The following is a draft question: The actual question can be answered if you understand these well.

Color Model (10 Marks)

1. Recently, the famous chess grandmaster, Magnus Carlsen, learned about color models in computer graphics, particularly the HSV color Model. He wanted to draw a background with a Dark Blue color. So, he considered using Hue = 240°, Saturation = 100% and Brightness = 100%. His friend Hikaru Nakamura opposed it and suggested that for a dark red color, Magnus should use Brightness = 50%. Do you agree with Hikaru Nakamura? Explain your answer also.
   Hints:
   If we convert HSV into RGB for H = 240^0, S = 1.0 (100%) and V or B = 1.0 (100%), we will find the RGB equivalent is R = 0.0, G = 0.0 and B = 1.0. (True Blue)
   On the other hand,
   If we convert HSV into RGB for H = 240^0, S = 1.0 (100%) and V or B = 0.5 (50%), we will find the RGB equivalent is R = 0.0, G = 0.0 and B = 0.5. (Dark Blue)

2. After deciding on a conclusion, Magnus started drawing and used his expensive MSI Optix-MAG274QRF-QD gaming monitor for visualization. RGB or CMY: Which color model is more appropriate for Magnus's monitor? Draw the color cube of your chosen model.
   Hints: Monitor is always RGB (additive) and Printer is always CMY (Subtractive)

3. For a CMY color model, values are given as follows: C=0.32, M=0.17, Y=0.21. Compute the Hue, Saturation, and Lightness of that model.
   Hints: At first convert CMY into RGB, R = 1-C, G = 1-M and so on.

Lighting Model (10 Marks)

a. Assume, you are given two different balls, one is glass-ball and the other is metal-ball. Where one has been polished extensively and another one that is a little dull. Identify which one has the lower specular exponent. What is the effect of specular exponent in Phong's model?
   Hints:
   Phong's illumination model is
   $I_{final} = I_{ambient} \times k_{ambient} + I_{source} \times k_{diffuse} \times N \bullet L + I_{source} \times k_{specular} \times (R \bullet V)^{shininess}$
   Here, shininess is specular exponent.
   Therefore, extensively polished object will have higher shininess or specular exponent.

b. Explain how light attenuation works in Phong's Lightning Model and discuss the relation between the attenuation factor and the path traveled by light.
   Hints:
   Light source attenuation factor is $f_{att} = \frac{1}{a_0+a_1 d+a_2 d^2}$, where f_{att} is the attenuation factor and d is the distance of path traveled.

c. Let (30, 40, 500) be the coordinate of the light source of intensity I_p= 0.90 unit. The light is illuminating a point on a sphere with coordinates (-25, 10, 60). Given that the center of the sphere is at (10, 0, 30) and the absorption coefficient for diffuse reflection is K_d=0.80 unit. Calculate the intensity of diffuse reflection for the point.
   Hints:
   Given:
   coordinate of the light source I = (30, 40, 500),
   coordinate of the point on the sphere P = (-25, 10, 60)

center of the sphere C = (10, 0, 30),
Light vector L = l – P and Normal vector N = P – C.

Transformation (10 Marks)

1. A point **P(30, 25)** was transformed to point **P'** with the help of the following homogeneous composite transformation matrix:

$$\begin{bmatrix} 0.5 & -0.866 & 23.66 \\ 0.866 & 0.5 & 56.66 \\ 0 & 0 & 1 \end{bmatrix}$$

A. Find the coordinates of the point P' after the transformation.

B. If the composite transformation was the result of a 2D rotation followed by a translation, find the angle of rotation and amount of translation along the axes.

Hints on the above question: (Answer of B)
For the case of 3D composite rotation, the rotation matrix can be across X-axis, Y-axis and Z-axis, across Z-axis is given below:

$$\begin{vmatrix} x' \\ y' \\ z' \\ 1 \end{vmatrix} = \begin{vmatrix} \cos\varphi_z & -\sin\varphi_z & 0 & c_x(1-\cos\varphi_z) + c_y \sin\varphi_z \\ \sin\varphi_z & \cos\varphi_z & 0 & c_y(1-\cos\varphi_z) - c_x \sin\varphi_z \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix} \cdot \begin{vmatrix} x \\ y \\ z \\ 1 \end{vmatrix}$$

However, for the case of 2D rotation the composite rotation matrix is:

$$\begin{vmatrix} x' \\ y' \\ 1 \end{vmatrix} = \begin{vmatrix} \cos\varphi & -\sin\varphi & c_x(1-\cos\varphi) + c_y \sin\varphi \\ \sin\varphi & \cos\varphi & c_y(1-\cos\varphi) - c_x \sin\varphi \\ 0 & 0 & 1 \end{vmatrix} \cdot \begin{vmatrix} X \\ Y \\ 1 \end{vmatrix}$$

If we relate the given matrix with 2D composite rotation matrix, then we can write:
$\cos\varphi = 0.5$ and $\sin\varphi = 0.866$ => $\varphi = 60^0$.
Also,

$c_x(1-\cos\varphi) + c_y \sin\varphi = 23.66$

$c_y(1-\cos\varphi) - c_x \sin\varphi = 56.66$

or,

$c_x(1\text{-}0.5) + c_y * 0.866 = 23.66$

$c_y(1\text{-}0.5) - c_x * 0.886 = 56.66$

or,

$0.5\, c_x + 0.866\, c_y = 23.66$

$0.5\, c_y - 0.866\, c_x = 56.66$

Or,

$c_x + 1.732\ c_y = 47.32$
$0.577cy - c_x = 65.43$
Or,
$2.309\ c_y = 112.75$
0r, $c_y = 48.83$
Putting the value of cy in the above equation, we get
$c_x + 1.732 * 48.83 = 47.32$
0r,
$c_x = -37.25$

C. Consider an object that has been horizontally scaled by a factor of 1.5 and vertically scaled by a factor of 2.5. Determine the matrix that, when applied, will reverse or undo the effects of this combined scaling transformation.

Hints:

The scaling matrix is: $\begin{bmatrix} 1.5 & 0 & 0 \\ 0 & 2.5 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

And the reverse scaling matrix is: $\begin{bmatrix} 1/1.5 & 0 & 0 \\ 0 & 1/2.5 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

Projection (5 Marks)

1. While exploring America, Emily decided to capture a photograph of the renowned Statue of Liberty. However, she observed that when she approached the statue, she needed to zoom out to encompass the entire structure within the camera frame. Which projection mechanism enables her to achieve this?

   Hints:

   For small viewing angles, it is relatively easy to distort this into an image on a flat piece of paper since this viewing arc is relatively flat. As the viewing angle increases, the viewing arc becomes more curved, and thus the difference between panorama projection types becomes more pronounced. Rectilinear image projections have the primary advantage that they map all straight lines in three-dimensional space to straight lines on the flattened two-dimensional grid. This projection type is what most ordinary wide-angle lenses aim to produce, so this is perhaps the projection with which we are most familiar.

   Therefore, Rectilinear projections mechanism enables her to achieve this.

2. While capturing the photograph of Statue of Liberty, Emily's eye was positioned at coordinates (-10, -40, 90), the camera was located at (0, 0, 100), and the highest point of the structure was situated at (10, -30, 300). Calculate the coordinates of the projected point of the Statue of Liberty after taking the photograph.

   Hints:

   Given: Zp = 100,

   COP is (-10, -40, 90)

   And P is (10, -30, 300),

   Determine P’ using general purpose projection matrix