

Physics 497

Medical Physics
Dr. Ann Schmiedekamp
Office 214W
Office Phone: 215-881-7572
email: ams@psu.edu

Spring 2002

Prerequisite: Physics 201, 202, 203/4 or Physics 215, 265; Math 140, 141

Objective: This course is a general survey of applications of physics in understanding the physiology and structure of the human body. It also covers physical principles behind instrumentation used in medical diagnosis and treatment. The course is appropriate for students intending professional work in a health profession.

Textbook: Cameron, Skofronick, Grant, *Physics of the Human Body*
Sprawls, Perry, *Physical Principles of Medical Imaging*

Grading Policy:

Exam 1 20% Hour exams will be closed book

Exam 2 20%.

Daily assignments and quizzes - 20% Included in this grade will be pop quizzes and assignments. There are no makeups for pop quizzes. If the student is absent from class a large number of times, the quiz grade will necessarily be low. Students are advised to attend class regularly.

Term Paper 20% A term paper will be required on a topic related to the course. The topic must be approved by the instructor.

Final Exam - 20% Final will be comprehensive but slightly weighted toward material since the last exam.

Any student who misses an exam will be given a zero for that exam unless arrangements are made with the professor on or before the date of the final. Written proof (doctor's note or other) will be required for a makeup exam.

Academic integrity is expected. Any reasonable proof of academic dishonesty in the completion of an exam or quiz will result in penalties which could be as severe as a grade of **F** in the course.

Jan. 7 Cameron: Chap. 1 Terminology, Modeling and Measurement

Chap. 8, sec. 6-9 Blood flow

Sprawls: Chap. 39 Statistics

Jan. 9 Cameron: Chap. 3 Muscles and Forces

Jan. 11 Cameron: Chap. 3 continued

Jan. 14 Cameron: Chap. 7 Lungs and breathing

Jan. 16 Cameron: Chap. 7 continued

Jan. 18 Sprawls: Chap. 2 Energy and Radiation

Jan. 21 Class cancelled.

Jan. 23 Sprawls: Chap. 2

Jan. 25 Sprawls: Chap. 3 Radiation Quantities and Units

Jan. 28 Sprawls: Chap. 3

Jan. 30 Sprawls: Chap. 4 Characteristics and Structure of matter

Feb. 1 Sprawls: Chap. 5 Radioactive Transitions

Feb. 4 Sprawls: Chap. 6 Radioactivity

Feb. 6 Sprawls: Chap. 6

Feb. 8 Exam 1

Feb. 11 Sprawls: Chap. 7 X-Ray production

Feb. 13 Sprawls: Chap. 8 Energizing and controlling the X-Ray Tube

Feb. 15 Sprawls: Chap. 8

Feb. 18 Sprawls: Chap. 10 Interaction of Radiation with Matter

Feb. 20 Sprawls: Chap. 11 Radiation Penetration

Feb. 22 Sprawls: Chap. 12 X-ray Image Formation and Contrast

Feb. 25 Sprawls: Chap. 13 Scattered Radiation and Contrast

Feb. 27 Sprawls: Chap. 20 Fluoroscopy

Mar. 1 Sprawls: Chap. 20

Mar. 11 Cameron: Chap. 9 Electrical Signals from the Body

Mar. 13 Cameron: Chap. 9

Mar. 15 Cameron: Chap. 11 Physics of the Ear

Mar. 18 Cameron: Chap. 11

Mar. 20 Cameron: Chap. 12 Physics of the Eye

Mar. 22 Cameron: Chap. 12

Mar. 25 Exam 2

Mar. 27 Sprawls: Chap. 23 Computed Tomography and Image formation; Term paper topic due

Mar. 29 Sprawls: Chap. 24 Computed Tomography Image Quality

Apr. 1 Sprawls: Chap. 25 Ultrasound Production and Interactions

Apr. 3 Sprawls: Chap. 26 Ultrasound Imaging

Apr. 5 Sprawls: Chap. 27 Ultrasound Imaging of Cardiac Motion and Flowing Blood

Apr. 8 Sprawls: Chap. 27

Apr. 10 Sprawls: Chap. 28 Magnetic Resonance Image

Apr. 12 Sprawls: Chap. 29 Nuclear Magnetic Resonance

Apr. 15 Sprawls: Chap. 30 Magnetic Characteristics of Tissue

Apr. 17 Sprawls: Chap. 31 Imaging Methods; Term paper due

Apr. 19 Sprawls: Chap. 32 Spatial Characteristics of the Magnetic Resonance Image

Apr. 22 Sprawls: Chap. 32

Apr. 24 Student Reports

Apr. 26 Student Reports

Final exam Monday, Apr. 29 8:30am-10:20 am

. Physical Aspects of the Human Body

A. Physics of the Skeleton

- 1) muscles acting as levers; first, second, third class levers. cameron, p. 21
- 2) strength of bones cameron p. 49ff
- 3) spinal structure cameron p. 27; stability while standing
- 4) joints

B. Physics of the Eye

1. Optics of the eye
cameron p. 263-8
2. retinal and light detection cameron pp. 268-
2. Diffraction and resolution cameron p. 274-6

C. Temperature Scales

1. Devices to measure temperature

2. Regulation of temperature in the human body

D. Physics of the Ear

1. decibels; general properties of sound cameron p. 220
2. outer ear p. 239 cameron
3. inner ear
4. deafness and hearing aids cameron p. 253
5. sense of balance cameron p. 256

E. Pressure

1. Blood pressure Webster p. 354ff
 - direct measurements
 - harmonic analysis of blood pressure waveforms
 - dynamic properties of pressure measurements systems
 - measurement of system response
 - effects of system parameters on response

2. The Lungs and Breathing cameron p. 92
3. other pressures in the body
 - a) eye pressure and glaucoma
 - b) pressure in the skull

- c) pressure in digestive system
- d) urinary bladder pressure
- e) hyperbaric oxygen therapy Cameron p. 104

F. Electricity and the Body

1. Nerve conduction Webster p. 150

2. Electrical diagnosis tools

- a. Electrocardiogram (ECG) Webster p. 172, p. 290ff
- b. Electroencephalogram (EEG) Webster p. 194
- c. Electroneurogram (ENG) Webster p. 165
- d. Electromyogram (EMG) Webster p. 169
- e. Magnetoencephalogram (MEG) Webster p. 216

3. Electrical safety

- a. important susceptibility parameters Webster p. 755
- b. microshock hazards Webster p. 765
- c. macroshock hazards Webster p. 763

Lasers as surgical tool

Radiation Therapy

II. Medical Imaging and Diagnosis

A. Fiber Optics Webster p. 99

- 1. index of refraction
- 2. total internal reflection
- 3. details of fiber bundles and scopes
- 4. electromagnetic spectrum

B. X-ray

1. production of X-rays Hendee, Ritenour p. 108ff
2. radiation units and exposure Hendee, Ritenour p. 146ff
 - a. Units
 - b. dosages
 - c. interaction of X- and gamma rays in the body Hendee, Ritenour p. 180ff
3. computed radiography
4. computed tomography

C. magnetic resonance imaging

1. Fundamentals of magnetic resonance Hendee, Ritenour p.p. 565
2. Interaction of Nuclei with static magnetic field
3. Interaction of nuclei with radio frequency wave
4. induction of magnetic resonance signal in a coil
5. magnetic resonance as a probe Hendee, Ritenour p. 586

D. Ultrasonic scanning Webster p.683

1. Ultrasonic properties of materials Hendee, Ritenour p. 483
2. attenuation of ultrasound Hendee, Ritenour p.484
3. reflection Hendee, Ritenour p. 488
4. refraction Hendee, Ritenour p. 492
5. absorption Hendee, Ritenour p.495
6. ultrasonic transducers Hendee, Ritenour p. 500
7. Doppler effect Hendee, Ritenour p. 547

E. Nuclear medicine

1. radiation detectors Hendee, Ritenour p. 191 ff

2 radioactive decay Hendee, Ritenour p. 36

3. instrumentation Hendee, Ritenour p. p. 307

4. . single-photon emission computed tomography Webster p.679

5. positron emission tomography Webster p. 679

III. Treatment Options

A. Laser Surgery

B. Radiation Therapy

1. Absorption of Radiation

2. Single beams

3. Brachytherapy

4. Ultrasound therapy