Graphics (INFOGR 2017/2018) – Final Exam

Thursday June 28th, 13.30 – 15.30 – EDUC-BETA / BBG 0.23 (ET)

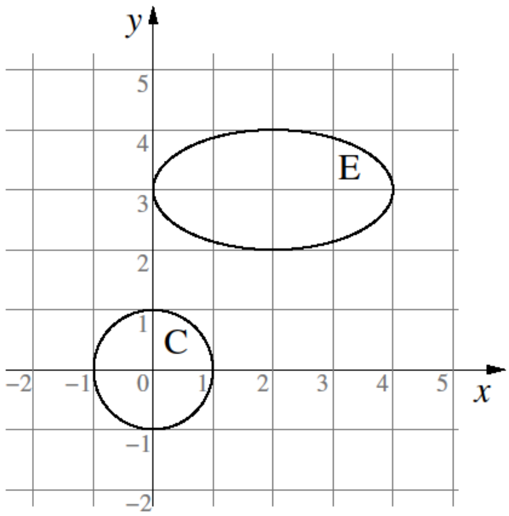
- Write your answers in the designated areas on the <u>question sheet</u>. There's also some room to write down the steps involved. If you need more space, please use the blank answer sheets supplied to you.
- If a question is unclear to you, write down how you interpret the question, then answer it.
- **Write clearly:** we cannot grade answers that we cannot read.
- No documents allowed. Use of electronic devices is forbidden.
- You may use a dictionary, and answer in English or Dutch.

	1	2	3	4	5	6	7
a							
b							
c	for grading, leave blank						
d							
e							

StudentID / studentnummer	Last name / achternaam	First name / voornaam

PART 1 – MATH - max 43 points

1. [2+3=5 points] We want to transform the ellipse E into circle C using a transformation matrix; see figure.



   a. Write down the elementary active transformations needed for this transformation.

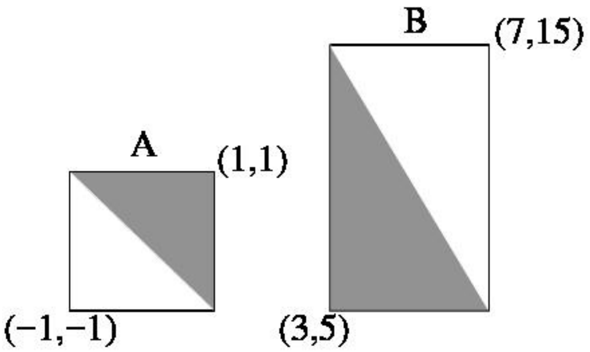
Transformations:

-

   b. Write down the final transformation matrix M.

$$M = \begin{bmatrix} \\ \\ \end{bmatrix}$$

2. [3+5=8 points] We want to transform square A to rectangle B, as shown in the figure (figure not to scale).



a. Write down the elementary active transformations that you need to achieve this.

Transformations:

-

b. Write down the final transformation matrix M.

$$M = \begin{bmatrix} \quad \end{bmatrix}$$

3. [1+3=4 points] Consider the two points $P = (1,1)$ and $Q = (4,5)$ in $\mathbb{R}^2$. Consider also the point $X = (x, y)$ such that the lines XP and XQ intersect each other at right angles (i.e., the lines are perpendicular).
The collection of all such points X that satisfy the above condition forms a primitive. Name the primitive and write down the equation for this primitive.

The primitive is a (or an):

Equation:

4. [3+3+5+3+2=16 points] Consider the plane $x + 2y + 2z = 9$ and point $O = (0,0,0)$ in $\mathbb{R}^3$.

a. Project O on the plane. Write down the coordinates of the projected point O'.

$O' = \quad (\qquad , \qquad , \qquad)$

b. Reflect O in the plane. Write down the coordinates of the reflected point R.

$R = \quad (\qquad , \qquad , \qquad)$

c. Reflect the vector $\vec{v} = \begin{bmatrix} v_x \\ v_y \\ v_z \end{bmatrix}$ in this plane using a transformation matrix. Write down the transformation matrix M_r and the reflected vector $\vec{v}_r$.

$M_r = \begin{bmatrix} \qquad \end{bmatrix} \qquad \vec{v}_r = M_r \vec{v} = \begin{bmatrix} \qquad \end{bmatrix}$

d. Reflect the point $P = (x, y, z)$ in this plane to obtain the coordinates of the reflected point $P' = (x', y', z')$.

$x' =$

$y' =$

$z' =$

e. Write down transformation matrix M that directly transforms P to P'.

$M = \begin{bmatrix} \qquad \end{bmatrix}$

5. [4+(3+3)=10 points] A camera is located at point $P = (3,4,5)$ in world space, gazing in direction $\hat{g} = -\frac{1}{3}\begin{bmatrix}1\\2\\2\end{bmatrix}$. The "view up vector" for the camera is $\hat{y}_c = \frac{1}{3}\begin{bmatrix}-2\\2\\-1\end{bmatrix}$.

   a. Determine the unit vectors $\hat{x}_c$ and $\hat{z}_c$ that together with $\hat{y}_c$ define the camera coordinate system.

$$\hat{x}_c = \begin{bmatrix} \\ \\ \end{bmatrix}, \hat{z}_c = \begin{bmatrix} \\ \\ \end{bmatrix}$$

   b. Write down the two transformation matrices that are required to transform from world space to camera space, in the correct order.

$$M = \begin{bmatrix} \\ \\ \\ \end{bmatrix}\begin{bmatrix} \\ \\ \\ \end{bmatrix}$$

PART 2 – THEORY - max 12 points

6. [3+3=6 points] In a rasterizer, we can use environment mapping to make objects appear reflective. Write down two limitations of this technique.

   1:

   2:

7. [max 6 points] A triangle has three vertices, located in screen space at $(-1,5)$, $(2,2)$ and $(3,9)$. Clip this triangle against the line $x = 0$ using the Sutherland-Hodgeman algorithm. Write down the emitted coordinates for each edge of the input triangle.

   Edge 1:

   Edge 2:

   Edge 3:

That's all, good luck!