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

Computer Graphics (in2770)
16 August 2004, 14.00 - 16.00 h.

N.B.: This examination contains 30 questions
Total number of pages: 10

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

Consider the following statements about the recursive 4-connected boundary-fill algorithm:
(I) Inside BoundaryFill(x, y, ...) there is a recursive call of BoundaryFill with parameters (x+1, y+1, ...).
(II) Inside BoundaryFill(x, y, ...) there is a recursive call of BoundaryFill with parameters (x-1, y, ...).

Are these statements correct?

	(I)	(II)
a.	correct	correct
b.	correct	incorrect
c.	incorrect	correct
d.	incorrect	incorrect

Question 2

Which vector below is a normal vector to the plain containing the points (0, 1, 0), (1, 2, 1) and (3, 1, 1) ?

a. $\begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}$ b. $\begin{pmatrix} 1 \\ -2 \\ 3 \end{pmatrix}$ c. $\begin{pmatrix} 1 \\ 2 \\ -3 \end{pmatrix}$ d. $\begin{pmatrix} 1 \\ -2 \\ -3 \end{pmatrix}$

Question 3

Which (exposed) field's value in a VRML 2.0 virtual world can be altered during navigation through the world, in order to change the size of a sphere in that world?

a. the radius (exposed) field of a Sphere node
b. the size (exposed) field of a Shape node
c. the scale (exposed) field of a Shape node
d. the scale (exposed) field of a Transform node

Question 4

Which visualization method is most suited to make images of transparent objects with refraction?

a. scan-line algorithm
b. z-buffer algorithm
c. depth sorting algorithm
d. ray tracing algorithm

Question 5

Consider the following statements

(I) The Cohen and Sutherland line clipping algorithm *rejects* all lines, that are *fully outside* the window, immediately on the ground of the codes of both end points.
(II) The Cohen and Sutherland line clipping algorithm *accepts* all lines, that are *fully inside* the window, immediately on the ground of the codes of both end points.

Are these statements correct?

	(I)	(II)
a.	correct	correct
b.	correct	incorrect
c.	incorrect	correct
d.	incorrect	incorrect

Question 6

Which viewing parameters are determined by means of the function `gluLookAt` from the OpenGL Utility Library?

a. only the view reference point
b. only the center of projection, the view reference point and the view up vector
c. only the center of projection, the view reference point, the view up vector and the view window
d. the center of projection, the view reference point, the view up vector, the view window and the near- and far planes

Question 7

Many things from reality can be modelled with the help of a model that consists of objects and relations between these objects. Often it is also practical to collect certain groups of objects in the model into compound objects and to create a hierarchy in the model in this way. Consider the following statements about the hierarchical composition of models:

(I) Collecting a number of objects into a compound object makes a model more manageable (= tractable) because less objects are present.
(II) Collecting a number of objects into a compound object enables working with the model on a higher level and therefore performing certain tasks more quickly.

Are these statements correct?

	(I)	(II)
a.	correct	correct
b.	correct	incorrect
c.	incorrect	correct
d.	incorrect	incorrect

Question 8

The z-buffer algorithm is a hidden surface removal algorithm. With this algorithm many times for a pixel (x, y) the z-coordinate of a point in a polygon with plane equation ax+by+cz+d=0 must be calculated. For pixels (x, y) and (x, y-1), that are above each other, this can be done with an incremental calculation: z(x, y-1) = z(x, y) + inc. Here, the meaning of z(x, y) is the depth (so the z-coordinate) of the polygon for pixel (x, y).
What is the correct increment inc that must be used to calculate the depth z(x, y-1) for pixel (x, y-1) from the depth z(x, y) for pixel (x, y)?

a. inc = -a / c
b. inc = -a / b
c. inc = -b / c
d. inc = b / c

Question 9

Shx and Shy are x-shearing and y-shearing matrices with shearing parameters hx and hy respectively. What is the condition (necessary and sufficient) for the parameters hx and hy in order that

$$Shx \cdot Shy = Shy \cdot Shx$$

a. $hx=0 \wedge hy=0$
b. $hx=0 \vee hy=0 \vee hx=hy$
c. $hx=0 \vee hy=0$
d. Shx . Shy = Shy . Shx for every value of hx and hy

Question 10

Which statement about a ROUTE in VRML is correct?

a. A ROUTE defines a chain of events between nodes, with which interaction and animation can be realized in a virtual world.
b. A ROUTE defines in which order the nodes in a scene graph must be visited in behalf of rendering the virtual world.
c. A ROUTE defines a new type of interpolator node.
d. A ROUTE defines a path, traveled by an object in an animation.

Question 11

For an image of a 3D object is given that parallel lines in the model all go through the same point in the image. The image is a(n)

a. orthographic projection
b. isometric projection
c. oblique projection
d. perspective projection

Question 12

In an animation of two moving objects with a fixed shape and size collision detection is performed, so that these objects can show the correct behavior after collision. For every frame of the animation is determined whether there is a collision or not. However, in some cases where there is a collision, the collision is not detected. Which of the possibilities (I) and (II) can be the cause of missing the collision?

(I) The objects move too fast relative to each other, so that they pass each other completely in-between two consecutive frames.
(II) In the collision detection, bounding volumes are used, which are too large to perform the collision detection with high accuracy.

a. both (I) and (II)
b. only (I)
c. only (II)
d. (I) not and (II) also not

Question 13

Which component of an elementary light reflection model is dependent on the direction **N** of the normal vector to the surface?

a. the diffuse reflection component and the specular reflection component
b. only the diffuse reflection component
c. only the specular reflection component
d. not the diffuse reflection component and also not the specular reflection component

Question 14

For a matrix $\begin{pmatrix} a & b & c \\ d & e & f \\ 0 & 0 & 1 \end{pmatrix}$ is given that it represents a 2D transformation that *does not reshape* objects (rigid body transformation). How many of the equations (i), (ii) and (iii) are satisfied *at least*? (So, in other words, what is the minimal number of equations that are satistied?)

(i) $a^2 + b^2 = 1$
(ii) $d^2 + e^2 = 1$
(iii) $ad + be = 0$

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

Question 15

Given is the following VRML code fragment

```
Transform {
  translation 1.0 2.0 0.0
  rotation 0.0 1.0 0.0 1.57
  children [
    Transform {
      translation 3.0 0.0 2.0
      scale 2.0 2.0 1.0
      children [...]
    }
  ]
}
```

Which composed transformation M is performed (by means of **p'**=M**p**) on the objects that are defined on place `...` in the code?

a. $M = T_{(1,2,0)} \cdot R_{y\text{-}as,90} \cdot T_{(3,0,2)} \cdot S_{2,2,1}$
b. $M = R_{y\text{-}as,90} \cdot T_{(1,2,0)} \cdot S_{2,2,1} \cdot T_{(3,0,2)}$
c. $M = T_{(3,0,2)} \cdot S_{2,2,1} \cdot T_{(1,2,0)} \cdot R_{y\text{-}as,90}$
d. $M = S_{2,2,1} \cdot T_{(3,0,2)} \cdot R_{y\text{-}as,90} \cdot T_{(1,2,0)}$

Question 16

How many of the transformations below are equal to the following combination of rotations: $R_{Z\text{-as, }+90} \cdot R_{Y\text{-as, }+90} \cdot R_{X\text{-as, }+90}$ (i.e. a rotation about the x-axis with 90 degrees, followed by a rotation about the y-axis with 90 degrees, followed by a rotation about the z-axis with 90 degrees).

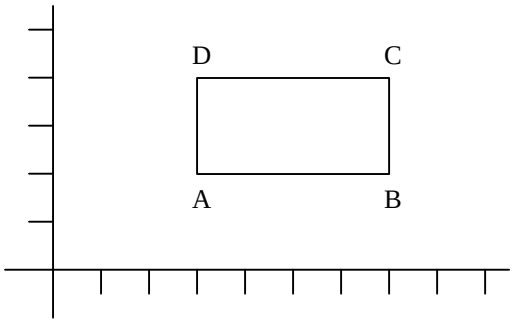
(i) $R_{X\text{-as, }+90} \cdot R_{Y\text{-as, }+90} \cdot R_{Z\text{-as, }+90}$
(ii) $R_{Y\text{-as, }+90}$
(iii) $R_{X\text{-as, }+90} \cdot R_{Z\text{-as, }-90} \cdot R_{X\text{-as, }-90}$

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

Question 17

We use the following notation for 2D transformations:
$T_{(a,b)}$ is a translation by the vector (a, b).
$R_{O,\alpha}$ is a rotation about the origin by α degrees.
$S_{(sx,sy)}$ is a scaling relative to the origin with scale factors sx and xy.

Rectangle ABCD from the figure below can be mapped on itself in different ways (by a combination of mirroring, rotation, translation and scaling).



Which compound transformation maps ABCD on BCDA, i.e. A is transformed to B, B to C, C to D and D to A ?

a. $T_{(5,3)} \cdot R_{O,90} \cdot S_{(0.5,2.0)} \cdot T_{(-5,-3)}$
b. $T_{(5,0)} \cdot S_{(-1,1)} \cdot T_{(-5,0)}$
c. $T_{(0,3)} \cdot S_{(1,-1)} \cdot T_{(0,-3)}$
d. $T_{(5,3)} \cdot R_{O,180} \cdot T_{(-5,-3)}$

Question 18

In which order the steps (I), (II) and (III) below are applied in Phong shading?

(I) interpolate normal vectors on a polygon
(II) determine the average normal vector for vertices
(III) apply light reflection model

a. first (I), then (II) and finally (III)
b. first (II), then (I) and finally (III)
c. first (II), then (III) and finally (I)
d. first (I), then (III) and finally (II)

Question 19

Consider the following statements:

(I) Performing backface removal is necessary to get a correct image with the depth sorting algorithm.
(II) Performing backface removal is necessary to get a correct image with the scan-line algorithm.

Are these statements correct?

	(I)	(II)
a.	correct	correct
b.	correct	incorrect
c.	incorrect	correct
d.	incorrect	incorrect

Question 20

A cube is placed in a world coordinate system with edges parallel to the coordinate axes. A perspective projection image is made of this cube. The image appears to be a 1-point perspective. After changing which viewing parameter, the image may change into a 2-point perspective?

a. the View Reference Point (VRP)
b. the View Up Vector (VUV)
c. the view angle
d. the view distance

Question 21

Which step in the 3D transformation process introduces points with homogeneous coordinate (w-coordinate) that is not equal to 1 ?

a. the modelling transformation
b. the viewing transformation
c. the perspective transformation
d. the window to viewport transformation

Question 22

Consider the following statements:

(I) If two images must be totally visible on a monitor at the same time, then the *windows (in world coordinates)* may not overlap each other.
(II) If two images must be totally visible in the same display window on a monitor at the same time, then the *viewports (in screen coordinates)* may not overlap each other.

Are these statements correct?

	(I)	(II)
a.	correct	correct
b.	correct	incorrect
c.	incorrect	correct
d.	incorrect	incorrect

Question 23

A square texture is displayed by means of a perspective mapping on an arbitrary rectangle on the screen. What is the shape of the pre-image (in texture space) of a square pixel (in screen space)?

a. always a square
b. always a rectangle; it does not need to be a square
c. an arbitrary quadrilateral; it does not need to be a rectangle
d. an arbitrary area with curved edges; it does not need to be a quadrilateral

Question 24

Supersampling is

a. a hidden surface removal method
b. an antialiasing method
c. a scan conversion method
d. a texture mapping method

Question 25

A texture is mapped on a polygon by means of linear interpolation along polygon edges followed by linear interpolation along the scan lines. A = (300, 150) and B = (450, 350) are two consecutive polygon vertices. On vertex A the point from the texture with coordinates (uA, vA) = (0.2, 0.1) is mapped. On vertex B the point from the texture with coordinates (uB, vB) = (0.8, 1.0) is mapped.
Scan conversion takes place from the scan line containing point A in the direction of the scan line containing point B. What is the u-increment for edge AB when proceeding to the next scan line?

a. 0.003
b. 0.004
c. 0.0045
d. 0.006

Question 26

A line has a slope between –1 and 0. When scan converting that line with the DDA algorithm, which condition holds for the step width in x-direction (x-increment)?

a. the step width in x-direction is equal to 1
b. the step width in x-direction is equal to –1 or 1
c. the step width in x-direction is in-between 0 and 1
d. the step width in x-direction is in absolute value smaller than 1

Question 27

Consider the following code fragments with OpenGL function calls:

(I)
```
glBegin (GL_LINES);
  /* define points for n line segments */
  ...
glEnd ();
```

(II)
```
glBegin (GL_LINE_STRIP);
  /* define points for n line segments */
  ...
glEnd ();
```

How many points more must be defined with code fragment (I) relative to code fragment (II) in order to generate graphical output consisting of n connected line segments?

a. 1
b. n-1
c. n
d. n+1

Question 28

The following OpenGL calls are in a program (in the given order):

```
glMatrixMode (GL_MODELVIEW);
glLoadIdentity ();
glScalef(1.0, 2.0, 1.0);
glTranslatef (2.0, 1.0, -3.0);
glRotatef (90.0, 1.0, 0.0, 0.0);
```

What is the value of the modelview matrix after execution of this program fragment?

a. $\begin{pmatrix} 1 & 0 & 0 & 2 \\ 0 & 0 & -1 & 1 \\ 0 & 2 & 0 & -3 \\ 0 & 0 & 0 & 1 \end{pmatrix}$ b. $\begin{pmatrix} 1 & 0 & 0 & 2 \\ 0 & 0 & -2 & 6 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$ c. $\begin{pmatrix} 1 & 0 & 0 & 2 \\ 0 & 0 & -1 & 3 \\ 0 & 2 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$ d. $\begin{pmatrix} 1 & 0 & 0 & 2 \\ 0 & 0 & -2 & 2 \\ 0 & 1 & 0 & -3 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

Question 29

The line segment AB with A = (-4, -3) and B = (6, 2) is clipped with the Liang-Barsky line clipping algorithm. The window boundaries are xmin = -3, xmax = 3, ymin = -2 and ymax = 2. The algorithm uses the parameter equation p(u) = **a** + u (**b** - **a**) for the line, where **a** and **b** are the position vectors of points A and B.

The algorithm starts with the parameter interval $[u_0, u_1] = [0, 1]$. Which parameter interval remains after clipping against all (four) window boundaries?

a. [0.1, 0.7]
b. [0.2, 0.7]
c. [0.1, 0.8]
d. [0.2, 0.8]

Question 30

Polygon scan conversion algorithms determine per scan line which spans must be colored. Therefore, an active edge list (AEL) is kept up to date. When proceeding to the next scan line, the data per edge in the AEL must be adapted. Which adaptation takes place?

a. The slope of the edges is adapted.
b. The reference to the span to which the edge belongs, is adapted.
c. The x-increment, that must be used to proceed to the next scan line, is adapted.
d. The x-coordinate of the intersection with the scan line is adapted.

end of examination