AMERICAN INTERNATIONAL UNIVERSITY–BANGLADESH (AIUB)

FACULTY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICS

PHYSICS 1 LAB

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LAB REPORT ON

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

Supervised By

Md. Saiful Islam

Submitted By

Name	ID	Contribution
1. Sha Sultan Sowhan	22-47014-1	Procedure and Experimental Data
2. Mahmuda Khatun	22-47016-1	Discussion and References
3. Farjana Yesmin Opi	22-47018-1	Analysis and Calculation, Result
4. Md. Abu Towsif	22-47019-1	Theory and Apparatus
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<u>Experiment Name:</u> Verification of Newton's Second Law of motion by Atwood's Machine

1. <u>Theory</u>

Newton's second law of motion can be formally stated as "The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object".So it tells that force causes acceleration and the relationship between net force acting on an object, F_{net} and its acceleration, a is: F_{net} = ma, where m is the mass of that object.

In Atwood machine, two masses m and M are suspended by a piece of inelastic light string that passes over a pulley in a vertical plane as the fig. 2.1 shows. The two masses are connected with a string, because of this, they must have same tension, T and acceleration,a.

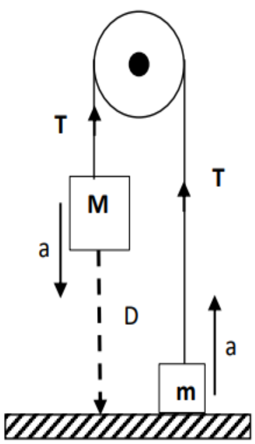

Figure 1:Arrangement of an Atwood machine.Here M>m

If we consider 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 : $F_{net} = T - mg = mg$

If we solve these two equations,we get the theoretical acceleration as,

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

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

$$a_{ex} = \frac{2D}{t^2}$$

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

1.Pulley

2.Two hangers

3.Different masses

4.String

5.Stand and clamp

6.Meter scale

7.Stop watch

3. Procedure

1. We have to hold the lighter mass on the floor attached to one end of a string & keep the heavier one attached to the other end of the string up in to the air at the height 'D' from the floor.
2. Then we measure the height 'D' with a meterscale.
3**.** Now we have to release the lighter mass and measure the time with stop watch that what time it takes for the heavier mass to fall to the floor.
4.Then we test for 7 different mass differences,(M-m) for each run, we get the acceleration value(m/s^2) experimentally as well as theoretically and we have to make sure that total mass (M+m) is always constant.
5.Now using excel we plot acceleration (a_{tn} and a_{ex}) versus mass difference (M-m) graph.

4. Experimental Data

Table :Acceleration for 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})	$a_{th} = \frac{(M-m)}{(M+m)} \times g$ (cm.s^{-2})	(M-m) (gm)
500	200	79.5	0.56 0.55 0.54	0.55	525.619	420	300
475	225	79.5	0.62 0.65 0.64	0.637	392.217	350	250
450	250	79.5	0.76 0.74 0.75	0.75	282.666	280	200
425	275	79.5	0.80 0.83 0.79	0.8067	244.3278	210	150
400	300	79.5	0.90 0.94 0.93	0.9233	186.514	140	100
375	325	79.5	1.09 1.10 1.13	1.106	129.983	70	50
350	350	-	0		0	0	0

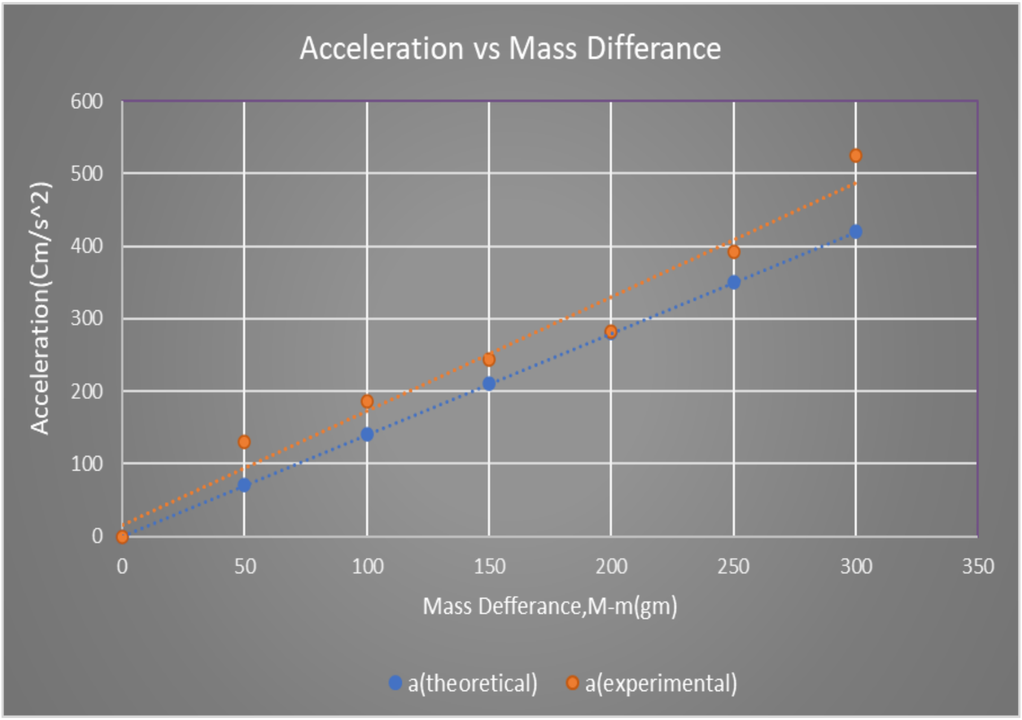

Figure 2:Graph of Acceleration vs Mass Difference(M-m)

5. Analysis and Calculation

i)The slope of the straight line:

From the graph-

$$\text{Slope}=\frac{g}{M+m}=1.4$$

Or, M+m=700gm

(ii)Error of (M+m) = =0%

6. Result

From the "acceleration vs mass difference" graph, the relationship between experimental acceleration and mass difference is directly proportional linear for the Atwood machine same as the theory says. Thus we can say that Newton's second law is verified.

7. Discussion

In the Modified Atwood Machine Lab, Newton's second law relating the net force, mass, and acceleration was examined, as well as how to use frictionless surfaces and objects, along with a pulley, to confirm this relationship. By using the mass of the cart and adjusting the hanging masses, which changes the acceleration of the cart, we can observe Newton's second law in effect. Overall, the data supports Newton's second law, as it only deviates from the law slightly, which could be explained by imperfections in the lab setup and the measurements. One peculiarity of the data was that as the mass increased, the difference between observed acceleration and acceleration predicted by Newton's second law increased. This may able to be explained by the fact that as the mass increases, the force on the pulley by the string increases, which increases the pulley's friction. This results in the net force on the cart decreasing, which therefore reduces its acceleration and increases its deviation from the prediction. The friction of the pulley being unaccounted for was one possible source of error in the lab. One other could possibly be the track not being at the most ideal angle to allow the gravitational and normal forces to counteract its own friction.

8. References

- Fundamental of Physics (10th Edition): Newton's second law of motion (chapter 5, page 98-109)

Video Links:

- Newton's second law: https://www.youtube.com/watch?v=xzA6IBWUEDE
- Atwood Machine: https://www.youtube.com/watch?v=a0KVxh8iPP4