Computer Graphics – 5. April 2016

Angaben zur Person (Bitte in *DRUCKSCHRIFT* ausfüllen):
Personal Information (please use *BLOCK LETTERS*):

Name / Last Name .... Vorname / First Name ....

Mat.-Nummer ....

Please read the instructions carefully

- you will be given **sixty (60)** minutes to complete the written examination
- check that the examination is complete and readable
- please use a blue or black pencil, not a red or green one
- only text on the stapled sheets will be evaluated, if needed, we staple additional blank sheets
- only writing material and non programmable calculators are allowed
- fill in the **TN** from your seat number

Die Hinweise bitte aufmerksam lesen

- Die Bearbeitungszeit beträgt **60 Minuten**
- Überprüfen Sie die Prüfungsunterlagen auf Vollständigkeit und einwandfreies Druckbild
- Schreiben Sie deutlich und ausschließlich mit blauer oder schwarzer Tinte. Unleserliche Antworten gehen **nicht** in die Bewertung ein. Benutzen Sie **keinen Bleistift**.
- Nur angeheftete Blätter werden bewertet. Sollte der Platz nicht ausreichen, so müssen Sie bei der Aufsicht weitere Zusatz-Seiten anfordern und einheften lassen
- Nur Schreibzeug und nicht programmierbare Taschenrechner sind erlaubt
- Übertragen Sie die Teilnehmernummer (**TN**) aus Ihrer Platzkarte

I have read and understood the instructions above
Durch meine Unterschrift bestätige ich die Kenntnisnahme der obigen Informationen

Erlangen, 5. April 2016 ....
(Signature / Unterschrift)

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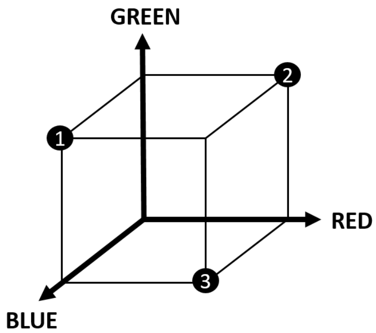
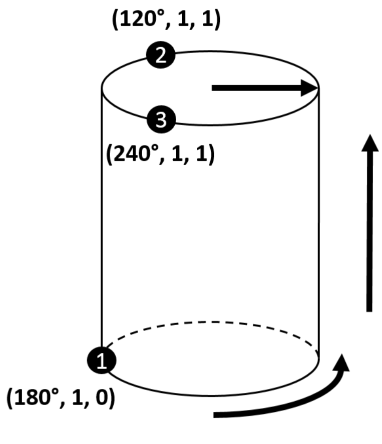
Aufgabe	1	2	3	4	5	6	**Gesamt**
Max. Punktzahl	6	4	13	13	11	15	**62**
Erreichte Punkte							

Aufgabe 1: Color Spaces 6 Punkte

1. From the lecture and the exercises you know that there are different color spaces. The most common color space is the RGB color space. Which colors are at the corners 1, 2 and 3 of the color cube in the figure below? Write down the color names (not the RGB tripples)!



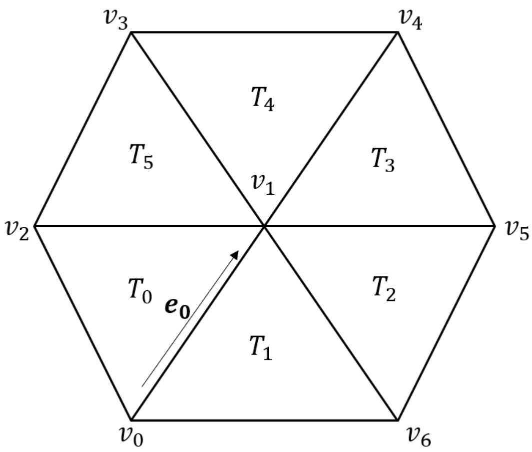
2. Another popular color space is the HSV color space. Label the axis and determine the color at the points 1, 2 and 3. 1 has the HSV color $(180°, 1, 0)$, 2 has the HSV color $(120°, 1, 1)$ and 3 has the HSV color $(240°, 1, 1)$.



3. Does Gouraud Shading in RGB and HSV color space result in the same output? Explain your answer!

Aufgabe 2: Directed Edge **4 Punkte**

1. Fill in the directed edge data structure of the triangle-mesh below. The edges are numbered from 0 to 17 and a triangle is formed by three consecutive edges in counterclockwise order. (for example e_0, e_1 and e_2 form the triangle $T_0 = \Delta(v_0, v_1, v_2)$. The field 'neighbor' should contain the index of the neighboring edge or -1 if there is none. Use the predefined ordering of the triangles $(T_0, T_1, ...)$.



e	v	neigh
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		

Aufgabe 3: Affine Transformations **13 Punkte**

Specify the 4×4 matrices for the following cases:

1. A translation by +4 in the x-direction and by +3 in the z-direction:

$$\mathbf{M} = \begin{pmatrix} \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \end{pmatrix}$$

2. First a sheering **and then** a translation by +3 in the y-direction. The sheering is specified by the following transformations:

   - $(1, 0, 0) \rightarrow (1, 0, 0)$
   - $(0, 1, 0) \rightarrow (1, 2, 0)$
   - $(0, 0, 1) \rightarrow (0, 0, 1)$

$$\mathbf{M} = \begin{pmatrix} \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \end{pmatrix} \cdot \begin{pmatrix} \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \end{pmatrix}$$

3. First a rotation about the z-axis by an angle α **and then** a rotation about the y–axis by an anlge θ:

$$\mathbf{M} = \begin{pmatrix} \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \end{pmatrix} \cdot \begin{pmatrix} \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \\ \Box & \Box & \Box & \Box \end{pmatrix}$$

4. Name 3 different ways to represent a rotation:

   - ....
   - ....
   - ....

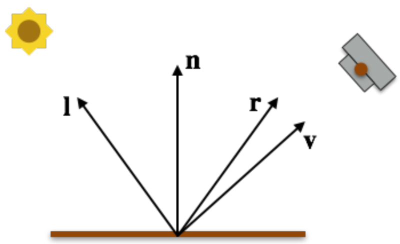
Aufgabe 4: Phong Shading 13 Punkte

1. Write down the three terms of the Phong lighting equation for the configuration shown in the figure bellow.

$L_{ambient}$ = ...

$L_{diffuse}$ = ...

$L_{specular}$ = ...



2. Write down the formula to compute the reflection vector **r** given the unit vector **l** pointing to the light source and the normal vector **n**.

r = ...

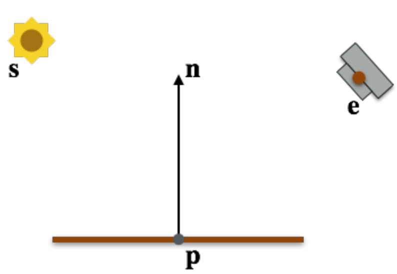
3. The following quantities are given:

$$\mathbf{p} = \begin{pmatrix} 2 \\ 3 \\ 1 \end{pmatrix} \qquad \mathbf{n} = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} \qquad \mathbf{s} = \begin{pmatrix} -1 \\ 3 \\ 5 \end{pmatrix} \qquad \mathbf{e} = \begin{pmatrix} 3 \\ 5 \\ 3 \end{pmatrix}$$

where **p** is a point in space, **n** the normal at **p**, **s** is the position of the light source, **e** is the position of the camera.

At the point **p** compute the following quantities:

- **l** the normalized direction to the light source
- **r** the normalized reflection vector
- **v** the normalized viewing vector



$$\mathbf{l} = \begin{pmatrix} \\ \\ \\ \end{pmatrix}$$

$$\mathbf{r} = \begin{pmatrix} \\ \\ \\ \end{pmatrix}$$

$$\mathbf{v} = \begin{pmatrix} \\ \\ \\ \end{pmatrix}$$

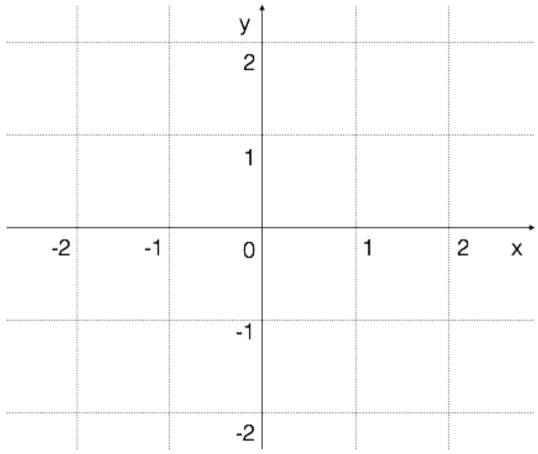
Aufgabe 5: Clipping: Cohen-Sutherland 11 Punkte

Given the line segment $\mathbf{P_1P_2}$ with $\mathbf{P_1} = (-2, 2)$ and $\mathbf{P_2} = (2, -1)$, and the rectangle $[-1, 1] \times [-1, 1]$.

1. Draw the line segment and the clipping area. There are 9 regions with different outcodes. Mark these regions in the figure below and provide the corresponding outcodes. Determine the outcodes for P_1 and P_2.

outcode($\mathbf{P_1}$) = | | | |

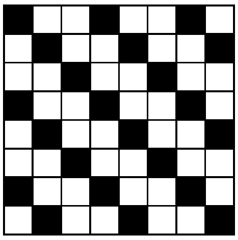
outcode($\mathbf{P_2}$) = | | | |



2. Perform the Cohen-Sutherland line clipping algorithm for the line segment $\mathbf{P_1P_2}$ and the clipping rectangle $[-1, 1] \times [-1, 1]$. List the processing steps and the corresponding results:

Aufgabe 6: Textures — 15 Punkte

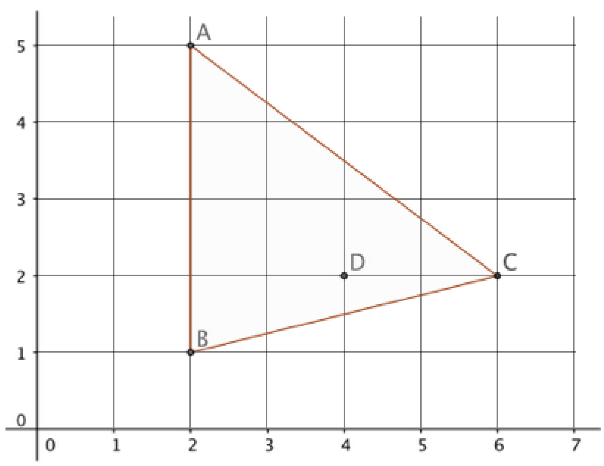
1. Fill in the missing levels of the MIP-map-pyramid below. Use grey values instead of rgb-values as indicated in the figure. To compute the value of a pixel in the next lower level of resolution use the simple **box filter**.



0	1	1	0	1	1	0	1
1	0	1	1	0	1	1	0
1	1	0	1	1	0	1	1
0	1	1	0	1	1	0	1
1	0	1	1	0	1	1	0
1	1	0	1	1	0	1	1
0	1	1	0	1	1	0	1
1	0	1	1	0	1	1	0

2. For the triangle below the vertex coordinates after the perspective projection, the values of the z–coordinates and the texture coordinates at the vertices are known:

vertex	z-coord	texture coords.
$\mathbf{A} = (2, 5)$	$z_A = 2$	$(u_A, v_A) = (1, 1)$
$\mathbf{B} = (2, 1)$	$z_B = 1$	$(u_B, v_B) = (0, 0)$
$\mathbf{C} = (6, 2)$	$z_C = 2$	$(u_C, v_C) = (1, 0)$



Use the **scanline algorithm** to compute the **perspective correct** texture coordinates at $\mathbf{D} = (4, 2)$.

3. Using **nearest neighbor** interpolation and the texture coordinates $(0.48, 0.20)$ determine the color of the pixel from the texture given below.