503 Osteopathic Manipulative Medicine - III
Summer. 1(0-2) Interdepartmental with Osteopathic Manipulative Medicine. Administered by Department of Osteopathic Manipulative Medicine. P:M: (OMM 502) R: Open only to students in the College of Osteopathic Medicine.

Students will use their palpatory skills as they learn the principles of functional (indirect) and myofascial release osteopathic manipulative treatment.

504 Osteopathic Manipulative Medicine - IV
Fall. 1(0-2) Interdepartmental with Osteopathic Manipulative Medicine. Administered by Department of Osteopathic Manipulative Medicine. P:M: (OMM 503) R: Open only to students in the College of Osteopathic Medicine.

Basic cranio-sacral osteopathic manipulative medicine. Exposure to various osteopathic approaches to the extremities.

505 Osteopathic Manipulative Medicine - V
Spring. 1(0-2) Interdepartmental with Osteopathic Manipulative Medicine. Administered by Department of Osteopathic Manipulative Medicine. P:M: (OMM 504) R: Open only to students in the College of Osteopathic Medicine.

Use of patient complaints/conditions to integrate material presented in OMM 501, 502, 503, 504 while preparing the student for OMM 506.

506 Osteopathic Manipulative Medicine - VI
Summer. 1(0-2) Interdepartmental with Osteopathic Manipulative Medicine. Administered by Department of Osteopathic Manipulative Medicine. P:M: (OMM 505) R: Open only to students in the College of Osteopathic Medicine.

The osteopathic component in the context of total patient care in disorders of various systems.

590 Special Problems
Fall, Spring, Summer. 1 to 12 credits. A student may earn a maximum of 24 credits in all enrollments for this course. Each student works under faculty direction on an experimental, theoretical or applied problem in physical medicine and rehabilitation.

601 Physical Medicine and Rehabilitation Clerkship
Fall, Spring, Summer. 2 to 12 credits. Fall: Michigan Capital Med. Spring: Michigan Capital Med. Summer: Michigan Capital Med. A student may earn a maximum of 12 credits in all enrollments for this course. Physical medicine and rehabilitation inpatient and ambulatory setting clinical experience, didactic sessions, case documentation and presentation, hospital rounds. Physical medicine and rehabilitation inpatient and ambulatory setting clinical experience, didactic sessions, case documentation and presentation, hospital rounds. Strong emphasis on evaluation of neuromusculoskeletal disorders and treatment of function deficits.

620 Directed Studies
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 24 credits in all enrollments for this course. R: Open only to seniors or juniors in the College of Osteopathic Medicine. Completion of S–mester 6 in the graduate-professional program. Individual or group projects on special problems related to physical medicine and rehabilitation.
183 Physics for Scientists and Engineers I
Fall, Spring, 4(5-0) P.M.: (MTH 132 or MTH 152H or LBS 118) Not open to students with credit in LBS 164 or PHY 181B or PHY 183B or PHY 193H or PHY 231 or PHY 231B. Mechanics, Newton’s laws, momentum, energy conservation laws, rotational motion, oscillation, gravity, waves.

183A Physics I, CBI
Fall, Spring, Summer. 1 credit. P.M.: (PHY 181B) Not open to students with credit in LBS 164 or PHY 183B or PHY 193H or PHY 231 or PHY 231B or PHY 231C. Topics from: frames of reference, special relativity, rocket equation, forced oscillations, resonances, fluid motion, numerical solutions, moments of inertia, gyroscopic motion. This course plus PHY 251 or LBS 271L.

183B Physics for Scientists and Engineers II
Fall, Spring, Summer. 4 credits. P.M.: (MTH 132 or MTH 152H or LBS 118) Not open to students with credit in LBS 164 or PHY 181B or PHY 183B or PHY 193H or PHY 231 or PHY 231B or PHY 231C. Mechanics, Newton’s laws, momentum, energy conservation laws, rotational motion, oscillation, gravity, waves. Competency based instruction.

184 Physics for Scientists and Engineers II
Fall, Spring, 4(5-0) P.M.: (PHY 183 or PHY 183B or PHY 193H or PHY 233B or PHY 183A) or (LBS 164 and PHY 233B) and (MTH 132 or MTH 152H or LBS 118) Not open to students with credit in LBS 267 or PHY 182B or PHY 184B or PHY 232 or PHY 232B or PHY 294H.

184A Physics II, CBI
Fall, Spring, Summer. 1 credit. P.M.: (PHY 182B) Not open to students with credit in PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 294H or PHY 232C or LBS 267.

185B Physics for Scientists and Engineers II, CBI
Fall, Spring, Summer. 3 credits. P.M.: (PHY 183 or PHY 183B or PHY 193H) or (PHY 181B and PHY 183A) or (PHY 231B and PHY 233B) or (LBS 271 and PHY 233B) P:N:M. (MTH 132 or MTH 152H or LBS 118) Not open to students with credit in LBS 272 or PHY 182B or PHY 184 or PHY 232 or PHY 232B or PHY 294H.

191 Physics Laboratory for Scientists, I
Fall, 1(0-3) P.M.: (PHY 183 or concurrently or PHY 183B or concurrently or PHY 193H or PHY 231 or concurrently or PHY 231B or concurrently or LBS 271 or concurrently or PHY 181B or concurrently) Not open to students with credit in PHY 251 or LBS 271L.

192 Physics Laboratory for Scientists, II
Spring, 1(0-3) P.M.: (PHY 191 or MSM 211 or MSM 250) and (PHY 184 or concurrently or PHY 182B or concurrently or PHY 184B or concurrently or PHY 294H or concurrently or PHY 232 or concurrently or PHY 232B or concurrently or simultaneously with PHY 232 or PHY 271L.

193H Honors Physics I-Mechanics
Spring, 1(0-3) P.M.: (MTH 132 or concurrently or MTH 152H or concurrently or LBS 119 or concurrently) Not open to students with credit in PHY 183 or PHY 183B or PHY 231 or PHY 231B or LBS 164 or PHY 183B.

201 Physics Computations II
Fall, Spring. 3 credits. P:M: (PHY 184 or concurrently or PHY 184B or concurrently or PHY 294H or concurrently) P:N:M: (PHY 102) R:B: (MTH 132)

205 Directed Studies
Fall, Spring. 1 to 3 credits. A student may earn a maximum of 3 credits in all enrollments for this course. R: Approval of department. Guided individualized study in an area of physics.

215 Thermodynamics and Modern Physics
Fall, Spring. 3(4-0) P.M.: (PHY 184 or concurrently or PHY 231 or PHY 232B or PHY 294H or concurrently) or PHY 184B or PHY 231 or PHY 232 for concurrently or PHY 294H or concurrently or PHY 184B or concurrently or PHY 231 or PHY 232B or PHY 294H.

215B Thermodynamics and Modern Physics, CBI
Fall, Spring, Summer. 3 credits. P.M.: (PHY 184 or concurrently or PHY 231 or PHY 232B or PHY 294H or concurrently or PHY 184B or concurrently or PHY 231 or PHY 232B or PHY 294H or concurrently or PHY 231B or PHY 182B or PHY 184 or PHY 232 or PHY 232B or PHY 294H or concurrently or PHY 184B or PHY 232 or PHY 232B or PHY 294H or concurrently or PHY 184B or PHY 232 or PHY 232B or PHY 294H or PHY 232.

231 Introductory Physics I
Fall, Spring, 3(4-0) P:M: (PHY 102 or PHY 116 or PHY 124 or PHY 132) Not open to students with credit in PHY 116 or PHY 124 or PHY 132 or concurrently. Not open to students with credit in PHY 182B or PHY 183 or PHY 193H or PHY 231B or PHY 231C.

231B Introductory Physics I, CBI
Fall, Spring, Summer. 3 credits. P:M: (MTH 103 or MTH 116 or MTH 124 or MTH 132 or concurrently) Not open to students with credit in LBS 164 or PHY 181B or PHY 183 or PHY 183B or PHY 193H or PHY 231 or PHY 231C. Mechanics, Newton’s Laws, momentum, energy conservation laws, thermodynamics, waves, sound.

232 Introductory Physics II
Fall, Spring, 3(4-0) P.M: (PHY 231 or PHY 231B or PHY 181B or PHY 183 or PHY 183B or PHY 193H or PHY 231B or PHY 231C or LBS 164) Not open to students with credit in PHY 184 or PHY 184B or PHY 232 or PHY 232B or LBS 267 or PHY 182B. Electricity and magnetism; optics; atomic, nuclear, and subnuclear physics.

232B Introductory Physics II, CBI
Fall, Spring, Summer. 3 credits. P:M: (PHY 231 or PHY 231B or PHY 232B or PHY 294H or PHY 181B or PHY 183 or PHY 193H or LBS 271) Not open to students with credit in PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 232C or PHY 294H or PHY 232 or PHY 294H or LBS 272. Electricity and magnetism; optics; atomic, nuclear, and subnuclear physics. Competency based instruction.

232C Introductory Physics II, Virtual
Fall, Spring. 3 credits. P.M: (PHY 232B or PHY 181B or PHY 183B or PHY 193H or PHY 231B or PHY 231C or LBS 164) Not open to students with credit in PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 294H or PHY 182B or PHY 232.

233B Calculus Concepts in Physics I, CBI
Fall, Spring, Summer. 2 credits. P.M: (PHY 231) and (MTH 132 or MTH 152H or LBS 118) Not open to students with credit in PHY 183 or PHY 193H.

Kinematics, dynamics, applications of Newton’s laws. Competency based instruction. PHY 231B plus PHY 233B is equivalent to PHY 183B.
234B Calculus Concepts in Physics II, CBI  
Fall, Spring, Summer. 2 credits. P:M: (PHY 232 or PHY 232B) and (MTH 133 or concurrently or MTH 153H or concurrently or LBS 119 or concurrently)  
Electricity and magnetism. Competency based instruction. PHY 232B plus PHY 234B equals PHY 184B.

251 Introductory Physics Laboratory I  
Fall, Spring, Summer. 1(0-3) P:M: (PHY 231 or concurrently or PHY 231B or concurrently or LBS 271 or concurrently or MTH 133 or concurrently or MTH 153H or concurrently or PHY 183B or concurrently or PHY 231C or concurrently or PHY 193H or concurrently) P:NM: (PHY 103) Not open to students with credit in PHY 191 or LBS 271L.  
Laboratory exercises involving simple mechanical systems.

294H Honors Physics II-Electromagnetism  
Fall. 3(4-0) P:M: (PHY 183H) and (MTH 234 or concurrently or PHY 234B and concurrently or LPS 234B) or concurrently or PHY 234C or concurrently or PHY 235H or concurrently or PHY 234C or concurrently or PHY 240B or concurrently or PHY 240B or concurrently or PHY 240C or concurrently or PHY 240B and concurrently or PHY 240C or concurrently or PHY 240C or concurrently or PHY 240C or concurrently or PHY 240C or concurrently or PHY 240C or concurrently. Not open to students with credit in PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 232C or PHY 240H or LBS 267.  
Electricity and magnetism, electromagnetic waves and optics.

301 Physics Computations III  
Spring. 1(0-3) P:M: (PHY 471) P:NM: (CSE 232)  
Use of computer software to solve, analyze and graph equations and data from physics problems. Tools include Mathematica, Fortran 90 and C++.

305 Directed Studies  
Fall, Spring, Summer. 1 to 3 credits. A student-electron atom. Maximum 3 credits in all enrollments for this course. P:M: (PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 232C or PHY 240H or LBS 272) R: Approval of department.  
Guided individualized study in an area of physics.

321 Classical Mechanics I  
Spring, Summer. 3(3-0) P:M: (PHY 184 or PHY 184B or PHY 232 or PHY 272) and (PHY 215 or concurrently or PHY 215B or concurrently) and (MTH 234 or concurrently or MTH 253H or concurrently or LBS 220 or concurrently)  

351B Computational Physics, CBI  
Fall, Spring, Summer. 3 credits. P:M: (PHY 215 or PHY 215B) P:NM: (CSE 131 or CSE 230)  
Computer applications in physics research: printer graphics, Schroedinger equation solution, physics-symbol processing, physics information retrieval, Analysis of typical research data. Competency based instruction.

357B Topics in Contemporary Physics, CBI  
Fall, Spring, Summer. 3 credits. P:M: (PHY 215 or PHY 215B) P:NM: (PHY 184 or PHY 184B or PHY 294H or PHY 234B or LBS 267) R: Not open to students in the Department of Physics and Astronomy. Atoms and nuclei, weak decay interaction, weak bosons, strong interaction, conservation laws, quarks and gluons. Competency based instruction.

390 Physics Journal Seminar  
Spring. 1(3-0) P:M: Completion of Tier I writing requirement. R: Open only to juniors or seniors in the Department of Physics and Astronomy or Lyman Briggs School. Written and oral reports on selected articles in the current literature. Critique of presentations by peers.

405 Directed Studies  
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 5 credits in all enrollments for this course. P:M: (PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 232C or PHY 294H or LBS 272) R: Approval of department.  
Guided independent study of special topics.

410 Thermal and Statistical Physics I  
Spring. 3(3-0) P:M: (PHY 471)  
Equilibrium statistical mechanics and thermodynamics, kinetic theory, phase transformations.

422 Classical Mechanics II  
Fall. 3(3-0) P:M: (PHY 321)  

423B Special Relativity, CBI  
Summer. 3 credits. P:M: (PHY 321) R: Some understanding about electric and magnetic fields. Concepts of special relativity applied to coordinate transformations, mechanics, and electrodynamics. Competency Based Instruction.

425B Mathematical Physics, CBI  
Summer. 3 credits. R: Calculus through differential equations. Some experience with complex variables. Fourier series and complex variables as applied to problems in quantum mechanics, electrodynamics, and mechanics. Competency based instruction.

431 Optics I  
Fall. 3(2-3) P:M: (PHY 192) and (PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 232C or PHY 294H or LBS 272) R: Completion of Tier I writing requirement. SA: PHY 331  
Lenses, aberrations, apertures, and stops. Diffraction, interferometry, spectroscopy, fiber optics.

440 Electronics  
Spring. 4(3-3) P:M: (PHY 192) and (MTH 235 or concurrently or MTH 253H or concurrently or PHY 220 or LBS 220 or concurrently) and (PHY 184 or concurrently or PHY 184B or PHY 294H or LBS 272)  
Concepts of electronics used in investigating physical phenomena. Circuits, amplifiers, diodes, LEDs, transistors.

451 Advanced Laboratory  
Fall. 3(1-6) P:M: (PHY 440) and completion of Tier I writing requirement. R: Completion of Tier I writing requirement.  
General research techniques, design of experiments, and the analysis of results based on some historical experiments in modern physics.

452 Advanced Projects Laboratory  
Spring. 3(0-6) P:M: (PHY 451 and PHY 431)  
A projects laboratory that builds on optics, electronics and advanced lab courses.

471 Quantum Physics I  
Fall. 3(3-0) P:M: (PHY 215 or PHY 215B) and (PHY 321 or concurrently) and (MTH 235 or MTH 253H or LBS 220)  
Schoedinger equation, hydrogen atom, harmonic oscillator, and other one-dimensional systems.

472 Quantum Physics II  
Spring. 3(3-0) P:M: (PHY 471) R: A Mathematics course on Boundary-Value Problems  
Matrix formulation of quantum mechanics, perturbation theory, scattering.

480 Computational Physics  
Spring of even years. 3(3-0) P:NM: (CSE 131 or CSE 220)  
Applications of scientific computational techniques to solutions of differential equations, matrix methods, and Monte Carlo methods used in physics.

481 Electricity and Magnetism I  
Fall. 3(3-0) P:M: (MTH 234 or MTH 254H or LBS 220) R: Open only to juniors or seniors or graduate students. Electrostatics, dielectrics, magnetic fields of steady state currents, Faraday law of induction.

482 Electricity and Magnetism II  
Spring. 3(3-0) P:M: (PHY 481) R: A Mathematics course on Boundary-Value Problems.  
Maxwell's equations, scalar and vector potentials, electromagnetic plane waves.

490 Senior Thesis  
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 5 credits in all enrollments for this course. P:M: (PHY 390) and completion of Tier I writing requirement. Design, carry out, and analyze an original experiment or computation. A written and oral report is required.

491 Atomic, Molecular, and Condensed Matter Physics  
Fall. 3(3-0) P:M: (PHY 471 and PHY 410) and completion of Tier I writing requirement. Many-electron atoms, Molecules, crystal structure, lattice dynamics. Band models of metals and semiconductors. Transport properties.

492 Nuclear and Elementary Particle Physics  
Spring. 3(3-0) P:M: (PHY 471) and completion of Tier I writing requirement. P:NM: (PHY 472)  

800 Research Methods  
Fall, Spring. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. Design and setup of experiments in various faculty research areas. Data collection and analysis. Study and practice of theoretical methods.

810 Methods of Theoretical Physics  
Fall. 3(3-0)  
Theoretical methods used in classical mechanics, quantum mechanics, electrodynamics, and statistical mechanics.
**Physics–PHY**

820  **Classical Mechanics**  
Fall. 3(3-0)  
Two-body central force problem, Hamilton’s principle, Lagrangian and Hamiltonian equations of motion, variational methods, small oscillations, classical fields.

825  **Epidemiologic Modeling**  
Spring. Odd years. 3(3-0) Interdepartmental with Epidemiology. Administered by Epidemiology. P:NM: (EPI 810 and STT 422) R: Approval of department; SA: HM 825  
Mathematical modeling of epidemics. Stochastic and chaotic systems approaches. Applications through personal computer software.

831  **Statistical Mechanics**  
Spring. 3(3-0)  

832  **Topics in Statistical Mechanics (MTC)**  
Spring. 3(3-0) A student may earn a maximum of 12 credits in all enrollments for this course. P:NM: (PHY 831)  
Advanced topics in statistical matter physics and nuclear physics.

841  **Classical Electrodynamics I**  
Spring. 3(3-0) P:NM: (PHY 810)  

842  **Classical Electrodynamics II**  
Fall. 3(3-0) P:NM: (PHY 841 and PHY 810 or concurrently)  

850  **Electrodynamics of Plasmas**  
Spring. Odd years. 3(3-0) Interdepartmental with Electrical and Computer Engineering; Astronomy and Astrophysics. Administered by Department of Electrical and Computer Engineering. P:NM: (EE 835 or PHY 488) SA: AST 850, EE 850  

851  **Quantum Mechanics I**  
Fall. 3(3-0) R: Open only to graduate students in the College of Engineering or College of Natural Science.  
Axioms of quantum and wave mechanics, applications to spherically symmetric potentials. Hydrogen atom, harmonic oscillator, matrix mechanics, angular momentum theory, rotations.

852  **Quantum Mechanics II**  
Spring. 3(3-0) P:NM: (PHY 851)  

853  **Advanced Quantum Mechanics**  
Fall. 3(3-0) P:NM: (PHY 852)  
Quantum description of relativistic particles and fields. Dirac equation, interpretation of negative energy states, Lagrangian field theory, quantization of free fields, interactions, perturbation theory, S matrix, and Feynman rules.

854  **Quantum Electrodynamics**  
Spring. Odd years. 3(3-0) P:NM: (PHY 853)  
Application of quantum field theory to the interaction of electrons and photons: pair annihilation, Compton scattering. Bound states, renormalization theory.

861  **Beam Physics (MTC)**  
Spring. 3(3-0) P:NM: (PHY 820 and PHY 841)  
Particle accelerator theory and design.

871  **Condensed Matter Physics**  
Spring. 3(3-0) P:NM: (PHY 852)  

881  **Subatomic Physics**  
Fall. 3(3-0) P:NM: (PHY 851)  
Application of conservation laws and physical principles to basic quantum mechanical problems in MeV energy range and femtometer size range. Application to nuclear data.

891  **Elementary Particle Physics**  
Spring. 3(3-0) P:NM: (PHY 853)  
Nonabelian gauge theory, spontaneously broken gauge theory, electroweak interaction, QCD, W and Z boson coupling to quarks and leptons, charm, top and bottom quarks, particle generations.

899  **Master’s Thesis Research**  
Fall, Spring. Summer. 1 to 6 credits. A student may earn a maximum of 24 credits in all enrollments for this course. R: Open only to graduate students in Physics. Master's thesis research.

901  **Frontiers in Physics and Astronomy**  
Spring. 1(1-0)  
Seminar and discussions in physics. Attendance at weekly colloquium.

902  **Case Studies in Physics Applications**  
Fall, Spring. Summer. 1 to 3 credits. P:NM: (PHY 471 and PHY 481)  
Assessment of an application of physics; written report and oral presentation required. Projects from industry and government agencies; optional internship.

905  **Special Problems**  
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 9 credits in all enrollments for this course. P:NM: (PHY 861)  
Selected topics in accelerator physics.

962  **Topics in Beam Physics (MTC)**  
Fall, Spring. Summer. 3 credits. A student may earn a maximum of 12 credits in all enrollments for this course. P:NM: (PHY 831 and PHY 852 and PHY 871)  
Advanced topics in many-body problems, disordered solids, superfluidity, superconductivity, magnetism, or macroscopic systems.

972  **Topics in Condensed Matter Physics (MTC)**  
Fall, Spring. 3(3-0) A student may earn a maximum of 12 credits in all enrollments for this course. P:NM: (PHY 831 and PHY 852 and PHY 871)  
Advanced topics in many-body problems, disordered solids, superfluidity, superconductivity, magnetism, or macroscopic systems.

980  **Advanced Reading in Physics**  
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 4 credits in all enrollments for this course. R: Approval of department.

982  **Topics in Nuclear Physics (MTC)**  
Fall, Spring. 3(3-0) A student may earn a maximum of 12 credits in all enrollments for this course. P:NM: (PHY 852 and PHY 881)  
Heavy ion reactions or nuclear structure.

999  **Doctoral Dissertation Research**  
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 99 credits in all enrollments for this course. R: Open only to graduate students in Physics. Doctoral dissertation research.