

Faculty of Architecture & the Built Environment

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

Location: Faculty of Civil Engineering and Geosciences Room 3.98

Date & time: 23 June 2023, 9:00

Responsible teacher: Ken Arroyo Ohori

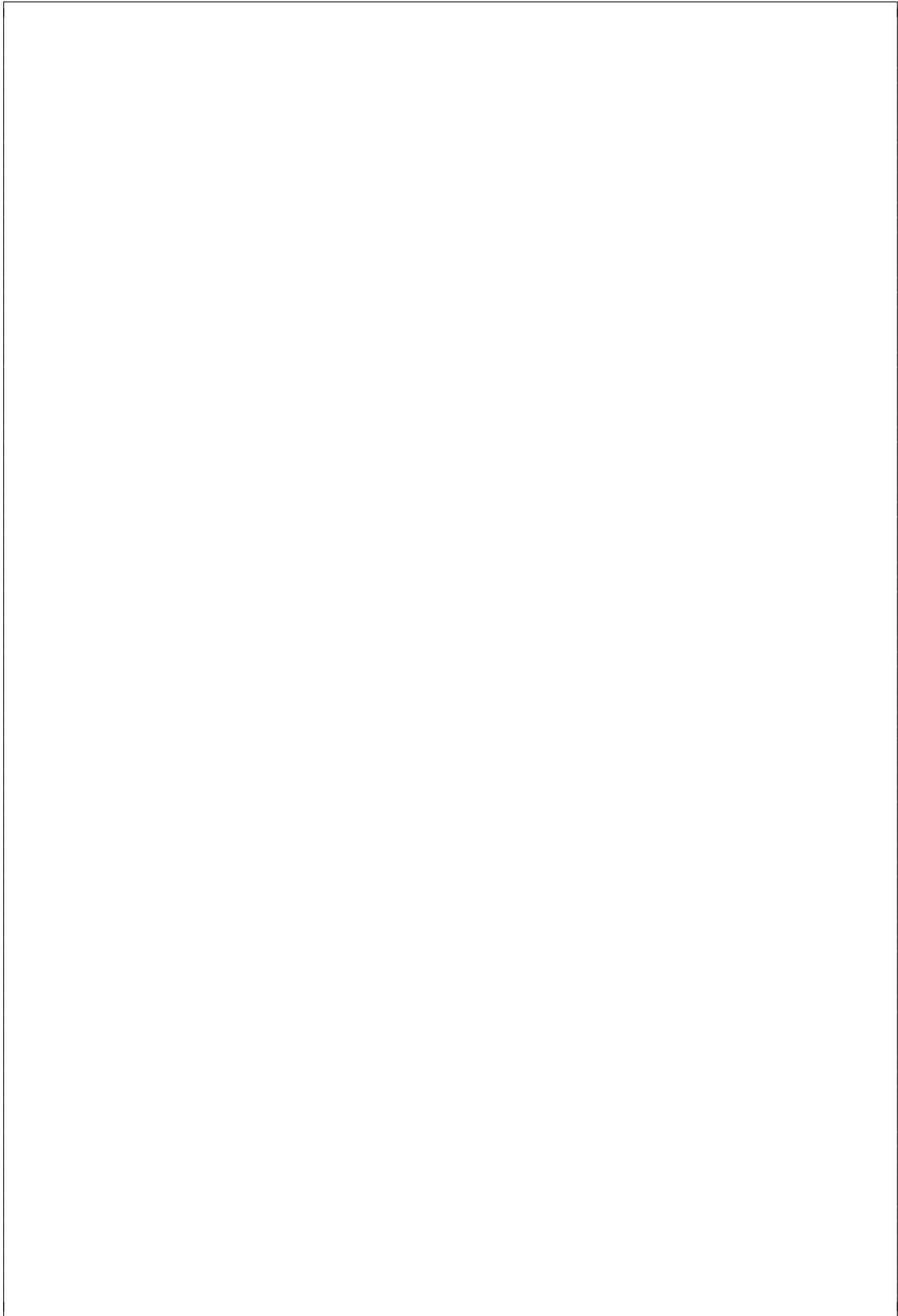
1. The subject matter is in full accordance with the study guide.
2. This resit exam is worth 50% of the final mark for the course. Your result will replace your previous marks for both the midterm and the final exam.
3. The maximum grade for this course is 10.0. The minimum (unrounded) final mark to pass this course is 5.75, which will be rounded up to 6.0. However, you need at least 50% in this exam 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 resit exam has 12 questions, and 14 pages.
8. Fill out your name and student ID.
9. You have 2 hours to do this exam.

Name: \_\_\_\_\_

Student ID: \_\_\_\_\_

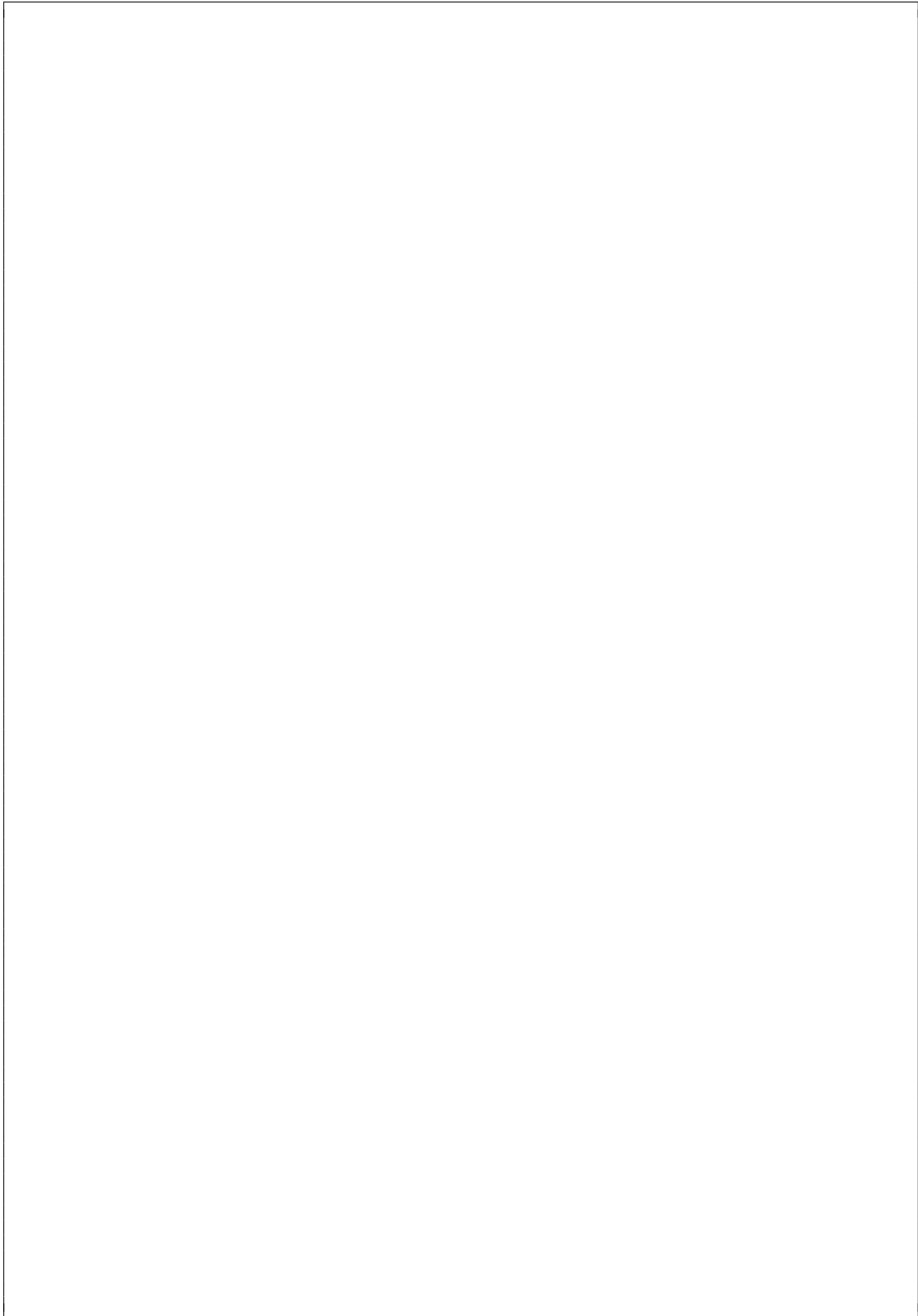
Lesson 1.1

Describe in detail a data structure that you could use to implement the Homework 1 resit (same as Homework 1 but with semantics for each face/triangle).



Lesson 1.2

How does a constrained triangulation or tetrahedralisation help you adequately represent objects with holes? **(a)** Explain it in your own words ( $\frac{1}{2}$  point) and **(b)** illustrate it with an example ( $\frac{1}{2}$  point).




Lesson 2.1

Say you have one OBJ of a valid building (e.g. BK-City).

**(a)** What are the differences between creating a constrained Delaunay tetrahedralisation and creating a constrained triangulation of the surfaces? Name 3 differences. ( $\frac{2}{3}$  point)

**(b)** If you wanted to calculate the volume of the building, would both methods allow you to do it? If yes, explain how. If not, explain why not. ( $\frac{1}{3}$  point)



Lesson 2.2

- (a) Explain in your own words why octrees can be an efficient representation for some voxel models ( $\frac{1}{2}$  point).
- (b) Provide an example that can be efficiently stored using an octree but inefficiently with other representations ( $\frac{1}{2}$  point). The model should be more complex than the trivial examples of completely filled space or completely empty space.



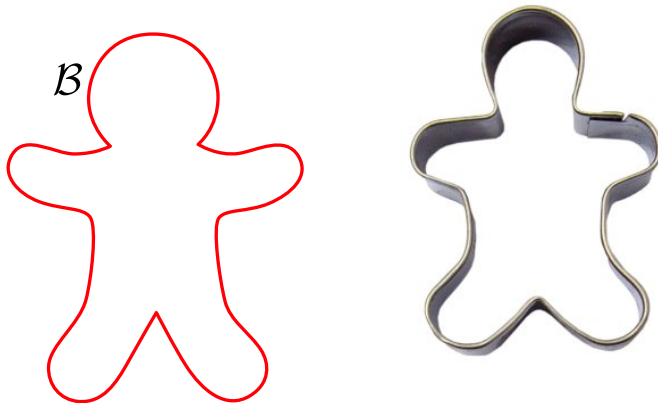
### Lesson 3.1

The software val3dity implements several checks to verify whether a volume conforms to the definitions of ISO19107. One of them is checking whether the boundaries form a watertight volume. Based on what you've learned in this course, explain how this could be concretely implemented (describe data structures + algorithms).



Lesson 3.2

Say you have a 2D shape and you extrude it vertically into 3D. To illustrate, think of the gingerbread man from the 3D book and a cookie cutter with that shape.



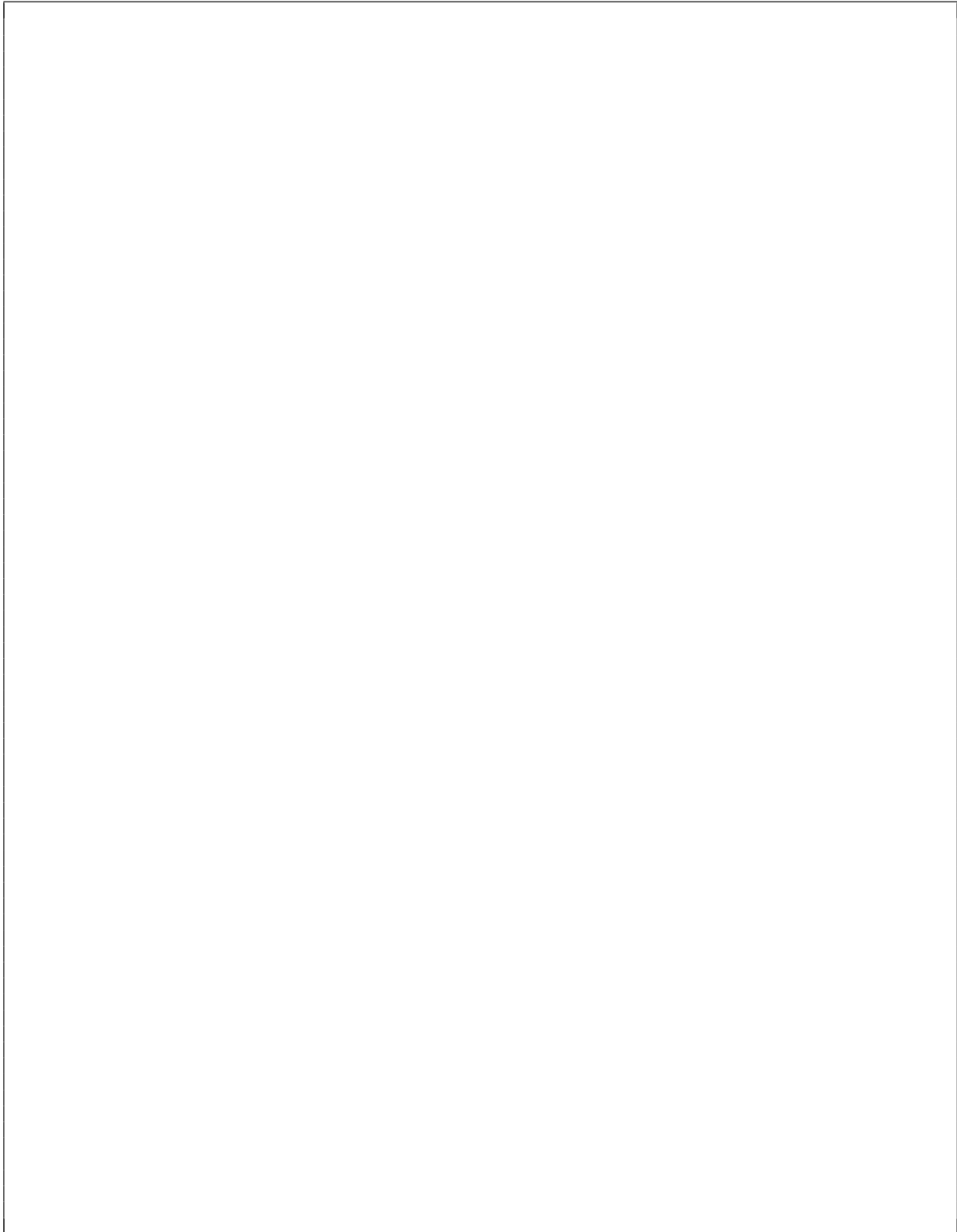
- (a) Explain what is the relationship between the different elements (i.e. medial atoms, branches, sheets) of the MAT of the 2D shape and the 3D shape (½ point).
- (b) Describe one example of equivalent elements between the gingerbread man and cookie cutter to illustrate your explanation (½ point).

#### Lesson 4.1

Imagine you're doing an internship at the City of Almere, where they have a LoD2.2 model of all their buildings (but no other LoDs). Your boss asks you to give her a LoD1.2 model of all the buildings in an area. Note: check page 12 if you need a reminder of the LoDs.

**(a)** Describe in details a methodology to perform this (assume the input is a CityJSON file) (½ point).

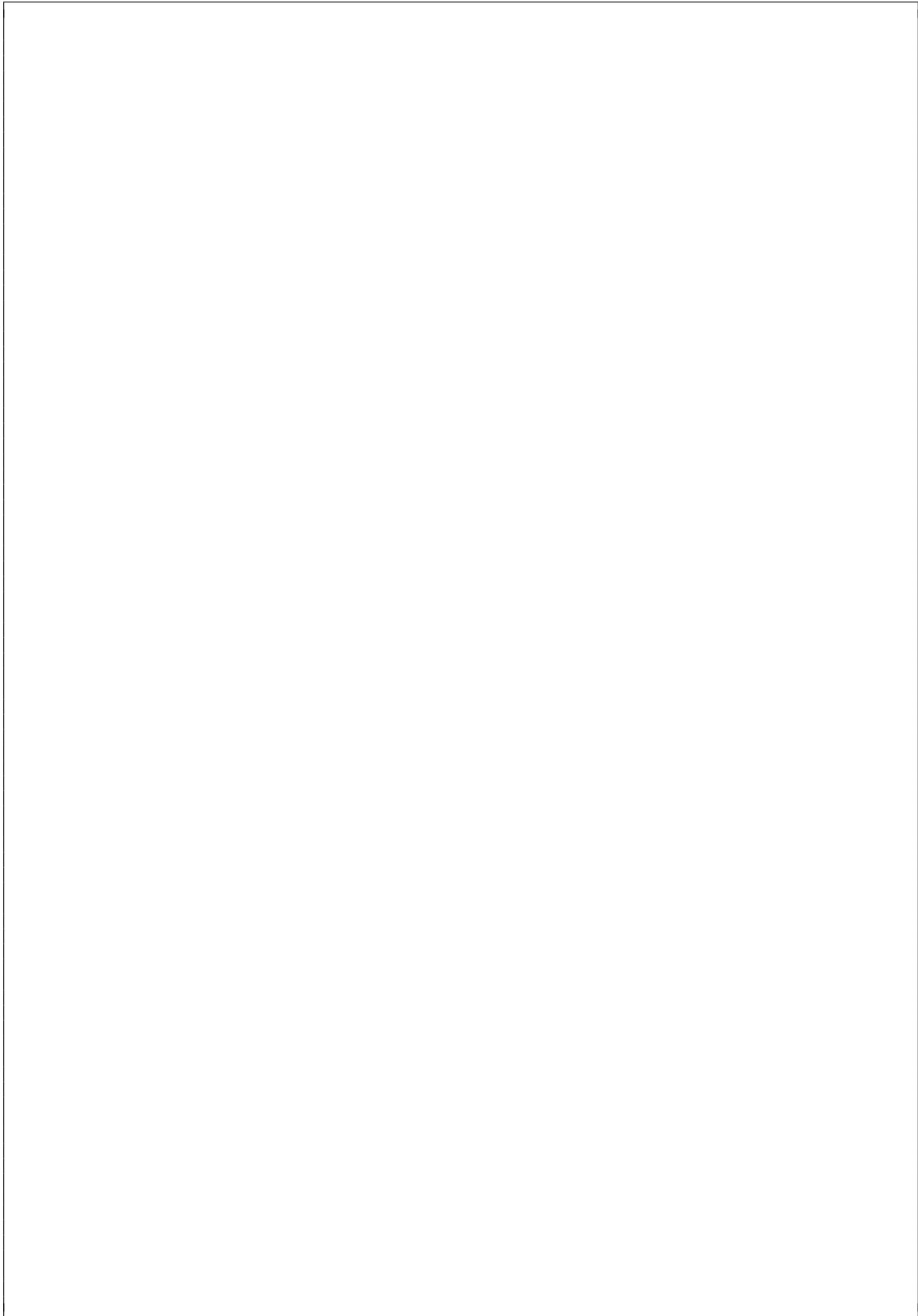
**(b)** Why did your boss ask you this? Give 2 possible reasons why having a LoD1.2 can be "better" than a LoD2.2 one. (½ point)






Lesson 4.2

You want to apply the reconstruction method from Chapter 12 of the 3D book, but the building footprints are inaccurate. Explain in detail how would this affect the method and the results obtained with it.



Lesson 5.1

Why is there no  $\beta_0$  in a combinatorial map? Explain in your own words.



Lesson 5.2

Given a quadratic Bézier curve with point coordinates  $(0, 0)$ ,  $(2, 2)$ ,  $(4, 0)$ .

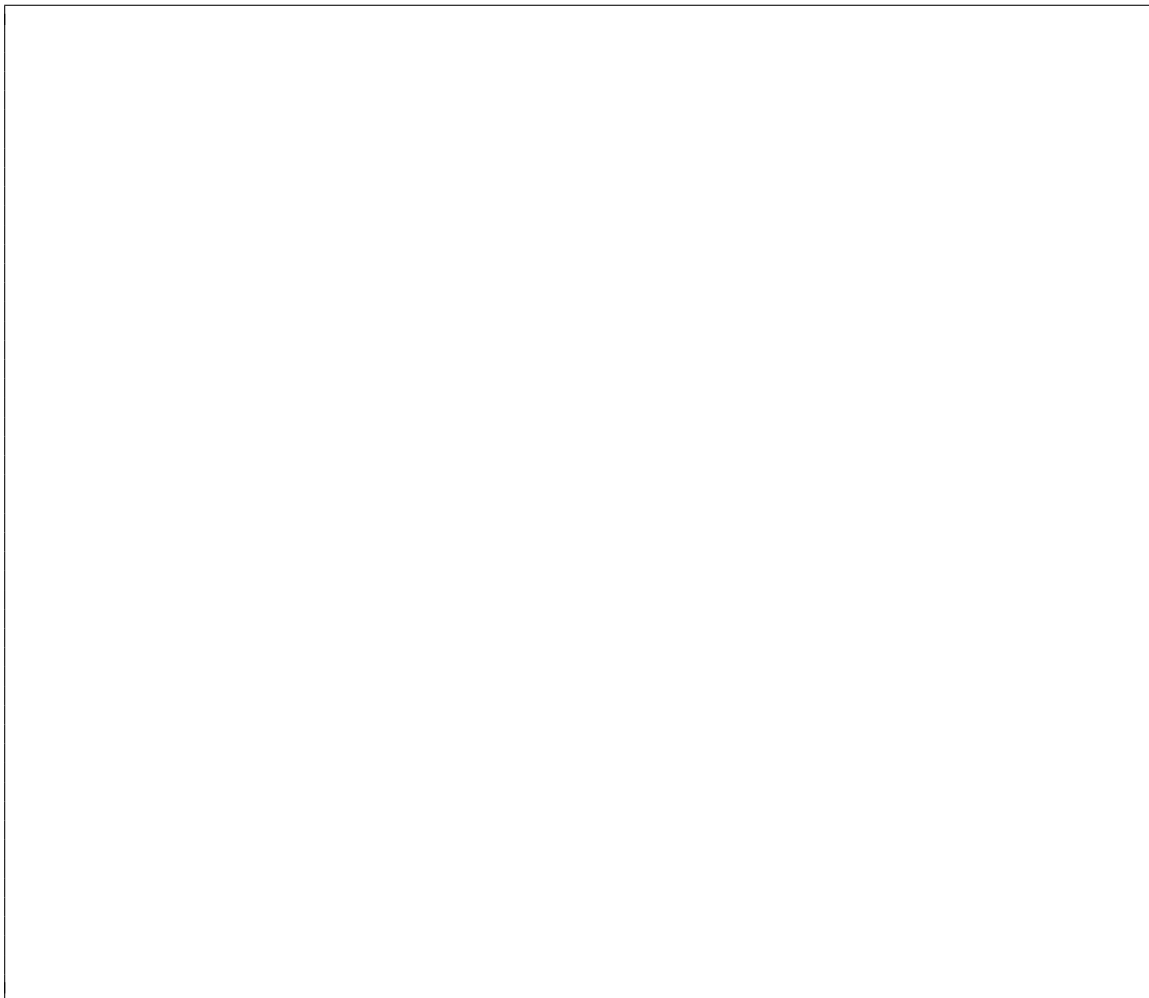
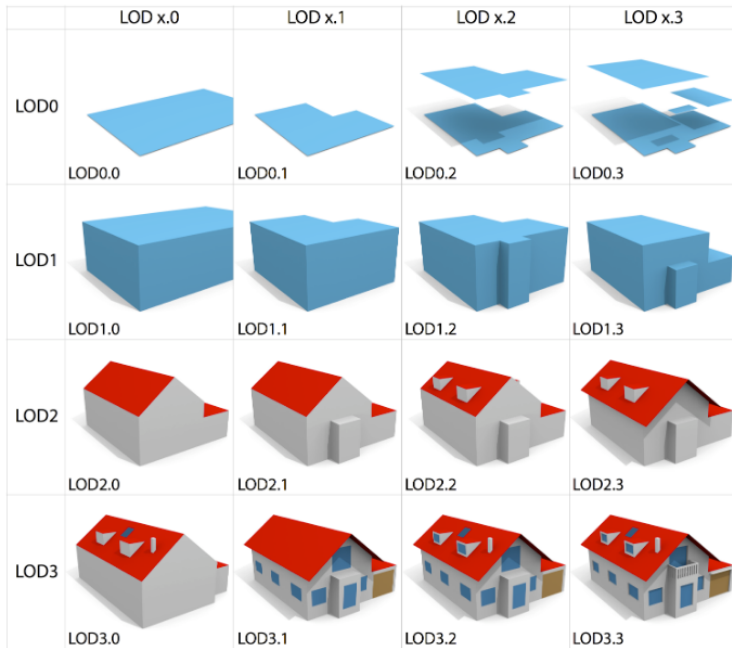
**(a)** What coordinates do we obtain when we evaluate it at  $t = 0.5$ ? ( $\frac{1}{2}$  point)

**(b)** Explain your reasoning ( $\frac{1}{2}$  point). Note: if you do the math on paper, that is enough of an explanation.



Lesson 6.1

Draw one CSG tree that produces the model from the LOD1.1 panel below. You can only use half-spaces as primitives.



## Lesson 6.2

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

```
#206= IFCCARTESIANPOINT((-861.428571428573,-477.142857142857));
#208= IFCCARTESIANPOINT((1878.57142857143,-477.142857142857));
#210= IFCCARTESIANPOINT((1878.57142857143,522.857142857139));
#212= IFCCARTESIANPOINT((28.5714285714302,522.857142857142));
#214= IFCCARTESIANPOINT((-1031.42857142857,522.857142857144));
#216= IFCCARTESIANPOINT((-1031.42857142857,-307.142857142857));
#218= IFCCARTESIANPOINT((-861.428571428572,-307.142857142857));
#220= IFCPOLYLINE((#206,#208,#210,#212,#214,#216,#218,#206));
#222= IFCARBITRARYCLOSEDPROFILEDEF(.AREA.,$,#220);
#223= IFCCARTESIANPOINT((-3412.85714285716,-1121.88894482269,0.));
#225= IFCAXIS2PLACEMENT3D(#223,#19,#17);
#226= IFCEXTRUDEDAREASOLID(#222,#225,#19,2438.4);
#227= IFCSHAPEREPRESENTATION(#74,'Body','SweptSolid',(#226));
#230= IFCPRODUCTDEFINITIONSHAPE($,$,(#227));
#234= IFCSPACE('',#42,'0.1',$,$,#204,#230,'BR',.ELEMENT.,.INTERNAL.,$);
```



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