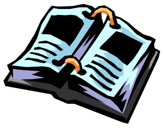

AP Physics Class Calendar: Chapter 4

Date	Location	Activities & Textbook References	Teacher Initials	Homework
Sept 16 & 19	Classroom	Demo: *Tablecloth Inertia*	__________	C #C, D, 2, 11
	Any Computer	Lecture 4-1: *Inertia & Newton's 1^{st} Law* (Textbook Sections 4.1 and 4.2)		
	Any Computer	Lecture 4-2: *Forces & Free Body Diagrams* (Textbook Section 4.1)		
	Any Computer	Short Lab 4-A: *Shockwave Free Body Diagrams*		
	Any	Complete Ch 4 HW Assignment #1		
Sept 20 & 21	Any Computer	Lecture 4-3: *Newton's 2^{nd} Law* (Textbook Section 4.3)		C #14 *P #1, 2, E, F **P #7, 9, 11 ***P #12
	Any Computer	Lecture 4-4: *Mass and Weight* (Textbook Section 4.3)		
	Classroom	Demo: *Action-Reaction Forces*	__________	
	Any Computer	Lecture 4-5: *Newton's 3^{rd} Law* (Textbook Section 4.3)		
	Any	Complete Ch 4 HW Assignment #2		
	Classroom	**Quiz 4-A**		
Sept 22 & 23	Any Computer	Lecture 4-6: *Tension (Part I)* (Textbook Section 4.5)		*P #16, G **P #15 ***P #17, 18
	School Computer	Short Lab 4-B: *Tension at Unequal Angles*		
	Any Computer	Lecture 4-7: *Tension (Part II)* (Textbook Section 4.5)		
	Any	Complete Ch 4 HW Assignment #3		
Sept 26	Any Computer	Lab Introduction Vodcast: *Lab #4*		
	Classroom	**PRE-LAB QUIZ: Lab #4**		
	Classroom	Lab #4: *Vector Components of Force*		
Sept 27 & 28	Classroom	Demo: *Atwood Machines*	__________	C #13 *P #30 **P #A, 34 ***P #26
	Any Computer	Lecture 4-8: *Atwood Machine (Part I)* (Textbook Section 4.5)		
	School Computer	Short Lab 4-C: *Atwood Machines*		
	Any Computer	Lecture 4-9: *Atwood Machine (Part II)* (Textbook Section 4.5)		
	Any	Complete Ch 4 HW Assignment #4		
	Classroom	**Quiz 4-B**		
Sept 29 & Oct 3	Classroom	Demo: *Friction I*	__________	C #20 *P #35 **P #37, 58, H, 43 ***P #B, 49
	Any Computer	Lecture 4-10: *Friction (Part I)* (Textbook Section 4.6)		
	Classroom	Demo: *Friction II*	__________	
	Any Computer	Lecture 4-11: *Friction (Part II)* (Textbook Section 4.6)		
	Any	Complete Ch 4 HW Assignment #5		
	Classroom	**Quiz 4-C**		

AP Physics Class Calendar: Chapter 4 (cont)

Oct 4 — Any Computer: Lab Introduction Vodcast: *Lab #5*
Classroom: **PRE-LAB QUIZ: Lab #5**
Classroom: Lab #5: *The Atwood Machine*

SHORT LABS & DEMOS DUE: Chapter 4
HOMEWORK DUE: Chapter 4
(<u>All</u> Conceptual due)
(<u>10</u> Problems due)

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* Problems with *<u>Lowest</u>* difficulty level
** Problems with *<u>Medium</u>* difficulty level
*** Problems with *<u>Highest</u>* difficulty level

~ "Numbered" Homework in Textbook (pg 105 – 115)
~ "Lettered" Homework on Worksheet

Oct 13 & 14 — Classroom: Review & Work Days — - - - - - -
HOMEWORK DUE: AP Review Questions

Oct 17 — Classroom: Review: *AP Question Presentations* — - - - - - -

Oct 18 — Classroom: **TEST: Chapters 4 & 5** — - - - - - -

<u>IMPORTANT NOTE REGARDING *INTERACTIVE PHYSICS* FILES:</u>

The program "*Interactive Physics*" has been purchased by the Sioux Falls School District and should run on most school computers. However, the program is not installed directly on most computers and will require a few special procedures to run as intended! Therefore, students should follow the steps below when opening *Interactive Physics* files.

<u>First</u>, locate the *Interactive Physics* file you wish to open from the "Assignments" tab of the class web site (www.student.PhysicsVodcasts.com). Right-click on the link for the file and select "*Save Target As*" to download a copy of the file to your home folder.

<u>Then</u>, open the *Interactive Physics* program by going to the "*RHS Software*" folder on the computer and choosing "*Science*".

<u>Finally</u>, use the "*File*" and "*Open*" commands in the *Interactive Physics* program to locate the downloaded file in your home folder and open it.

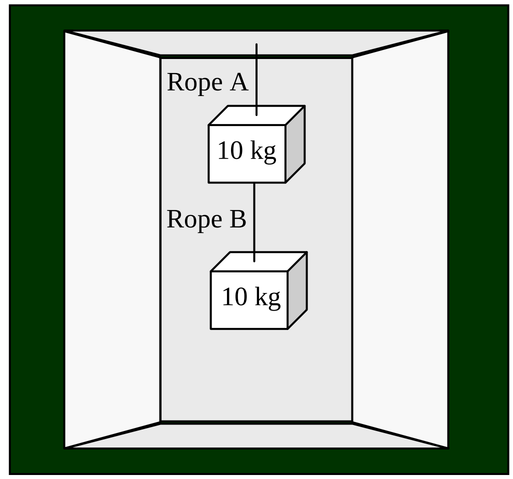
Name ________________________

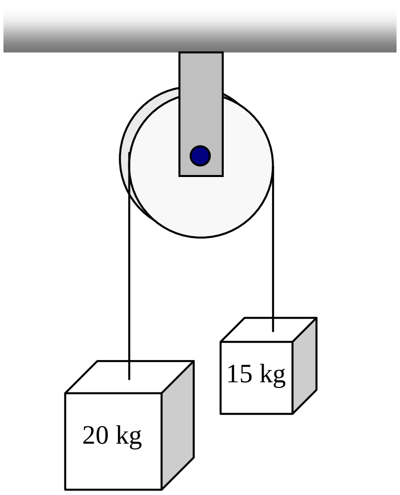
Hour _______

AP Physics: Chapter 4
Newton's Laws of Motion

Question A:
Two blocks of mass 10.0 kg are fastened to the ceiling of an elevator, as shown in the diagram below. The elevator accelerates upward at 2.00 m/s^2. Draw a free body diagram of each block and calculate the tension in . . .

a) Rope B.
b) Rope A.





Question B:
Two blocks of mass 15.0 kg and 20.0 kg are connected by a light string that passes over a pulley, as shown in the diagram below. The blocks are released from rest.

a) Calculate the tension in the string and the acceleration of the masses if the pulley is assumed frictionless.

b) Calculate the tension in the string and the acceleration of the masses if a frictional force of 5.75 N is present on the pulley.

Question C:
Draw and label a free body diagram for the following situations:

a) A Physics textbook sits motionless on a table. Diagram the forces acting on the book.
b) A truck is moving to the right with a constant velocity. Diagram the forces acting on the truck, including air resistance.
c) A nail falls from the hand of a rooftop worker. Neglecting air resistance, diagram the forces acting on the nail.

Question D:
Draw and label a free body diagram for the following situations:

a) A rope attached to a water pail is used to pull the pail up from a water well. Diagram the forces acting on the pail if the pail is raised at a constant velocity.
b) A rope attached to a water pail is used to pull the pail up from a water well. Diagram the forces acting on the pail if the pail is raised with an upwards acceleration.

Question E:

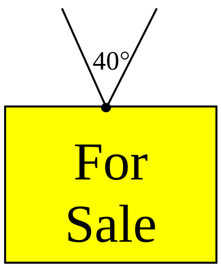
Superman exerts a force of 1810.0 N to push a 910.0 kg boulder. The force of friction acting on the boulder is 720.0 Newtons.

a) Calculate the weight of the boulder.
b) Draw a free body diagram of the forces acting on the boulder.
c) Determine the net force acting on the boulder.
d) Calculate the acceleration of the boulder.

Question F:

Wally, the weightlifter, can lift a 210.0 kg barbell overhead on Earth.

a) How much weight is Wally lifting in Newtons?
b) The acceleration of gravity on the moon is approximately 1/6 of the gravity on the Earth. What is the mass of the barbells on the moon?
c) Approximately how many kilograms would Wally be able to lift on the moon? Why?



Question G:

A realtor hangs a 12.0 N "For Sale" sign from two wires. The wires hang at a 40° angle to each other, as shown in the diagram at left.

a) Draw a free body diagram of the sign. Label all forces and force components.
b) Calculate the vertical tension in each wire.
c) Calculate the horizontal tension in each wire.
d) Calculate the overall tension in each wire.

Question H:

A 25.0 kg toy cart rolls down a hill, inclined at an angle of 14°. The coefficient of friction between the cart's wheels and the hill is .23.

a) Calculate the gravitational force component acting to move the cart down the hill.
b) Calculate the force of friction acting on the cart.
c) Calculate the acceleration of the cart as it rolls down the hill.

AP Physics: Lab #4

Vector Components of Forces

Name ______________________ Hour ______

Lab Partners ____________________________________

Purpose:

* Add and subtract vector quantities using graphical and analytical methods.
* Verify the concept of static equilibrium.

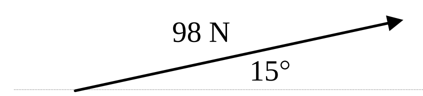
Equipment:

Force table
Electronic balance
Assorted masses

Introduction:

The physical quantities used in scientific study can be classified into two major categories: *scalars* and *vectors*. A *scalar* is any quantity that can be completely described using only a magnitude. For example, time, volume, mass, and temperature are all scalar quantities.

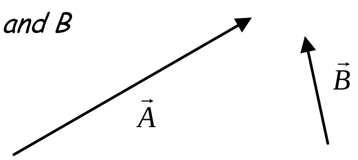
A *vector*, in contrast, cannot be completely described without both the magnitude and direction of the quantity. Velocity, acceleration, and force are all examples of vector quantities. A vector can be represented graphically by an arrow. The length of the arrow represents the magnitude of the vector, while the direction of the arrow represents the direction of the vector.



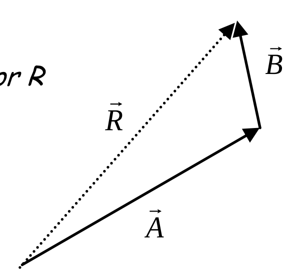
In order for vectors to be a useful scientific tool, it must be possible to add multiple vectors to obtain a vector sum, or resultant vector. This can be accomplished using either *graphical* or *analytical* methods.

To *graphically* add two or more vectors, first represent each vector with an arrow of the appropriate length and direction. Then redraw the vectors using the "head to tail" method, connecting the vectors without changing their length or direction. This forms a new vector arrow, representing the resultant vector. The length of the resultant vector arrow represents its magnitude and the direction of the resultant vector arrow represents its direction. An example of graphical addition of vectors is shown below, where the original vectors *A* and *B* are combined to form resultant vector *R*.

Vectors A and B



Resultant Vector R

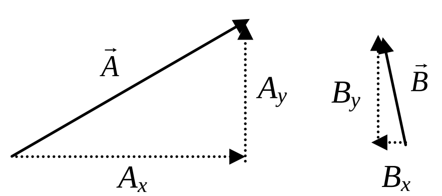


To *analytically* add two or more vectors, first use the cosine and sine functions to calculate the *x* and *y* components of each vector to be added. Then add the *x* components to obtain the *x* component of the resultant, and add the *y* components to obtain the *y* component of the resultant. When the *x* and *y* components of the resultant are determined, the magnitude of the resultant can be found with the Pythagorean Theorem and the direction of the resultant can be found with the inverse tangent function. The equations used for the analytical method are shown below, where the original vectors *A* and *B* are combined to form resultant vector *R*.

Calculating Vector Components

$$V_x = \vec{V} \cdot \cos\theta$$

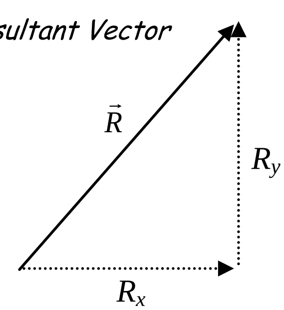
$$V_y = \vec{V} \cdot \sin\theta$$



Determining the Resultant Vector

$$\vec{R} = \sqrt{R_x^2 + R_y^2}$$

$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right)$$



Introduction *(cont)*:

This lab will use vectors to study the effects of Newton's Laws on a force table. The net force acting on an object is the vector sum of all individual forces acting on that object. Newton's 2nd Law states that the acceleration experienced by that object is proportional to and in the same direction as the net force. It is modeled in this equation:

$$F_{net} = \sum F = m \cdot a$$

According to the equation above, any object with a net force of zero will experience an acceleration of zero. If this object begins in a state of rest, this object will remain at rest, and is said to be in static equilibrium.

Procedures:

Use the base, protractor, center ring, and pin to set up the force table on a lab stool, as shown in the diagrams at right.

Obtain the mass amounts and angles for two individual forces from your teacher and record them in Data Table A. Set up the two given forces at the correct angles on the force table. Observe the motion of the center ring.

Without attaching the third force, calculate the magnitude and angle of the equilibrant force needed to produce a state of static equilibrium on the center ring.

Have your instructor initial your prediction, then add the calculated equilibrant force to the two forces already on the force table. Remove the pin and observe the motion of the center ring. If necessary, adjust the equilibrant force so that the center ring is in a state of static equilibrium.

Repeat the above procedure for the three individual forces given in Data Table B.

Calculations:

The calculations below must be completed during lab:

Calculate the force exerted by each of the given mass amounts.

Calculate the *x* and *y* components for each individual given force. Use this information to calculate the *x* and *y* components of the resultant force and the magnitude and angle of the resultant force for each vector combination.

Calculate the equilibrant force and mass amount required to produce static equilibrium for each vector combination.

The calculations below may be completed after lab:

For Data Table A, create a graphical solution showing the two original individual forces in head-to-tail form and the resultant vector. Use your graphical solution to determine the magnitude and direction of the resultant vector, and include the graphical solution with your lab report.

Analysis:

To summarize the lab report, answer the application questions below in complete sentences. In addition, include a brief statement of the overall results for the lab.

- Were any of your predictions incorrect? If so, address possible areas of error in your calculations or experimental procedures.
- Compare the magnitude and direction of the resultant force determined analytically in Data Table A to the magnitude and direction of the same resultant force found with the graphical method. Which method (graphical or analytical) appears to be the better method to determine the resultant force?
- Discuss the motion of the center ring *before* the equilibrant force was applied in Data Table A. How does Newton's 2nd Law apply to your observations? What was the net force acting on the center ring *after* you added the equilibrant force? How did this net force affect the motion of the center ring? How does this net force relate to the concept of static equilibrium?
- Suppose that the magnitudes of the two given forces in Data Table A remained the same, but the directions were altered. Give two new angles that would produce a . . . smaller resultant force . . . larger resultant force. Using the two given forces, what is the magnitude of the . . . largest possible resultant force? . . . smallest possible resultant force? How would the largest and smallest resultant forces be formed?

Data Table A: Two Unequal Forces

		FORCE VECTORS		FORCE COMPONENTS	
	Mass	Magnitude	Direction	*x*-component	*y*-component
Force #1	50 g				
Force #2	100 g				
Resultant Force					
Equilibrant Force					

Data Table B: Three Unequal Forces

		FORCE VECTORS		FORCE COMPONENTS	
	Mass	Magnitude	Direction	*x*-component	*y*-component
Force #1	50 g				
Force #2	100 g				
Force #3	100 g				
Resultant Force					
Equilibrant Force					

Lab Report:

Title Page, Objectives, & Overall Report – 5 pts
Procedures – 3 pts
Data Table – 5 pts
Calculations & Graphical Solutions – 11 pts
Analysis – 10 pts

AP Physics: Lab #5 The Atwood Machine

Name ____________________ Hour ______

Lab Partners ______________________________

Purpose:

* Use Newton's 2nd Law to analyze two masses on an Atwood machine.
* Determine the force of friction acting on an Atwood machine.

Equipment:

LabQuest Mini with USB cord	Mass set
Computer with LoggerPro software	Nylon string
Photogate and Photogate cord	Ring stand
Atwood machine smart pulleys (2)	Electronic balance

Introduction:

Newton's 2nd Law states that the net force acting on a system is proportional to the acceleration of that system according to the equation: $F_{net} = m \cdot a$. In an Atwood machine, a pulley connects two unequal masses, causing one mass to accelerate upwards while the other accelerates downwards.

Consider an Atwood machine with two masses such that $m_1 > m_2$, as shown in FIGURE 1 below. The net forces accelerating these masses can be found by analyzing the free body diagrams of each mass individually. Three forces act on each mass, as shown in FIGURE 2 and FIGURE 3 below. *Weight* acts on each mass in a downwards direction, *tension* acts on each mass in an upwards direction, and *friction* acts in the direction to oppose the motion of the system. If $m_1 > m_2$, the net force on m_1 accelerates it downwards, while the net force on m_2 accelerates it upwards. Thus, friction acts upwards on m_1, but downwards on m_2.

This experiment will measure the acceleration of such a system as one mass is pulled upwards and the other mass falls downwards. The values for the tension in the string and force of friction acting on the pulley can then be determined.

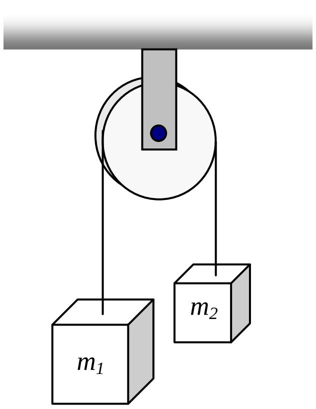


FIGURE 1

$$F_{net} = W_1 - T - F_f$$

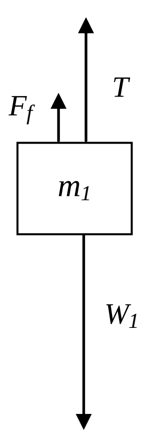


FIGURE 2

$$F_{net} = T - F_f - W_2$$

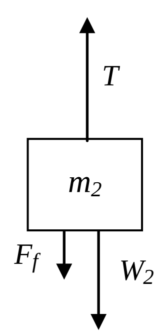
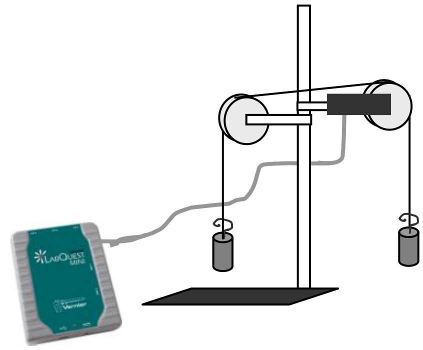


FIGURE 3

Procedures:



Securely attach the smart pulleys and photogate to a support stand, allowing the pulleys to extend over the edge of the lab table. Thread the nylon string through the smart pulleys to construct an Atwood machine. *(NOTE: Two pulleys are used to prevent the masses from striking each other; however only one pulley needs to be attached to a photogate for data collection.)*

Insert the plug of the photogate cord into the DIG I port of the LABQUEST. Use the USB cord to connect the LABQUEST to the computer. Then open the "*Lab #5 Template*" LOGGERPRO file from the class web site or Shared folder.

Attach masses to each end of the pulleys, distributing the masses so that Mass #1 is slightly greater than Mass #2. Then click the green COLLECT button on the LOGGERPRO toolbar. Carefully release the Atwood machine masses. As the pulley begins spinning in the photogate, it will trigger the LABQUEST to begin collecting data. Be sure to have a member of your lab group catch the masses before they strike the floor!

If the LABQUEST continues to collect data after the masses have stopped moving, following the instructions in the LOGGERPRO program to decrease the number of data points collected. Use the ANALYZE → AUTOSCALE commands to view the data collected. If necessary, repeat the experiment until the data collected is acceptable for analysis. Then save the LOGGERPRO file for Trial #1 on your home folder for future analysis. Repeat the experiment until you have obtained two additional data sets using the same masses that are suitable for analysis. Save the data for these trials as well, being sure not to overwrite the file containing your previous trials.

Move some of the mass from Mass #2 to Mass #1, creating a larger difference between the two masses. Repeat the experiment for 3 trials, using the new combination of masses and recording the data on Data Table B. Repeat the experiment for a third combination of masses, recording the data on Data Table C.

Calculations:

Calculate the weight W of each mass for each trial.

Use the ANALYZE → CURVEFIT command to produce an appropriate regression line to determine the acceleration of the masses for each trial. Print copies of your data, graphs and regression line from one of your trials to include in your report. *(NOTE: For best printing results, use the FILE → PAGE SETUP command to change the orientation to landscape and the FILE → PRINTING OPTIONS command to add a footer with your Name and Trial #.).*

Use a system of two equations to calculate the force of friction F_f acting on the pulley and the tension T in the string for each combination of masses.

Analysis:

To summarize the lab report, answer the application questions below in complete sentences. In addition, include a brief statement of the overall results for the lab.

- Draw a free body diagram of the forces acting on each mass during the situation in Data Table A. Include the type, amount and direction of each force.
- For the situation in Data Table A, calculate the net force acting on each mass. How do the net forces acting on the two masses compare to each other? How do the accelerations of the two masses compare to each other? Explain your answers.
- Use a system of two equations or the Short Lab 4-C *Interactive Physics* file to calculate the theoretical acceleration of the masses and tension in the string for the situation in Data Table A if friction is ignored. By what percentage do these amounts vary from . . . the actual acceleration . . . the actual tension?
- Does the tension in the string depend on the difference between the masses? If so, which case produces . . . the largest amount of tension? . . . the smallest amount of tension? Why do you think this might be so?

Data Table A:

	Mass $_1$	*Mass $_2$*	*Weight $_1$*	*Weight $_2$*	*Acceleration*
Trial 1					
Trial 2					
Trial 3					
Average					

Tension = ____________ Force of Friction = ____________

Data Table B:

	Mass $_1$	*Mass $_2$*	*Weight $_1$*	*Weight $_2$*	*Acceleration*
Trial 1					
Trial 2					
Trial 3					
Average					

Tension = ____________ Force of Friction = ____________

Data Table C:

	Mass $_1$	*Mass $_2$*	*Weight $_1$*	*Weight $_2$*	*Acceleration*
Trial 1					
Trial 2					
Trial 3					
Average					

Tension = ____________ Force of Friction = ____________

Lab Report:

Title Page, Objectives, & Overall Report – 5 pts
Procedures – 3 pts
Data Table – 5 pts
Calculations – 6 pts
Analysis – 12 pts

AP Physics: Short Lab 4-A

Virtual Free Body Diagrams

Name ________________________

Hour ______

Purpose:

To practice creating free body diagrams for various situations.

Equipment:

Computer with Internet access and Shockwave program installed.

Preparation:

1. Open the Virtual Free Body Diagram web page located at http://www.physicsclassroom.com/shwave/fbd.cfm and click "*Begin*" and then "*Start*." (You do not need to enter your name.)

2. The program will present you with several Free Body Diagram situations in a random order. Click "*Try New Problem*" until you are given one of the 6 situations listed below.

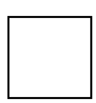
   Book
   Car
   Elevator – moving down, constant speed
   Elevator – moving down, slowing down
   Football – at the peak
   Ice Skater

3. Create a virtual free body diagram by adjusting the type of force and relative size of force acting on the object in each direction. Use the "*Large*," "*Medium*," and "*Small*" commands to describe the size of the force, relative to the force acting in the opposite direction.

4. When you have adjusted the forces acting on the object, click the "*Check Answer*" command at the bottom of the screen. The program will tell you whether or not your diagram is correct. If your diagram is incorrect, you may adjust the forces and try again. When you have created the correct diagram for each situation, sketch your answer in the spaces below. Draw each vector of the appropriate length to show whether it is a large, medium, or small force. Also label each vector with the type of force used. You do *not* need to submit your answers to the computer. *(NOTE: For extra practice, you may create free body diagrams for other situations that are given. However, you only need to record your answers for the 6 situations listed below and on the back page.)*

Answers:

Book:



Car:

Elevator – Moving Down
at Constant Speed:

Elevator – Moving Down
and Slowing Down:

Football – At the Peak:

Ice Skater:

AP Physics: Short Lab 4-B
Tension at Unequal Angles

Name ______________________________ Hour ________

Lab Partners ____

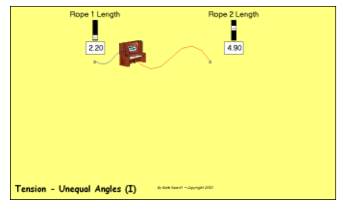
Purpose:

Analyze relationships between horizontal tension, vertical tension, and resultant tension in situations with unequal angles.

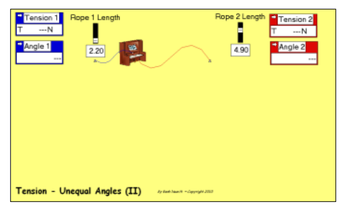
Equipment:

- Interactive Physics computer software

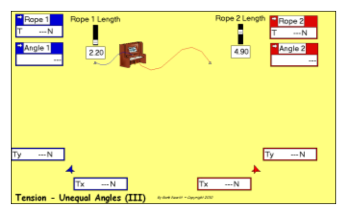
Procedures:



1. Open the Interactive Physics file "*Tension – Unequal Angles (I)*". Run the simulation and study the two ropes used to support the piano. In the space below, make a prediction regarding the tension in the 2 ropes. Will they share the tension equally? If not, which one will have a greater tension? Why do you think so?

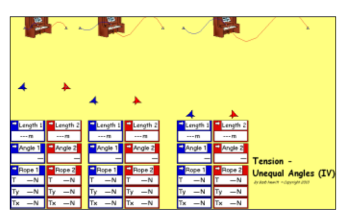


2. Open the Interactive Physics file "*Tension – Unequal Angles (II)*". Run the simulation and study the angles of the 2 ropes and their overall tension. Was your prediction correct?



3. Open the Interactive Physics file "*Tension – Unequal Angles (III)*". Run the simulation and study the horizontal and vertical components of tension in each rope. How do the horizontal tension components compare to each other? How do the vertical tension components compare to each other? If you know the angles of both ropes and the relationship between the horizontal components of tension, can you predict how the resultant tension values will compare between the two ropes?

4. Experiment with different rope angles by increasing or decreasing the lengths of the two ropes. *(NOTE: You may need to try a different situation if the program shows an error message or gives tension values of zero.)* Each time, observe the angles of the two ropes and the resultant tension values. Can you now predict which rope will have a greater tension?



5. Open the Interactive Physics file "*Tension – Unequal Angles (IV)*". Run the simulation and study the angles and horizontal and vertical components of tension in each of the 3 situations. Does the actual length of the two ropes appear to have a direct impact on how the tension is distributed between the ropes? Justify your answer.

AP Physics: Short Lab 4-C
Atwood Machines

Name ______________________________ Hour ________

Lab Partners ____

Purpose:

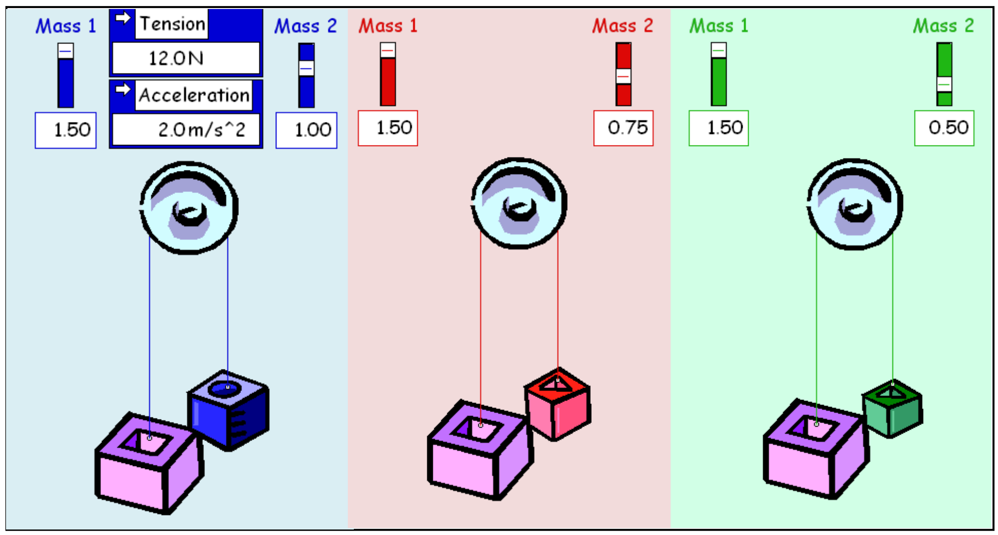
Analyze how tension and acceleration values in an Atwood machine change as the masses change.
Analyze Atwood machines on an incline.

Equipment:

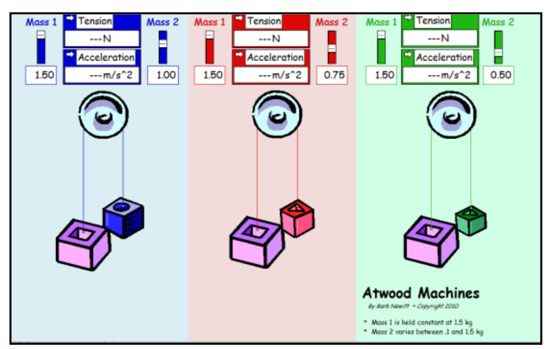
- Interactive Physics computer software

Procedures (Part I):

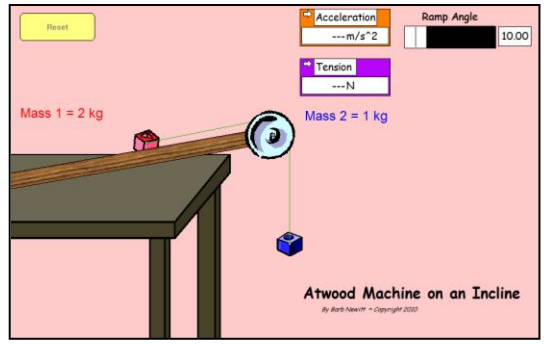
1. Study the 3 Atwood machine situations shown at right. The 1st situation uses masses of 1.5 kg and 1.0 kg and produces a tension of 12 N and an acceleration of 2 m/s^2. The larger mass remains at 1.5 kg in the other two Atwood machines, but the smaller mass changes to .75 kg and .50 kg as shown. Make a prediction regarding the acceleration and tension of the other 2 Atwood machines. Will the tension change from 12 N as the masses change? If so, how? Will the acceleration change from 2 m/s^2 as the masses change? If so, how?



2. Open the Interactive Physics file "*Atwood Machines (I)*". Run the simulation and study the tension and acceleration of the three Atwood Machine situations. Was your prediction correct? Change the values of Mass 2 and observe the results for several different situations. If the larger mass is held constant, what general pattern describes the changes in tension as the smaller mass decreases? If the larger mass is held constant, what general pattern describes the changes in acceleration as the smaller mass decreases? *(NOTE: The Interactive Physics files "Atwood Machines (II) and Atwood Machines (III) provide the opportunity to vary both masses or add greater precision to the masses if needed.)*



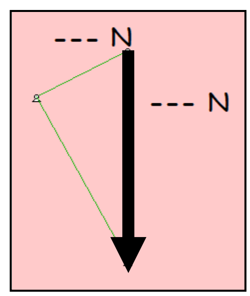
Procedures (Part II):



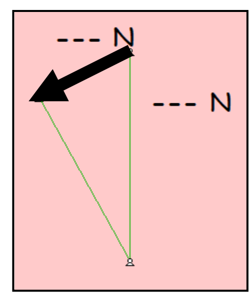
1. It is easy to determine the direction of motion in a vertical Atwood Machine, since the lighter mass always moves up and the heavier mass always moves down. However, this process is more complex when one of the masses is on an incline. Open the Interactive Physics file "*Atwood Machine on an Incline*". This simulation shows an Atwood Machine with a 1 kg mass hanging vertically and a 2 kg mass on a ramp with an adjustable angle. Run the simulation at a very low angle of incline and again at a very high angle of incline and observe the results. *(NOTE: If an error message is given at very extreme angles, simply click "Yes" and continue.)* How can you predict the direction of motion of the masses when the Atwood Machine is at extreme angles?

2. The results from Question #1 indicate that there must be an angle at which the masses on this particular Atwood Machine remain at rest. Try a variety of angles of incline until you find this angle and record it in the space below. Why do you think this particular angle causes the masses to remain at rest in this Atwood Machine?

3. Open the Interactive Physics file "*Atwood Machine on an Incline (II)*". This simulation shows the same Atwood Machine, but also includes an important vector diagram. This vector diagram is similar to the diagram used to analyze the acceleration on a ramp in *Lab #3 – Galileo's Incline Plane*. However, rather than represent the *acceleration* of the object with vectors, this diagram represents the *forces* acting on an object with vectors. The hypotenuse of the triangle represents the resultant, or the weight of the object directed straight downwards. The vector component pointed in the same direction as the ramp represents the component of weight that actually pulls the object down the ramp. Set the simulation to use the same angle that you found in Question #2 and run the simulation. How does the vector diagram help explain why this particular angle used with the 2 kg and 1 kg masses allows them to remain at rest? *(NOTE: The Interactive Physics simulations use 10 m/s^2 for the acceleration of gravity.)*



Resultant Vector (Weight)



Vector Component (Force Pulling Down Ramp)

4. Open the Interactive Physics file "*Atwood Machine on an Incline (III)*". This simulation allows you to change the value of both masses. Experiment with different mass combinations and angles of incline. Explain how you could use the vector diagram to predict which direction the masses will move in each situation.

AP Physics Demos:

Name ______________________________

Chapter 4

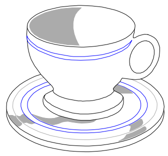
Hour _________

<u>**Demo:** *Tablecloth Inertia*</u>

Equipment:

Metal and/or glass dishes
Tablecloth

Procedures/Analysis:



1. Set several dishes on a tablecloth, leaving a small portion of the tablecloth hanging over the edge of the table. Give the tablecloth a quick pull. Practice this until you can pull the tablecloth out from under the dishes without moving the dishes significantly!

2. What forces do you think act on the tablecloth and the dishes during this activity?

3. What type of movement when pulling the tablecloth allows the dishes to remain on the table successfully? Why do you think this is the best technique?

<u>**Demo:** *Action-Reaction Forces*</u>

Equipment:

Skateboard
Fan Cart

Procedures/Analysis:

1. Position the skateboard near an open wall as shown at right. Hold the skateboard so that it does not move while one member of your lab group balances themselves on the skateboard, using the wall, a lab table, or another lab group member as a support. The student on the skateboard should push <u>*gently*</u> against the wall in front of them until they begin to move.

2. On the diagram below, draw and label a vector representing the force exerted by the lab group member on the wall. On the same diagram, use a different color to draw and label a vector representing the force that caused the lab group member to move. What is important about the relationship between the two vectors?

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Demo: *Action-Reaction Forces (cont)*

3. Position the fan cart on the floor in an open space. Turn on the fan and observe the results. What allows the fan cart to move? How are the skateboard and fan cart activities similar?

4. What do you know already about Newton's 3rd Law? How might Newton's 3rd Law apply to the situations in this activity?

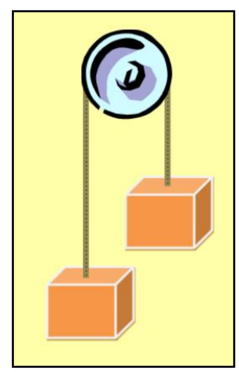
Demo: *Atwood Machine*

Equipment:

Assorted Masses
Pulley with Attached String

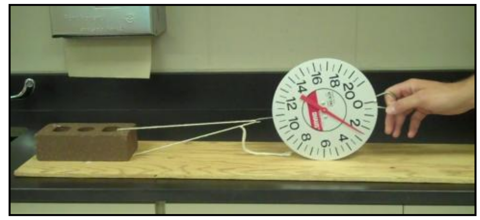
Procedures/Analysis:

1. Use the large pulley in the classroom to create an Atwood Machine by attaching 1.0 kg to one side of the string and 1.5 kg to the other side of the string. *Carefully* release the masses and observe their motion. *(NOTE: Be ready to grab the string to stop the masses if they begin to move too quickly!)* Do you think the masses move at a constant velocity? If so, do the 2 masses appear to move with the same speed as each other? If not, do the 2 masses appear to move with the same acceleration as each other?



2. Change the Atwood Machine to include masses of 1.0 kg on one side of the string and 1.6 kg on the other side of the string. *Carefully* release the masses and observe their motion. *(NOTE: Be ready to grab the string to stop the masses if they begin to move too quickly!)* How does their motion compare to the motion from Question #1? Do you think the masses move at a constant velocity in this case? If so, do the 2 masses appear to move with the same speed as each other? If not, do the 2 masses appear to move with the same acceleration as each other?

Demo: *Friction (I)*



Equipment:

Brick with Attached String
Spring Scale
Wooden Board

Procedures/Analysis:

1. Place the wooden board on the lab table to prevent scratches from the motion of the brick and have one member of your lab group hold the board so that it does not move. Attach the spring scale to the brick. Slowly pull on the spring scale, causing the brick to slide across the wooden board at as much of a constant velocity as possible. Carefully observe the reading on the spring scale as you pull on the brick before it begins to move, as it starts to go into motion, and as it moves across the wooden board. When does it appear that the greatest applied force is required to act on the brick? When do you think the greatest amount of friction acts on the brick?

2. How should the magnitudes of the friction force and applied force compare to each other in order for the brick to slide at a constant velocity? Use Newton's 2^{nd} Law to justify your answer.

Demo: *Friction (II)*

Equipment:

Brick with Attached String
Wooden Board

Procedures/Analysis:

1. Place the wooden board on the lab table to prevent scratches from the motion of the brick and have one member of your lab group hold the board so that it does not move. Slowly pull the brick across the wooden board at as much of a constant velocity as possible. Observe the approximate amount of applied force required to pull the brick at a constant velocity across the board. Then, pull the brick again across the wooden board. This time, have one of your lab partners push down on the brick with a relatively large force as you pull the brick. How does the applied force required to pull the brick change from your first trial?

2. Why do you think pushing *down* on the brick affects the amount of friction acting *horizontally* on the brick? Use the friction equation to explain your answer.