13.3: Visualizing Two-Dimensional Scalar and Vector Field

Plotting scalar and vector fields in Python is straightforward, as long as the space is two-dimensional. Here is an example of how to plot a 3-D surface plot:

```
from pylab import *
from mpl_toolkits.mplot3d import Axes3D

xvalues, yvalues = meshgrid(arange(-5, 5.5, 0.05), arange(-5, 5.5, 0.05))
zvalues = sin(sqrt(xvalues**2 + yvalues**2))

ax = gca(projection='3d')
ax.plot_surface(xvalues, yvalues, zvalues)
show()
```

The scalar field \(f(x, y) = \sin(\sqrt{x^2 + y^2})\) is given on the right hand side of the \texttt{zvalues} part. The result is shown in Fig. 13.3.1.
Figure \(\PageIndex{1}\): Scalar field visualized as a 3-D surface using Code 13.1.

And here is how to draw a contour plot of the same scalar field:

```python
from pylab import *
xvalues, yvalues = meshgrid(arange(-5.5, 0.05), arange(-5, 5.5, 0.05))
zvalues = sin(sqrt(xvalues**2 + yvalues**2))

cp = contour(xvalues, yvalues, zvalues)
clabel(cp)
show()
```

The `clabel` command is used here to add labels to the contours. The result is shown in Fig. 13.3.2.

Figure \(\PageIndex{2}\): Scalar field visualized as a contour plot using Code 13.2
If you want more color, you can use `imshow`, which we already used for CA:

```python
from pylab import *
xvalues, yvalues = meshgrid(arange(-5, 5.5, 0.05), arange(-5, 5.5, 0.05))
zvalues = sin(sqrt(xvalues**2 + yvalues**2))
imshow(zvalues)
show()
```

The result is shown in Fig. 13.3.3. Colorful!

![Scalar field visualized as a color image using Code 13.3.](image)

*Figure 13.3.3*: Scalar field visualized as a color image using Code 13.3.

Finally, a two-dimensional vector field can be visualized using the streamplot function that we used in Section 7.2. Here is an example of the visualization of a vector field \( v = (vx, vy) = (2x, y-x) \), with the result shown in Fig. 13.3.4:

```python
from pylab import *
xvalues, yvalues = meshgrid(arange(-3, 3.1, 0.1), arange(-3, 3.1, 0.1))
vx = 2 * xvalues
vy = yvalues - xvalues
streamplot(xvalues, yvalues, vx, vy)
show()
```
Exercise 1:
Plot the scalar field \( f(x,y) = \sin{(xy)} \) for \(-4 \leq x,y \leq 4\) using Python.

Exercise 2:
Plot the gradient field of \( f(x,y) = \sin{(xy)} \) for \(-4 \leq x,y \leq 4\) using Python.

Exercise 3:
Plot the Laplacian of \( f(x,y) = \sin{(xy)} \) for \(-4 \leq x,y \leq 4\) using Python. Compare the result with the outputs of the exercises above.