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

Computer Graphics (in2770)
3 November 2005, 9.00 - 11.00 h.

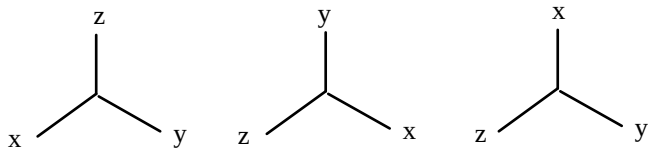
N.B.: This examination contains 30 questions
Total number of pages: 11

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 coordinate systems, which are shown in the figures looking from point (1, 1, 1) to the origin:



How many of these coordinate systems are right handed?

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

Question 2

Given is that point (5, -2, 3) lies in the plane V. The normal vector of V is $\begin{pmatrix} 2 \\ 3 \\ -4 \end{pmatrix}$.

Which of the following points is in the plane V?

a. (-1, 1, 2)
b. (0, 0, 2)
c. (1, 2, 3)
d. (2, 2, 4)

Question 3

For a texture, containing 512 x 512 pixels, a mip-map data structure was built. Colors are stored with 24 bits. What is the total size of the mip-map?

a. 0.75 Mbyte
b. 1 Mbyte
c. 1.5 Mbyte
d. 2 Mbyte

Question 4

Consider the following statements about texture mapping.

(I) For a bilinear mapping, straight lines (in an arbitrary direction) in texture space are mapped on straight lines in screen space.
(II) For a perspective mapping, straight lines (in an arbitrary direction) in texture space are mapped on straight lines in screen space.

Are these statements correct?

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

Question 5

The 2D viewing transformation can be built from a translation, a scaling and another translation. The parameters **xwmin**, **xwmax**, **ywmin**, **ywmax**, **xvmin**, **xvmax**, **yvmin** and **yvmax** determine the size of the window and viewport. Which are the correct translation vector components **tx1** and **ty1** of the first translation and the correct translation vector components **tx2** and **ty2** of the second translation?

NB. With the first translation is meant: The translation that is executed first.

a.	**tx1 = xwmin**	**ty1 = ywmin**	**tx2 = xvmin**	**ty2 = yvmin**
b.	**tx1 = xwmin**	**ty1 = ywmin**	**tx2 = -xvmin**	**ty2 = -yvmin**
c.	**tx1 = -xwmin**	**ty1 = -ywmin**	**tx2 = xvmin**	**ty2 = yvmin**
d.	**tx1 = -xwmin**	**ty1 = -ywmin**	**tx2 = -xvmin**	**ty2 = -yvmin**

Question 6

On a screen with 512 × 512 pixels a line drawing must be shown. However, the image is calculated with a resolution 1024 × 1024. Then pixel intensities are calculated by averaging 2 × 2 values in the 1024 × 1024 image for every pixel. This method can be used to

a. increase the width of all lines.
b. increase the intensity of all lines.
c. decrease aliasing.
d. amplify depth cuing.

Question 7

Two methods to interpolate colors for the interior points of a curved surface, approximated with polygons, are Gouraud shading and Phong shading. Why is Phong shading more calculation intensive than Gouraud shading?

a. For Phong shading the interpolation can not be done with an incremental method and for Gouraud shading it can.
b. For Phong shading the light reflection calculation can not be done with an incremental method and for Gouraud shading it can.
c. For Phong shading the light reflection calculation must be done for every pixel and for Gouraud shading it must not.
d. For Phong shading the light reflection calculation must be done for every vertex of every polygon and for Gouraud shading it must not.

Question 8

In ray tracing shadow rays are used to determine cast shadows. The shadow rays are defined by the position of the light source and

a. the intersection points of the primary rays and the image plane.
b. the intersection points of the primary rays and the objects.
c. the normal vectors on the object surfaces.
d. the object contours as seen from the light source.

Question 9

Which parameter is <u>not</u> used to determine the viewing coordinate system in the 3D viewing pipeline?

a. view reference point
b. view plane normal
c. projection window
d. view up vector

Question 10

Graphical displays can be divided into *emitters* (displays which emit / send light) and *non emitters* (displays which do not emit / send light, but reflect or transmit light). Which of the displays below is a non emitter?

a. liquid crystal display (LCD)
b. plasma panel
c. shadow mask CRT
d. all three types of displays are *non emitters*

Question 11

A program for the visualization of 3D objects draws a cube by means of a call of a function DrawBox. The code of DrawBox is as follows:

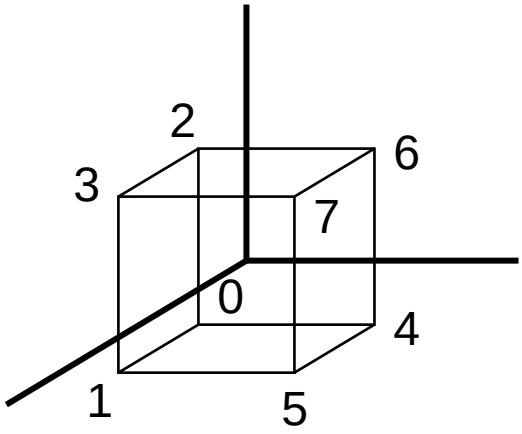
```
void DrawBox (Point *p)
{   glBegin (GL_LINE_LOOP);
      glVertex2f (p[0].x, p[0].y);
      glVertex2f (p[1].x, p[1].y);
      glVertex2f (p[3].x, p[3].y);
      glVertex2f (p[2].x, p[2].y);
    glEnd ();

    glBegin (GL_LINE_LOOP);
      glVertex2f (p[4].x, p[4].y);
      glVertex2f (p[5].x, p[5].y);
      glVertex2f (p[7].x, p[7].y);
      glVertex2f (p[6].x, p[6].y);
    glEnd ();

glBegin (GL_LINE_LOOP);
      glVertex2f (p[0].x, p[0].y);
      glVertex2f (p[1].x, p[1].y);
      glVertex2f (p[5].x, p[5].y);
      glVertex2f (p[4].x, p[4].y);
    glEnd ();

    glBegin (GL_LINE_LOOP);
      glVertex2f (p[2].x, p[2].y);
      glVertex2f (p[3].x, p[3].y);
      glVertex2f (p[7].x, p[7].y);
      glVertex2f (p[6].x, p[6].y);
    glEnd ();
}
```

The cube vertices are numbered in the same way as in the figure.



Which statement is correct?

a. edge p[1]p[5]is drawn 2 times.
b. edge p[4]p[5] is drawn 2 times.
c. edge p[5]p[7] is drawn 2 times.
d. al edges are drawn 1 time.

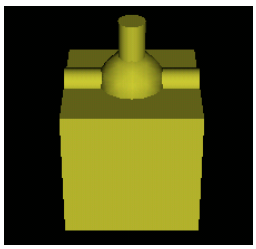
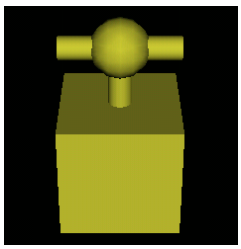
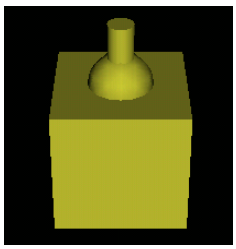
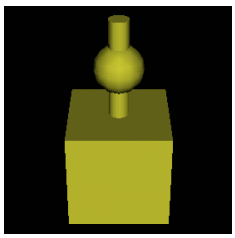
Question 12

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 2 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

A polygon's plane equation is V: x + y – z + 3 = 0 in world coordinates. The polygon is transformed to viewing coordinates. The viewing transformation is represented by the matrix

$$M_{wc->vc} = \begin{pmatrix} 0 & -1 & 0 & 2 \\ 1 & 0 & 0 & 3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}.$$

What is the plane equation of plane V in viewing coordinates?

a. x – y – z + 2 = 0
b. x – y + z – 2 = 0
c. x + y + z + 2 = 0
d. x + y – z – 2 = 0

Question 14

The Cohen and Sutherland line clipping algorithm uses 4-bits codes to define the position of a line endpoint relative to the clipping window. Let codeA = $a_1a_2a_3a_4$ and codeB = $b_1b_2b_3b_4$ be the two 4-bits codes for a line segment AB. Which condition must hold for the two 4-bits codes, in order that the line segment can be *accepted* (so the line segment is displayed)?

a. codeA AND codeB = 0000
b. codeA AND codeB ≠ 0000
c. codeA OR codeB = 0000
d. codeA OR codeB ≠ 0000

Question 15

$M = \begin{pmatrix} m_{1,1} & m_{1,2} & m_{1,3} \\ m_{2,1} & m_{2,2} & m_{2,3} \\ m_{3,1} & m_{3,2} & m_{3,3} \end{pmatrix}$ is the matrix for a reflection relative to the line y = - x + 2. Point p is mapped on p' by this transformation: p' = M p. What is the correct value for the matrix element $m_{1,3}$?

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

Question 16

With Gouraud shading polygon vertex colors are linearly interpolated along the polygon edges followed by linear interpolation along a scan line to find the color of an arbitrary pixel inside the projected polygon.

Given is the polygon ABC. The vertex coordinates are given in screen coordinates. Furthermore, the vertex colors for the Gouraud shading are given. See the table below for the coordinates and the colors.

point	screen coordinates		color		
	x	y	R	G	B
A	100	100	120	150	110
B	200	300	80	130	90
C	500	200	240	175	135

What is the color (R, G, B) that is assigned to pixel (300, 200) as a result of Gouraud shading?

a. (R, G, B) = (160, 145, 120)
b. (R, G, B) = (160, 155, 115)
c. (R, G, B) = (150, 145, 120)
d. (R, G, B) = (150, 155, 115)

Question 17

In OpenGL, for the definition of the position of a display window on the screen, a call of the function `glutInitWindowPosition` is necessary.
For the definition of a viewport inside the display window the function `glViewport` is used.

Which vertex of the display window and which vertex of the viewport is specified by means of arguments (x- and y-coordinate) of the two function calls?

	in `glutInitWindowPosition`	in `glViewport`
a.	the lower left vertex	the lower left vertex
b.	the lower left vertex	the upper left vertex
c.	the upper left vertex	the lower left vertex
d.	the upper left vertex	the upper left vertex

Question 18

How many polygons are contained in an OpenGL *triangle fan* defined by n points?

a. n / 3
b. n - 2
c. n - 1
d. n

Question 19

Consider the *scan line hidden surface algorithm*. Which sorting step decides which polygon is visible on a span?

a. the sorting of the spans on one scan line
b. the sorting of the active face list
c. the sorting of the active edge list
d. the bucket sorting of the edges

Question 20

With points in a 2D coordinate system, lines in 3D homogeneous coordinates correspond. Which line corresponds with the point (1, 0)?

a. $\begin{pmatrix} x \\ y \\ w \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} + \lambda \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}$

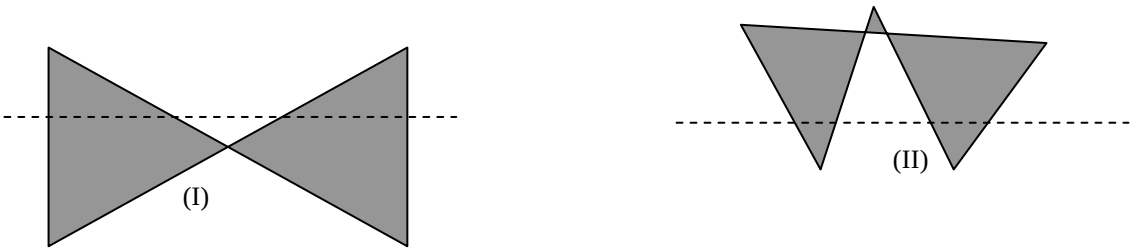
b. $\begin{pmatrix} x \\ y \\ w \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} + \lambda \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}$

c. $\begin{pmatrix} x \\ y \\ w \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} + \lambda \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$

d. $\begin{pmatrix} x \\ y \\ w \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} + \lambda \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$

Question 21

The Sutherland Hodgman clipping algorithm clips a polygon against an extended window boundary. Next, the result is clipped against the next extended window boundary. This goes on until clipping against all four extended window boundaries is finished.

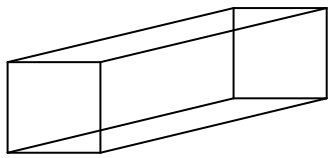


Consider the figures above. Both the left and the right image contains a polygon with intersecting edges and the extended bottom window boundary (the dashed line). Are the polygons (I) and (II) clipped correctly by the Sutherland Hodgman algorithm?

	(I)	(II)
a.	yes	yes
b.	yes	no
c.	no	yes
d.	no	no

Question 22

Given is the image below of a rectangular block. The image contains 3 times 4 parallel lines.



Which type of projection is used in this image?

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

Question 23

A line segment AB with A =(100, 700) and B = (400, 100) is displayed with the DDA scan conversion algorithm. Drawing starts in point A. What is the increment in y-direction used in the algorithm?

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

Question 24

A VRML file contains

```
DEF <name> ...
```

and further on

```
USE <name>
```

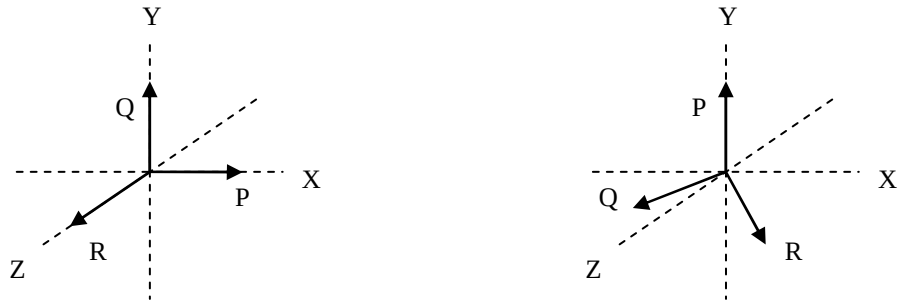
For <name> a correct name is inserted.

What is reused in this case?

a. a field
b. a node
c. a route
d. a field, node or route

Question 25

In the figures below with a right handed coordinate system XYZ the angles between the vectors P, Q and R are 90 degrees (both in the left and the right figure). In the right figure the angle between Q and the negative X-axis is 45 degrees.



Object PQR in the left figure is mapped on PQR in the right figure by a transformation. Which is the correct matrix for this transformation?

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

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

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

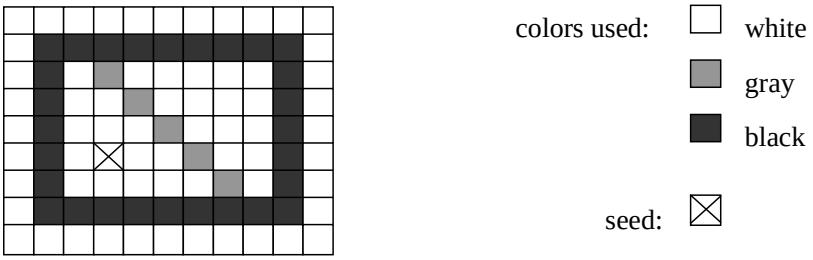
d. $\begin{pmatrix} 0 & \frac{1}{2}\sqrt{2} & \frac{1}{2}\sqrt{2} & 0 \\ 1 & 0 & 0 & 0 \\ 0 & -\frac{1}{2}\sqrt{2} & \frac{1}{2}\sqrt{2} & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

Question 26

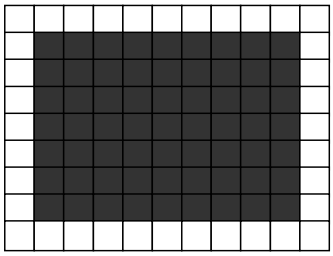
How many polygons are removed by applying back face removal (back face culling) before the hidden surface removal?

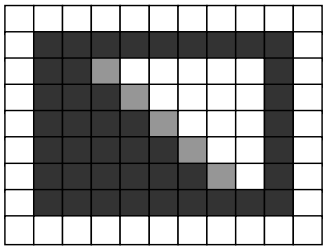
a. Half of the polygons in the model.
b. Always more than half of the polygons in the model.
c. Always less than half of the polygons in the model.
d. Sometimes more than and sometimes less than half of the polygons in the model.

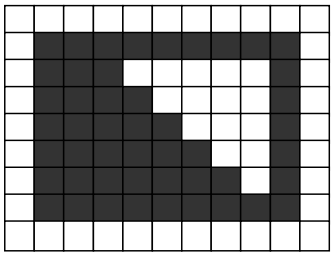
Question 27

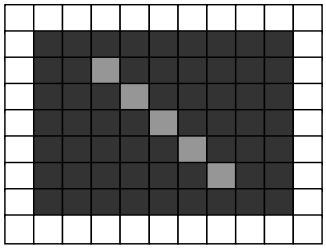


What does the polygon look like after applying the 4-connected flood fill algorithm, using the pixel with the cross as start pixel (seed) and with fill color black?

a. 

b. 

c. 

d. 

Question 28

Which component(s) of a simple empirical light reflection model is/are dependent on the direction of the normal vector on the surface?

a. only the diffuse reflection component
b. only the specular reflection component
c. only the diffuse reflection component and the specular reflection component
d. the diffuse reflection component, the specular reflection component and the ambient component

Question 29

The following node defines in VRML a 360° rotation with constant speed around the x-axis in counterclockwise direction. The rotation is applied to an object during a certain time interval.

```
OrientationInterpolator {
  key [0.0, 0.5, 1.0]
  keyValue [
    1.0 0.0 0.0 0.00,
    1.0 0.0 0.0 3.14,
    1.0 0.0 0.0 6.28 ] }
```

Why is it not possible to define the rotation with the following node?

```
OrientationInterpolator {
  key [0.0, 1.0]
  keyValue [
    1.0 0.0 0.0 0.00,
    1.0 0.0 0.0 6.28 ] }
```

a. because always for an interpolator node at least 3 keys must be given.
b. because the last interpolator node defines a rotation with a very small angle in clockwise direction.
c. because the last interpolator node defines a rotation with a changing rotation axis during the animation.
d. because the last interpolator node defines a rotation with a rotation speed which is not constant.

Question 30

Consider the following matrices for 2D transformations:

$$\begin{pmatrix} -\frac{1}{2}\sqrt{2} & \frac{1}{2}\sqrt{2} & 0 \\ \frac{1}{2}\sqrt{2} & \frac{1}{2}\sqrt{2} & 0 \\ 0 & 0 & 1 \end{pmatrix} \qquad \begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix} \qquad \begin{pmatrix} 0 & -1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

How many of these matrices represent a rotation around the origin?

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

end of examination