NOTE!!!

On question 4, I made a mistake. That question should be 10 points, now it's only 8. I will correct it by increasing the points for question a) to 3 points and question c) to 5 points.

Written examination in

PPU080 – Advanced Computer Aided Design

Date: 2023-10-26, 8.30 – 12:30

Teacher: Lars Lindkvist
Questions: Lars Lindkvist, phone 772 8616
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 2023-11-18

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

- 2023-11-21, 12.00-13.00
- 2023-11-22, 12.00-13.00

Aids

None.

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) Mention three different aspects that has to be included in an assembly model (in e.g. a CAD system). (3p)

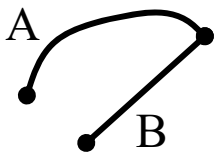
Answers

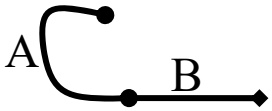
a)

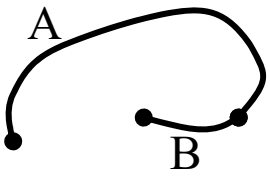
- Create wireframe elements (points, lines, planes, curves) in 3D or sketches
- Create surfaces from the wireframe geometries (sweep, revolve, ...)
- Trim the surfaces together
- Join the surfaces together to a uniform element
- Transform into a solid (Thick, Closed Surface, ...)
- (Add fillets)

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)
An assembly model needs to include

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

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 consists 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) Describe the RGB color model (2p)
b) Describe (with text, figures and equations) the four steps for collision detection between two objects defined by triangle surfaces (6p)
a) Bump-mapping is a way of using textures to give a smooth surface an irregular appearance. Describe how it works. (2p)

Answers

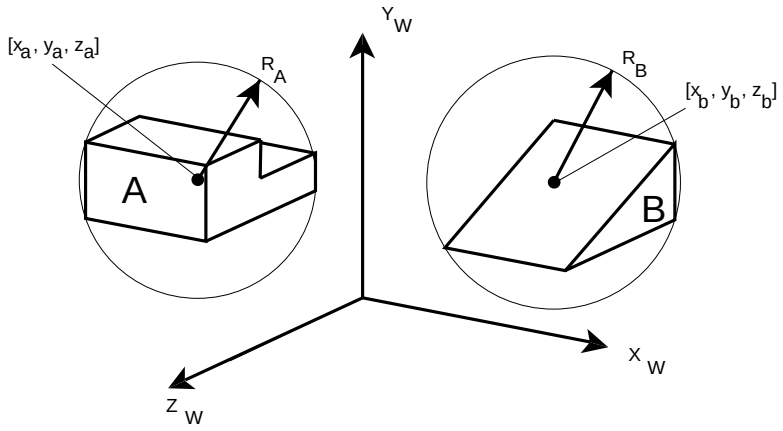
a)

The color is accomplished with a mixture of three primary colors

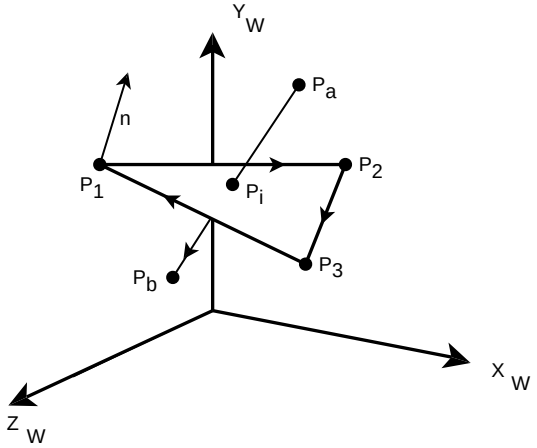
- Red [0 – 1] (or [0 – 255])
- Green [0 – 1]
- Blue [0 – 1]

b)

- Do a (fast) coarse ”Mini-max-test” with Bounding Boxes/Spheres to determine if a collision might be possible at all



- If yes, check if any of the points on body A is inside body

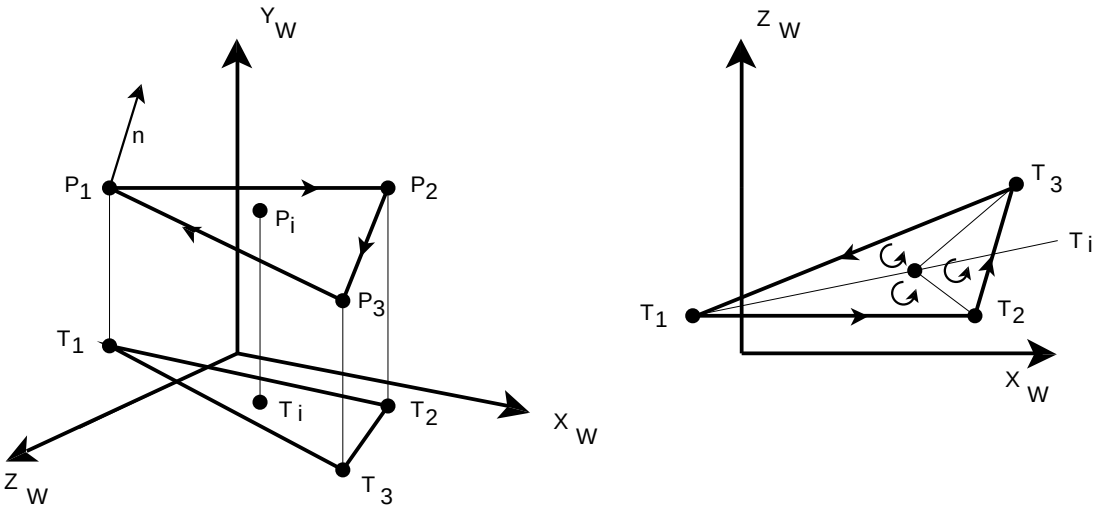


B

  - Test if any of the edges on body A intersects an infinite plane defined by some of the polygons on body B:
    - Test if the endpoints of the edge are on different sides of the plane. This is done by using the equation of the plane

  - If yes, calculate the intersection point between the edge and the plane:
    - Use the equation for the line between the points and the equation of the plane.

- Check if the intersection point is on the polygon:



  - Calculate the area of the three sub triangles defined by the intersection point and the original vertices of the triangle.
  - If all these areas have the same sign, the intersection point is inside the triangle and it is a collision.
  - To speed up the calculation this can be done in 2D by projecting the triangle on a plane.

c)

- 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.

4. Miscellaneous

a) What are the industrial benefits of using parameterization to reuse engineering knowledge? (2p)
b) Give two examples of usage of ergonomic simulation with computer manikins. (2p)
c) The Method of Influence Coefficients can be used to perform Monte Carlo variation simulations on non-rigid parts. How does it work? (4p)

Answers

a)
Shorter time – means more iterations, i.e. more design solutions can be evaluated.
More iterations mean better products because:

- Larger amount of designs considered and evaluated in concept phase
- Knowledge related to lifecycle aspects (design for: assembly, manufacturing, serviceability, environment…) can be integrated in detail design phase
- Synthesis – analysis loops can be shortened – verification feedback instant

b)

- Evaluation of user interfaces
- Evaluation of concept for manual assembly

c)

- When doing a Monte Carlo variation simulation more than 1000 iterations have to be done
- To do this with traditional FE methods would take too long time
- Therefore, a FE solver is used to create a linearized model of the assembly
- The linearized model is then used in the simulations
- This gives a very large reduction of the simulation time (~ a factor 1000)
- If the locators or support points are moved, a new linearization has to be done

5. Miscellaneous

a) Mention four different standards for geometry exchange and what type of geometry data they can handle. (4p)
b) Mention two different tasks in the product realization process where off-line programming can be used. (2p)
c) Three different types of coordinate systems are used in virtual reality models (and also in CAD models). Specify these and what they are used for. (4p)

Answers

a) (four of)

- IGES
  - Mathematical description
- STL
  - Triangulated format
- VRML
  - Triangulated format
- JT
  - Both mathematical and triangulated
- STEP
  - Mathematical description

b) (two of)

- Programming of industrial robots
- Programming of NC-machines
- Programming of CMMs

c)

1. World coordinate system (w)
   - Only one in each model
   - The position of other objects is related to this
2. Object coordinate system (o)
   - One coordinate system per object in the model
   - Positions the object relative to the world coordinate system or relative to a superseding object
3. The coordinate system of the observer (Virtual Observer)
   - Makes it possible to travel around in the model