TU Delft Delft University of Technology

Faculty of Architecture & the Built Environment

3D modelling of the built environment (GEO1004) — 5 ECTS

Location: Pulse Hall 6
Date & time: 21 April 2023, 9:00
Responsible teacher: Ken Arroyo Ohori

1. The subject matter is in full accordance with the study guide.
2. This midterm exam is worth 45% of the final mark for the course.
3. The maximum grade for this course is 10.0. The minimum (unrounded) final mark to pass this course is 5.75, which will be rounded up to 6.0. However, you need a weighted average of at least 50% in the combined exams (midterm + this one) to be able to pass the course.
4. All questions have equal weight in this exam.
5. Answer directly on these pages. If there is not enough space, use the extra sheet and its back side at the end.
6. This is an open book exam, so you are free to check the course materials (videos/handouts/assignments), both printed or on your computer, as well as any other materials you can find. However, you are **not allowed to communicate with others** and **the use of your phone is forbidden**.
7. This midterm exam has 12 questions, and 15 pages.
8. Fill out your name and student ID.
9. You have 2 hours to do this exam.

Name: _____

Student ID: _____

Lesson 1.1

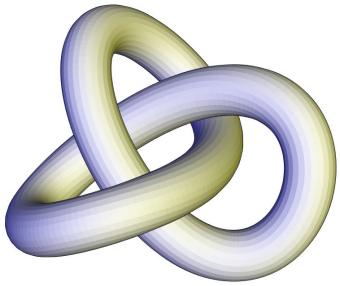
Describe in detail the data structure you used to store the voxel model of Homework 3.

Lesson 1.2

Consider the object pictured below.

(a) Is it a 3-manifold? Explain why or why not (½ point).

(b) Is its boundary a 2-manifold? Explain why or why not (½ point).



Lesson 2.1

Say you download the CityJSON file of BK-City from `https://3dbag.nl` and your task is to calculate its volume. As you likely noticed during Homework 2, its LoD2.2 geometry is not valid: the tower has intersecting surfaces and there are holes.

(a) Describe the consequences of these errors for the volume calculation as you had to implement it for Homework 2. (⅓ point)

(b) Provide a simple example where the volume calculated is wrong. (⅓ point)

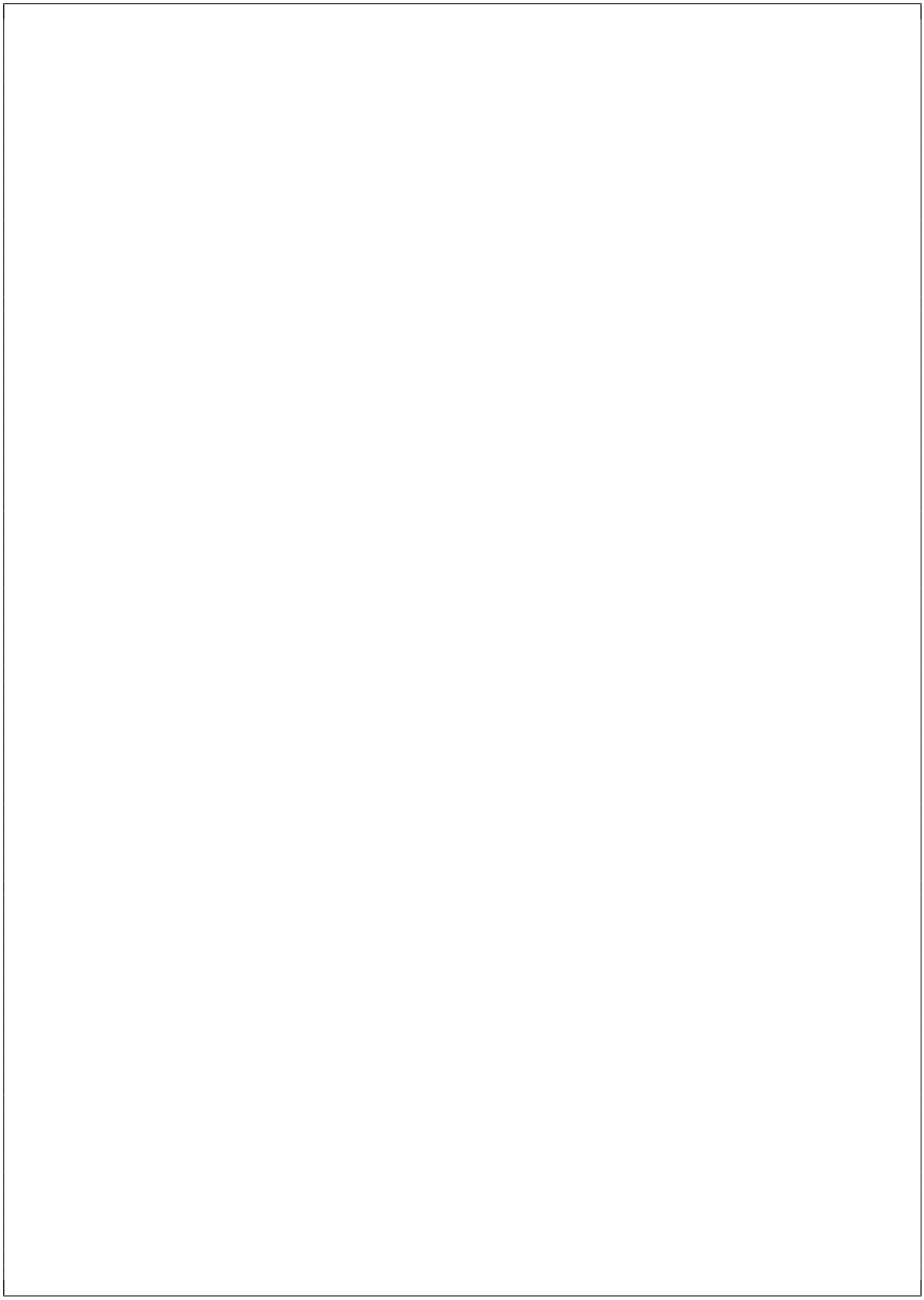
(c) Based on what you learned in this course, describe one method you could use to obtain a reliable approximation of the volume of any building, valid or not. (⅓ point)

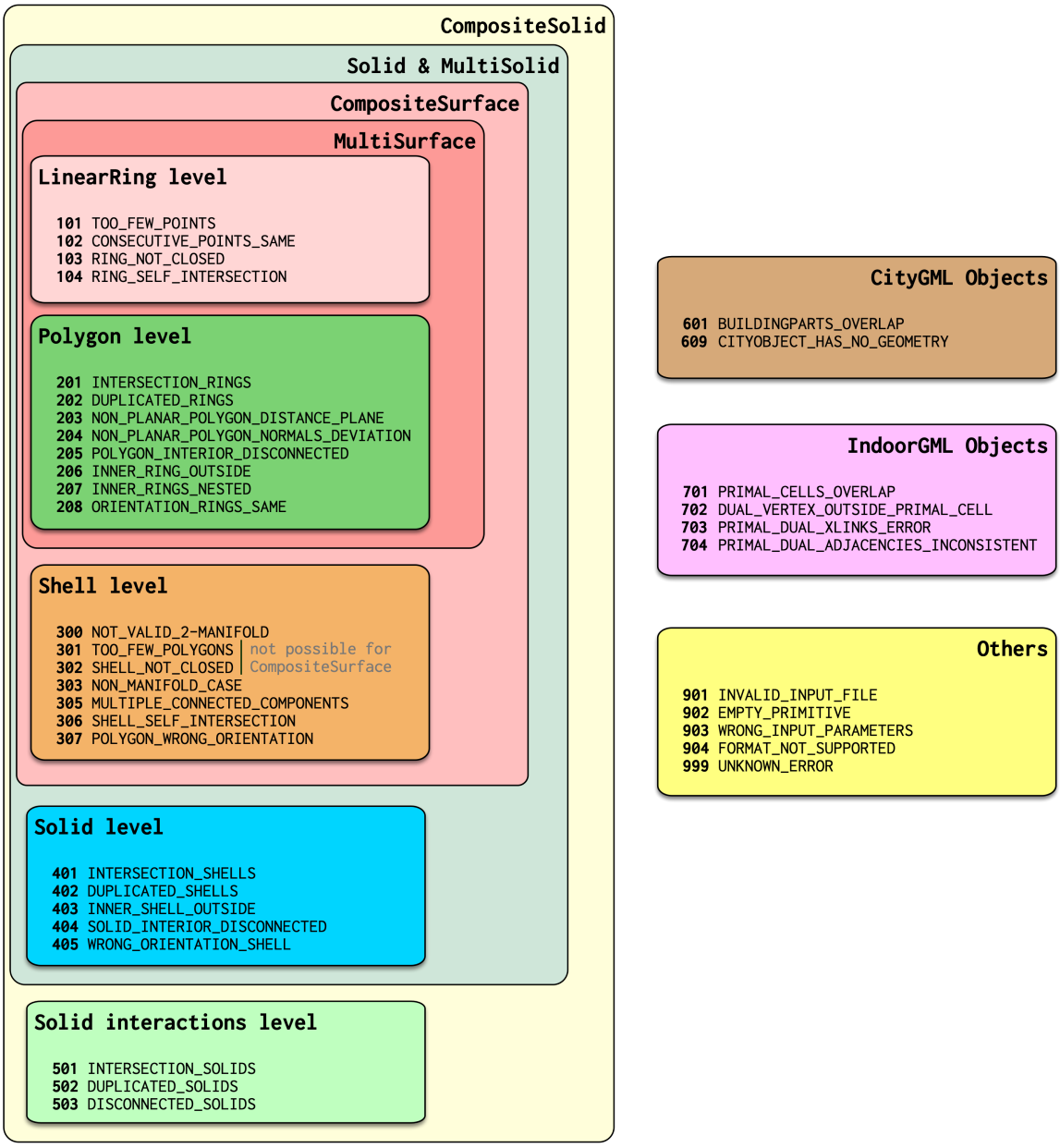
Lesson 2.2

How does choosing different connectivity models affect the code you had to write for Homework 3? Hint: think of the different steps of the assignment and whether they are affected or not.

Lesson 3.1

Draw two Solids having the same topology, one should be valid according to ISO19107 and the other one should not be (⅓ point each). Explain briefly what you drew and why the first is valid and why the second is not and give the val3dity error code(s), which are included in the next page (⅓ point).

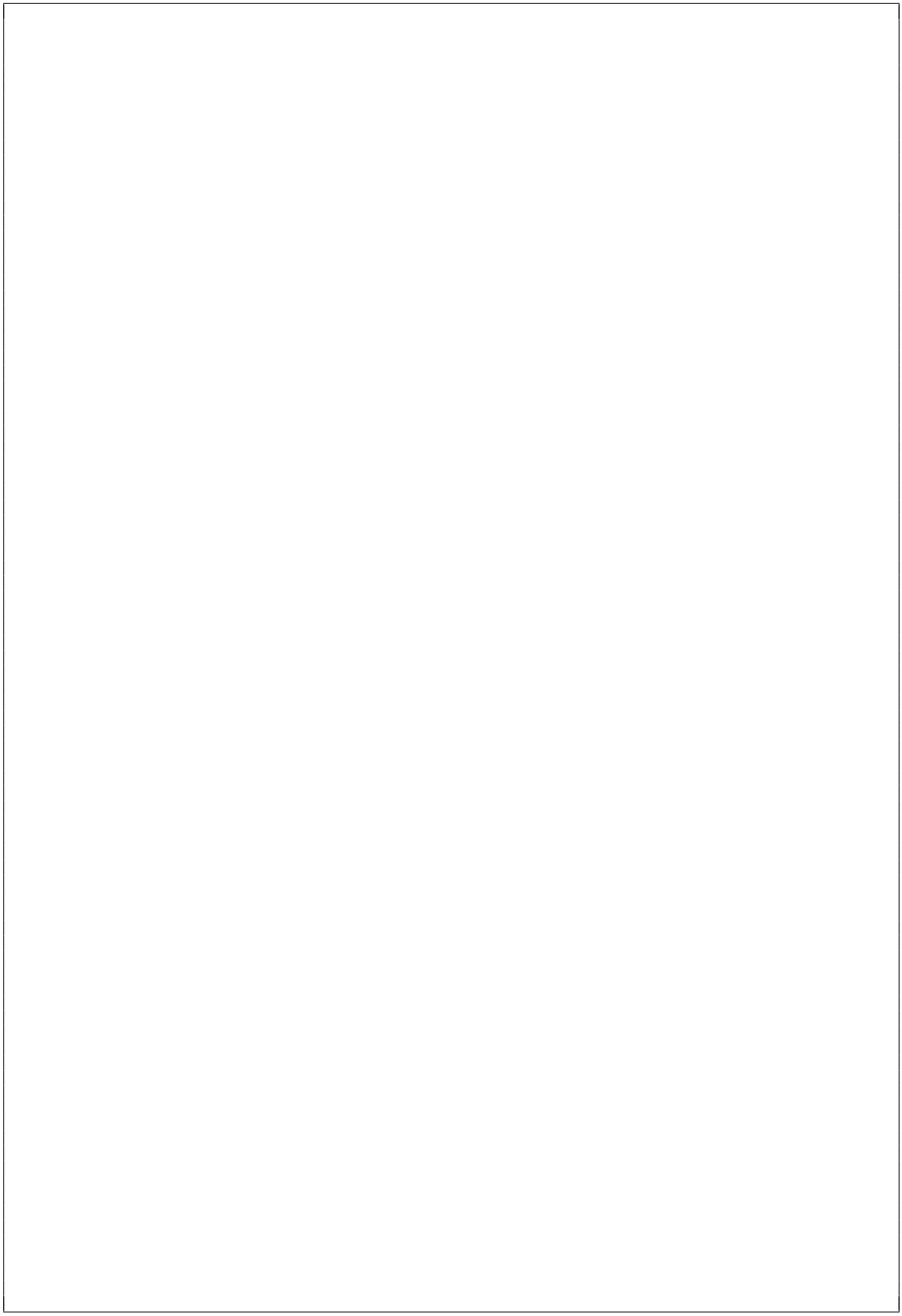



CompositeSolid
Solid & MultiSolid
CompositeSurface
MultiSurface
LinearRing level
101 TOO_FEW_POINTS
102 CONSECUTIVE_POINTS_SAME
103 RING_NOT_CLOSED
104 RING_SELF_INTERSECTION
Polygon level
201 INTERSECTION_RINGS
202 DUPLICATED_RINGS
203 NON_PLANAR_POLYGON_DISTANCE_PLANE
204 NON_PLANAR_POLYGON_NORMALS_DEVIATION
205 POLYGON_INTERIOR_DISCONNECTED
206 INNER_RING_OUTSIDE
207 INNER_RINGS_NESTED
208 ORIENTATION_RINGS_SAME
Shell level
300 NOT_VALID_2-MANIFOLD
301 TOO_FEW_POLYGONS
302 SHELL_NOT_CLOSED
not possible for CompositeSurface
303 NON_MANIFOLD_CASE
305 MULTIPLE_CONNECTED_COMPONENTS
306 SHELL_SELF_INTERSECTION
307 POLYGON_WRONG_ORIENTATION
Solid level
401 INTERSECTION_SHELLS
402 DUPLICATED_SHELLS
403 INNER_SHELL_OUTSIDE
404 SOLID_INTERIOR_DISCONNECTED
405 WRONG_ORIENTATION_SHELL
Solid interactions level
501 INTERSECTION_SOLIDS
502 DUPLICATED_SOLIDS
503 DISCONNECTED_SOLIDS
CityGML Objects
601 BUILDINGPARTS_OVERLAP
609 CITYOBJECT_HAS_NO_GEOMETRY
IndoorGML Objects
701 PRIMAL_CELLS_OVERLAP
702 DUAL_VERTEX_OUTSIDE_PRIMAL_CELL
703 PRIMAL_DUAL_XLINKS_ERROR
704 PRIMAL_DUAL_ADJACENCIES_INCONSISTENT
Others
901 INVALID_INPUT_FILE
902 EMPTY_PRIMITIVE
903 WRONG_INPUT_PARAMETERS
904 FORMAT_NOT_SUPPORTED
999 UNKNOWN_ERROR

Lesson 3.2

(a) Draw an object whose exterior MAT consists of three parts (½ point).

(b) Draw its interior MAT and exterior MAT (½ point).



Lesson 4.1

You download the 3D city model of Delft (in CityJSON) and you notice that the buildings are stored as 'MultiSurface' (and not 'Solid') and that there is only geometry (and no semantics).

(a) Explain how you could modify/repair the file to fix those 2 issues (½ point).

(b) Modify the JSON snippet below to fix one building (½ point).

```
{
  "type": "MultiSurface",
  "lod": 2.2,
  "boundaries": [
    [[0, 3, 2, 1, 22]], [[4, 12, 123, 5, 6, 7]], [[0, 1, 5, 4]], [[1, 2, 6, 5]],
    [[240, 243, 124]], [[244, 246, 724]], [[34, 414, 45]], [[111, 246, 5]]
  ]
}
```

Lesson 4.2

In the reconstruction method described in Chapter 12 of the book, explain why having a valid 2D roof partition helps you have a valid 3D model.

Lesson 5.1

In the triangulation of the `station.hw1` file of Homework 1, could we use the barycentric triangulation implied by gmaps instead of a constrained triangulation? **(a)** Yes/no (½ point). **(b)** Explain your reasoning (½ point).

Lesson 5.2

Given a quadratic Bézier triangle with point coordinates:

$$p_{0,2,0} = (0, 1, 0)$$

$$p_{0,1,1} = (0, 1/2, 1) \qquad p_{1,1,0} = (1/2, 1/2, 1)$$

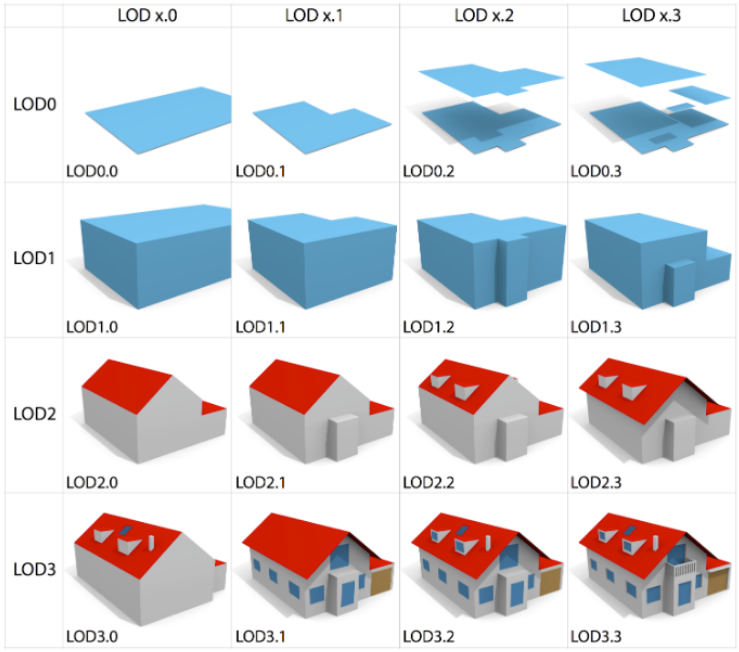
$$p_{0,0,2} = (0, 0, 0) \qquad p_{1,0,1} = (1/2, 0, 1) \qquad p_{2,0,0} = (1, 0, 0)$$

(a) What coordinates do we obtain when we evaluate it at $(u, v, w) = (0.5, 0.5, 0)$? (½ point)

(b) Explain your reasoning (½ point).

Lesson 6.1

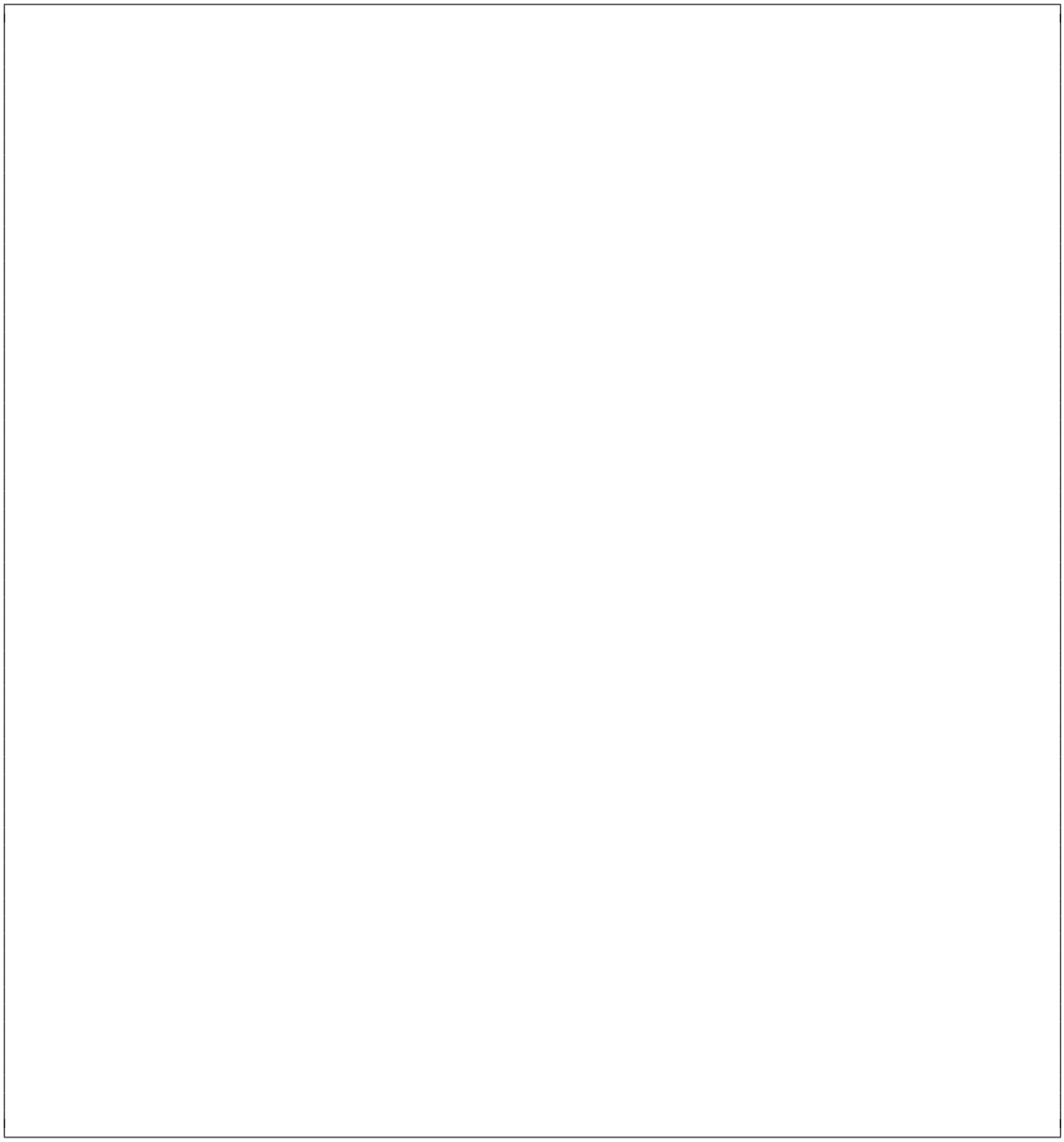
Draw one CSG tree that produces the model from the LOD2.0 panel below. You can use half-spaces and cuboids (boxes) as primitives.



Lesson 6.2

Describe the geometry that is being represented in this IFC snippet. Provide as much information as you can obtain from it.

```
#1=IFCDIRECTION((1.,0.,0.));
#2=IFCDIRECTION((0.,0.,1.));
#3=IFCCARTESIANPOINT((3000.,1000.,4000.));
#4=IFCAXIS2PLACEMENT3D(#3,#2,#1);
#5=IFCBLOCK(#4,2000.,4000.,1000.);
#6=IFCDIRECTION((1.,0.,0.));
#7=IFCDIRECTION((0.,1.,0.));
#8=IFCCARTESIANPOINT((4000.,1000.,4000.));
#9=IFCAXIS2PLACEMENT3D(#8,#7,#6);
#10=IFCRIGHTCIRCULARCYLINDER(#9,4000.,900.);
#11=IFCBOOLEANRESULT(.INTERSECTION.,#10,#5);
```



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