Al-Mustaqbal University

Biomedical Engineering Department

Class: 3rd

Subject: Rehabilitation Science

Lecturer: Mr. Mahir Rahman Al-Hajaj

2nd term – Lect. 1: Introduction to Rehabilitation Engineering and Assistive Technology (AT).

Email: mahir.rahman@uomus.edu.iq

Rehabilitation Science and Engineering.

What is Rehabilitation Engineering?

• First Definition (1971): "To improve the quality of life of the physically handicapped through a total approach to rehabilitation, combining medicine, engineering, and related sciences."

• The "Total Approach":

- It is not just about designing a gadget.
- It involves the Patient, the Environment, the Device, and the Clinical Team.

• Key Goal: To restore function or provide a compensatory mechanism for lost function, allowing the individual to participate fully in society.

Rehabilitation Science and Engineering.

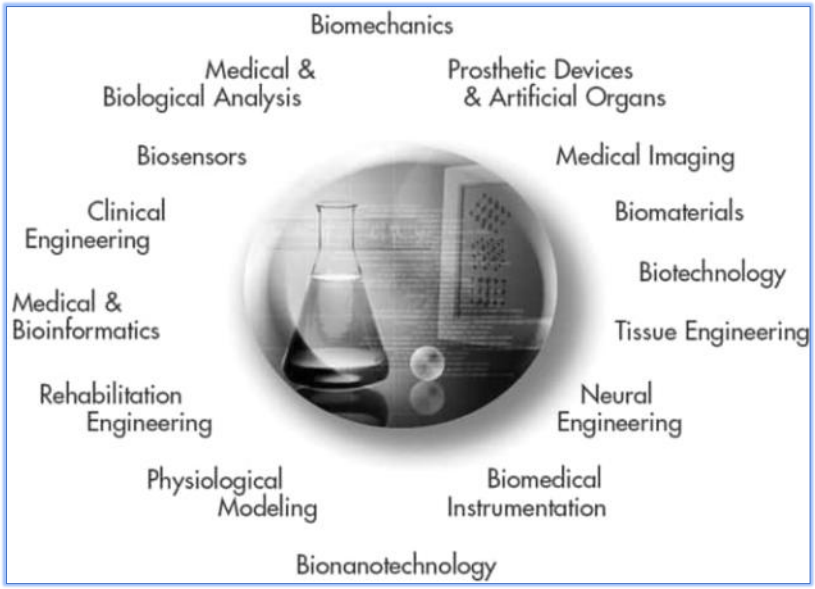
The World of Biomedical Engineering

•Context: Rehabilitation Engineering is a specialized subset of the broader Biomedical Engineering (BME) field.

•Sister Disciplines:

- Biomechanics: Analysis of forces on the body (essential for prosthetics).
- Biosensors: Detecting biological signals (essential for diagnostics).
- Medical Imaging: MRI, CT, X-Ray.
- Clinical Engineering: Hospital equipment management.

Rehabilitation Science and Engineering.



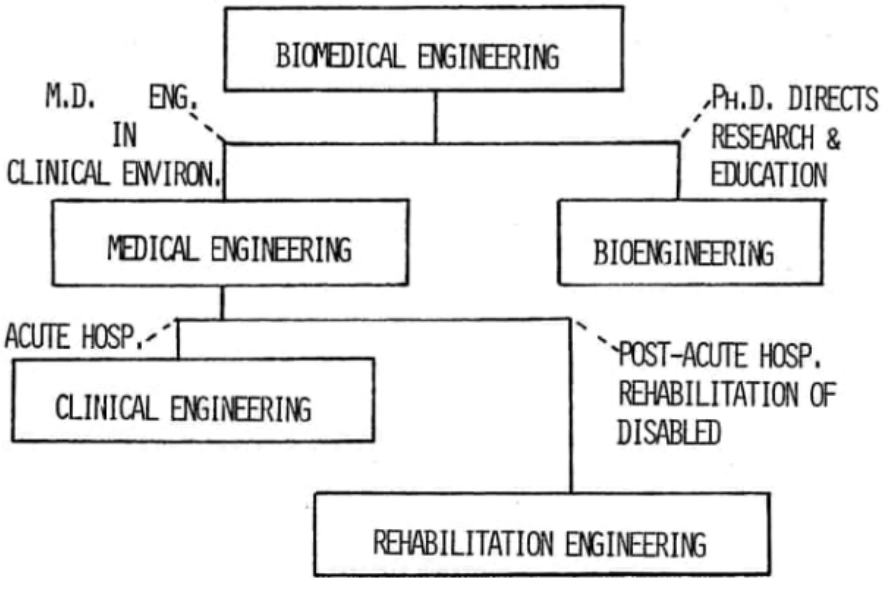
The world of Biomedical Engineering

Rehabilitation Science and Engineering.

Classifying Engineering in Medicine

- Biomedical Engineer:
  - Role: Applies electrical, mechanical, chemical, and other engineering principles to understand, modify, or control biological systems.
  - Example: Designing a pacemaker or an artificial hip.
- Clinical Engineer:
  - Role: A sub-specialty of BME responsible for the management of medical equipment within a hospital.
  - Example: Ensuring ventilators are calibrated and electrically safe.
- Rehabilitation Engineer:
  - Role: Involved with patients on a continuing and active basis to develop devices for people with disabilities.
  - Example: Customizing a wheelchair controller for a user with cerebral palsy.

Rehabilitation Science and Engineering.



Engineering in medicine classification

Rehabilitation Science and Engineering.

Ancient History of Engineering in Medicine

- Imhotep (3000 BC):
  - The first named engineer and architect (Step Pyramid of Saqqara).
  - Also a physician who wrote early medical texts.
  - Significance: Shows that Medicine and Engineering have been linked for 5,000 years.
- Hippocrates (460–370 BC):
  - The "Father of Medicine."
  - Used engineering principles to treat fractures (splints) and reduce dislocations (using mechanical traction/leverage).
- Herophilus (300 BC):
  - Studied the pulse and connected it to the heart's pumping action (Fluid Dynamics).

Rehabilitation Science and Engineering.

Egyptian toe.

The Renaissance & The "Iron Hand"

• Götz von Berlichingen (1504): A German Imperial Knight who lost his right hand in the Battle of Landshut.

• The Device: He commissioned an iron hand with fingers that could be mechanically locked in place.

• Mechanism:

- Internal gears and springs allowed the fingers to "ratchet" closed.
- A button on the back of the hand released the lock.

• Function: It was robust enough to hold a sword or the reins of his horse, allowing him to continue his career as a knight for 40 more years.

Rehabilitation Science and Engineering.

Iron hand prostheses.

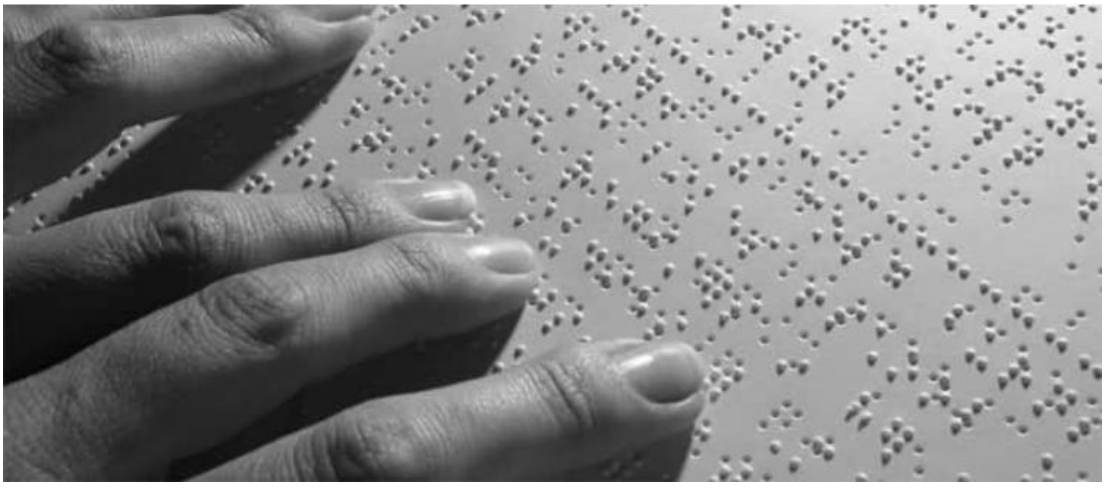
The US Civil War (1861–1865)

• The "Great Civil War Benefaction":
  - The war resulted in 30,000 amputations in the Union Army alone.
  - The US Government committed to providing artificial limbs to all veterans.
• James Edward Hanger:
  - The first documented amputee of the war (Confederate soldier).
  - Dissatisfied with the standard "peg leg," he designed a prosthesis with rubber bumpers in the ankle.
  - Innovation: This introduced "dampening" and a smoother gait.
• Legacy: He founded J.E. Hanger, Inc., which remains one of the largest prosthetic providers in the world today.

Rehabilitation Science and Engineering.

Early Sensory Aids - Vision

•Spectacles (1280 AD):
  - Invented in Italy.
  - Originally, convex lenses were used to treat presbyopia (farsightedness) in older scholars.
•Braille (1829):
  - Louis Braille: Blinded at age 3.
  - Origin: He modified "Night Writing," a complex military code used by soldiers to read orders in the dark.
  - Innovation: He simplified it to a 6-dot cell that fits perfectly under a single fingertip, allowing for rapid reading.



Braille page.

The Typewriter - A Disability Invention

•Pellegrino Turri (1808):

- Built the first typewriter for his friend, Countess Carolina Fantoni da Fivizzano, who was blind.
- Goal: To allow her to write letters legibly without seeing the paper.

•Mainstream Impact:

- Like many assistive technologies (e.g., text-to-speech, voice recognition), the typewriter started as a disability aid and became a standard tool for the entire world.

The "Patellar Tendon Bearing" (PTB) Socket

• Context (1950s): Before this, amputees walked on "plug fit" sockets that put painful pressure on the end of the stump.

• Radcliffe & Foort: Researchers at UC Berkeley.

• The Innovation:

- They designed a socket that distributed weight onto the Patellar Tendon (the ligament below the kneecap).
- This area is pressure-tolerant, unlike the cut end of the bone.

• Significance: This marked the transition of prosthetics from "art/carving" to "biomechanical science."

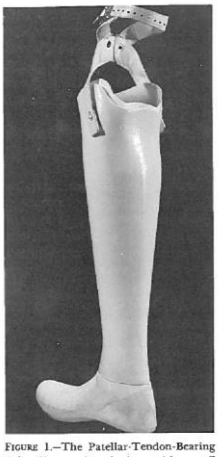


FIGURE 1.—The Patellar-Tendon-Bearing Below-Knee Prosthesis with cuff suspension.

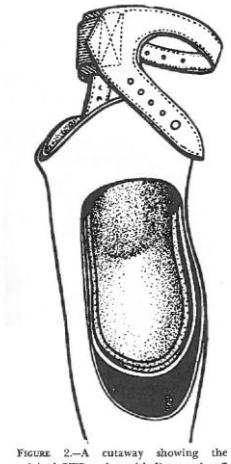


FIGURE 2.—A cutaway showing the original PTB socket with liner and cuff suspension.

Rehabilitation Science and Engineering.

The Flex-Foot (Cheetah) - 1984

•Van Phillips: An engineer who lost his foot in a waterskiing accident.

•The Problem: Traditional feet were "dead" wood or rubber sponges.

•The Solution: Carbon Fiber Composites.

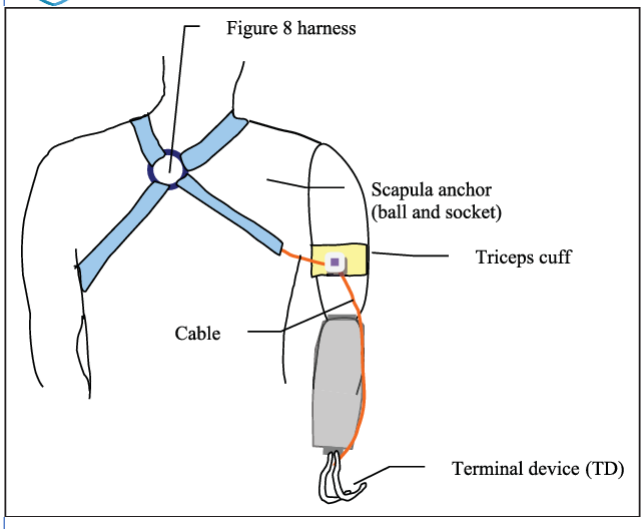
•Mechanism (Energy Storage & Return):

- The foot acts like a spring (or a diving board).
- Compression at heel strike stores potential energy.
- Release at toe-off converts it to kinetic energy, propelling the user forward.

Upper Extremity Prosthetics

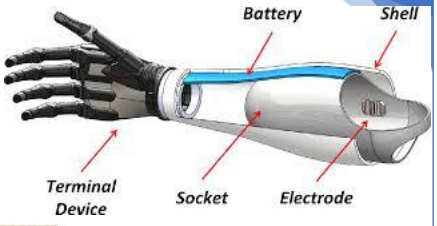
- Body-Powered:
  - Uses a harness across the back.
  - Shrugging the shoulder pulls a cable that opens the hook.
  - Pros: Very durable, provides sensory feedback (tension).
- Myoelectric:
  - Uses electrodes on the skin to detect Electromyography (EMG) signals from residual muscles.
  - These signals trigger battery-operated motors to open/close the hand.
  - Pros: stronger grip, looks more natural.
- Targeted Muscle Reinnervation (TMR):
  - Surgical rewiring of nerves (e.g., from the missing hand) to chest muscles.
  - When the user "thinks" about closing their hand, their chest twitches, and the robot arm closes.

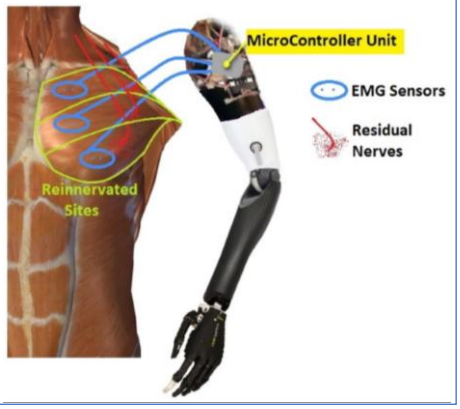
Rehabilitation Science and Engineering.



Body-powered

Myoelectric





Targeted Muscle Reinnervation (TMR)

The "Quickie" - High Performance (1979)

• Marilyn Hamilton: A paraplegic athlete and hang-glider pilot.

• The Problem: Standard wheelchairs weighed 50+ lbs and were "medical" (chrome/heavy).

• The Solution:

- She used aluminum tubing (from hang gliders).
- Reduced weight to 25 lbs.
- Added adjustable centers of gravity and bright colors.

• Legacy: Founded Quickie Wheelchairs (now Sunrise Medical). Changed the wheelchair from a "medical appliance" to "sports gear."

Rehabilitation Science and Engineering.

Power Mobility

•George Klein (Canada):

- Invented the first mass-producible electric wheelchair for WWII veterans (1950s).
- Key Feature: The Joystick Control.
- Adapted from aviation technology, it allowed users with limited hand function to control speed and direction simultaneously.

•Modern Impact: Enabled mobility for high-level quadriplegics who lack the arm strength to push a manual chair.

Hearing Technologies

•Acoustic Era:

- Ear Trumpets: Used passive physics (funneling sound) to increase volume by ~20dB.

•Electronic Era:

- The Telephone: Alexander Graham Bell's work on "visible speech" for the deaf led directly to the invention of the telephone.

•Neuroprosthetic Era:

- Cochlear Implants: A surgically implanted device that bypasses damaged hair cells in the cochlea and stimulates the auditory nerve directly with electricity.

Reading Machines for the Blind

•The Optophone (1912):

- Converted light intensity into sound.
- Users heard a "buzzing" musical chord that changed as they scanned over letters. Very difficult to learn.

•The Kurzweil Reading Machine (1977):

- Invented by Ray Kurzweil.
- The first device to combine a Flatbed Scanner, OCR (Optical Character Recognition), and Text-to-Speech synthesis.
- allowed blind people to read any printed book, not just Braille books.

Rehabilitation Science and Engineering.

Augmentative and Alternative Communication (AAC): it refers to a diverse set of tools, strategies, and techniques used to support or replace spoken language for individuals with severe speech or language impairments

Bliss Symbols (1971):

- Charles Bliss invented a visual language to promote world peace.
- It was adapted by Shirley McNaughton for children with Cerebral Palsy who could not speak or read. Proved that non-verbal people could communicate complex thoughts using symbols.

•Electronic AAC:

- Tufts Interactive Communicator (TIC): An early scanner-based device.
- Modern SGDs (Speech Generating Devices): Use eye-gaze or head-tracking to allow totally paralyzed users (like Stephen Hawking) to speak.

Rehabilitation Science and Engineering.

RESNA (1979)

•Name: Rehabilitation Engineering and Assistive Technology Society of North America.

•Purpose:

- To provide a professional "home" for the interdisciplinary field (Engineers, OTs, PTs, Suppliers).
- To develop standards (e.g., wheelchair crash testing).
- To promote research and networking.

Professional Certification: Why Certify? To protect the consumer from unqualified providers.

•ATP (Assistive Technology Professional):

- The current standard certification.
- Requires a mix of education and work experience.
- Exam covers assessment, funding, and ethical practice.

•RET (Rehabilitation Engineering Technologist):

- A historical certification for high-level engineers (now largely merged or specialized).

Rehabilitation Science and Engineering.

Service Delivery Models

•The Clinical Team Approach:

- Physician: Writes the prescription based on medical necessity.
- Therapists (PT/OT): Evaluate the patient's functional skills and goals.
- Rehab Engineer: Designs, modifies, or configures the technology.
- Supplier: Orders the device, handles insurance/billing, and maintains the equipment.

•The User: The most important member of the team.

Complex Rehabilitation Technology (CRT)

•Definition: Medically necessary, individually configured products (e.g., custom molded seating, power wheelchairs with alternative drive controls).

•Contrast: Distinct from "Durable Medical Equipment" (DME) like standard walkers or basic hospital beds.

•Engineering Role: CRT requires an engineer or ATP to specify the programming and mechanical configuration.

Rehabilitation Science and Engineering.

Impact on Mainstream Technology

•Universal Design: The concept that designing for disability improves the product for everyone.

•Examples:

- Curb Cuts: Designed for wheelchairs, but used by strollers, delivery carts, and skateboarders.
- Texting: Originally related to TTY technology for the deaf.
- Voice Recognition: Originally for paralyzed users, now used in Siri/Alexa.

Thank You
For Your Attention