

Topics for the Premed Physics Course
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Traditional subject areas are listed with topics that could be used in the introductory course. Major themes are in bold; the other entries are examples. Reference SFFP (below) indicates a topic recommended by our customers; the other references point to examples of how a topic can be discussed in the introductory course.

REFERENCES

Blog: <http://hobbieroth.blogspot.com>

IPMB: Intermediate Physics for Medicine and Biology, 4th ed., page, section or chapter number, or homework (HW) problem chapter:number

MP-2: Resource Letter MP-2: Medical Physics, R. K. Hobbie and B. J. Roth, Amer. J. Phys. 77 (11): 967-978 (2009), reference number

PUMS: Physics Useful to a Medical Student. R. K. Hobbie, Amer. J. Phys. **43**(2): 121–132 (1975). Available at <https://files.oakland.edu/users/roth/web/PhysicsUsefulToAMedicalStudent.pdf>, page number (which contains references to the literature)

SFFP: Scientific Foundations for Future Physicians, Association of American Medical Colleges and Howard Hughes Medical Institute, (http://services.aamc.org/publications/showfile.cfm?file=version132.pdf&prd_id=262&prv_id=321&pdf_id=132), page number

SKILLS THAT OCCUR IN SEVERAL AREAS

Powers of Ten (IPMB Sec 1.1; Blog 10/12/07, 8/15/08)

Back-of-the-envelope estimations
(IPMB Sec 1.1, HW 1:1-4)

Exponential growth and decay
 $dy/dt = \pm by$

See SFFP, p. 22, 23, and especially p. 24, which says that the language of differential calculus should be used. The exponential crops up in many places.

Medical examples include pharmacology (loading dose), physiology (clearance) and oncology (tumor recurrence), Newton's law of cooling (IPMB HW 1.45), nuclear decay and half life (IPMB Sec. 17.2).

Data analysis, scatter plots, regression
(SFFP, p. 23; PUMS, p. 122; IPMB Sec. 11.1)
Semilog plots and log-log plots; (power law) scaling (PUMS, p. 122; IPMB, Ch. 2; Blog 3/28/08, 3/20/09; <http://www.gwu.edu/~ipls/2010AAPTSUMMER/bonefiles.html>)

There are dangers using semi log and log-log plots (Blog, 5/14/10; AAPT Talk on Medical Physics)

Stochastic vs. deterministic processes (SFFP, p. 23)

Dimensional analysis (SFFP, p. 22) **and Dimensionless numbers** (IPMB Sec. 1.18, HW 4.16, 4.37)

Analyzing experimental data: accuracy, precision, reproducibility; operate basic lab equipment (SFFP, p. 25)

Poisson distribution blood cells, radioactive decay, neurotransmitters at synapses and neuromuscular junctions; patch clamp experiments (PUMS, p. 122; IPMB, Appendix J)

Feedback systems (SFFP, p. 24, 28, 34; PUMS, p. 125; IPMB, Ch. 10)
positive feedback: nerve firing; hot tub deaths
negative feedback: temperature regulation, breathing (PUMS, p. 125; IPMB, p. 256ff)

MECHANICS (SFFP, p. 26)

Work, energy, force, acceleration (PUMS p. 122-123; IPMB Ch. 1)

Forces in muscles and bones (SFFP, p. 33; IPMB, Ch. 1)
Centrifuge (SFFP, p. 26; IPMB HW 1:21-23)
Atomic force microscope
Stress and strain IPMB Sec 1.9
Compliance, Law of Laplace IPMB HW 1:18,19, Surface Tension (PUMS, p. 123)

FLUIDS

Buoyancy (IPMB Sec 1.12, HW 1:20; Blog 7/10/09)

Decompression sickness (Blog 10/3/08)

Viscous flow and circulatory system (SFFP, p. 28, 33; IPMB 15-20; PUMS, p. 123)

Flow from capillary (IPMB, 115)

Stokes' law (IPMB, p. 87)

Turbulence (IPMB 21)

Reynolds numbers (IPMB Sec. 1:18, Blog, 2/1/08)

THERMODYNAMICS AND TRANSPORT (SFFP, p. 28)

First and second laws (PUMS, p. 124)

Heat Capacity (IPMB Sec. 3.11)

Boltzmann factor (PUMS, p. 124; IPMB, Ch. 3, Ch. 6)

Gibbs free energy (constant T, P) IPMB 65-67

Osmotic pressure and flow (IPMB Ch 5, HW 5:4-6)

Diffusion: Fick's first and second laws; x proportional to $t^{1/2}$, diffusion and solvent drag (PUMS, p. 124; IPMB, Ch. 4)

Stokes-Einstein relationship (IPMB, 89-90); See Mark Reed's lab experiments on diffusion at <http://www.gwu.edu/~ipls/2010AAPTSSUMMER/workshopfiles.html>

Heat transfer (PUMS, p. 124)

Counter-current heat transfer (PUMS, p. 125; IPMB Sec. 5.8, HW 5:17)

SOUND

dB (IPMB 347)

Impedance matching of middle ear (IPMB 349)

Hearing curve (lab)(IPMB 348)

Threshold of hearing and range of movement of ear drum (IPMB 355)

Hearing protection

Ultrasound Imaging (SFFP, p. 28; IPMB, Ch. 13; MP-2 36-47)

Interference

Acoustic impedance (IPMB Sec. 13.3)

Attenuation

Echoes

Doppler flow measurement (PUMS, p. 127; IPMB, p. 353)

Artificial cochlea (Blog, 9/25/09; MP-2 144)

ELECTRICITY AND MAGNETISM (SFFP, p. 27)

Nernst equation (IPMB Sec. 3.8)

Potential across cell membrane

Resistor ladder

RC network

Ion channel permeability (SFFP, p. 34; IPMB Sec. 9.7, Blog 3/26/10)

Electrotonus (IPMB Sec. 6.12)

Hodgkin and Huxley Model (IPMB Sec 6.13; Blog 5/2/08)

Myelinated fibers (lower capacitance), Nodes of Ranvier (SFFP, p. 27, 33; IPMB Sec. 6.16)

Exterior potential; EKG (Blog 6/20/08, 8/21/09; <http://www.phys.gwu.edu/ipslwiki/index.php/Laboratories>),

EEG, EMG (IPMB, Ch. 7; MP-2 115-126)

Magnetic field of nerve (IPMB Sec. 8 3; Blog 3/5/10)

Electrophysics of the brain (Blog 2/17/09)

Electrophoresis

Cardiac and deep brain stimulation (Blog, 5/29/09; MP-2 147)

Cardiac bioelectric therapy (Blog, 1/16/09; IPMB Sec. 7.10; MP-2 127-129, 137, 138)

Cardiac arrhythmias (MP-2 130-134; IPMB HW 10:39-40)

Magnetic forces (IPMB Sec 8.1, Blog 12/26/08)

Magnetic Cell Sorter (IPMB HW 8:31; MP-2 124)

Transcranial magnetic stimulation (IPMB Sec. 8.7; Blog, 12/12/2008; MP-2 125, 126)

OPTICS

Geometrical optics of the eye: vergence (SFFP, p. 28; IPMB, p. 388ff; Blog 6/18/10)

Ophthalmoscope (PUMS, p. 128)

Diffraction and visual image resolution (SFFP, p. 28, PUMS, p. 128)

Color vision (Young, Helmholtz, Maxwell) (Blog, 5/8/09)

Photon-limited sensitivity to dim light (PUMS, p. 128)

Blackbody radiation (IPMB Sec 14.7; Blog 4/30/10)

ATOMIC AND MOLECULAR PHYSICS (SFFP, p. 28)

Atomic and molecular energy levels

Vibrational spectra

UV and skin cancer

Fluorescence: optical mapping of trans-membrane potentials, immunofluorescence (PUMS, p. 129)

Photon diffusion (Blog, 4/17/09)

Blood flow oximeter (MP-2 156; IPMB Sec. 14.6.1)

Blue light to treat neonatal jaundice

Cell phones and cancer (Blog 12/5/08)

Compound microscope (IPMB HW 14.45)

Interference, diffraction, microscope resolution (PUMS, p. 128)

Total internal reflection (IPMB HW 14.46) and endoscopes

Raman scattering

Laser surgery (MP-2 150-152)
 Electron microscope (Blog 2/19/10)
 Optical coherence tomography (MP-2 153-156)

XRAYS (SFFP, p. 28)

PE, Compton, pair production (IPMB Ch 15; Blog 5/9/08)

Energy loss of charged particles

Detectors: film, computed, digital

Diagnostic imaging: radiographs, CT (MP-2 17-35, 48-57)

Image examples – optimum photon energy (IPMB 447)

Dose

Radiation risk (IPMB Sec. 16.10)

Cross section (IPMB Sec. 14.4)

Radon (IPMB Sec. 16.13.4; MP-2 107)

Image Gently (Blog, 2/13/09; 3/6/09)

Therapy (Blog 8/28/09)

Proton therapy (IPMB Sec 16.11.3, Blog, 4/24/09)

NUCLEAR PHYSICS (IPMB Ch. 17)

Alpha, beta, gamma

Technetium (Blog 3/13/09)

Tc-99, Mo-99, shortage (Blog, 10/14/07, 5/23/08, 7/7/09, 2/26/10)

Nuclear images (gamma camera, SPECT) (MP-2 58-67)

PET, 18FDG (IPMB Sec. 17.14)

MRI (SFFP, p. 28; MP-2 68-90)

Generation, detection and analysis of MRI signals (IPMB, Ch. 18)

Functional MRI (BOLD) (IPMB Sec. 18.12)

Diffusion Tensor Imaging (IPMB Sec 18.13 and HW 4:22 and 18:40; Blog 5/30/08)

NON-TRADITIONAL

Damped harmonic oscillator (PUMS, p. 126)

Fourier series; circulation; image reconstruction (PUMS, p. 126; IPMB, Ch. 11, Ch. 12)

Non-linear systems

Chaos (IPMB Sec. 10.8, HW 37-38; Blog 10/17/08)

Alternative Medicine (MP-2 163, 164; Blog 3/21/08, 4/23/10)