

Practice Problems: Coordinate Systems

Online Problems

Problem 1 Find the Cartesian coordinates of each point, which is given in polar coordinates.

$$(r, \theta) = (2, \pi/6)$$

$$(x, y) = \boxed{(\sqrt{3}, 1)}$$

$$(r, \theta) = (\sqrt{2}, 3\pi/4)$$

$$(x, y) = \boxed{(-1, 1)}$$

$$(r, \theta) = (1, 0)$$

$$(x, y) = \boxed{(1, 0)}$$

$$(r, \theta) = (3, \pi)$$

$$(x, y) = \boxed{(-3, 0)}$$

Problem 2 Find the polar coordinates of each point, which is given in Cartesian coordinates. Your answers should satisfy $0 \leq r$ and $0 \leq \theta < 2\pi$.

$$(x, y) = (\sqrt{3}, 0)$$

$$(r, \theta) = \boxed{(\sqrt{3}, 0)}$$

$$(x, y) = (0, 2)$$

$$(r, \theta) = \boxed{(2, \pi/2)}$$

$$(x, y) = (-1, -1)$$

$$(r, \theta) = \boxed{(\sqrt{2}, 5\pi/4)}$$

$$(x, y) = (1, \sqrt{3})$$

$$(r, \theta) = \boxed{(2, \pi/3)}$$

Learning outcomes:
Author(s):

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Problem 3 Find the Cartesian coordinates of the point $(\pi/2, \pi, 2)$, given in cylindrical coordinates.

$$(x, y, z) = \boxed{(0, -\pi/2, 2)}$$

Problem 4 Find cylindrical coordinates for the point $(0, -1, 3)$, written in Cartesian coordinates. Your answer should satisfy $0 \leq r$ and $0 \leq \theta < 2\pi$.

$$(r, \theta, z) = \boxed{(1, \pi, 3)}$$

Problem 5 Consider the surface described in Cartesian coordinates by

$$2z^2 = x^2 + y^2.$$

Describe this surface with an equation in cylindrical coordinates, of the form $0 = f(r, \theta, z)$.

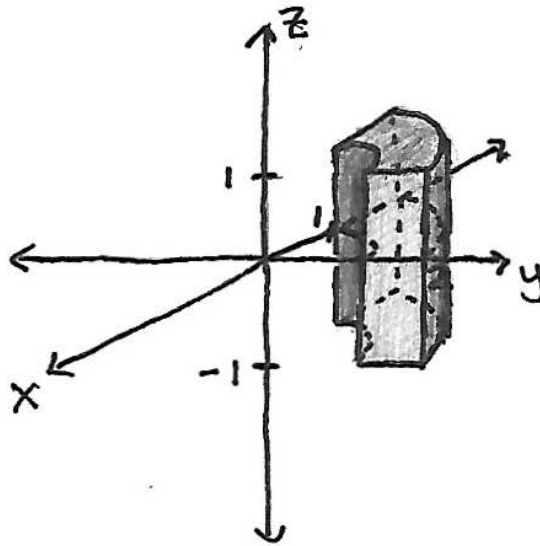
$$0 = \boxed{r^2 - 2z^2}$$

FIGURE OUT HOW TO HANDLE THIS!!! What type of shape is this?

Multiple Choice:

- (a) Plane
- (b) Cylinder
- (c) Sphere
- (d) Cone ✓
- (e) Other

Problem 6 Consider the following region in \mathbb{R}^3 .



This region is the set of points (r, θ, z) , in cylindrical coordinates, satisfying the inequalities

$$\begin{aligned} 1 &\leq r \leq 2 \\ \pi/2 &\leq \theta \leq \pi \\ -1 &\leq z \leq 1 \end{aligned}$$

Problem 7 For each of the following equations in cylindrical coordinates, select the type of shape they define.

FIGURE OUT CORRECT ANSWERS

$$r = \cos \theta$$

Multiple Choice:

- (a) plane
- (b) cylinder
- (c) sphere
- (d) other

$$z = r \cos \theta$$

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Multiple Choice:

- (a) plane
- (b) cylinder
- (c) sphere
- (d) other

$$z = -r$$

Multiple Choice:

- (a) plane ✓
- (b) cylinder
- (c) sphere
- (d) other

Problem 8 Find the Cartesian coordinates of each point, given in cylindrical coordinates.

$$(r, \theta, z) = (1, 1, 1)$$

$$(x, y, z) = (\cos(1), \sin(1), 1)$$

$$(r, \theta, z) = (\pi, \pi, \pi)$$

$$(x, y, z) = (-\pi, 0, \pi)$$

$$(r, \theta, z) = (2, 4\pi/3, -2)$$

$$(x, y, z) = (-\sqrt{3}, -1, -2)$$

Problem 9 Find the cylindrical coordinates of each point, given in Cartesian coordinates. Your answers should satisfy $r \geq 0$ and $0 \leq \theta < 2\pi$.

$$(x, y, z) = (1, 1, 1)$$

$$(r, \theta, z) = (\sqrt{2}, \pi/4, 1)$$

$$(x, y, z) = (\pi, \pi, \pi)$$

$$(r, \theta, z) = (\sqrt{2}\pi, \pi/4, \pi)$$

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$$(x, y, z) = (2, 2\sqrt{3}, -2)$$

$$(r, \theta, z) = \boxed{(4, \pi/6, -2)}$$

Problem 10 Find the Cartesian coordinates of the point $(2, \pi, \pi/2)$, given in spherical coordinates.

$$(x, y, z) = \boxed{(-2, 0, 0)}$$

Problem 11 Find spherical coordinates for the point $(-\sqrt{2}, \sqrt{2}, 2\sqrt{3})$, written in Cartesian coordinates. Your answer should satisfy $0 \leq \rho$, $0 \leq \theta \leq 2\pi$, and $0 \leq \phi \leq \pi$.

$$(\rho, \theta, \phi) = \boxed{(4, 3\pi/4, \pi/6)}$$

Problem 12 Consider the surface described in Cartesian coordinates by

$$2z^2 = x^2 + y^2.$$

Describe this surface with an equation in spherical coordinates, of the form $0 = f(\rho, \theta, \phi)$.

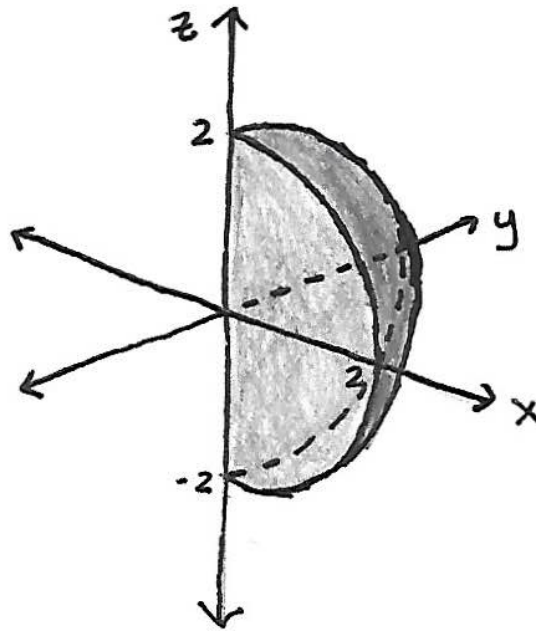
$$0 = \boxed{\rho^2 \sin^2 \phi - 2 \cos^2 \phi}$$

FIGURE OUT HOW TO HANDLE THIS!!! What type of shape is this?

Multiple Choice:

- (a) Plane
- (b) Cylinder
- (c) Sphere
- (d) Cone ✓
- (e) Other

Problem 13 Consider the following region in \mathbb{R}^3 .



This region is the set of points (ρ, θ, ϕ) , in spherical coordinates, satisfying the inequalities

$$\begin{aligned} 0 &\leq \rho \leq 2 \\ 0 &\leq \theta \leq \pi/2 \\ 0 &\leq \phi \leq \pi \end{aligned}$$

Problem 14 For each of the following equations in spherical coordinates, select the type of shape they define.

FIGURE OUT CORRECT ANSWERS

$$\rho = \cos \phi$$

Multiple Choice:

- (a) plane
- (b) cylinder
- (c) sphere
- (d) other

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$$\rho = \sin \theta$$

Multiple Choice:

- (a) plane
- (b) cylinder
- (c) sphere
- (d) other

$$\rho \cos \theta \sin \phi = 1$$

Multiple Choice:

- (a) plane ✓
- (b) cylinder
- (c) sphere
- (d) other

Problem 15 Find the spherical coordinates of each point, given in Cartesian coordinates. Your answers should satisfy $0 \leq r$, $0 \leq \theta < 2\pi$, and $0 \leq \phi \leq \pi$.

$$(x, y, z) = (1, 1, 1)$$

$$(\rho, \theta, \phi) = \boxed{(\sqrt{3}, \pi/4, \pi/4)}$$

$$(x, y, z) = (1, -1, -1)$$

$$(\rho, \theta, \phi) = \boxed{(\sqrt{3}, 3\pi/4, 3\pi/4)}$$

$$(x, y, z) = (1, \sqrt{3}, 0)$$

$$(\rho, \theta, \phi) = \boxed{(\sqrt{4}, \pi/6, \pi/2)}$$

Problem 16 Find the Cartesian coordinates of each point, given in spherical coordinates.

$$(\rho, \theta, \phi) = (\pi, \pi, \pi)$$

$$(x, y, z) = \boxed{(0, 0, -\pi)}$$

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$$(\rho, \theta, \phi) = (3, \pi/2, \pi/4)$$

$$(x, y, z) = \boxed{(0, 3\sqrt{2}/2, 3\sqrt{2}/2)}$$

$$(\rho, \theta, \phi) = (2, 7\pi/6, 3\pi/4)$$

$$(x, y, z) = \boxed{(-\sqrt{6}/2, -\sqrt{2}/2, -\sqrt{2})}$$

Written Problems

Problem 17 For several values of the constant a , sketch the graph of the curve in \mathbb{R}^2 given by the polar equation

$$r = a \sin \theta.$$

What do you notice about these curves?

Problem 18 Which points in \mathbb{R}^2 have the same coordinates when written in Cartesian and polar coordinates? (That is, for what points do we have $x = r$ and $y = \theta$?)

Problem 19 Consider the surface described by $(r-3)^2 + z^2 = 1$ in cylindrical coordinates, with the restriction $r \geq 0$.

- (a) Sketch the intersection of the surface with the half-plane $\theta = 0$.
- (b) Sketch the intersection of the surface with the half-plane $\theta = \frac{\pi}{2}$.
- (c) Sketch the intersection of the surface with the plane $z = 0$.
- (d) Sketch the surface.

Problem 20 Sketch the region in \mathbb{R}^3 with cylindrical coordinates satisfying the inequality

$$r \leq z \leq 4 - 2r$$

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Problem 21 Convert the following equation, given in cylindrical coordinates, into Cartesian coordinates.

$$r = 0$$

Problem 22 Sketch the region in \mathbb{R}^3 given by

$$\begin{aligned} r &\leq z \leq 3 \\ 0 &\leq \theta \leq \pi/2 \end{aligned}$$

in cylindrical coordinates.

Problem 23 Sketch the region in \mathbb{R}^3 given by

$$r^2 - 2 \leq z \leq 2 - r^2$$

in cylindrical coordinates.

Problem 24 Which points in \mathbb{R}^3 have the same coordinates when written in Cartesian and cylindrical coordinates?

Problem 25 (a) Given a function f , consider the graphs of the equations $r = f(\theta)$ and $r = 2f(\theta)$, in polar coordinates. How are these graphs related?

(b) Given a function f , consider the graphs of the equations $\rho = f(\theta, \phi)$ and $\rho = 2f(\theta, \phi)$, in spherical coordinates. How are these graphs related?

(c) Given a function f , consider the graphs of the equations $r = f(\theta)$ and $r = -f(\theta)$, in polar coordinates. How are these graphs related?

(d) Given a function f , consider the graphs of the equations $\rho = f(\theta, \phi)$ and $\rho = -f(\theta, \phi)$, in spherical coordinates. How are these graphs related?

Problem 26 Sketch the surface in \mathbb{R}^3 given by the equation

$$1 - \cos \phi$$

in spherical coordinates.

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Problem 27 Consider the surface in \mathbb{R}^3 given by the equation

$$\rho \sin \phi \sin \theta = 1$$

in spherical coordinates.

Convert this equation to Cartesian coordinates and cylindrical coordinates, and sketch the surface.

Problem 28 Consider the region in \mathbb{R}^3 consisting of points whose spherical coordinates satisfy

$$1 \leq \rho \leq 3$$

Sketch this region.

Problem 29 Consider the region in \mathbb{R}^3 consisting of points whose spherical coordinates satisfy

$$0 \leq \phi \leq \pi/2$$

$$0 \leq \rho \leq 1$$

Sketch this region.

Problem 30 Consider the region in \mathbb{R}^3 consisting of points whose spherical coordinates satisfy

$$\cos \phi \leq \rho \leq 2$$

Sketch this region.

Problem 31 Which points in \mathbb{R}^3 have the same coordinates when written in Cartesian and spherical coordinates?
