**DEPARTMENT OF PHYSICS**

**General Syllabus**

**Physics 31500**

**Medical Physics**

**Designation:** Undergraduate

**Catalog description:**
Physical aspects of the skeletal, circulatory, nervous, muscular, respiratory, and renal systems; diagnostic imaging including EKG, EEG, x-rays, CAT, MRI, lasers and fiber optical probes; radiation therapy and safety; nuclear medicine; artificial organs.
Prerequisites: Physics 20400 or 20800. 3 hr./wk.; 3 cr.

**Prerequisites:** Physics 203 and 204, Mathematics 205 and 209; or Physics 207 and 208, Mathematics 201, 202 and 203
Preferred (but not required): Chemistry 10301 and 10401

**Textbook:**

Resource Books (optional):

a. Physics of the Human Body, Irving P. Herman, (Springer, 2007), 857 pages (H). The presentation is at the level of this course but the material is restricted to the major organ systems of the human body.

   - Vol. 1: Mechanics, 548 pages;
   - Vol. 2: Statistical Physics, 640 pages;
   - Vol. 3: Electricity and Magnetism, 752 pages.


e. Biomechanics: Mechanical properties of Living Tissue, Second Edition, (Springer 1993), 568 pages (F2). In-depth study of the tissues of the body (constitutive equations, flow properties of blood, mechanics of erythrocytes, leukocytes and other cells, red cell-vessel wall interactions, bioviscoelastic fluids and solids, heart muscle, smooth muscle, bones and cartilage).
**Course Objectives:**
After taking this course the students will
a. develop a detailed understanding of the relation between subfields of physics including: rigid body mechanics, fluid mechanics, electricity, magnetism, modern physics and nuclear physics; and the functioning of the human body.
b. be able to describe in quantitative terms the physical operation of some of the major organ systems of the human body including: the skeletal system, the muscular system, the cardiovascular system, the nervous system, the respiratory system and the renal system.
c. gain a quantitative understanding of the physics underlying some of the major techniques used to image the human body including: EKG, EEG, EMG, X-rays, CAT, MRI, fiber optics, PET, SPECT and ultrasound and to be able to solve problems involving these instruments.
d. become familiar and be able to solve problems relating to the use of radioisotopes in nuclear medicine.
e. become familiar with and evaluate the efficacy of some of the devices used as artificial organs, including: the pacemaker, defibrillator, insulin pump, stents, artificial heart and artificial heart valves.
f. extend the boundaries of this survey course by researching a topic for the term paper.

**Class schedule:**
3 hours/week

**Relationship of course to program outcomes:**
   a) Learn laws of physics and solve problems.
   c) Communicate by written and oral means.

**Assessment Tools**
Grading policy:
   30% Midterm examination, 30% Final examination; 20% Term paper; 20% homework and class participation.

**Topics Covered:**
Week 1. Biomechanics and the skeletal system (Properties of materials, review of equilibrium, stress analysis, structural instability, review of work and energy, walking and running, dimensional analysis, arthroscopic, ligaments, tendons, muscle, joints). BSBLH Chapter 1. [Resource material: H Chapters 2, 4; HR Chapter 1; F2 Chapter 7, 12].

Week 2. The muscular system (kinematics and musculature, standing, walking, running, jumping, throwing, collisions), (skeletal muscles, structure of muscles, passive muscles, fatigue, coordination, active/tetanized muscles, sliding filament model). [H Chapters 3 and 5; HR Chapter 1; F2 Chapters 9, 10, 11]

Week 3. Biofluid mechanics and the circulatory system (Pressures in the cardiovascular system: bladder pressure, respiratory pressures, foot pressures, eye and ear
pressures; fluids in motion: blood flow rheology: Newtonian and non-Newtonian fluids; review of fluid dynamics; flow of viscous fluids in tubes; flow through an orifice; role of elastic walls; pulsatile flow, turbulent flow, microcirculation). BSBLH Chapter 2. [Resource material: H Chapters 7, 8; F1 Chapter 1, 2, 3, 4, 5, 6, 7]

Week 4. Pressure measurement and blood flow measurement (transducers, intraocular pressure, indicator dilution techniques, indicator transport techniques, thermal techniques, flowmeters, plethysmography, blood velocity measurement). BSBLH Chapters 18 and 19.

Week 5. The nervous system (physics of the senses; electrophysiology, the nervous system, muscle action potentials, evoked potentials, electrocardiogram (EKG), electroencephalogram (EEG), electromyogram (EMG), magnetoencephalogram (MEG)). BSBLH Chapter 3, 16. [Resource material: H Chapter 12, HR Chapter 6, HR Chapters 7.11].

Week 6. The respiratory system (respiratory function, lung capacity and ventilation, measurement of gas flow and volume (spriometer, pneumotachograph, plethysmography, rotameters, peak-flow meters, residual volume, flow volume curves), pulse oximetry, pneumography, bronchoscope, rhinoscope). BSBLH Chapter 17. [Resource material: H Chapter 9].

Week 7. The renal system (diffusion, osmotic pressure, hemodialysis, peritoneal dialysis, hemofiltration). The digestive system (endoscopy, colonoscopy, capsule endoscope, peristaltic flow). BSBLH Chapter 6.6, 6.7, 22.3.

Week 8. Ultrasound (generation, transducers, reflection, refraction, scattering, Doppler ultrasound). BSBLH Chapter 7, 12.3 [Resource material: HR Chapter 13]

Week 9. X-rays (Ionizing radiation, radiotherapy, production of x-rays, dose rate monitoring, dosimetry). BSBLH Chapter 21 [Resource material: HR Chapter 15, 16].

Week 10. CT scans (image formation, basic imaging theory, the point spread function, Fourier transformations, back-projection, the Radon transform, resolution, contrast and dynamic range) BSBLH Chapter 11, 12.5, 14 [HR Chapter 16]

Week 11. Radiation therapy (absorption, scattering and attenuation of gamma rays (photoelectric effect, Compton effect, pair production, biological effects, shielding, absorbed dose and biological equivalent dose, ionization chambers, Geiger-Mueller tubes, scintillation counters, PIN diodes, film dosimeters, PET, SPECT, proton therapy). BSBLH Chapter 5. [Resource material: HR Chapters 14, 15].

Week 12. Radioisotopes and nuclear medicine (review of nuclear structure, isotopes, halflife, radioactivity, energetics, neutron reactions and man-made isotopes, counters, volume measurements, clearance measurements, surface counting, hematological measurements, angiography, glomerular filtration rate, bone imaging, dynamic renal
function, myocardial perfusion, gamma cameras, brachytherapy, boron neutron capture therapy (BNCT)). BSBLH Chapter 6. [Resource material: HR Chapter 17, internet sources].


Week 14. Artificial organs (pacemakers, defibrillators, artificial heart valves, insulin pump, artificial heart, dental fillings) Elements of laparoscopy. Vison correction (lenses, LASIK). Audiology and hearing aids. BSBLH Chapter 22, 15. [Resource material: H Chapter 10, 11, HR Chapter 14]

Partial list of topics for term papers:
A Biosensors (temperature, strain (resistive, piezoelectric, inductive, capacitive, magnetostrictive), displacement, optical, blood-gas, acoustic, electrical and microprocessors.
B Drug delivery systems.
C Biomedical materials and artificial tissues.
D Artificial limbs.
E Electron microscopy.
F Structural NMR, x-ray crystallography, mass spectrometry.
H Fluorescent probes.
I Microelectrodes.
J Biofeedback.
K Neural networks (Hopfield nets, Hebbian learning, adaptive algorithms).
L Pattern recognition.
M Bioinformatics (DNA sequencing, proteomics, genome sequencing, gene expression, metabolic fluxes, cell signaling) and the instruments employed in these studies.
N Biomimetic materials.
O Space medicine for astronauts.
P Clinical aspects of pathologies for any of the various modalities covered in class.

Person who prepared this syllabus:

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Academic Integrity and Plagiarism

The CUNY Policy on Academic Integrity can be found at http://web.cuny.edu/academics/info-central/policies/academic-integrity.pdf

This policy defines cheating as “the unauthorized use or attempted use of material, information, notes, study aids, devices or communication during an academic exercise.” The CUNY Policy on plagiarism says the following about plagiarism (the CUNY Policy can be found in Appendix B.3 of the CCNY Undergraduate Bulletin 2007 -2009 as well as the web site listed above):

Plagiarism is the act of presenting another person’s ideas, research or writings as your own. The following are some examples of plagiarism, but by no means is it an exhaustive list:

1. Copying another person’s actual words without the use of quotation marks and footnotes attributing the words to their source.
2. Presenting another person’s ideas or theories in your own words without acknowledging the source.
3. Using information that is not common knowledge without acknowledging the source.
4. Failing to acknowledge collaborators on homework and laboratory assignments.
5. Internet plagiarism includes submitting downloaded term papers or parts of term papers, paraphrasing or copying information from the internet without citing the source, and “cutting and pasting” from various sources without proper attribution.

The City College Faculty Senate has approved a procedure for addressing violations of academic integrity, which can also be found in Appendix B.3 of the CCNY Undergraduate Bulletin.”