Incline Plane Activity

Purpose

During the activity, students will become familiar with solving static and dynamic incline plane problems. The students will use standard component methods and free body diagrams to determine forces, accelerations and tensions. At the end of the lab, the students will be required to determine if a hanging mass will move up or down while connected to the cart at a specified angle. The students will also be required to determine the tension of the string while the system is in motion.

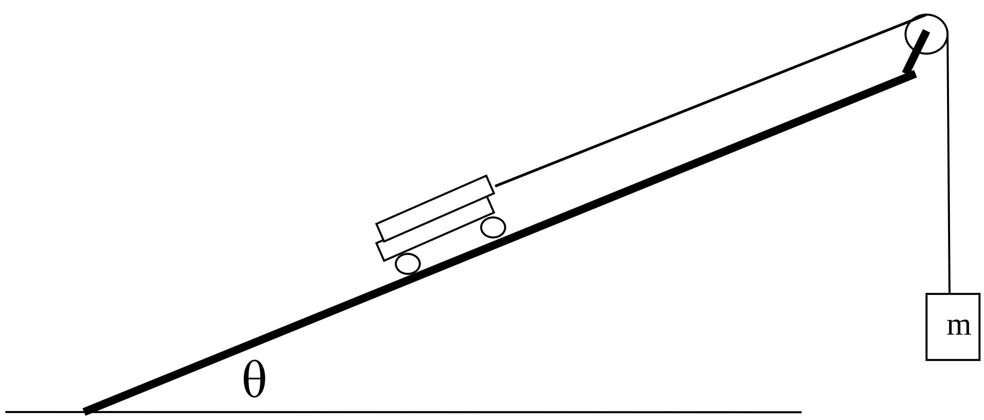
Part I (30pts total)

Before collecting data, it is recommended to review the list of hints that are located on the first page of the Data Sheet.

Log on to the computer and choose the COSAM pool. Double click the ‘phy-lab’ icon on the desktop, and open the PASCO Capstone program. Under File, select Open Experiment, choose the file folder named “capstone-activities”, and then select the *Incline Plane Activity*. After the file opens, there should be a graph of force vs time displayed.

Use the digital scale at the front of the room to determine the mass of your cart. Try not to include the mass of the cord that is attached to the cart.

A Force Sensor is a device that measures compression and/or tension type forces, and it will be used to record the string tension. Physically connect the Force Sensor that is attached to the cart to the PASCO interface, and make sure the interface is turned on.



Set the track such that the angle is approximately 10^0. Note that the Angle Indicator’s scale is quite small and it is divided into one degree increments. Taking the scale into consideration and the thickness of the thread, it should be reasonable to assume that the angle can be read to an accuracy of at least 0.5^0, and depending on how good one’s eyesight is it would not be unreasonable to read the angel to an accuracy of 0.25^0. However, the Angle Indicator does have limitations, and it is assumed that the error associated with the Angle Indicator is $\pm 0.25^0$ regardless of how carefully the angle is measured. Use the Angle Indicator to determine the angle as accurately as possible, and theoretically determine the amount of mass (m) required to keep the cart in equilibrium. Based on the $\pm 0.25^0$ error of the Angle Indicator, it may be prudent to calculate a range for the mass that should place the system in equilibrium. A free body diagram and all work should be neatly recorded on the Data Sheet for this first equilibrium condition. After you have determined the theoretical value and a range, test your theoretical value by hanging an actual mass that is as close to the value of the theoretical mass as possible. Adjust the mass to put the system in equilibrium if necessary. Even though you can only fine tune the hanging mass in 2.5g increments, you should be able to establish a reasonable equilibrium condition (the cart may creep slightly) as long as the hanging mass is within the mass range that you calculated based upon the $\pm 0.25^0$ error of the Angle Indicator. Does the actual mass that places the system in equilibrium fall within the expected range?

After you have established equilibrium, temporarily unhook the string from the cart, and press the TARE button located on the side of the Force Sensor. The Force Sensor needs to be TARED while there is no load on the Force Sensor. After TARING the Force Sensor, reconnect the string to the Force Sensor and return the cart and hanging mass to equilibrium. When the cart and hanging mass are in equilibrium, click the record button and collect data for approximately 6 seconds. After collecting the data, the Select Data Tool  located on the graph's toolbar can be used to select a portion of the data that appears relatively constant. (i.e. excludes any obvious outlying data) if necessary. When the Select Data Tool is used, the mean tension that is displayed on the graph to the left of the run will be calculated using only the data that is selected.

Quickly determine the theoretical mass required to put the system in equilibrium for two additional angles and test these theoretical values against the actual mass required to put the system in equilibrium as above. Use angles between 10^0 and 25^0.

Before moving on to Part II, your TA will remove the mass hanger from your station and position the track at an angle between 10^0 and 25^0. Your TA will request your group to determine and agree upon the track angle, and the TA will record the track angle on Part II of your Data Sheet. Your TA will also specify a mass to hang from the string. However in this case, the mass will be selected such that the cart and hanging mass will not be in equilibrium. (i.e. when the mass is attached to the cart via the string, the cart will move up or down the track.)

After your angle and mass for Part II have been established and recorded by your TA, you may begin working on Part II. However at some point, your TA will return to your station while you are working on Part II and ask your group one question from the list on the next page. The question will be worth 20 points. Only one person within the group will be selected to answer the question. If the person selected answers the question correctly, the group will be awarded 20 points. However if the person answers incorrectly, the point value will be reduced by five points, and the TA will select a second person to answer the same question. Each time the question is answered incorrectly, the point value will be reduced by five points.

The questions below refer to a system in equilibrium as explored in Part I. The TA will expect an answer in general terms; not a numerical value.

(1) When the cart and hanging mass are in equilibrium, what is the relationship between the value of the Force Sensor and the Hanging Mass?

(2) When the cart and hanging mass are in equilibrium, what is the relationship between the Cart Mass and the Hanging Mass?

(3) If the string was cut while the cart and hanging mass were in equilibrium, what would the magnitude of the cart's acceleration be as it moved down the track?

(4) Why is it important that the string be parallel with the track?

(5) What is the Normal Force of the Cart?

Part II (60pts total)

During Part II, the students will make various predictions associated with a dynamic incline plane problem. The value of the hanging mass provided by your TA was calculated such that when the hanging mass is connected to the cart via the string the hanging mass and the cart will accelerate.

The Static Tension (T_{static}) will be defined as the string tension supplied by the hanging mass while the **CART is being held by your hand** and not allowed to move (Do Not hold or touch the hanging mass or string). The Dynamic Tension ($T_{dynamic}$) will be defined as the string tension while the cart is accelerating up or down the incline.

Using the angle and the mass recorded by your TA on Part II of your Data sheet, theoretically determine the following: (Adequate work/diagrams must be shown and attached to the data sheet to explain each of the predictions.)

Determine if the *hanging mass* will move up or down when the cart is released.

The group will need to predict and explain why $T_{dynamic}$ will be greater than, less than, or equal to T_{static}.

The group will also need to theoretically determine $T_{dynamic}$.

When the group has theoretically determined the above items, the TA will return to the station with the mass hanger and proceed to test the group's predictions.

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Name: ______________________________ **Banner ID:** ______________________________

Lab Group ID: ______________________ **Number of Lab Partners:** _________________

Data Sheet
Lab Incline Plane

Hints:

1. Tare the Force Sensor while it is "unloaded"
2. Tare the Force Sensor between each equilibrium trial.
3. Adjust the pulley such that the string is parallel to the track.
4. Ensure that the protractor is properly aligned in the groove on the side of the track.
5. Adjust the pulley such that the string does not drag or rub against any of the equipment.
6. Use pennies as small masses. Pennies minted after 1983 have a mass of approximately 2.5g.
7. Actually weigh the total mass of m versus relying on the total of the imprinted values.
8. If your theoretical hanging masses are significantly different from the actual mass required to establish equilibrium, check your work closely.
9. Read the angle to an accuracy of 0.5^0 or better.
10. Try not to include the mass of the cord attached to the Force Sensor in the mass of the cart.
11. Make sure the Force Sensor cord does not affect the equilibrium in Part I.
12. Make sure the Force Sensor Cord does not drag during Part II.
13. Part II is related to the classic problem of determining your apparent weight in an accelerating elevator. (the force sensor is the scale)

Pre- Lab (10pts)

Part I (30pts total)

Show your work and a diagram for the 1st equilibrium condition. You may attach a separate sheet if necessary. (10 points)

Group Question (20 pts total)

Points for Question (20, 15, 10, or 0 points): _______________

Part II (60pts total)

Cart Mass: _______________

Track Angle as read by the group and recorded by the TA: ______________________

Hanging Mass Specified by TA: ___________________

The group predicts that the hanging mass will move UP or DOWN (15 or 0 points)

Group Points: _____________

Predict if $T_{dynamic}$ will be greater, less, or equal to T_{static}? (15, 5 or 0 points)

1st answer ________________________ 2nd answer if first answer is incorrect ____________________

Group Points: _____________

(A) Group's Theoretical Value $T_{dynamic}$ Work should be attached): ___________

(B) Value of $T_{dynamic}$ experimentally determined by the TA: _______________

Percent Difference $= \frac{|A-B|}{A} x100\%$ = ___________________

Percent Difference	<=4%	<=7%	<=10%	<12%	<=14%	>14%
Points	30	25	20	15	10	5

Group Points for Prediction of $T_{dynamic}$: _____________