ARTIFACT-BASED COMPUTING & USER RESEARCH

TU WIEN

# Design & Fabrication

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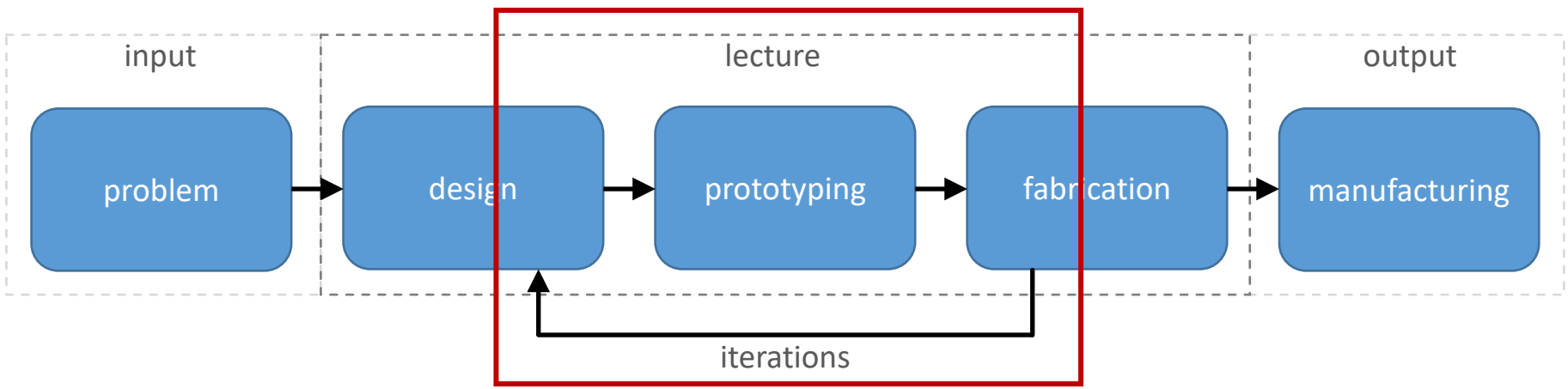
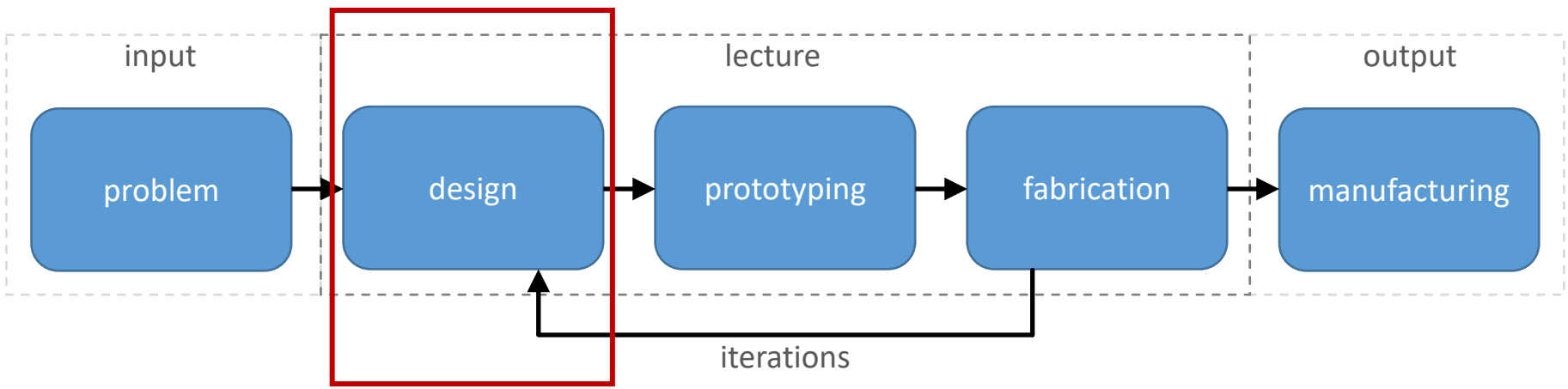
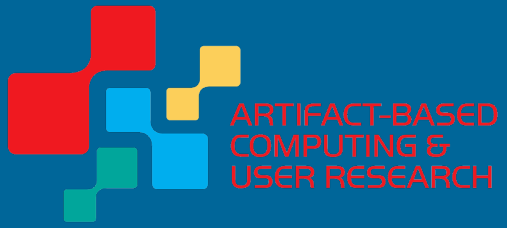
# From Design to Fabrication

## Recapitulation



# From Design to Fabrication
## Recapitulation



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# Lecture 4
## Computer-Aided Design

# Please scan the QR code:

mentimeter.com

# What is the length of the (black) line?

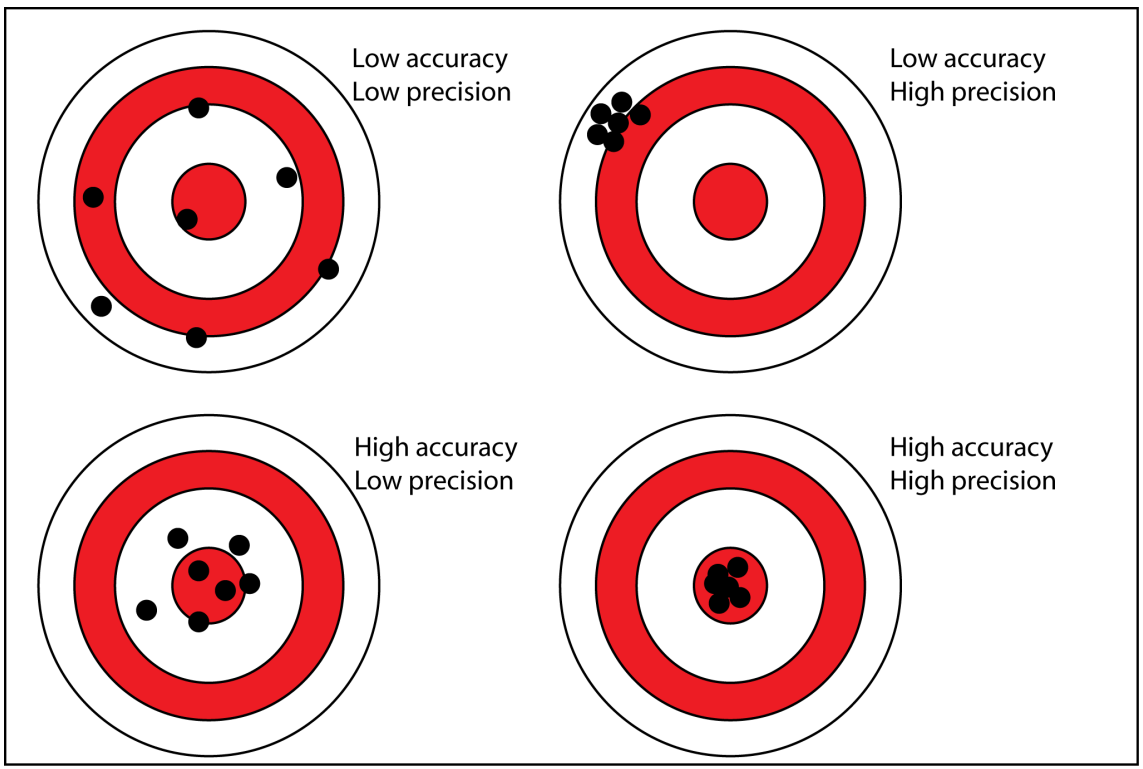
# What can we learn from this?

"Wer misst, misst Mist."
German engineers' saying basically meaning
"Who measures, measures garbage."

Which one is more accurate?

Which one is more precise?


# Computer-Aided Design
## Measuring and Tolerances






https://www.antarcticglaciers.org/glacial-geology/dating-glacial-sediments-2/precision-and-accuracy-glacial-geology/ (accessed on 2024-10-23).

## Sources of Inaccuracies

- Human errors: unclear, inaccurate, ambiguous communication or design flaws
- Rounding errors: e.g., in the CAD tool
- Production errors: e.g., machine errors
- Measuring errors: e.g., inaccuracies of the measuring tools
- Environmental influences: e.g. due to temperature, cooling/heating, shrinkage

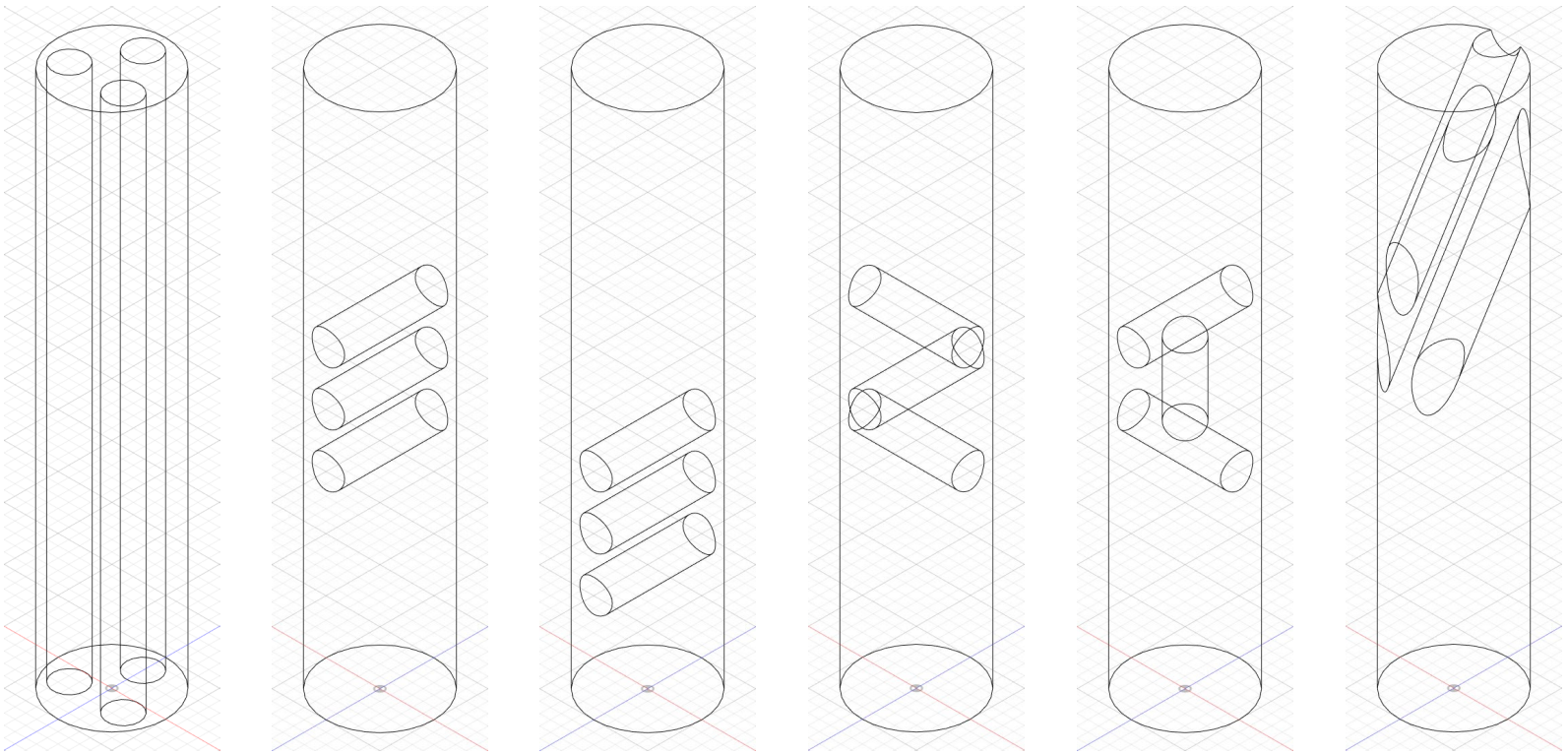
# Can you please 3D-print this?

A cylinder of 1 cm diameter and 5 cm height with three holes of 3 mm in the distance of 5 mm passing through it.

# What is going to happen?

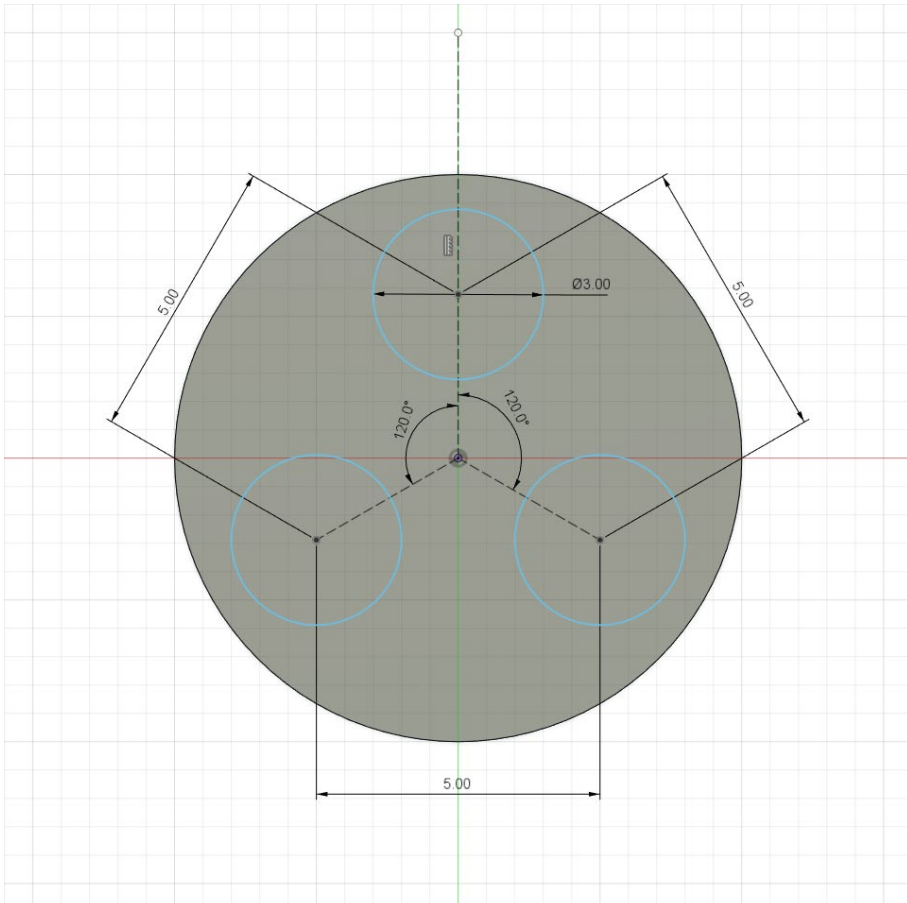
## Ambiguity

# Computer-Aided Design
## Technical Drawings



## Technical Drawing

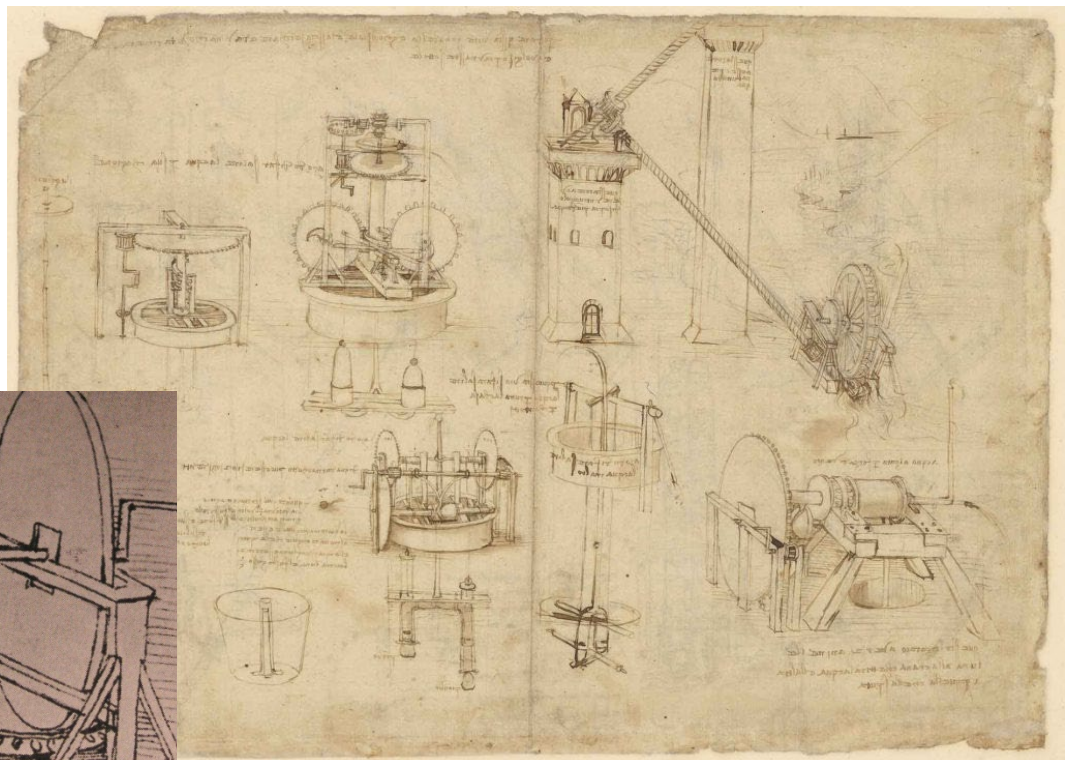
- Conveys information about an object
- Specifies geometry for construction
- Disambiguation
- Requirements Specification
  (German: Lasten- und Pflichtenheft)

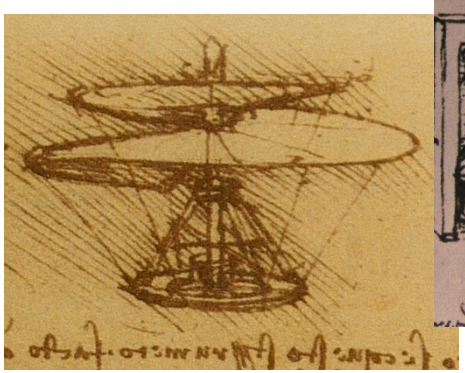


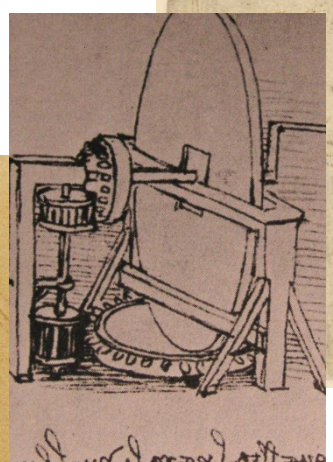
# Computer-Aided Design
## History

## Leonardo da Vinci (1452 – 1519)

- Multi-talented “polymath”
- “The Vitruvian Man” (1490)
- Gifted engineer and inventor







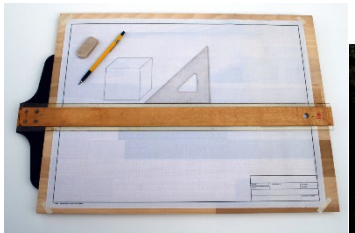


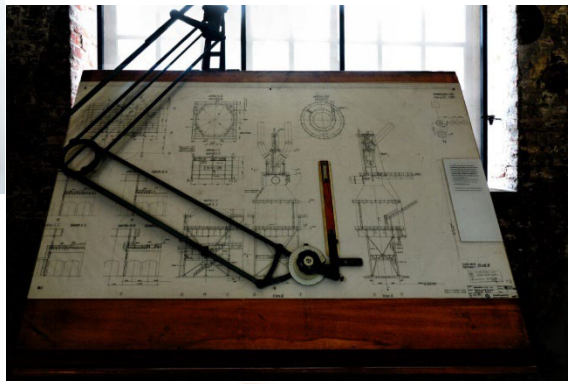
Wikipedia, https://en.wikipedia.org/wiki/Science_and_inventions_of_Leonardo_da_Vinci (accessed on 2023-10-24).
Files: Uomo_Vitruviano.jpg, Leonardo_machine_for_grinding_convex_lenses.jpg, Leonardo_machines.jpg, Leonardo_da_Vinci_helicopter.jpg

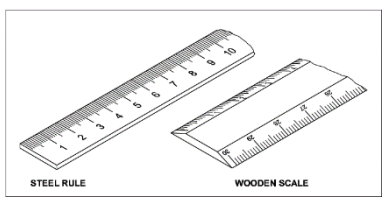
# Computer-Aided Design
History

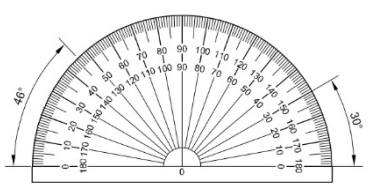
## Drawing Instruments

› Drawing Board
› T Square
› Drafting Machine
› Scales and Protractors
› Templates







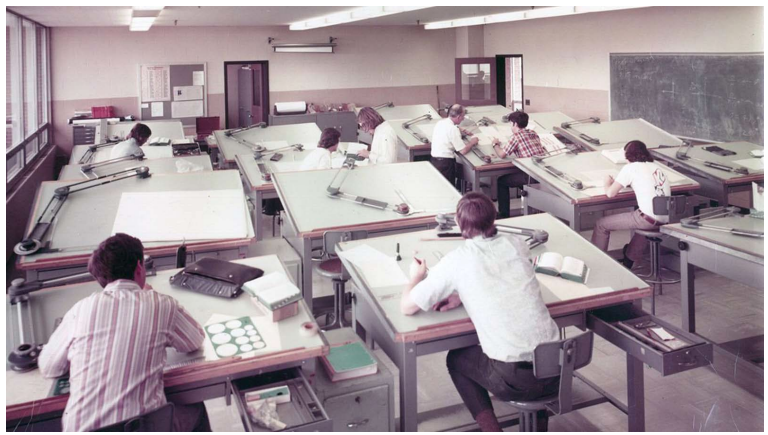


https://www.educationalstuffs.in/engineering-drawing-instruments/ (accessed on 2023-10-24).

# Computer-Aided Design
## History

A technical drawing class in the early 2000

Drafting department of Tamron in the late 1970s.



A drafting class in the early 1970s.

General Motors Technical Center.



https://www.designingbuildings.co.uk/wiki/Manual_drafting_techniques (accessed on 2023-10-24)

https://rarehistoricalphotos.com/life-before-autocad-1950-1980/ (accessed on 2023-10-24).

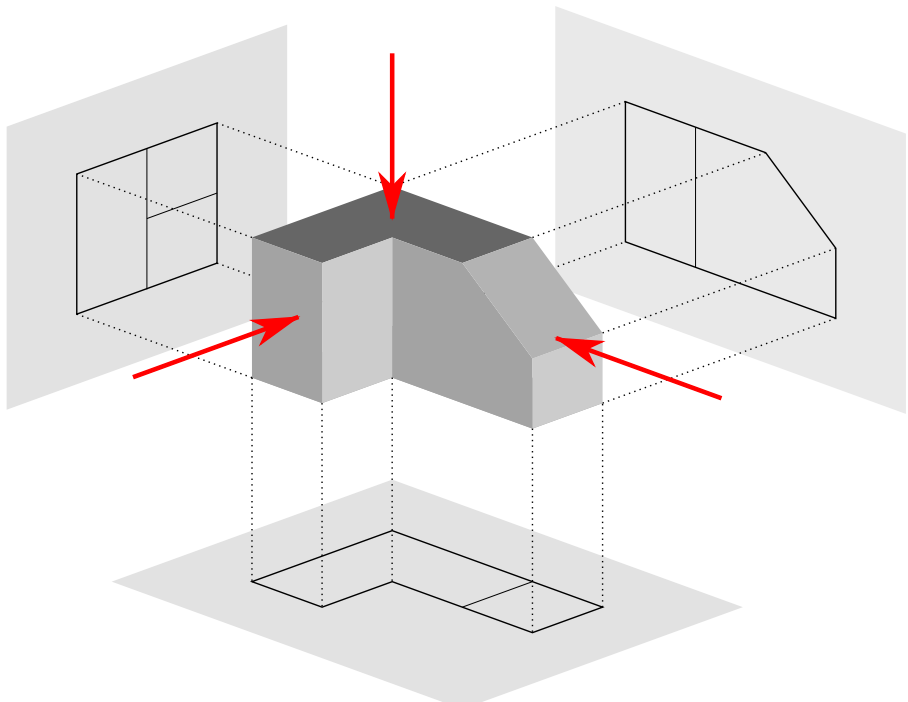
# Norms and Standards

- Very domain-specific (e.g. architecture)
- Notation and units (e.g. inch or meter)
- Projection (e.g. isometric)
- Line widths and styles (e.g. dotted)
- Hatching styles (e.g. diagonals)
- Symbols (e.g. center marks)

# Computer-Aided Design
Projection and Perspective

## Orthographic Projection

- Introduced in 1765 by Gaspard Monge (1746 – 1818)
- Representing 3D objects in 2D
- Form of parallel projection
- The projection lines are orthogonal to the projection plane

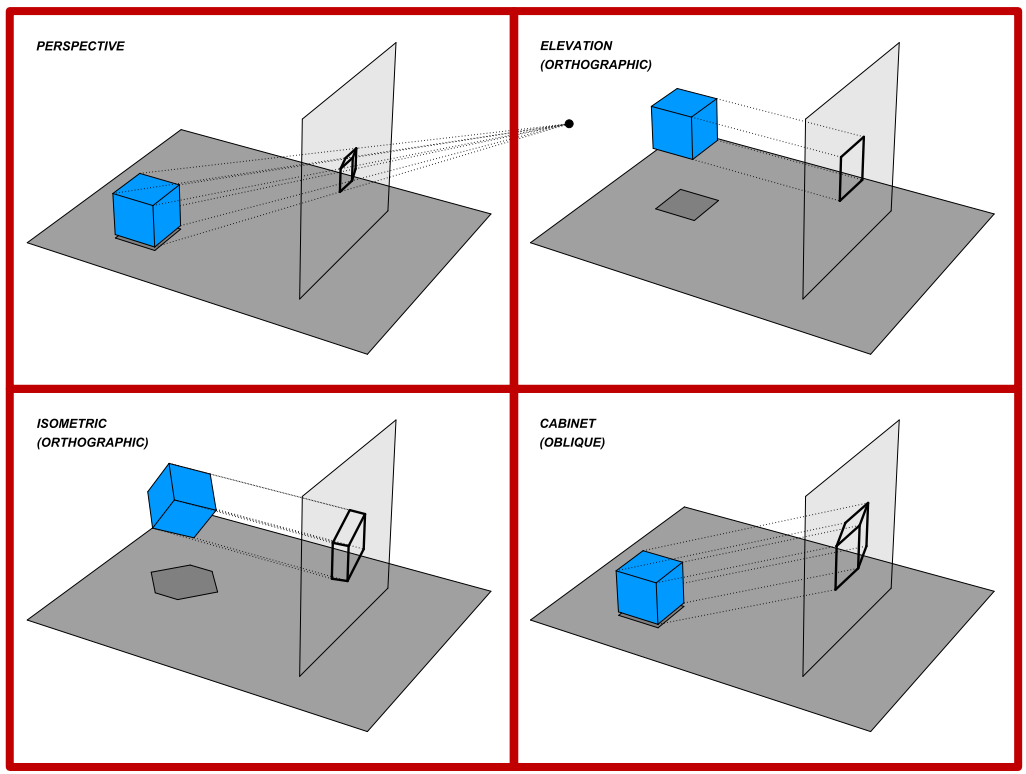


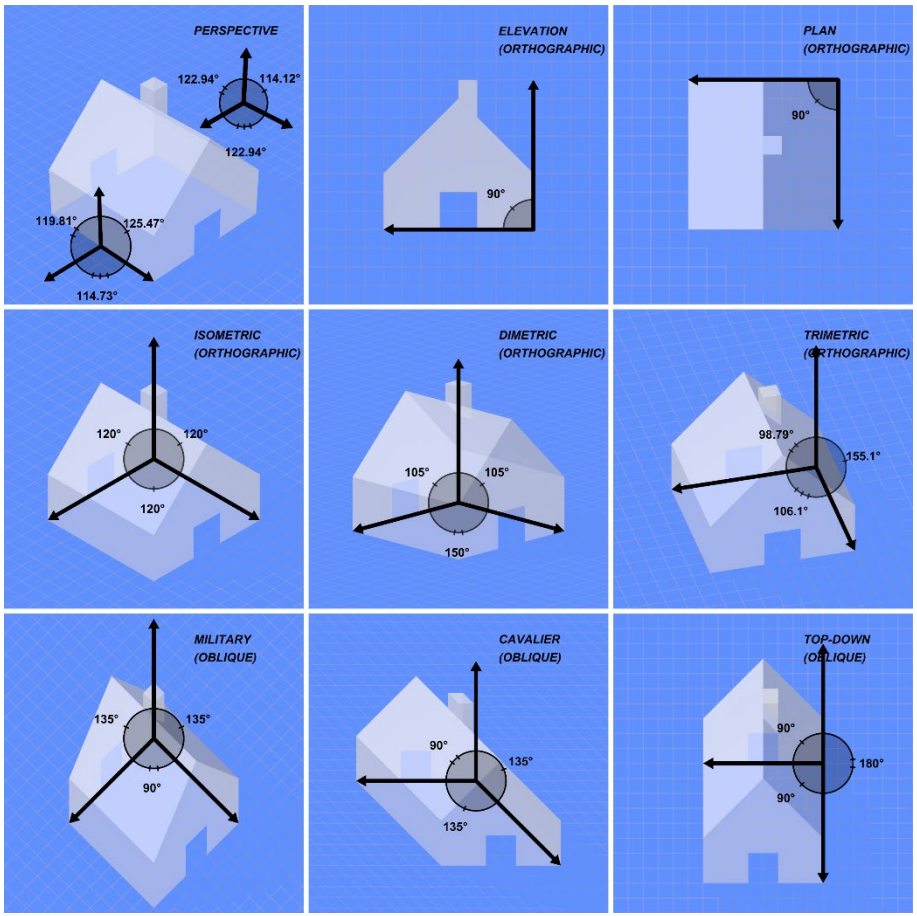


Wikipedia, https://en.wikipedia.org/wiki/Engineering_drawing , https://en.wikipedia.org/wiki/Gaspard_Monge , https://en.wikipedia.org/wiki/Descriptive_geometry (accessed on 2023-10-24).
Files: First_angle_projection.svg

# Computer-Aided Design
## Projection and Perspective

## Different Perspectives






Wikipedia, https://en.wikipedia.org/wiki/Engineering_drawing (accessed on 2023-10-24).
Files: Various_projections_of_cube_above_plane.svg , Graphical_projection_comparison.png

# 3D CAD Tools

- Different CAD tools on the market
- 3D Studio Max
- Rhinoceros 3D
- SolidWorks
- Autodesk AutoCAD
- Autodesk Fusion 360 (free-form models)

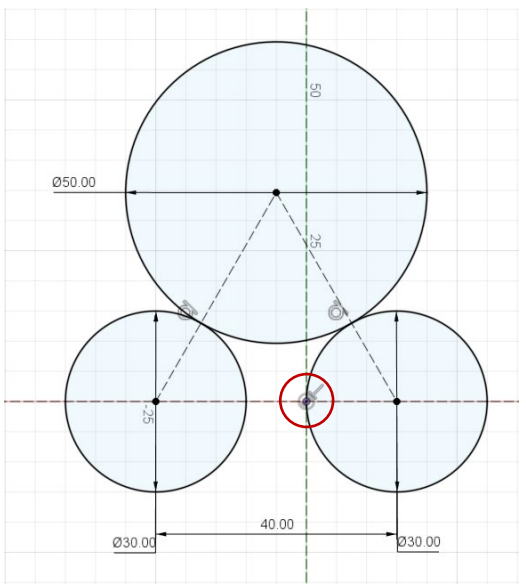
Utah Teapot



https://en.wikipedia.org/wiki/Utah_teapot (accessed on 2023-10-24).

# Parametric Modeling

- Creation of automatically adjusting models based on parameters and constraints
- Unambiguous definition of the geometry and behavior of the drawing and model to ensure consistency and accuracy
- Parameters are dimensions and angles, but also constraints such as features and relationships between elements (e.g., fixed, symmetric, coincident, tangential, parallel, perpendicular, concentric, collinear, …)
- Based on pre-programmed rules (e.g., automatic adjustment, scaling, …)
- Non-parametric tools (e.g., dragging, …)



# Computer-Aided Design
Simulation

## Simulation

› Mechanical components

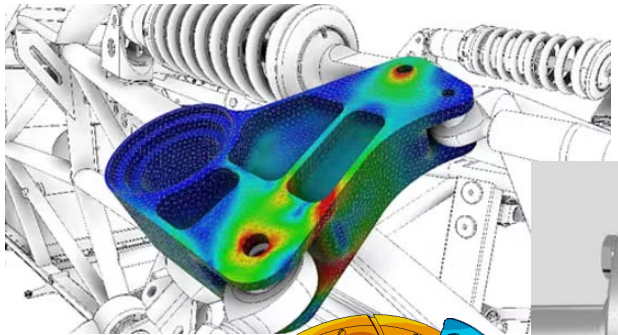
› Fatigue of material

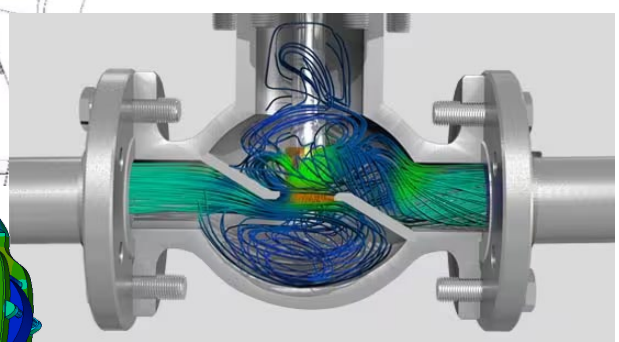
› Fluid and flow

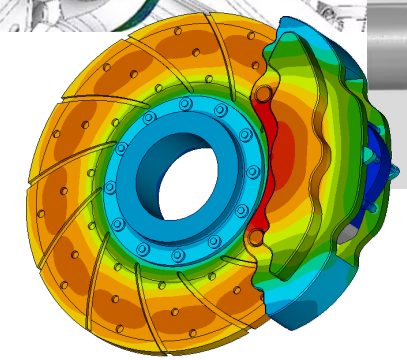
› Thermal, heat propagation

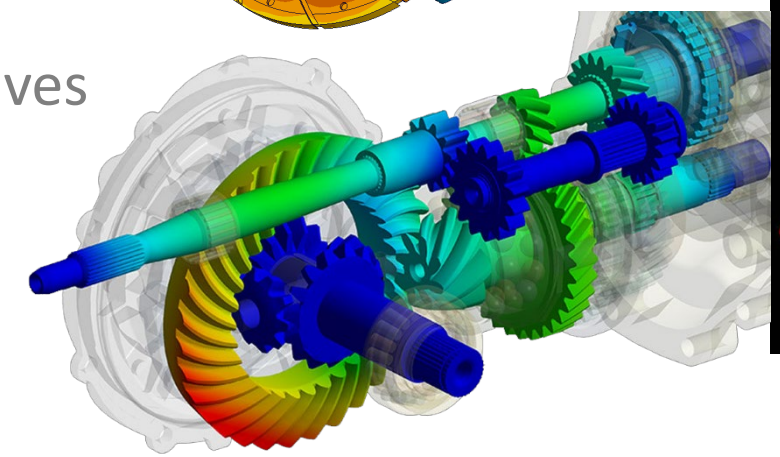
› Electrical fields and radio waves

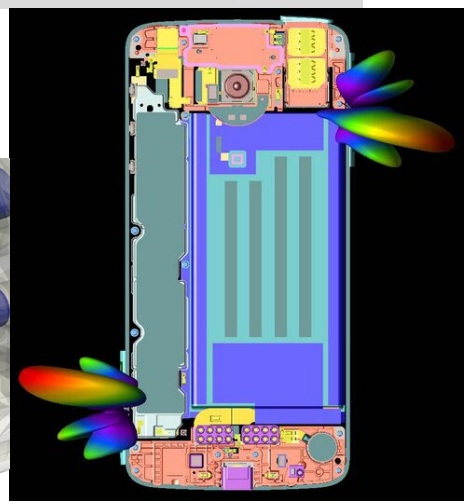
› …









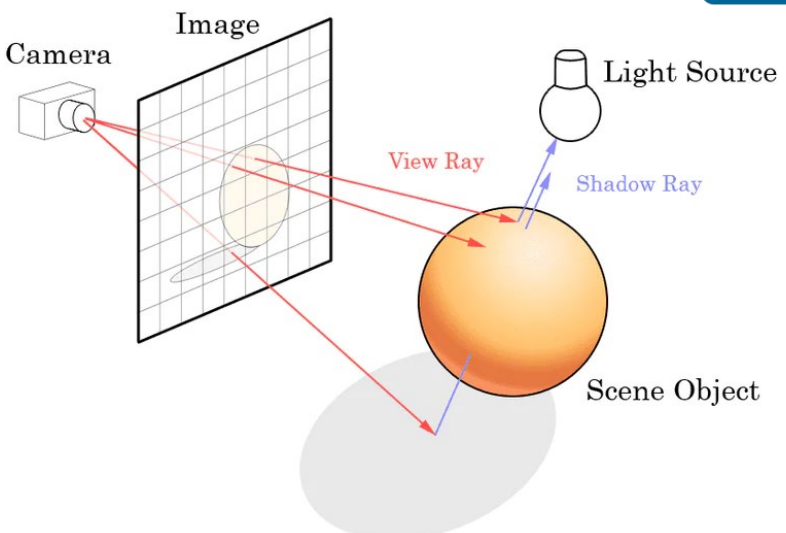


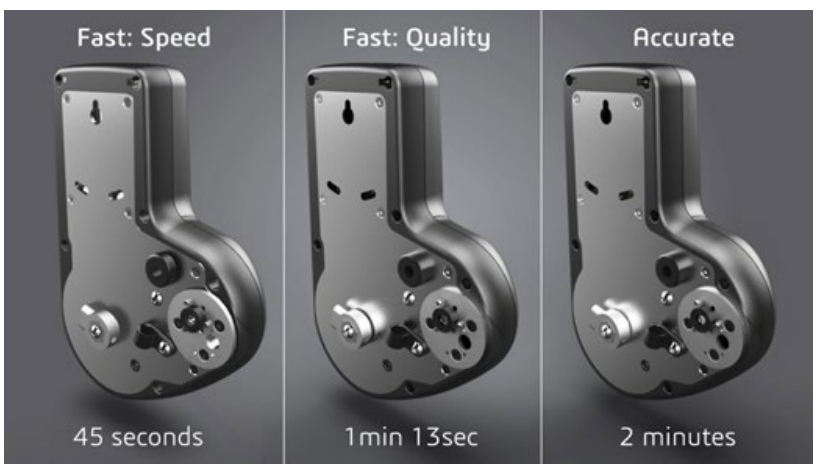


https://www.autodesk.de/solutions/simulation/overview , https://www.remcom.com/antenna-design-simulation-software , https://www.theseus-fe.com/simulation-software/heat-transfer-analysis , https://www.padtinc.com/simulation/simulation-product/ansys-mechanical/ (accessed on 2023-10-24).

## Rendering

- 2D projection of 3D objects
- Often aiming at photorealistic images
- Environment, texture, lighting, shading, reflections, …
- Recent algorithms:
  - Ray Tracing (often with Monte Carlo)
  - Path Tracing (unbiased, expensive)
- Software: Blender, Cinema 4D, …

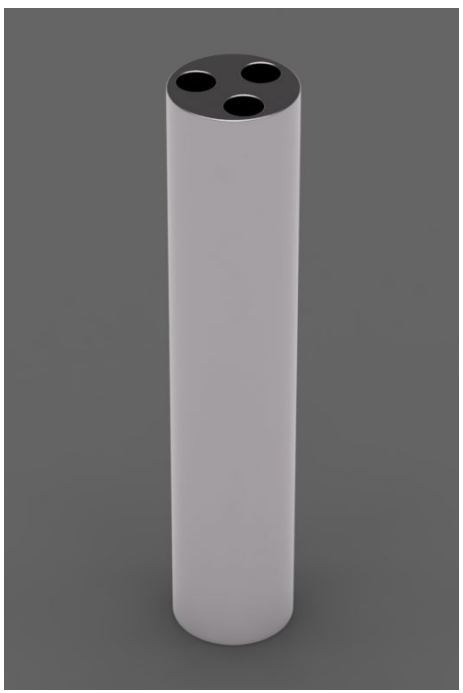




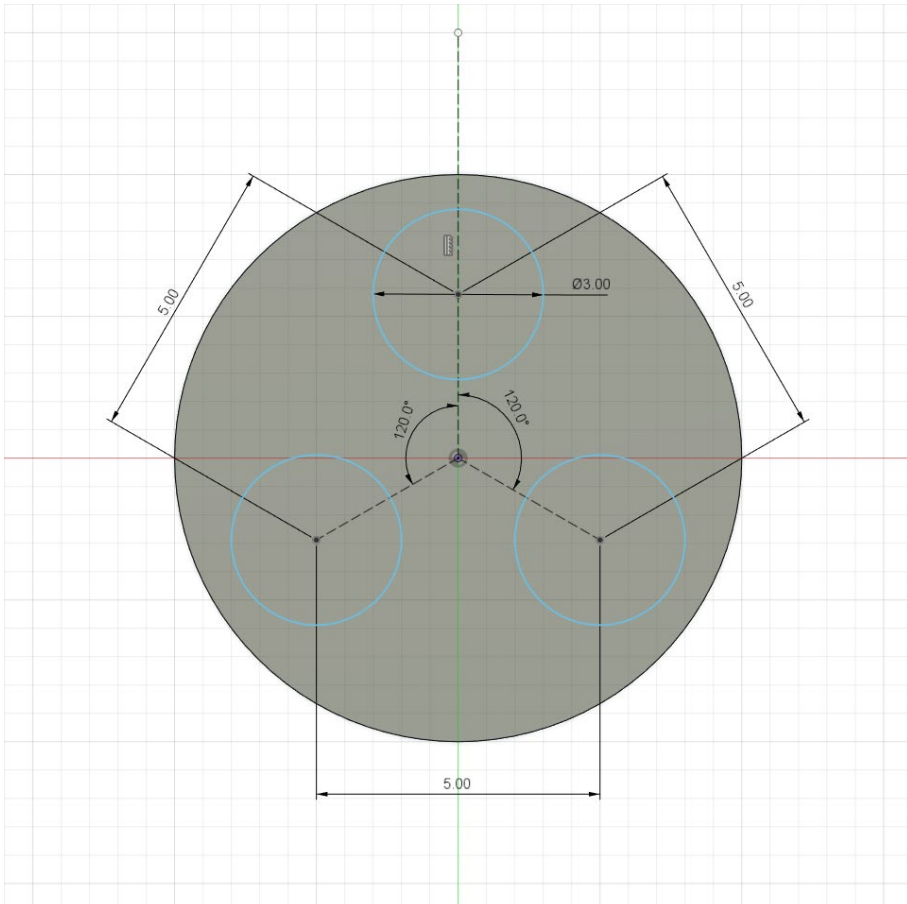

https://ventiontech.com/blogs/technology-overview/what-is-ray-tracing , https://help.solidworks.com/2022/english/Visualize/c_fast_raytracing_mode_switch.htm (accessed on 2023-10-24).

# How can we properly represent this object?



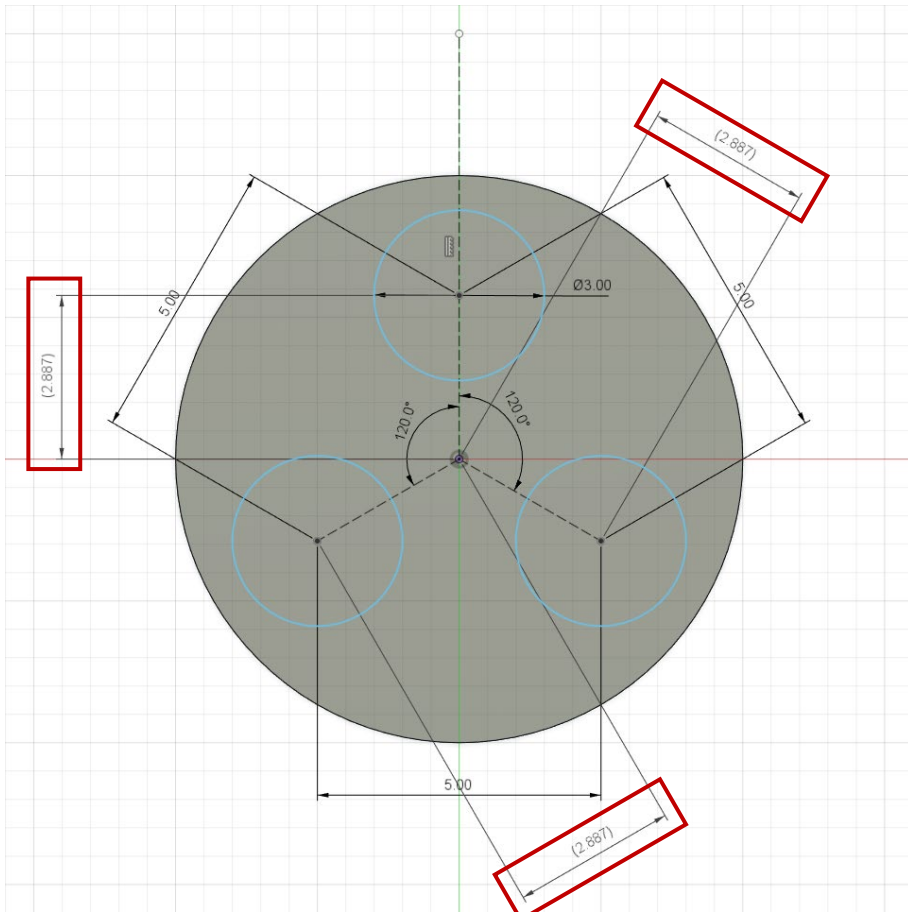
# Technical Drawing

- Information about an object
- Specifications for construction
- Must be unambiguous
- Detail drawing
  - Specifies geometry of a single component
  - Multiple views and details
  - Dimensions, requirements, and tolerances
- Assembly drawing
  - Specifies quantities and materials

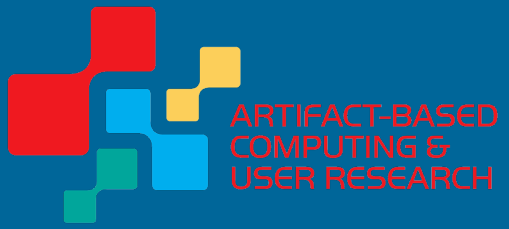


## Golden Rules

› Fully defined to avoid ambiguity
› Use of industry standards (e.g., ISO)
› Specify constraints
› Avoid over-constraining
› Avoid redundancy and inconsistency
› Specify accuracies and tolerances
› Driven dimensions for quality test



What are your questions?

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# **Organization**
Lab Introduction

# Introduction to the Lab

Mandatory part of the lecture

**Date:** 06.11.2024 / 13.11.2024

**Group numbers:** 1-5 / 6-11

**Room:** HE 02 13 (Yellow lab)

- Laser Cutter
  - 20 mins
  - Covered - Machine operation, Software usage, Available materials, Alignment and Calibration and Safety instructions
  - Not covered - Vector drawing software
  - Instructor: Florian

- 3D Printer
  - 20 mins
  - Covered - 3D Printing technology overview, Printer operation, Material and Printing parameters
  - Not covered - 3D Modeling software
  - Instructor: Ambika & Thomas

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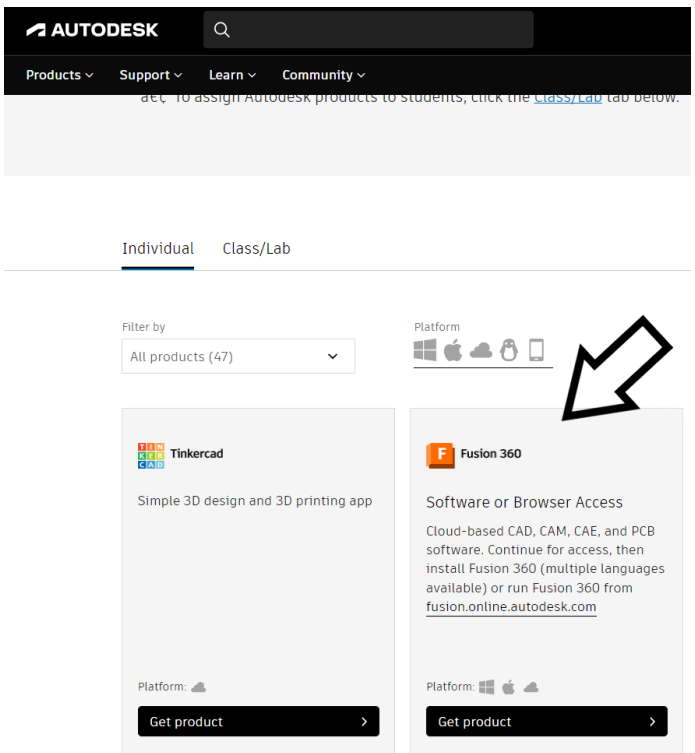
# Tutorial

Autodesk Fusion 360

# Tutorial

## Autodesk Fusion 360

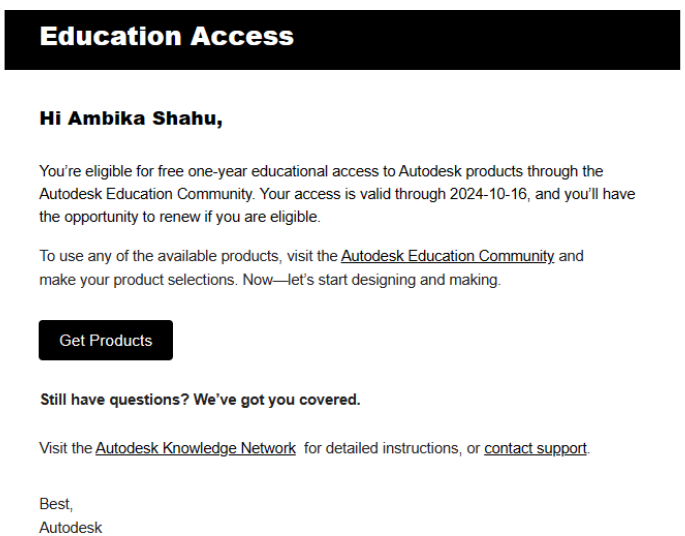
- Go to the Autodesk Education Community website: https://www.autodesk.com/education/home
- Create or Log In to Your Account
- Navigate to the "Products & Services" section - Look for "Fusion 360"



# Tutorial

## Autodesk Fusion 360

- Verify your student status
- Once you are eligible, you should find an option to download in your email
- After downloading the installer, run it to install Fusion 360 on your computer



**Education Access**

**Hi Ambika Shahu,**

You're eligible for free one-year educational access to Autodesk products through the Autodesk Education Community. Your access is valid through 2024-10-16, and you'll have the opportunity to renew if you are eligible.

To use any of the available products, visit the Autodesk Education Community and make your product selections. Now—let's start designing and making.

Get Products

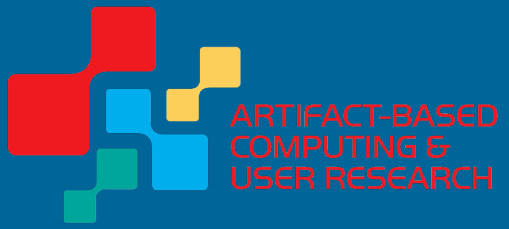
**Still have questions? We've got you covered.**

Visit the Autodesk Knowledge Network for detailed instructions, or contact support.

Best,
Autodesk

# Live Demonstration

## Autodesk Fusion 360

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# Exercise 2

Announcement

# Exercise 2: CAD Design

## Description

### Individual Submission, due date is Tuesday, November 26, 2024 until 23:59h

Four 3D modeling tasks, each with increasing complexity.

### 1. Perforated Cylinder (2 points)

- Reproduce the cylinder example following the steps shown during the lecture.
- It must have three holes cut out as specified in the technical drawing.

### 2. Hollowed Cylinder with Tangential Plane Cut (4 points)

- Create a hollow cylinder and use tangent planes to partially remove parts of it.
- Follow the dimensions provided in the technical drawing.

# Exercise 2: CAD Design

## 3. Measure and Replicate (5 points)

- Measure the provided 3D-printed model with the provided measurement tools.
- Record all dimensions to fully specify the object and use them to replicate it in Fusion 360.
- Measurement errors are generously tolerated (error margin of ±0.5 mm).
- Submit a photo of your hand-drawn sketch.

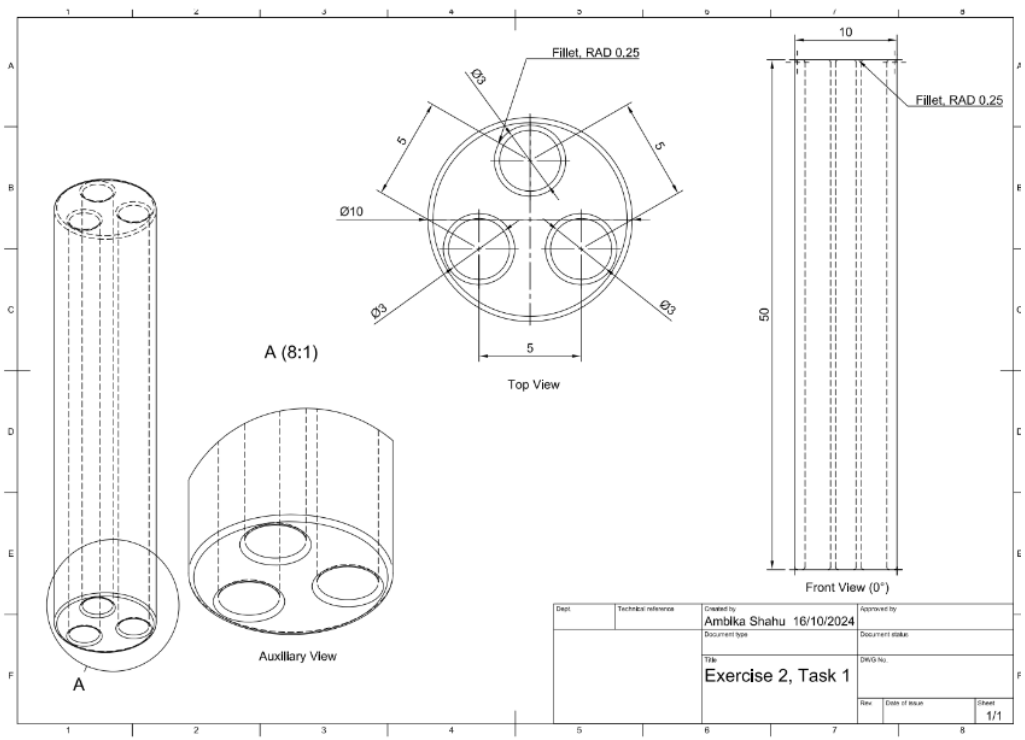
## 4. Sheet Metal Elephant (4 points)

- Use the Metal Sheet Bend Tool as shown in the lecture.
- Create the sheet metal elephant based on the technical drawing.
- Inaccuracies due to bending are generously tolerated (error margin of ±0.2 mm).

Note: Make sure your sketches in Fusion 360 are fully defined and not ambiguous (blue: underdefined, black: fully defined).

# Exercise 2: CAD Design

## Sample Technical Drawing



# Exercise 2: CAD Design
## Submission Details

Individual submission of a *.zip archive named "[family name]_exercise2.zip" , containing the following files:

- Photo of your hand-drawn sketch with dimensions for task 3.
- *.f3d files for all 4 tasks (exported from Autodesk Fusion 360), named task1, task2, etc.
- Rendered images (.png or .jpg) for each task, named accordingly (e.g., task1.png, task2.jpg).
- A *.pdf document providing brief descriptions (1-2 sentences per design step) of the timelines for all tasks (timeline = bottom line in Autodesk Fusion 360).

- Deadlines are strict! Late submissions are not considered.

# Thank You!

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