ES 115
Design, Innovation and prototyping

5 Human factors

Design and Innovation Centre
IIT Gandhinagar

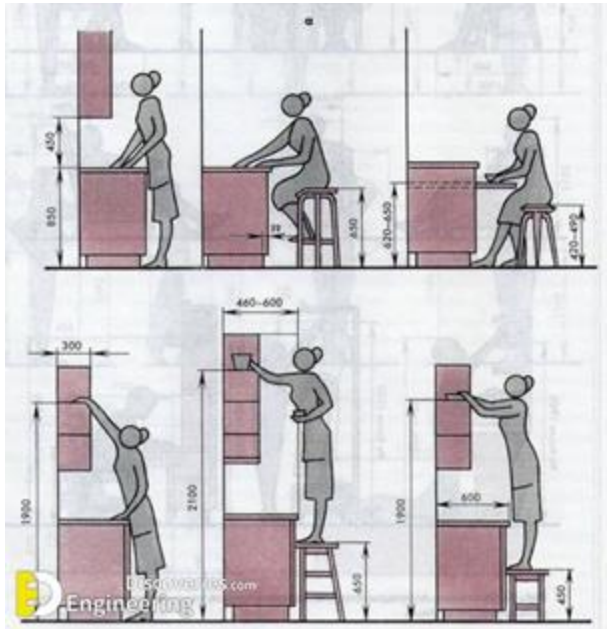
Manasi Kanetkar
September 2024

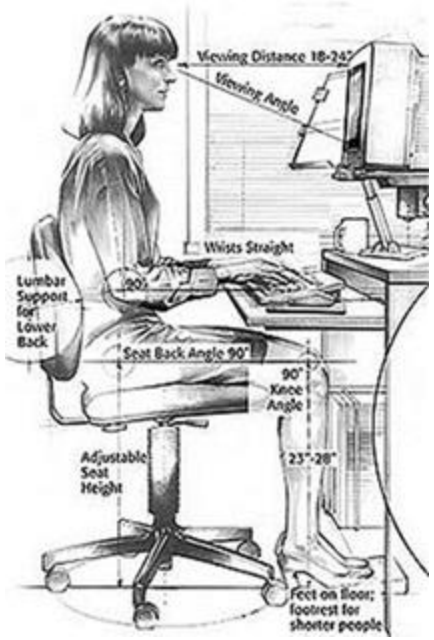
Human factors

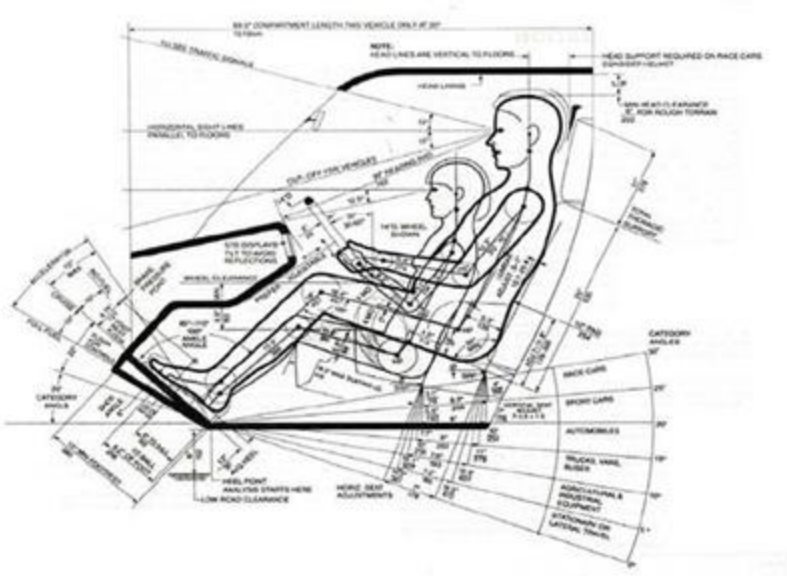
Study of human **behavior, abilities, limitations, application to design** of systems, tasks/activities, environments, equipment and technologies.

Human factors

Construction of **good methods of work,** in order to have *minimum expenditure* of human energy for *maximum production*.







An ergonomic product/ space is…..

Safe

Comfortable

Intuitive

Inclusive

Safety

Safety

Indicators

Protective gear

Protocols

Safety against injuries

Blunt force trauma

Cuts and bruises

Burns

Toxic substances

Safety against RSI

Repetitive strain injury:

Workers in certain fields are at risk of repetitive strains.

Most occupational injuries are ***musculoskeletal disorders***, and many of these are caused by cumulative trauma

Comfort

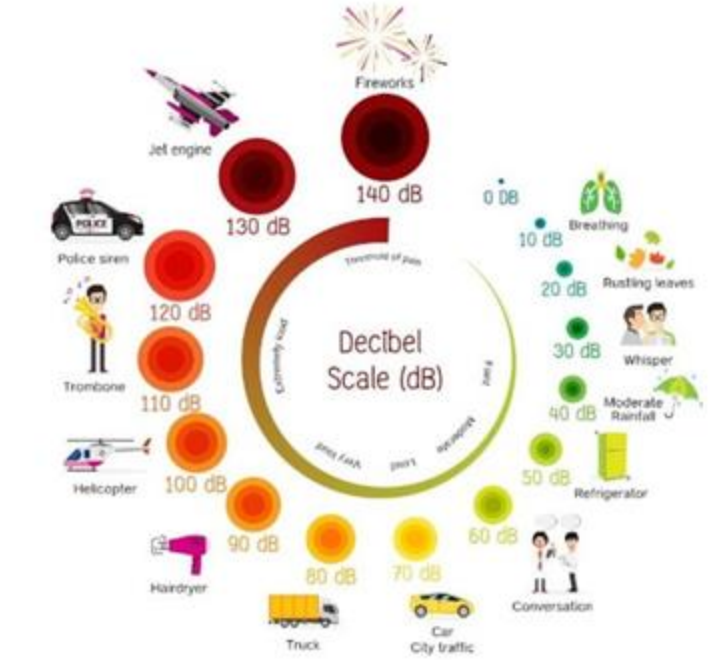
Comfort

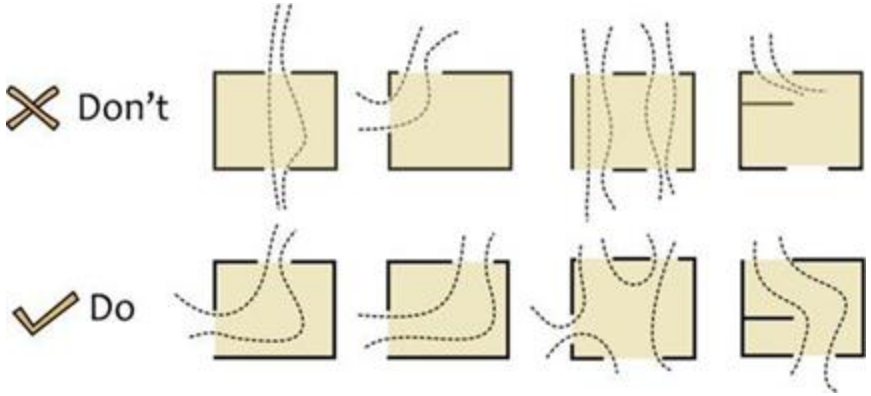
Lighting

Ventilation

Sound levels

Temperature





Comfort

Breathability

Textures

Weight

Intuitiveness

Intuitive

Clarity of thought

and decision

Norman doors

Book: Design of Everyday things by Don Norman

Intuitive

- Controls for interfaces
- Feedback loops

Inclusive

Inclusive

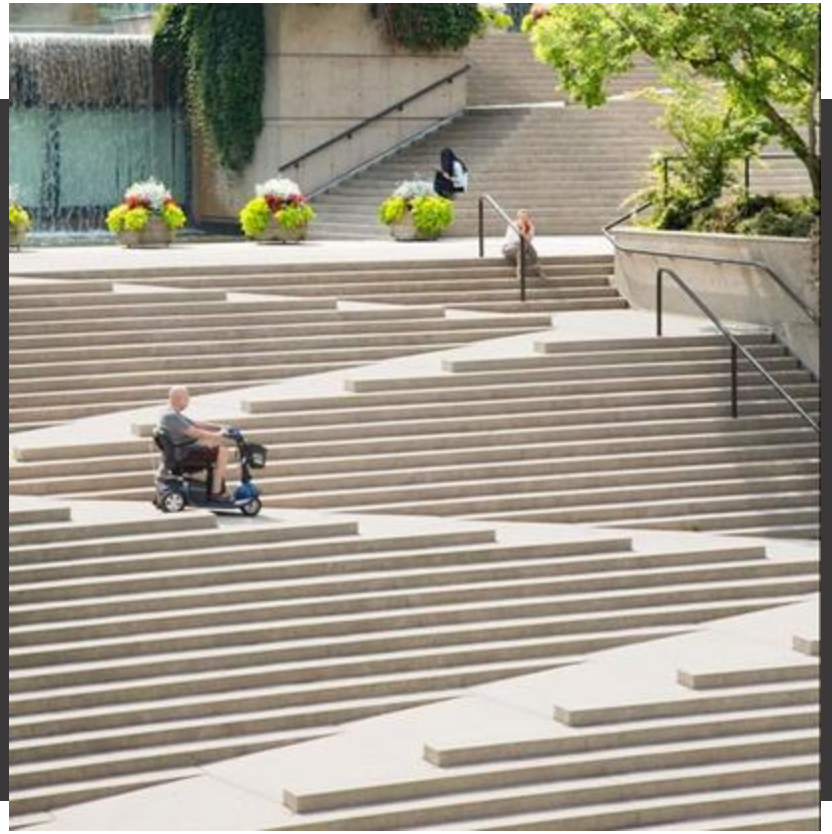

REDesign Exit
For Everyone
Children
Adult
Disabled
People in the fire
(Smoke everywhere)

Inclusive

Physical abilities

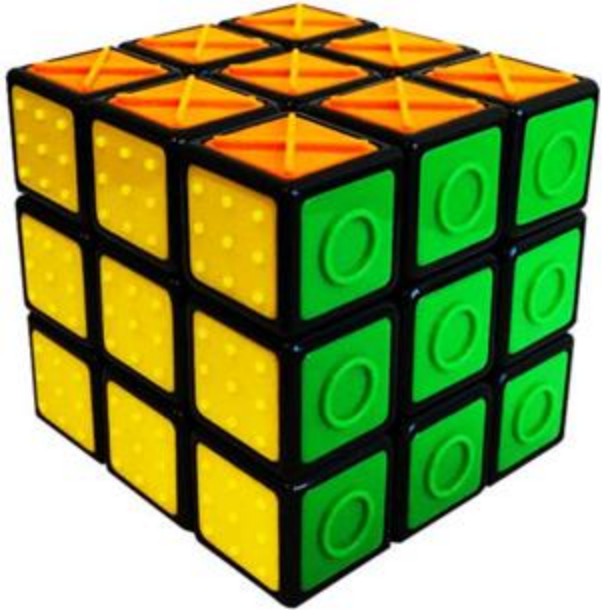
Stimuli cutlery: Jinhyun Jeon

Oneware: Lim Loren



Robson Square waterfalls Vancouver, B.C. Canada Planned and designed 1973

Inclusive



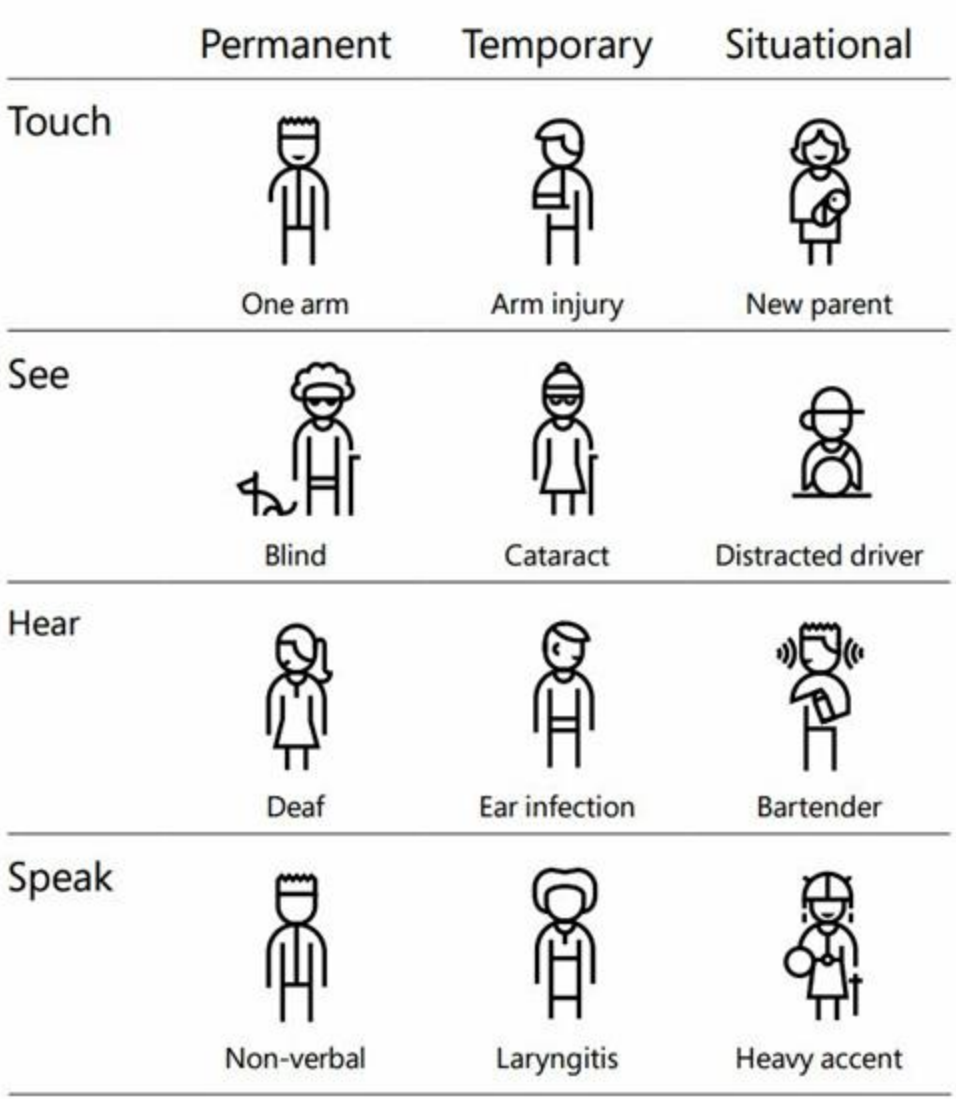
Rubik's tactile cube

Inclusive

Physical abilities

Inclusive

Spectrum of disability



https://www.microsoft.com/design/inclusive/
Inclusive design 101

Inclusive
A Microsoft Design Toolkit

Inclusive

Language barriers to

be removed

Specializations

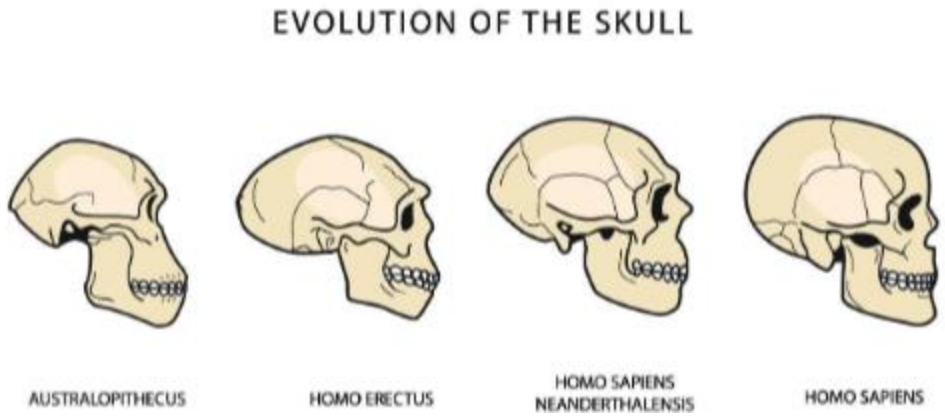
Domains of specialization

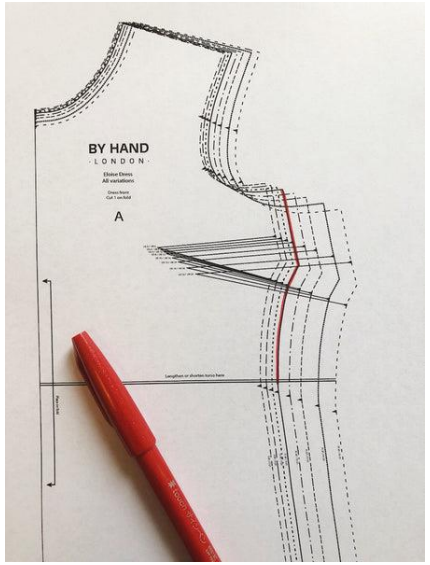
- Physical ergonomics
- Visual ergonomics*
- Organizational ergonomics
- Cognitive ergonomics

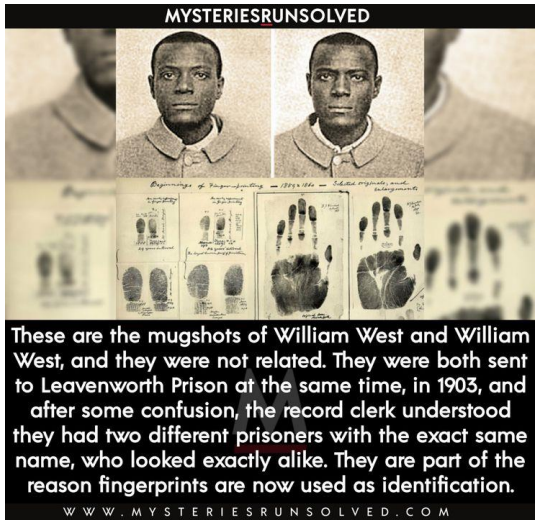
Visual ergonomics may not be recognized as a separate specialization by many; but has distinct thumb-rules for visual design

Physical ergonomics

Is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to **physical** activity.





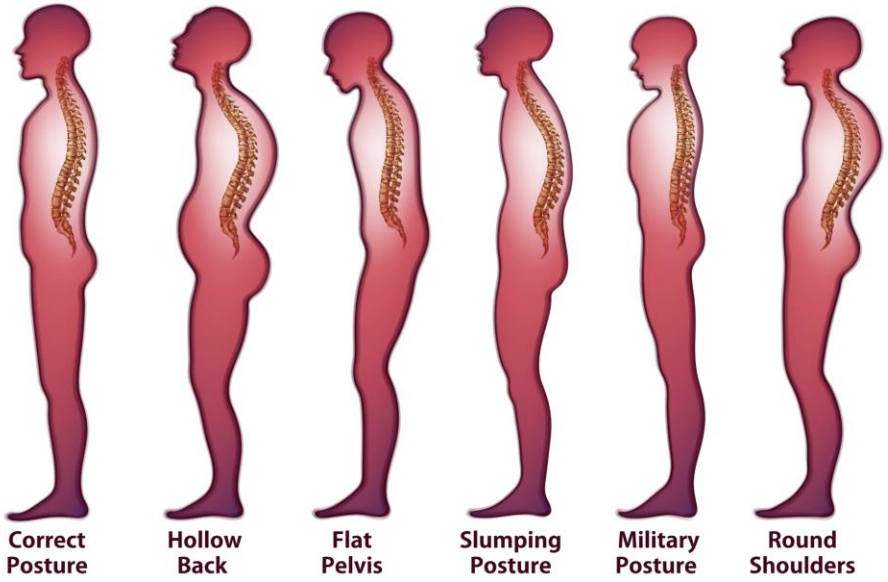


Physical ergonomics - dimensions

pngtree.com

Physical ergonomics - Safety

Physical ergonomics - postures + practices



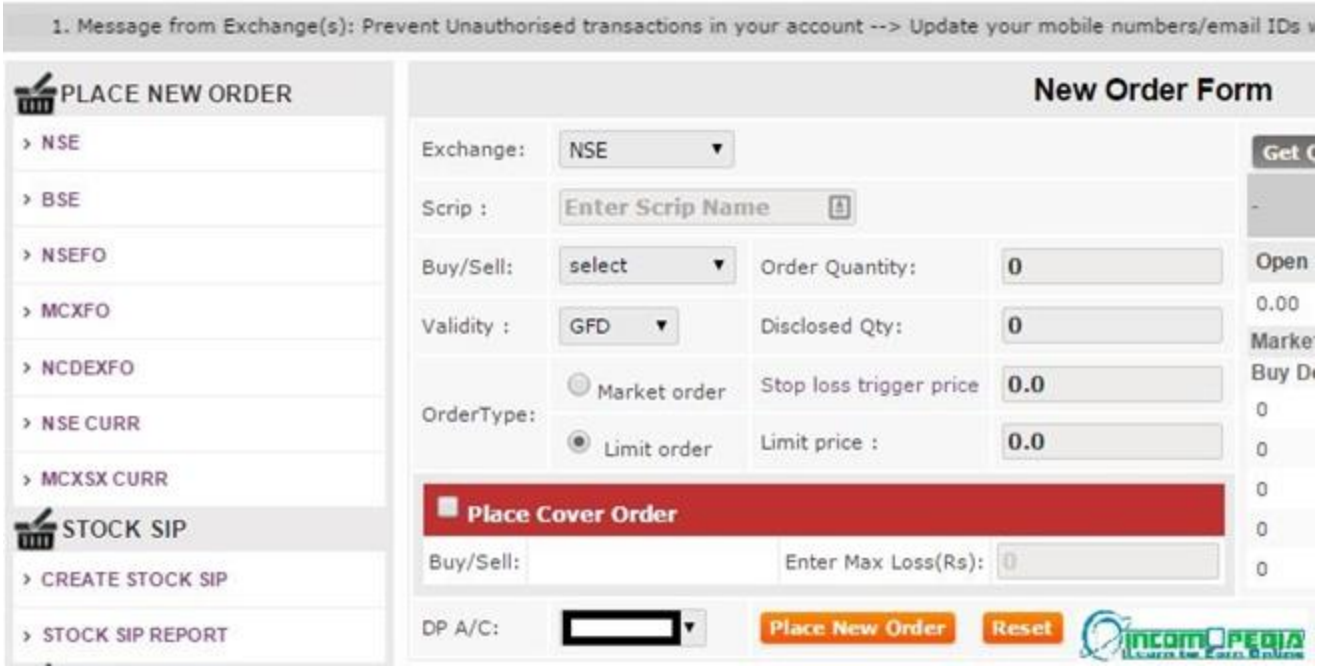
Visual ergonomics

- Concerned with **visual processes**: viewing comfort + safety.
- It deals with **readability, legibility** and avoiding visual stresses

Visual ergonomics may not be recognized as a separate specialization by many; but has distinct thumb-rules for visual design

Visual ergonomics : displays

Visual ergonomics : Interfaces

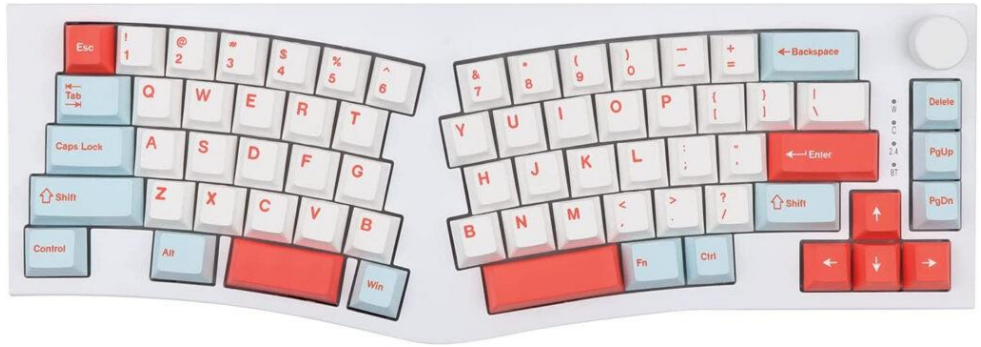


Organizational ergonomics

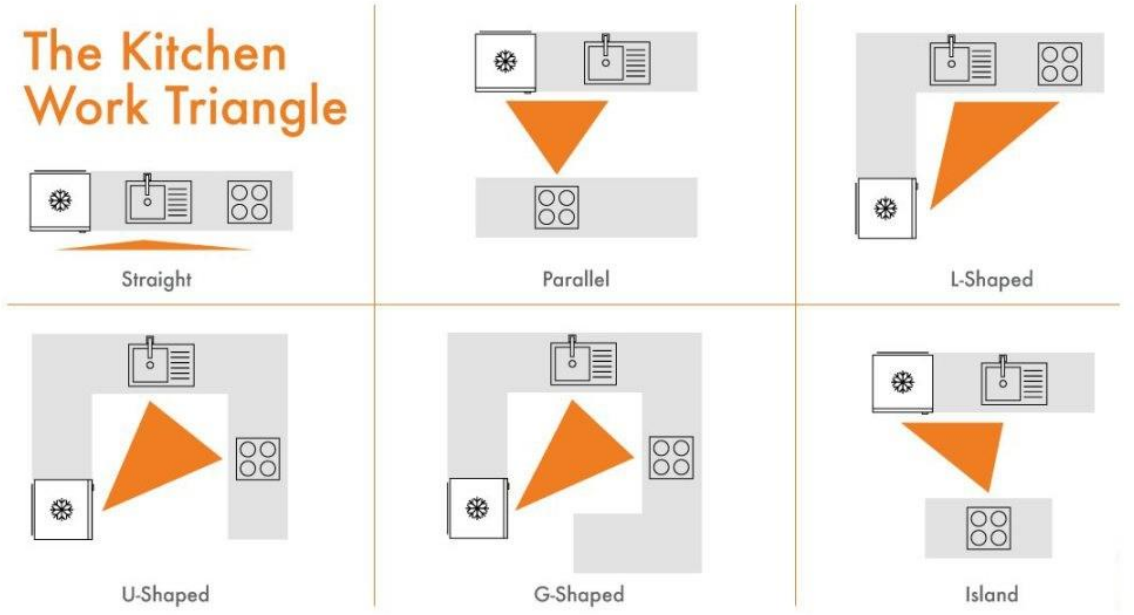
Socio-technical **systems**, organizational structures, policies, and processes.

- Work design
- Design of working times
- Teamwork, Cooperative work

Organizational ergonomics: Layouts

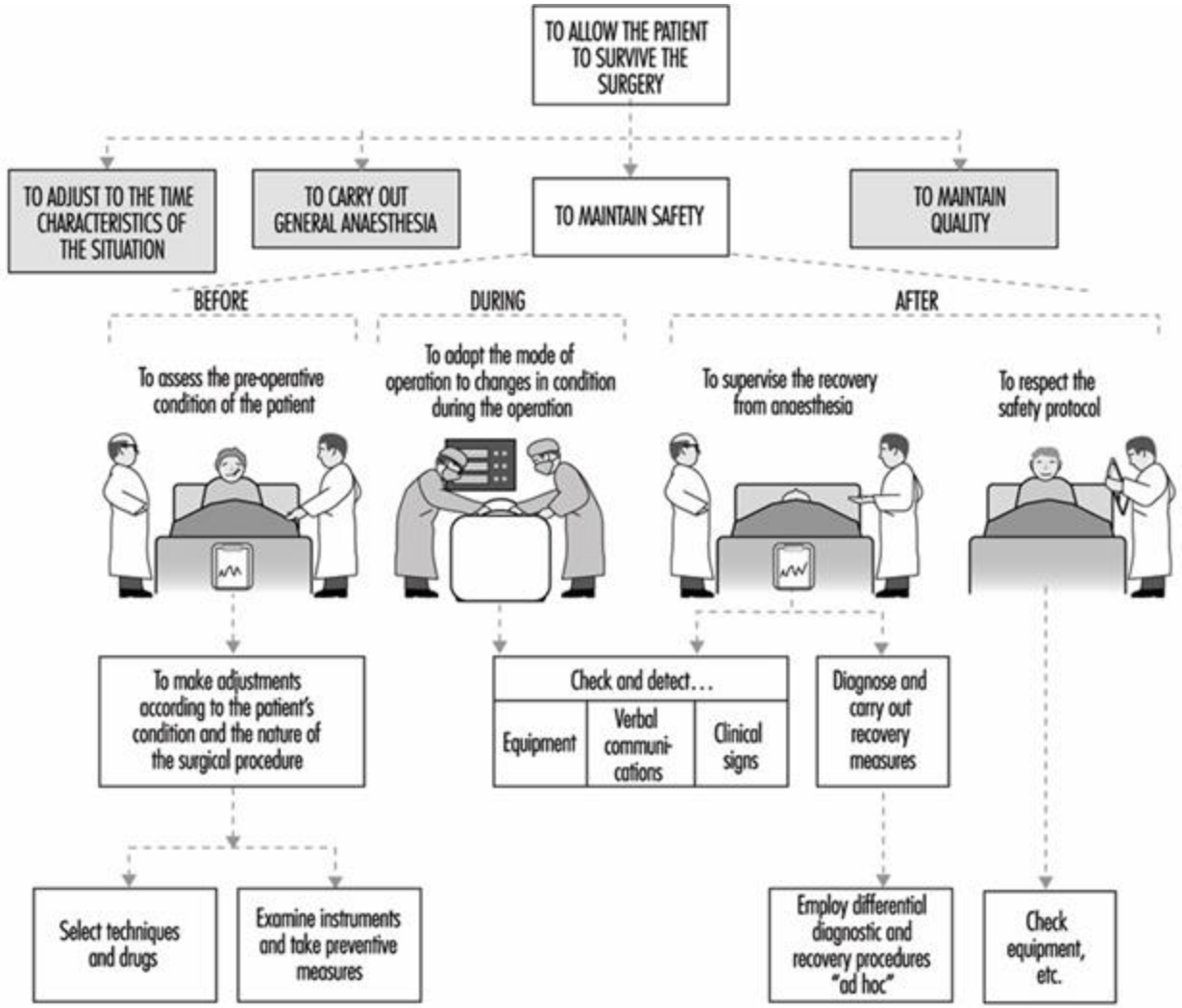


https://technobrax.com/what-is-an-alice-keyboard/



https://danielscottkitchens.co.uk/blog/can-the-work-triangle-improve-your-kitchen-design/

Organizational ergonomics: Process



Source: De Keyser and Nyssen 1993.

Organizational ergonomics: policies

Ensuring the physical and mental well-being of employees

Studying and understanding human behavior in the workplace

Improving both individual and organization performance

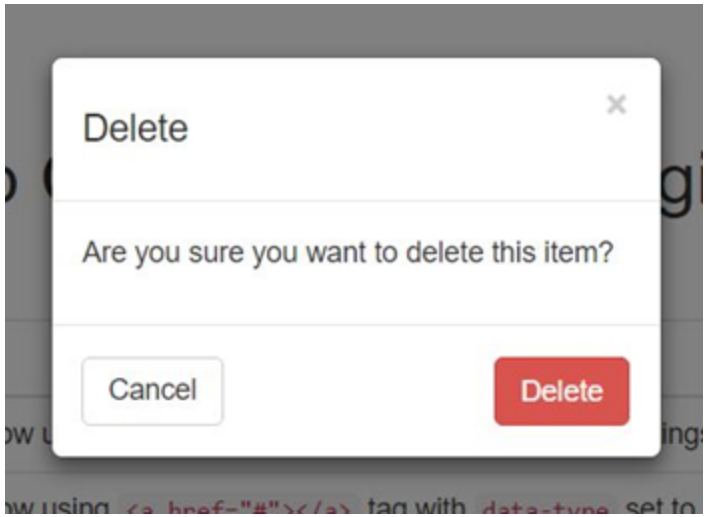
Increasing workplace productivity

Cognitive ergonomics

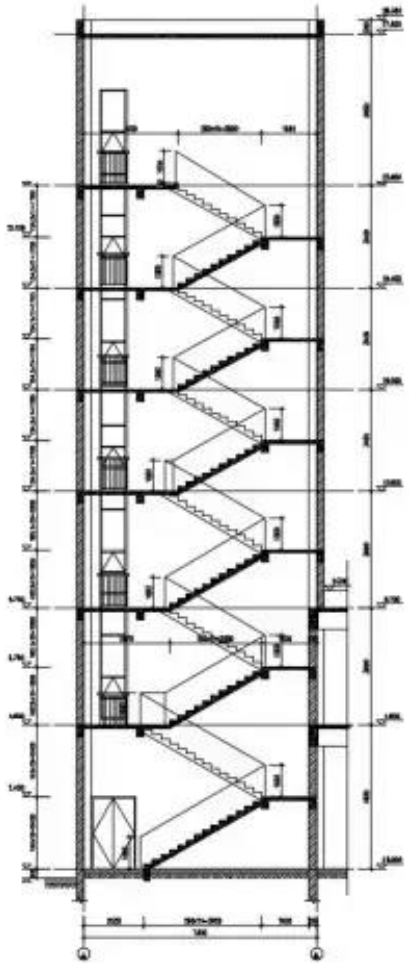
Is concerned with **mental processes**, such as perception, memory, reasoning, and motor response

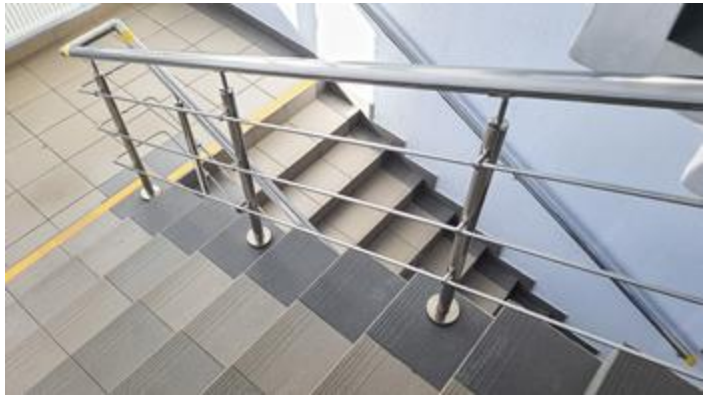
- Mental workload
- Decision-making
- Skilled performance
- Human-machine interaction

Cognitive ergonomics



Messages/ warnings





Fire safety in staircases

Cognitive ergonomics

Bad examples

Cognitive ergonomics

Bad example

Summary

- An ergonomically designed product is: ***safe, comfortable, inclusive and intuitive***
- **Specializations:** physical, visual, cognitive and organizational ergonomics
- Construction of ***good methods of work :*** minimum expenditure of human energy and maximum production.

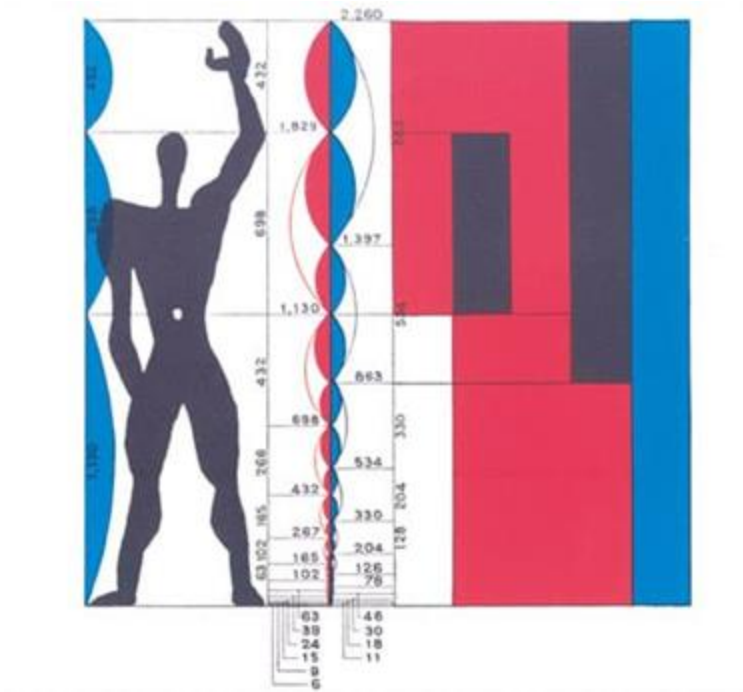
Visual ergonomics may not be recognized as a separate specialization by many; but has distinct thumb-rules for visual design

Applied ergonomics

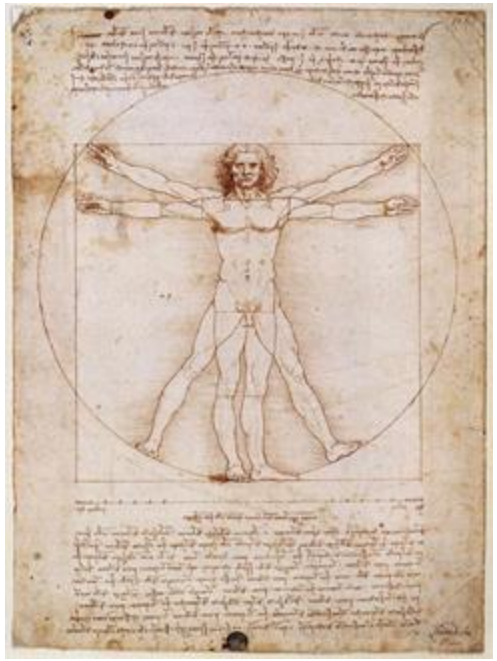
- Anthropometry
- Design for ergonomics
- Thumb Rules

Good read: https://ehs.oregonstate.edu/sites/ehs.oregonstate.edu/files/pdf/ergo/ergonomicsanddesignreferenceguidewhitepaper.pdf

Anthropometry

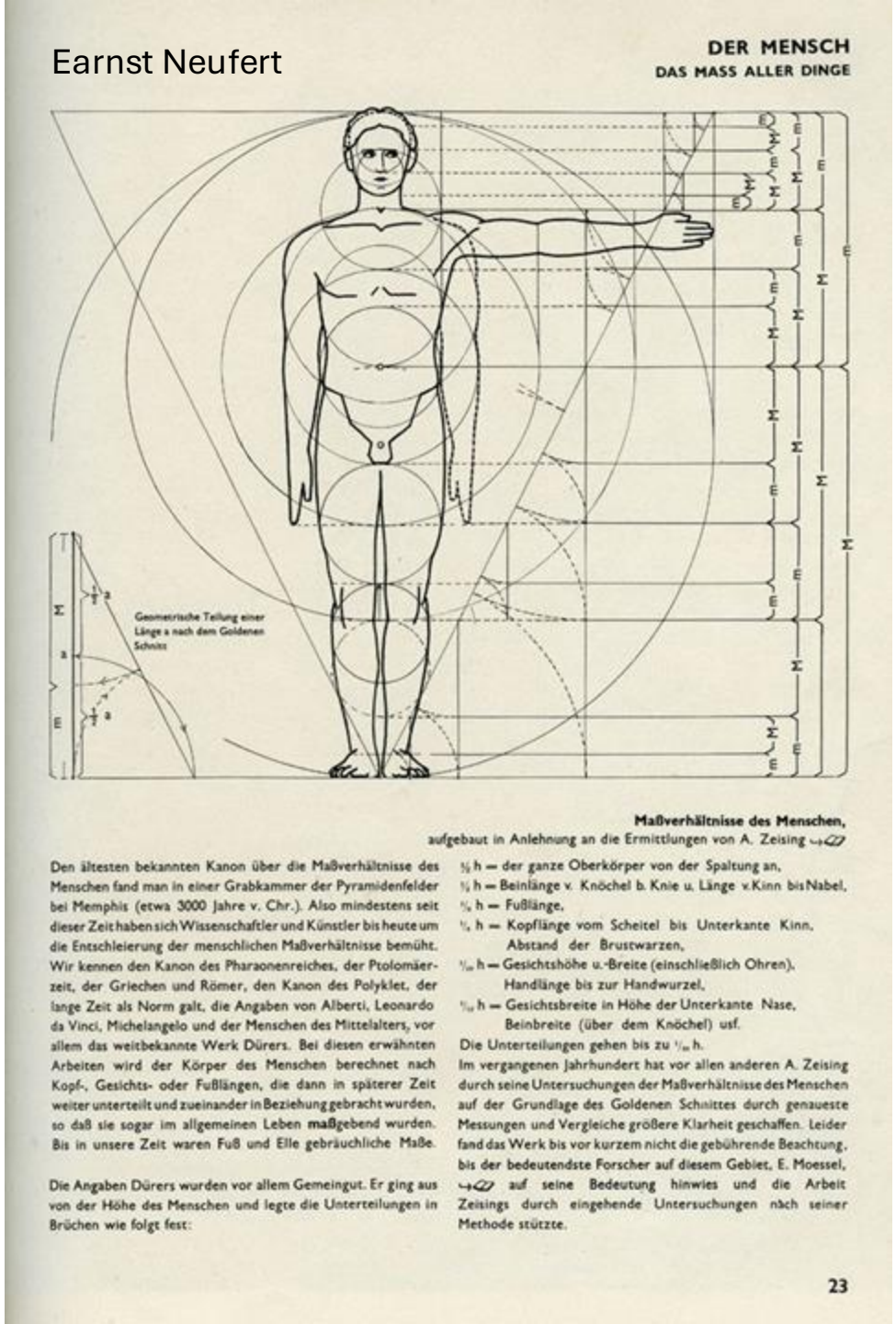


The Corbusier man
Le Corbusier



The Vitruvian man
Leonardo Da Vinci

Earnst Neufert



Anthropometry

- Measurements of the human body
- Product/space dimensions should **fit** extremes.
- Is used in various fields such as biometric design, forensic sciences, evolutionary biology etc
- Plays an important role in industrial design, clothing design and architecture to optimize products/spaces for use

Anthropometry: Need

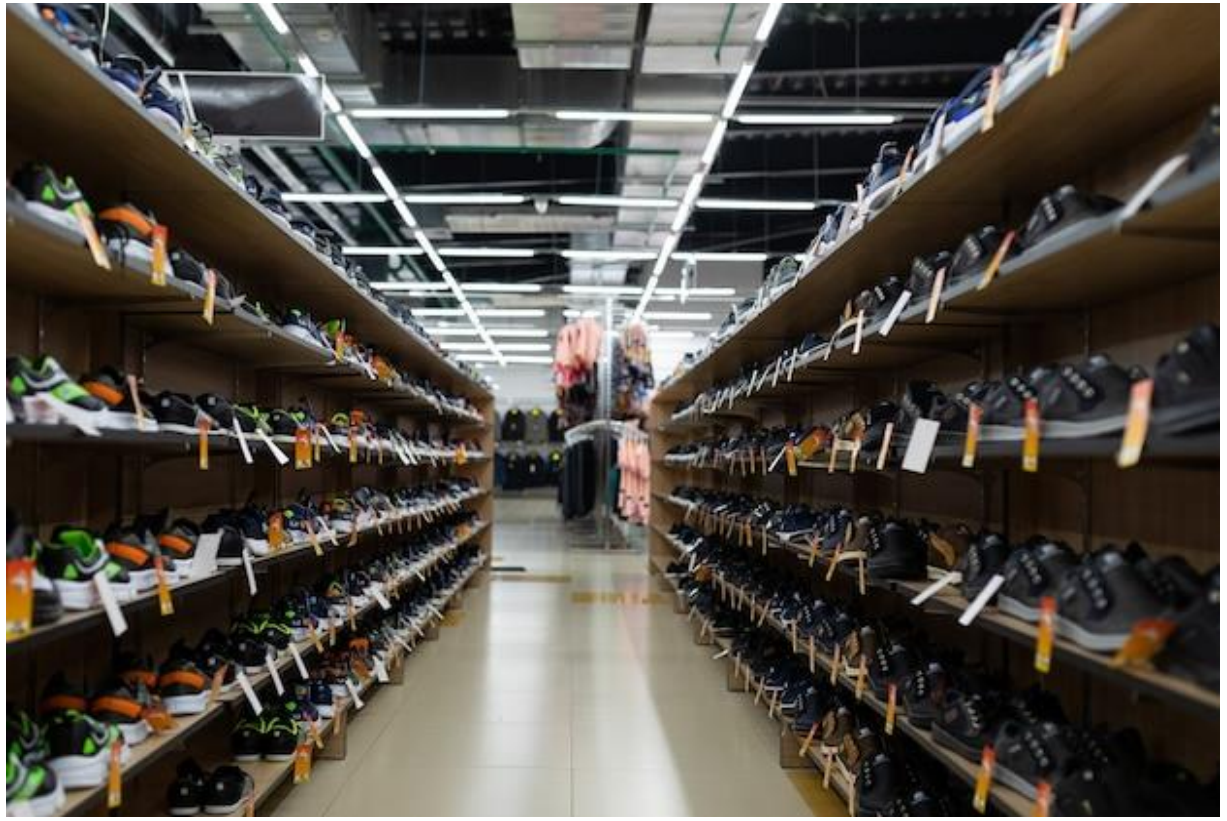
Custom-made products according to individual customer’s need

Anthropometry: Need

What happens when you have to mass produce a product?

“India is the second largest global producer of footwear (**16 billion pairs**)

- India Trade Fair report, 2019



https://indiatradefair.com/uploads/About_Indian_Footwear_Industry_14_05_2019.pdf

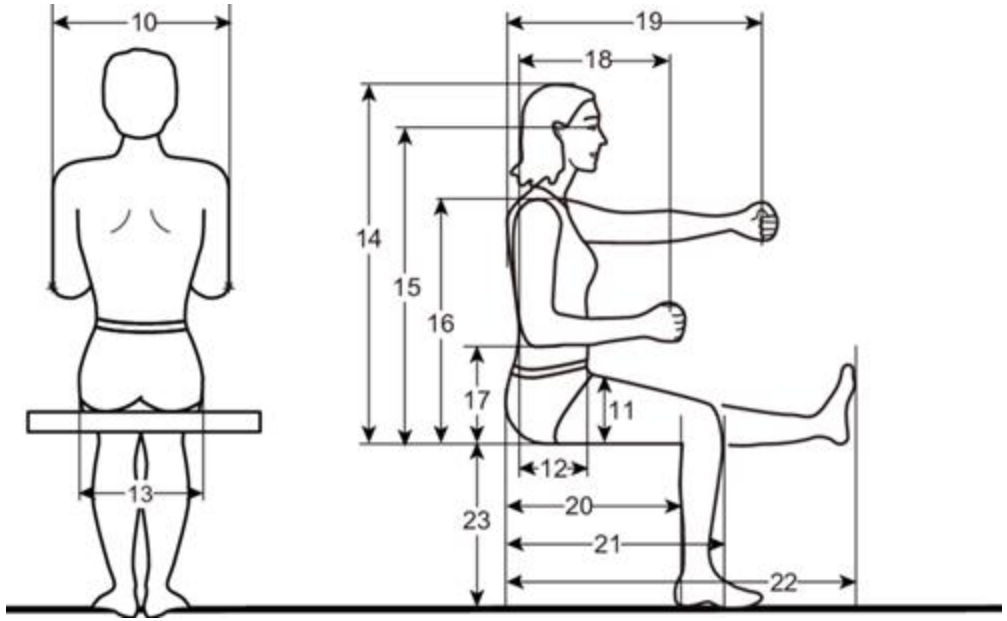
Anthropometric data

DINED / Anthropometry in design

Indian Anthropometric Dimensions for Ergonomic Design Practice - Debkumar Chakrabarti

The Measure of Man: Human Factors in Design, Henry Dreyfuss

R No.	Parameters		Min	Percentiles					Max	Mean	±SD	Ratio
				5th	25th	50th	75th	95th				
1	Weight, Kg.	Male	34	42	48	54	62	76	118	57	11	
		Female	30	35	41	48	55	66	88	49.5	9.9	
		Combined	30	40	47	53	60	74	118	55.2	11.3	
2	Normal standing	Male	1396	1529	1598	1645	1688	1751	1939	1645	74	0.99
		Female	1276	1406	1457	1504	1548	1615	1681	1506	68	0.99
		Combined	1276	1439	1541	1610	1671	1741	1939	1607	98	0.99
3	Stature	Male	1486	1537	1599	1648	1691	1781	1950	1650	70	1
		Female	1288	1429	1478	1517	1567	1632	1711	1523	66	1
		Combined	1288	1465	1555	1619	1673	1771	1950	1614	87	1
4	Eye	Male	1293	1419	1485	1529	1571	1645	1821	1530	68	0.93
		Female	1215	1315	1368	1411	1454	1514	1600	1411	62	0.93
		Combined	1215	1355	1445	1507	1557	1633	1821	1502	84	0.93



Percentile data

It's a characteristic of human variation that ***most people are near to the average***, then there are proportionately fewer and ***fewer people towards the extremes***.

R No.	Parameters		Min	Percentiles					Max	Mean	±SD	Ratio
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1	**Weight, Kg.**	Male	34	42	48	54	62	76	118	57	11	
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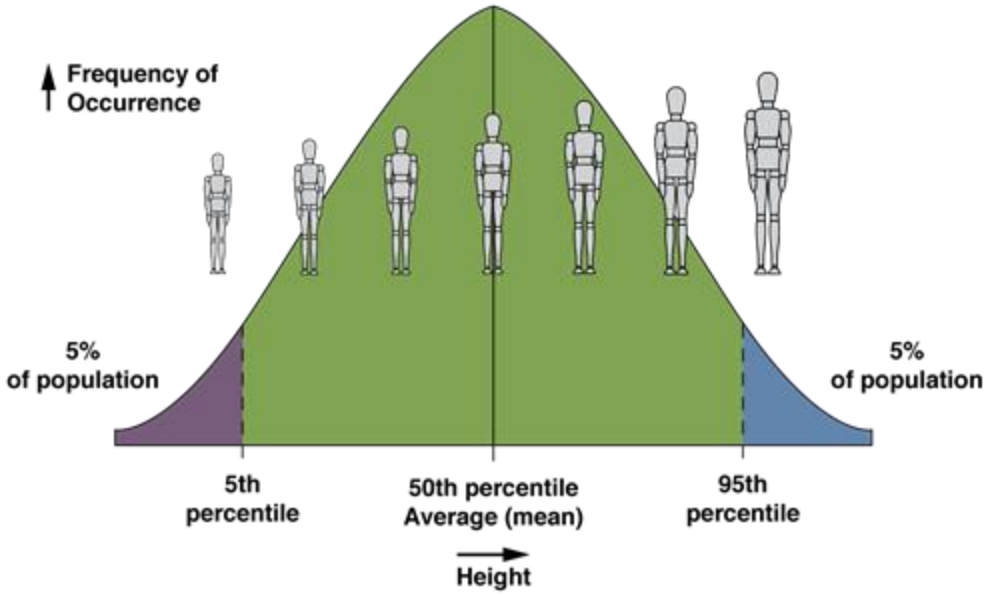


https://www.bostontec.com/designing-an-industrial-workbench-for-adjustability/

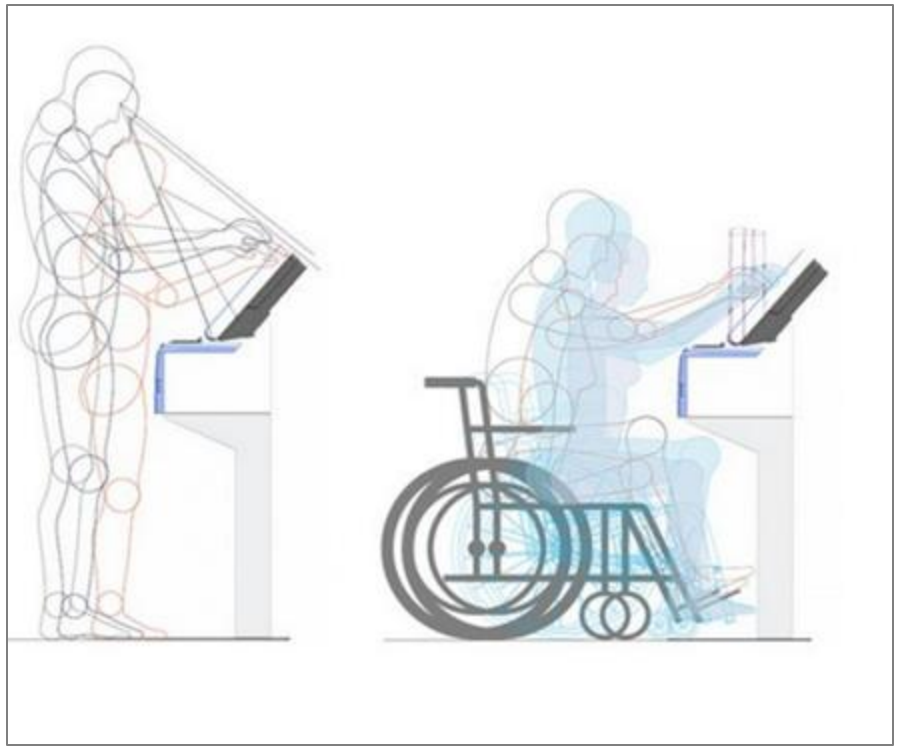
Percentile data: discussion

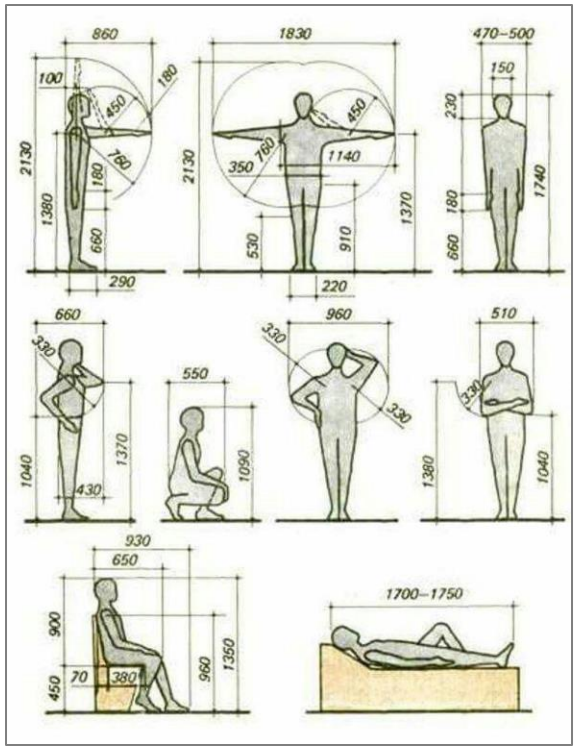
Percentile data

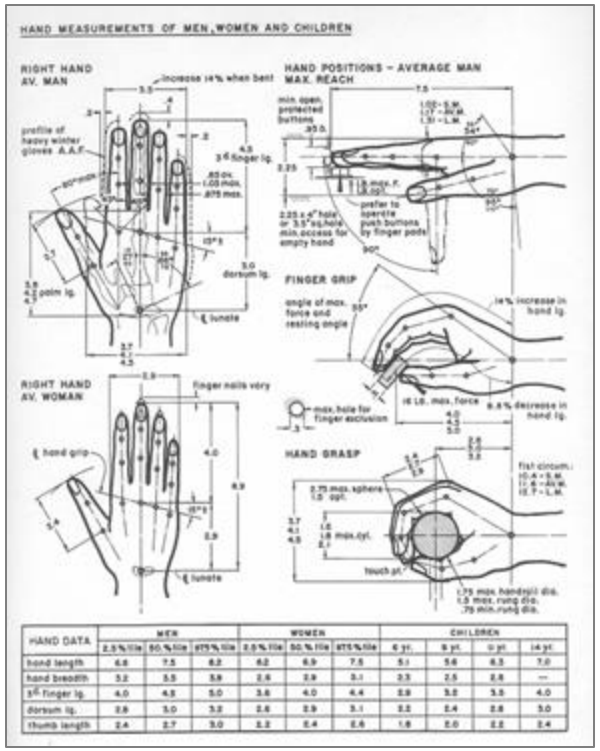
- Design should address to the needs from 5^{th} to 95^{th} percentile as applicable
- A person may have **95^{th} percentile height** but may have **50^{th} percentile weight** and **5th percentile distance between eyes**
- Factors like age/ gender/ race / somatotype / living conditions will affect anthropometry

Static anthropometry

When a **person is in a static posture:** standing , sitting or adopted postures



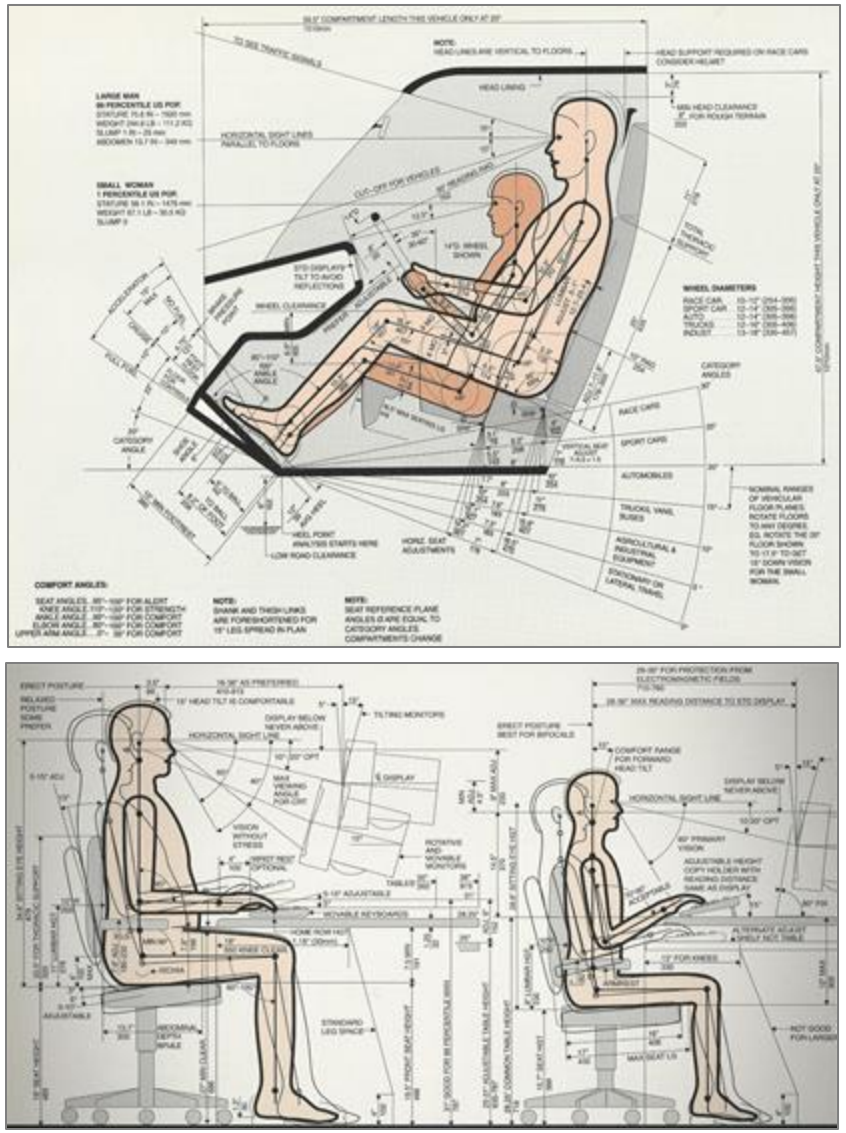




Dynamic anthropometry

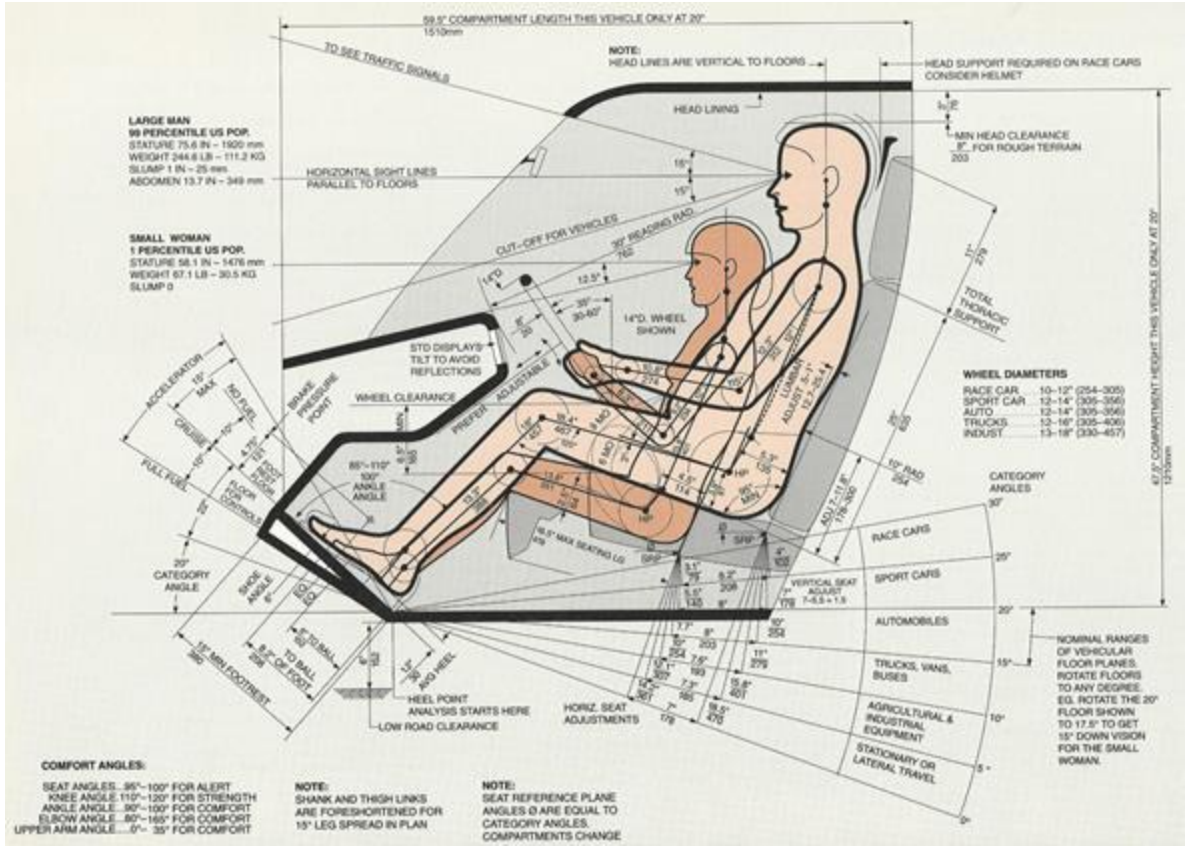
The human rather, always dynamic.

The dimensional **measurements of the human body with various movements** taken into consideration in different adopted postures which the work context demands, are termed ***dynamic anthropometry***.



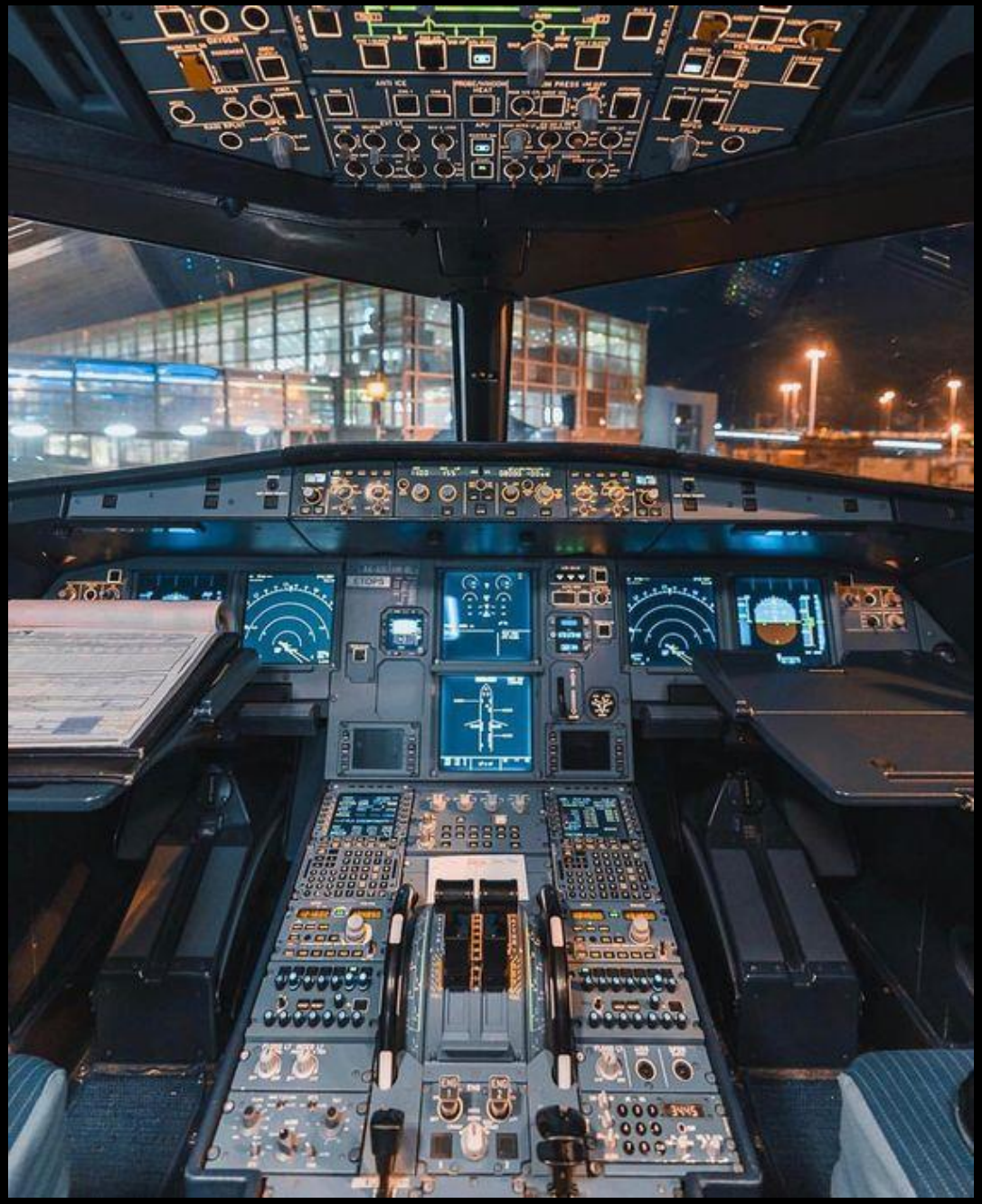
The Measure of Man and Woman: Human Factors in Design, Henry Dreyfuss Associated

Anthropometry : spaces



The Measure of Man and Woman: Human Factors in Design, Henry Dreyfuss Associated

Interface



Airbus 320

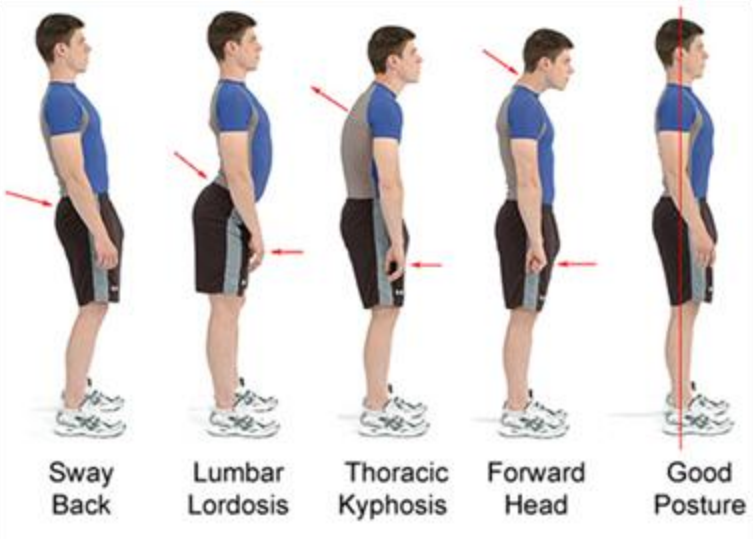
Image credit: https://in.pinterest.com/pin/307018899594765105/

Let’s watch some examples

Good practices: thumb rules

Communication

Postures and methods



Design assisting good postures

Standards

Automotive Research Association of India

Conformité Européenne (French for European Conformity)

Bureau of Indian Standards

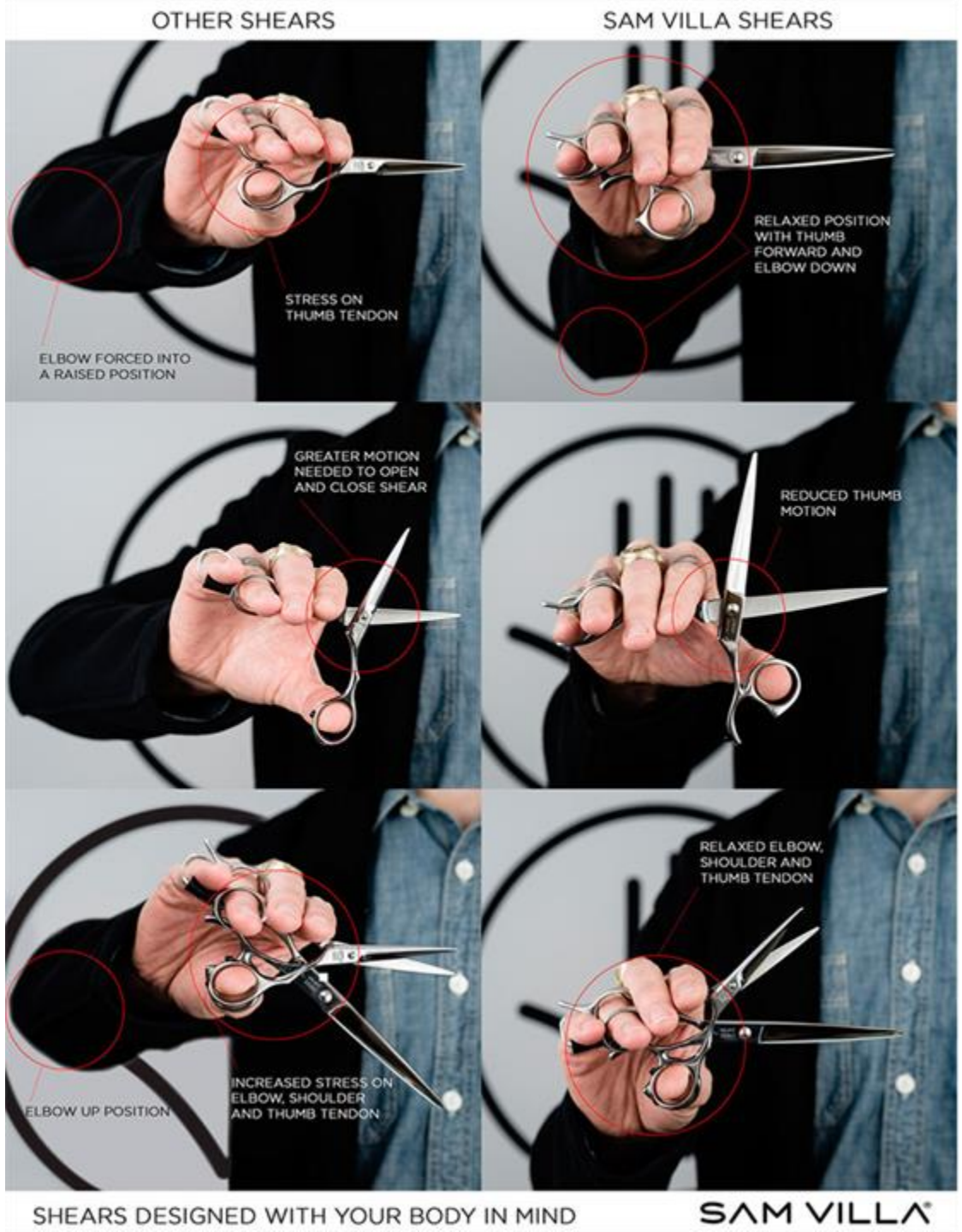
Process in short

- Consider ***all the possible dynamics*** between user and the product
- ***Prioritize*** them: amount of time and nature of hazard
- ***Study standards*** and/or ***anthropometric data*** to define product attributes.
- Design and ***validate***

Few straightforward applications

- Deciding bulk of the product
- Designing Grip/ Handles
- Adjustments of height/ width
- Providing flexibility of use through pivots/levers/ ratchets etc.

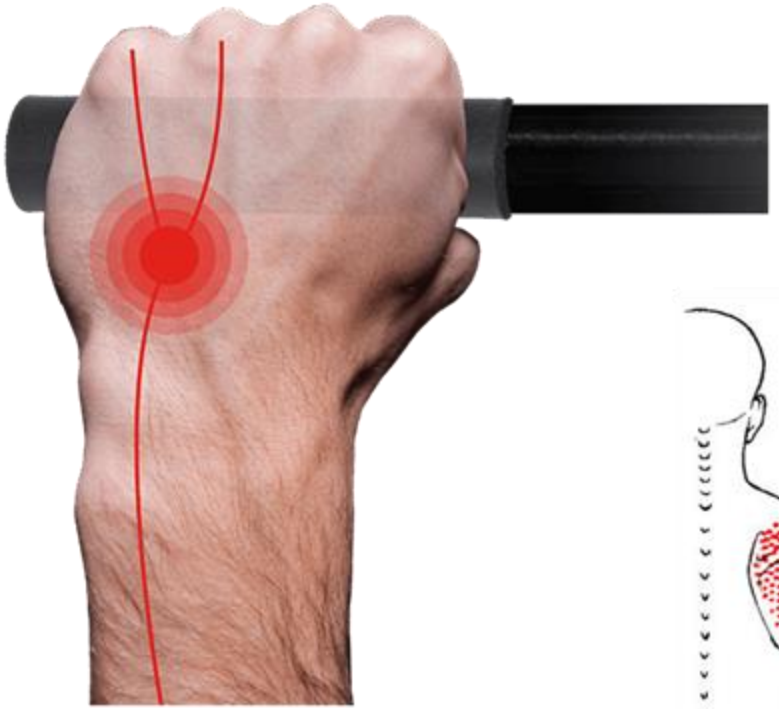
Analyze interaction

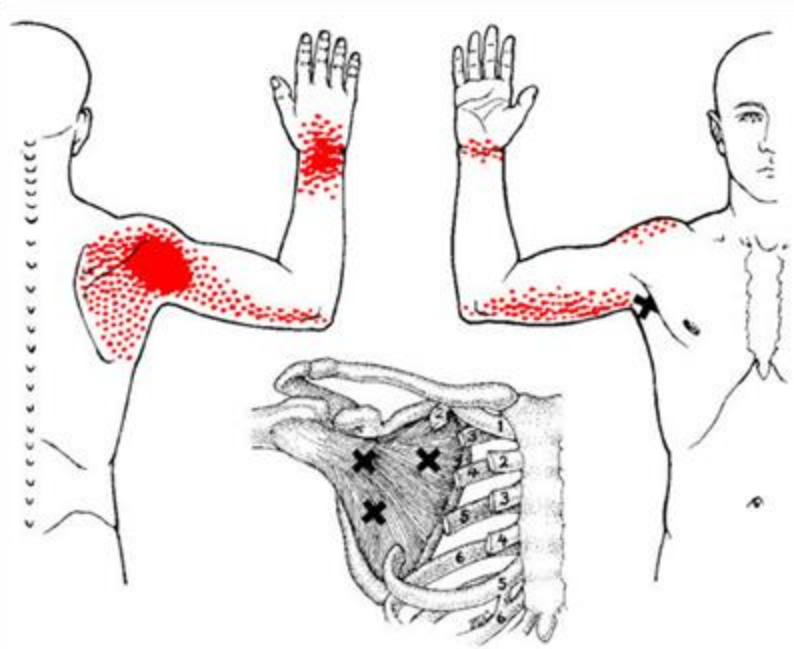


Prioritize

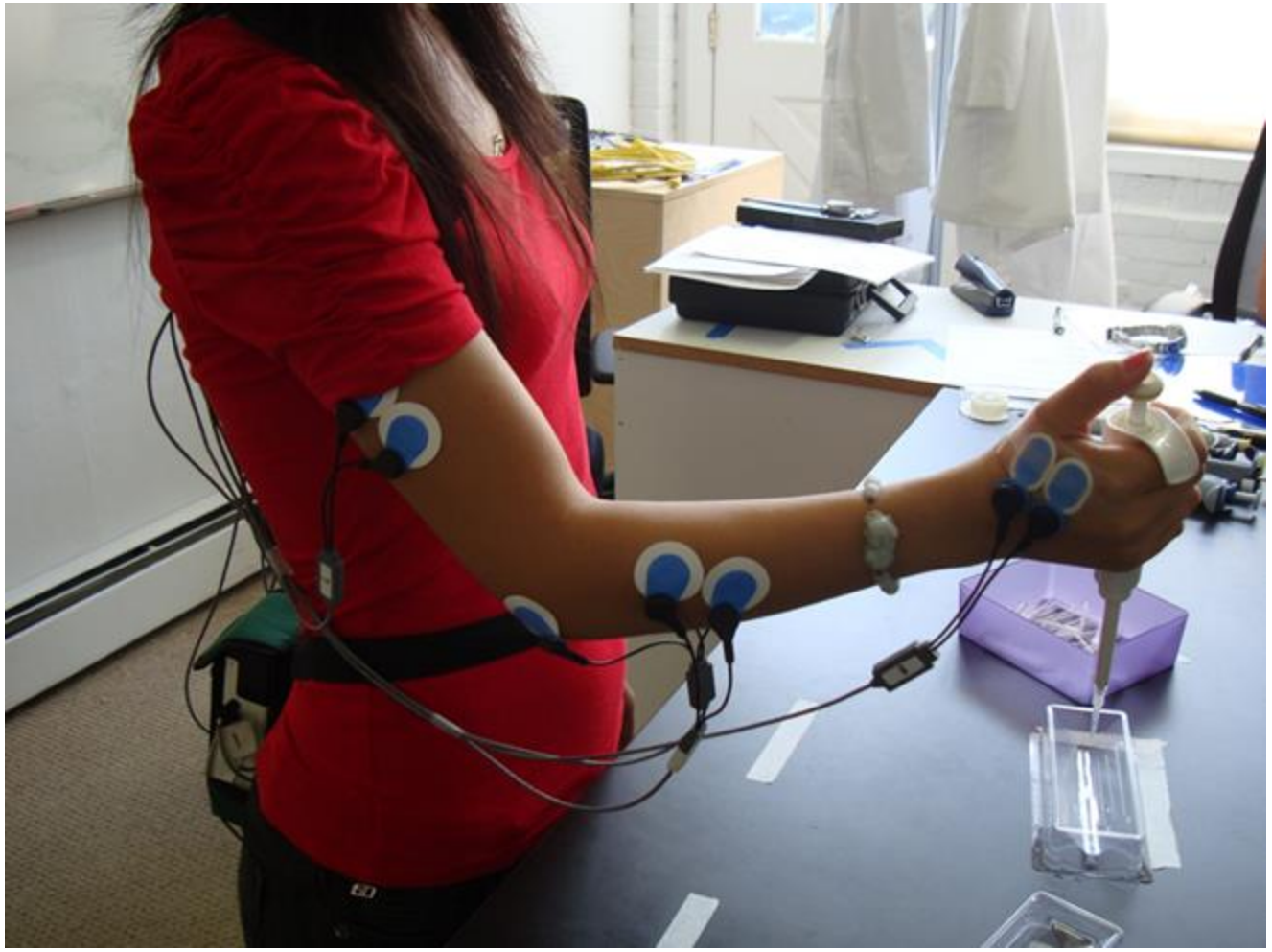
- **Fatality** of any issue
- The amount of **time spent** (energy expenditure / RSI)
- Define **desired experience** (safety/ comfort/ intuitiveness and inclusivity)

Indicating and representing ergonomic issues





Quantifying (strains, energy expenditure)

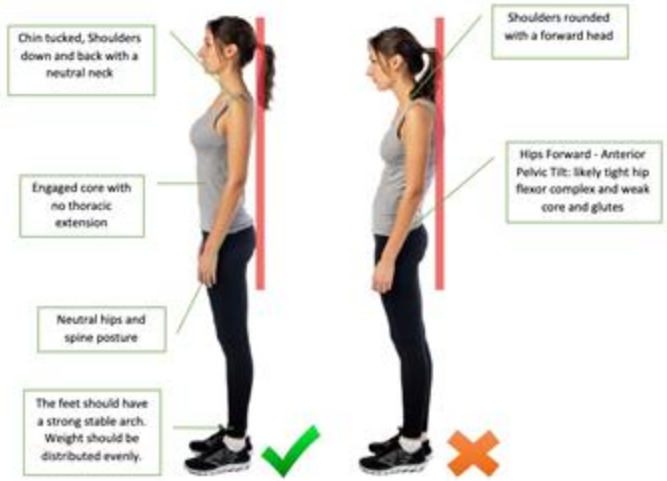


Study anthropometry

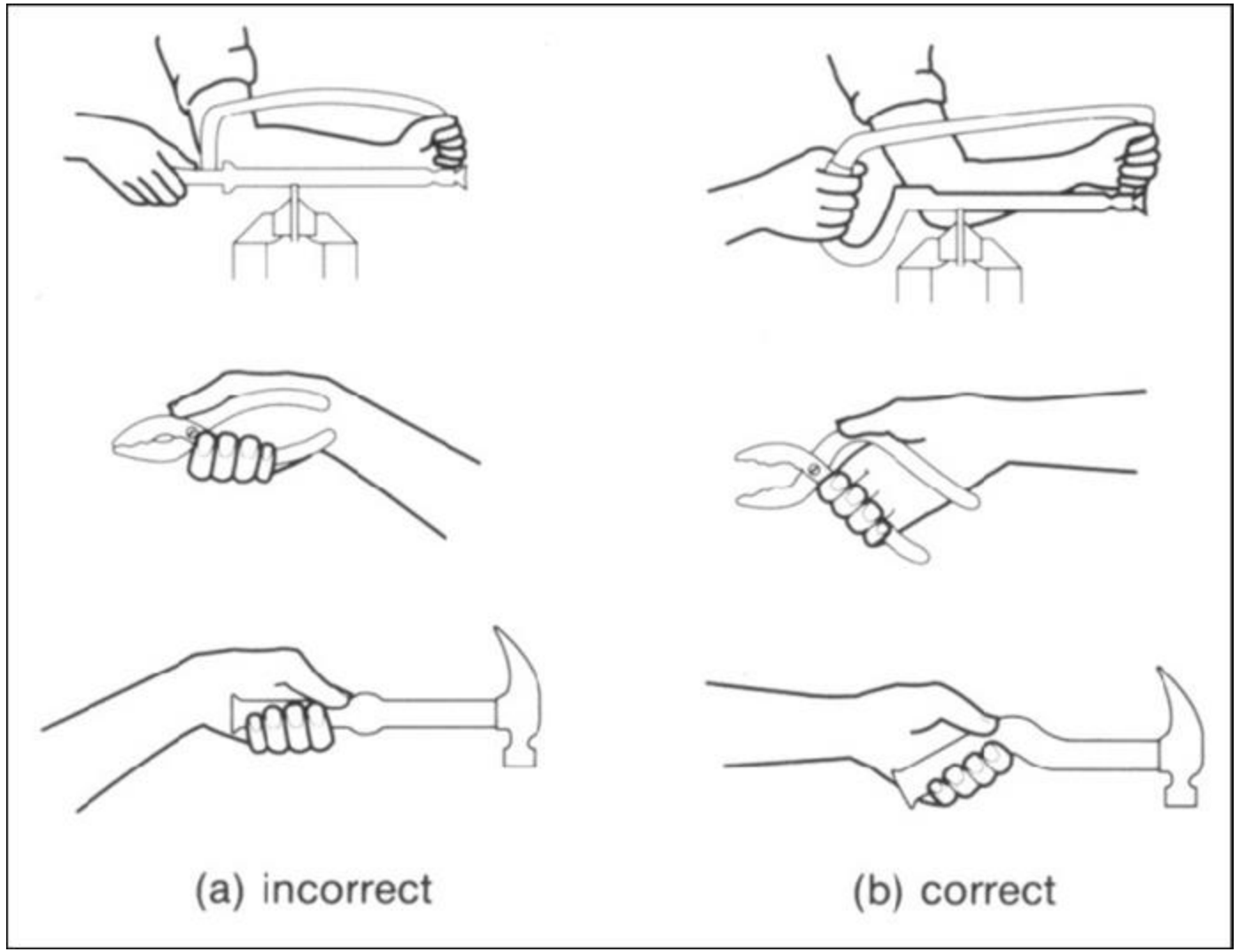
Thumb rules

1. Neutral postures

- ‘S’ curve of spine
- Proper angles for limbs e.g. 90^{O} angle for the elbow and knees
- Natural wrist position
- Neck alignment



https://ehs.stanford.edu/topic/ergonomics/postural-awareness



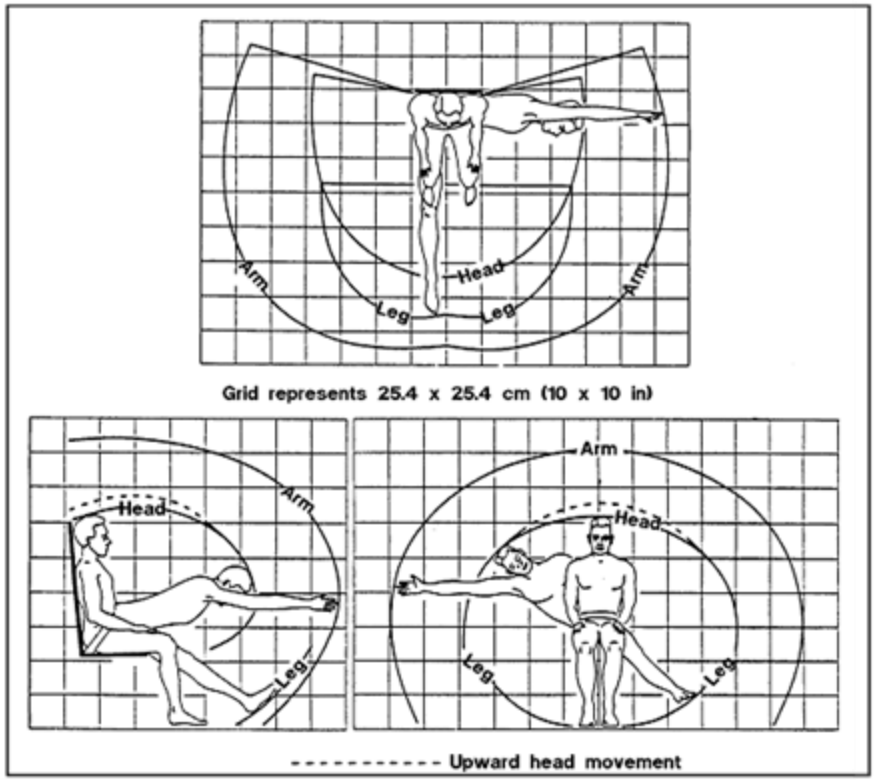
https://www.researchgate.net/figure/Recommendations-for-hand-tool-handle-design-5_fig10_234056130

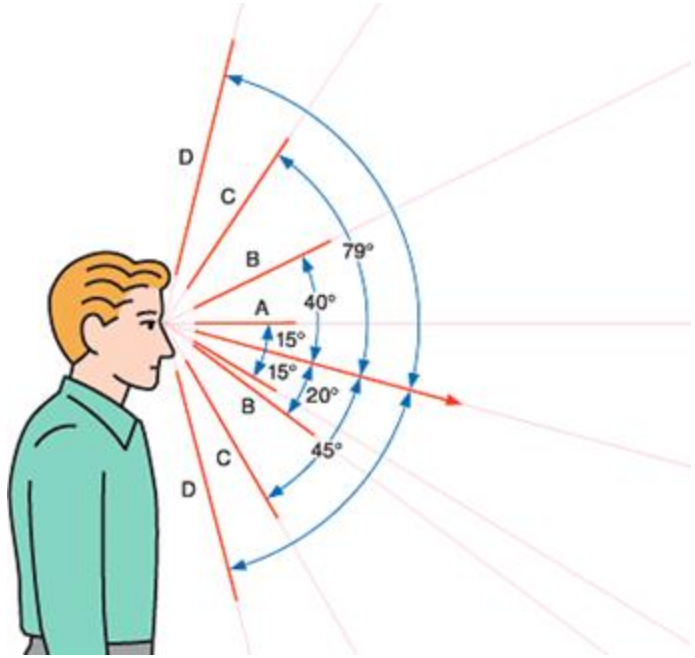
2. Reduce effort (force / motion)

- By means of adjusting bulk/ size etc.
- Use of power or mechanical tools to reduce repetitive motions
- Removing hurdles such as uneven surfaces or

3. Easy reach

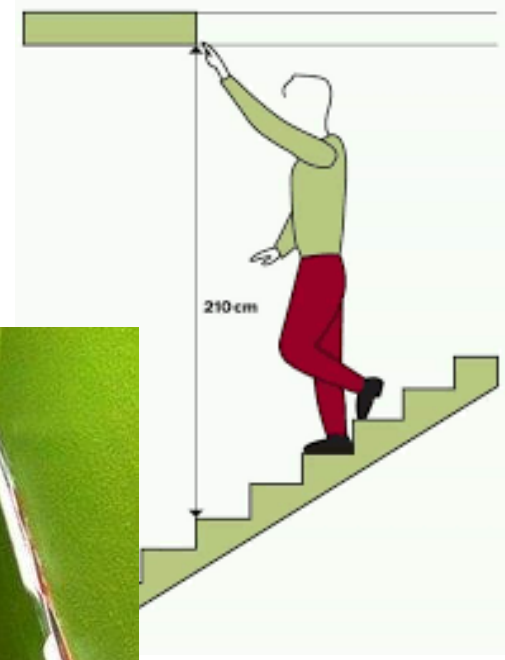
Hands and feet, visibility etc.

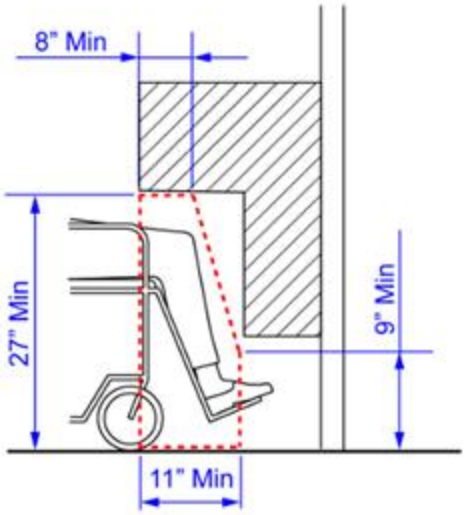




4. Appropriate Clearance

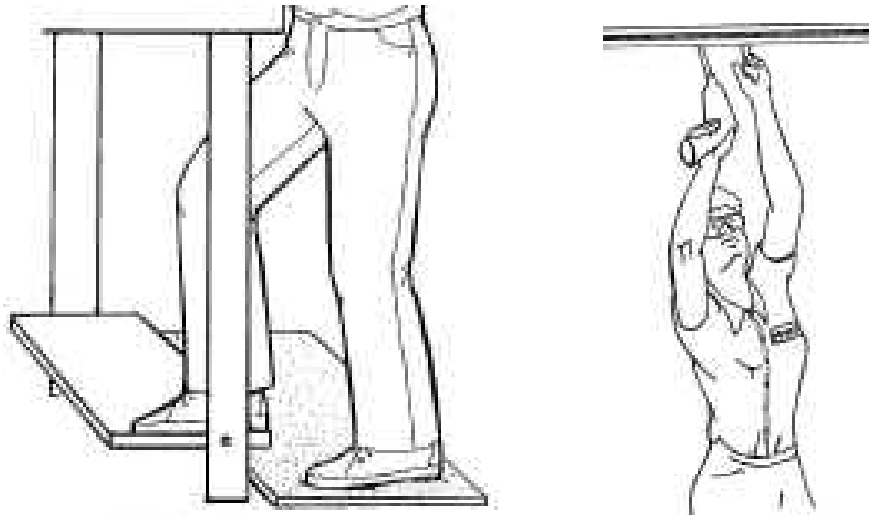
- Clearances become important especially in case of movements
- Knees, Elbows, Head injuries could occur with lack of clearances





5. Minimize Fatigue & Static Load

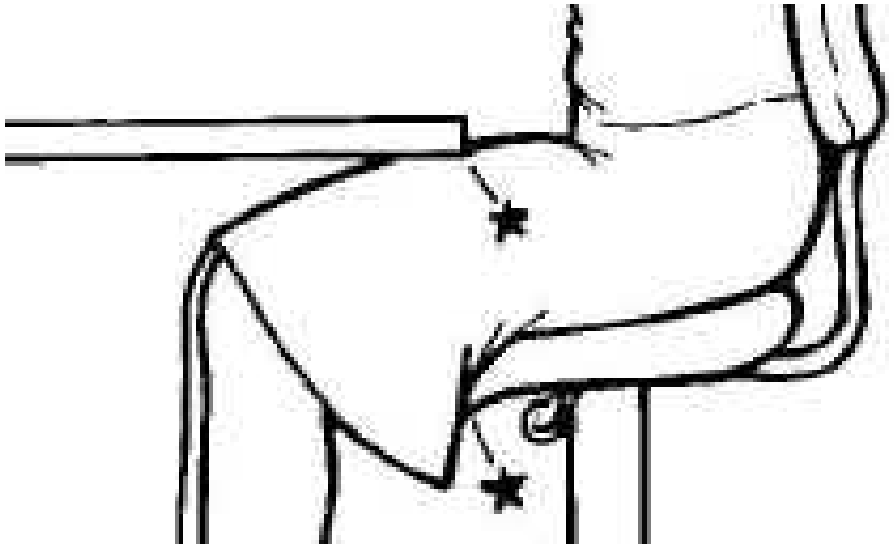
- Standing on feet, raising arms overhead etc.
- Design of proper grips, working heights/ footrests can solve the issues.



6. Minimize Pressure Points

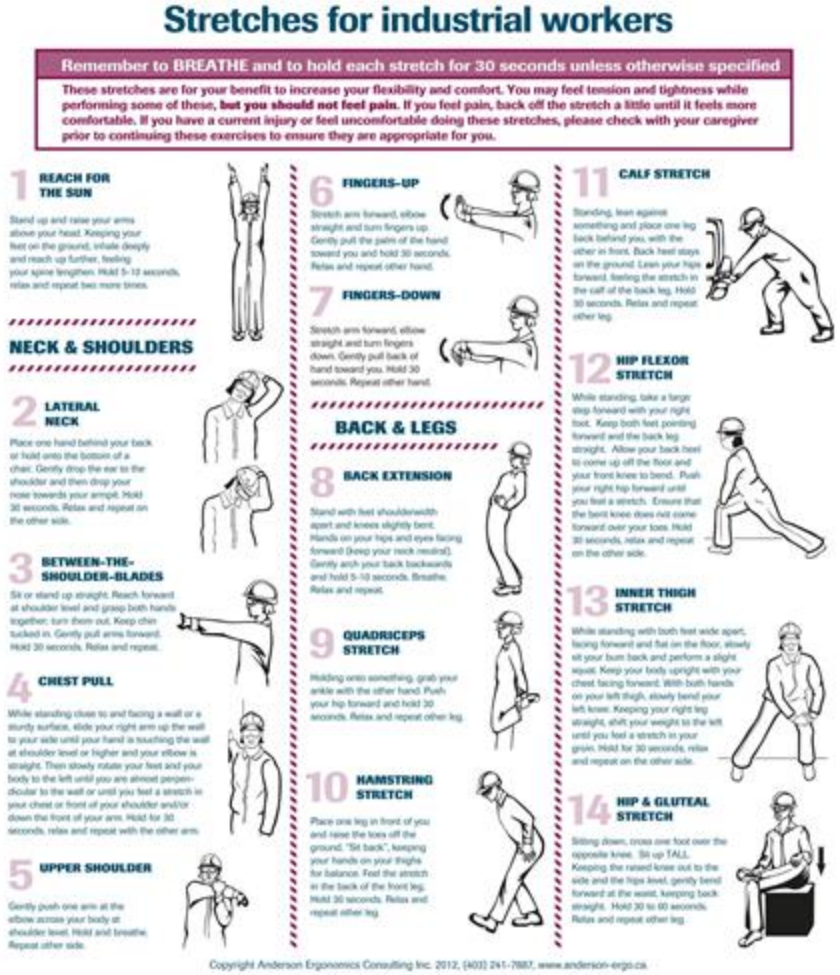
Minimizing pressure points is critical

E.g. Pressure on legs in a chair / Pain in fingers and palm while writing



7. Move, Exercise, and Stretch

- Take adequate breaks to avoid stress and strain
- Make sure that workstation allows change of postures

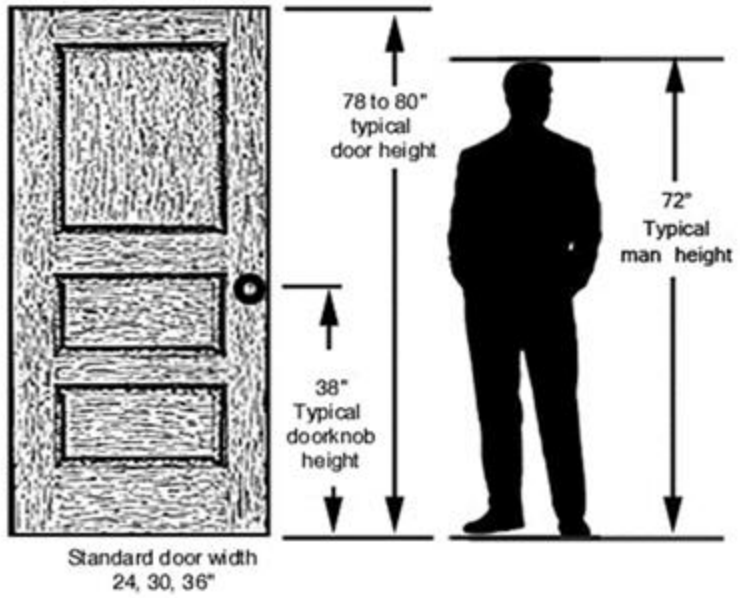


https://anderson-ergo.ca/about-us/resources/industrial-stretching-poster-2012-colour-2/

Adjustability and trade-offs

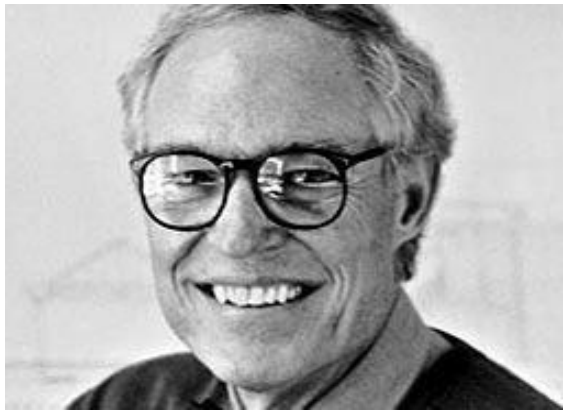
- Reach, operational force etc for

  5^{th} percentile
- Clearance for 95^{th} percentile
- Adjustable sizes for all variations



Recommended videos

- Niels Diffrient
- Applied ergonomics by NPTEL



Standards

Indian Society of Ergonomics (ISE)

International Ergonomics Association (IEA)

Chartered Institute of Ergonomics & Human Factors

Human Factors and Ergonomics Society

Human factors

"Human factors is the **scientific discipline** concerned with the understanding of **interactions** among humans and other elements of a system, and the profession that applies **theory, principles, data,** and other methods to design in order to optimize **human well-being** and overall system performance"

(International Ergonomics Association, 2010)

Summary

- Human factors : ***scientific discipline*** understanding ***interactions*** among humans and other elements of a system
- An ergonomic product : **safe, comfortable, intuitive, inclusive.**
- Ergonomics: Physical, visual*, cognitive and organizational
- Anthropometry
- Thumb rules (reach, clearance, neutral postures)

ES 115
Design, Innovation and prototyping

5 Human factors

Next class ... ‘Presentation and Representation ’

Two submissions: 22nd September
Glider demo on 20th September.