22. If we write $\vec{r}\,' = x'\,\hat{\mathrm{i}} + y'\,\hat{\mathrm{j}} + z'\,\hat{\mathrm{k}}$, then (using Eq. 3-30) we find $\vec{r}\,' \times \vec{F}$ is equal to

$$(y'F_z - z'F_y)\,\hat{\mathrm{i}} + (z'F_x - x'F_z)\,\hat{\mathrm{j}} + (x'F_y - y'F_x)\,\hat{\mathrm{k}}\ .$$

(a) Here, $\vec{r}\,' = \vec{r}$ where $\vec{r} = 3\,\hat{\mathrm{i}} - 2\,\hat{\mathrm{j}} + 4\,\hat{\mathrm{k}}$, and $\vec{F} = \vec{F}_1$. Thus, dropping the primes in the above expression, we set (with SI units understood) $x = 3$, $y = -2$, $z = 4$, $F_x = 3$, $F_y = -4$ and $F_z = 5$. Then we obtain $\vec{\tau} = \vec{r} \times \vec{F}_1 = \left(6.0\,\hat{\mathrm{i}} - 3.0\,\hat{\mathrm{j}} - 6.0\,\hat{\mathrm{k}}\right)$ N·m.

(b) This is like part (a) but with $\vec{F} = \vec{F}_2$. We plug in $F_x = -3$, $F_y = -4$ and $F_z = -5$ and obtain $\vec{\tau} = \vec{r} \times \vec{F}_2 = \left(26\,\hat{\mathrm{i}} + 3.0\,\hat{\mathrm{j}} - 18\,\hat{\mathrm{k}}\right)$ N·m.

(c) We can proceed in either of two ways. We can add (vectorially) the answers from parts (a) and (b), or we can first add the two force vectors and then compute $\vec{\tau} = \vec{r} \times \left(\vec{F}_1 + \vec{F}_2\right)$ (these total force components are computed in the next part). The result is $\left(32\,\hat{\mathrm{i}} - 24\,\hat{\mathrm{k}}\right)$ N·m.

(d) Now $\vec{r}\,' = \vec{r} - \vec{r}_{\mathrm{o}}$ where $\vec{r}_{\mathrm{o}} = 3\,\hat{\mathrm{i}} + 2\,\hat{\mathrm{j}} + 4\,\hat{\mathrm{k}}$. Therefore, in the above expression, we set $x' = 0$, $y' = -4$, $z' = 0$, $F_x = 3 - 3 = 0$, $F_y = -4 - 4 = -8$ and $F_z = 5 - 5 = 0$. We get $\vec{\tau} = \vec{r}\,' \times \left(\vec{F}_1 + \vec{F}_2\right) = 0$.