Written examination in

PPU080 – Advanced Computer Aided Design

Date: 2020-10-29, 8.30 – 10:00

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Department: Industrial and Materials Science

Solution to the exam: On the course home page the day after the exam.
Preliminary results: On the course home page before 2020-11-19

Inspection of your exam result (at Lars Lindkvists office):

- 2029-11-23, 12.00-13.00
- 2029-11-24, 12.00-13.00

Aids

All.

The examination contains 5 tasks, each worth 10 points.
Grades:

< 20 points: Fail
20-29 points: Grade 3
30-39 points: Grade 4
40-50 points: Grade 5

Do not treat more than one task on each page.

Special Instructions for Canvas/Zoom exam

- The answers should be uploaded to Canvas as one file in MS Word or pdf-format
- Write your name and Personal Identification Number (Swedish: Personnummer) at the top of the first page
- Mark each answer, clearly, with the number of the question and also the letter for sub-questions
- Typed answers are preferred, not in hand writing
- If you want to draw an illustration by hand, take a photo, or scan, your illustration and include it in your document
- Simple illustrations can also be drawn directly in e.g. MS Word
- IT IS NOT ALLOWED TO COPY DIRECTLY FROM THE COURSE MATERIAL AND PASTE INTO THE WORD DOCUMENT. You have to formulate all answers by yourself.

1. Geometry modeling

a) Mention three different aspects that has to be included in an assembly model (in e.g. a CAD system). (3p)
b) Mention two advantages of using solid models instead of e.g. surface models. (2p)
c) Describe how trimmed parametric surfaces are defined/created (3p)
d) Bézier and B-spline are two types of curves used in geometry modeling. What are the advantages of B-spline curves? (2p)

Answers

a)
An assembly model needs to include

- Hierarchical relations
  - assembly -> sub-assembly -> part
- Mating conditions
  - geometrical restrictions, etc
- Mechanical degrees of freedom

b)

- Solid models support higher levels of functionality and automation than surface models
  - Example: Calculation of mass and moments of inertia
- Solid models allow the designer to work with higher level objects rather than points, curves and surfaces

c)

- Parametric surfaces are defined in a similar way as parametric curves but with two parameters u and v.
- Parametric curves are defined in the same 2D parametric space.
  - They are used to create holes (inner trim curves)
  - Or the outer boundary of the surface (outer trim curve)
- The trimmed parametric surface is transformed to 3D space

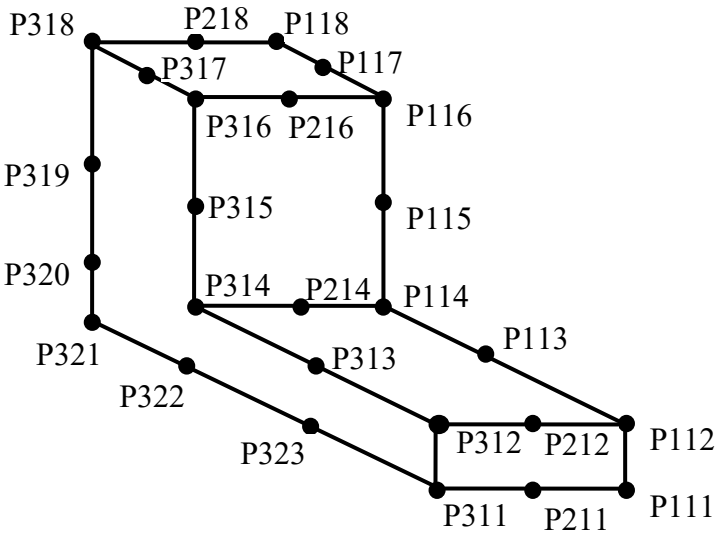
d)

- Better local control of the curve
- Order of the polynomial does not increase with the number of control points
- Easier to define joined curve segments

2. Geometry assurance

a) How does *stability analysis* work and for what is it used? (4p)

b) Define a 3-2-1 locating scheme for the part in the figure. (6p)
   1. Use the points in the figure (P111-P323, located on the visible surfaces)
   2. Try to make it as robust as possible
   3. For 6 points you have to **motivate** your selection of points



Answers

a)

Simulation:

- Each locating point is disturbed with a unit disturbance
- The amplification to the output, color-coding, part position or critical product dimension, is calculated
- The amplification for each individual locating point is summarized with RSS to give a value for the locating scheme

It is used to identify sensitive areas and sensitivity factors and guides optimization of locator position

b)

Select P311, P321 and P318 as A1, A2 and A3 defining the plane. This will maximize the area of the triangle which makes it robust.
Select P311 and P321 as B1 and B2 defining a line. This gives a long line which makes it robust.
The selection of C1 does not have a large influence on the robustness we can, e.g., select P321 which might make it easier to make a fixture.
Many other solutions could be correct, some even more robust (but with other disadvantages). In order to get 6 points, the choices should be motivated in a correct way.

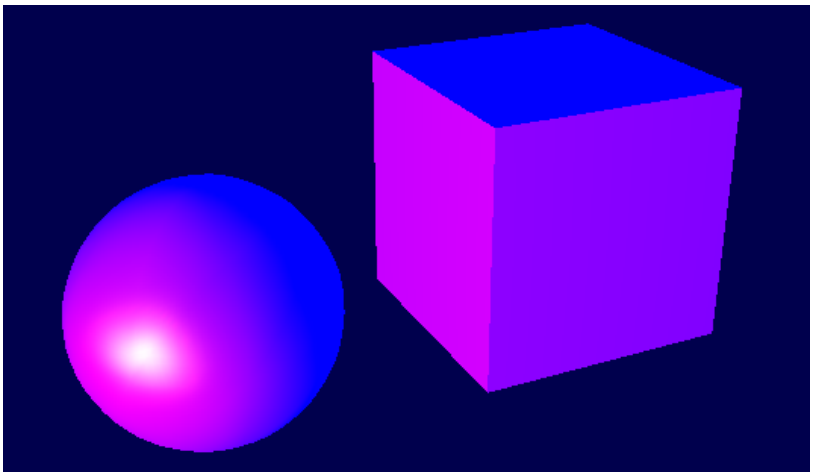
3. Computer graphics and virtual reality

a) Describe what LOD (Level of Detail) is and how it can be used to increase the performance of a visual simulation. (2p)

b) Describe how a *shadow buffer* can be used to create shadows. (4p)

c) Describe how so called shutter glasses can be used to obtain stereo projection on an ordinary computer screen. (2p)

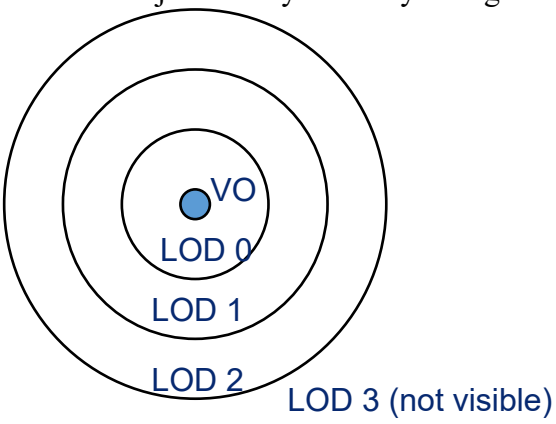
d)



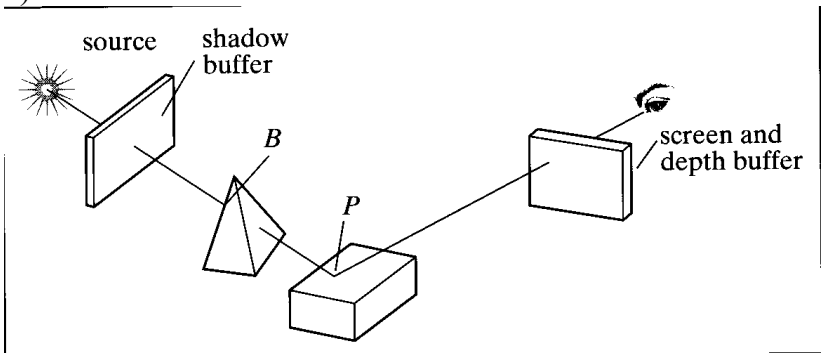
The model above has a white light source
Specify RGB values for the three color components, Specular Color, Emissive Color and Diffuse Color for the material used for both objects. Motivate your answers! (4p)

Answers

a)
Many representations with different precision is stored. Depending on the distance to the object, one suitable representation is shown, i.e. when an object is far away a simple representation is shown. When an object is very far away it might not even be drawn at all.



b)



- Create a buffer, corresponding to the depth buffer, containing the distance from the light source to the closest surface

- When drawing the point P on a surface:
    - Find the corresponding position in the shadow buffer for the point that is being drawn
    - Compare the value in the shadow buffer with the distance from the light source to P
    - If the value is less than the distance: draw only with ambient light

c)

Emissive Color makes the object visible without light source so even surfaces without direct light are visible. Diffuse Color gives diffuse reflection which is dependent on the placement of the light source but not the placement of the observer. Specular Color is a shiny reflection and depends on the placement of both the light source and the observer.

The light source in the figure is down to the left (indicated by the specular reflection). Therefore, some surfaces, e.g., the top surface of the box, does not get any direct light. This means that they get only Emissive Color. Therefore, Emissive Color has to be blue, or RGB(0,0,1).
Specular Color depends on the placement of both the light source and the observer and is thereby shown only on a smaller part of a curved surface (the sphere). In the figure a white spot is shown on the sphere. This comes from the Specular Color which has to be white or RGB(1,1,1).
The other surfaces that are hit by light, but does not have specular reflection, are different shades of purple. This color is a mix of Emissive and Diffuse Color. This means that the Diffuse Color has to be red or RGB(1,0,0).

4. Miscellaneous

a) What are the six most central functions of a PLM system? (6p)
b) On a higher level, a PLM system have two major tasks. One is to manage information, what is the other? Give some examples of tools used for the second task. (2p)
c) What are homogenous coordinates and why are they used in computer graphics? (2p)

Answers

a)

The most central functions of PLM systems are:

- Item (part, assembly, component) management
- Product structure management
- Document management
- Change management
- Retrieval of information
- Workflow and distribution management

b)

Create Information, e.g. with CAD systems or simulation software.

c)

Homogenous coordinates are created by adding an extra coordinate, w, to the Cartesian coordinates: $P_{cartes}[x\ y\ z] \rightarrow P_{homogen}[x\ y\ z\ w]$ normally (in computer graphics) w = 1.

They are used in order to simplify the calculation of transformations. With homogenous coordinates all transformations can be calculated as the same matrix multiplication which can be optimized for speed in the graphics processor.

5. Virtual Geometry Assurance

a) What is virtual geometry assurance? (2p)
b) What are the benefits of using it (4p)?
c) Describe how it can be used in some tasks in the geometry development process. (4p)

Answers

a)

- Using computer tools to perform geometry assurance tasks on virtual product models

b)

- Minimizing the need for costly physical prototypes
- Finding problems as early as possible in the development process (easier and cheaper to fix)
- Faster development process with efficient tools (time to market)
- Increased quality

c)

- Analyze different assembly concepts
- Analyze and define robust locating systems
- Simulate and verify the final demands
- Virtual matching for trimming the production process