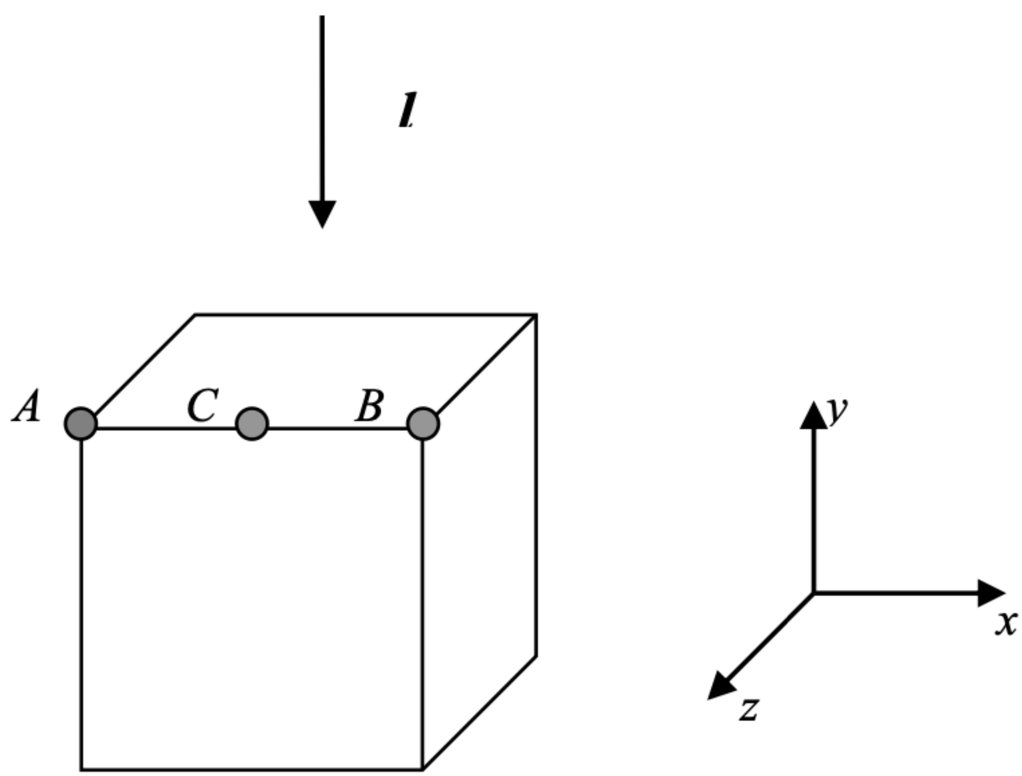
COMP410 - Quiz 3

Question 1

Consider the object below, which is a cube composed of 6 polygonal faces. Let the shades at points A and B be I_A and I_B when lit with a light source $l = (0, -1, 0, 0)$ under the Phong reflection model. Compute the shade I_C at the midpoint C in terms of I_A and I_B by using Phong shading. Assume that the surface is perfectly diffuse (with no specular and ambient components), and the cube has identical material properties at every point.

Hint: Diffuse surfaces reflect light equally in all directions in proportion to the cosine of the angle between incoming light direction and surface normal vector.

Hint: In Phong shading (not to be confused with the Phong reflection model), the normal vector of a vertex is computed based on normal vectors of the incident polygons (as an average).



Answer 1

We first need to find the normals at point A and point B :

$$\bar{n}_A = (-1, 1, 1)/\sqrt{3} \qquad \bar{n}_B = (1, 1, 1)\sqrt{3}$$

Hence $\bar{n}_C$ can be interpolated as :

$$\bar{n}_C = \frac{(-1,1,1) + (1,1,1)}{2\sqrt{2}} = \frac{(0,1,1)}{\sqrt{2}}$$

Recall that diffuse component is given by

$$\underbrace{k_d \cdot L_d}_{\text{Some constant } C} \cdot (\bar{n} \cdot \bar{\ell}) \qquad \underbrace{\bar{\ell}}$$

this vector's direction is from surface to light.

$$\text{So,} \quad I_A = C \cdot \frac{1}{\sqrt{3}}(-1,1,1) \cdot (0,1,0)$$

$$= \frac{C}{\sqrt{3}} . \implies C = \sqrt{3}\, I_A$$

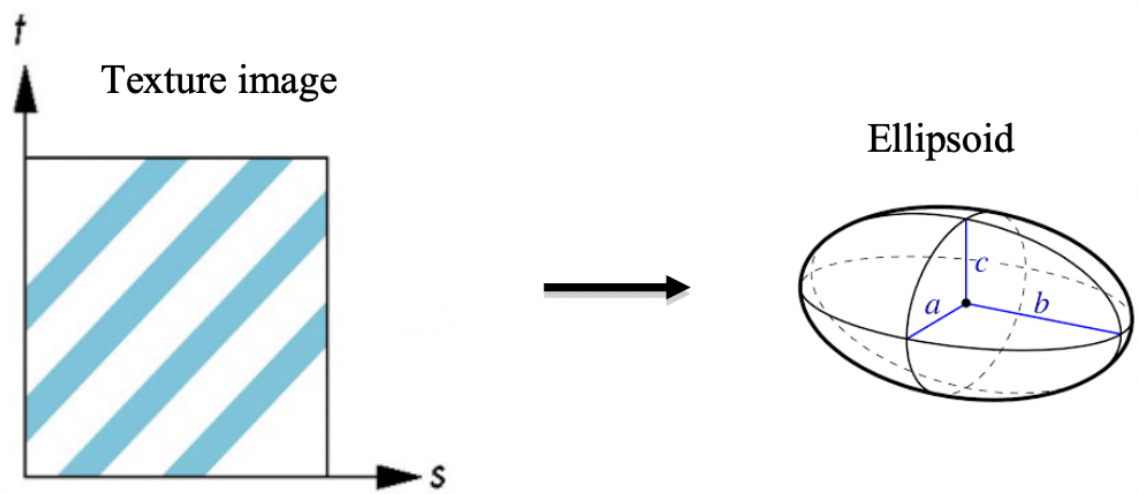
$$I_C = C \cdot (\bar{n}_C \cdot \ell) = \sqrt{3}\, I_A \cdot \frac{(0,1,1)}{\sqrt{2}} \cdot (0,1,0)$$

$$= \sqrt{\frac{3}{2}}\, I_A$$

Question 2

Consider two functions $s(x,\ y,\ z)$ and $t(x,\ y,\ z)$ that would map a texture image onto an ellipsoid with radii a, b and c (see below) such that, for a given point $(x,\ y,\ z)$ on the surface, the texture coordinates s and t will be given by these functions. Use the parametrization method described in the lecture slides to find these two functions, such that for example the texture coordinates of the point $(a,\ 0,\ 0)$ on the ellipsoid are given by $(0,\ 0.5)$. What are then the texture coordinates associated with the point $(-\ a,\ 0,\ 0)$?

Hint: Think of the parametrization of an ellipsoid.



Answer 2

The parametric form of an ellipsoid can be written as:

$$x = a \sin \pi u \cdot \cos 2\pi v$$

$$y = b \sin \pi u \cdot \sin 2\pi v \qquad \text{where } 0 \leq u, v \leq 1$$

$$z = c \cos \pi u$$

For $u = 0.5$ and $v = 0.0$ we see that

$x = a$, $y = 0$ and $z = 0$.

Hence the mapping should be

$t = u$
$s = v$ to satisfy the condition

And in this case $(s = 0.5, t = 0.5)$ is mapped to $(u = 0.5, v = 0.5)$, which is mapped to $(x = -a, y = 0, z = 0)$.

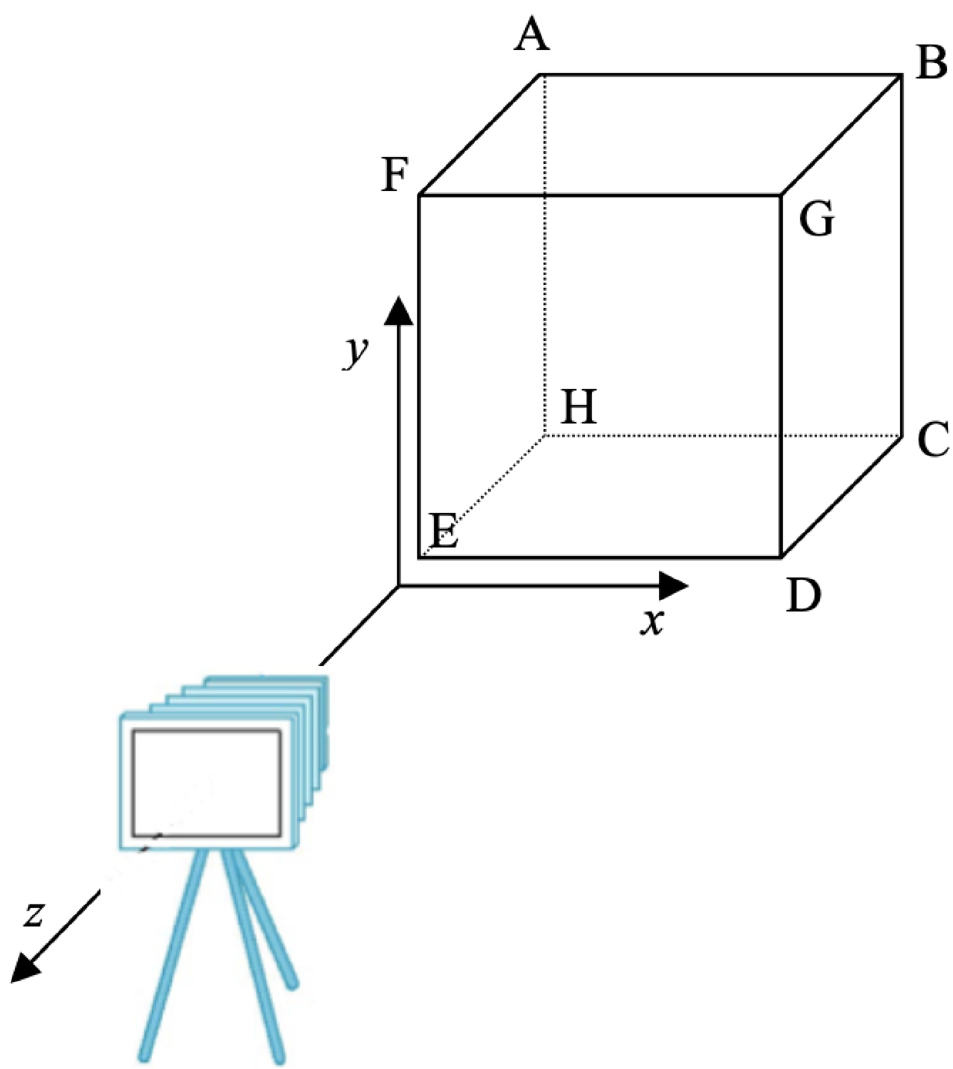
So the correct answer is $(0.5, 0.5)$.

Question 3

Consider the following configuration, where the camera is located at $z = d$ $(d > 0)$ looking along the negative z-axis direction. Assume the default orthographic projection. Assume also that the cube is precisely aligned with the coordinate axes (that is, each face of the cube is either parallel or perpendicular to the axes).

Which of the following faces of the cube below are NOT rendered if culling is applied?

Consider only the outer faces of the cube. Note also that the corner points of the cube are represented with capital letters.



Answer 3

Culling discards all the faces looking away from the camera.

Since the projection is orthographic, $\bar{v} = (0,0,1)$.

Note that we need to check whether $\bar{v}.\bar{n} > 0$ to decide on the faces to cull; in this case only the front face is rendered, the others culled.

If you assume $\bar{v}.\bar{n} \geqslant$ for visibility, then only the back face is rendered.

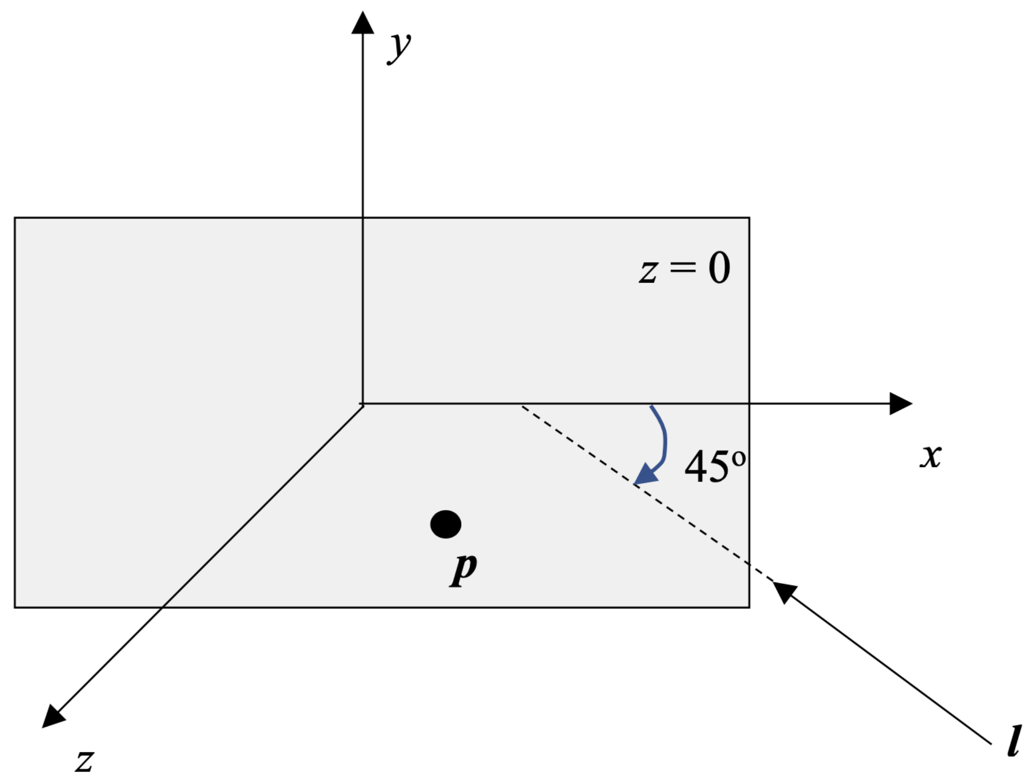
So both of the following answers are accepted:

- AFEH, ABCH, BCDG, CDEH, ABFG

- ABCH

Question 4

Consider the planar surface $z = 0$ below, which is lit with a directional light source $l = (-1, 0, -1, 0)$. Which of the following is the point on this surface, at which the specular component of the reflection is maximum with respect to the viewer that is located at point $p = (1, 0, 1, 1)$?



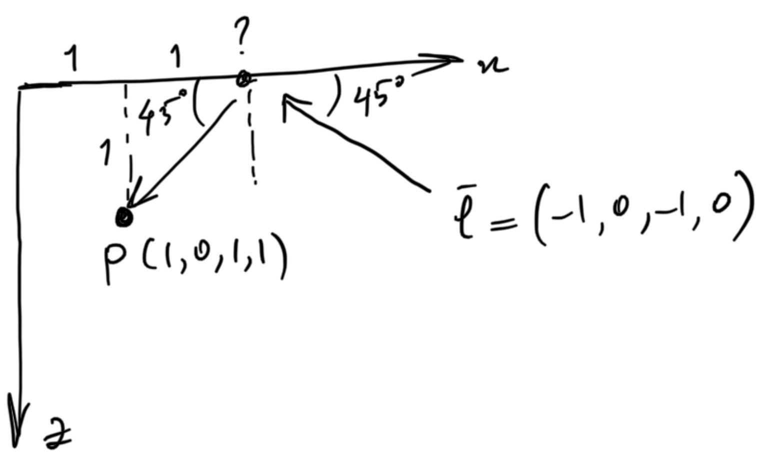
Answer 4

Recall that the specular component in Phong illumination model is given by $k_s L_s (\bar{v} \cdot \bar{r})^{\alpha}$, where $\bar{r}$ is the direction of perfect reflection.

Hence the maximum occurs when $\bar{v}$ and $\bar{r}$ coincide, that is, they are in the same direction. Note also that $\bar{v}$ and $\bar{r}$ are unit vectors.

So we have to find the point on the plane from which the reflection goes directly to point $(1,0,1,1)$.

Top view



Hence the point is located at $(2,0,0,1)$.