Unit-04 One Dimension of Motion Experiment II

Objective：

Place a trolley on the nearly frictionless inclined aluminum trajectory. Imitate Atwood′s machine and measure the acceleration of the system.

Apparatus：

Aluminum trajectory, trolley, smart Pulley, photogate, digital device, weight, hook, level, electronic scales, string, ruler, stand for the inclined trajectory

Principle：

Figure 1 is the schematic diagram of the set-up of Atwood's machine experiment. m_1 is the total mass of the trolley and the weights on the trolley. The trolley and the trajectory are nearly frictionless. m_2 is total mass of the hook and the weights on the hook and m_{eff} is the effective mass caused by the spinning of the pulley.

Use a string to connect the trolley and the hook and place the string on the groove of the pulley which is above the inclined plane. F is acting force in the system. According to Newton's second law of motion, we know that

$$F = m_2 g - m_1 g \sin\theta = Ma$$

So, the acceleration a of system's can be represented as

$$a = \frac{F}{M} = \frac{F}{m_1 + m_2 + m_{eff}} = \frac{m_2 g - m_1 g \sin\theta}{m_1 + m_2 + m_{eff}}$$

When $\theta <<$ $\sin\theta \approx \theta$,the system's acceleration a can be represented as

$$a \approx \frac{m_2 g - m_1 g\theta}{m_1 + m_2 + m_{eff}}$$

When $m_1 >> m_2$, and $m_1 >> m_{eff}$

$$a \approx \frac{m_2 g}{m_1} - g\theta$$

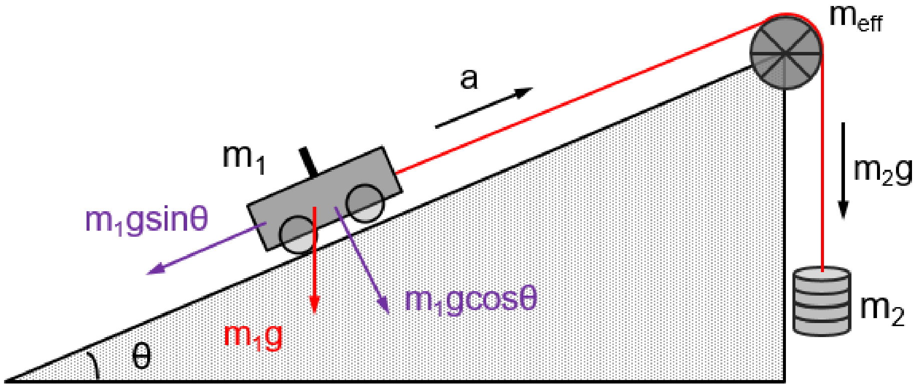


Figure 1. The schematic diagram of the set-up of Atwood's machine experiment

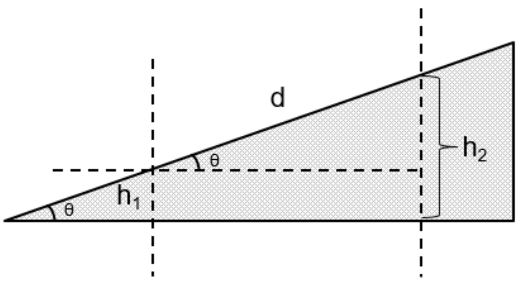
Remarks：

1. Thoroughly check whether the screws in the stand of the inclined plane are tightened to prevent damage of equipment. Loosened screws may cause the inclined plane to slip.
2. The effective mass resulted from the spinning of the pulley should be accounted for the system's total mass m_{eff}.
3. The total mass of hooks and the weights on the hook should not be too heavy, otherwise the tension will be too strong which would result in breakage of strings or trolley derailment.

Procedure：

➢ **Preparation**

1. Put the level on the trajectory. Adjust the screws on both sides underneath the trajectory to level it.
2. Fix the stand on one side of the trajectory. Raise the trajectory at an angle θ
3. Use protractor to record the angle of the inclined trajectory or use trigonometric formulas to calculate the angle of the inclined trajectory (shown in the figure below).



$$\sin\theta = \frac{h_2 - h_1}{d}$$

$$\theta = \sin^{-1}\left(\frac{h_2 - h_1}{d}\right)$$

4. Take an appropriate length of string. Tie one end of the string on the anti-dazzling board above the trolley, and tie the other end on the hook.
5. Place the string on the Smart Pulley's groove and adjust the position of the trolley. Make the string paralleled to the trajectory.
6. In this experiment the effective mass of the pulley m_{eff} = 4.50 g.

A. Keep the hook's total mass m_2 and the angle of the inclined trajectory θ constants. Change the trolley's total mass m_1.

1. Weigh the hook and the weights on the hook with electronic scale and record the number as m_2.
2. Weigh the trolley and the weights on the trolley with electronic scale and record the number as m_1
3. Calculate the total mass M is $M = m_1 + m_2 + m_{eff}$.
4. Fix the stand on one side of the trajectory.
5. Raise the trajectory at an angle θ (radian).
6. Open the software and set the related parameters by instruction book.
7. Place the trolley on the trajectory. Make sure that the string crosses the Smart Pulley and gently presses the pulley. Release the trolley, then you can acquire the velocity-time diagram of the trolley. The slope of the diagram is the acceleration

   $a_n = \overline{a_n} \pm \sigma_{a_n}$. Repeat above steps. Then, record the value of acceleration as

   $a = \overline{a} \pm \sigma_a$ (Delivering error should be considered.)
8. Change the total mass of the trolley and the weights on the trolley m_1. Repeat above steps.

B. Keep the hook's total mass m_2 and the angle of the inclined trajectory θ constants. Change the trolley's total mass m_1.

1. Weigh the hook and the weights on the hook with electronic scale and record the number as m_2.
2. Weigh the trolley and the weights on the trolley with electronic scale and record the number as m_1
3. Calculate the total mass M is $M = m_1 + m_2 + m_{eff}$.
4. Raise the trajectory at an angle θ (radian).
5. Open the software and set the related parameters by instruction book.

6. Place the trolley on the trajectory. Make sure that the string crosses the Smart Pulley and gently presses the pulley. Release the trolley, then you can acquire the velocity-time diagram of the trolley. The slope of the diagram is the acceleration $a_n = \overline{a_n} \pm \sigma_{a_n}$. Repeat above steps. Then, record the value of acceleration as $a = \bar{a} \pm \sigma_a$ (Delivering error should be considered.)
7. Keep total mass of the trolley m_1 and total mass of the hook m_2 constants. Change the angle of the inclined trajectory θ (radian). Repeat above steps.
8. Plot $a - \theta$ diagram.

Questions：

1. Can you infer the gravity g by the inclined acceleration a? Is the value you acquired equals to the value that we know?
2. Can we get the same result if the car downward move? Please explain.