

Design & Fabrication

Dr.-Ing. **Florian Wolling** (Lecture), M.Sc. **Ambika Shahu** (Exercises),
Thomas Mantschko (Tutor), Prof. Florian Michahelles

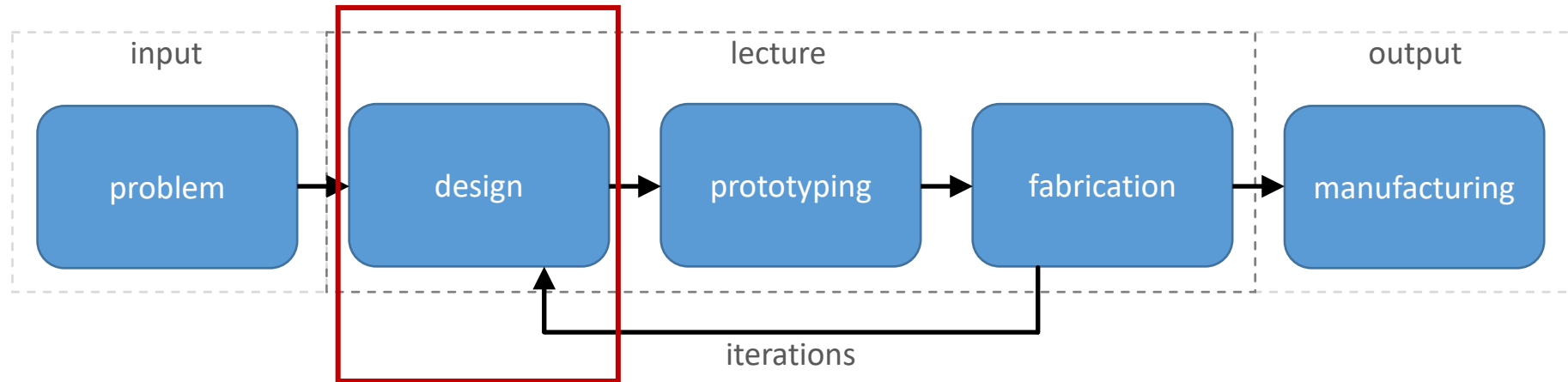
Technische Universität Wien

Artifact-Based Computing & User Research (<http://media.tuwien.ac.at>)
florian.wolling@tuwien.ac.at, ambika.shahu@tuwien.ac.at



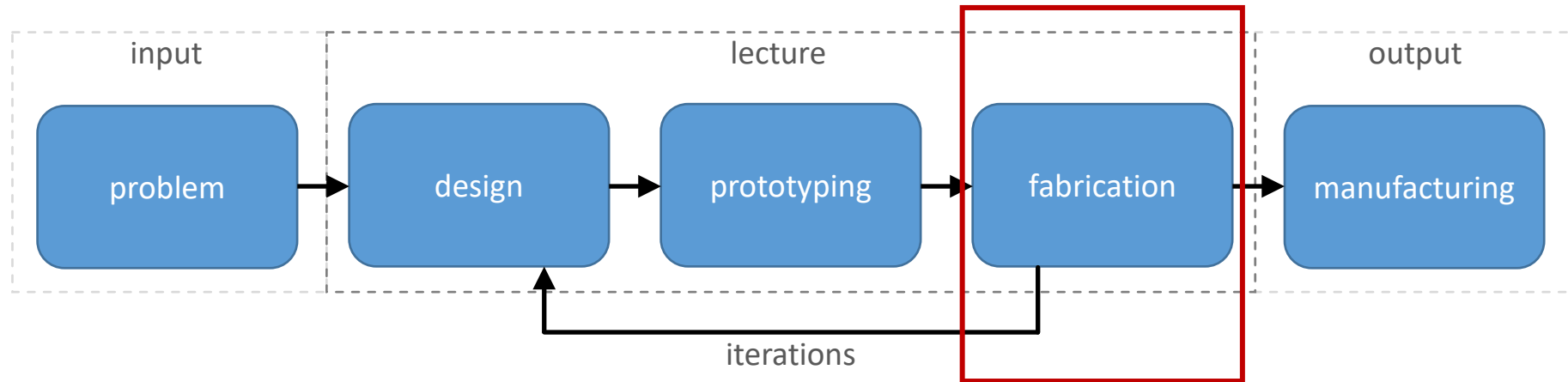
From Design to Fabrication

Recapitulation



From Design to Fabrication

Recapitulation



Lecture 5

Materials

Please scan the QR code:
[mentimeter.com](https://www.mentimeter.com)



Materials Overview

PAPER



WOOD



METAL



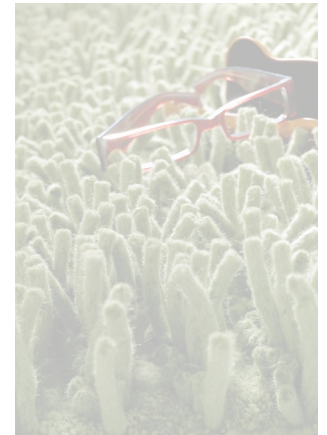
PLASTICS



CERAMICS



TEXTILES




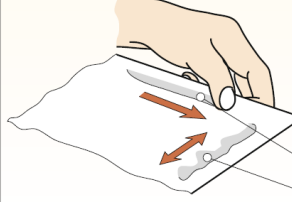
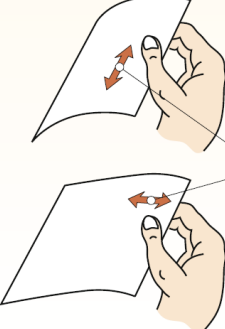
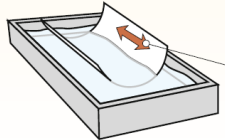
Materials


Paper



Paper

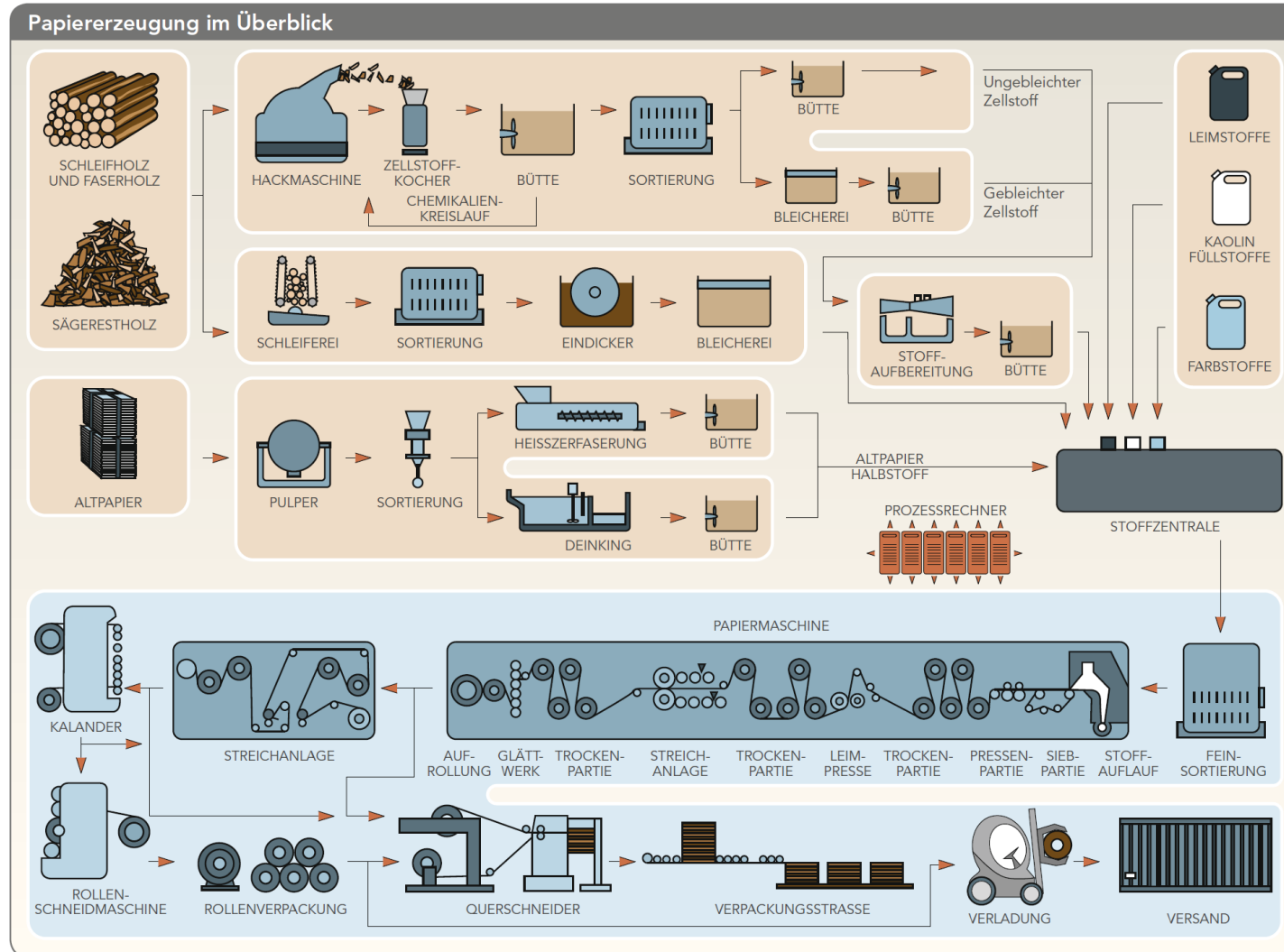
- › Egyptian “papyrus” (2,500 BC)
- › Very universal and versatile
- › Based on **wood** (prone to yellowing)
- › Wood-free pulp, **cellulose**-based
- › Bleaching (preferably chlorine-free)
- › Running/**fiber direction** (strength)
- › Rigidity and aging resistance
- › Lamination
- › **Folding and creasing**

Möglichkeiten zur Feststellung der Laufrichtung	
Reißprobe 	<p>Beim Einreißen rechtwinkligen Papiers in beide Richtungen wirkt der Einriss in Laufrichtung gerader. Das Reißen verläuft leichter.</p>
Nagelprobe 	<p>Nach Durchziehen des zu prüfenden Papierbogens in beide Richtungen zwischen Daumen und Zeigefinger sind quer zum Faserverlauf Wellen zu erkennen.</p>
Biegeprobe 	<p>Papier weist in Faserrichtung eine höhere Biegefestigkeit auf als quer dazu. Mit einem quadratischen Papierbogen lässt sich dies leicht überprüfen. Der Biegeradius ist in Faserrichtung größer.</p>
Feuchtigkeitsprobe 	<p>Unter Einfluss von Feuchtigkeit rollt sich Papier immer quer zur Laufrichtung.</p>



Materials

Paper



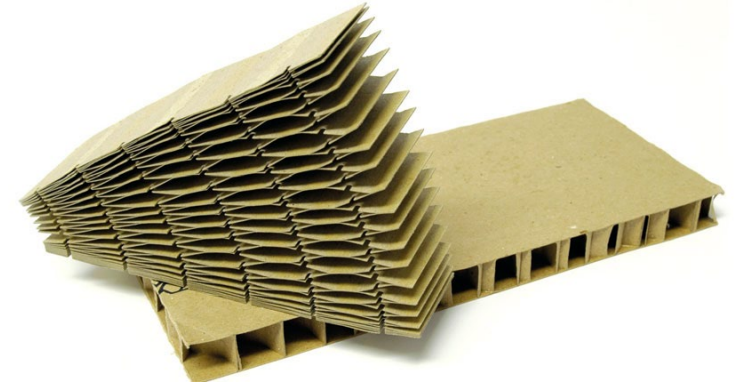
Materials

Paper



Cardboard

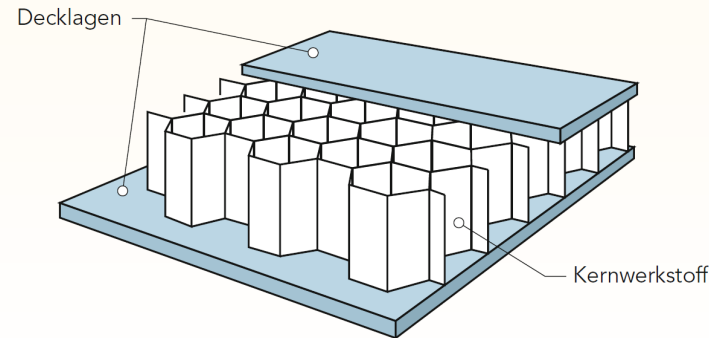
- › Paperboard and cardboard
- › Heavy paper sheets



Corrugated Fiberboard

- › One fluted sheet (core)
- › One or two flat liner boards
- › Bending and impact resistance
- › **Cushioning**, shock absorption

Sandwichaufbau mit Wabenkern

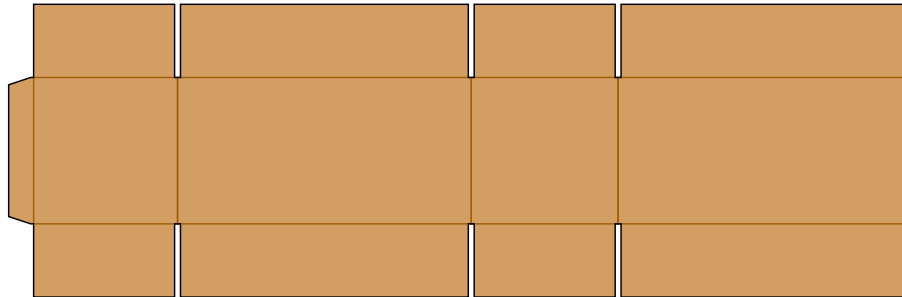


Materials

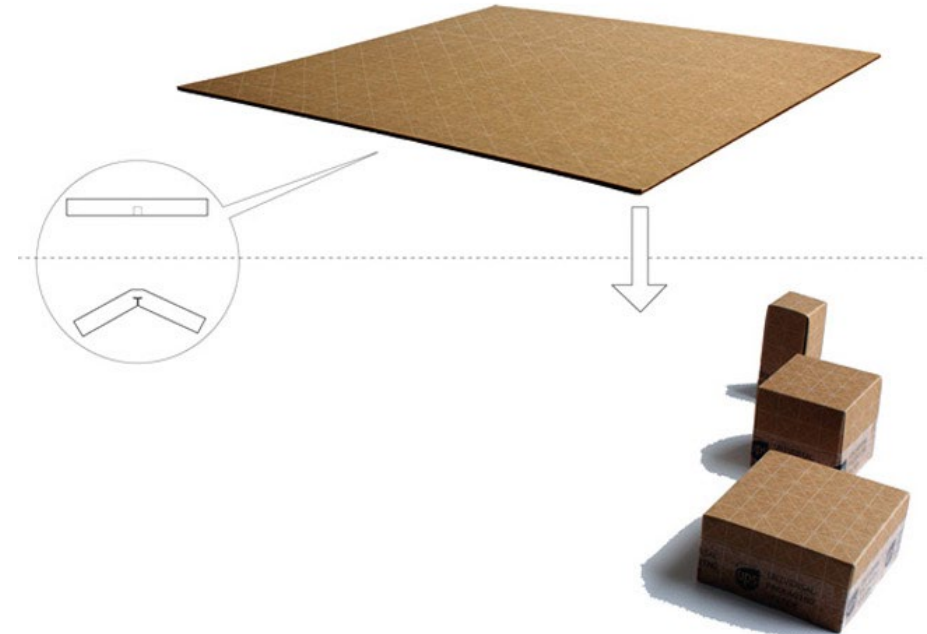
Paper

Packaging

regular slotted container



packaging for complex shapes



Materials

Paper

folded and creased gift card



lamps



furniture



paper foam



When does it make sense to
use paper and corrugated fiberboard?



Materials Overview

PAPER



WOOD



METAL



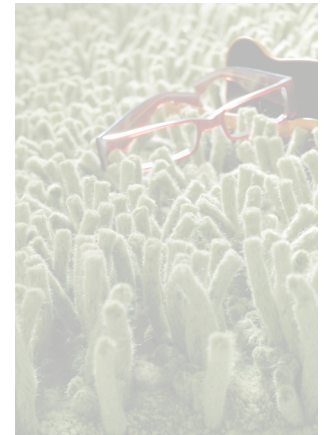
PLASTICS



CERAMICS



TEXTILES

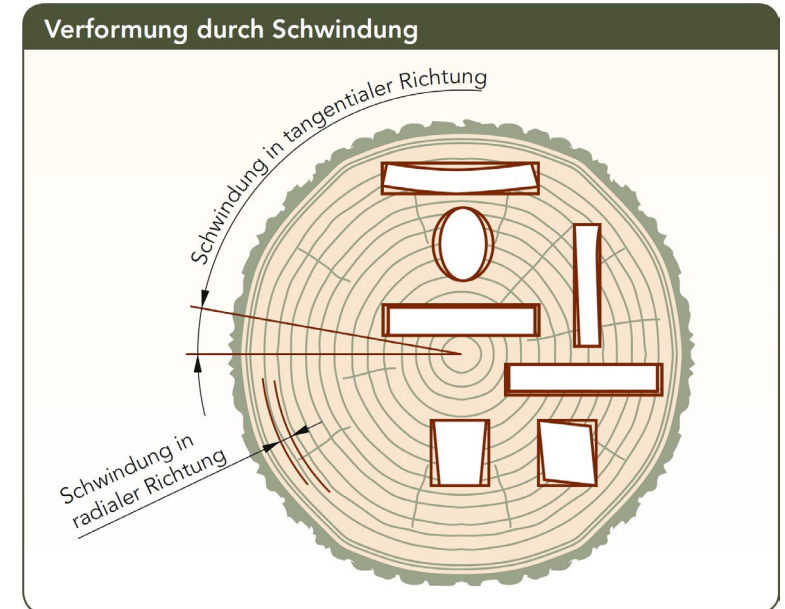
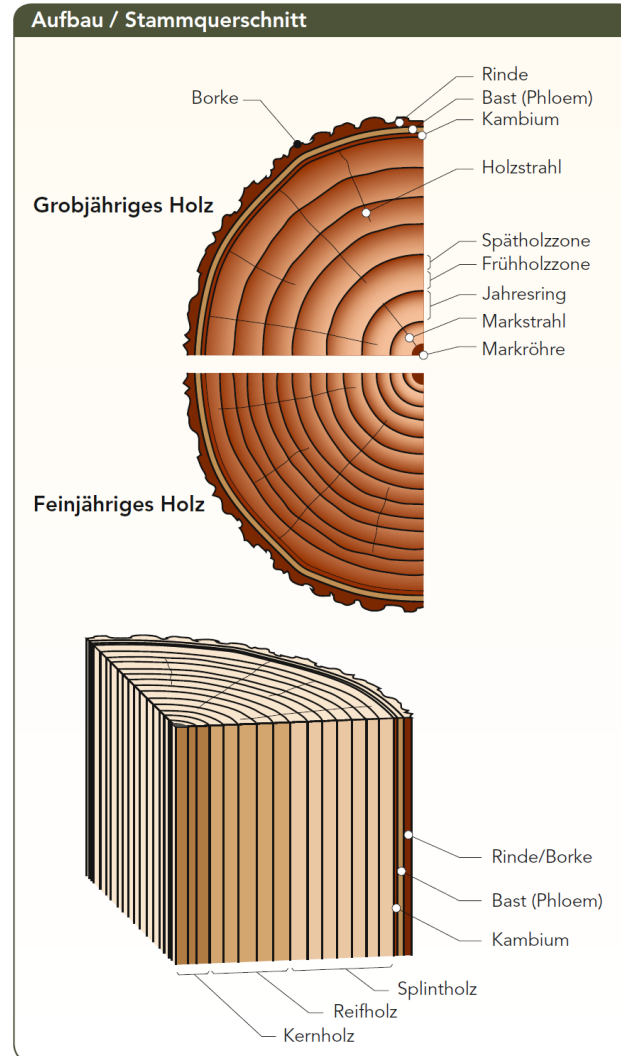


Materials

Wood

Wood



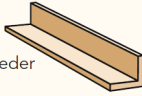



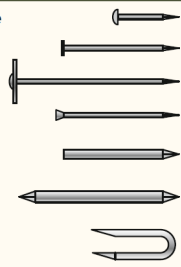

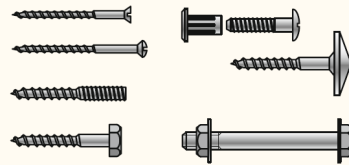
- › Natural material
- › Shrinkage



Materials

Wood

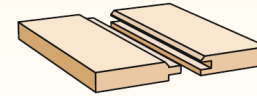
Connections

Verbindungsmittel	
Feder-Nut  Langholzfeder	 Lamello-Feder
 Winkelfeder	
Dübel  	
Nägel 	Drahtstifte 
Klammern 	
Schrauben 	

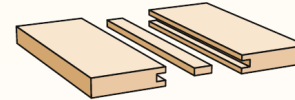
Konstruktionsbeispiele für eine Holzverbindung

Fugenverbindung

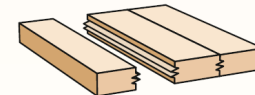
Fugenverbindung mit Profil



gefederte Fugenverbindung



Kronenfuge



Doppelt gespundete Fugenverbindung

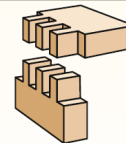


Hirnleisten

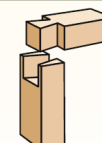


Eckverbindung

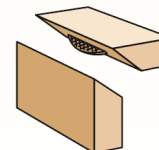
Fingerverzinkung



Einzinker

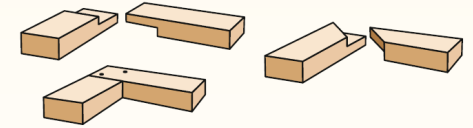


Eckverbindung mit Lamello-Feder

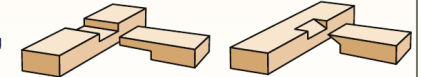


Rahmenverbindung

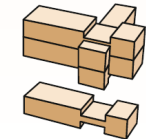
Überblattung



Halbe T-Überblattung



Stapelbare Überblattung



Längsverbindung

Keilzinken

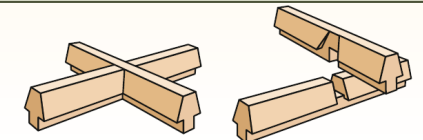


Längsverbindung mit angewinkeltem Zapfen



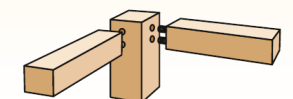
Sprossenverbindung

Kreuzsprossen



Gestellverbindung

gedübelte Gestellverbindung



Materials

Wood

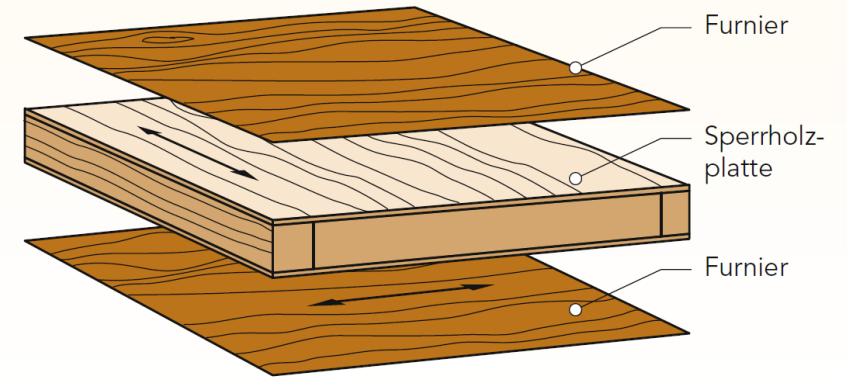
Veneer

- › Plastic or wooden veneers
- › Plywood or solid wood with sheets

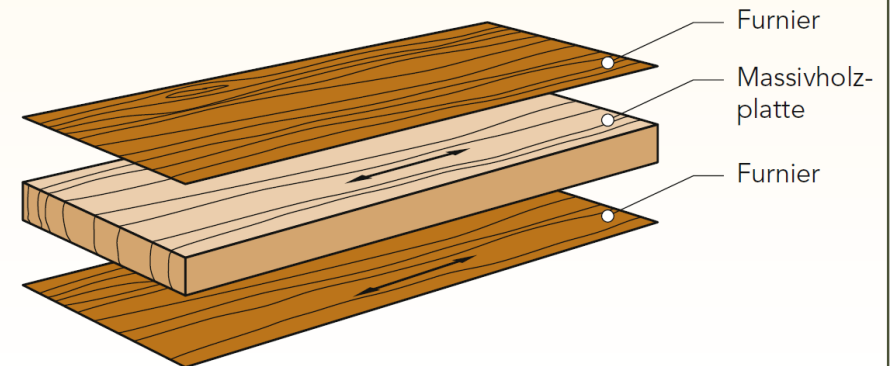


Grundprinzipien beim Furnieren

Beim Furnieren auf **Sperrholz** sollte die Faserrichtung des Furnieres immer quer zu der des Sperrholzes liegen



Beim Furnieren auf **Massivholz** sollte die Faserrichtung des Furnieres immer in gleicher Richtung zu der des Massivholzes liegen



Materials

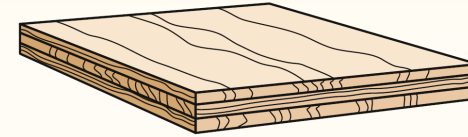
Wood

Composite Boards

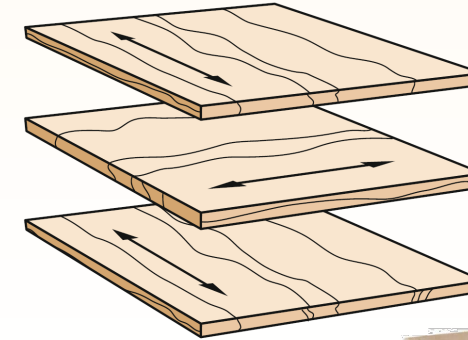
- › Multiple layers
- › Less deformation through shrinkage
- › High resistance to bending and impact

Aufbau einer Furnierplatte (FU)

dreilagige Furnierplatte



Absperren der Furniere
(kreuzweises Verleimen
von Schäl furnieren)



Materials

Wood

Medium-Density Fiberboard (MDF)

- › Breaking wood residuals into fibers
- › Wax or resin binder
- › Consistent in size and shape
- › Flexible
- › Higher density than plywood
- › Soaks water and swells/breaks



Why do we often use composite boards
and medium-density fiberboards?



Materials Overview

PAPER



WOOD



METAL



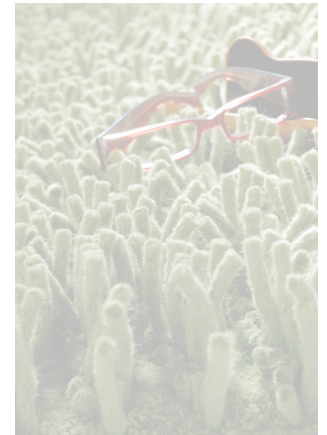
PLASTICS



CERAMICS



TEXTILES



Materials














Metal

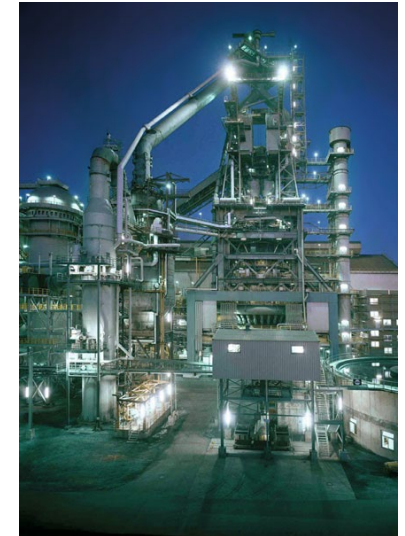
Metal

- › Electrical and thermal conduction
- › Luster (glossy, shiny)
- › Ductility (drawing, hardness)
- › Additional individual physical and chemical characteristics

Alloy

- › Mixture of elements (> 1 metal)
- › Often entirely different characteristics
- › Examples: stainless steel, brass, ...

Handelsformen von Stahlwerkstoffen	
Form	Bezeichnungsbeispiele
Stabstähle   	Flach DIN 174 – 40x4 – X6CrNiMoTi17-12-2 Blanker Flachstahl, 40 mm breit, 4 mm dick, aus rostfreier Stahl
	Rund DIN 670 – 50 – 9S20+C Blanker Rundstahl, Ø50 mm, ISO-Toleranzfeld h8 aus Automatenstahl 9S20, kaltverformt
	Vierkant DIN 1014 – 6 – C60 Warmgewalzter Vierkantstahl mit 6 mm Seitenlänge aus Werkzeugstahl
Formstähle   	U-Profil DIN 1026 – U60 – S355 U-Profil mit 60 mm Höhe aus Stahl S355
	I-Profil DIN 1025 – IPB100 – S275 I-Träger (oder Doppel-T-Träger), 100 mm hoch, aus Stahl S275
	L-Profil EN 10056 – 150x10x8 – S355 Ungleichschenkeliger Winkel, Schenkel 150 mm und 10 mm, Schenkeldicke 8 mm, aus Stahl S355
Hohlprofile, Rohre   	Rohr DIN 2391 – 12x1 – S355J2G3 Nahtloses Präzisionsrohr, Außen-Ø 12 mm, Wanddicke 1 mm, aus Stahl S355J2G3
	Rohr DIN 2906 – 800x100x10 – S235JRG1 Rechteckiges Vierkantrrohr, Aussenmaße 100 mm x 800 mm, Wanddicke 10mm, aus Stahl S235JRG1
	Hohlprofil EN 10210 – 70x70x6 – S355J2H, Quadratisches Hohlprofil, 70 mm breit, Wanddicke 6 mm, verzinkt, aus Stahl S355J2H
Bleche, Bänder  	Blech EN 10130 – 3 – DC05 – Bm Kaltgewalztes Blech aus weichen Stählen, 3 mm dick, beste Oberfläche, matte Ausführung
	Blech EN 10029 – 6x3000x4500 – S355J2+N Warmgewalztes Stahlblech, 6 mm dick, 3000 mm breit, 4500 mm lang, aus S355J2+N
Drähte  	Draht DIN 2077 – 50CrV4G25 warmgewalzter, runder Federstahl, Ø5 mm, aus 50CrV4, gegläht Draht DIN 2077 – 50CrV10 Warmgewalzter, runder Federdraht, Ø10 mm, aus 50CrV

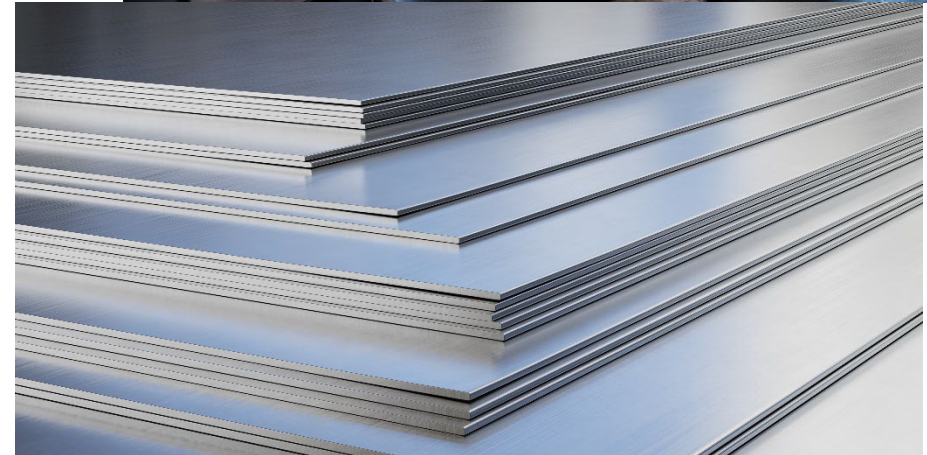


Materials

Metal

Sheet Metal

› Band or sheet segments

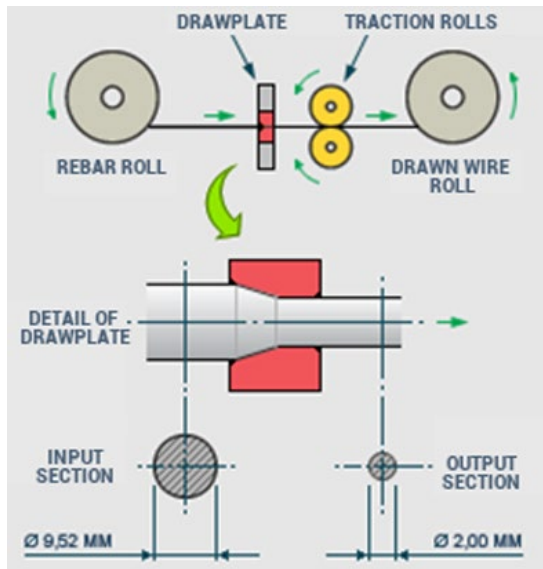


Materials

Metal

Wires

- › Typically round profile
- › Wire drawing is a complex process



Materials

Metal

High-tech Metals

- › Metal foam
- › Shape-memory alloys (e.g. Nitinol)
- › Amorphous metal
 - › Non-crystalline, glass-like
 - › Produced by extremely rapid cooling



Why are metal sheets preferably used?



Materials Overview

PAPER



WOOD



METAL



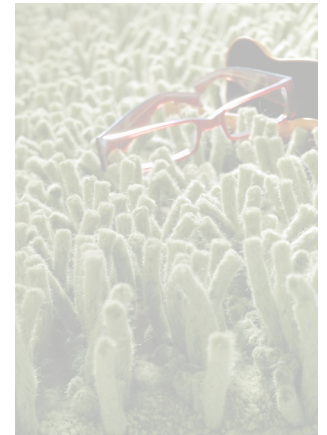
PLASTICS



CERAMICS



TEXTILES



Materials

Plastics

Plastics

- › Natural rubber or cellulose (19th c.)
- › Mostly **mineral oil**-based (today)
- › Long polymer chains
- › **Insulating**, from **soft to rigid**
- › Infinite possible shapes and colors
- › Difficult image:
 - › Peak of popularity in the 1970s
 - › Then image of cheap and poor quality
 - › Positive image again in the 1990s
- › Polluting, careful **recycling** required

“Blow Inflatable Armchair” (1967), Zanotta, Italy, PVC



Fiber-reinforced Plastics (1960), Vitra, Germany

Materials

Plastics

Classification

› Thermosetting Polymers

- › Close-mesh polymers
- › Extensive crosslinks (red)
- › Irreversible solidified

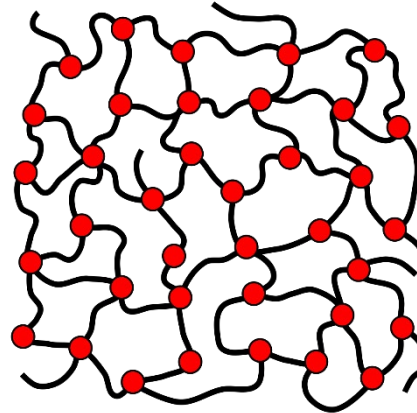
› Elastomers

- › Wide-mesh polymers
- › Sparse crosslinks (red)
- › Elastic

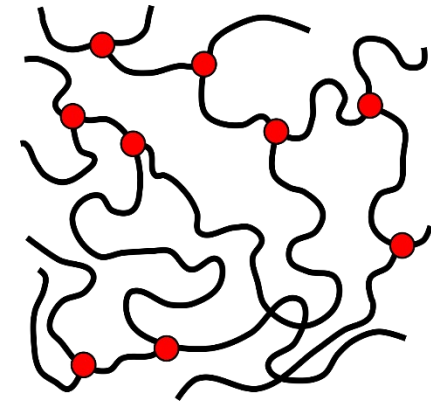
› Thermoplastics

- › Uncured polymers
- › Partially crystalline structures
- › Meltable

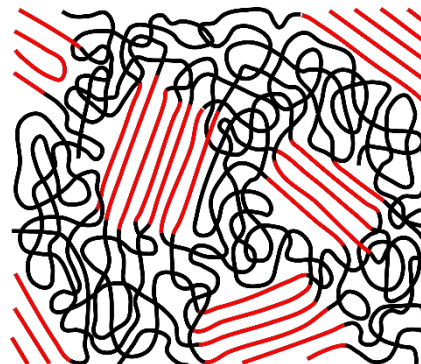
Thermosetting Polymer



Elastomers



Thermoplastics

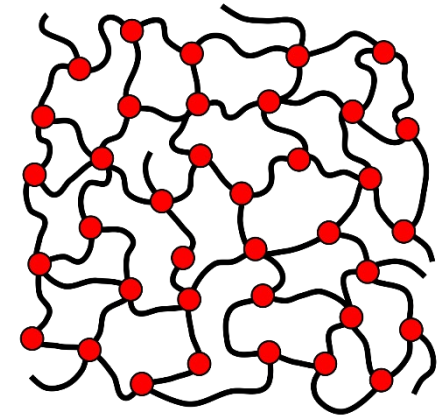


Materials

Plastics

Thermosetting Polymers

- › Irreversible hardening (**curing**) of a viscous liquid prepolymer (**resin**)
- › Polymerization through heat, solidifying upon cooling
- › Hard, amorphous, unsolvable polymers
- › **Do not soften again through heat**

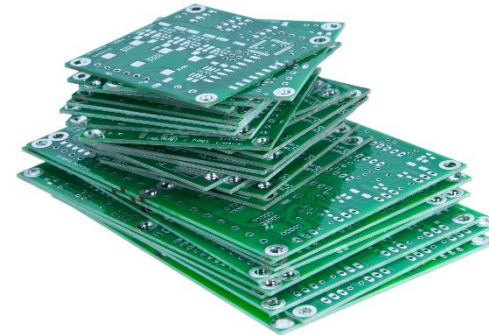


Materials

Plastics

Thermosetting Polymers

- › Polyester Resin
- › Epoxy Resin (EP)
- › Phenolic Resin (PF) – Bakelit
- › Aminoplastic – Melamine
- › Polyurethane (PU)

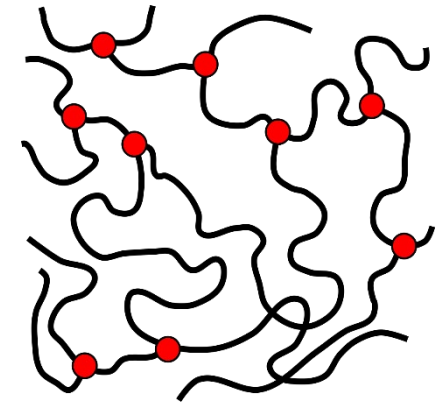


Materials

Plastics

Elastomers

- › Amorphous polymers with weak intermolecular forces
- › Viscoelasticity, flexible, deformable at ambient temperature
- › Usually require **vulcanization** to form cross-links through heat (curing)

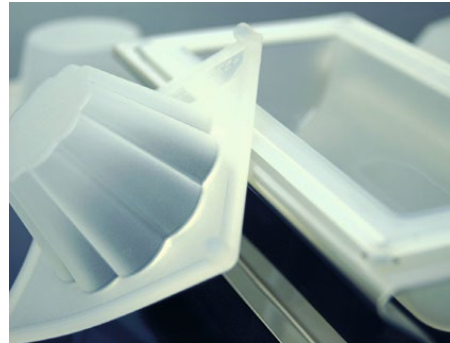


Materials

Plastics

Elastomers

- › Natural Rubber (Latex)
- › Rubber
- › Silicone
- › Acrylic Rubber
- › Thermoplastic Elastomers (TPE)

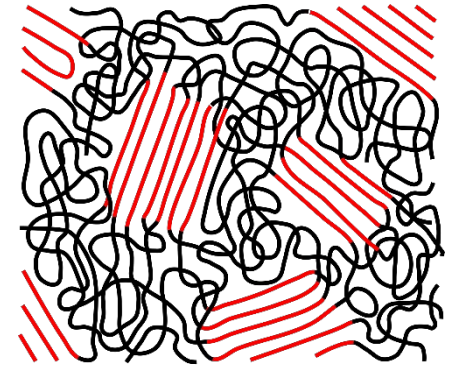


Materials

Plastics

Thermoplastics

- › Thermo-softening plastics
- › **Moldable** at a certain temperature
- › Solidifies upon cooling



Materials

Plastics

Thermoplastics

- › Polyethylene (PE)
 - › most popular, rigid, chemically stable
- › Polypropylene (PP)
 - › very lightweight, rigid and hard
- › Polystyrene (PS)
 - › glossy, weather-resistant, rigid, hard, e.g. Styropor
- › Polycarbonate (PC)
 - › crystal clear, resistant, rigid, isolating
- › Polyvinyl Chloride (PVC)
 - › cheap, chemically stable
- › Polyamide (PA)
 - › abrasion and light resistant, chemically stable

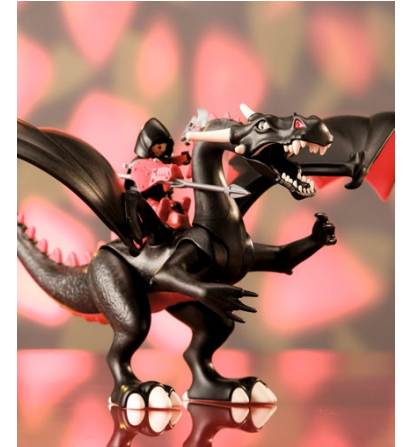


Materials

Plastics

Thermoplastics

- › Polymethyl Methacrylate (PMMA)
 - › transparent, flexible, e.g. Acrylic and Plexiglas
- › Polyoxymethylene / Polyacetal (POM)
 - › rigid, hard, chemical resistant
- › Ethylene Vinyl Acetate (EVA)
 - › transparent, flexible, stable, chemical resistant
- › Fluoropolymers (e.g. PTFE, FEP, ...)
 - › highest chemical resistance, fire-proof, soft, flexible
- › Polyester
 - › Polybutylene Terephthalate (PBT)
 - › Polyethylene Terephthalate (PET)
 - › milky-white, abrasion-resistant, rigid, isolating



Which class of plastics do
Polylactide (PLA) and
Acrylonitrile Butadiene Styrene (ABS)
belong to?



Materials Overview

PAPER



WOOD



METAL



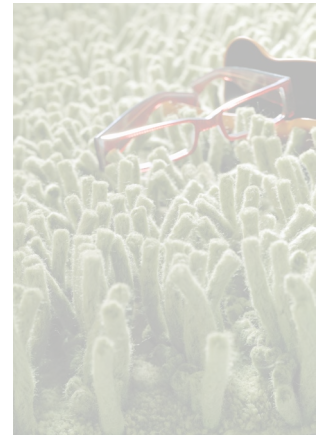
PLASTICS



CERAMICS



TEXTILES

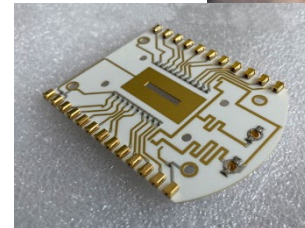


Materials

Ceramics

Ceramics

- › Everything started with clay, loam, and water
- › Baked clay (20,000 b.C.)
- › Today, also glass, enamel, gypsum, cement
- › Diverse additives
- › Hard, insulating, chemical, temperature, and abrasion resistant
- › Roof tiles, bricks, and clinker
- › Meißen porcelain (Saxony, Germany)
- › Dishes and kitchen utensils
- › Sanitary facilities
- › Technical ceramics (insulators, substrates, ...)



Materials

Ceramics

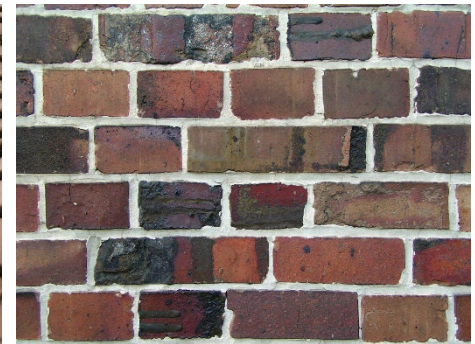
Silicate Ceramics

› Porcelain

- › Only natural clay mineral materials: kaolin, quartz, feldspar
- › White, translucent shard, hard, electrically insulating, non-corroding

› Building Materials

- › Baking of clay and silicon dioxide
- › Additives: chamotte, silica, and magnesite
- › Particularly acid- and temperature-resistant
- › Clinker: dense, frost- and pressure-resistant
- › Tiles: flat, impact-resistant

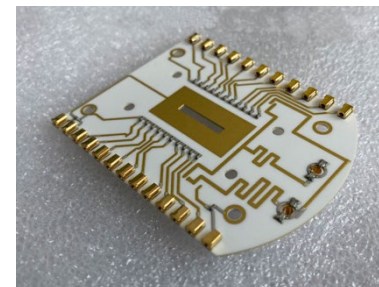
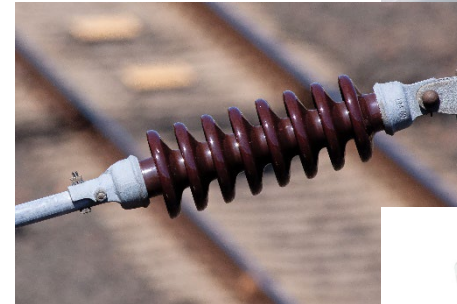


Materials

Ceramics

Silicate Ceramics

- › Earthenware
 - › Baking of clay and silica
 - › Additives: chamotte, silica, and magnesite
 - › Sanitary facilities, garden pots, pottery
 - › High porosity, white or yellow-orange to red-brown shard
- › High-performance Ceramics
 - › Steatite, cordierite, ...
 - › Mechanically and thermally resilient, stable and electrically isolating
 - › White-gray shard



Materials

Ceramics

Ceramics

- › Aluminium Oxide
- › Zirconium Oxide
 - › Very hard
- › Silicon Carbide
 - › High temperature resilience, thermally conductive, corrosion- and chemical resistant, very high hardness

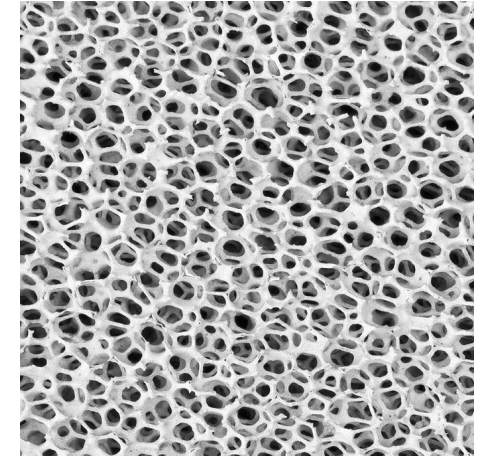


Materials

Ceramics

High-tech Ceramics

- › Bioceramics
 - › Bio-compatible or even eventually replaced by body-inert materials
- › Ceramic Foams
 - › Very high porosity, very light, very good insulation properties
- › Superconductors
 - › At the critical temperature, the resistance abruptly drops to zero
- › Heat Shields
 - › Thermal insulation, e.g. space shuttles



Materials Overview

PAPER



WOOD



METAL



PLASTICS



CERAMICS



TEXTILES



Materials

Textiles

Textiles

› Felt

- › Originally from animal hair
- › Today, mostly synthetic felt

› Crochet vs. weaving

Materials

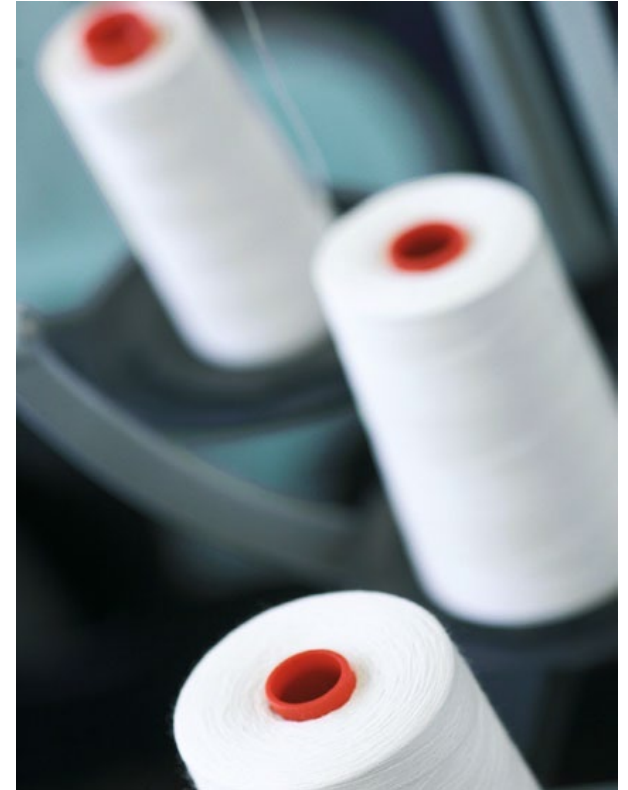
Textiles

Threads

- › Natural threads
- › Chemical threads
- › Yarns = spun threads

Fibers and Filaments

- › **Fibers:** finite length (staple length)
- › **Filaments:** theoretically infinite

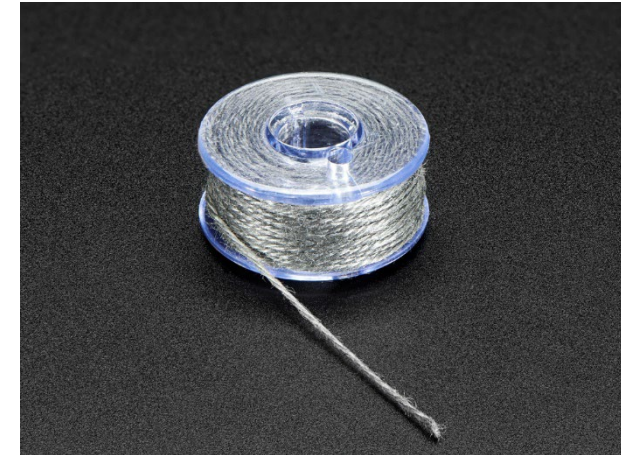


Materials

Textiles

High-tech Textiles

- › Spider Silk
 - › Natural
 - › Artificial
- › Conductive Fabrics
 - › Coated threads



Which materials to choose
for your prototype or product?



Materials Selection

Selection of Materials

- › Prototype or market-ready product?
- › Requirements on the materials
 - › Physical characteristics
 - › Suitable manufacturing processes
 - › Required machines
 - › Costs of material and fabrication
- › Perceptual requirements



Materials

Summary

- › Diverse materials
- › Diverse **physical characteristics**
- › Different complexity in handling
- › Different areas of application
- › Provoke **emotional responses**

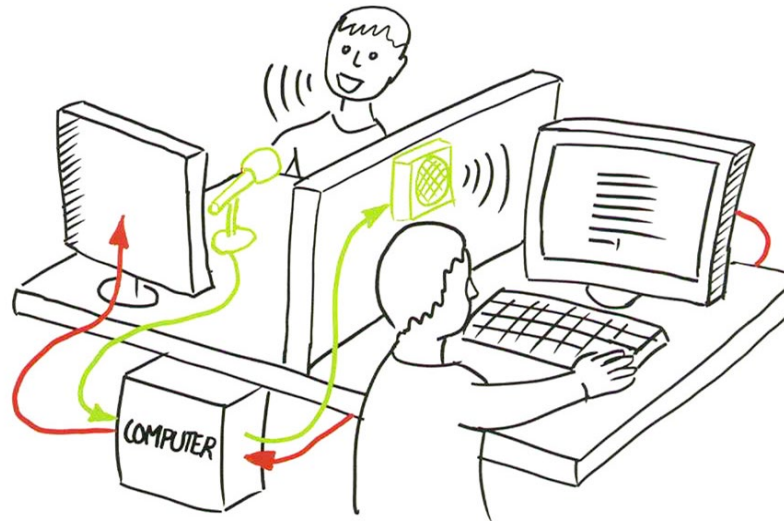
What are your questions?



Project Wizard of Oz

Wizard of Oz

- Simulates functionality with a “human computer” (wizard).
- The user has the impression that the system is working as intended.
- Based on the novel “The wonderful wizard of Oz” (Lyman Frank Baum, 1900).



Wizard of Oz

- <https://youtu.be/X7Fkmf0XHiY>
- https://youtu.be/WtrO6b_oUYI
- <https://youtu.be/Z3fq0UJL7Kw>
- https://youtu.be/vetw8sE8I_s
- <https://youtu.be/xQ8BerhpWk4>



Quelle <https://youtu.be/X7Fkmf0XHiY>

Project

Feasibility and Safety

Feasibility



Technical Feasibility



Economic Feasibility



Legal and Ethical Feasibility

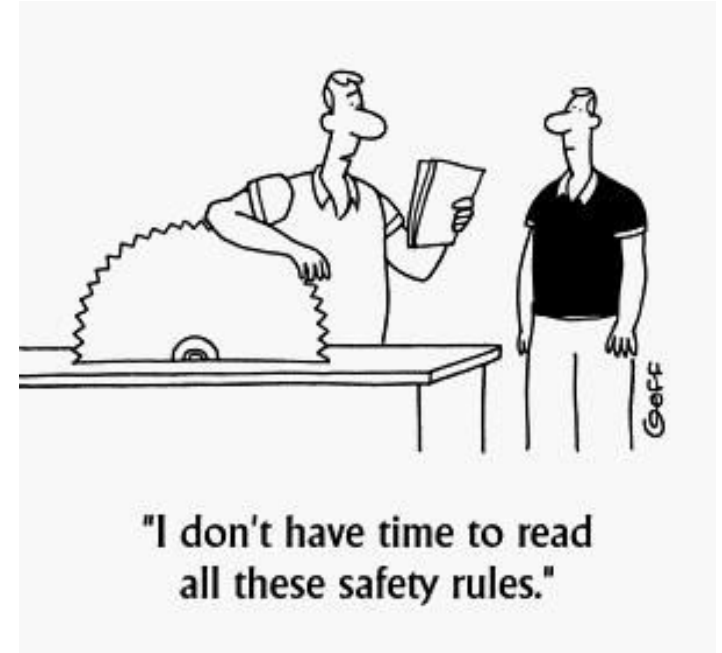


Time Constraints



Safety Considerations

- Practice electrical safety: use caution.
- Exercise heightened caution when positioning sensors or actuators in proximity to the body, particularly near sensitive areas such as the eyes.
- Be aware of voltage and current limits for components.
- When in doubt: Work under supervision and seek guidance from us.



Project

Milestone 2: Prototyping Submission

Project Milestone 2: Prototyping Submission

Group Submission, due date is Tuesday, December 3, 2024 until 23:59h

1. Market Research (2 points)

- › Research existing products similar to your idea.
- › Identify their weaknesses, limitations, or areas where they could be improved.
- › Tailor your core concept based on your findings.

2. Feasibility Assessment (2 points)

- › Engage in critical reflection and thoughtful reasoning to evaluate your idea's feasibility (in scope of this course).
- › Discuss technical, legal, and ethical aspects of your idea.

3. Form Factor (4 points)

With the help of drawings clarify the following aspects of your products' physical form:

- › Physical appearance
- › Affordances
- › Size estimation – consider a reasonable energy source such as a battery
- › Materials that align with design goals
- › Configuration for user-centric functionality and interactions

Project Milestone 2: Prototyping Submission

4. Advanced Mockup (10 points)

- › Use a 3D CAD program like Fusion360 (preferred) or a vector-based graphics tool to design a prototype.

5. Reflection (2 points)

- › A brief of your understanding, experience, knowledge, learning process, challenges faced, and insights gained.
- › Allocation of work for each group member.
- › Must not exceed one page.

Project Milestone 2: Prototyping Submission

Submission Details

Group Submission of a *.zip archive "group[number]_project_concept.zip", containing the following files:

- A *.pdf of your market research (about 0.5 page).
- A *.pdf of your feasibility assessment (about 0.5 page).
- A *.pdf of your form factor descriptions (about 1 page).
- Depending on your chosen tool, hand in only one of these formats:
 - 3D-CAD file (*.f3d [preferred] or *.STEP)
 - Vector graphics file
- A *.jpeg or *.png of your rendered prototype.
- A *.pdf of your reflection (max. 1 page).

• Deadlines are strict!
Late submissions are
not considered.

Thank You!



Design & Fabrication

Dr.-Ing. **Florian Wolling** (Lecture), M.Sc. **Ambika Shahu** (Exercises),
Thomas Mantschko (Tutor), Prof. Florian Michahelles

Technische Universität Wien

Artifact-Based Computing & User Research (<http://media.tuwien.ac.at>)
florian.wolling@tuwien.ac.at, ambika.shahu@tuwien.ac.at

