Graphics (INFOGR 2016-2017) – Final Exam

Thursday June 29th, 13.30 – 16.30 – OLYMPOS-HAL2

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- Fill in your name and student ID at the top of this page, and write it on every additional paper you want to turn in.
- Answer the questions **in the designated areas on these exam sheets**. For the math questions, only the final answer is needed. If you need more space for a problem, state this in the designated area for the problem and continue on the paper provided by us. On the additional paper, state your name and student ID, and clearly indicate the problem number.
- If a question is unclear to you, write down how you interpret the question, then answer it.

PART 1 – THEORY

[redacted] 1. Complete the following text with appropriate terms: (12 pts)

"In the early days of OpenGL, the ...ARB... was responsible for decisions regarding the development of the standard. In 1997, an attempt was made to unify OpenGL and Direct3D. This was named ..Fahrenheit...... . In 2006, the control over OpenGL was transferred to the ...Khronos Group............ , which considerably sped up development. In 2016, OpenGL was succeeded by "OpenGL next", also known as ...Vulkan.................. . The coordinate system of OpenGL is ...right handed.......... , which is why the ..negative..........-z points away from the camera along the view direction."

[redacted] 2. Complete the following statements with appropriate terms: (6 pts)

a) To efficiently use color correction / color grading in a real-time engine, we use a ...color cube...... .

b) Darkening the edges of the rendered image is called ....vignetting.... .

c) Separating red, green and blue at the edges of the screen simulates ....chromatic aberration...... .

[redacted] 3. Given:

- line L, with end points (0,0) and (8,8).
- triangle T, with vertices A: (2,1), B: (2,7) and C: (8,1).

We want to clip T against L so that the part of T below L remains.

a) Write down the coordinates emitted by the Sutherland-Hodgeman algorithm for edge **AB**. AB: ...(2,2).............................

b) Write down the coordinates emitted by the Sutherland-Hodgeman algorithm for edge **BC**. BC: ...($2\frac{1}{2}$,$2\frac{1}{2}$) and (8,1).............

c) Write down the coordinates emitted by the Sutherland-Hodgeman algorithm for edge **CA**. CA: ...(2,1).............................

Note: write down answer a, b and c separately. (6 pts)

[redacted] 4. For a scene we use a linear gradient texture converted to, and stored in, non-linear RGB space (gamma=2). We render a full-screen quad using the texture to a monitor that does not respond linearly to input (gamma=3). Our aim is to show a linear gradient on the screen.

a) Write down the formula to convert texture data to linear RGB data for use in the renderer. (3 pts) ......$I = a^2$...........................

b) Write down the formula to convert the linear RGB output of the renderer so that the monitor displays a linear gradient. (3 pts) ...... $I = a^{\frac{1}{3}}$...........................

[redacted] 5. In the lecture a method was described to efficiently render fur. Complete the following sentence by writing down what a single hair consists of (max 10 words).

A single hair is a collection of: (6 pts)

...opaque pixels in the shell texture(s)..

This exam is printed using the Open-Dyslexic font for your convenience.

Math questions on the next pages!

PART 2 – MATHEMATICS

[redacted]

6. Write down the equation of the plane passing through the three points $(1,1,1)$, $(4,3,4)$ and $(2,4,3)$ in $\mathbb{R}^3$. (6 pts)

$\begin{pmatrix}3\\2\\3\end{pmatrix} \times \begin{pmatrix}1\\3\\2\end{pmatrix} = \begin{pmatrix}-5\\-3\\7\end{pmatrix}; \begin{pmatrix}-5\\-3\\7\end{pmatrix} \cdot \begin{pmatrix}1\\1\\1\end{pmatrix} = -1;$ ➔ plane: $-5x - 3y + 7z + 1 = 0$ or $5x + 3y - 7z - 1 = 0$.

Verify: $-5 * 4 - 3 * 3 + 7 * 4 + 1 = 0; \quad 5 * 4 + 3 * 3 - 7 * 4 - 1 = 0$. Optional normalize: $\left(\frac{1}{83}\right)$.

[redacted]

7. Write down the determinant of the matrix $M = \begin{bmatrix} 2 & 0 & 4 \\ 5 & 1 & 10 \\ 3 & 2 & 6 \end{bmatrix}$: (2 pts)

$det(M) =$ ...0.........(note: z and x are colinear) ....

[redacted]

8. Given: matrix $M = \begin{bmatrix} 0 & a \\ a & 0 \end{bmatrix}$ and matrix $N = \begin{bmatrix} 0 & b \\ c & 0 \end{bmatrix}$. (2+4 pts)

a) If matrix M is its own inverse, what is the value of a? $a =$ ...1 or -1.........

b) Matrix N describes a rotation around in the origin in $\mathbb{R}^2$. Write down the pair (b, c). $(b, c) =$ ...(1,-1) or (-1,1)...

[redacted]

9. Given: vectors $A = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$, $B = \begin{bmatrix} 2 \\ -1 \end{bmatrix}$ and line L in $\mathbb{R}^2$: $8x - 4y + 5 = 0$. (2+2+6 pts)

a) Reflect vector A in line L. Write down the new vector. ......(1,2)...............................

b) Reflect vector B in line L. Write down the new vector. ......(-2,1).............................

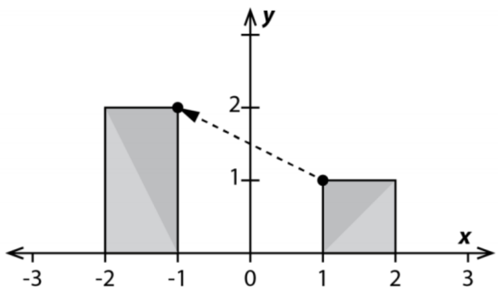
c) Write down the 2x2 matrix that describes reflection about the line $2x - y + 3$ in $\mathbb{R}^2$. .... $\begin{bmatrix} -\frac{3}{5} & \frac{4}{5} \\ \frac{4}{5} & \frac{3}{5} \end{bmatrix}$ ....

[redacted]

10. Write down the equation of the plane P tangent to the sphere $(x-3)^2 + (y-4)^2 + z^2 = 9$ at point $(5,5,2)$. (4 pts)

...... $2x + y + 2z - 19 = 0$ ....

[redacted] 11. Determine the transformation matrix that transforms a vector in $\mathbb{R}^2$ as illustrated in the image below, i.e. the matrix that transforms the black dot on the right rectangle to the indicated position of the one on the left – and transforms all other points accordingly. Write down this matrix, and its inverse. (6+4 pts)



Matrix:

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

Inverse:

$$\begin{bmatrix} -1 & 0 \\ 0 & 1/2 \end{bmatrix}$$

[redacted] 12. Consider the circle $(x-2)^2 + (y-3)^2 = 1$ in $\mathbb{R}^2$. We transform all the points on this circle by scaling them in the x-direction by a factor 3, and in the y-direction by a factor 2, with respect to the origin of the coordinate system. (6+2 pts)

a) Write down the equation of the resulting primitive: ... $\frac{(x'-6)^2}{9} + \frac{(y'-6)^2}{4} = 1$ ....

b) Write down the name of this primitive: ....ellipse.............................

[redacted] 13. Consider a point originally located at (x, y, z) in $\mathbb{R}^3$. We translate this point by an amount of (x_0, y_0, z_0) and then rotate it counterclockwise around the y-axis by an angle φ. We construct matrix M to perform this transformation, by combining matrix M_t (for translation) and matrix M_r (for rotation).

a) Write down the matrix multiplication that correctly combines M_t and M_r into M. (2 pts) $M =$ ..... $M_r M_t$ ......

b) Write down the translation matrix M_t, the rotation matrix M_r and the final matrix M. (2+2+4 pts). Recall that in $\mathbb{R}^2$ the matrix $\begin{bmatrix} \cos\varphi & -\sin\varphi \\ \sin\varphi & \cos\varphi \end{bmatrix}$ describes a counterclockwise rotation around the origin.

$$M_t = \begin{bmatrix} 1 & 0 & 0 & x_0 \\ 0 & 1 & 0 & y_0 \\ 0 & 0 & 1 & z_0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad M_r = \begin{bmatrix} \cos t & 0 & \sin t & 0 \\ 0 & 1 & 0 & 0 \\ -\sin t & 0 & \cos t & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad M = \begin{bmatrix} \cos t & 0 & \sin t & x_0 \cos t + z_0 \sin t \\ 0 & 1 & 0 & y_0 \\ -\sin t & 0 & \cos t & z_0 \cos t - x_0 \sin t \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

That's all, good luck!