Solution Review: Plotting Torus

This lesson discusses the solution of the plotting torus exercise.

WE'LL COVER THE FOLLOWING

Solution

A torus is defined by the following equation:

$$x(\theta, \phi) = (R + rcos\theta)cos\phi$$

$$y(\theta, \phi) = (R + rcos\theta)sin\phi$$

$$z(\theta, \phi) = rsin\theta$$

```
# importing modules
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.cm as cm
from mpl_toolkits.mplot3d import Axes3D

# defining function
def torus(r, R, theta, phi):
  x = (R + r * np.cos(theta)) * np.cos(phi)
  y = (R + r * np.cos(theta)) * np.sin(phi)
  z = r * np.sin(theta)
  return x, y, z

# initializing values of arrays
angle = np.linspace(0, 2 * np.pi, 100)
theta, phi = np.meshgrid(angle, angle)
x, y, z = torus(1, 2, theta, phi)

# initializing figure
fig = plt.figure(figsize = (12, 8))

# plotting commands for first plot
ax1 = fig.add_subplot(1, 2, 1, projection = '3d')
ax1.plot_surface(x, y, z, cmap = cm.cool)
```

```
ax1.view_init(36, 26)
ax1.set_zlim(-3, 3)


# plotting commands for second plot
ax2 = fig.add_subplot(1, 2, 2, projection = '3d')
ax2.plot_surface(x, y, z, cmap = cm.rainbow)
ax2.view_init(15, 45)
ax2.set_zlim(-3, 3)

# plot saving command
plt.savefig('output/torus.png')
```

Explanation

- In lines 8 - 12, we have defined the function `torus` which returns the `x`, `y` and `z` cartesian coordinates depending on its input arguments: `r`, `R`, `theta` and `phi`.
- On lines 15 - 16, we have initialized the values of `theta` and `phi`.
- On line 17, we have called the `torus` function to obtain the `x`, `y` and `z` coordinates for various points on the torus. The function is called with the following input arguments:
  - The tube radius, `r` is set to 1.
  - The distance from the center of the tube to the center of the torus, `R` set to 2.
  - The angles `theta` and `phi` are set in the range $0 - 2\pi$ since we need full circles: the cross-section of the tube and the torus itself.
- Note that in line 16, we have initialized a `meshgrid` across `theta` and `phi` because we need a surface plot.
- In lines 26 and 32, we have set the `zlim` to [-3, 3] to get a better view of the torus.

> The z-coordinate of the above torus lies in the range [-1, 1] because of the equation
>
> $$z = 1 \times sin\theta$$

> Setting `zlim` to [-1, 1] could work as well but it will not give a better view.

- In lines 24 and 30, surface plots are made.
- The viewing angles are set on lines 25 and 31.

This is it for plotting! We'll learn how to solve systems of linear equations in the next lesson.