AMERICAN INTERNATIONAL UNIVERSITY–BANGLADESH (AIUB)

FACULTY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICS

PHYSICS LAB 1

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Section: J , Group: 6

LAB REPORT ON

Verification of Newton's Second Law of Motion by Atwood Machine.

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Submitted By

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1.Theory

Newtons second law:

The rate of change of momentum of body over time is directly proportional to the force applied, and occurs in the same direction as the applied force.

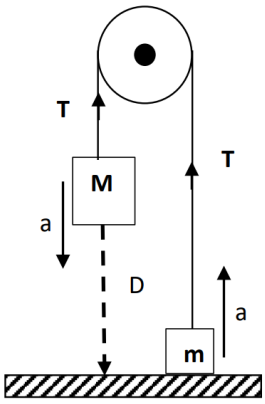


Figure 2.1: Arrangement of an Atwood machine. Here M > m.

In fig 2.1 , two masses m and M are suspended by a piece of inelastic light string that passes over a pulley in a vertical plane. They have same tension because two masses are connected with a string. T and acceleration, a. Considering the upward direction as positive, neglecting friction and mass of the pulley and applying Newton's second law of motion we get

For M: F_{net}= T –Mg = -Ma,

For m: F_{net}= T –mg = ma

Solving these two equations, we get the theoretical acceleration as

$$a_{th} = \frac{g}{(M+m)}(M - m) \qquad \text{.....(A)}$$

As acceleration due to gravity g is constant in a particular place and taking total mass (M+m) constant for the Atwood machine, according to Newton's second law we get

$$a_{th} \propto (M - m)$$

According to fig.2.1 the mass M falls a distance D in time t from rest. Applying the knowledge of equations of motion (D = ut +$\frac{1}{2}at^2$), we can calculate the experimental acceleration by

$$a_{ex} = \frac{2D}{t^2} \quad \text{.....(B)}$$

For different mass combination, (M-m) we will get different experimental accelerations, a_{ex}. If we find a linear relationship between a_{ex} and (M-m) for the Atwood machine, we can say that Newton's second law is verified.

2. Apparatus

- Pulleys
- Weight hangers
- Weight
- String
- Stopwatch
- Meter stick

3.Procedure

Hold the lighter mass on the floor attached to one end of a string. The heavier one attached to the other end of the string is up in the air at a height D from the floor. D is measured with a meter scale.

The string runs over the pulley in the vertical plane. Now release the whole system. Measure the time the heavier mass takes to fall onto the floor.

Run the experiment for 7 different mass-differences. (Mm). For each run, obtain the value of the acceleration in (m/s^2) experimentally from equation (B) as well as calculate it theoretically from equation (A).

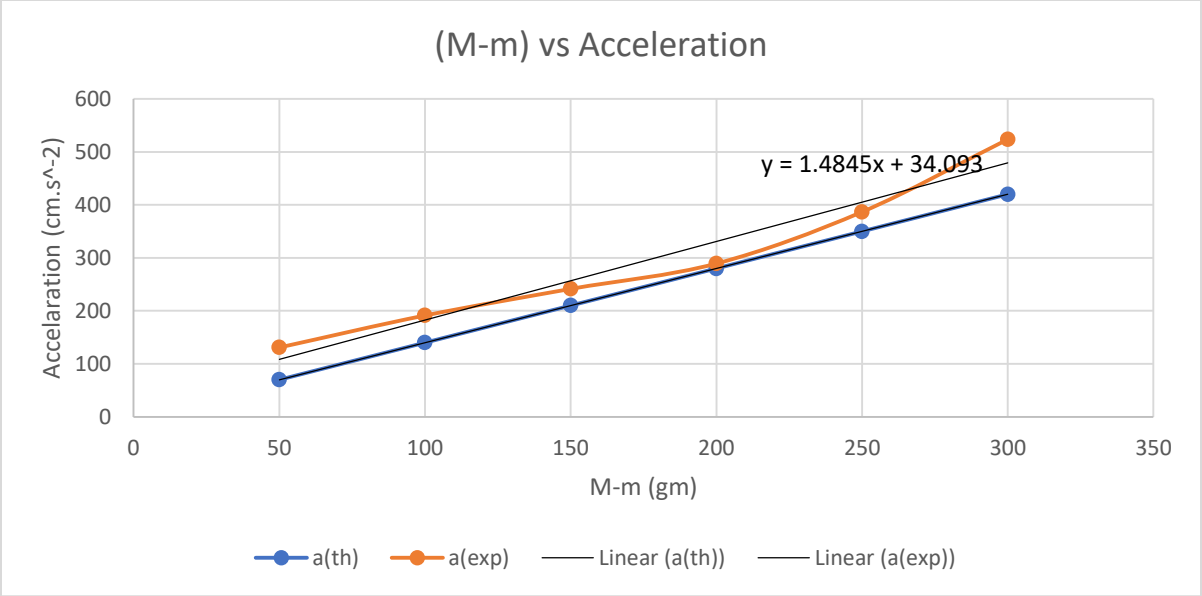
Make sure to keep (M+m=700 m) constant.

Using EXCEL plot acceleration (a_{th} and a_{ex}) versus (M-m), and find the slope of the best-fit line. Add Trendline to the plot. Set Slope= g /(M+m) and solve for (M+m).

4.Experimental Data

Acceleration of different mass combination

M (gm)	m (gm)	Height D (cm)	Time t (s)	Mean Time t (s)	$a_{exp} = \frac{2D}{t^2}$ ($cm.s^{-2}$)	$a_{th} = \frac{M-m}{M+m} g$ (cm.s^-2)	(M − m) (gm)
500	200	79.2	0.56 0.54 0.55	0.55	523.64	420	300
475	225	79.2	0.62 0.65 0.64	0.64	386.72	350	250
450	250	79.2	0.74 0.74 0.75	0.74	289.26	280	200
425	275	79.2	0.80 0.81 0.82	0.81	241.43	210	150
400	300	79.2	0.90 0.91 0.93	0.91	191.28	140	100
375	325	79.2	1.09 1.09 1.11	1.10	130.91	70	50
350	350	—	0		0	0	0



5.Analysis and Calculation

(i) The slope of the straight line :

From the graph :

$$\text{Slope} = \frac{g}{M+m} = 1.4845$$

$$\text{or, } M+m = \frac{g}{\text{slope}} = 660.1549343 \text{ gm}$$

(ii) Error :

$$\frac{700-660.1549343}{700} \times 100 = 5.69\ \%$$

6 . Result

The slope of the straight line from the graph :

Slope = 1.4845

M+m = 660.1549343 gm

Error = 5.69 %

7.Discussion

- Readings might not have been taken to eye level for measuring height.
- Reaction time while taking reading from the stop-watch might have affected our result.
- Take minimum three reading of time from a stop-watch and then calculate mean value to minimize errors.
- As there are lots of variable, calculation should be done carefully.
- The string was not moving freely because of some frictional problems.

9. References

1. Fundamental of Physics (10th Edition): Newton's second law of motion (Chapter 5, page 98-109).
2. Video Links:
    - Newton's second law: https://www.youtube.com/watch?v=xzA6IBWUEDE
    - Atwood Machine: https://www.youtube.com/watch?v=a0KVxh8iPP4

(*The following part is only to be followed in preparing the report*)

Instructions

- The **font** is '**Times new Roman**'.
- The **font size** of all the **titles** are **16 down to 12**, 16 being the main title, 14 **subtitle**, and so on.
- The **font size** of all the **text** must be **11** and all text should be **justified**.
- From the **Paragraph→Indents & Spacing tab**.
    - **Line spacing→1.5 lines**.
    - **Spacing→Before** and **After** both will be **6 pt**.
    - Check √the box '**Don't add space between paragraphs of the same style**'.
- All the gaps between the paragraphs, titles, etc. should be same.