Homework 1

1. What is a digital phantom?
A. A ghost image in MRI caused by motion
B. A physical model made of plastic or gel
C. A computer-generated model used to simulate anatomy and medical imaging
D. A 3D-printed replica of the human body
Answer:_____

2. Why are digital phantoms useful for AI in medicine?
A. They make patient scans unnecessary forever
B. They can generate large, labeled datasets for training AI safely
C. They remove the need for computers in hospitals
D. They are cheaper than MRIs
Answer:_____

3. Which of the following is an example of a classic digital phantom?
A. Anthropomorphic chest phantom
B. Shepp–Logan phantom
C. Gel ultrasound phantom
D. Wooden skull model
Answer:_____

4. Coding Question (Bonus)

Explore the full workflow of how digital phantoms can be used to test imaging processing, reconstruction algorithms, etc.

4.1 Generate a digital phantom

You can leverage the Shepp Logan phantom which is already provided by **skimage** module (along with **numpy** module) using Python development environment, as shown in the code snippet below:

```

from skimage.data import shepp_logan_phantom

# Create Shepp-Logan phantom and resize to desired dimensions

phantom = resize(shepp_logan_phantom(), (phantom_size, phantom_size),

                anti_aliasing=True)


 phantom = np.asarray(phantom, dtype=float)  # Ensure real ndarray
```

4.2 How does CT measure sinogram?

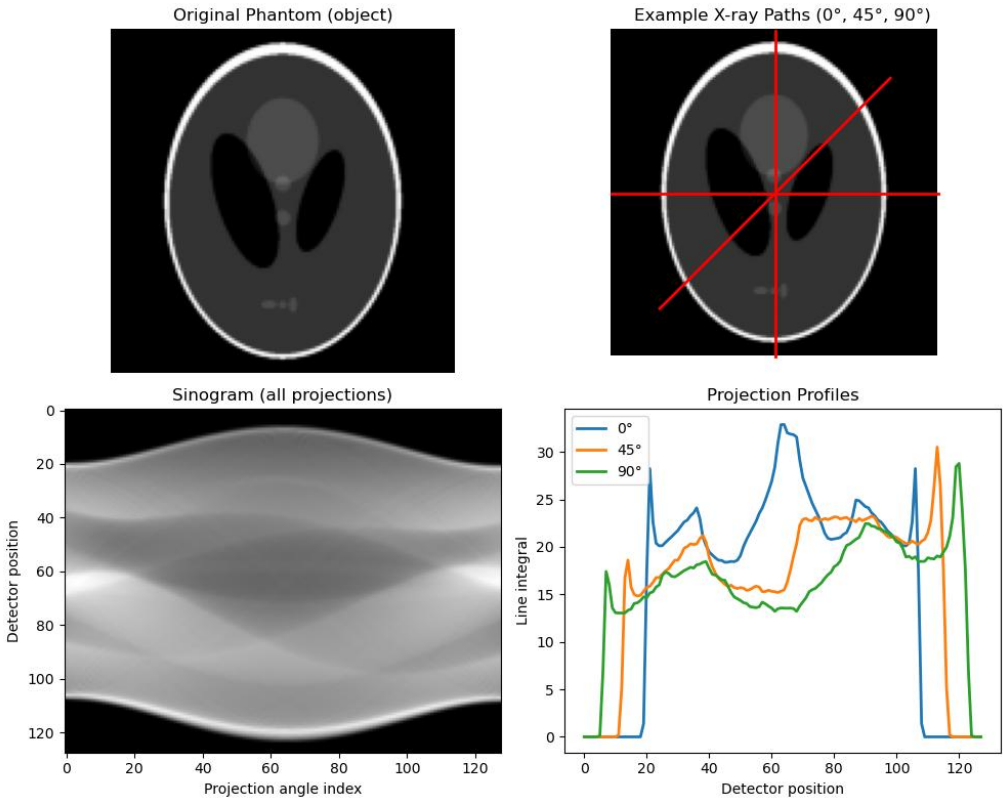
Examine how a Computed Tomography (CT) system operates on the Shepp–Logan phantom: the phantom is scanned from multiple projection angles, producing a sinogram that records the line integrals of the object, which can then be used for image reconstruction.

A code snippet below is provided as an example showing how CT can measure the so called “sinogram” from the phantom. A sinogram is shown here too for reference.

```

  # Compute Radon transform (sinogram)

  sinogram = radon(phantom, theta=theta_angles, circle=True)
```



4.3 How does FBP reconstruct the brain image from the sinogram?

If you have not yet studied the mathematics behind the Radon transform and its inversion, also known as the Filtered Back Projection (FBP) reconstruction, do not worry. We will revisit the theoretical aspects in detail later. For now, you may simply use the following two lines of example code to implement the inverse Radon transform or FBP in practice.

```

*# Perform inverse Radon transform (FBP reconstruction)*

reconstruction = iradon(sinogram, *theta*=theta_angles,

*filter_name*=filter_name, *circle*=True)

```

Now, compare the reconstructed medical image with the original phantom. Do they appear visually similar? Beyond visual inspection, what quantitative metrics can we apply to evaluate whether the Filtered Back Projection (FBP) or other reconstruction algorithms are performing effectively?