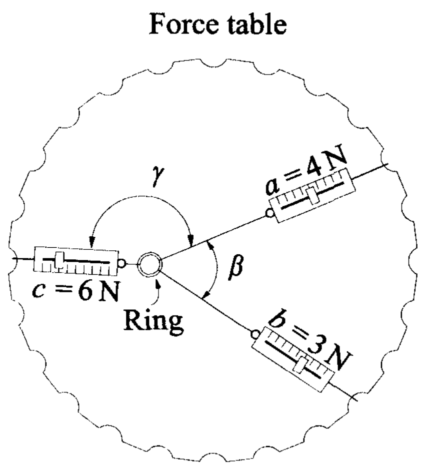
Name **Section #**

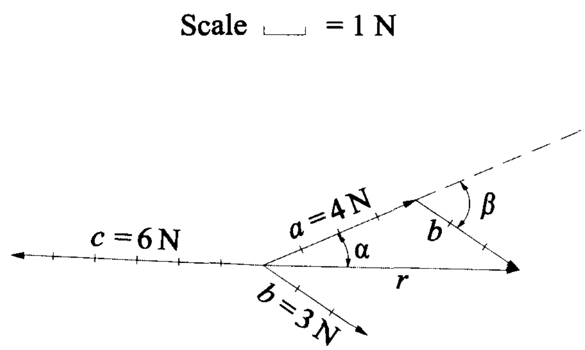
Adding Forces

Purpose

In order to specify forces, both magnitude and direction must be provided. Are forces then true vectors? You will determine whether vector addition can be used to add forces.

The illustration below shows the ring at the center of the force table in equilibrium with the three forces $\boldsymbol{a}$, $\boldsymbol{b}$, and $\boldsymbol{c}$, so that the vector sum $\mathbf{a} + \mathbf{b} + \mathbf{c} = 0$. Let the resultant of the two forces $\boldsymbol{a}$ and $\boldsymbol{b}$ be $\mathbf{r} = \mathbf{a} + \mathbf{b}$, then $\mathbf{r} + \mathbf{c} = 0$, or $\mathbf{r} = -\mathbf{c}$. This means that if forces are indeed vectors, it should be possible to take any two of them say $\boldsymbol{a}$ and $\boldsymbol{b}$ to obtain a resultant $\boldsymbol{r}$ which will be opposite in direction to the equilibrant $\boldsymbol{c}$ and equal to it in magnitude.





Procedure

Lay each of the three newton scales flat on the table and note the position of the pointer. If it deviates from zero you will have to include the deviation for each measurement made with that scale.

Set up the force table as shown above and insert a sheet of paper so that the ring lies approximately on the center of the sheet. (Use the third page marked 'Trial #1'.) Mark this position with a dot. Draw a dot under each of the wires connecting the spring scales with the ring and mark the number of newtons shown for each spring next to the dot drawn. Remove the sheet and connect the dots drawn for each spring with the center dot. You should now have three lines roughly in the shape of a 'Y'. Extend the three lines so that their lengths are proportional to the spring readings. Draw arrowheads on these lines and arbitrarily label the forces as $\boldsymbol{a}$, $\boldsymbol{b}$, and $\boldsymbol{c}$. Measure the angle β between $\boldsymbol{a}$ and $\boldsymbol{b}$, and γ the angle between $\boldsymbol{a}$ and $\boldsymbol{c}$. Enter all the information into the row 'Trial #1' of Table 1 on the next page.

Table 1

Trial #	a (N)	b (N)	c (N)	β	γ
1					
2					
3					
4					

Add $\boldsymbol{b}$ to $\boldsymbol{a}$ by extending $\boldsymbol{a}$, marking off angle β, and redrawing $\boldsymbol{b}$ as shown in the diagram of the previous page. Then draw a vector from the beginning of $\boldsymbol{a}$ to the end of $\boldsymbol{b}$ and label it $\boldsymbol{r}$. Use your drawing scale to determine its magnitude, measure the angle α between $\boldsymbol{r}$ and $\boldsymbol{a}$ and enter these *measured values* in Table 2. You can also calculate these values as follows: $r = \sqrt{a^2 + b^2 + 2 \cdot a \cdot b \cdot \cos \beta}$, and

$$\alpha = \sin^{-1}\left[\frac{b \cdot \sin \beta}{r}\right].$$

Enter these *calculated values* in Table 2. Also enter the percent difference between the calculated magnitude of $\boldsymbol{r}$ and the equilibrant $\boldsymbol{c}$, and also the sum of the angles α and γ.

Table 2

Trial #	Measured		Calculated		Equilibrant	% Difference Between measured r and c	Angle α between measured r and a	$\alpha + \gamma$
	r (N)	α	r (N)	α	c (N)			
1								
2								
3								
4								

Repeat the experiment three more times with different forces and angles, and enter your data for each of the tables in the rows marked Trials 2–4. Use one side of a sheet for each set of drawings. After completing the lab, answer the questions on the last page.

Trial #1

Trial #2

Trial #3

Trial #4

Questions

- Is the procedure for vector addition valid for combining forces? Justify your answer.

- What are some of the sources of error in determining a resultant by adding vectors graphically?

- Under what conditions will forces ***a***, ***b***, and ***c*** be equal in magnitude?