

Problem 3.22 Convert the coordinates of the following points from Cartesian to cylindrical and spherical coordinates:

- (a) $P_1 = (1, 2, 0)$,
- (b) $P_2 = (0, 0, 2)$,
- (c) $P_3 = (1, 1, 3)$,
- (d) $P_4 = (-2, 2, -2)$.

Solution: Use the “coordinate variables” column in Table 3-2.

(a) In the cylindrical coordinate system,

$$P_1 = (\sqrt{1^2 + 2^2}, \tan^{-1}(2/1), 0) = (\sqrt{5}, 1.107 \text{ rad}, 0) \approx (2.24, 63.4^\circ, 0).$$

In the spherical coordinate system,

$$\begin{aligned} P_1 &= (\sqrt{1^2 + 2^2 + 0^2}, \tan^{-1}(\sqrt{1^2 + 2^2}/0), \tan^{-1}(2/1)) \\ &= (\sqrt{5}, \pi/2 \text{ rad}, 1.107 \text{ rad}) \approx (2.24, 90.0^\circ, 63.4^\circ). \end{aligned}$$

Note that in both the cylindrical and spherical coordinates, ϕ is in Quadrant I.

(b) In the cylindrical coordinate system,

$$P_2 = (\sqrt{0^2 + 0^2}, \tan^{-1}(0/0), 2) = (0, 0 \text{ rad}, 2) = (0, 0^\circ, 2).$$

In the spherical coordinate system,

$$\begin{aligned} P_2 &= (\sqrt{0^2 + 0^2 + 2^2}, \tan^{-1}(\sqrt{0^2 + 0^2}/2), \tan^{-1}(0/0)) \\ &= (2, 0 \text{ rad}, 0 \text{ rad}) = (2, 0^\circ, 0^\circ). \end{aligned}$$

Note that in both the cylindrical and spherical coordinates, ϕ is arbitrary and may take any value.

(c) In the cylindrical coordinate system,

$$P_3 = (\sqrt{1^2 + 1^2}, \tan^{-1}(1/1), 3) = (\sqrt{2}, \pi/4 \text{ rad}, 3) \approx (1.41, 45.0^\circ, 3).$$

In the spherical coordinate system,

$$\begin{aligned} P_3 &= (\sqrt{1^2 + 1^2 + 3^2}, \tan^{-1}(\sqrt{1^2 + 1^2}/3), \tan^{-1}(1/1)) \\ &= (\sqrt{11}, 0.44 \text{ rad}, \pi/4 \text{ rad}) \approx (3.32, 25.2^\circ, 45.0^\circ). \end{aligned}$$

Note that in both the cylindrical and spherical coordinates, ϕ is in Quadrant I.

(d) In the cylindrical coordinate system,

$$\begin{aligned} P_4 &= (\sqrt{(-2)^2 + 2^2}, \tan^{-1}(2/-2), -2) \\ &= (2\sqrt{2}, 3\pi/4 \text{ rad}, -2) \approx (2.83, 135.0^\circ, -2). \end{aligned}$$

In the spherical coordinate system,

$$\begin{aligned} P_4 &= (\sqrt{(-2)^2 + 2^2 + (-2)^2}, \tan^{-1}(\sqrt{(-2)^2 + 2^2} / -2), \tan^{-1}(2 / -2)) \\ &= (2\sqrt{3}, 2.187 \text{ rad}, 3\pi/4 \text{ rad}) \approx (3.46, 125.3^\circ, 135.0^\circ). \end{aligned}$$

Note that in both the cylindrical and spherical coordinates, ϕ is in Quadrant II.
