Chapter 2 Problem 48 †

Given
$\vec{D_1} = (3.0\hat{\imath} - 4.0\hat{\jmath} - 2.0\hat{k})\ mm$
$\vec{D_2} = (1.0\hat{\imath} - 7.0\hat{\jmath} + 4.0\hat{k})\ mm$
$\vec{D_3} = (-7.0\hat{\imath} + 4.0\hat{\jmath} + 1.0\hat{k})\ mm$

Solution
a) What is the resultant displacement vector of the particle.

Add all the displacements together

$$\vec{D_{total}} = \vec{D_1} + \vec{D_2} + \vec{D_3}$$

$$\vec{D_{total}} = (3.0\hat{\imath} - 4.0\hat{\jmath} - 2.0\hat{k})\ mm + (1.0\hat{\imath} - 7.0\hat{\jmath} + 4.0\hat{k})\ mm + (-7.0\hat{\imath} + 4.0\hat{\jmath} + 1.0\hat{k})\ mm$$

Combine similar terms

$$\vec{D_{total}} = \{(3.0 + 1.0 - 7.0)\hat{\imath} + (-4.0 - 7.0 + 4.0)\hat{\jmath} + (-2.0 + 4.0 + 1.0)\hat{k}\}\ mm$$

$$\vec{D_{total}} = \{-3.0\hat{\imath} - 7.0\hat{\jmath} + 3.0\hat{k}\}\ mm$$

b) What is the magnitude of the resultant displacement?

The magnitude is

$$D_{total} = \sqrt{(-3.0)^2 + (-7.0)^2 + (3.0)^2} = 8.19\ mm$$

This answer should be reported to 2 significant digits. Therefore, $D = 8.2\ m$.

c) If all the displacements were along one line, how far would the particle travel.

If motion is all in one direction, then we need to add the magntitudes of each displacement vector. For each of the displacements, the magnitudes are

$$D_1 = \sqrt{(3.0)^2 + (-4.0)^2 + (-2.0)^2} = 5.39\ mm$$

$$D_2 = \sqrt{(1.0)^2 + (-7.0)^2 + (4.0)^2} = 8.12\ mm$$

$$D_3 = \sqrt{(-7.0)^2 + (4.0)^2 + (1.0)^2} = 8.12\ mm$$

The total distance is then

$$D_{total} = D_1 + D_2 + D_3 = 5.39 + 8.12 + 8.12 = 21.63\ mm$$

Each magnitude is good to 2 significant digits, which means they are good to the 1/10 th place. When adding them, we can keep the 1/10 th place in the calculation. Therefore, the answer is good to 3 sig. figs.

$$D_{total} = 21.6\ mm$$

†Problem from University Physics by Ling, Sanny and Moebs (OpenStax)