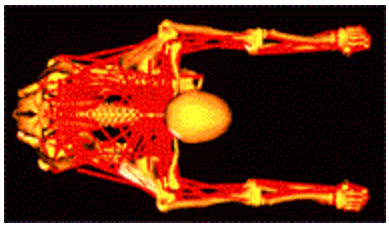
Building Better Bodies

An Introduction to Biomedical Engineering



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USING THIS MANUAL

A. OVERVIEW

The key to doing an effective Outreach presentation is finding the right level for your audience. Children hate being talked down to and no one likes being lectured at so keep the presentation as interactive as possible. When you feel a spark with a certain topic and piece of information, go with it and build on it. Remember, you're doing the presentation to help the students learn about a new topic, but you're also there to have fun and make sure that they have fun as well. Be sure to keep that in mind, especially if you get nervous.

This manual is meant to be a guide and will not be the only tool to prepare you for the presentation. In order to deliver an effective presentation, you must practice and have a strategy. Think about the purpose of the presentation and what you are trying to convey by being there. Also, pay attention to your audience. If something isn't working, change it. There are no rigid rules that you need to follow. Just keep your purpose in mind and you will be fine.

You will be representing the Biomedical Engineering department, the College of Engineering and the University of Wisconsin-Madison. You can be proud of that but remember that you are not an expert and no one expects you to be. You will likely be asked questions that you cannot answer. Do not feel pressured to answer all questions…do the best you can and if you get stuck, acknowledge that you have a very good question at hand, admit that you don't know the answer, and provide a resource where a correct answer can be found.

Most importantly, enjoy yourself. The kids may or may not say it, but they love having you there. Show them that you want to be there too. If you do, you are guaranteed an excellent, one-of-a-kind experience.

B. PREPARATION FOR PRESENTATION

Below is a list of tasks to complete in preparation for your presentation:

1. Review manual
2. Inventory kit and check that all parts are present
3. View prepared video of previous presentation
4. Craft your own script for the presentation
5. Practice the presentation on your own
6. Practice the presentation at least 2 times with other group members

OVERVIEW

1. PURPOSE

K-12 ENGINEERING OUTREACH PROGRAM:

The mission of the K-12 outreach program is to improve science and engineering literacy, to engage and interest school children and their teachers, to expose undergraduate students to outreach and to its rewards, and to make science and technology fun.

For science teachers,
...the outreach program offers hands- on demonstrations and in-class discussions about the state of the art in technology.
For the U.W. students,
... this is a chance to talk to younger people about their studies and to polish their presentation skills in front of a "real world" audience.
For the school children,
...the outreach program provides an opportunity to interact with young adults who can give them information and advice about the value of studying science and math.

BIOMEDICAL ENGINEERING OUTREACH PROGRAM:

The mission of the Biomedical Engineering Outreach program is to introduce students to Biomedical Engineering, help them to learn about the many applications of Biomedical Engineering, promote and encourage teamwork and trouble shooting to solve problems, and engage the students in interesting and thought provoking discussions and activities relating to Biomedical Engineering. The primary goal of this outreach is to leave the students with an enhanced and positive conception of mathematics, science and engineering. We want them to feel empowered and able to conquer the field of engineering and dispel all misconceptions they had about the field.

2. AUDIENCE

This presentation can be tailored to a variety of different audiences; however the initial development of the Outreach kit was done with a fourth grade audience in mind. Students at this grade level (age 9-10) are restless and very eager to help, but constantly need to be involved in something. They also pride themselves when they are chosen to lead, or to help demonstrate a concept.

The following bulleted list has been created to remind presenters of the capacity of the students for which this presentation is designed.

- Keep things: short, simple and interactive.
- Younger children have a very short attention span, but don't underestimate them…they are very bright and very sharp.
- They understand ideas through comparisons to things that they already know so try to give them examples of things that they see everyday in your attempts to convey a concept.

- Make sure to give them time to think about a question before you provide the answer…they can usually get it if you give them time.

- Just get them involved and excited. It will definitely help to show your own enthusiasm. Children are very good at sensing excitement and enthusiasm and it reflects in their own actions, so try to be conscious of that.

3. PRESENTATION FORMAT

1. Set up and Preparation (10 minutes)
2. Interactive game and Introductions (10 minutes)
3. Presentation Modules (20 minutes for each one)
4. Conclusion (10 minutes)

4. PRESENTATION OVERVIEW

Below, you will find a brief overview of the elements of the presentation. A detailed outline with specific guidelines is included in the next section of this document.

4.1 Set-up and Preparation

Arrive at least 10-15 minutes before the presentation to allow time to meet the teacher, set-up materials for the presentation, and review notes. Make sure to keep a bottle of water on hand as you will be talking for over an hour. (Taking a sip occasionally allows you to collect your thoughts and assess your pace and audience focus).

4.2 Introductions

Before you introduce yourselves, you are going to get the students involved in an interactive game to get them excited about your being there. The purpose of the introduction is to introduce yourselves and the topic that you are discussing. Your first impression to the students carries a great deal of weight so be prepared and excited to talk. You'll continue the introduction with a brief discussion of why you're there (the purpose of the BME Outreach program) and of Biomedical Engineering.

4.3 Presentation Modules

4.3.1 Ergonomic Backpack Workstation: Start the presentation by illustrating ergonomics to the kids (Large pencil activity). Once they understand the concept of ergonomics, ask them where else they see it. Get some examples, but get them to say backpacks. Then, prompt them to think about those times when it felt like there was an elephant in their backpacks or that their straps were digging into their shoulders. Start out with the Eddie Bauer and Ogio brand backpacks. Make a design matrix with the group (using the white pad or chalk board) to compare the backpacks looking at different features. After the matrix is completed and the score is calculated, break them up into 3 groups and give each group a new backpack (Moda brand backpack, Metro Carrier backpack, Jansport with Airlift technology). They'll use these features from the matrix to evaluate the one backpack that their group is assigned. Then, each group will present their evaluation and their total for their backpack. Decide on the most ergonomic backpack but help them understand that each feature comes with a price…sometimes a very costly one.

4.3.2 Radiology Fundamentals Workstation: Start this presentation by breaking the students into groups of 3 to 4 students. Begin with the riddle and scenario outlined in the section to get them

loosened up and excited about the activity. X-Rays are used for many things, but you really want them to understand how they are used in a medical sense. When conveying the fundamentals of how X-Rays work, *stress* how the properties of matter that the X-Ray penetrates appear on film. This is very important regardless of which option chosen for presentation. You may also find the X-Ray examples in the kit useful for enhancing the student's understanding of the topic.

Option 1: Students will be given one of the four suggested anatomical features to depict. The purpose is for them to understand that broken bones, metal, muscle, air, etc. appear differently on the printed film. They will use the black construction paper and white chalk to create an X-Ray. Allow students to use the skeleton to reference where bones are and where bones are not. After 10 minutes, have the individual groups finish what they have been assigned and allow for the other groups to guess the problem and feature that is drawn/shaded on the black construction paper. Every group gets one guess. When each group has presented their drawing, the activity is completed.

Option 2: Students will be given a baggie that has (puzzle) pieces of one anatomical feature. As a group they are to arrange the pieces into the appropriate arrangement. Once they have successfully done this, they are to then use a Post-It (if available), or scratch paper to label and locate air, bones, and muscle. If time permits, you can have the students look at each other's completed puzzle; if time is up, the activity is complete at this point.

4.4 Conclusion

The purpose of the conclusion is to tie everything together. The students have just seen at least two different applications of Biomedical Engineering. Encourage them to think about that and other applications. Also, help them realize that they have the capability of being an engineer someday; so let them see how many opportunities there are in the field of Biomedical Engineering. Before you leave, try to address as many questions as you have time for and provide the list of resources found at the end of this manual with you contact information. Finally, be sure to thank the teacher and students for having you.

5. SPECIFIC PRESENTATION GUIDELINES

This section contains information as to what to expect when you first begin the presentation. Guidelines for set up and introduction of the activities are specified to prepare you for things that they may not otherwise consider.

5.1 Set Up

Before you begin the presentation, take a few moments to get to know the teacher and find out how things are run in the classroom. Briefly inform them about your presentation as well.

5.1.1 What are the rules and methods for maintaining discipline in the classroom? What are the rewards and consequences?

- Are students supposed to raise their hands when they have a response or just yell out the answer? It will be easier for you to follow the rules that have already been established in the classroom rather than asking the teacher and students to change.
- If there are not any rules, be sure to set some (i.e., no yelling, do not speak out of turn…). You may want to enforce some type of two-finger rule or clapping rhythm to alert students to be silent.

5.1.2 Explain the format of the presentation to the teacher. For the presentation modules, the class will be divided in half so that each group will spend 20 minutes at each module. Within the modules, the students will be divided further into teams. Let the teacher divide the class into halves since he/she will know the students much better and can do it more efficiently.

5.1.3 Provide the teacher with evaluations and ask that he/she fill them out whenever possible.

5.2 Introductions

5.2.1 Ice Breaker (see background information section **7.3** for Telephone description):
- The telephone game
- Riddle (use your own but be tasteful)

5.2.2 Introduce yourselves

a. Hi, my name is …[*]

b. I am majoring/minoring in … engineering at the University of Wisconsin-Madison.

c. We are here today to talk and share our experiences with Biomedical Engineering.

5.2.3 Introduce Biomedical Engineering

a. *Who's heard of Biomedical Engineering?* If no one has, ask about Engineering.

b. Find out what they know about Biomedical Engineering (don't spend too much time here) *What do you think a Biomedical Engineer does?*

c. Break down the words. Write them on the board.
   - Bio-: life, living things, biology
   - Medical: medicine or treatment given by health care providers (like doctors)
   - Engineering: application of science and math to designing things

d. Tie it together for them:
   A Biomedical Engineer uses traditional engineering knowledge and skills to analyze and solve problems in biology and medicine to provide better health care.

[*] All items in this manual in *italics* are things that should be said aloud to the students.

6. PRESENTATION MODULES

6.1 ERGONOMIC BACKPACK DESIGN MODULE

6.1.1 Materials Needed:

1. 5 backpacks: Eddie Bauer, Ogio brand backpack (yellow), Moda brand backpack (rolling), Metro Carrier backpack (one strap), Jansport with Airlift technology
2. White paper and markers to make design matrix
3. Measuring tapes
4. A smile ☺

6.1.2 Introduction to Ergonomics

6.1.2.1 *Has anyone heard of ergonomics before? What is ergonomics?* (Don't spend too much time here.) Write the parts of the word on the board.
-Ergon: work
-Nomics: the science that deals with
-Ergonomics: the science that deals with work

6.1.2.2 Now illustrate ergonomics. ACTIVITY: Have a child sit on the floor. Give them an oversized pencil to write on a plastic board on the ground.

1. Ask the student: *How does that feel?*
2. Ask the class: *Does the student look comfortable? What could you do to make him/her more comfortable?* Possible ideas below:
   - Raise the plastic board
   - Support the back
   - Give him/her a smaller pencil that fits into his/her hands
   - Can't write on plastic (Give him/her a different writing utensil and/or writing surface)
3. *Ergonomics involves designing to make activities easier and more comfortable for people. You just made ergonomic changes.*

6.1.2.3 *Where else do we see ergonomics? HINT: Think of things that can be arranged or adjusted?*

- Chairs
- Keyboards
- Airplane seats
- Pens/pencils
- BACKPACKS (clue: it's something you use every day to bring your books to and from school)
- Many more ideas!!! Translate their "ideas" into real applications if needed.

6.1.2.4 *You may not think that you have heard of ergonomics before but you know what it is. Does it ever feel like you're carrying an elephant in your backpack or do your straps ever dig into your shoulders so much that it hurts?*

6.1.3 Evaluation of 2 backpacks

6.1.3.1 *What makes a backpack ergonomic? Look at these 2 backpacks. Which one do you think is more ergonomic?* (Get some responses but don't spend too much time.)

6.1.3.2 *Those were some great ideas. Let's look at them in detail. A design matrix is a common tool used by engineers to compare features of products. We're going to make a design matrix to compare the backpacks.*

6.1.3.3 Draw the table below on the board without the features. Have the students come up with features by looking more closely at the packs. The students will be tempted to give you

accessory features (see table below for examples). Help them understand the difference between features and characteristics that serve ergonomic purposes and those that serve style/convenience purposes. Ask them about the specific parts of the backpack. (Ex. What do you think about these straps? Are they good?) Help them understand why each feature is important. Also, have them rate the packs 1-3 for each feature (1 being bad and 3 being excellent).

Ergonomic Features	**Function**	**Eddie Bauer**	**Target Brand**
Wide shoulder straps	Spread the load (so straps won't dig in)		
Chest/waist straps	Spread the load (more support)		
Padded straps	Comfort (so they won't dig in)		
Length of backpack***	Fits the body (bottom of pack should touch lower back)		
Width of backpack	Fits the body		
Padding in lower back	Comfort		
Adjustable straps	Fits the body		
Fabric	Comfort		
TOTAL:			

Accessory Features	**Function**	**Eddie Bauer**	**Target Brand**
Pockets (pencil, keys, CDs, phone)	Convenience		
Logos, pictures	Style		
Color	Style		
Other…			

6.1.4 Teamwork

6.1.4.1 Split into teams to evaluate backpacks: Each team will evaluate one backpack using the list of features developed in part c. (Only ergonomic features are to be used in the evaluation.)

6.1.4.2 Presentation of evaluations to the group and the total score for each backpack.

*** You can use the measuring tapes to measure the length and width of the backpacks. You can also measure the length of a child's back to illustrate a backpack that may be too big or too small. Make sure to ask the child if it is OK for you to measure his/her back before you do it. Always tell the child where you will be putting your hands BEFORE you put them there. For the back length, you can measure from the nape of the neck down to the small of the back. For the width, you can measure from shoulder to shoulder and along the small of the back (where the backpack often rests). Most of these measurements can be done without you touching a child but you can touch their back as long as they feel comfortable with it. Approximate measurements are fine.

6.1.5 Discussion

6.1.5.1 *Based on the design matrix, which backpack is the most ergonomic?* Look at the totals for each bag. Largest point value should be the best backpack.[****] (If it doesn't turn out that way, try to fix any major errors. Otherwise it doesn't really matter as long as they understand the concept.)

6.1.5.2 *There are other features to consider too. Understand that each feature comes with a price tag. While the Jansport pack is the most* ergonomic, it is also very expensive. It can cost over $100. The wheels on the backpack help, but some don't want the added weight or they don't like the look?

6.1.6 Wrap-up

All of these features are things that an engineer considered in designing your backpack. Now, you probably know more than most people do about your backpack, even college students.

[****] The Jansport brand backpack rated the highest by our standards, but it is also the most expensive.

6.2 X-RAY FUNDAMENTALS PRESENTATION MODULE

6.2.1 Materials Needed:

1. Flashlight
2. Idea of body parts to image (Section 7)
3. Black and white film negatives
4. Black Construction Paper
5. Colored pencils or chalk
6. Post-It Notes (Option 2)
7. Description of anatomical features with problem (Option 1)
8. Enthusiasm!

6.2.2 Introduction

6.2.2.1 Riddle to begin this section. Presenter may opt not to do this.

Dogs love me,
People break me,
I can be found in your hand…
I even help carry you over land
I am not in your eye? So what am I?
(Bones!!!)

6.2.2.2 *Here's a scenario. Let's say you're walking to the bus stop on a cold January morning and you're just about to the stop when you see the bus coming. You begin to run and then slip on a patch of ice. You fall forward and break your fall with your hands. When you hit the ground, you feel an immense pain in your wrist. You don't see any scrapes or bruises, but it really hurts.*

- *What could be wrong?* (Bones are broken, organs damaged, you could get some crazy ideas here but narrow in on the bones.)
- *How could you check to see that everything is OK inside your body?* (Get them to say, X-ray!)

6.2.2.3 Has anyone here ever had an X-ray? What was it for? What *are other reasons people get X-rays?* (List the reasons on the board.)

1. Detection of cavities
2. Detection of fractures, tumors, degenerative conditions (decreased size/function)

6.2.2.4 *What is an X-ray?* Obtain ideas from students. Then, tell them the formal definition:
-An X-ray is a detailed look inside a structure. X-Rays are high energy light waves that penetrate through and surface and scatter inside. This scatter is what creates a picture/ X-Ray. These high intensity waves cannot be seen with the human eye.

6.2.2.5 *What if we didn't have X-rays?* Obtain ideas from students.
-Painful and unneeded procedures would occur. Surgery was performed to see if bones were broken before this procedure.

6.2.2.6 *So, how does an X-ray work? There are 3 main concepts.* List the 3 concepts below (photograph, shadow, and negative) on board. Define the words with the help of students on the board.

a. Photograph: recorded light image
b. Shadow: blocked light
c. Negative: think "opposite" or "backwards"; light items dark, dark items light (*You've seen them before. They come with the photo's you get back from the store. Those "negatives" are the film that was in your camera!)*
d. *An X-ray (also called a radiograph) is a lot like the negatives from your camera. The image is produced by X-rays instead of light rays. The X-rays are like tiny bundles*

with a lot of energy so they can pass through the body. Light has less energy so it cannot pass through the body.

- *There are some structures like bone and metal that even X-rays cannot pass through because they are very dense. Structures that are dense (i.e., bone and metal) will appear white.*
- *Air will appear black because the rays can pass through air. (That's why people hold their breath before an image is captured… so that the X-rays are not blurry.)*
- *Structures that are more dense than air but less dense than bone or metal will show up gray.*

6.2.3 Activity

6.2.3.1 Break students into three groups (Presenter may want to do this at beginning… it builds excitement and may help to keep students interested if they know they are going to be involved in a project)

6.2.3.2 Assign parts of the skeleton or joint to students. Tell them that the particular feature has a fracture, or puncture (i.e., Jasmine has a ring on her left forefinger, Dwayne has a nail stuck in his foot, Karen fractured her radius…etc.) Do not allow groups to know what others groups are doing. This will be revealed at the end.

- **Option 1**: Remind students of how air, metal and bone behave on an X-ray film/ surface. In their groups have them depict the anatomical feature they've been assigned with the black paper and white chalk. They will be allowed to look at the mini skeleton and knee joint. After 10 minutes, have each group present their pictures. The other groups are expected to guess the feature as well as the problem.[******]
- **Option 2**: If X-ray film is available cut into shapes to create a puzzle. Have students arrange the pieces and guess the anatomical feature. Once the pictures are together, each group should label structures of air, metal, bone and possibly muscle.

6.2.4 Wrap Up

Today you have all learned about the fundamentals of an X-ray!! It took many years to discover these, and you've just learned the basics in 15 minutes. X-rays can be used to diagnose a wide range of conditions from bronchitis/ bad-cold to a broken arm. In airports, fundamentals of X-ray are used to "see" inside of luggage. In a few years, they may be used for many other things. How do the concepts of X-Ray relate to biomedical engineering? Other options may be found in the background section. You want the students to understand the connection between life sciences and engineering (i.e., human biology and teamwork….).

[******] Suggestions for anatomical features with problems for Option 1: Chest- with broken rib(s), Hand -person is wearing ring, Foot- broken middle toe, Spine- crooked at top or slipped disk

7. CONCLUSION

1. *We hope that you have learned some useful information today. More importantly, we hope that you had a great time.*
2. *Today, we did a few of the things that Biomedical Engineers do. There are many more things though. I am going to ask a bunch of questions and if any of them pertain to you, raise your hand and keep it raised.*
   a. Do any of you like to use computers?
   b. Do any of you like learning about how things work?
   c. Do any of you like helping others?
   d. Do any of you like to designing or building things?
   e. Do any of you like sports?
   -If you have your hand raised right now, you have at least one thing in common with a Biomedical Engineer. That means that you could become a Biomedical Engineer and you could build better bodies too!
3. *Another fun fact is that engineers are among the highest paid professionals entering the work force after college.*
4. *Thank you for having us here!*
5. Provide any sources of additional information to students and teachers. Encourage the students to seek out more information and take advantage of the opportunities available to them.
   a. Opportunities to come to UW-Madison: one of the top universities in the nation is out their back door!
   b. Internet resources: provide list of resources included at the end of this document
   c. Contact information (in case they have questions after you leave)

8. BACKGROUND INFORMATION

8.1 What does a Biomedical Engineer do?

1. Design instruments, devices, systems and software
2. Develop new concepts and procedures using knowledge from many sources
3. Conduct research to solve clinical problems
4. Design and constructing cardiac pacemakers, defibrillators, artificial kidneys, blood oxygenators, hearts, blood vessels, joints, arms, and legs.
5. Design computer systems to monitor patients during surgery or in intensive care, or to monitor healthy persons in unusual environments, such as astronauts in space or underwater divers at great depth.
6. Design and build sensors to measure blood chemistry, such as potassium, sodium, 02, CO2, and pH.
7. Design instruments and devices for therapeutic uses, such as a laser system for eye surgery or a device for automated delivery of insulin.
8. Design systems for laparoscopic and arthroscopic surgery or devices for fracture fixation or joint replacement.
9. Develop strategies for clinical decision-making based on expert systems and artificial intelligence, such as a computer-based system for selecting seat cushions for paralyzed patients or for, managing the care of patients with severe burns or for diagnosing diseases.
10. Design clinical laboratories and other units within the hospital and health care delivery system that utilize advanced technology. Examples would be a computerized analyzer for blood samples, ambulances for use in rural areas, or a cardiac catheterization laboratory.
11. Design, build and investigate medical imaging systems based on X-rays (computer assisted tomography), isotopes (position emission tomography), magnetic fields (magnetic resonance imaging), or ultrasound.
12. Construct and implement mathematical/computer models of physiological systems.
13. Design and construct biomaterials and determining the mechanical, transport, and biocompatibility properties of implantable artificial materials.
14. Implement new diagnostic procedures, especially those requiring engineering analyses to determine parameters that are not directly accessible to measurements, such as in the lungs or heart.
15. Investigate the biomechanics of injury and wound healing.
16. Create replacements for damaged tissues.
17. Develop new devices and systems for augmenting or substituting for loss of sight, hearing, balance, touch, and spatial orientation.

8.2 Applications of Biomedical Engineering

1. Bioinstrumentation: the application of electronics and measurement techniques to develop devices used in diagnosis and treatment of disease.
2. Biomaterials: includes both living tissue and artificial materials used for implantation. Understanding the properties and behavior of living material is vital in the design of implant materials. The selection of an appropriate material to place in the human body may be one of the most difficult tasks faced by the biomedical engineer.
3. Biomechanics: applies classical mechanics (statics, dynamics, fluids, solids, thermodynamics, and continuum mechanics) to biological or medical problems. It includes the study of motion, material deformation, flow within the body and in devices, and transport of chemical constituents across biological and synthetic media and membranes. Progress in biomechanics has led to the development of the artificial heart and heart valves, artificial joint replacements, and a better

understanding of the function of the heart and lung, blood vessels and capillaries, and bone, cartilage, intervertebral discs, ligaments and tendons of the musculoskeletal system.

4. Cellular, Tissue, and Genetic Engineering: involve more recent attempts to attack biomedical problems at the microscopic level. These areas utilize the anatomy, biochemistry, and mechanics of cellular and sub-cellular structures in order to understand disease processes and to be able to intervene at very specific sites. With these capabilities, miniature devices deliver compounds that can simulate or inhibit cellular processes at precise target locations to promote healing or inhibit disease formation and progression.
5. Clinical Engineering: the application of technology to health care in hospitals. The clinical engineer is a member of the health care team along with physicians and other hospital staff. Clinical Engineers are responsible for developing and maintaining computer databases of medical instruments and equipment for records and for the purchase and use of sophisticated medical instruments. They may also work with physicians to adapt instrumentation to the specific needs of the physician and the hospital. This often involves the interface of instruments with computer systems and customized software for instrument control and data acquisition and analysis. Clinical engineers are involved with the application of the latest technology to health care.
6. Medical Imaging: combines the knowledge of a unique physical phenomenon (sound, radiation, magnetism, etc.) with high speed electronic data processing, analysis, and display to generate an image. Often, these images can be obtained with minimal or completely noninvasive procedures, making them less painful and readily repeatable than invasive techniques.
7. Orthopedic Bioengineering: specialty where methods of engineering and computational mechanics have been applied for the understanding of the function of bones, joints, and muscles, and for the design of artificial joint replacements. Orthopedic bioengineers analyze the friction, lubrication, and wear characteristics of natural and artificial joints; they perform stress analysis of the musculoskeletal system; and they develop artificial biomaterials for replacement of bones, cartilages, ligaments, tendons, meniscus, and intervertebral discs. They perform gait and motion analyses for sports performance and patient outcome following surgical procedures.
8. Rehabilitation Engineering: enhance the capabilities and improve the quality of life for individuals with physical and cognitive impairments. They are involved in prosthetics, the development of home, workplace and transportation modifications and the design of assistive technology that enhance seating and positioning, mobility, and communication. Rehabilitation engineers are also developing hardware and software computer adaptations and cognitive aids to assist people with cognitive difficulties.
9. Systems Physiology is the term used to describe that aspect of biomedical engineering in which engineering strategies, techniques, and tools are used to gain a comprehensive and integrated understanding of the function of living organisms ranging from bacteria to humans. Computer modeling is used in the analysis of experimental data and in formulating mathematical descriptions of physiological events. In research, predictor models are used in designing new experiments to refine our knowledge. Living systems have highly regulated feedback control systems that can be examined with state-of-the-art techniques. Examples are the biochemistry of metabolism and the control of limb movements.

8.3 Ergonomics

1. Definition of Ergonomics:
   -The study of the design and arrangement of equipment so that people will interact with the equipment in healthy, comfortable, and efficient manner. (As related to computer equipment, ergonomics is concerned with such factors as the physical design of the keyboard, screens, and related hardware, and the manner in which people interact with these hardware devices.)
2. Overview of Ergonomics:
   a. Human factors engineering and ergonomics are scientific and technical disciplines that seek to design products and technologies that take into account the psychological and physiological

characteristics, capabilities and limitations of human users. Ergonomics has historically been concerned with accommodating humans' physical capabilities and limitations in the design of products. The objective of ergonomics is to influence the design of new technologies and systems so that their normal use will not result in physical injury to the user. Ideally, ergonomics makes new systems, products and technologies much easier, more enjoyable, safer and ultimately more productive to use.

b. The impact of ergonomics on consumer product design has grown dramatically within the past decade. The growth in "ergonomic design" can be attributed to a number of key factors, including: A growing public awareness of the purpose and benefit of ergonomic design, and the nature of the principles that underlie it.

i. Tremendous growth in the scientific and "applied" areas of ergonomics. This growth is reflected both in the number of advanced degree programs available at some of the world's leading universities (e.g., Cornell University, University of Michigan, Ohio State University, etc.), and in the number and quality of leading corporations with in-house ergonomics programs (e.g., 3M, John Deere, Blue Cross Blue Shield, etc.)

ii. A growing database of scientifically rigorous, empirical data on human physiological response to work and work systems, published in journals devoted to ergonomic and health issues (e.g., Human Factors, Applied Ergonomics, Ergonomics in Design, etc.).

iii. The growing number of human factors and ergonomic professionals, as indicated by continued growth in professional societies such as the Human Factors and Ergonomics Association and International Ergonomics Association.

iv. Enhanced awareness among industrial and consumer product designers, as well as the general public, of the importance of "user-centered design." This approach to the design of new technologies emphasizes the primary role of usability and comfort in determining whether or not a novel design is "successful."

3. Objective of Ergonomics:

-To improve the efficiency of operation by taking into account a typical person's size, strength, speed, visual acuity, and physiological stresses, such as fatigue, speed of decision making, and demands on memory and perception

4. Applications of Ergonomics:

-Applications range from the design of work areas (including office furniture, automobile interiors, and aircraft cockpits) to the disposition of switches and gauges on the control panels of machinery to determining the size, shape, and layout of keys on computer terminals and character height, color, and clarity on video displays. The field of ergonomics is also sometimes called human or human-factors engineering, engineering psychology, and biotechnology.

8.4 X-ray Information

1. Discovery of the X-ray

X-rays were first presented to the medical world by a German physicist named Wilhelm Roentgen in 1895. He was experimenting one day in his laboratory when he stumbled upon something so amazing he was unsure if it was actually real. Although many books state that Wilhelm was the first, A.W. Goodspeed was actually the first person to make this incredible discovery, on February 22, 1890. With no information or even proof that he had discovered what he had, Goodspeed did not take credit but instead renamed his discovery an accident.

With this technology physicians and medical experts can easily and quickly find out what is wrong without causing pain. He called them "X-rays" because he knew so little about them, hence the "x".

The process of what Wilhelm discovered in his dark laboratory that day is as follows-
He enclosed a glass tube inside of a black paper box. The glass tube had wiring that was running inside of it, much like what a light bulb has. This allowed for electrical currents to build up inside the glass tube. The tube was connected with an induction coil apparatus which let an electric current travel into the tube. When this occurred a faint green colored light appeared across the room. He was not quite sure if his eyes were fooling him or not, so he decided to make sure of the newfound light that he had discovered. Lighting a match, he discovered a small screen across the room, which was coated with a chemical. He blew out his match and once again, sent the current. The exact same light appeared. Wilhelm was incredibly thrilled! As days and weeks passed, he also found these rays, naked to the eye, could penetrate through objects like wood and metal. One day, his hand came in contact with the tube, and to his surprise he saw shadows of his hand and fingers with darker shadows representing the bones. When he moved his hand, the shadow on the screen moved too. This shadow became known as the first X-ray picture.

2. How does an X-ray work?
   X-rays were found to be able to penetrate through materials like flesh and air. The heavier atoms like metal absorb them. A beam of high-energy electrons crashes into a metal target and X-rays are produced. A filter near the X-ray source blocks the low energy rays so only the high-energy rays pass through a patient toward a sheet of film. Along with the sheet of film, a second sheet of film prevents the scattered X-rays from fogging the picture. Calcium in bones is considered a type of metal and when photographic film is placed on the body, this allows the technician to take the picture and an X-ray is developed to solve or analyze the problem. These rays were found to be harmful to the skin and soon new ways of medical imagers were developed.

3. What are X-rays used for?
   a. Radiation treatment
   b. To look at bones that could have a stress fracture or be broken
   c. To see something in the body that could have been swallowed
   d. To see the image of a gun-shot wound such as a bullet that entered the body
   e. To look at gallstones
   f. To examine teeth
   g. To scan baggage at the airport

4. More frequently asked questions about X-rays:
   a. What did X-rays replace?
      -X-rays replaced some very painful methods of finding broken bones. Things like feeling the bone or surgery. Sometimes doctors would do surgery on a patient and the bone would not even be broken! If X-rays were not around, it would be a time-consuming and agonizing procedure to find broken bones.
   b. Why not regular light?
      -Light does not have enough energy to pass through opaque structures like skin and bone. X-rays can penetrate and normal light cannot. X-rays can also provide shades of grey with densely opaque structures. Light can only do this with glass and some plastics.

X-rays do not reflect. The purpose of an X-ray is to see how well inside structures can block each ray. Light is blocked by everything. That is why we cannot *see* through people.

c. What's the future of the X-ray?
X-ray film is becoming obsolete. X-ray images will be viewed on a high-tech, high-resolution computer monitor. By physicians having images on electronic file, they are more easily stored and can be sent to specialist for review in different cities where the patient is not.

d. How is an ultrasound like an X-ray?
An ultrasound uses sound waves, not high-energy light waves. These waves are not harmful when absorbed by the muscle and bone it penetrates; that is why pregnant women can have ultrasounds with little risk to the fetus.

2. Why not just use film? What's the purpose of a film cassette?
You would roast! This is what happened in early years, the X-rays would burn people's skin because there was nothing to absorb the X-Rays that hit air and muscle.

The cassette has two absorbent layers, which absorbs 50% of the X-rays a patient is exposed to. Therefore, X-ray dose and exposure time is decreased.

f. How big does the source of light need to be?
An X-ray comes from a very small source. The smaller the opening for the x-ray, the clearer the image… and we want SHARP, CLEAR images.

8.5 Introductory game to "break the ice"

TELEPHONE ICEBREAKER

Depending on Room Set-up:
1. If easily able to place students in a

9. REFERENCES

Ranallo, Ph. D., F. Personal interview. 03 December 2001.

Ergoweb, Inc. *Applied Workplace Ergonomics.* Accessed 12/04/01. <http://www.ergoweb.com/>

Goldtouch Technologies. *An Introduction to Ergonomics.* Accessed 12/03/01.
<http://www.goldtouch.com/ergonomics/index.html>

Jacikas, K. and Woodland, M. *X-RAYS!* Accessed 11/20/01.
<http://www.sanjuan.edu/schools/arcade/xraywj.html>

Juhl, K. *How do X-Rays Work?* Accessed 11/20/01.
<http://www.cord.edu/faculty/manning/physics215/studentpages/katiejuhl.html>

Meister, D. *The History of Human Factors and Ergonomics.* Accessed 12/04/01.
<http://www.questia.com/Index.jsp>

10. RESOURCES FOR TEACHERS AND STUDENTS

ERGONOMICS

- http://www.ergoweb.com/
- http://www.goldtouch.com/ergonomics/index.html

X-RAYS

- http://www.cord.edu/faculty/manning/physics215/studentpages/katiejuhl.html
- http://www.bih.harvard.edu/radiology/frameset_info.html
- http://www.sanjuan.edu/schools/arcade/xraywj.html
- http://www.lakemedicalimaging.com/exams/xrays.htm

BIOMEDICAL ENGINEERING

- http://www.engr.wisc.edu
- http://www.engr.wisc.edu/bme/
- http://www.bmes.org/

K-12 OUTREACH

- http://tc.engr.wisc.edu/zwickel/Outreach/

UNIVERSITY OF WISCONSIN AT MADISON

- http://www.wisc.edu

TEACHER EVALUATION

Form to be completed by the class instructor.

School_____
Grade/ Age of Students_____
Teacher's Name_____

Please rate your current knowledge level for each subject, with a 5 indicating a strong knowledge of the subject and a 1 indicating little or no knowledge of the subject.

Please complete this section prior to the presentation.

Rate your knowledge of engineering
1 2 3 4 5
Rate your knowledge of biomedical engineering
1 2 3 4 5
What are your expectations for this presentation?

_____

_____

_____

Please complete this section after the presentation.

Rate your knowledge of engineering
1 2 3 4 5
Rate your knowledge of biomedical engineering
1 2 3 4 5
How familiar were the presenters with the material?
1 2 3 4 5
Were your expectations fulfilled? YES/ NO

What would make this outreach presentation more informative?

_____

_____

_____

May we contact you in future semesters? YES/NO

INVENTORY LIST

University Bookstore:
- ❑ Black Construction Paper
- ❑ Chalk (10 pieces) in container
- ❑ Sketch Pad
- ❑ Crayola Markers

Target:
- ❑ Ogio Brand Backpack
- ❑ Eddie Bauer Brand Backpack
- ❑ Jansport Brand Backpack with Airlift Technology
- ❑ Metro Carrier Brand Bag (one strap)
- ❑ Moda Brand Backpack (rolling)
- ❑ Plastic Clipboard
- ❑ Measuring tape

Office Depot:
- ❑ 6-foot Tape Measure

Anatomical Chart Company:
- ❑ Skeleton
- ❑ Knee Joint