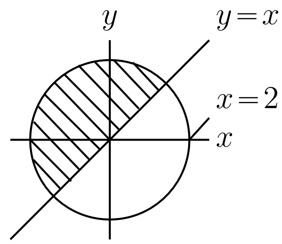
Exercise 1. In this exercise, we will review the use of polar coordinates.

1. Consider the following figure:



   Using the information provided in the figure, describe the **shaded** region in terms of polar coordinates.

2. Consider the following integral:

$$\int_{-\sqrt{2}}^{0}\int_{-\sqrt{4-x^2}}^{x} \mathrm{d}y\mathrm{d}x + \int_{0}^{\sqrt{2}}\int_{-\sqrt{4-x^2}}^{-x} \mathrm{d}y\mathrm{d}x.$$

   Sketch the region represented by this integral and express its bounds in polar coordinates.

Exercise 2. Consider the vector field $\mathbf{F}(x,y,z)=(z,0,-x)$ and the curves $\mathcal{C}_1$ and $\mathcal{C}_2$ parametrized as follows:

$$\begin{cases} r_1(t)=(1-2t,1,1-2t), & 0\leqslant t\leqslant 1, \\ r_2(s)=(s^3,1,s^3), & -1\leqslant s\leqslant 1. \end{cases}$$

Perform the following tasks:

1. Compute the Jacobian matrix of $\mathbf{F}$, denoted $J\mathbf{F}$, and demonstrate that $\mathbf{F}$ is **not** conservative.
2. Evaluate the line integrals

$$\int_{\mathcal{C}_1} \mathbf{F}\cdot d\vec{x} \quad \text{and} \quad \int_{\mathcal{C}_2} \mathbf{F}\cdot d\vec{x}.$$

3. Use the substitution $t=(s^3+1)/2$ in the parametrization $r_1(t)$, and explain why the results of the integrals are identical, despite the fact that $\mathbf{F}$ is not conservative.