Question 1 (20 points): Brief Descriptions

Give brief descriptions of the following:

a. (4 points) Instance Transformation

b. (4 points) Convert the point (4, 6, 8, 2) in homogeneous coordinates to ordinary coordinates

c. (4 points) Mach Band effect

d. (4 points) Yaw of a Camera

e. (4 points) Local Illumination (as opposed to Global Illumination)
Question 2 (15 points): Texture Mapping

a. (10 points) During cube mapping, the reflected vector $\mathbf{R}$ is calculated as $(x,y,z) = (-6,-4,3)$. Using $\mathbf{R}$ to look up the cube map, what face of the cube is looked up? What are the values of $s$ and $t$ used to perform this look up?

b. (5 points) Explain mipmapping

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Question 3 Lighting and Shading (20 points)

a. (4 points) In the Cook Torrance BRDF, give an example of a real world surface that would exhibit masking and self-shadowing
a) (16 points) Assuming that the vertices of a 2D polygon have the properties described in Table 1, what is the RGB color at location (70, 60) when Gouraud shading is used?

<table>
<thead>
<tr>
<th>Vertex</th>
<th>X, Y</th>
<th>R, G, B (after Phong lighting model has been applied)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₁</td>
<td>10, 20</td>
<td>100, 200, 10</td>
</tr>
<tr>
<td>V₂</td>
<td>90, 20</td>
<td>200, 10, 100</td>
</tr>
<tr>
<td>V₃</td>
<td>90, 120</td>
<td>10, 100, 200</td>
</tr>
<tr>
<td>V₄</td>
<td>10, 120</td>
<td>10, 100, 200</td>
</tr>
</tbody>
</table>
**Question 4: Projection (15 points)**

a) (5 points) What graphics operation is the matrix below used for?

\[
\begin{pmatrix}
    \frac{2N}{x_{\text{max}} - x_{\text{min}}} & 0 & \frac{x_{\text{max}} + x_{\text{min}}}{0} \\
    0 & \frac{2N}{y_{\text{max}} - y_{\text{min}}} & \frac{y_{\text{max}} + y_{\text{min}}}{0} \\
    0 & 0 & -(F + N) \\
    0 & 0 & F - N
\end{pmatrix}
\]

b) What are these elements of the matrix used for (5 points)?

\[
\begin{pmatrix}
    -(F + N) & -2FN \\
    F - N & F - N
\end{pmatrix}
\]

c) (5 points) After applying the matrix in part a to the vertices of a straight line, how would straight lines with directions that pass through the eye before transformation get transformed?
Question 5: Rotation Transformation (15 points)

a. Using Euler's rule, write out in matrix form, the sequence of X, Y and Z rolls that can be used to achieve a rotation of 30 degrees about an arbitrary axis that has azimuth = 35 degrees and latitude = 46 degrees. You don't have to multiply these matrices together. Just write out the matrices.
**Question 6: Viewing (15 points)**

Using the header file mat.h in your projects, a programmer made the following sequence of commands.

```c
vec3 eye = (4,4,4);
vec3 look = (0,1,0);
vec3 up = (2,1,0);

m = lookAt(eye, look, up);
```

The variable `m` then contained the following 4x4 matrix.

\[
\begin{pmatrix}
  a & b & c & d \\
  e & f & g & h \\
  i & j & k & l \\
  m & n & o & p \\
\end{pmatrix}
\]

(15 points) What would the values of the matrix elements \( e, f, g \) in the matrix above? (Show all your work!!!