

MEDICAL VISUALIZATION EXAM

Date:	21/07/2021
Duration:	120 Minutes
Allowed Tools:	Ruler
Name:	
Student Number:	
Study Program:	

Information:

- **Blocks A to D are mandatory to work on, between block E and F you can choose one.** Please cross out the deselected block in the list below. If you have not explicitly deselected either block E or F, block F will automatically not be assessed.
- If you want to conclude the exam with an **ungraded performance (Schein)**, please tick the box below.
- Only the **appended blank pages** shall be used for completing the tasks. If you need more pages, please contact the supervisor.
- Please include your **name** and **student number** on **each sheet**.
- **From the guidelines for conducting written examinations of the Faculty of Computer Science:**

We hereby inform you that, cheating, attempted cheating (e.g., usage of prohibited additional material, copying from other students, etc.) and unruly behavior will result in a "failed" grade for the exam. Any violation of the rules will be recorded.

	Mandatory				Cross one out		Total	Grade
	Block A	Block B	Block C	Block D	Block E	Block F		
Points:	/24	/24	/24	/14	/14	/14	/100	

Ungraded performance (Schein): Yes

Name:

Student Number:

Points

Block A: Interaction and Multimodal Visualization

/24

1. Name and describe 2 common interaction techniques for examining medical volume data, such as CT or MRI data. Also reason why these interaction techniques are fundamental. /4
2. Describe the windowing function. What are its two parameters and what is it used for? /2
3. Describe 2 aspects that must be considered when integrating measurements into medical visualizations? /4
4. Describe 2 selection strategies for a scene with multiple, possibly transparent objects? If there are ambiguities, how would you resolve them? /3
5. Name and describe the 3 steps to integrate and compare multimodal data, such as PET/CT. /3
6. Describe the nature and resolution of each acquired data in PET/CT. What is shown by the CT data and what is captured by PET? /4
7. Describe 2 strategies for 2D slice-based visualization of PET/CT data. /4

Block B: Surface Visualization

Points

/24

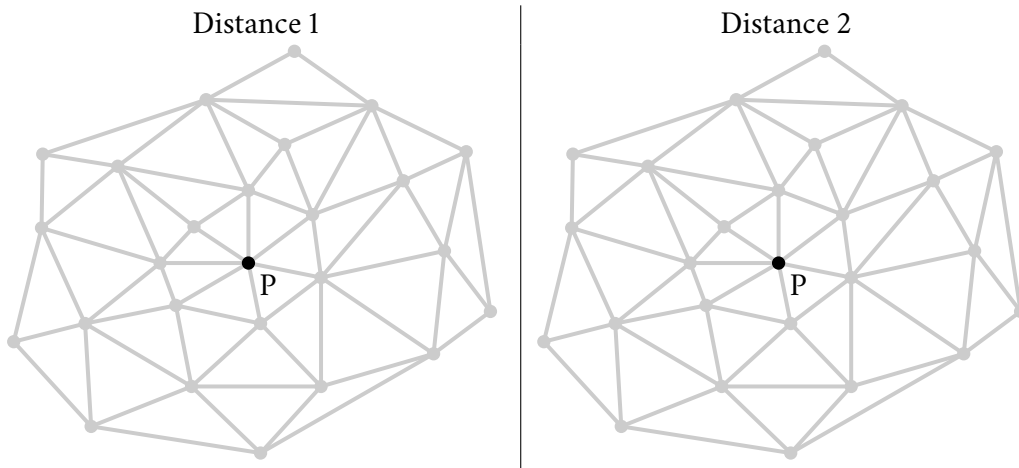
- How can you extract a surface mesh from segmented or raw medical volume data?
 - Name and explain the best known method.
 - Name and describe one improvement each in processing speed and quality of results.
- Given a surface mesh, illustrate the topological neighborhood of distances 1 and 2 of point P in the following images:

/8

4 Pt

4 Pt

/2

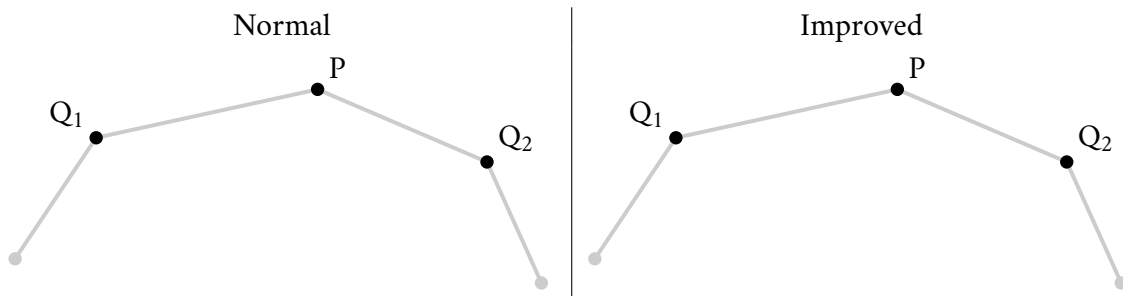


- Name and describe 2 criteria for **assessing** the quality of a surface smoothing algorithm.
- Name 3 criteria for **comparing** different surface smoothing algorithms.
- Illustrate Laplacian surface smoothing and its improvement at point P in the following images:

/4

/3

/5



- Describe **distance-aware** smoothing.

/2

Block C: Direct Volume Visualization

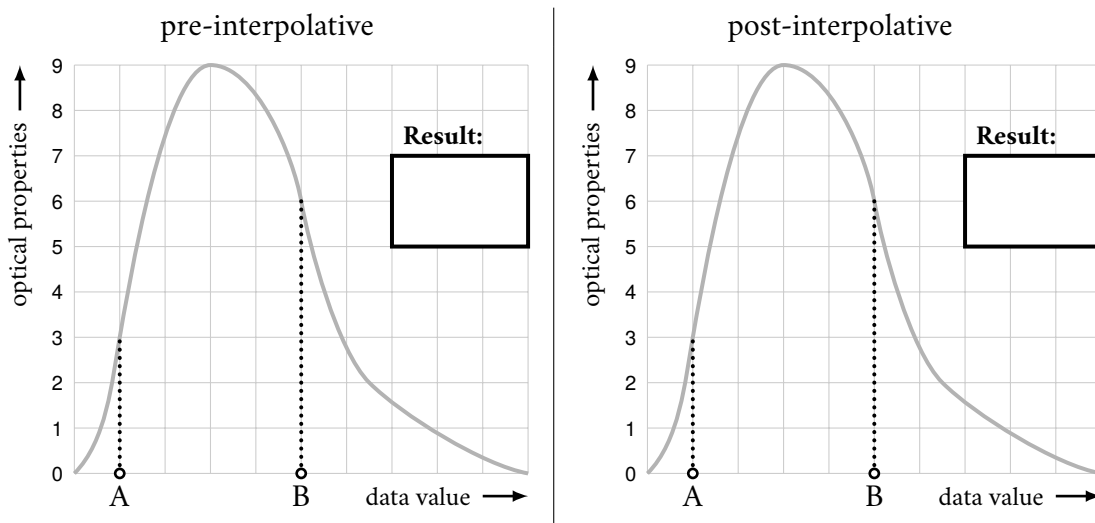
1. Below are the main steps in the volume rendering pipeline and two steps that do **not** belong there (A-H). Put the steps in the correct order and sort out the two steps that are incorrect:

/3

- | | |
|-------------------------------|--|
| A Gradient computation | E Ray-triangle intersection |
| B Compositing | F Classification (post-interpolative) |
| C Data traversal | G Shading and illumination |
| D Interpolation | H Triangle decimation |

2. Calculate and illustrate the difference between pre- and post-interpolative classification for the average of $A = 1$ and $B = 5$ in the following images:

/4



3. Name one advantage and disadvantage of pre- and post-interpolative classification and justify which one you would prefer.

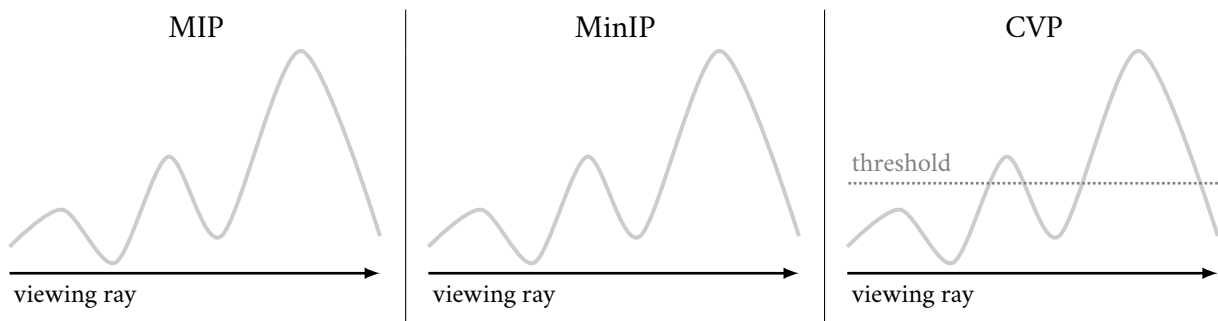
/5

4. Pick another step of the volume rendering pipeline (not classification) and describe it in detail.

/4

5. Mark the results for Maximum Intensity Projection (MIP), Minimum Intensity Projection (MinIP), and Closest Vessel Projection (CVP) on the intensity profiles of the given viewing rays in the following images:

/3



6. Name two strategies for specifying or generating transfer functions.

/2

7. Describe the motivation for multidimensional transfer functions and name one advantage and disadvantage of multidimensional transfer functions?

/3

Block D: Case Study

1. You are working as a programmer in a software company that specializes in the visualization of medical data. A new assignment from a hospital is given to you: the ablation planning of a liver tumor. You get the high-quality segmentation masks of the liver, the tumor, and the surrounding vessels, as well as the CT data set. Your task is now to develop a visualization system that presents the necessary steps with appropriate visualizations. High value is put on performance and accuracy.

(a) In the first development phase, your task is to visualize the liver, the tumor, and the surrounding vessels. Describe and justify which visualization methods you choose. Also describe all the steps necessary to meet the desired requirements and what problems, if any, are encountered.

4 Pt

(b) After you have completed the first task, however, the customers are not completely satisfied, the visualizations of the objects should be rendered smoother. Describe and justify which technique you choose and its impact, especially on the navigation of the ablation needle.

4 Pt

(c) In the third development phase, you are asked to improve the navigation of the needle. Describe and justify 2 visualizations that you would display during needle navigation. Note that accuracy and patient safety have the highest priority, i.e., the needle must not hit a vessel under any circumstances.

4 Pt

(d) Last but not least, a trainee physician noted that spatial orientation can be improved because anatomical location is often ambiguous. Describe an approach how you could accomplish this. Please note that this must not distract the physician too much from the navigation.

2 Pt

Name:

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Points

Block E: Vessel Visualization

/14

1. Explain the difference between model-based and model-free vessel visualization approaches in terms of:

/8

(a) input data requirements,

2 Pt

(b) output surface mesh quality,

2 Pt

(c) how accurately they represent a real vessel, and

2 Pt

(d) performance.

2 Pt

2. Pick one model-based vessel visualization approach and describe it in detail. Name at least one suitable application and 2 advantages and disadvantages.

/6

Block F: Virtual Endoscopy

/14

1. Explain the basic principle of virtual endoscopy. What data is required and what preprocessing is necessary.

/5

2. Describe 2 advantages and disadvantages of virtual endoscopy compared to real endoscopy.

/4

3. Name 3 requirements of virtual endoscopy.

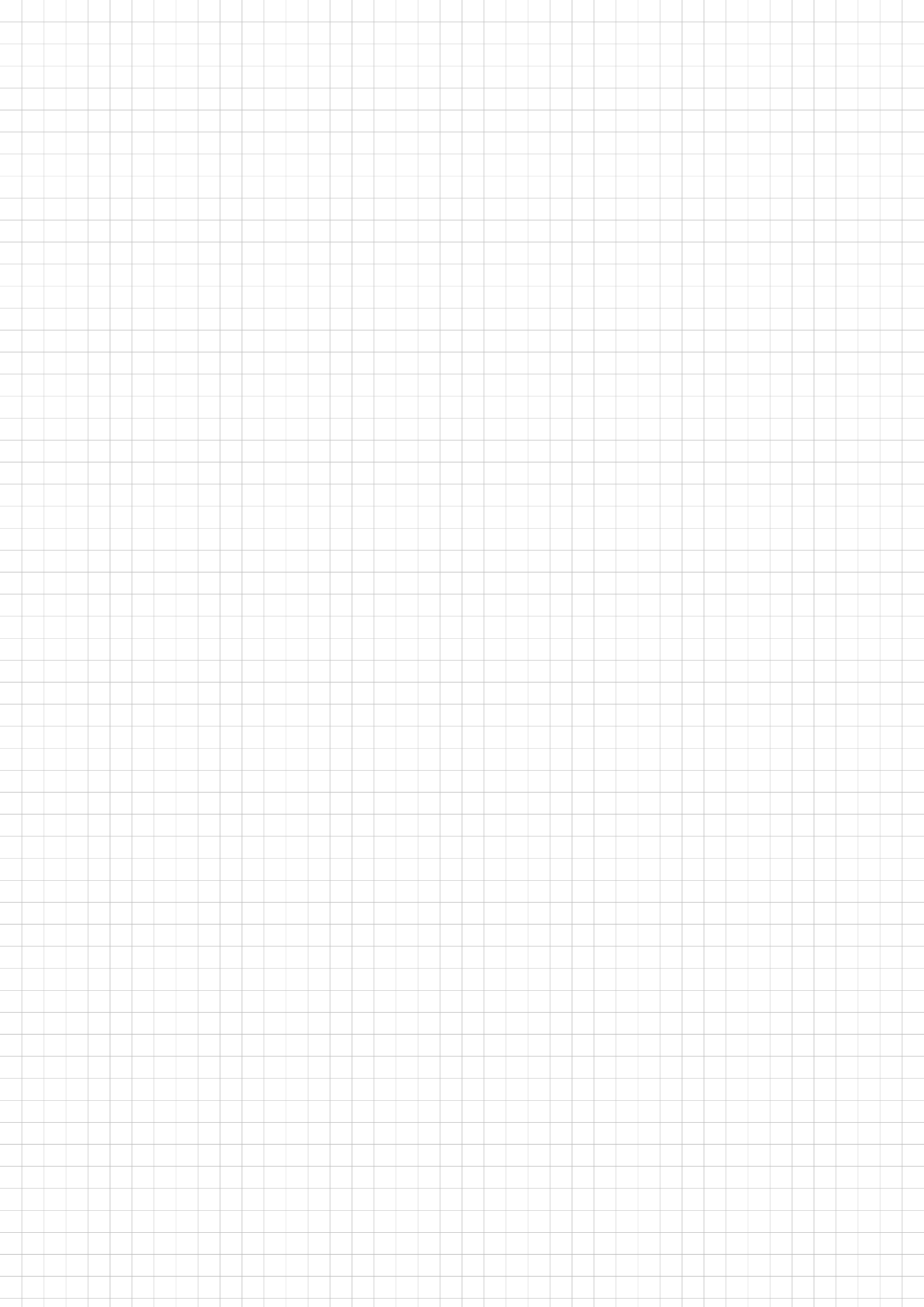
/3

4. Name 2 possibilities to assess the performance of a virtual endoscopy system, e.g., in virtual colonoscopy.

/2

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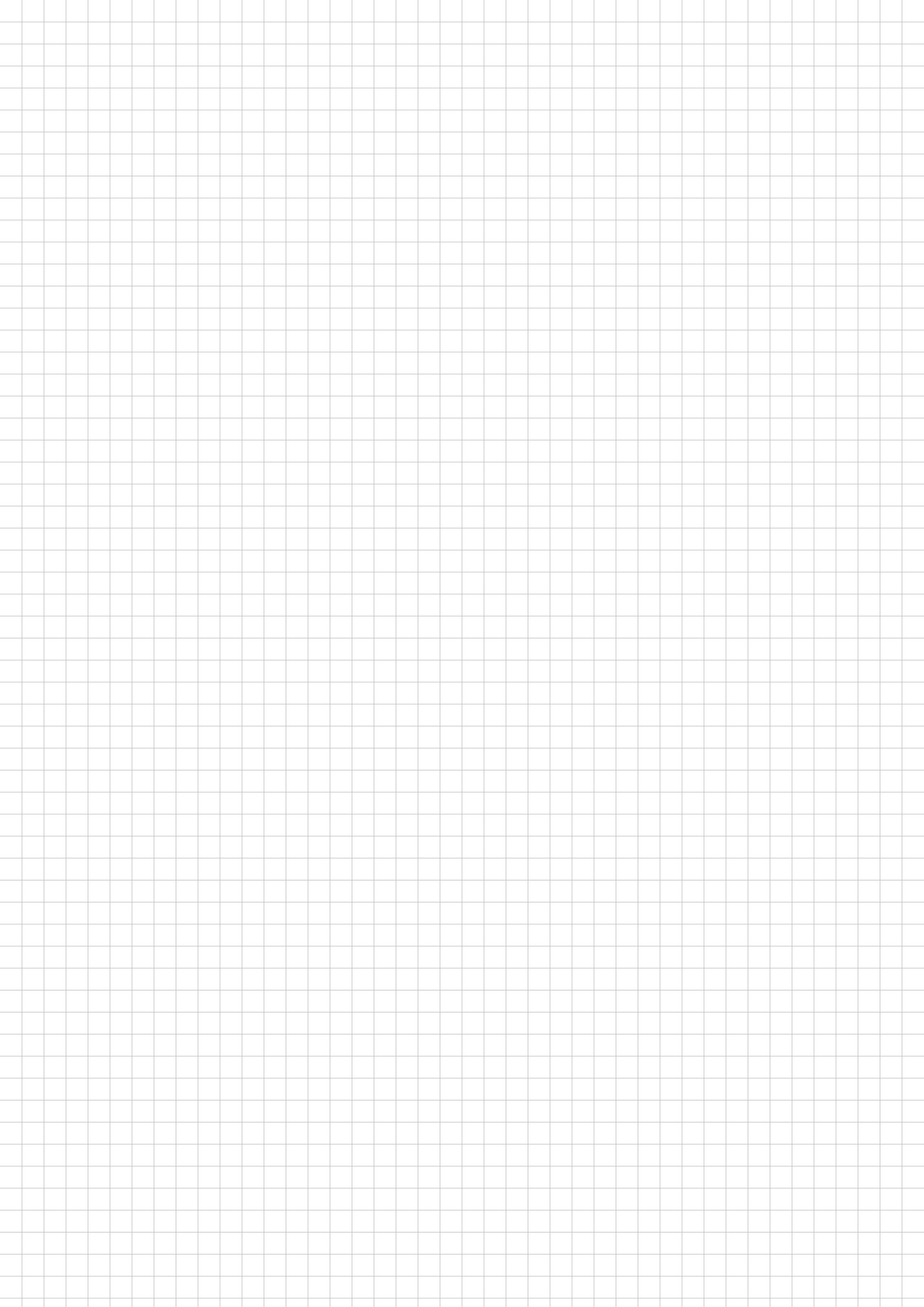
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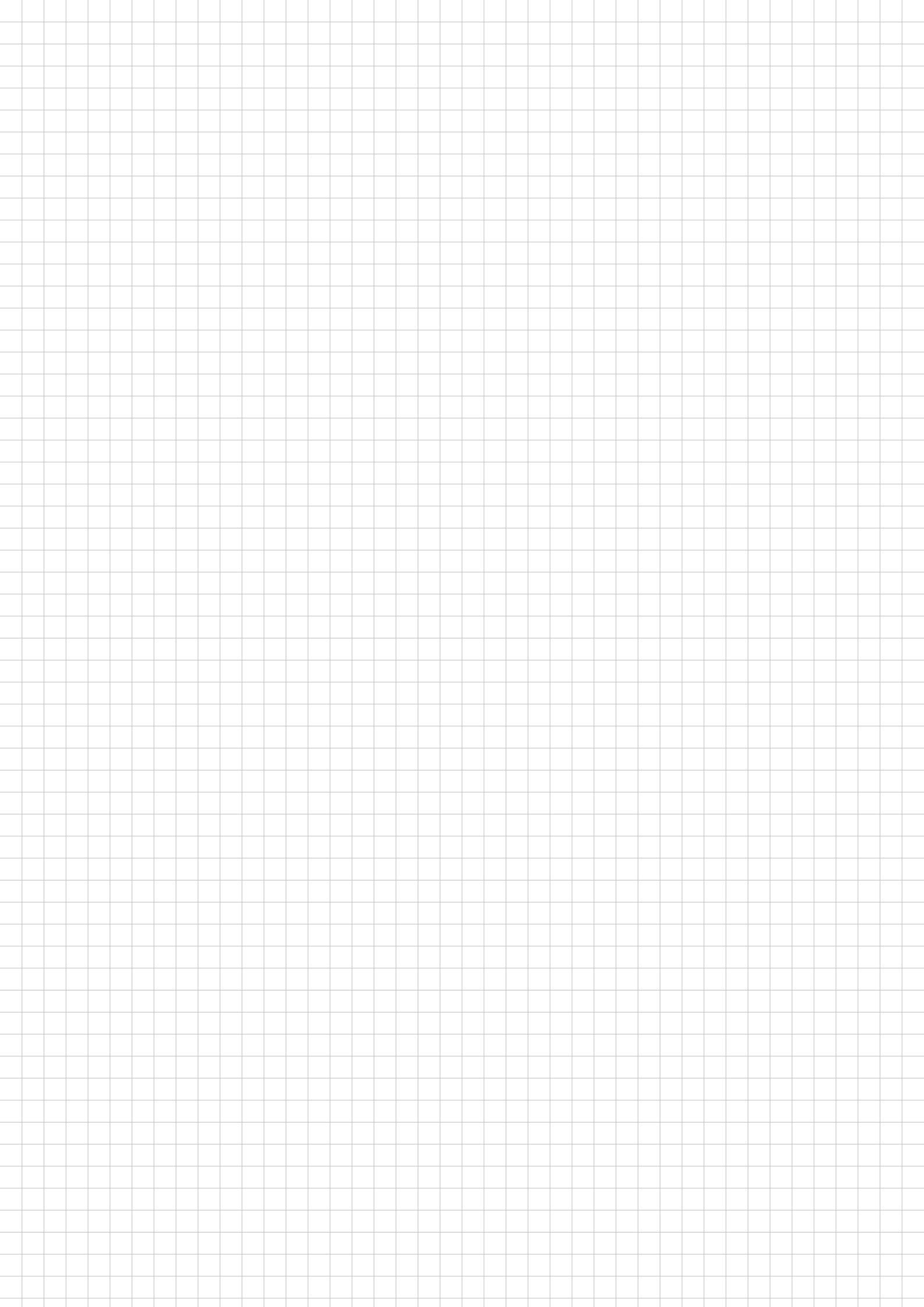
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