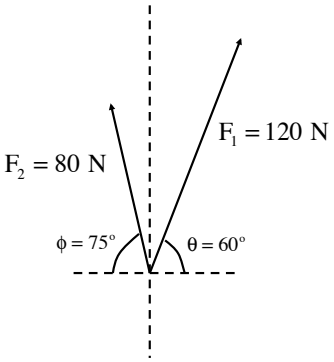
Problem 3.20

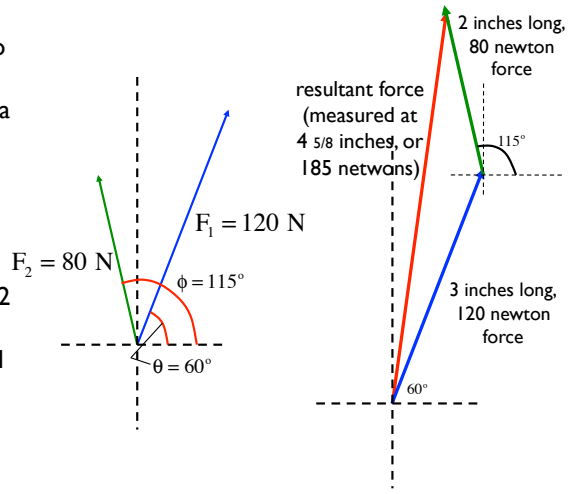
A mule is being pulled by an 80-newton force and a 120-newton force as shown.

a.) Determine the single force "equivalent" force that could take the place of the two forces and have the same effect on the donkey.

b.) Determine the single force that could be added to the mix to make the net force on the donkey equal to zero.



a.) The first way to do this is using graphical vector addition. Use a protractor to get the angles. Using a ruler and scaling factor of one-inch per 40 newtons, the 80 newton force will be 2 inches long and the 120 newton force will be 3 inches long.

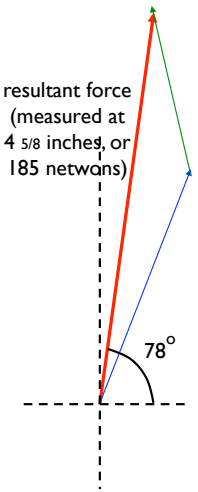


To the right, the tail of the 2 inch long, 80 newton force is placed on the head of the 3 inch long, 120 newtons force with the resultant AS MEASURED WITH A RULER, of (4.625 inches)(40 nts/inch)= 185 nts.

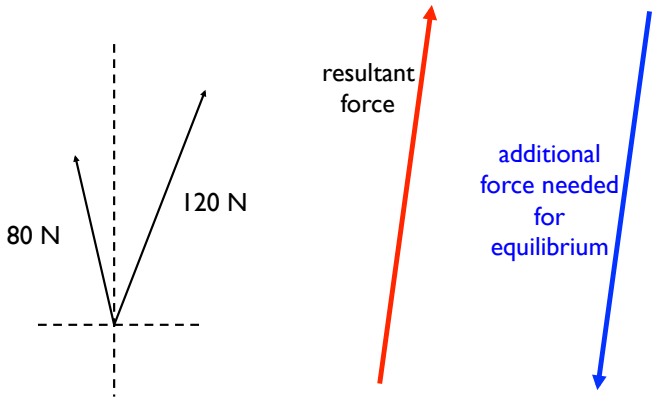
A protractor should be used to determine the resultant's angular position, relative to the +x-axis. In this case, that angle is approximately 78°. This is all that's needed to identify the net vector due to the addition.

The net resultant vector is:

$$\vec{F} = (185 \text{ nts}) \measuredangle 78°$$



b.) The force required to null out the resultant is a second vector in the opposite direction of the resultant. That is, one with a magnitude of 185 newtons at an angle of (78 + 180) degrees.



a.) A second way to do part "a" is by breaking the vectors into components in the x and y directions, then adding. Looking at the sketch, then the math:

In the x-direction:

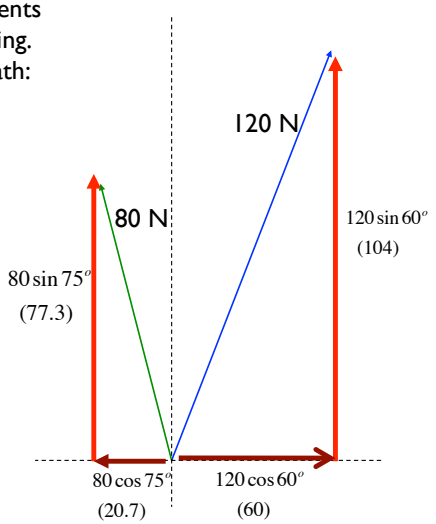
$$F_x = 60 - 20.7$$
$$= 39.3 \text{ newtons}$$

In the y-direction:

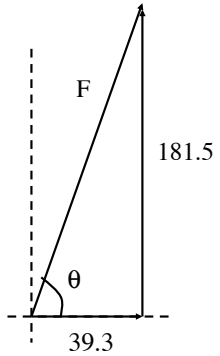
$$F_y = 77.3 + 104$$
$$= 181.3 \text{ newtons}$$

That is, the resultant is:

$$\vec{F} = 39.3\hat{i} + 181.3\hat{j}$$



To get this into polar notation:



$$|\vec{F}| = \left(F_x^2 + F_y^2\right)^2$$
$$= \left((39.3)^2 + (181.3)^2\right)^2$$
$$= 185.5$$

$$\theta = \tan^{-1}\left(\frac{181.5}{39.3}\right)$$
$$= 77.8^o$$

$$\Rightarrow \quad \vec{F} = (185.5 \text{ nts}) \angle 78^o$$

This is what we got using the graphical vector addition approach!

In summary, the unit vector notation of the resultant is:

$$\vec{F}_1 + \vec{F}_2 = (39.3)(\hat{i}) + (181.2)(\hat{j})$$

The polar notation of the resultant is:

$$\vec{F}_1 + \vec{F}_2 = (39.3^2 + 181.2^2)^{1/2} \angle \tan^{-1}\left(\frac{181.2}{39.3}\right)$$
$$= (185.4 \text{ nts}) \angle 77.8^o$$