DELFT UNIVERSITY OF TECHNOLOGY
Faculty of Electrical Engineering, Mathematics and Computer Science
Department of Mediamatics

Computer Graphics (in2770)
Friday 18 August 2006, 14.00 - 16.00 h.

N.B.: This examination contains 30 questions
Total number of pages: 12

Instructions for filling in the Multiple Choice answer form:

- Fill in the form preferably with ballpoint or lead-pencil. Do not use red ink. Do not cross out. Erasing, when using lead-pencil, is allowed.

- Do not forget to fill in your **name**, **branch of science** and **student number**.

- Fill in your **student number** in the student number area **in cipher** and also **by filling in the squares** (check carefully).

Question 1

Supersampling is an anti-aliasing method that

a. stores a texture on several resolutions.
b. represents a pixel as a circular or square shaped area for which the overlap with the polygons of a scene to be rendered is calculated.
c. calculates whether a pixel is on a polygon boundary or not, using the slopes of edges and the polygon vertex coordinates.
d. calculates an image on a higher resolution than the final resolution of the rendered image.

Question 2

On the boundary of a polygon that is shown on a raster scan display ‘jaggies’ (staircase effect) show up because of

a. the low resolution of the display.
b. rounding errors in the calculations during the line generation process.
c. the display being a pixel array.
d. the limited number of possible intensity levels for a pixel.

Question 3

Given a system that is able to show animations on a raster screen. The frame rate of the animations must be 25 frames per second. The frame buffer contains 24 bits per pixel. If the frame buffer can be written with a velocity of 96000 Kilobyte (1 Kilobyte is 1024 bytes) per second, then what is the maximal size of the window that can be used to show the animation?

a. 1280 x 1024
b. 1024 x 1024
c. 640 x 512
d. 320 x 128

Question 4

Given are the following VRML nodes, that are used in a description of a virtual world in order to let an object with name MovingSphere move in that world:

```
DEF Clock TimeSensor {
   cycleInterval  4
   loop TRUE
}

DEF Path PositionInterpolator {
   key [
      0.0 0.5 1.0
   ]
   keyValue [
       0.0 0.0 0.0,
      10.0 0.0 0.0,
       0.0 0.0 0.0
   ]
}
```

and the route:

```
ROUTE Clock.fraction_changed TO Path.set_fraction
ROUTE Path.value_changed TO MovingSphere.set_translation
```

The MovingSphere object starts moving on time T (absolute time in seconds).
How far is the object away from the starting position on time T+7 and in which direction moves the object on time T+7?

	distance from starting position	moving direction
a.	2.5	to the starting position
b.	5	to the starting position
c.	17.5	from the starting position
d.	0	object does not move on time T+7

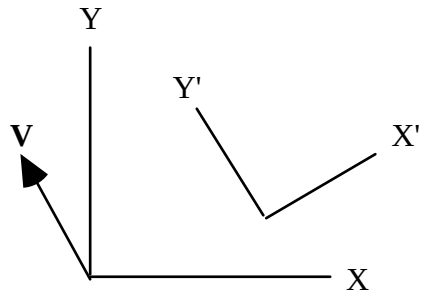
Question 5

Which optical effect can <u>not</u> be calculated with standard ray tracing?

a. reflection (mirroring)
b. transparency
c. diffuse inter-reflection
d. shadowing

Question 6

An image description in a 2D world coordinate system must be shown on a display. The orientation of the image on the display is determined by the view up vector $\mathbf{V} = \begin{matrix} -1 \\ 2 \end{matrix}$. To get this orientation a transformation is applied that maps objects from the world coordinate system XY to a coordinate system X'Y' with direction of the Y'-axis determined by **V** and with origin equal to (3, 1).



What is the matrix of the transformation that realizes the conversion to the new coordinate system?

a. $\begin{pmatrix} \frac{2}{5}\sqrt{5} & \frac{1}{5}\sqrt{5} & -\frac{7}{5}\sqrt{5} \\ -\frac{1}{5}\sqrt{5} & \frac{2}{5}\sqrt{5} & \frac{1}{5}\sqrt{5} \\ 0 & 0 & 1 \end{pmatrix}$

b. $\begin{pmatrix} -\frac{2}{5}\sqrt{5} & -\frac{1}{5}\sqrt{5} & \frac{7}{5}\sqrt{5} \\ \frac{1}{5}\sqrt{5} & -\frac{2}{5}\sqrt{5} & -\frac{1}{5}\sqrt{5} \\ 0 & 0 & 1 \end{pmatrix}$

c. $\begin{pmatrix} \frac{2}{5}\sqrt{5} & -\frac{1}{5}\sqrt{5} & -\sqrt{5} \\ -\frac{1}{5}\sqrt{5} & \frac{2}{5}\sqrt{5} & \frac{1}{5}\sqrt{5} \\ 0 & 0 & 1 \end{pmatrix}$

d. $\begin{pmatrix} -\frac{2}{5}\sqrt{5} & \frac{1}{5}\sqrt{5} & \sqrt{5} \\ \frac{1}{5}\sqrt{5} & -\frac{2}{5}\sqrt{5} & -\frac{1}{5}\sqrt{5} \\ 0 & 0 & 1 \end{pmatrix}$

Question 7

An image using Phong shading looks better than an image using Gouraud shading. Why?

a. With Phong shading the approximation of the shape of the light source is better.
b. With Phong shading the normal vector is interpolated on the object surface.
c. With Phong shading the colour of the light source is used in the calculations.
d. With Phong shading the influence of the ambient term is determined.

Question 8

Line clipping against a **3D** normalized view volume can be done with the Cohen and Sutherland algorithm. For the position of line endpoints relative to the view volume **6 bit codes** are used. How many different codes are possible for an arbitrary point?

a. 9
b. 16
c. 27
d. 64

Question 9

A polygon has a plane equation with coefficients a, b, c and d. This polygon is displayed with the z-buffer algorithm. The depth for a polygon in pixel P = (x, y) has already been determined and is equal to z_P. What is the depth for this polygon in pixel Q = (x+1, y) ?

a. $z_Q = z_P + a / c$
b. $z_Q = z_P - a / c$
c. $z_Q = z_P + b / c$
d. $z_Q = z_P - b / c$

Question 10

A scene is displayed with a window to viewport transformation, defined by the following OpenGL calls:

```
glViewport(100, 200, 300, 300)
glMatrixMode(GL_PROJECTION);
glLoadIdentity();
gluOrtho2D(163, 271, 55, 160);
glMatrixMode(GL_MODELVIEW);
glFlush();
```

Which name is used for the action that takes place on the screen when the following code fragment is executed?

```
glViewport(100, 200, 300, 300)
glMatrixMode(GL_PROJECTION);
glLoadIdentity();
gluOrtho2D(208, 316, 25, 130);
glMatrixMode(GL_MODELVIEW);
glFlush();
```

a. Zoom in
b. Zoom out
c. Panning
d. Clipping

Question 11

The Sutherland Hodgman polygon clipping algorithm adds 0, 1 or 2 points to the output polygon for every edge of the input polygon, depending on the position of the edge relative to the extended clipping boundary.
In one case, when both line endpoints are outside the extended clipping boundary (i.e. not on the side of the extended clipping boundary where the window is), no points are added to the output polygon. The other three cases are (for edge P_sP_e):

- P_s outside, P_e inside the extended clipping boundary
- P_s inside, P_e outside the extended clipping boundary
- P_s inside, P_e inside the extended clipping boundary

In how many of these three cases, exactly two points are added to the output polygon?

a. 0
b. 1
c. 2
d. 3

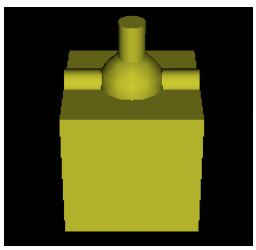
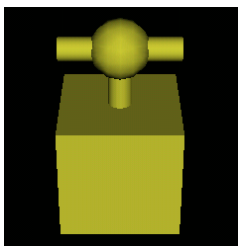
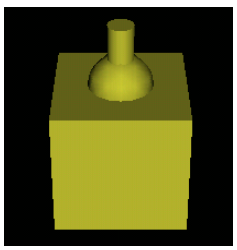
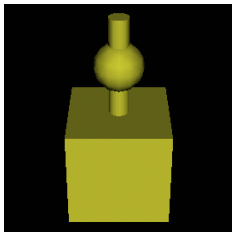
Question 12

Consider the following VRML virtual world:

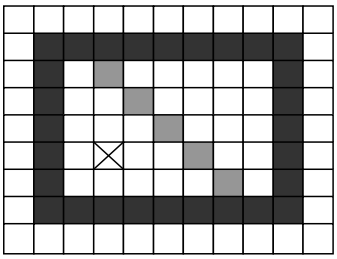
```
#VRML V2.0 utf8
Shape {
  appearance DEF Yellow Appearance
{
    material Material {
      diffuseColor .8 .8 .2
    }
  }
  geometry Box {}
}
Transform {
  translation 0 1 0
  children [
    Shape {
      appearance USE Yellow
      geometry Cylinder {
        radius 0.2
      }
    }
  ]
}
```

```
Transform {
  translation 0 1 0
  children [
    Shape {
      appearance USE Yellow
      geometry Sphere {
        radius 0.5
      }
    }
    Transform {
      rotation 0 1 0 1.57
      children Shape {
        appearance USE Yellow
        geometry Cylinder {
          radius 0.2
        }
      }
    }
  ]
}
```

What does the model defined in this world look like?

a.  b.  c.  d. 

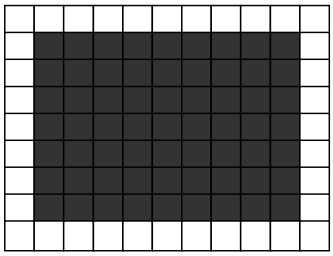
Question 13

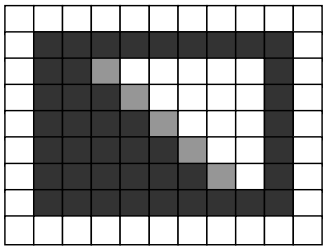


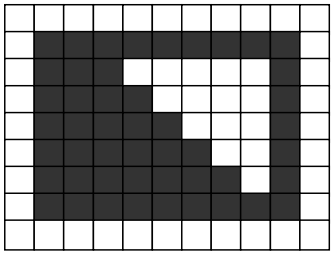
colors used: white
gray
black

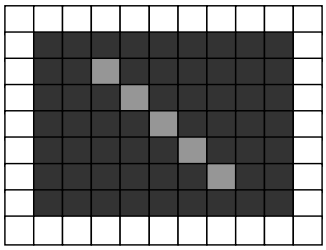
seed:

What does the polygon look like after applying the 8-connected flood fill algorithm, using the pixel with the cross as start pixel (seed) and with fill color black?

a. 

b. 

c. 

d. 

Question 14

Given is the following program code with OpenGL function calls

```
glBegin (polygonMode);
  ...        /* n points */
glEnd ();
```

With which polygonMode (GL_TRIANGLE_STRIP or GL_TRIANGLE_FAN) the largest amount of polygons is defined?

a. with GL_TRIANGLE_STRIP
b. with GL_TRIANGLE_FAN
c. it depends on the value of n
d. always exactly the same amount

Question 15

3D transformations can be represented with 3 x 3 matrices or with 4 x 4 matrices (in homogeneous coordinates). All transformations can be represented in homogeneous coordinates. However, with 3 x 3 matrices certain types of transformations can not be represented.
Consider the following types of transformations:
(I) shearing
(II) translation
(III) perspective projection

Which of these types of transformations can be represented with a 3 x 3 matrix?

a. only the shearing transformation
b. only the translation
c. only the perspective projection
d. all three of these transformations

Question 16

The matrix $\begin{pmatrix} -0.28 & -0.96 & 0 \\ -0.96 & 0.28 & 0 \\ 0 & 0 & 1 \end{pmatrix}$ represents a 2D reflection (mirroring) in the line y = *m*x.
What is the slope *m* of this line?

a. $m = 3/4$
b. $m = -3/4$
c. $m = 4/3$
d. $m = -4/3$

Question 17

In a VRML virtual world a route is defined from a TimeSensor node via a PositionInterpolator node to a node with name MovingBall (defined with DEF). The result is that a sphere is moving in the virtual world.
What kind of node is MovingBall?

a. a Sphere node
b. a Shape node
c. a Group node
d. a Transform node

Question 18

The window to viewport transformation M (for window boundaries xwmin, xwmax, ywmin and ywmax and viewport boundaries xvmin, xvmax, yvmin and yvmax) transforms viewing coordinates to screen coordinates with a combination of a translation T_1, followed by a scaling S, followed by another translation T_2. Given is:

$$T_2 = \begin{pmatrix} 1 & 0 & e \\ 0 & 1 & f \\ 0 & 0 & 1 \end{pmatrix} \qquad S = \begin{pmatrix} c & 0 & 0 \\ 0 & d & 0 \\ 0 & 0 & 1 \end{pmatrix} \qquad T_1 = \begin{pmatrix} 1 & 0 & a \\ 0 & 1 & b \\ 0 & 0 & 1 \end{pmatrix} \qquad M = T_2.S.T_1$$

with (I) or (II) and (III) or (IV):
(I) a = -xwmin, b = -ywmin, e = xvmin en f = yvmin
(II) a = -xvmin, b = -yvmin, e = xwmin en f = ywmin
(III) c = (xwmax – xwmin) / (xvmax – xvmin) en d = (ywmax – ywmin) / (yvmax – yvmin)
(IV) c = (xvmax – xvmin) / (xwmax – xwmin) en d = (yvmax – yvmin) / (ywmax – xwmin)

What is the correct combination?

a. (I) and (III)
b. (I) and (IV)
c. (II) and (III)
d. (II) and (IV)

Question 19

Given is the following program fragment with OpenGL function calls:

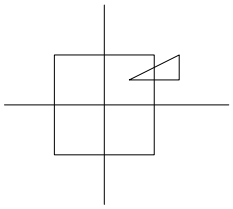
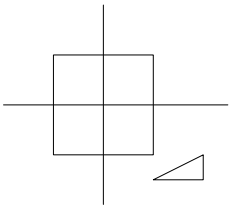
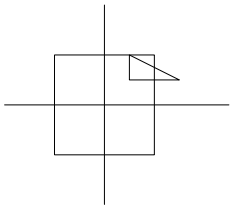
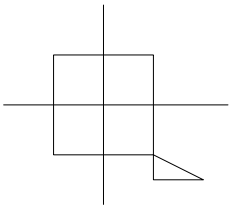
```
glMatrixMode(GL_MODELVIEW);
glLoadIdentity();

glBegin(GL_QUADS);
glVertex2f(-2.0, 2.0);   glVertex2f(2.0, 2.0);
glVertex2f(2.0, -2.0);   glVertex2f(-2.0, -2.0);
glEnd();

glScale2f(2.0, -1.0);
glTranslate2f(1.0, 2.0);

glBegin(GL_TRIANGLES);
glVertex2f(0.0, 1.0);   glVertex2f(1.0, 1.0);   glVertex2f(1.0, 0.0);
glEnd();
```

Which figure shows the correct graphical output?

a.  b.  c.  d. 

Question 20

Consider the scan line hidden surface removal algorithm. This algorithm uses an active edge list (AEL) and an active face list (AFL). Answer the following questions about the AEL and the AFL:

(I) On which moment are edges added to or deleted from the active edge list (AEL)?
(II) On which moment are faces added to or deleted from the active face list (AFL)?

	(I)	(II)
a.	when proceeding with the next scan line	when proceeding with the next scan line
b.	when proceeding with the next scan line	when proceeding with the next span
c.	when proceeding with the next span	when proceeding with the next scan line
d.	when proceeding with the next span	bij overgang naar de volgende span

Question 21

Given is the following light reflection model $I = k_a I_a + k_d I_l (N \cdot L) + k_s I_l (N \cdot H)^{n_s}$
Which parameter of the object surface (material property) must change its value in order to alter for instance a green object into red?

a. k_d
b. I_a
c. I_l
d. n_s

Question 22

ABCD is a polygon. A texture with texture coordinates between 0 and 1 in u- and v-direction is mapped on ABCD. The table below shows the correspondence between the points A, B, C and D and the texture.

vertex	texture space		screen space	
	u	v	x	y
A	0	0	200	200
B	1	0	600	100
C	1	1	200	700
D	0	1	100	600

The texture is mapped on the polygon with a bilinear mapping. On which point in screen coordinates point (0.5, 0.25) in texture coordinates will be mapped?

a. (325, 250)
b. (325, 275)
c. (337.5, 250)
d. (337.5, 275)

Question 23

A texture must be mapped on a polygon. In order to avoid Moiré patterns we apply anti-aliasing. What is a good reason to use a mip-map for the anti-aliasing?

a. The mip-map enables mapping of the texture on the polygon with arbitrary scale factors.
b. The mip-map reduces the amount of memory space needed to store the texture.
c. The mip-map speeds up the anti-aliasing.
d. The mip-map improves the quality of the mapped texture in screen space.

Question 24

In a light model the light intensity on an object surface is supposed to be independent of the distance to the light source. Two light sources $light_1$ and $light_2$ (on a finite distance) have equal light intensity $I_1 = I_2$. Light of both light sources reaches a polygon with plane equation $2x - 3y + z + 5 = 0$. The vector in the direction to the light source $light_1$ and $light_2$ is $L_1 = (4, 2, 0)$ and $L_2 = (3, 0, 1)$ respectively. What is the ratio between the value of the diffuse reflection component of $light_1$ and $light_2$ for a point on the polygon surface?

a. diffuse reflection of $light_1$: diffuse reflection of $light_2 = 1 : 7$
b. diffuse reflection of $light_1$: diffuse reflection of $light_2 = \sqrt{2} : 7$
c. diffuse reflection of $light_1$: diffuse reflection of $light_2 = 2 : 7$
d. diffuse reflection of $light_1$: diffuse reflection of $light_2 = 2\sqrt{2} : 7$

Question 25

In a polygon model the polygon vertices are <u>not</u> defined in a consequent order (for instance counter clockwise when looking at an object from the outside). For which step in the viewing pipeline this inconsequence is a problem?

a. the modelling transformations
b. the perspective projection
c. the back face removal
d. the z-buffer algorithm

Question 26

Are isometric projections and cavalier projections parallel projections or perspective projections?

	<u>isometric projection</u>	<u>cavalier projection</u>
a.	parallel	parallel
b.	parallel	perspective
c.	perspective	parallel
d.	perspective	perspective

Question 27

A rotation about a vector (x, y, z) with 30°, denoted as $R_{(x,y,z)}(30°)$, is built from the following elementary transformations:

1. a rotation about the x-axis with 45°, denoted as $R_{x\text{-as}}(45°)$
2. a rotation about the y-axis with 45°, denoted as $R_{y\text{-as}}(45°)$
3. a rotation about the z-axis with 30°, denoted as $R_{z\text{-as}}(30°)$
4. a rotation about the y-axis with -45°, denoted as $R_{y\text{-as}}(-45°)$
5. a rotation about the x-axis with -45°, denoted as $R_{x\text{-as}}(-45°)$

So: $R_{(x,y,z)}(30°) = R_{x\text{-as}}(-45°) \,.\, R_{y\text{-as}}(-45°) \,.\, R_{z\text{-as}}(30°) \,.\, R_{y\text{-as}}(45°) \,.\, R_{x\text{-as}}(45°)$

What is the correct vector (x, y, z) of this transformation?

a. $(\sqrt{2}, 1, 1)$
b. $(-\sqrt{2}, 1, 1)$
c. $(\sqrt{2}, \sqrt{2}, 1)$
d. $(-\sqrt{2}, -\sqrt{2}, 1)$

Question 28

A line segment AB with start point A = (800, 300) and end point B = (300, 550) is scan converted with the DDA algorithm. What is the y-increment used by this algorithm for line segment AB?

a. -1
b. -0.5
c. 0.5
d. 1

Question 29

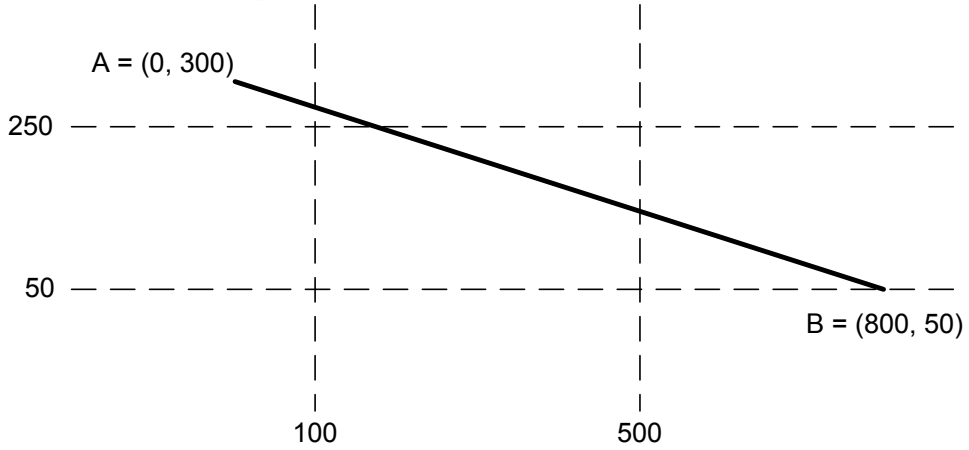
The matrix $\begin{pmatrix} -1 & 0 & p \\ 0 & -1 & q \\ 0 & 0 & 1 \end{pmatrix}$ represents a rotation about the point (a, b) with an angle α.

What are the values of p and q?

a. $p = a + b$ en $q = -a + b$
b. $p = -a + b$ en $q = a + b$
c. $p = 2a$ en $q = 2b$
d. $p = -2a$ en $q = -2b$

Question 30

The line segment AB in the figure below is clipped with the Liang and Barsky algorithm. The window boundaries are ordered left, right, bottom, top in the algorithm. The size of the window and the coordinates of points A and B are given in the figure below.



How does the parameter interval change during the clipping of line segment AB with this algorithm?

a. [0.0, 1.0] => [0.125, 1.0] => [0.125, 0.625] => [0.2, 0.625]
b. [0.0, 1.0] => [0.125, 1.0] => [0.2, 1.0] => [0.2, 0.625]
c. [0.0, 1.0] => [0.2, 1.0] => [0.2, 0.7] => [0.3, 0.7]
d. [0.0, 1.0] => [0.2, 1.0] => [0.3, 1.0] => [0.3, 0.7]

end of examination