Work Environment Physics 2

PhD Katarzyna Jach
Katarzyna.jach@pwr.edu.pl
http://ksz.pwr.edu.pl/

office hours:
B1 building r. 415c

Grading requirements

- Passing the final test (last lecture 27.05)
- Alternative: grading by activity
  - Presence and active listening
  - Small project/homework
  - Short presentation
  - Answers / questions

After the course you’ll get to know:

- The effects of some environmental factors on the human body work and workload
- Chosen tools and methods for the accessibility increasing
- Some legal and normative basis for occupational safety and ergonomics
- Usability problems

Work Environment Physics = Ergonomics

Ergonomics

Science about relation between human beings and their work environment.

/Kenneth Frank Hywel Murrell 1949/
Ergonomics

- Ergonomics is the science of designing the workplace environment to fit the user.

Ergonomics

Body of knowledge about human abilities, limitations and characteristics that are relevant to design. Ergonomic design is the application of this knowledge to the design of tools, machines, systems, tasks, jobs, and environment for safe, comfortable and effective human use.

/Board of Certification for Professional Ergonomists - BCPE /

The Basics of Ergonomics

Utmost Goal: “Humanization” of Work

Ergonomics = laws of work

Science of fitting workplace conditions and job demands to the capabilities of the working population.

Ergonomic study areas

- WORKERS - what they bring to the job
- TOOLS - what they bring to the worker
- TASKS - what the worker must do
- ENVIRONMENT- the conditions surrounding the worker and the tool
Ergonomics

- Ergonomics is the science of improving employee performance and well-being in relation to the
  - job tasks
  - equipment.
  - the environment.

- Ergonomics is a continuous improvement effort to design the workplace for what people do well, and design against what people don’t do well.

Human - Millieu system

Human

Physical features
- Anatomy
- Body measures
- Physiology
- Stamina

Psychological features
- memory
- perception
- attention

Millieu

Material environment
- microclimate
- lighting
- noise

Technical devices
- Work tools
- Transport
- Supporting equipment

EWCS 2015 (European Working Conditions Survey, 2017)

Work satisfaction in UE 2015

Work quality indices
The division of ergonomics

- Physical ergonomics - human anatomical, anthropometric, physiological and bio mechanical characteristics as they relate to physical activity
- Cognitive ergonomics - mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system
- Organizational ergonomics - optimization of socio technical systems, including their organizational structures, policies, and processes

Physical ergonomics

- Biomechanical overload
- Layout design
- Steering and control design
- Workstation design
- Work environment

Cognitive ergonomics

- mental workload
- decision-making
- human-computer interaction
- human reliability
- work stress
- Work training

Organizational ergonomics

- Communication
- Crew resource management
- Work design
- Teamwork
- Community ergonomics
- Cooperative work
- Virtual organizations
- Quality management
The division of ergonomics

- Corrective ergonomics - the improvement of the existing state
- Conceptive ergonomics - proper design

Human - Millieu system

<table>
<thead>
<tr>
<th>Human Physical features</th>
<th>Millieu Material environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anatomy</td>
<td>microclimate</td>
</tr>
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<td>Body measures</td>
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</table>

Universal Design

- Designing products, buildings and exterior spaced to be usable by all people to the greatest extend possible

Universal design checklist

1. Disability:
   - sensory,
   - physical,
   - psychic,
   - cultural
2. Basic requirements about:
   - mobility,
   - orientation,
   - information access,
   - safety.

7 UD principles

1. Equitable use - avoid segregating or stigmatizing
2. Flexibility in use - i.e. right and left hand
3. Simple and intuitive use - consistent with expectation
4. Perceptible information - redundant, contrast and compatible
5. Tolerance for errors - warnings and restricted access to most hazardous elements
6. Low physical effort - fatigue minimizing
7. Size and space for approach and use - good approach, reach and manipulation regardless to user body size, posture or mobility
Homework

- An example of universal design at PW r with explanation
- Pd f or ppt file, maximum 3 slides
- Your name in the presentation title
- Deadline: 1.03.2020

Long-term work

- Choose the topic for 15 min. presentation
- Let me know till 22.03.2020
- Presentation + task for group
- 2 persons in group maximum

Stages of ergonomic design

1. Body measures
2. Biomechanical activity
3. User - workstation relations

1. Body measures

Body measures

- Most important for design
- Human body is the main part of every workstation
- Variety of body measures
  - In population
  - Purpose: designing for everyone
Standard distribution

Height Probability Distribution for US men and women

Restraining values - 5 and 95 percentile

Height Probability Distribution
for US men and women

Simplex limitations
- Minimal - reach
- Maximal
  - Heights (headroom)
  - Safety measures

Duplex limitations
- User population
- Adjustment

<table>
<thead>
<tr>
<th>Main aim</th>
<th>Design examples</th>
<th>Examples of measurements</th>
<th>Users should accommodate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy reach</td>
<td>Vehicle dashboards, Shelving</td>
<td>Arm length, Shoulder height</td>
<td>Smallest user: 5th percentile</td>
</tr>
<tr>
<td>Adequate clearance</td>
<td>Manholes, Cinema seats</td>
<td>Shoulder or hip width, Thigh length</td>
<td>Largest user: 95th percentile</td>
</tr>
<tr>
<td>A good match</td>
<td>Seats, Cycle helmets, Pruchairs</td>
<td>Knee-floor height, Head Circumference, Weight</td>
<td>Maximum range: 5th to 95th percentile</td>
</tr>
<tr>
<td>A comfortable and safe postures</td>
<td>Lawnmowers, Monitor positions, Worksurface heights</td>
<td>Elbow height, Sitting eye height, Elbow height (sitting or standing)</td>
<td>Maximum range: 5th to 95th percentile</td>
</tr>
<tr>
<td>Easy operation</td>
<td>Screw bottle tops, Door handles, Light switches</td>
<td>Grip strength, Hand width, Height</td>
<td>Smallest or weakest user: 5th percentile</td>
</tr>
<tr>
<td>To ensure that an item can’t be reached or operated</td>
<td>Machine guarding mesh, Distance of ralisings from hazard</td>
<td>Finger width, Arm length</td>
<td>Smallest user: 5th percentile, Largest user: 95th percentile</td>
</tr>
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</table>
Three approaches

1. Design for adjustable ranges - particularly when health and safety issues are involved (driving a car, computer workstation)
2. Design for extremes - maximum or minimum values
3. Design for average users - 50 percentile figures

Biomechanical and physiological features

- Physiological features
  - Senses activity
  - Fatigue
- Biomechanical agility
  - Permissible spread of joint mobility
  - Prompted forces and torques

Visual field

1. Often vision without head and torso movements
2. Observation and manipulation with bend head
3. Rare observations
4. Rare observations with head and torso leaned back

Arm and forearm surface area

Approximated data for design

A - normal reach
B - maximal reach
C - two-handed work area
Principles of motion economy

1. Two hands should begin and complete motions at the same time
   • Counterbalance to each other
   • Equal workload
   • Minimizing total time required

2. Two hands should not be idle at the same time
   • Except: rest 😊
   • Preferred hand for more complex control actions
   • Allocating the time between two hands → minimizing the cycle time

3. Upright and forward facing posture
   • Twisting and bending is always harmful and need counterbalance
   • Worse hand - eye coordination if people not directly face the work

4. Several different natural and safe postures at work
   • Postural freedom
   • Avoiding stress and overload by static and unnatural postures

5. Motions of arms opposite and symmetrical directions simultaneously
   • Keeping body balance
   • Motions require less effort
   • Movement compatibility
6. Momentum should be used whenever possible
   - Reducing forces and muscular effort

7. Smooth curved motions are better than straight-line and sharp changes
   - Sharp changes in direction require added physical force to overcome momentum and sustain high rates in acceleration
   - \( F = ma \rightarrow \) change in directions takes time, force and effort

Consulting the workers measures

Example: working height for standing posture

Factors influencing working height

- Worker’s measures
- Task features
  - Precision
  - Used force
  - Object size

Working height for standing posture

Satisfaction

- Fitted to user
- Safe
- Functional
  - Pouring
  - Boiling
  - Cleaning
- Nice to see...
Six Pillars of Ergonomic Design

1. User Orientation: Design and application of tools, procedures, and systems must be user-oriented, rather than just “task” oriented
2. Diversity: Recognition of diversity in human capabilities and limitations, rather than “stereotyping” workers/users
3. Effect on Humans: Tools, procedures, and systems influence human behaviour and well-being
4. Objective Data: Empirical information and evaluation is key in design process, rather than just use of “common sense”
5. Scientific Method: Test and retest hypothesis with real data, rather than “anecdotal” evidence or “good estimates”
6. Systems: Object, procedures, environments, and people are interconnected, affect one another, and do not exist in “isolation”