Incline Plane Activity

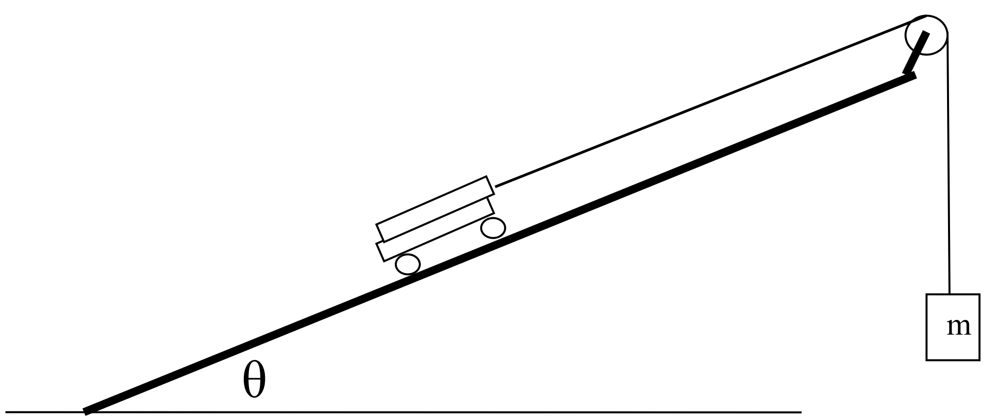
Purpose

During the activity, students will become familiar with solving static and dynamic incline plane problems. 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 a 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.

Use the digital scale at the front of the room to determine the mass of the plastic cart and the mass of the black bar located at your station. The black bar will be placed on the cart while establishing the three equilibrium conditions for Part I.



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 at least $\pm 0.25^0$ 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 plastic cart (with black bar) 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. Although the smallest mass provided is 2g, you should be able to establish a reasonable equilibrium condition (the cart may creep slightly). Does the actual hanging mass that places the system in equilibrium fall within the expected range?

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 provide the mass of a cart with a force sensor. In addition, the TA will position the track at an angle between 10^0 and 25^0. The 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 then specify a hanging mass to hang from the string. The mass will be selected such that the cart with the force sensor and the hanging mass will not be in equilibrium. (i.e. when the mass is attached to the cart via the string, the cart will accelerate up or down the track.)

Neither the plastic cart nor the black bar located at your station will be used for Part II. The TA will test the groups predictions using a cart with a force sensor.

After your angle and mass for Part II have been established and recorded by your TA, you may begin working on Part II.

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 with a force sensor 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, the mass of the cart with a force sensor, and the hanging 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 and use the cart with force sensor to test the group's predictions.

Name: ______________________________ **Banner ID:** ______________________________

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

Data Sheet
Lab Incline Plane

Hints:

1. Adjust the pulley such that the string is parallel to the track.
2. Ensure that the protractor is properly aligned in the groove on the side of the track.
3. Adjust the pulley such that the string does not drag or rub against any of the equipment.
4. Actually weigh the total mass of m versus relying on the total of the imprinted values.
5. If your theoretical hanging masses are significantly different from the actual mass required to establish equilibrium, check your work closely.
6. Read the angle to an accuracy of +/- 0.5^0 or better.
7. Make sure the black bar is on the plastic cart for Part I.
8. The mass hanger has a mass of 50g.
9. 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. (15 points for placing the system in equilibrium at three different angles and 15 points for neatly showing work with diagrams used to calculate the 1st equilibrium condition)

Part II (60pts total)

Mass of Cart with Force Sensor: _______________ (Provided by TA)

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 $T_{dynamic}$: _____________