Lab 6: Newton's Second Law: The Atwood Machine

PHYS 121: General Physics I

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1. Write Newton's second law in mathematical form, and describe how the acceleration of an object or system varies with a net force and mass of the system.

According to the Newton's second law

F = m*a

Here F is the resultant force,m is the mass of the object and a is the acceleration produced due to this force.

So from the above equation it is clear that the acceleration depends upon the mass of the object and the resultant force.

So the net force induces the acceleration in the body.Also the acceleration depends upon the mass of the object and varies with the mass of the object.For example in case of the rocket the mass of the fuel continuously changes and hence acceleration.

2. What are F and m in Newton's second law in terms of the Atwood machine?

Acceleration of the system = Net force along line of motion / Total mass in motion

Let m2>m1 , and a is the net acceleration

Therefore total mass = m1 + m2

Net force along line of motion = m2g - m1g = (m2-m1)g

Thus Acceleration of the system = (m2-m1)g /(m1 + m2)

Force , F = total mass* Acceleration of the system
F = (m1+m2)*(m2-m1)g /(m1 + m2)

Thus F = (m2-m1)g

3. Explain how F and m are individually varied while the other is held constant. Why is this done?

According to Newton's second law, an object of mass m is subjected to a new force and the object undergoes an acceleration a. The direction of acceleration is the same as of the direction of the force. In other words, the force experienced by an object is defined as the product of the mass F = ma. Here, a is the acceleration and can be referred to as gravity on earth and has constant value equal to 9.8 $\frac{m}{s^2}$. If acceleration is constant, Force is directly proportional to mass.

4. How can the frictional force be experimentally determined, and how is it used in the calculations?

When an object is subject to a non-balanced force, it tends to move from its rest position. If the applied force is continuous for some time, then the object would accelerate until it reaches the maximum possible speed. The acceleration is proportional to the applied force. In the Atwood experiment the acceleration is basically a constant and is calculated from the kinematic equations which include the distance and time of fall. $a = \frac{2y}{t}$, here y is the distance of fall and t the time of fall. The net force when pulley is non-frictionless then $F_{net} - f = (m_1 + m_2 + m_{eq})a$, As we know the masses of the blocks and the pulley and acceleration can be determined from time of fall, it's easy to determine the frictional force value from the above equation.

5. What is measured in the experiment, and how is this used to compute the acceleration of the system?

The distance of fall of the hanging weights and the time of fall is measured to determine the acceleration of the system. The experiment of Atwood machines basically determines the theoretical and experimental values of acceleration. The difference in the accelerations is calculation and % of variation of experimental against theatrical acceleration is calculated.

Data Table 1

m_{eq}________( )	Trial							
	*	1	*	2	*	3	*	4
Descending Mass M_2 ( )		60g		160g		260g		360g
Ascending Mass M_1 ( )		50g		150g		250g		350g
Distance of Travel y ( )		0.60m		0.57m		0.55m		0.52m
Time of Travel t ( ) — Run 1		1.42s		1.76s		2.52s		2.55s
Time of Travel t ( ) — Run 2		1.38s		1.80s		2.50s		3.01s
Time of Travel t ( ) — Run 3		1.40s		1.60s		2.70s		3.00s
Time of Travel t ( ) — Average		1.40s		1.72s		2.57s		2.95s
Measured acceleration $a_m = 2y/t^2$ ( )		0.61s		0.38s		0.16s		0.11s
Total mass $= m_1 + m_2 + m_{eq}$ ( )		167g		367g		567g		767g
Measured frictional mass $m_f = m_2 - m_1$	10		10		10		10	
Net force $= (m_2 - m_1 - m_f)g$ ( )		0.098g		0.098g		0.098 g		0.098g
Theoretical acceleration a_t = Net force/Total mass		0.58g		0.26g		0.17g		0.12g
Percent different Between a_m and a_t		5.04%		37.5%		6.06%		8.69%

Data Table 2

m_{eq}________( )		Trial				
		*	5	6	7	8
Descending Mass M_2 ( )			261g	263g	265g	267g
Ascending Mass M_1 ( )			259g	257g	255g	253g
Distance of Travel y ( )			0.55m	0.52m	0.50m	0.48m
Time of Travel t ( )	Run 1		5.69s	3.30s	2.40s	2.20s
	Run 2		5.70s	3.60s	2.35s	2.15s
	Run 3		5.50s	3.31s	2.42s	2.22s
	Average		5.63s	3.40s	2.39s	2.19s
Measured acceleration $a_m = 2y/t^2$ ( )			0.036s	0.08s	0.17s	0.23s
Total mass $= m_1 + m_2 + m_{eq}$ ( )			577g	577g	577g	577g
Measured frictional mass $m_f = m_2 - m_1$						
Net force $= (m_2 - m_1 - m_f)g$ ( )			0.098g	0.098g	0.098g	0.098g
Theoretical acceleration a_t = Net force/Total mass			0.16s	0.16s	0.16s	0.16s
Percent different Between a_m and a_t			1.29%	66.66%	6.06%	0.606%

Conclusion:

Newton's second law states that the Force of an object is the mass of an object multiplied by its acceleration. In this lab, we conducted several experiments using the Atwood Machine, which is made up of a pulley, a string, and two objects of varying masses. In conducting our experiments, we witnessed Newton's second law in action; When we increased the mass of the object, the acceleration at which it fell increased as well, and vice versa when we decreased the mass of the object.