AMERICAN INTERNATIONAL UNIVERSITY–BANGLADESH (AIUB)

FACULTY OF SCIENCE & TECHNOLOGY

DEPARTMENT OF PHYSICS

PHYSICS LAB 2

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LAB REPORT ON

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

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T A B L E O F C O N T E N T S

1. Theory

The acceleration of an object starting from rest and acquiring a final velocity (v) in time (t) can be computed from the equation,

$$D = \frac{1}{2} a_{ex} t^2$$

$$\text{or, } a_{ex} = \frac{2D}{t^2} \qquad (a_{ex} = \text{experimental acceleration}) \ \ldots\ldots\ldots\ldots\ (A)$$

where, D is the distance traveled by the object during time t.

In Atwood's machine, two masses (m), and (M) are suspended by a piece of inelastic light string that passes over a pulley in the vertical plane. If $M > m$, the acceleration, a, with which the whole system moves is given by,

$$a_{th} = \frac{M-m}{M+m} g \qquad (a_{th} = \text{theoretical acceleration}) \ \ldots\ldots\ldots\ldots\ (B)$$

where, (g) is the acceleration due to gravity (9.80 m/s^2).

$$a_{ex} = \left(\frac{g}{M+m}\right)(M-m)$$

$$y = bx + c$$

where,

$$\text{slope, } b = \left(\frac{g}{M+m}\right)$$

$$\text{error of a} = \left(\frac{a_{th} - a_{ex}}{a_{th}}\right) \times 100\%$$

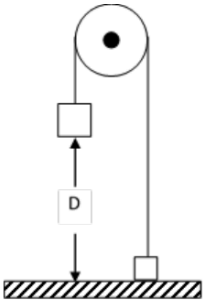


Figure: Atwood's Machine

2. Apparatus

- ☐ Pulleys
- ☐ Weight Hangers
- ☐ Weights
- ☐ String
- ☐ Stop Watch
- ☐ Meter Stick

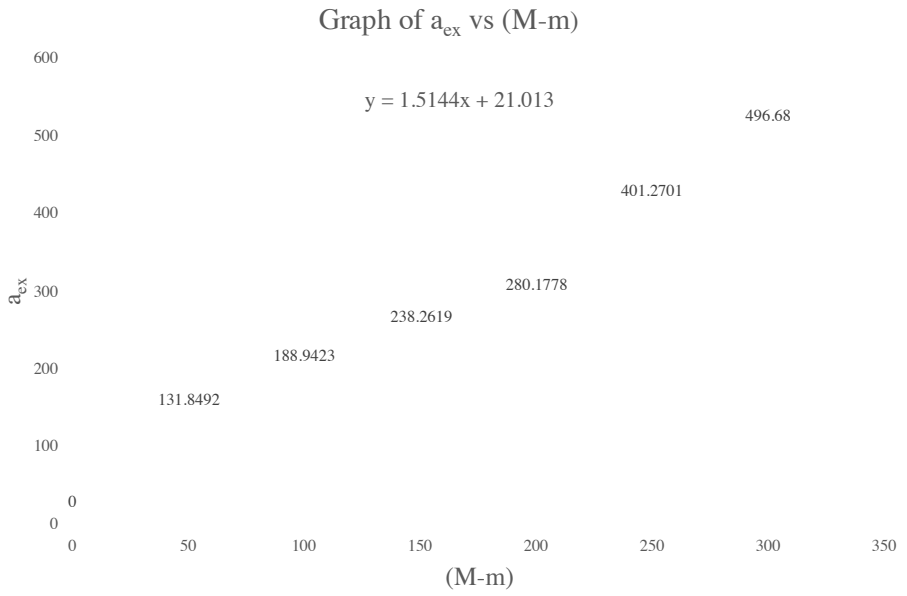
3. Procedure

The lighter mass (m) was held on the floor while attached to an end of the string. At height (D) from the floor, the heavier mass (M) was attached to the other end of the string. The height (D) was measured with a measuring scale. The string was ran over the pulley in the vertical plain. The whole system was then released. The time for the heavier mass to fall onto the floor was measured. The experiment was ran for 7 different mass differences (M-m). For each run, the value of acceleration in (m/s^2) was obtained experimentally from equation (A) and theoretically from equation (B). It was made sure that ($M + m \approx 700g$) was constant. Excel was used to plot graph of experimental data (a_{ex} VS M-m) and the slope was found from the best fit line. A trend line was added to the graph. Slope was set ($\frac{g}{M-m}$) and was solved for (M + m). The percentage difference in (M + m) was found.

4. Experimental Data

Table: Acceleration for different mass combination

M (gm)	m (gm)	Height D (cm)	Time t (sec)	Mean Time (sec)	$a_{ex} = \frac{2D}{t^2}$ (cm / s^2)	$a_{th} = \frac{M - m}{M + m} g$ (cm / s^2)	% Diff in $a = (\frac{a_{th} - a_{ex}}{a_{th}}) \times 100$	M - m (gm)
			0.56					
500	200	78.8	0.58	0.5633	496.6800	420	-18.2571 %	300
			0.55					
			0.61					
475	225	78.8	0.63	0.6267	401.2701	350	-14.6486 %	250
			0.64					
			0.76					
450	250	78.8	0.74	0.7500	280.1778	280	-0.0635 %	200
			0.75					
			0.80					
425	275	78.8	0.82	0.8133	238.2619	210	-13.4580 %	150
			0.82					
			0.90					
400	300	78.8	0.91	0.9133	188.9423	140	-34.9588 %	100
			0.93					
			1.09					
375	325	78.8	1.10	1.0933	131.8492	70	-88.3560 %	50
			1.09					
350	350		0	0	0	0	0 %	0


Graph of a_{ex} vs (M-m)
y = 1.5144x + 21.013
496.68
401.2701
280.1778
238.2619
188.9423
131.8492
600
500
400
300
200
100
0
0
0
50
100
150
200
250
300
350
a_{ex}
(M-m)

5. Analysis and Calculation

(i) The slope of the straight line from the graph:

$$m = \frac{g}{(M+m)_{graph}}$$

$$\text{or, } 1.5144 = \frac{980}{(M+m)_{graph}}$$

$$\text{or, } (M+m)_{graph} = \frac{980}{1.5144}$$

$$\text{or, } (M+m)_{graph} = 647.1210\ grams$$

(ii) Error of (M+m) :

$$\text{Error} = \frac{700-(M+m)_{graph}}{700} \times 100$$

$$= \frac{700-647.1210}{700} \times 100$$

$$= 7.5541\%$$

6. Result

Sum of masses (M+m) obtained from the graph = 647.1210 grams.

7. Remarks

With an error percentage of 7.5541%, the theoretical and the experimental values are very close. As a result Newton's second law has been verified.