College Physics 201
Vector Addition

Materials: *Vector tables, 4 pulleys, 4 50-g mass hangers, slotted mass sets*

1 Purpose

The goal of this exercise is to test the component method for vector addition by comparing a calculated resultant vector to an experimentally determined resultant vector.

2 Introduction

The addition of vectors can be done experimentally with the force table system which will be shown to you in the laboratory. The force table takes advantage of the constant nature of the gravitational force to generate vectors. These vectors all pull on the same ring at the center of the force table which serves as the center of the coordinate system. A set of 360° markings around the outer edge of the table provide the angle of each force.
The equilibrant force is the the force (magnitude and angle) necessary to balance out the forces being summed together and bring the ring at the center into central equilibrium. Given the nature of this balance, $\Sigma\vec{F} = m\vec{a} = 0$, the equilibrant vector is equal to the resultant vector in magnitude and exactly 180° different in direction.

3 Procedure

First, ensure that the force table is level. Then, for each setup

1. Load and position the mass hangers around the force table, as prescribed in Table 1.

   Note that these masses *include* the mass of the hanger itself.

2. Experimentally determine the *equilibrant* vector by adding mass to an additional hanger and adjusting its position until you have brought the system into balance (by re-centering the ring). Record the total mass and its position in your spreadsheet.

Table 1: Prescribed total masses and positions for hangers in each setup.

Setup	Mass 1 (kg)	θ_1 (deg)	Mass 2 (kg)	θ_2 (deg)	Mass 3 (kg)	θ_3 (deg)
1	0.55	0	0.35	90	-	-
2	.25	180	0.55	90	-	-
3	0.35	20	0.45	270	-	-
4	0.550	74	0.300	206	-	-
5	0.550	90	0.350	140	0.700	230

4 Analysis

Begin your analysis for each setup on a fresh sheet of paper. Clearly label each page with 'Setup' followed by the setup number for which that page corresponds.
For each setup,

1. Make a force diagram of the setup. Use arrows that have a size and direction commensurate with the magnitude and direction of the force they represent. Clearly label each force.

2. Calculate the magnitude of each force vector. Record each value in your spreadsheet.

3. Use the experimentally determined *equilibrant* force to calculate the magnitude and direction of the corresponding *resultant* vector. Record this in your spreadsheet.

4. Calculate the *theoretical* resultant force vector by using the component method to sum all of the force vectors except for the equilibrant vector. Record the x and y components from this sum (R_{Th}: F_x and F_y) in your spreadsheet.

5. Calculate the magnitude and direction of the *theoretical* resultant force vector from the components you just calculated. Record these [R_{Th}: 'Force' and 'Direction'] in your spreadsheet.

6. Calculate the percent difference between the magnitude of the experimental and theoretical resultant forces (R_{Exp} and R_{Th}) with Equation 1. Record these results in your spreadsheet.

$$\frac{R_{Exp} - R_{Th}}{R_{Th}} * 100\% \tag{1}$$

7. Calculate the percent difference between the experimental and theoretical resultant directions. Record these results in your spreadsheet. To provide a more standardized comparison between setups, calculate the percent difference in resultant angle with Equation 2.

$$\frac{(\theta_{Exp} - \theta_{Th})}{180^\circ} * 100\% \tag{2}$$

5 References

1. OpenStax, Chapter 2, section 2

2. OpenStax, Chapter 3, sections 1, 2, and 3