Engineering Design *An Introduction*

Chapter 15

Human Factors in Design and Engineering

Engineering Design *An Introduction*

Introduction

- We expect to live and work in environments that fit us
- Human factors
  - Also called ergonomics
- Henry Dreyfuss
  - Father of human factors in the US
  - Books *Designing for People* (1955) and *Measure of Man* (1960)


Engineering Design An Introduction
Introduction (cont'd.)
• Common workplace injuries
– Carpal tunnel syndrome
– Tendonitis
• Occupational Safety and Health Administration (OSHA)
– Responsible for enforcing safety and health in the workplace
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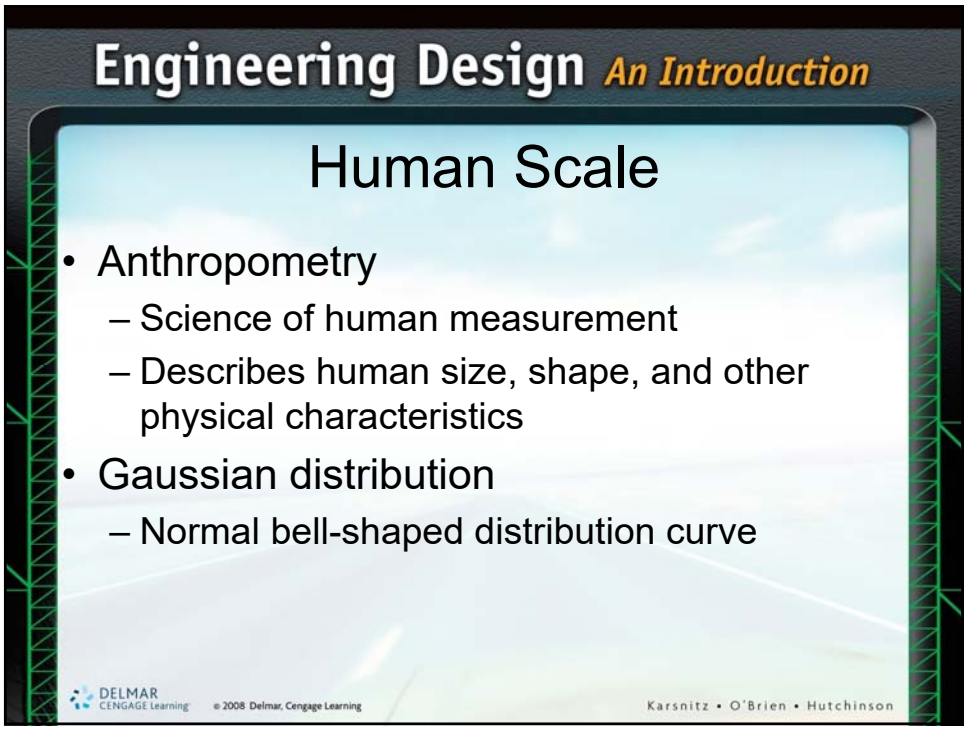
Engineering Design An Introduction
Human Scale
• Anthropometry
– Science of human measurement
– Describes human size, shape, and other physical characteristics
• Gaussian distribution
– Normal bell-shaped distribution curve
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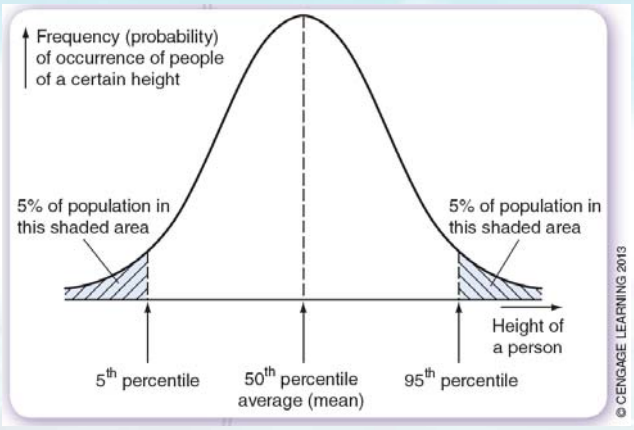

Figure 15-12 Data representing the height of a population of all high school students would take on a bell-shaped form, called a Gaussian curve

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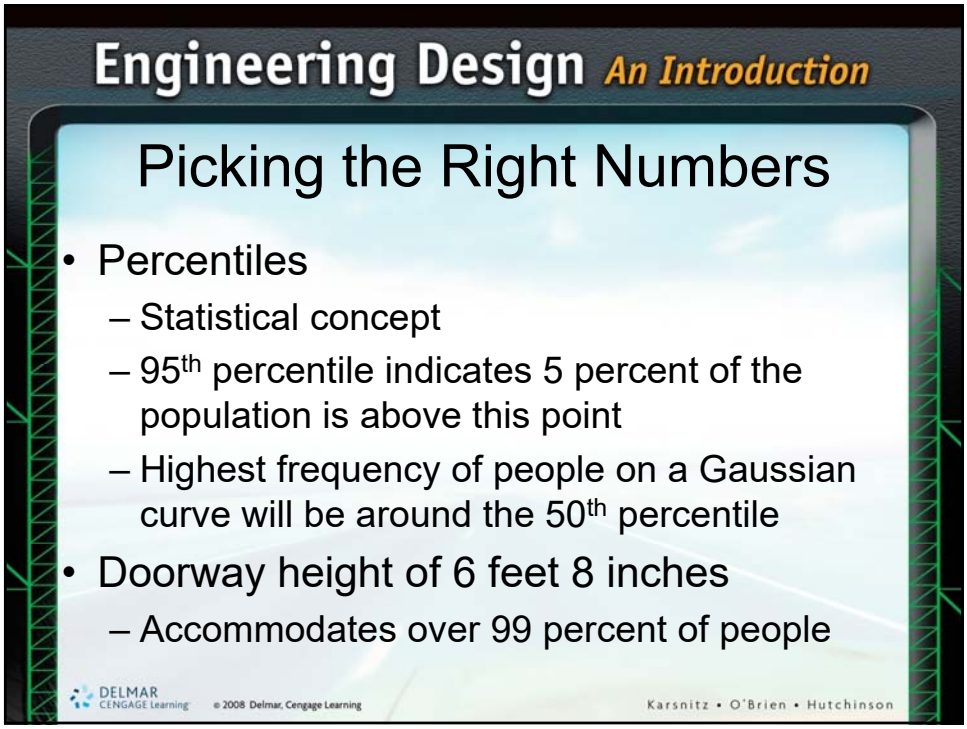
The Myth of the Average Person

- Mass-produced products
  - Designed for a broad range of consumers
  - Less-expensive to produce and sell than custom items
- Doorway
  - Designed to allow nearly all adults to pass through without bending over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Picking the Right Numbers
• Percentiles
– Statistical concept
– 95th percentile indicates 5 percent of the population is above this point
– Highest frequency of people on a Gaussian curve will be around the 50th percentile
• Doorway height of 6 feet 8 inches
– Accommodates over 99 percent of people
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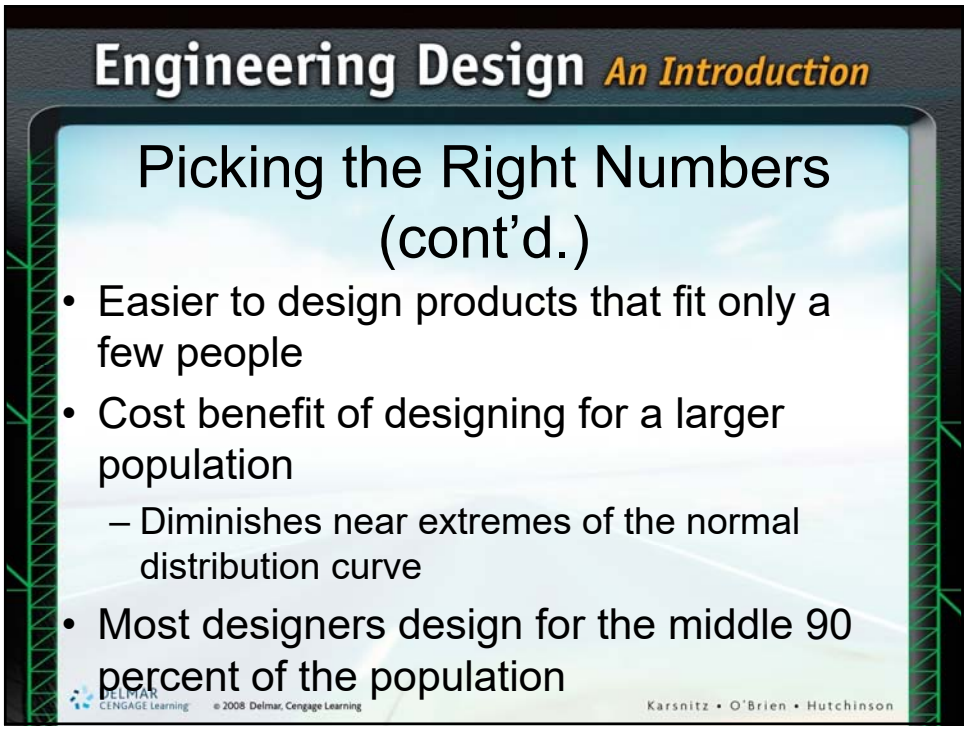
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Picking the Right Numbers (cont'd.)
• Easier to design products that fit only a few people
• Cost benefit of designing for a larger population
– Diminishes near extremes of the normal distribution curve
• Most designers design for the middle 90 percent of the population
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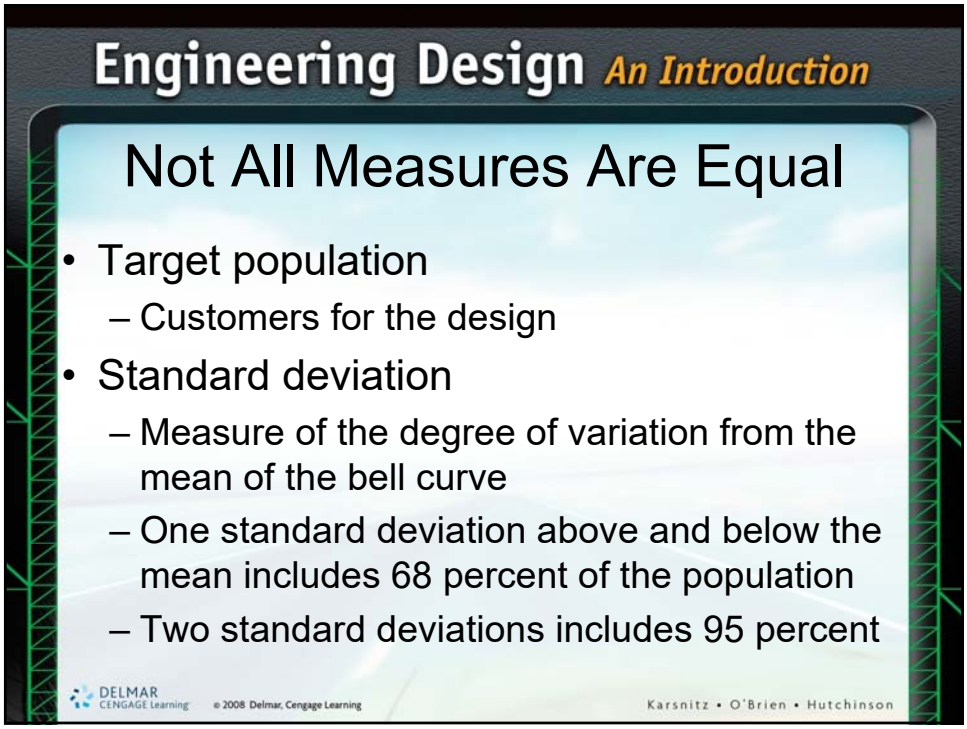
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Not All Measures Are Equal
• Target population
– Customers for the design
• Standard deviation
– Measure of the degree of variation from the mean of the bell curve
– One standard deviation above and below the mean includes 68 percent of the population
– Two standard deviations includes 95 percent
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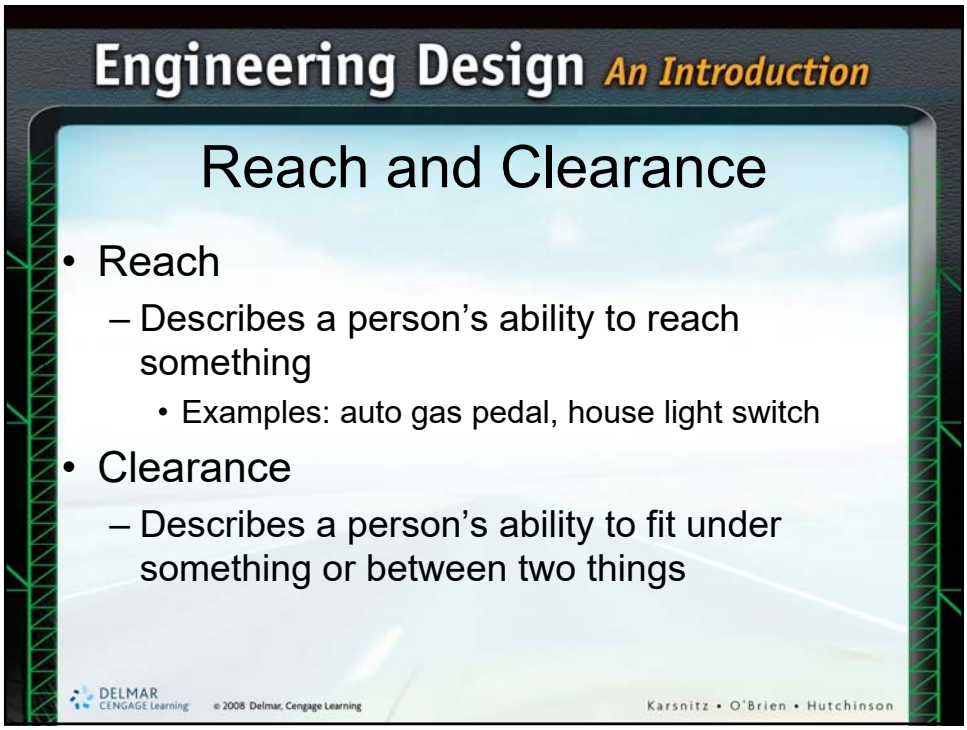
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Reach and Clearance
• Reach
– Describes a person's ability to reach something
• Examples: auto gas pedal, house light switch
• Clearance
– Describes a person's ability to fit under something or between two things
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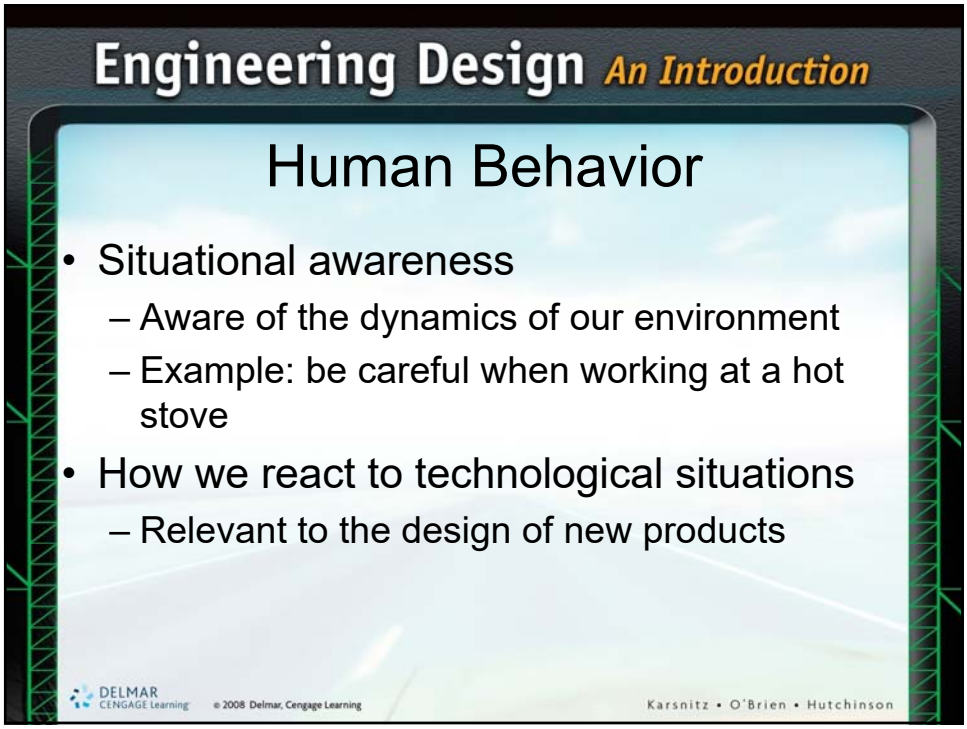
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Human Behavior
• Situational awareness
– Aware of the dynamics of our environment
– Example: be careful when working at a hot stove
• How we react to technological situations
– Relevant to the design of new products
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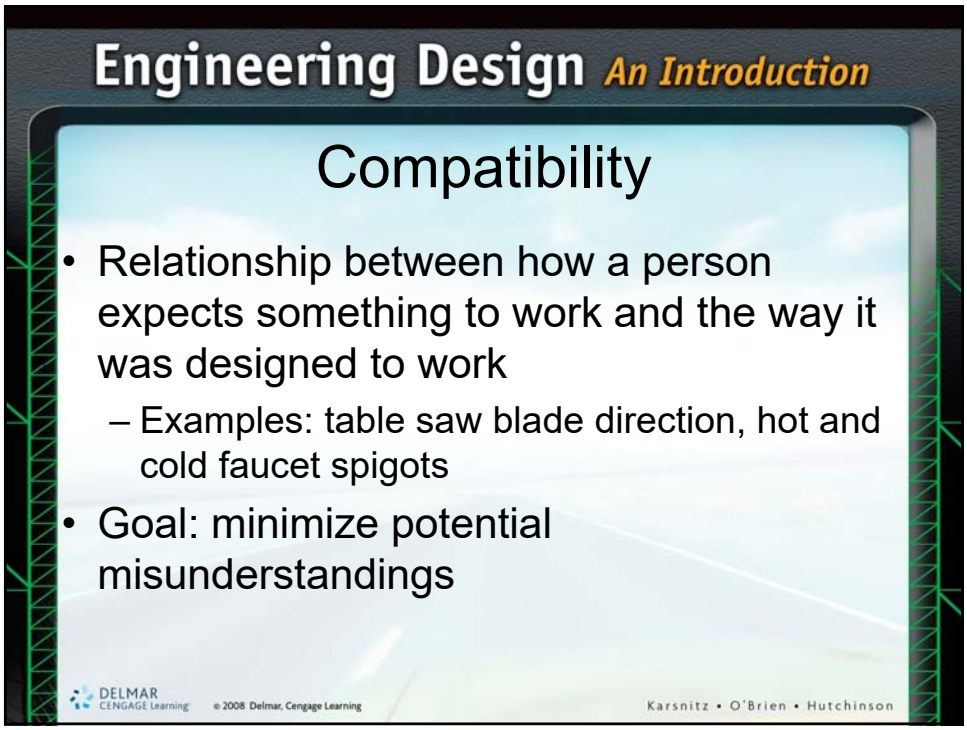
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Compatibility
• Relationship between how a person expects something to work and the way it was designed to work
– Examples: table saw blade direction, hot and cold faucet spigots
• Goal: minimize potential misunderstandings
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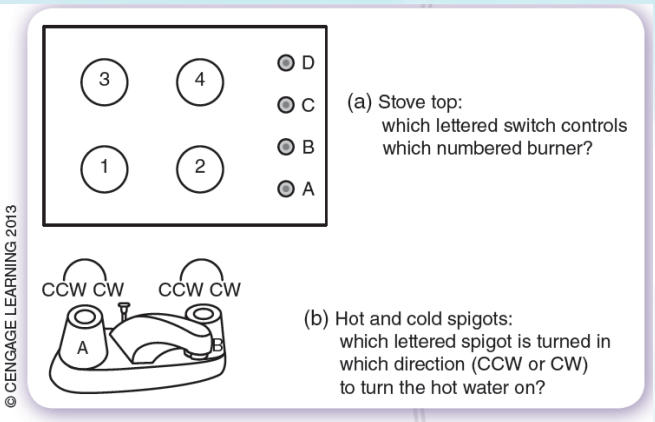

Figure 15-9: Stove and spigot illustration.

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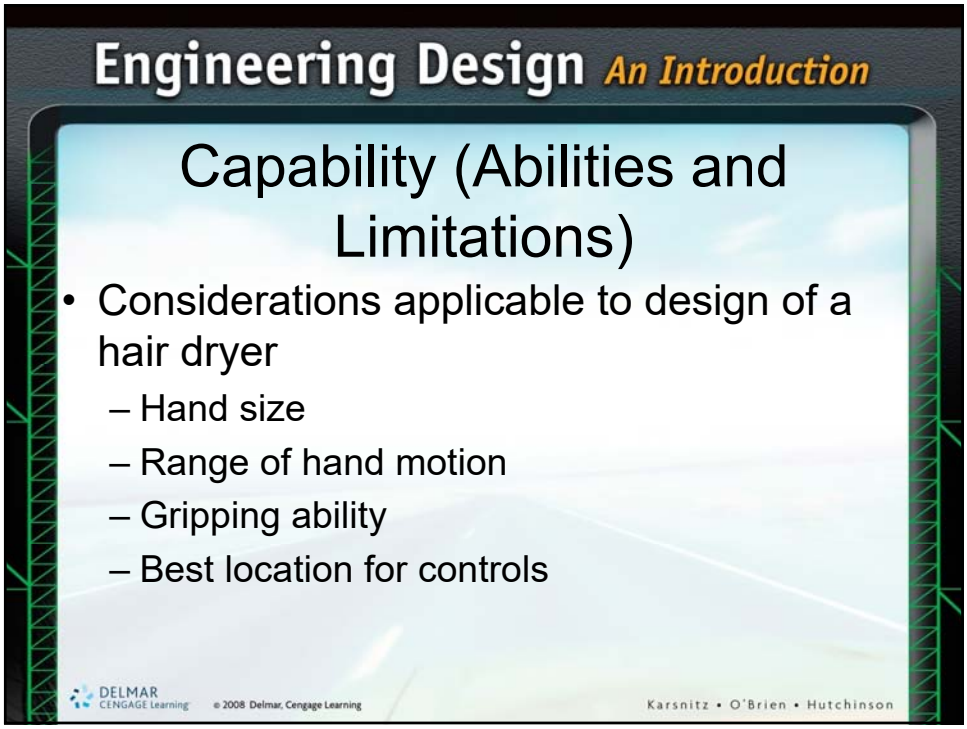
Posture and Movement

- Sitting
  - Body is better supported
  - Can generate less force than standing
- Standing
  - Body under more stress than sitting
  - Causes fatigue more easily
  - Can exert greater force than sitting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Capability (Abilities and Limitations)
• Considerations applicable to design of a hair dryer
– Hand size
– Range of hand motion
– Gripping ability
– Best location for controls
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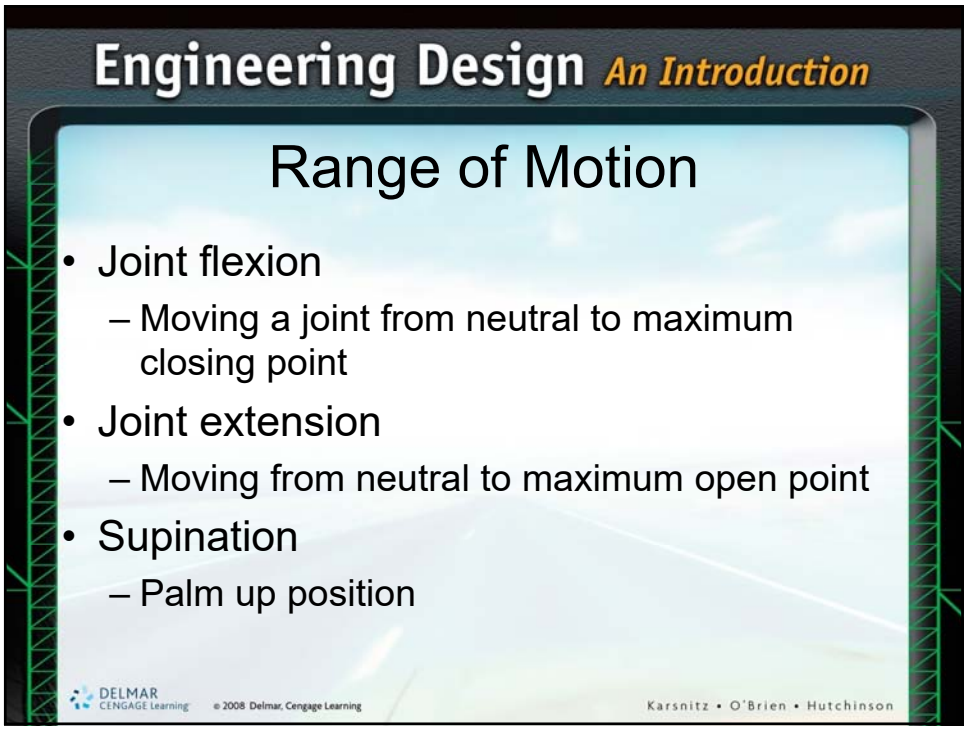
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Range of Motion
• Joint flexion
– Moving a joint from neutral to maximum closing point
• Joint extension
– Moving from neutral to maximum open point
• Supination
– Palm up position
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Range of Motion (cont'd.)

- Pronation
  - Palm down position
- Body generally most comfortable in neutral position
  - Stress and tension minimized

Engineering Design *An Introduction*

The Hand

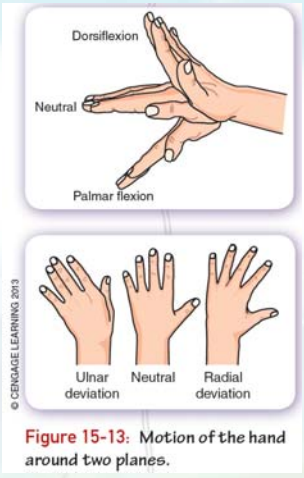
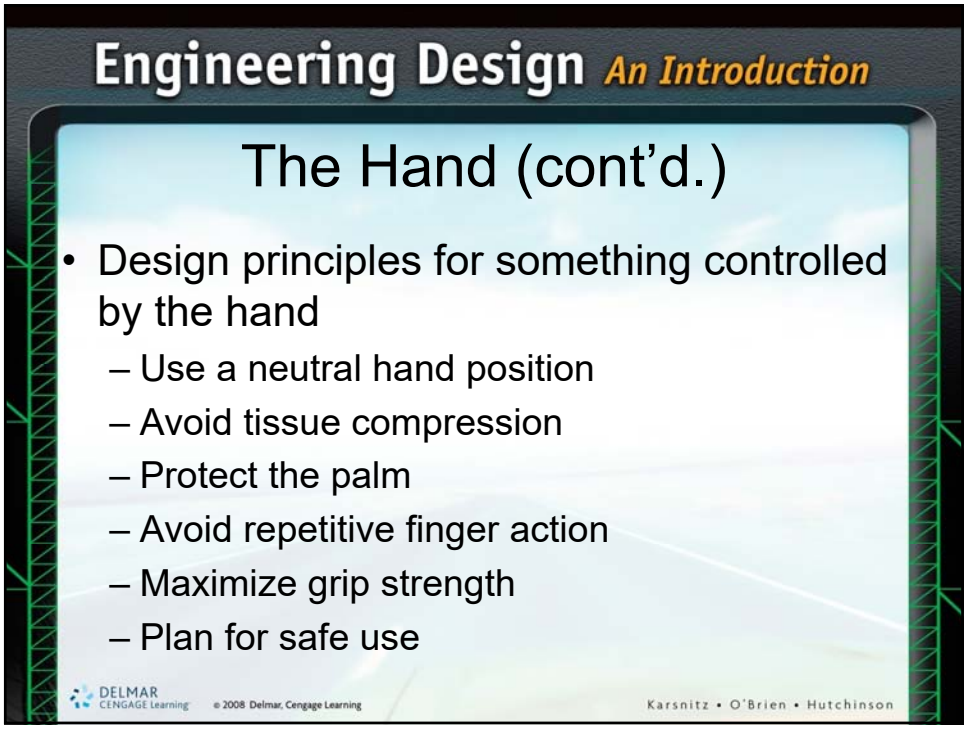


Figure 15-13: Motion of the hand around two planes.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The Hand (cont'd.)
• Design principles for something controlled by the hand
– Use a neutral hand position
– Avoid tissue compression
– Protect the palm
– Avoid repetitive finger action
– Maximize grip strength
– Plan for safe use
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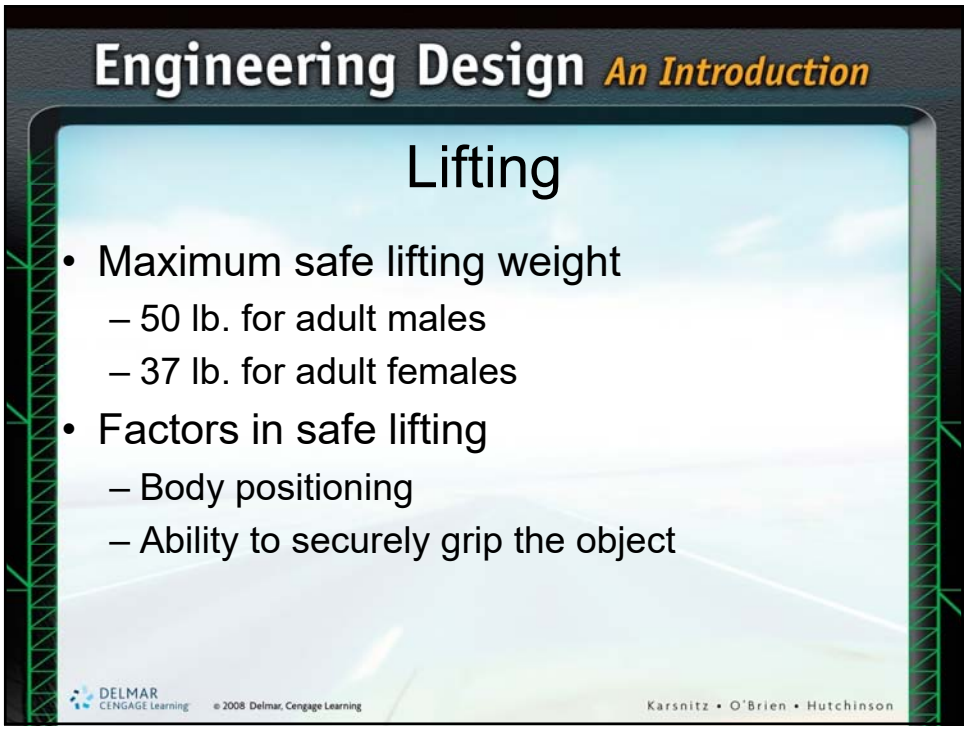
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Lifting
• Maximum safe lifting weight
– 50 lb. for adult males
– 37 lb. for adult females
• Factors in safe lifting
– Body positioning
– Ability to securely grip the object
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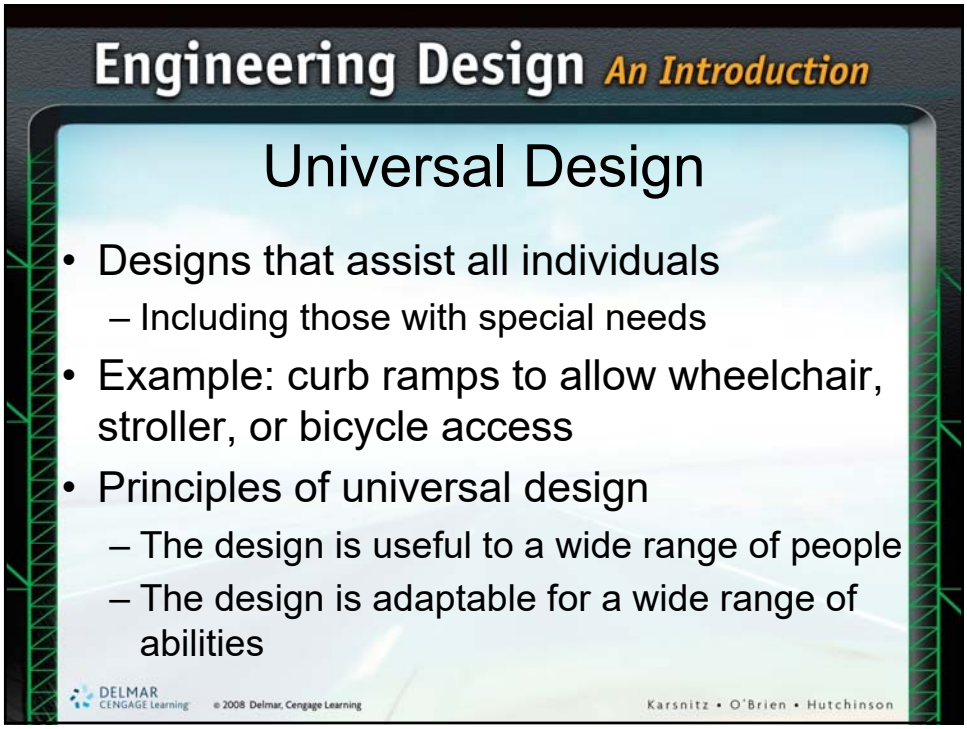
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Universal Design
• Designs that assist all individuals
– Including those with special needs
• Example: curb ramps to allow wheelchair, stroller, or bicycle access
• Principles of universal design
– The design is useful to a wide range of people
– The design is adaptable for a wide range of abilities
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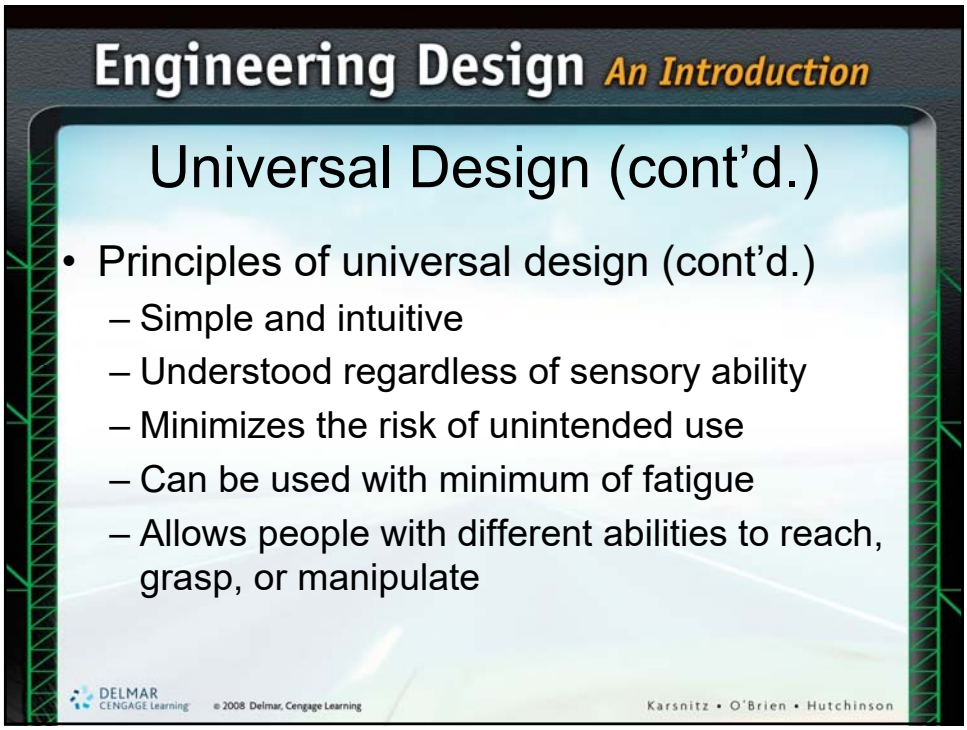
Engineering Design An Introduction
Universal Design (cont'd.)
• Principles of universal design (cont'd.)
– Simple and intuitive
– Understood regardless of sensory ability
– Minimizes the risk of unintended use
– Can be used with minimum of fatigue
– Allows people with different abilities to reach, grasp, or manipulate
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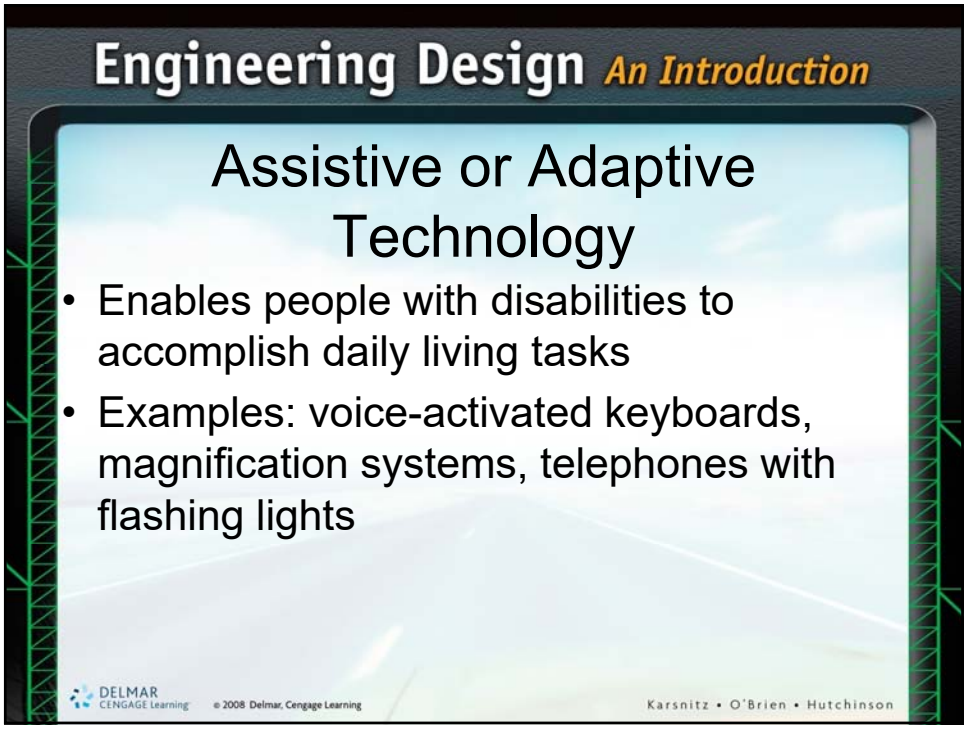
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Assistive or Adaptive Technology
• Enables people with disabilities to accomplish daily living tasks
• Examples: voice-activated keyboards, magnification systems, telephones with flashing lights
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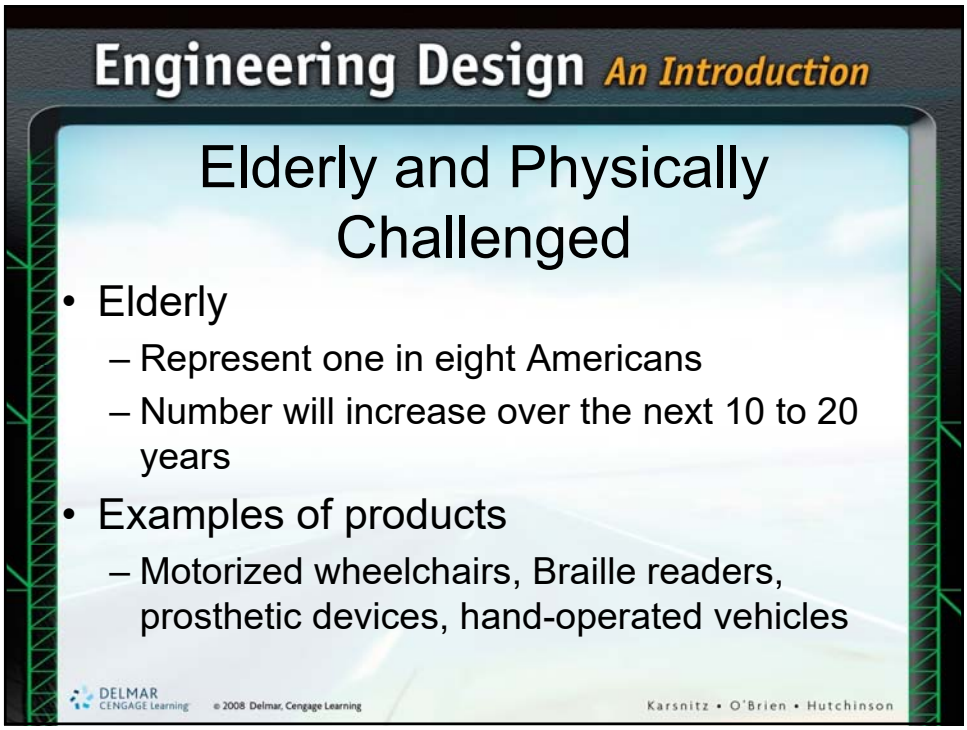
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Elderly and Physically Challenged
• Elderly
– Represent one in eight Americans
– Number will increase over the next 10 to 20 years
• Examples of products
– Motorized wheelchairs, Braille readers, prosthetic devices, hand-operated vehicles
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Designing with Anthropometric Data

- Steps when considering human factors
  - Identify target population
  - Find appropriate human factors data about the target population
  - Apply that data to all possible solutions
  - Test solution using members of the target population

Engineering Design *An Introduction*

Designing a Chair

- General purpose adult chair
- North American market
- 5th to 95th percentiles will be used
- Seat height
  - Determined by popliteal height
  - See measurement "A" in Figure 15-20

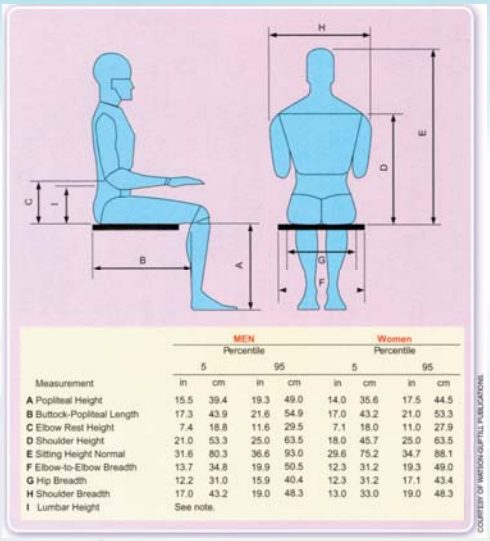

Figure 15-20: Key anthropometric dimensions required for a chair design.

	MEN Percentile				Women Percentile			
	5		95		5		95	
Measurement	in	cm	in	cm	in	cm	in	cm
A Popliteal Height	15.5	39.4	19.3	49.0	14.0	35.6	17.5	44.5
B Buttock-Popliteal Length	17.3	43.9	21.6	54.9	17.0	43.2	21.0	53.3
C Elbow Rest Height	7.4	18.8	11.6	29.5	7.1	18.0	11.0	27.9
D Shoulder Height	21.0	53.3	25.0	63.5	18.0	45.7	25.0	63.5
E Sitting Height Normal	31.6	80.3	36.6	93.0	29.6	75.2	34.7	88.1
F Elbow-to-Elbow Breadth	13.7	34.8	19.9	50.5	12.3	31.2	19.3	49.0
G Hip Breadth	12.2	31.0	15.9	40.4	12.3	31.2	17.1	43.4
H Shoulder Breadth	17.0	43.2	19.0	48.3	13.0	33.0	19.0	48.3
I Lumbar Height	See note.							

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Designing a Chair (cont'd.)

- Seat height determines posture
- Other measures
  - Seat width and depth
  - Seat tilt
  - Angle and size of the back
  - Lumbar support
  - Location of arm rests

Figure 15-22: Standards are developed by the Business and Institutional Furniture Manufacturer's Association (BIFMA) Engineering Committee and recommended to the American National Standards Institute (ANSI) for adoption every five years.

ANSI/BIFMA Commercial-Grade Chair Specifications Summary:
• Chair back can support a load of 113 kg (250 pounds). • Chair remains stable when an adult load of 79 kg (173 pound) weight is transferred to the front or back legs. • Chair leg maintains its structural integrity when a 52 kg (115 pound) weight is applied to a side. • Chair seat can withstand a static test of 136 kg (300 pounds) dropped from 152 mm (6 inches) above the seat. • Chair is considered durable if a weight of 57 kg (125 pounds) dropped 100,000 repetitions from 51 mm (2 inches) above the seat does not change its structural integrity.

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Evaluating Design for Human Factors

- Designs must be evaluated against human factors principles
  - In addition to other design evaluation criteria

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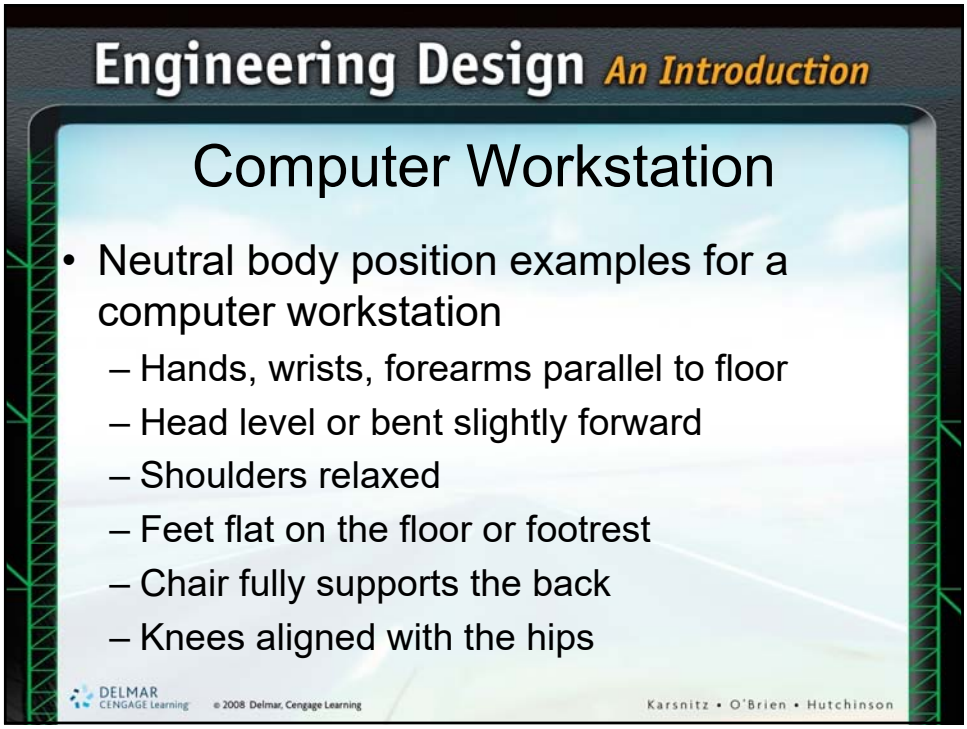
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Computer Workstation
• Neutral body position examples for a computer workstation
– Hands, wrists, forearms parallel to floor
– Head level or bent slightly forward
– Shoulders relaxed
– Feet flat on the floor or footrest
– Chair fully supports the back
– Knees aligned with the hips
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