1)

Model space: The coordinate space for each object in the scene. The object's vertices are defined relative to its own coordinate system.
World Space: Global coordinate system that positions and orients objects in a scene. Provides a common frame of reference ie all objects share the same coordinate system with the same origin.
view/camera space: represents the view or perspective of the camera. Defined relative to the camera's own coordinate system where the camera is at the center.
Projection/screen space: final coordinate space before rendering to the screen. Projects the 3d scene onto a 2d plane to create the 2d image that the player sees.

2)

Transformation

$$\begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 1 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Rotation

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(45) & -\sin(45) & 0 \\ 0 & \sin(45) & \cos(45) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\downarrow$$

$$M = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & \cos(45) & -\sin(45) & 2 \\ 0 & \sin(45) & \cos(45) & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3)

real / Imaginary

$$\underbrace{\cos(45)}_{\text{real}} + \underbrace{\sin(45)\begin{bmatrix} 0 & 0 & 1 \end{bmatrix}}_{\text{Imaginary}} \rightarrow$$

$$\begin{array}{ccc} x & y & z \end{array}$$

$$= \begin{bmatrix} 0 \\ 0 \\ \sin(\frac{45}{2}) \\ \cos(\frac{45}{2}) \end{bmatrix}$$

4)

Describe how the ambient, specular, and diffuse components of the Phong reflection model each contribute to illuminating an object within a scene, and how these illumination effects are created using calculations in terms of the N, L, R, and V vectors and the shininess a:

Ambient light: provides the overall illumination of the scene. This is independent of the location of lights and the camera. The ambient component is calculated by multiplying the ambient light color by the ambient reflection coefficient. It is added to the final color of the pixel without considering the surface's normal or the direction of the light source.

Diffuse: Primary reflection of light off of surfaces. This depends on the normal of the surface and the location of the lights. The diffuse component is calculated by taking the dot product between the surface normal N and the light direction L. The result is multiplied by the diffuse color of the surface and the color of light source.

Specular reflection: Specular reflection models the shiny, mirror-like reflection of light off a surface. It depends on the viewer's position, the direction of the light source, and the surface's properties, such as its shininess or smoothness. To calculate the specular component, the reflection vector R is computed using the light direction L and the surface normal N. Then, the dot product between the reflection vector R and the viewer's direction V is calculated. The result is raised to the shininess a.

To calculate the final color of a pixel, the ambient, diffuse, and specular components are combined.

$$I_\mathrm{p} = k_\mathrm{a} i_\mathrm{a} + \sum_{m \in \text{lights}} \left(k_\mathrm{d} (\hat{L}_m \cdot \hat{N}) i_{m,\mathrm{d}} + k_\mathrm{s} (\hat{R}_m \cdot \hat{V})^\alpha i_{m,\mathrm{s}}\right).$$