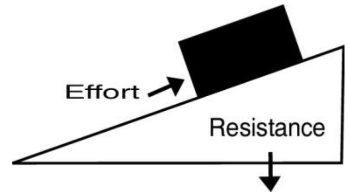
Part B - Pulley



	Section 1 One Pulley	Section 2 Two Pulleys	Section 3 Three Pulleys	Section 4 Four Pulleys
1. Distance (meters) a. Resistance Distance D_R	0.100	0.100	0.100	0.100
b. Effort Distance D_E	.1012	.1991	.3102	.3893
2. Force (Newton's) a. Resistance R	5.0	5.0	5.0	5.0
b. Effort E	5.1	2.5	1.7	1.3
3. Ideal Mechanical Advantage $IMA = D_E / D_R$				
4. Ideal Effort (Newton) $IE = R / IMA$				
5. Actual Mechanical Advantage $AMA = R / E$				
6. Error (between IMA & AMA)				
7. %Error for IMA and AMA where IMA is the theoretical value				

1. Explain any difference between the Ideal Mechanical Advantage and the Actual Mechanical Advantage. Should they be the same? Explain why or why not.

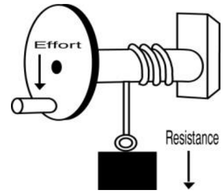
Part C - Inclined Plane



	Trial 1	Trial 2	Trial 3
Support Rod Placement	1	3	5
1. Distance (meters) a. Resistance Distance D_R	.2800	.4738	.6671
b. Effort Placement (notch on inclined plane)	2	2	2
b. Effort Distance D_E	1.087	1.087	1.087
2. Force (Newton's) a. Resistance R	5.0	5.0	5.0
b. Effort E	1.3	2.2	3.1
3. Ideal Mechanical Advantage $IMA = D_E / D_R$			
4. Ideal Effort (Newton) $IE = R / IMA$			
5. Actual Mechanical Advantage $AMA = R / E$			
6. Error (between IMA and AMA)			
7. %Error for IMA and AMA where IMA is the theoretical value			

1. Explain any difference between the Ideal Mechanical Advantage and the Actual Mechanical Advantage. Should they be the same? Explain why or why not.

Part D - Wheel and Axle



	Trial 1	Trial 2	Trial 3
1. Distance (meters) a. Resistance Placement (Axle)	0.045	0.045	0.045
b. Resistance Distance D_R	.1422	.2910	.4444
c. Effort Placement (Wheel)	0.045	0.090	0.135
d. Effort Distance(1 rotation $2\pi r$) D_E	0.283	0.565	0.848
2. Force (Newton's) a. Resistance R	5.0	5.0	5.0
b. Effort E	2.5	2.5	2.5
3. Ideal Mechanical Advantage $IMA = D_E / D_R$			
4. Ideal Effort (Newton) $IE = R / IMA$			
5. Actual Mechanical Advantage $AMA = R / E$			
6. Error			
7. %Error for IMA and AMA where IMA is the theoretical value			

1. Explain any difference between the Ideal Mechanical Advantage and the Actual Mechanical Advantage. Should they be the same? Explain why or why not.