DELFT UNIVERSITY OF TECHNOLOGY
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Computer Graphics (in2770)
2 November 2004, 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:

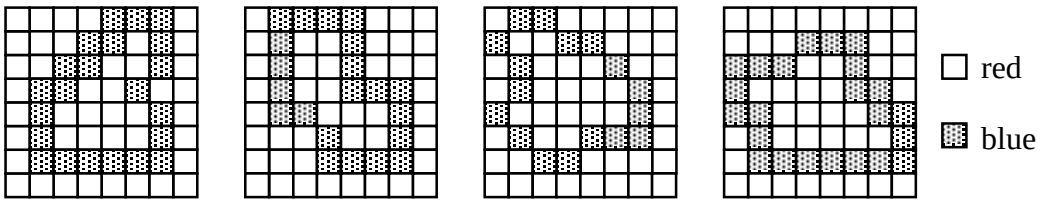
- Fill in the form preferably with ballpoint or lead-pencil. Do not use red ink. Do not cross out. Erasing, when using lead-pencil, is allowed.

- 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

In a color raster all pixels have color red. Then several pixels are changed to blue like in the figures below. The four figures show the boundary of four polygons.



Consider the following statements about these polygons:

(I) There is a polygon that can be filled with blue using the 8-connected boundary fill algorithm.
(II) There is a polygon that can be filled with yellow using the 4-connected flood fill algorithm.

Are these statements correct?

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

Question 2

A line segment PQ with P=(x_P, y_P) and Q=(x_Q, y_Q) is converted to raster format with the DDA algorithm. Pixel 'setting' starts with (x_P, y_P). Further is given that:
$x_Q - x_P > 0$
the slope of the line is smaller than -1

Which statement is correct?

a. a step size of 1 is used in x-direction
b. a step size of 1 is used in y-direction
c. a step size of -1 is used in x-direction
d. a step size of -1 is used in y-direction

Question 3

$$Ax + By + Cz + D = 0$$

is the plane equation of a polygon in 3D space, where the coefficients A, B, C and D can be determined from three polygon vertices that do not lie on a straight line. The coefficients are important for

a. the viewing transformation matrix and shading.
b. the viewing transformation matrix and the hidden surface algorithm.
c. shading and the hidden surface algorithm.
d. the viewing transformation matrix, shading and the hidden surface algorithm.

Question 4

$$\begin{matrix} 1 & 0 & \frac{1}{8}\sqrt{3} & 0 \\ 0 & 1 & \frac{1}{8} & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{matrix}$$ is the matrix of a parallel projection.

A line parallel to the projection plane preserves its real length in the display when this parallel projection is applied. With what length a line is displayed, that is perpendicular to the projection plane and has a real length of 1?

a. $\frac{1}{8}$

b. $\frac{1}{4}$

c. $\frac{1}{2}$

d. $\frac{1}{2}\sqrt{3}$

Question 5

With anti-aliasing of textures, normally a pre-image is determined of a pixel that is represented by a square or circle shaped area. In this situation, the pre-image contains the texture values that are used to calculate a filtered color value for the pixel. For a method like mip-mapping, the filtered values are calculated in advance (pre-filtering). What is with mip-mapping the shape of the pre-image of a pixel?

a. a circle
b. an ellipse (in some cases a circle)
c. a square
d. a rectangle (in some cases a square)

Question 6

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 24000 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 7

In OpenGL graphical output is transformed to screen coordinates by means of multiplication of point coordinates with

a. the product of a scale-, rotate and translate matrix
b. the product of a modeling transformation matrix and a orthographic projection matrix
c. the product of a modeling transformation matrix and a viewing transformation matrix
d. the product of a model-view matrix and a projection matrix

Question 8

In a 2D computer animation two circles A (with radius R_A) and B (with radius R_B) move along paths b_A en b_B, during a time interval that is n frames long. The distance of the centers of A and B is d. Collision detection must be applied to A and B.
A good criterion for the occurrence of a collision is:

a. if at one frame i ($1 \leq i \leq n$) the following inequality holds: $d < (R_A + R_B)$
b. if the minimal distance of the curves b_A and b_B is smaller than d
c. if in one frame i ($1 \leq i \leq n$) the following inequality holds: $d < \min(R_A,R_B)$
d. if the curves b_A and b_B intersect.

Question 9

Given are the following matrices M1, M2 and M3:

$$M1 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \qquad M2 = \begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \qquad M3 = \begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Which of the transformation matrices M1, M2 and M3 are suitable for conversion from a right handed coordinate system to a left handed coordinate system?

a. none of all
b. only M1
c. only M1 and M2
d. M1, M2 and M3

Question 10

In OpenGL pop-up menus can be defined. Which statement about the callback function(s) for these menus is correct?

a. There is 1 callback function for all pop-up menus together.
b. There is one callback function for every (top level) pop-up menu. The submenus of these menus do not have their own callback function.
c. There is one callback function for every (top level) pop-up menu and also 1 callback function for every (lower level / sub) menu.
d. There is 1 callback function for every menu option of every menu.

Question 11

For which transformations M_1 and M_2 does <u>not</u> hold that

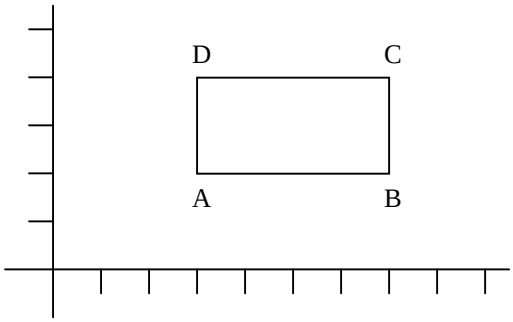
$$M_1 \,.\, M_2 = M_2 \,.\, M_1$$

a. for M_1 a translation along the vector (0, ty) and M_2 a scaling relative to O with scale factors sx and 1
b. for M_1 a rotation about O with $\theta°$ and M_2 a scaling relative to O with equal x-direction and y-direction scale factors s and s
c. for M_1 a translation along the vector (tx, ty) and M_2 a rotation about O with 180°
d. for M_1 a scaling relative to O with equal x-direction and y-direction scale factors s and s and M_2 an x-shearing with shear factor shx

Question 12

We use the following notation for 2D transformations:
$T_{(a,b)}$ is a translation along 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).

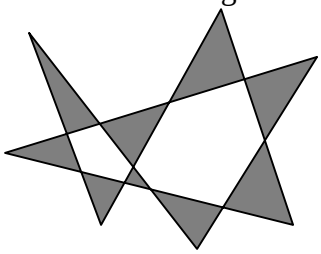


Which compound transformation maps ABCD on DCBA, i.e. A is transformed to D, B to C, C to B and D to A ?

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 13

Consider the image below of a polygon with crossing edges.



According to which rule(s) the polygon is colored in the same way as in the image?

a. according to the 'odd even' rule and according to the 'nonzero winding number' rule
b. only according to the 'odd even' rule
c. only according to the 'nonzero winding number' rule
d. not according to the 'odd even' rule and also not according to the 'non zero winding number' rule

Question 14

Which of the following 2D transformation matrices does not reshape the object to be transformed?

a. $\begin{pmatrix} 0.707 & 0 & 0 \\ 0.707 & 1.414 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

b. $\begin{pmatrix} 0.707 & -0.707 & 1 \\ 0.707 & 0.707 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

c. $\begin{pmatrix} 0.707 & 0.707 & 1 \\ 0.707 & 0.707 & 1 \\ 0 & 0 & 1 \end{pmatrix}$

d. $\begin{pmatrix} 0.5 & -0.866 & 1 \\ 0.866 & -1.5 & -1 \\ 0 & 0 & 1 \end{pmatrix}$

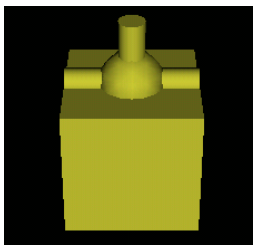
Question 15

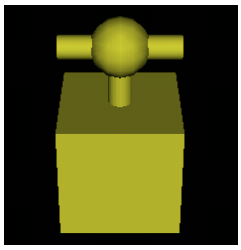
Consider the following VRML virtual world:

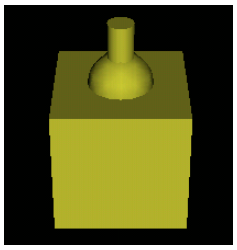
```
#VRML V2.0 utf8
Shape {
  appearance DEF Yellow Appearance
{
    material Material {
      diffuseColor .8 .8 .2
    }
  }
  geometry Box {}
}
Transform {
  translation 0 1 0
  children [
    Shape {
      appearance USE Yellow
      geometry Cylinder {
        radius 0.2
      }
    }
  ]
}
```

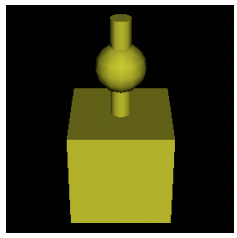
```
Transform {
  translation 0 1 0
  children [
    Shape {
      appearance USE Yellow
      geometry Sphere {
        radius 0.5
      }
    }
    Transform {
      rotation 0 0 1 1.57
      children Shape {
        appearance USE Yellow
        geometry Cylinder {
          radius 0.2
        }
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

What does the model defined in this world look like?

a. 

b. 

c. 

d. 

Question 16

One way to prevent aliasing in an image is by using *super sampling*. With super sampling

a. a pixel color is calculated by means of a determination of the size of the area of overlap between a polygon and a pixel and the use of this overlap as a weighting factor for averaging colors.
b. a pixel color is calculated as an average or weighted average of colors, that are read from a texture map (on one resolution).
c. a pixel color is calculated as an average or weighted average of colors from one or more levels of a texture map which is calculated and stored in advance on several resolutions.
d. a pixel color is calculated as an average or weighted average of sub-pixel colors from an image on a higher resolution.

Question 17

In order to be able to represent all 2D transformations with a 3 x 3 matrix, we use an xyw-coordinate system (homogeneous coordinates) instead of an xy-coordinate system. A 2D point corresponds in homogeneous coordinates with

a. a 3D point
b. a line parallel to the w=1 plane
c. a line in the w=1 plane
d. a line through the origin

Question 18

Consider the following VRML code

```
TimeSensor {
  enabled           TRUE
  startTime         1.0
  stopTime          0.0
  cycleInterval     10.0
  loop              TRUE
}
```

For how long the TimeSensor will generate events?

a. 0 seconds
b. 1 second
c. 10 seconds
d. as long as the application is running

Question 19

Consider the code fragment

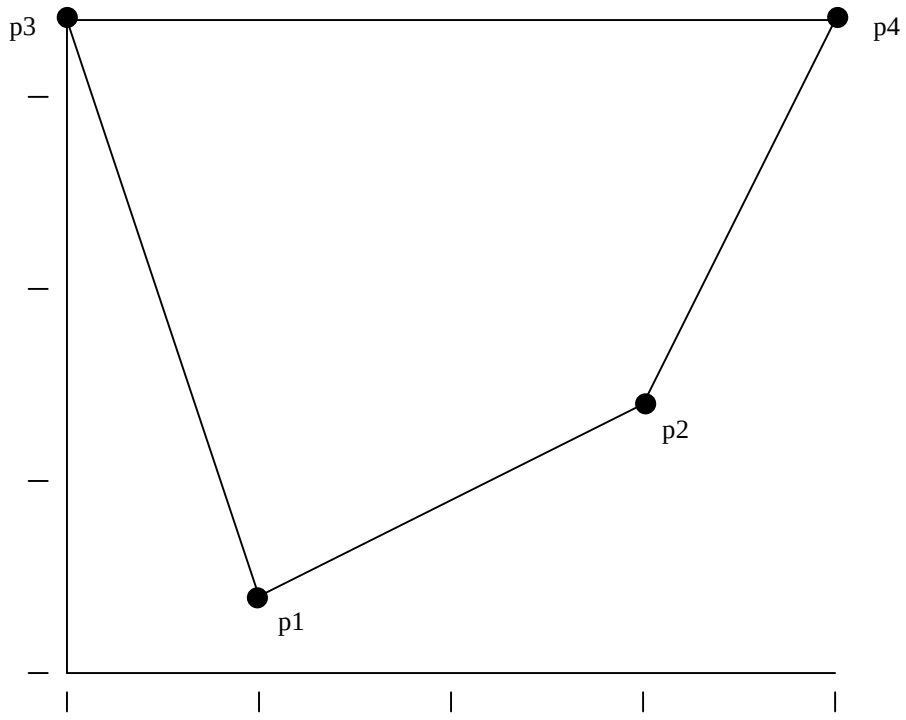
```
glBegin (GL_QUAD_STRIP);
  for (i=0; i<16; i++)
    glVertex2fv (points[i]);
glEnd();
```

How many quadrilaterals are contained in the quad strip that is defined by this code?

a. 4
b. 5
c. 6
d. 7

Question 20

A texture is mapped on the polygon below with a *bi-linear mapping*. Point (0, 0) in the texture is mapped on p1 = (50, 20), point (1, 0) on p2 = (150, 70), point (0, 1) on p3 = (0, 170) and point (1, 1) on p4 = (200, 170).



On which point in screen coordinates is the texture point (0.5, 0.6) mapped?

a. (100, 100)
b. (120, 100)
c. (100, 120)
d. (120, 120)

Question 21

With backface removal (backface culling) we divide the polygons in two groups: frontfaces and backfaces. Consider the following statements:

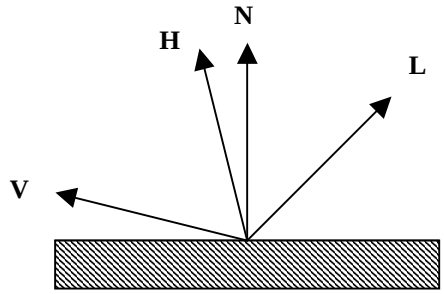
(I) All frontfaces are visible
(II) All backfaces are invisible

Are these statements correct?

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

Question 22

In the figure below **L** is a vector to the light source, **V** a vector to the observer, **N** a normal vector to the surface and **H** a vector that divides the angle between **L** and **V** into two equal parts. All vectors have length 1.



In which component of a simple light reflection model vector **H** is needed?

a. the specular reflection component
b. the refraction component
c. the diffuse illumination component
d. the diffuse reflection component

Question 23

In the Cohen and Sutherland line clipping algorithm 4-bits codes are used to indicate the position of the line endpoints relative to the window. Let cA and cB be the 4-bits line endpoint codes of line segment AB. Which statement expresses the meaning of the expression cA AND cB ≠ 0000 in the Cohen and Sutherland algorithm in the best way?

a. If this expression is TRUE then the line segment does not intersect the window.
b. If this expression is TRUE then the line segment intersects the window.
c. If this expression is TRUE then the line segment is totally contained in the window.
d. If this expression is TRUE then none of the end points is contained in the window.

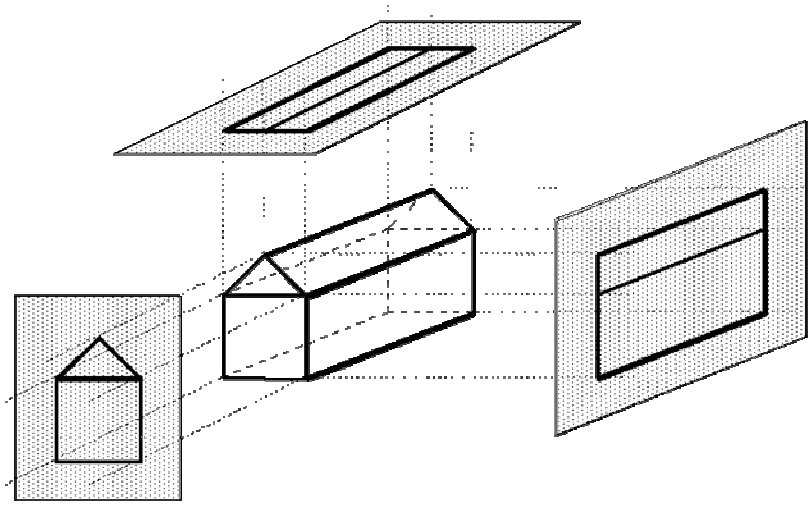
Question 24

What is in VRML the action to be performed by a PositionInterpolator node if the node receives an event-in?

a. The node performs a translation to an object.
b. The node calculates a translation vector and sends this vector to another node.
c. The node calculates a key frame of an animation.
d. The node decides the position of an object with use of the current transformation matrix.

Question 25

Which statement about the image below is correct?



a. The image is an orthographic projection and shows what an orthographic projection is.
b. The image is an orthographic projection and shows what an oblique projection is.
c. The image is an oblique projection and shows what an orthographic projection is.
d. The image is an oblique projection and shows what an oblique projection is.

Question 26

The outer product (cross product) of two vectors is

a. a scalar, equal to the area of the parallelogram spanned by the two vectors.
b. a scalar, equal to the length of the first vector times the length of the projection of the second vector on the first vector.
c. a vector with length equal to the area of the parallelogram spanned by the two vectors.
d. a vector with length equal to the length of the first vector times the length of the projection of the second vector on the first vector.

Question 27

What is the transformation matrix for the +90° rotation about the line through point (1, 2, 0), parallel to the z-axis?

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

Question 28

The window to viewport transformation can be constructed as XYZ. What kind of transformations are X, Y and Z in this case?

a. X and Z are translations and Y is a scaling
b. X and Z are translations and Y is a rotation
c. X and Z are scalings and Y is a translation
d. X and Z are rotations and Y is a translation

Question 29

The scan line algorithm for rendering a 3D scene consisting of polygons, uses an active face list (AFL) to record

a. which faces intersect the current scan line.
b. which faces are behind the current span.
c. which faces belong to the current object.
d. which faces are front faces relative to the current eye position.

Question 30

To which parts of a 3D polygon model Gouraud shading or Phong shading is applied?

a. to all polygons in the 3D model
b. only to the polygons which are lighted by at least one light source
c. only to the polygons which must be drawn with a texture on it
d. only to the polygons which together are an approximation of a curved surface

end of examination