EXPERIMENT #1 - PHYSICS 230

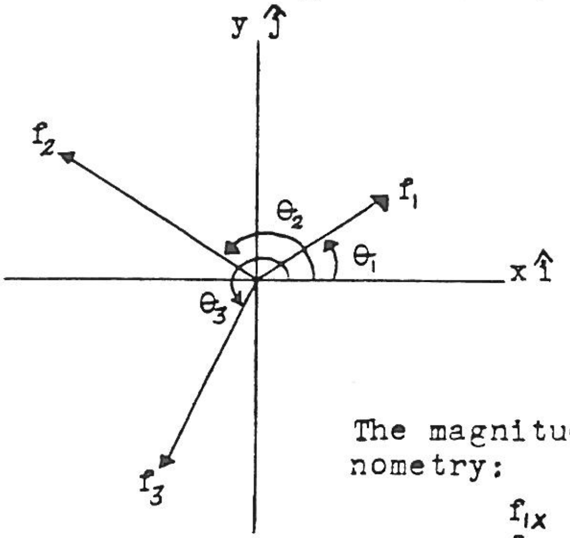
Vectors (Force Table)

OBJECT: To study the vector treatment of static forces by using a force table.

EQUIPMENT: force table and weights

THEORY: Static forces may be added vectorially by separating each force into its orthogonal or perpendicular components. A good procedure for resolving forces is to establish an x y type coordinate system and find the x and y force components systematically.

Example: If forces $\vec{f}_1$, $\vec{f}_2$, and $\vec{f}_3$ are in static equilibrium and $\vec{f}_1$ and $\vec{f}_2$ are known, then one may find $\vec{f}_3$ by the following method:



If three forces are in static equilibrium, the vector sum of these forces is zero (i.e., there is no net force left for movement).
This is expressed as: $\vec{f}_1 + \vec{f}_2 + \vec{f}_3 = \vec{0}$ where each force may be separated into its x and y components:
$\vec{f}_1 = f_{1x}\ \hat{i} + f_{1y}\ \hat{j}$, $\vec{f}_2 = f_{2x}\ \hat{i} + f_{2y}\ \hat{j}$, and $\vec{f}_3 = f_{3x}\ \hat{i} + f_{3y}\ \hat{j}$ where $\hat{i}$ and $\hat{j}$ are unit vectors.

The magnitude of these components may be found by trigonometry:

$$
\begin{aligned}
f_{1x} &= f_1 \cos\theta_1 \\
f_{2x} &= f_2 \cos\theta_2 = -f_2 \sin(\theta_2 - 90) \\
f_{3x} &= f_3 \cos\theta_3 = -f_3 \sin(270 - \theta_3) \\
f_{1y} &= f_1 \sin\theta_1 \\
f_{2y} &= f_2 \sin\theta_2 = f_2 \cos(\theta_2 - 90) \\
f_{3y} &= f_3 \sin\theta_3 = -f_3 \cos(270 - \theta_3)
\end{aligned}
$$

Substituting into the vector force equation one obtains:

$$(f_{1x} + f_{2x} + f_{3x})\hat{i} + (f_{1y} + f_{2y} + f_{3y})\hat{j} = \vec{0}$$

Since $\hat{i}$ and $\hat{j}$ are independent then:

$$f_{3x} = -(f_{1x} + f_{2x}) \qquad f_3 = \left[f_{3x}^2 + f_{3y}^2\right]^{\frac{1}{2}}$$
$$f_{3y} = -(f_{1y} + f_{2y}) \quad \text{and} \quad \tan\theta_3 = \frac{f_{3y}}{f_{3x}}$$

GENERAL DIRECTIONS:

1. Determine the weight of each hanger (device which holds the weights).

2. Examine the force table so as to understand its operation. The hangers may be loaded with weights in order to vary the forces acting on the center ring. Several hangers may be used to generate several forces in different directions on the ring. If all the forces are in equilibrium, the pin will be centered properly inside the ring.

3. Using 3 hangers only, place 2 hangers loaded with 100 grams each of additional weight 120° apart. Place the third hanger between the other two hangers (120° from nearest neighbor) and find the correct weight (or mass) needed to balance the force system. Verify this by theoretical calculations.

4. Using 4 hangers, place 2 hangers with 100 grams apiece 120 apart. Load the other 2 hangers with 100 gr. and 50 gr. Find the equilibrium position of the force system and record the angles for the system. Verify this by theoretical calculations.

5. Using 3 hangers only, load one hanger with an unknown mass. Using the other 2 hangers and the standard weights, determine the weight of the unknown mass. The only angle to be measured is the angle between the 2 known forces when the system is balanced.

6. Weigh the unknown mass on a scale and find the percent error =

$$\frac{\text{force table value} - \text{scale value}}{\text{scale value}} \times 100\%$$

7. Using only 3 hangers load 2 of the hangers with unknown masses (different values). Using the remaining hanger and the standard weights, determine the values of the unknown masses.

8. Weigh the unknown masses on a scale and find the percent error.

9. Explain why there may be any experimental errors in the results of this experiment.