# Take-Home Assignment weeks 35–36

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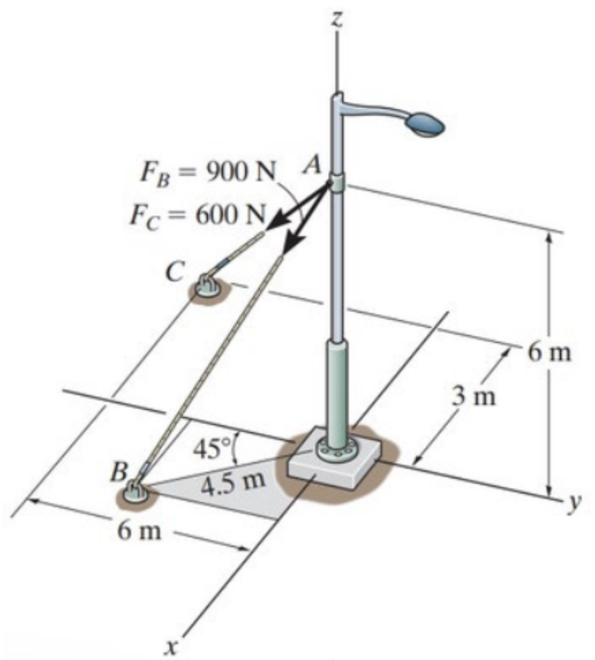
## Exercise P1-1

Determine the magnitude and coordinate direction angles of the resultant force acting at $A$.




We start by adding a coordinate system such that the point $A$ is located at the origin $O$. The resultant force here $\mathbf{F}_A$ is simply the sum of the two acting forces $F_B = 900\,\mathrm{N}$ and $F_C = 600\,\mathrm{N}$. We must therefore express these two in terms of Cartesian coordinates. First of all we start by determining the side length of the isoceles right triangle comprised by $\mathbf{r}_B$ and its components. These components can be found as:

$$\cos 45^\circ \cdot 4{,}5\,\mathrm{m} = \sin 45^\circ \cdot 4{,}5\,\mathrm{m} = 3{,}18\,\mathrm{m}.$$

This means that the position vector $\mathbf{r}_B$ can be written as:

$$\mathbf{r}_B = (3{,}18\,\mathrm{m}\mathbf{i} - 3{,}18\,\mathrm{m}\mathbf{j} - 6\,\mathrm{m}\mathbf{k})\,.$$

A unit vector along this direction can be found as:

$$\mathbf{u}_B = \frac{\mathbf{r}_B}{|\mathbf{r}_B|} = \frac{(3{,}18\,\mathrm{m}\mathbf{i} - 3{,}18\,\mathrm{m}\mathbf{j} - 6\,\mathrm{m}\mathbf{k})}{\sqrt{(3{,}18\,\mathrm{m})^2 + (3{,}18\,\mathrm{m})^2 + (6\,\mathrm{m})^2}} = 0{,}4241\mathbf{i} - 0{,}4241\mathbf{j} - 0{,}8002\mathbf{k}.$$

Now if we just multiply this by the magnitude of the force $F_B$ we get the force in the direction of $B$ in cartestian coordinates:

$$\mathbf{F}_B = F_B \cdot \mathbf{u}_B = 900\,\mathrm{N} \cdot (0{,}4241\mathbf{i} - 0{,}4241\mathbf{j} - 0{,}8002\mathbf{k}) = 381{,}69\,\mathrm{N}\,\mathbf{i} - 381{,}69\,\mathrm{N}\,\mathbf{j} - 720{,}18\,\mathrm{N}\,\mathbf{k}.$$

We can also find the unit vector along $\mathbf{r}_C$ as:

$$\mathbf{u}_C = \frac{\mathbf{r}_C}{|\mathbf{r}_C|} = \frac{(-3\,\mathrm{m}\,\mathbf{i} - 6\,\mathrm{m}\,\mathbf{j} - 6\,\mathrm{m}\,\mathbf{k})}{\sqrt{(3\,\mathrm{m})^2 + (6\,\mathrm{m})^2 + (6\,\mathrm{m})^2}} = -0{,}333\mathbf{i} - 0{,}666\mathbf{j} - 0{,}666\mathbf{k}.$$

Therefore we can now find $\mathbf{F}_C$ as:

$$\mathbf{F}_C = F_C\mathbf{u}_C = 600\,\mathrm{N} \cdot (-0{,}333\mathbf{i} - 0{,}666\mathbf{j} - 0{,}666\mathbf{k}) = -200\,\mathrm{N}\,\mathbf{i} - 400\,\mathrm{N}\,\mathbf{j} - 400\,\mathrm{N}\,\mathbf{k}.$$

The resultant force $\mathbf{F}_A$ can now be found as:

$$\mathbf{F}_A = \mathbf{F}_B + \mathbf{F}_C = 0{,}182\,\mathrm{kN}\,\mathbf{i} - 0{,}782\,\mathrm{kN}\,\mathbf{j} - 1{,}12\,\mathrm{kN}\,\mathbf{k}.$$

The magnitude of this can be found by the Pythagorean theorem as:

$$F_A = \sqrt{(0{,}182\,\mathrm{kN})^2 + (0{,}782\,\mathrm{kN})^2 + (1{,}12\,\mathrm{kN})^2} = 1{,}38\,\mathrm{kN}.$$

Now we can find the angles with each of the three axes as:

$$\begin{aligned}
\alpha &= \cos^{-1}\left(\frac{F_{Ax}}{F_A}\right) = \cos^{-1} 0{,}132 = 82{,}4^\circ \\
\beta &= \cos^{-1}\left(\frac{F_{Ay}}{F_A}\right) = \cos^{-1} -0{,}567 = 124{,}5^\circ \\
\gamma &= \cos^{-1}\left(\frac{F_{Az}}{F_A}\right) = \cos^{-1} -0{,}813 = 144{,}4^\circ.
\end{aligned}$$

Therefore the resultant force $\mathbf{F}_A$ is of magnitude 1,38 kN and makes angles of 82,4°, 124,5°, and 144,4° with the positive $x$-, $y$-, and $z$-axes respectively.