19. Many of the operations are done efficiently on most modern graphical calculators using their built-in vector manipulation and rectangular $\leftrightarrow$ polar "shortcuts." In this solution, we employ the "traditional" methods (such as Eq. 3-6). Where the length unit is not displayed, the unit meter should be understood.

(a) Using unit-vector notation,

$$\begin{aligned}\vec{a} &= 50\cos(30^\circ)\,\hat{\imath} + 50\sin(30^\circ)\,\hat{\jmath}\\ \vec{b} &= 50\cos(195^\circ)\,\hat{\imath} + 50\sin(195^\circ)\,\hat{\jmath}\\ \vec{c} &= 50\cos(315^\circ)\,\hat{\imath} + 50\sin(315^\circ)\,\hat{\jmath}\\ \vec{a}+\vec{b}+\vec{c} &= 30.4\,\hat{\imath} - 23.3\,\hat{\jmath}\ .\end{aligned}$$

The magnitude of this result is $\sqrt{30.4^2 + (-23.3)^2} = 38$ m.

(b) The two possibilities presented by a simple calculation for the angle between the vector described in part (a) and the $+x$ direction are $\tan^{-1}(-23.2/30.4) = -37.5^\circ$, and $180^\circ + (-37.5^\circ) = 142.5^\circ$. The former possibility is the correct answer since the vector is in the fourth quadrant (indicated by the signs of its components). Thus, the angle is -37.5°, which is to say that it is roughly 38° *clockwise* from the $+x$ axis. This is equivalent to 322.5° counterclockwise from $+x$.

(c) We find $\vec{a} - \vec{b} + \vec{c} = (43.3 - (-48.3) + 35.4)\,\hat{\imath} - (25 - (-12.9) + (-35.4))\,\hat{\jmath} = 127\,\hat{\imath} + 2.6\,\hat{\jmath}$ in unit-vector notation. The magnitude of this result is $\sqrt{127^2 + 2.6^2} \approx 1.3 \times 10^2$ m.

(d) The angle between the vector described in part (c) and the $+x$ axis is $\tan^{-1}(2.6/127) \approx 1^\circ$.

(e) Using unit-vector notation, $\vec{d}$ is given by

$$\begin{aligned}\vec{d} &= \vec{a} + \vec{b} - \vec{c}\\ &= -40.4\,\hat{\imath} + 47.4\,\hat{\jmath}\end{aligned}$$

which has a magnitude of $\sqrt{(-40.4)^2 + 47.4^2} = 62$ m.

(f) The two possibilities presented by a simple calculation for the angle between the vector described in part (e) and the $+x$ axis are $\tan^{-1}(47.4/(-40.4)) = -50^\circ$, and $180^\circ + (-50^\circ) = 130^\circ$. We choose the latter possibility as the correct one since it indicates that $\vec{d}$ is in the second quadrant (indicated by the signs of its components).