Name: **StudentID:**

TI1806 - Computer Graphics

The exam has two types of questions, simpler ones, marked with *, and more involved ones, marked with +.

For the questions marked with *, one point is added for each correct answer, **one point is subtracted for a wrong answer. No points are ever added or subtracted if no answer is given.**
In short: On these questions, guessing can have a negative impact!

The questions marked with +, do count twice as. Meaning 2 points are added for a correct answer, 2 points are subtracted, in case the answer is incorrect.

Please mark your answers directly below the exercise (before the separation line), or next to it. It is recommended to start with the simpler questions.

Example:

*Which of the following statements hold?

A pear…

a) is a fruit
b) is exclusively available in the Netherlands
c) grows on a tree
d) is bigger than a grown elephant

a) true b) false c) true d) false

Alternatively, you can also leave out the false cases and just write: *a, c*

Good luck!

Name: **StudentID:**

Raytracing and Rasterization

+1) When calculating the intersection between a ray and a triangle, usually, the intersection P between the plane containing the triangle (with corners P1, P2, P3) and the ray is determined. If P exists, we have to find out whether it lies inside of the triangle. Following the course, let u=P2-P1, v=P3-P1 and P be expressed in the form P=P1 + k1 u + k2 v. What condition on k1 and k2 implies that P lies inside of the triangle?

a) k1 + k2 <= 1 and k1>=0 and k2>=0
b) k1 + k2 <= 2 and k1>=0 and k2>=0
c) k1 <=1 and k2 <= 1 and k1>=0 and k2>=0
d) k1>=0 and k2>=0 and k1-k2=0

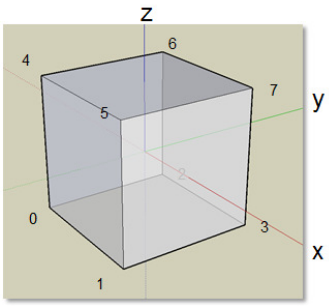
---

*2) Choose the statement that holds:

a) Rasterization is always faster than raytracing.
b) For modern games, 8 bit floats for the depth channel are enough for high-quality images
c) Triangular meshes with 60 vertices, which are all used, consist of at least 20 triangles

---

*3) Given a cube (see figure below), how many elements will minimally have to be in the index buffer and the vertex buffer, if this complete mesh was represented with an indexed face set.



Index buffer size: _____ (between 1 and 100)

Vertex buffer size:_____ (between 1 and 100)

---

*4) Choose the statement that is false:

a) Using the simple performance estimate discussed in the course; when implemented naïvely (no acceleration structure), raytracing will usually perform slower than rasterization.
b) A raytracing pipeline is the basis of OpenGL
c) A rasterization pipeline is the basis of OpenGL

Name: **StudentID:**

Homogeneous Coordinates

*5) Choose the **maximal** set of operations in R3 that can be described via a matrix when embedding this space in a projective space (using homogeneous coordinates):

a) Translation, Rotation, Scaling
b) Translation, Rotation
c) Translation
d) Rotation, Scaling
e) Rotation
f) Scaling
g)Scaling, Translation

---

*6) In the graphics pipeline, homogeneous coordinates are also used for normals. Their last entry is always considered to be 0. What effect does this choice have when transforming the normal with the model-view-projection matrix?

a) It avoids scaling the normal.
b) It avoids translating the normal.
c) It avoids rotating the normal.

+7) Complete the rotation matrix below such that an affine point (1,0) is moved to an affine position (1/sqrt(2), 1/sqrt(2)). In other words, complete the equation below, choosing from the terms:

-1/sqrt(2), 0, ¼, ½, 1/sqrt(2), 1

$$\begin{pmatrix} 1/sqrt(2) \\ 1/sqrt(2) \\ 1 \end{pmatrix} = \begin{pmatrix} & & \\ & & \\ & & \end{pmatrix} \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}$$

+8) One can test whether a point P:=(p1,p2,p3) lies on a plane H(a,b,c,d):={ (x,y,z) in R^3 | a x + b y +c z = d} by using a dot product between the homogenous versions of P and the point obtained by a "special mapping" M of planes onto points in projective space. How does the mapping M have to be defined to make this test work? In other words, we are looking for a mapping M, such that dotProduct(M(H(a,b,c,d)), P)=0 if and only if P lies in H(a,b,c,d).

Which one of the following mappings would work?

a) M(H(a,b,c,d)):= (a,b,c,d)
b) M(H(a,b,c,d)):= (-a,b,c,d)
c) M(H(a,b,c,d)):= (-a,-b,-c,d)
d) M(H(a,b,c,d)):= (-a,-b,-c,-d)

Name: **StudentID:**

+9) Please calculate the intersection point between a ray defined by its origin o:=(1,1,1) and direction d:=(1,2,1) with the plane defined by a point on the plane (3,3,3) and its two spanning vectors (1,-1,0) and (1,2,-3), by determining t, such that (1,1,1)+t*(1,2,1) results in the intersection point.

a) t=1
b) t=1.5
c) t=2
d) t=2.5
e) t=3.0

+10) Given the following camera projection matrix and a point (x,y,z,1) in homogeneous coordinates.

$$\begin{bmatrix} \frac{f}{aspect} & 0 & 0 & 0 \\ 0 & f & 0 & 0 \\ 0 & 0 & \frac{near+far}{near-far} & \frac{2near\,far}{near-far} \\ 0 & 0 & -1 & 0 \end{bmatrix}$$

Choose the resulting depth value, which will be used for the depth test, after projection:

1) ((near+far)z + 2 near far) /(near-far)$_z$
2) (Near- 2 (near far))/((near-far)z)
3) 1 + 2 (near far)/((near-far)z)
4) 2(near far)z/(near-far)

Shading

Given a surface point P at (1,0,0), a normal in direction (1,1,0), as well as a point light source at (1,2,0)
+11a) on which of the following rays do you have to locate the camera, such that the highlight (specularity) at P is the strongest using the Phong Model?

a) (1+alpha)*(1,0,0), where alpha >0

b) (1,0,0)+alpha*(1,1,0), where alpha >0

c) (1+alpha)*(1,1,0), where alpha >0

d) alpha*(1,0,0), where alpha >0

Name: **StudentID:**

+11b) if we assume that the surface at point P is perfectly diffuse, to what location would the light have to move to achieve a maximal reflection, according to the formula for diffuse surfaces (Lambertian)?

a) (2.5,1.5,0)

b) (1.5,0,0)

c) (0,0,0)

d) (15, 5, 0)

---

*12) The following code is supposed to compute a toon (cell) shading (as a reminder: the result should be 1 if the surface faces the light and 0 if it is opposing).

```
#1    Float toonShading      (Vec3D position, Vec3D normal, //attributes of surface point
#2                           Vec3D lightPosition) // position of the light source
#3    {
#4          Vec3D lightDir=position-lightPosition;
#5          Float v = DotProduct(normal,lightDir);
#6          If (v<0)  Return 1;
#8          else      Return 0;
#9    }
```

If there is a mistake in the code, indicate the line number or, else, write “none”. _____

---

*13) Please choose from the following list all elements that describe what the ambient term of a Phong model is often used for

1) Emulate indirect light
2) To make shadows slightly brighter
3) To increase specular highlights

---

*14) Assuming two pixels of a texture are linearly interpolated via a value alpha. Further, assume for alpha=0 the result is 0.4, for alpha=1 the result is 0.2. What is the result for alpha value of 0.3?

a) 0.37
b) 0.33
c) 0.34
d) 0.30

Name: **StudentID:**

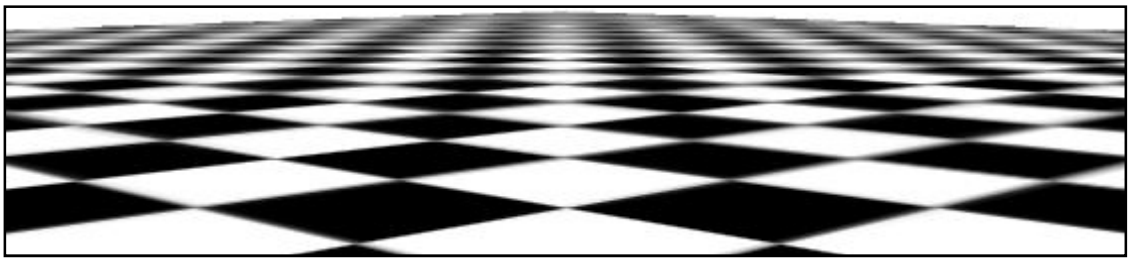
*15) Given a texture of resolution 2^n x 2^n, what resolution would its corresponding densely-represented anisotropic mipmap have?

a) 2^(2n)
b) 2^(4n)
c) 2^(2n+1)
d) 2^(2n+2)

---

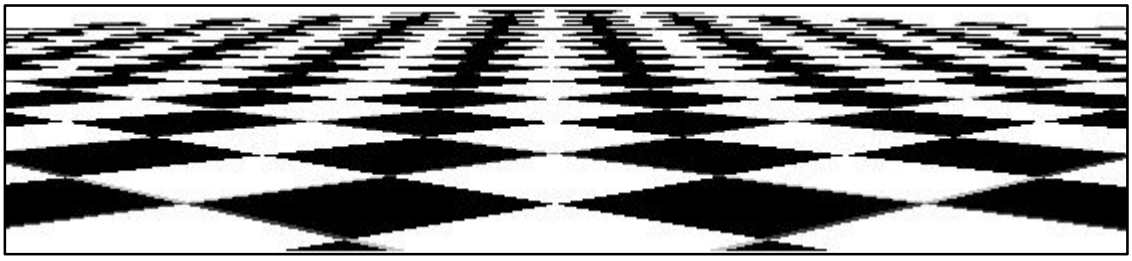
*16) In the following you will see a checkerboard texture mapped to a plane. In each case a different filtering modes are used. Distribute the filtering modes bilinear, nearest neighbor, and mipmapping to the images, where the mode is active and attribute each case only once.

a) _____



b) _____

c) _____



Name: **StudentID:**

Shadows

*17) A shadow, according to Hasenfratz[2003], is:

a) *the area on a surface for which at least one point of the light source is occluded.*
b) *the region of space for which at least one point of the light source is visible.*
c) *the region of space for which at least one point of the light source is occluded.*
d) *the region of space for which no point of the light source is visible.*

---

*18) What is a shadow map? Choose ONE of the following options:

a) A texture of shadows
b) A texture of depth values
c) A texture of color values

+19) Please complete the if-condition in the pseudocode, such that this algorithm becomes a robust shadow mapping algorithm – where robust means that it tries to avoid artifacts due to depth imprecision by introducing an offset O. Produce the missing expression using a combination of the following symbols, where each symbol can occur maximally once, but might also be left out:
O, depth, z, =, <, >, +, -

1. Render depth buffer from light ->Store result in a texture (**Shadow Map**)

2. Render from viewpoint – activate a fragment shader
For each pixel on the screen, compute its distance d to the light and recover the distance z stored in the Shadow Map at the corresponding position.

If ( ) pixel is lit, else pixel is in shadow.

---

*20) Shadow mapping can result in staircase artifacts. Which of the following measures are/is a suitable means to reduce this artifact?

a) Increase the shadow map resolution
b) Filter depth values similar to mipmaps and perform shadow mapping against this new texture.
c) Increase the energy of the light source
