Vector Addition

Equipment

Super pulley force table, Table clamp, String (spool of thread), Mass and Hanger set, Protractor, Metric Ruler Sheet of paper and graph paper

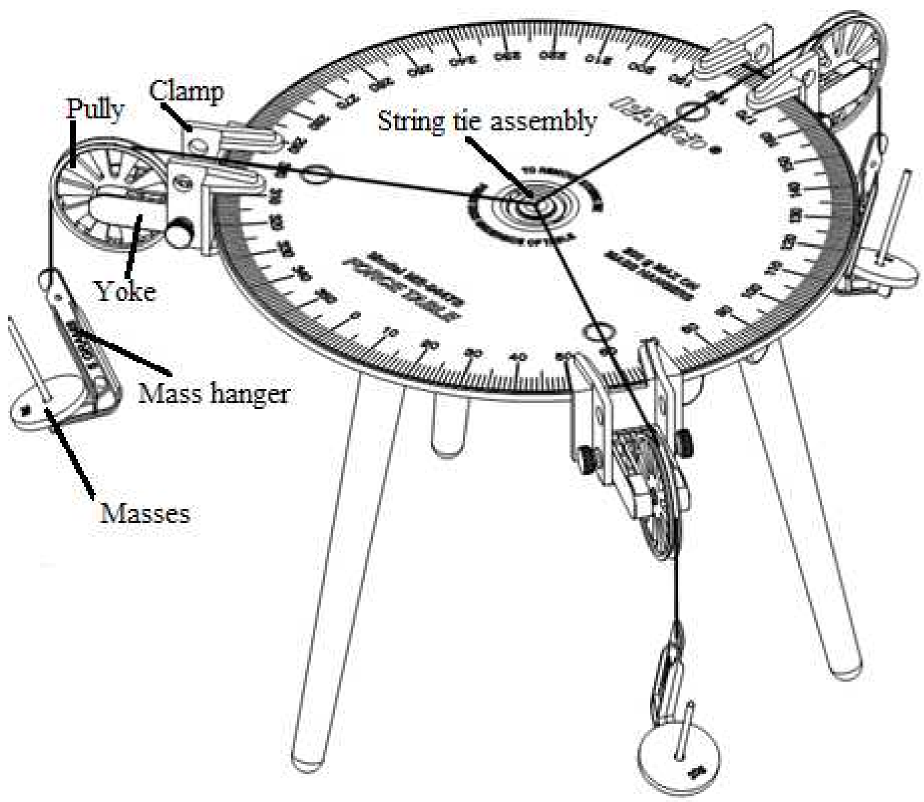


Figure 1. Force table with three pulleys

Purpose

The purpose of this experiment is to use the force table to experimentally determine the force that balances two other forces. This result is checked by (1) adding the two forces using their horizontal and vertical vector components, and (2) by graphically adding the force vectors.

Theory

This experiment finds the resultant of adding two vectors by three methods: experimentally, by adding components (analytically), and graphically.

Experimental procedure

Assemble the force table as shown in the figure 1. Use three super pulley clamps (two for the forces that will be added and one for the force balances the sum of the other two forces).

(1) Place a pulley at the 20.0^o mark on the force table and place a total of $0.100\,kg$ (including the mass holder) on the end of the string. Calculate the magnitude of the force (in N) produced by the mass. Assume that $g = 9.80\,m/s^2$ and record the value of this force as F_1 in data table 1.

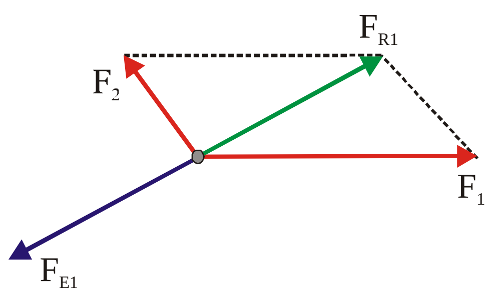
(2) Place a second pulley at the 90.0^o mark on the force table and place a total of $0.200\,kg$ on the end of the string. Calculate the force produced and record as F_2 in data table 1.

(3) Determine by trial and error the magnitude of mass needed and the angle at which it must be located for the ring to be centered on the force table. Jiggle the ring slightly to be sure that this equilibrium condition is met. Attach all strings to the ring so that they are directed along a line passing through the center of the ring. All the forces will then act through the point at the center of the table. Record this value of mass in data table 1 in the row labeled equilibrant F_{E1}.

(4) Calculate the force produced (mg) on the experimentally determined mass. Record the magnitude and direction of this equilibrant force F_{E1} in data table 1.

(5) The resultant F_{R1} is equal in magnitude to F_{E1}, and its direction is 180^o from F_{E1}. Record the magnitude of the force F_{R1}, the mass equivalent of this force, and the direction of the force in data table 1 in the row labeled resultant F_{R1}.

$$-\vec{F}_{E1} = \vec{F}_{R1} = \vec{F}_1 + \vec{F}_2$$



Method of finding equilibrium

The ring will be centered in the force table when the system is in equilibrium. Pull the ring slightly to one side and let it go. Check to see that the ring returns to the center. If not, adjust the mass and /or the angle of the super pulley clamp until the ring always returns to the center when pulled slightly to one side.

Calculations

(1) $F = mg$

(2) $Direction\ F_{E1}\ opposite\ F_{R1},\ so\ direction\ \ F_{R1} = direction\ F_{E1} - 180^o =$

(3) $F_{1x} = F_1 \cos\left(20^o\right) =$

(4) $F_{1y} = F_1 \sin\left(20^o\right) =$

(5) $F_{R1} = \sqrt{\left(F_{Rx}\right)^2 + \left(F_{Ry}\right)^2} =$

(6) $\overline{\ } = \tan^{-1}\left(\dfrac{F_y}{F_x}\right) =$

(7) $\%\ Error\ Experiment = \dfrac{\left|Experimental - Analytical\right|}{Analytical} \times 100\% =$

(8) $Absolute\ Error = \overline{\ }(experiment) - \overline{\ }(analytical) =$

Data table 1

Forces	Mass (kg)	Force (N)	Direction (θ)
F_1	0.100		20.0^o
F_2	0.200		90.0^o
Equilibrant F_{E1}			
Resultant F_{R1}			

Calculations table 1

Graphical solution			
Forces	Mass (kg)	Force (N)	Direction
F_1	0.100		20.0^o
F_2	0.200		90.0^o
Resultant F_{R1}			

Analytical solution					
Forces	Mass (kg)	Force (N)	Direction	x-component	y-component
F_1	0.100		20.0^o		
F_2	0.200		90.0^o		
Resultant F_{R1}					

Error Calculations

Percent error magnitude experimental compared to analytical = __________%

Percent error magnitude graphical compared to analytical = __________%

Absolute error in angle experimental compared to analytical = __________degrees

Absolute error in angle graphical compared to analytical = __________degrees

Answer Questions 1–3 with reference to figure 2 below.

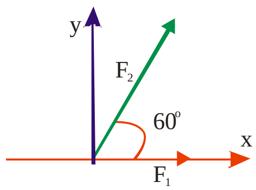


Figure 2 Addition of two force vectors.

1. If F_1 is a force vector of magnitude 30.0 N and F_2 is a force vector of magnitude 40.0 N acting in the directions shown in figure 2, what are the magnitude and direction of the resultant obtained by the vector addition of these two vectors using the analytical method? Show your work.

Magnitude = __________N Direct ion (relative to x axis) = __________degrees

2. What is the equilibrant force that would be needed to compensate for the resultant force of the vectors F_1 and F_2 that you calculated in question 1?

Magnitude = __________N Direction (relative to x axis) = __________degrees

3. Use the polygon method of vector addition (graphical solution) to the problem in figure 2. Use the scale 1.00 cm = 10.0 N.

Resultant vector length = __________c m

Force represented by this length = __________N

Direction of resultant (relative to x axis) = __________ degrees