Written examination in

PPU080 – Advanced Computer Aided Design

Date: 2015-10-30, 8.30 – 12:30

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Department: Product and Production Development

Solution to the exam: On the course home page the day after the exam.
Preliminary results: On the course home page before 2015-11-20

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

- 2015-11-23, 12.00-13.00
- 2015-11-25, 12.00-13.00

Aids

A Chalmers-approved calculator is permitted.

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.

1. Geometry modeling

a) Describe the steps necessary to create a solid, using surface modeling, in a modern CAD system. (5p)
b) What do C^0, C^1 and C^2 continuity between two curve segments mean? (2p)
c) What characterizes a feature (in the geometry modeling context)? (3p)

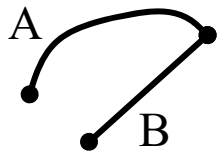
Answers

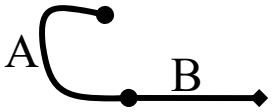
a)

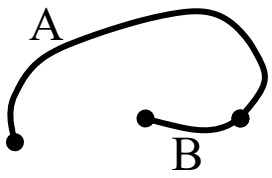
- Create wireframe elements (points, lines, planes, curves) in 3D or sketches
- Create surfaces from the wireframe geometries (sweep, revolve, ...)
- Trim the surfaces together
- Join the surfaces together to a uniform element
- Transform into a solid (Thick, Closed Surface, ...)
- (Add fillets)

b)

C^0-continuity	C^1-continuity	C^2-continuity
Two curve segments are joined without constraints	The curve segments have the same direction at the common point	The curve segments have the same curvature at the common point







c)

- A feature
  - is a physical part of a detail
  - can be linked to a generic form
  - has a specific engineering role (function, manufacturing method, simulation method, …)
  - has predictable properties

2. Geometry assurance

a) In order to perform a 3D variation analysis a 3D assembly model is needed. Describe the necessary components and inputs for a 3D assembly model. (6p)
b) How does *contribution analysis* work and for what is it used? (4p)

Answers

a)
A 3D assembly model consist of:

- Parts
- Subassemblies
- Positioning systems
- Input tolerances with range and type of distribution
- Critical measures

b)
Model consist of:

- 3D assembly model with defined locating schemes
- Input tolerances with range and type of distribution
- Critical measures

Simulation:

- All input parameters are varied (one at the time) within their tolerances on 3 levels
- Max output is registered for all measures
- Contribution is calculated in percent as $\% \, contribution_i = 100 \frac{\Delta output_i^2}{\sum_{i=1}^{n} \Delta output^2}$

It is used to calculate a ranked list of how all input tolerances contributes to the variation in the critical measures

3. Computer graphics and virtual reality

a) Bump-mapping is a way of using textures to give a smooth surface an irregular appearance. Describe how it works. (2p)
b) Gouraud and Phong are two methods for rendering over multiple polygon surfaces. Describe how they work. (4p)
c) Describe how a *shadow buffer* can be used to create shadows. (4p)

Answers

a)

- It works by modifying the surface normal that is used in the illumination model.
- The value of the modification is obtained from a texture.
- The color (RGB value) of each pixel indicates the surface normal modification.

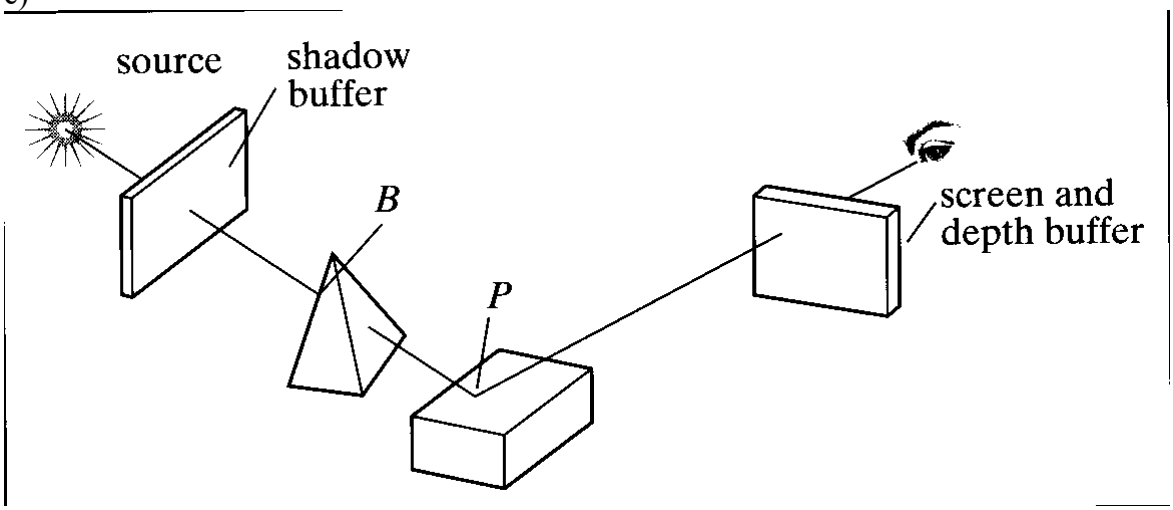
b)
Gourad:

- Calculate normal vector for all polygon surfaces
- Calculate ”mean normal vectors” for the vertices of the polygon
- Mean normal + Illumination model => calculation of intensities (colors) in the vertices
- Intensity values are interpolated line by line over the polygon

Phong:

- Calculate normal vector for all polygon surfaces
- Calculate ”mean normal vectors” for the vertices of the polygon
- Surface normals are interpolated line by line over the polygon
- Surface normal + Illumination model => calculation of intensities (colors) in each pixel

c)



- 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

4. Use of geometry data

a) Mention three benefits of using virtual product models in the product realization process (3p)
b) Mention two advantages of using off-line programming. (2p)
c) Geometry models, created in a CAD-system, are used by a number of different functions (departments etc.) within the product development process. Describe some problems related to this. (2p)
d) What is a digital mockup (DMU) and for what is it used? (2p)
e) What type of geometry representation is usually used in a digital mockup (DMU)? (1p)

Answers

a)

- 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)

b)
(two of)

- Avoid costly mistakes with real machines
- Faster and more efficient programming
- Possibility to make new programs without stopping the production

c)

- Different functions uses different software requiring different file formats: problem with file conversion
- Problem with access to the right models

d)

- Special type of component based assembly model developed to be able handle large assemblies (> 1000 parts) from different CAD-systems
- Can be used for e.g. packaging studies and assembly simulation but not for e.g. calculation of mass etc.

e)
The NURBS-geometry from the CAD-system is simplified to a triangulated surface model => large reduction in size

5. Miscellaneous

a) Mention the five basic needs of engineering information management. (5p)
b) What is the aim of a PLM system? (2p)
c) What are the tree types of modeling components in a multi-body system dynamic simulation? (3p)

Answers

a)

- Capture information at the source
- Organize information
- Distribute the information – when, where, what, to whom
- Search, re-use and present information
- Secure storage of information over a long time

b)
PLM systems aim to support the creation and management of all information related to a product throughout its lifecycle.

c)

- Rigid bodies
- Constraints (joints, motions)
- Forces (gravity, spring/dampers, friction etc.)