

PHYSICAL EDUCATION AND EXERCISE SCIENCE

866*. *Research on Sports for Athletes with Disabilities*
 Fall of odd-numbered years. 3(3-0)
 R: Graduate students
 Performance capabilities of athletics with disabilities with emphasis on areas such as exercise physiology, sport biomechanics, sport psychology, sport sociology, motor development, and motor learning.
 QA: HCP 845B

867*. *Practicum in Adapted Physical Activity*
 Fall, Spring, Summer. 1 to 4 credits.
 May reenroll for a maximum of 4 credits.
 R: Graduate student Approval by instructor
 Supervised practice in teaching physical activities and/or coaching sports for persons with disabilities.
 QA: HCP 845C

870*. *Physical Activity and Well-Being*
 Fall. 3(3-0)
 R: Graduate students
 Relationship of physical activity to human well-being. Influence of growth, biological maturity, aging, body composition, nutrition, training, and rest on health and performance.

871*. *Research Methods in Physical Education and Exercise Science*
 Spring. 3(3-0)
 R: Graduate students
 Research and analytical methodology in physical education and exercise science, including survey, qualitative, historical, philosophical, descriptive, meta-analytical, creative, and experimental methods.
 QA: HCP 802

882*. *Topics in Physical Education and Exercise Science(MTC)*
 Fall, Spring, Summer. 2 to 3 credits.
 May reenroll for a maximum of 9 credits.
 R: Graduate students
 Issues, problems, and/or topics in physical education and exercise science.

882A*. *Stress Management Techniques in Athletics*
 Summer. 3(3-0)
 R: Graduate students
 Theoretical bases of psychological stress. Impact of stress on performance. Application of appropriate stress management techniques to athletics. Application of research to working with athletes.

890*. *Independent Study in Physical Education and Exercise Science*
 Fall, Spring, Summer. 1 to 6 credits.
 May reenroll for a maximum of 6 credits.
 R: Graduate students
 Independent study of topics in physical education and exercise science.

893*. *Internship in Physical Education and Exercise Science*
 Fall, Spring, Summer. 2 to 6 credits.
 May reenroll for a maximum of 6 credits.
 R: Graduate students Must complete a total of 4-6 credits to receive a grade.
 Internship experience under the guidance and supervision of MSU faculty and internship consultants.

894*. *Field Experiences in Physical Education and Exercise Science*
 Fall, Spring, Summer. 1 to 6 credits.
 May reenroll for a maximum of 6 credits.
 R: Graduate students Approval by department
 Supervised graduate practica and observations in physical education and exercise science in schools and other settings.

897*. *Project in Physical Education and Exercise Science*
 Fall, Spring, Summer. 1 to 4 credits.
 May reenroll for a maximum of 4 credits.
 R: Graduate students Must complete a total of 4 credits to receive a grade.
 Project experience under the guidance and supervision of MSU faculty.

899*. *Master's Thesis Research*
 Fall, Spring, Summer. 1 to 6 credits.
 May reenroll for a maximum of 6 credits.
 P: PES 871 R: Graduate students Must complete a total of 6 credits to receive a grade
 QP: HCP 802

910*. *Current Issues in Exercise Physiology*
 Spring. 3(3-0) May reenroll for a maximum of 9 credits.
 R: Graduate students
 Selected issues in exercise physiology and related fields of study.

930*. *Current Issues in Biomechanical Aspects of Physical Activity*
 Spring. 3(3-0) May reenroll for a maximum of 9 credits.
 P: PES 830 R: Graduate students
 Selected issues of biomechanical analyses of sport and physical activity.

940*. *Current Issues in Psychosocial Aspects of Physical Activity*
 Fall. 3(3-0) May reenroll for a maximum of 9 credits.
 R: Graduate students
 Selected issues in the psychology and sociology of sport and physical activity.

950*. *Current Issues in the Design and Evaluation of Physical Activity Programs*
 Fall. 3(3-0) May reenroll for a maximum of 9 credits.
 R: Graduate students
 Selected issues in program design and evaluation with an emphasis on programs of physical activity.

960*. *Current Issues in Motor Behavior*
 Spring. 3(3-0) May reenroll for a maximum of 9 credits.
 R: Graduate student
 Selected issues in motor development, motor learning, adapted physical education, and related fields of study.

990*. *Independent Study in Physical Education and Exercise Science*
 Fall, Spring, Summer. 1 to 6 credits.
 May reenroll for a maximum of 6 credits.
 R: Doctoral students
 Independent study of topics in physical education and exercise science.

995*. *Research Practicum in Physical Education and Exercise Science*
 Fall, Spring, Summer. 1 to 4 credits.
 May reenroll for a maximum of 4 credits.
 R: Open only to doctoral students
 Supervised research practicum. Design, execution, analysis, presentation, critique, and revision of research projects.

999*. *Doctoral Dissertation Research*
 Fall, Spring, Summer. 0(-) May reenroll for a maximum of 24 credits.
 R: Doctoral students

PHYSICAL SCIENCE CEM

918*. *Seminar in Inorganic Chemistry*
 Fall, Spring. 1(1-0) May reenroll for a maximum of 3 credits.
 R: Graduate students Natural Science
 Chemistry
 Discussions of recent advances in inorganic chemistry and reports by graduate students on research
 QA: CEM 918

991*. *Quantum Chemistry and Statistical Thermodynamics I*
 Fall. 3(3-0)
 Mathematical background for quantum chemistry and statistical thermodynamics. Principles of quantum chemistry and applications to chemical problems. Partition functions, spectroscopic measurements, and thermodynamic applications
 QA: CEM 987 CEM 991 CEM 985

998*. *Seminar in Physical Chemistry*
 Fall, Spring. 1(1-0) May reenroll for a maximum of 3 credits.
 R: Graduate students Natural science
 Chemistry
 Discussions of recent advances in physical chemistry and reports by graduate students on research problems
 QA: CEM 998

PHYSICS PHY

170*. *Investigations in Physics*
 Fall. 3(0-6)
 Experiments in optics, electronics, sound and mechanics; analysis of data using computers, library research and oral presentations.

181B*. *Basic Physics I, CBI*
 Fall, Spring, Summer. 3(-)
 P: MTH 132 or concurrently. R: Not open to students with credit in PHY 231 or PHY 231B or PHY 183 or PHY 183B or PHY 193H.
 Newton's laws of motion, conservation of angular momentum, energy conservation, thermal physics, waves, and sound. Competency based instruction.
 QP: MTH 112 QA: PHY 281 PHY 237B PHY 237 PHY 287 PHY 287B

182B*. *Basic Physics II, CBI*
 Fall, Spring, Summer. 3(-)
 P: PHY 181B or PHY 183 or PHY 183B or PHY 231 or PHY 231B. R: Not open to students with credit in PHY 232 or PHY 232B or PHY 184 or PHY 184B or PHY 294H.
 Electricity and magnetism, optical phenomena, interference and diffraction of light, atomic and subatomic topics. Competency based instruction.
 QP: PHY 281 ORPHY 237ORPHY 237B OR PHY 291H LBS 267 QA: PHY 282 PHY 283B PHY 238 PHY 238B PHY 239 PHY 292H

183. *Physics for Scientists and Engineers I*
 Fall, Spring. 4(5-0)
 P: MTH 132 or concurrently. R: Not open to students with credit in PHY 183B, PHY 231, PHY 231B.
 Mechanics, Newton's laws, momentum, energy conservation laws, rotational motion, oscillation, gravity, waves.
 QA: PHY 287 PHY 287B PHY 291H PHY 237 PHY 281'

183A*. *Physics I, CBI*
 Fall, Spring, Summer. 1(-)
 P: PHY 181B. R: Not open to students with credit in PHY 183 or PHY 183B.
 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 181B is equal to PHY 183B.
 QP: PHY 281 QA: PHY 287A

PHYSICS

183B. Physics for Scientists and Engineers I, CBI
 Fall, Spring, Summer. 4(-)
 P: MTH 132 or concurrently. R: Not open to students with credit in PHY 183, PHY 231, PHY 231B.
 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: PHY 183 or PHY 183B, MTH 133 or concurrently. R: Not open to students with credit in PHY 184B, PHY 232, PHY 232B.
 Electricity and magnetism, electromagnetic waves, light and optics, interference and diffraction.
 QP: PHY 239 PHY 289BPHY 239PHY239BPHY 287 QA: PHY 288 PHY 288B PHY 238 PHY 288B PHY 292H

184A*. Physics II, CBI
 Fall, Spring, Summer. 1(-)
 P: PHY 182B. R: Not open to students with credit in PHY 184 or PHY 184B or PHY 294H.
 Topics from: standing wave phenomena, atoms, electromagnetic fields, alternating currents, optics, quantum mechanics, elementary particles. This course plus PHY 182B is equivalent to PHY 184B.
 QP: PHY 281 QA: PHY 288B PHY 289B PHY 288A PHY 289A

184B. Physics for Scientists and Engineers II, CBI
 Fall, Spring, Summer. 4(-)
 P: PHY 183 or PHY 183B, MTH 133 or concurrently. R: Not open to students with credit in PHY 184, PHY 232, PHY 232B.
 Electricity and magnetism, electromagnetic waves, light and optics, interference and diffraction. Competency based instruction.
 QA: PHY 288 PHY 288B PHY 238 PHY 238B PHY 292H

191. Physics Laboratory for Scientists, I
 Fall. 1(0-3)
 P: PHY 183 or PHY 183B or PHY 193 or concurrently. R: Not open to students with credit in PHY 251.
 Error analysis, exercises in motion, forces, conservation laws and optics.

192. Physics Laboratory for Scientists, II
 Spring. 1(0-3)
 P: PHY 184 or PHY 184B or PHY 194H or concurrently. R: Not open to students with credit in PHY 252.
 Electric and magnetic fields, circuits, wave optics, and radioactivity.

193H*. Honors Physics I-Mechanics
 Spring. 3(04-0)
 P: MTH 133 or MTH 153H or concurrently.
 Mechanics and waves.
 QP: MTH 113 QA: PHY 291H PHY 287 PHY 287B PHY 237 PHY 237B

205*. Directed Studies
 Fall, Spring, Summer. 1 to 3 credits.
 May reenroll for a maximum of 3 credits.
 R: Approval of department.
 Guided individualized study in an area of physics.

215. Thermodynamics and Modern Physics
 Fall, Spring, Summer. 3(4-0)
 P: PHY 184 or PHY 184B or PHY 194H.
 R: Not open to students with credit in PHY 215B.
 Thermodynamics, atomic physics, quantized systems, nuclear physics, solids, elementary particles.

215B. Thermodynamics and Modern Physics, CBI
 Fall, Spring, Summer. 3(-)
 P: PHY 184 or PHY 184B or PHY 194H.
 R: Not open to students with credit in PHY 215.
 Thermodynamics, atomic physics, quantized systems, nuclear physics, solids, elementary particles. Competency based instruction.

231. Introductory Physics I
 Fall, Spring. 3(4-0)
 P: Mth 116 or concurrently. R: Not open to students with credit in PHY 183 or PHY 183B or PHY 231B.
 Mechanics, Newton's Laws, momentum, energy, conservation laws, thermodynamics, waves, sound.
 QP: MTH 109 QA: PHY 237 PHY 237B PHY 281 PHY 287 PHY 287B

231B. Introductory Physics I, CBI
 Fall, Spring, Summer. 3(-)
 P: MTH 116 or concurrently. R: Not open to students with credit in PHY 183 or PHY 183B or PHY 231.
 Mechanics, Newton's laws, momentum, energy, conservation laws, thermodynamics, waves, sound. Competency based instruction.
 QP: MTH 109 QA: PHY 237 PHY 237B PHY 281 PHY 287 PHY 287B

232. Introductory Physics II
 Fall, Spring. 3(4-0)
 P: PHY 183 or PHY 183B or PHY 231 or PHY 231B. R: Not open to students with credit in PHY 184 or PHY 184B or PHY 232B.
 Electricity and magnetism; optics; atomic, nuclear, and subnuclear physics.
 QP: PHY 237 ORPHY 237BORPHY 287B QA: PHY 238 PHY 239 PHY 238B PHY 238B PHY 288

232B. Introductory Physics II, CBI
 Fall, Spring, Summer. 3(-)
 P: PHY 183 or PHY 183B or PHY 231 or PHY 231B. R: Not open to students with credit in PHY 184 or PHY 184B or PHY 232.
 Electricity and magnetism; optics; atomic, nuclear, and subnuclear physics. Competency based instruction.
 QP: PHY 237 ORPHY 237BORPHY 287 OR PHY 291H QA: PHY 238 PHY 239 PHY 238B PHY 238B PHY 239B PHY 288

233B*. Calculus Concepts in Physics I, CBI
 Fall, Spring, Summer. 2(-)
 P: PHY 231 or PHY 231B; MTH 132 or concurrently.
 Kinematics, dynamics, applications of Newton's laws. Competency based instruction. PHY 231B plus PHY 233B is equivalent to PHY 183B.
 QP: MTH 112 PHY 237 QA: PHY 284 PHY 287 PHY 287B PHY 291B PHY 291H

234B*. Calculus Concepts in Physics II, CBI
 Fall, Spring, Summer. 2(-)
 P: PHY 232 or PHY 232B; MTH 133 or concurrently.
 Electricity and magnetism. Competency based instruction. PHY 232B plus PHY 234B equals PHY 184B.
 QP: MTH 113 PHY 238PHY 239PHY 284 QA: PHY 285 PHY 286 PHY 288 PHY 288B PHY 289

251. Introductory Physics Laboratory I
 Fall, Spring, Summer. 1(0-3)
 P: PHY 183 or PHY 183B or PHY 231 or PHY 231B or concurrently. R: Not open to students with credit in PHY 191.
 Laboratory exercises involving simple mechanical systems.

252. Introductory Physics Laboratory II
 Fall, Spring, Summer. 1(0-3)
 P: PHY 251. R: Not open to students with credit in PHY 192.
 Laboratory exercises involving simple electromagnetic and optical systems.

294H*. Honors Physics II-Electromagnetism
 Fall. 3(04-0)
 P: PHY 193H; MTH 234 or MTH 254H or concurrently.
 Electricity and magnetism, electromagnetic waves and optics.
 QP: MTH 214 QA: PHY 292H PHY 288 PHY 288B PHY 238 PHY 238B

305*. Directed Studies
 Fall, Spring, Summer. 1 to 3 credits.
 May reenroll for a maximum of 3 credits.
 P: PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 294H; R: approval of department.
 Guided individualized study in an area of physics.
 QA: PHY 304

321*. Classical Mechanics I
 Spring, Summer. 3(03-0)
 P: PHY 294H or PHY 215 or concurrently, MTH 235 or MTH 255H or concurrently.

The mechanics of point particles as application of Newton's laws. Conservation of energy and momentum. Central force fields.
 QP: MTH 310 PHY 291HPHY 289 QA: PHY 427 PHY 428

331*. Optics I
 Spring. 3(02-3)
 P: PHY 192, PHY 215.
 Lenses, aberrations, apertures, and stops. Diffraction, interferometry, spectroscopy, fiber optics.
 QP: PHY 289 PHY 299PHY 239B QA: PHY 438 PHY 439

351B*. Computational Physics, CBI
 Fall, Spring, Summer. 3(-)
 P: CPS 130 or CPS 131 or CPS 230; PHY 215 or PHY 215B.
 Computer applications in physics research: printer graphics, Schroedinger equation solution, physics-symbol processing, physics information retrieval. Analysis of typical research data. Competency based instruction.
 QP: PHY 289 ORPHY 289BORPHY 293H QA: PHY 351

357B*. Topics in Contemporary Physics (CBI)
 Fall, Spring, Summer. 3(-)
 P: PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 294H. R: Not open to students in Department of Physics and Astronomy.
 Atoms and nuclei, weak decay interaction, weak bosons, strong interaction, conservation laws, quarks and gluons. Competency based instruction.
 QP: PHY 239 ORPHY 239BORPHY 289 QA: PHY 357

390*. Physics Journal Seminar
 Spring. 1(03-0)
 R: Open only to juniors in Physics.
 Written and oral reports on selected articles in the current literature. Critique of presentations by peers.
 QA: PHY 399

405*. Directed Studies
 Fall, Spring, Summer. 1 to 3 credits.
 May reenroll for a maximum of 5 credits.
 P: PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 294H; R: approval of department.
 Guided independent study of special topics for seniors.
 QA: PHY 404

PHYSICS

- 410*. Thermal and Statistical Physics**
 Spring. 3(3-0)
 P: PHY 471.
 Equilibrium statistical mechanics and thermodynamics, kinetic theory, phase transformations.
 QP: MTH 310 PHY 427 PHY 391 QA: PHY 395 PHY 396
- 411*. Conceptual Physics**
 Spring, Summer. 4(3-0)
 P: MTH 116. R: Not open to Physics or Astrophysics students.
 Physical phenomena evident in the world around us: mechanics, heat, properties of matter, waves and sound, electricity and magnetism, light, atmosphere and hydrosphere, and naked eye astronomy.
 QP: MTH 109 QA: PHS 203
- 422*. Classical Mechanics II**
 Fall, Summer. 3(03-0)
 P: PHY 321, MTH 235 or MTH 255H.
 Analytic mechanics. Dynamics of systems of particles. Hamiltonian and Lagrangian mechanics. Vibrations and normal modes.
 QP: PHY 427 QA: PHY 428 PHY 429
- 423B*. Special Relativity, CBI**
 Summer. 3(-)
 P: PHY 321, PHY 481.
 Concepts of special relativity applied to coordinate transformations, mechanics, and electrodynamics. Competency based instruction.
 QP: PHY 427 PHY 447
- 425B*. Mathematical Physics, CBI**
 Summer. 3(-)
 P: PHY 321, PHY 481.
 Fourier series and complex variables as applied to problems in quantum mechanics, electrodynamics, and mechanics. Competency based instruction.
 QA: PHY 817
- 432*. Optics II**
 Fall. 3(02-03)
 P: PHY 331.
 Experimental projects involving advanced topics in optics. Holography, spatial filtering, study of physical systems using optical devices.
 QP: PHY 438 MTH 334 QA: PHY 439
- 440*. Electronics**
 Fall. 4(03-3)
 P: PHY 184 or PHY 184B or PHY 294H; PHY 192; MTH 235 or MTH 255H.
 Concepts of electronics used in investigating physical phenomena. Circuits, amplifiers, diodes, LEDs, transistors.
 QP: MTH 310 PHY 288/PHY288B/PHY 292HPHY 298 QA: PHY 419
- 451*. Advanced Laboratory**
 Fall. 3(00-06)
 P: PHY 331 or PHY 440.
 General research techniques, design of experiments, and the analysis of results based on some historical experiments in modern physics.
 QP: PHY 438 ORPHY 439ORPHY 419 QA: PHY 457G
- 452*. Advanced Projects Laboratory**
 Spring. 3(00-06)
 P: PHY 331, PHY 440.
 A projects laboratory that builds on optics and electronics courses.
 QP: PHY 457G QA: PHY 457S PHY 457N PHY 420
- 471*. Quantum Physics I**
 Fall. 3(03-0)
 P: PHY 215 or PHY 215B; MTH 235 or MTH 255H; PHY 321.
 Schroedinger equation, hydrogen atom, harmonic oscillator, and other one-dimensional systems.
 QP: PHY 391 QA: PHY 492 PHY 493
- 472*. Quantum Physics II**
 Spring. 3(03-0)
 P: PHY 471.
 Matrix formulation of quantum mechanics, perturbation theory, scattering.
 QP: PHY 492 QA: PHY 493
- 480*. Computational Physics**
 Spring of even-numbered years. 3(3-0)
 P: CPS 130 or CPS 131 or CPS 230.
 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, Summer. 3(03-0)
 P: MTH 234 or MTH 254H. R: Open only to juniors or seniors.
 Electrostatics, dielectrics, magnetic fields of steady state currents, Faraday law of induction.
 QP: MTH 310 QA: PHY 447 PHY 448
- 482*. Electricity and Magnetism II**
 Spring. 3(03-0)
 P: PHY 481.
 Maxwell's equations, scalar and vector potentials, electromagnetic plane waves.
 QP: PHY 447 QA: PHY 448 PHY 449
- 490*. Senior Thesis**
 Fall, Spring, Summer. 1 to 4 credits.
 May reenroll for a maximum of 5 credits.
 R: Open only to seniors. Approval of department.
 Design, carry out, and analyze an original experiment or computation. A written and oral report is required.
 QA: PHY 406
- 491*. Atomic, Molecular, and Condensed Matter Physics**
 Fall. 3(03-0)
 P: PHY 380.
 Many-electron atoms. Molecules, crystal structure, lattice dynamics. Band models of metals and semiconductors. Transport properties.
 QP: PHY 491 PHY 395 QA: PHY 496
- 492*. Nuclear and Elementary Particle Physics**
 Spring. 3(03-0)
 P: PHY 472.
 Properties of nuclei, nuclear models, nuclear reactions. High-energy accelerators. Weak, electromagnetic and strong interactions. Symmetries and conservation laws. Elementary particle spectrum, quarks, gluons.
 QP: PHY 492 QA: PHY 497 PHY 498
- 800*. Research Methods**
 Fall, Spring, Summer. 3(3-0) May reenroll for a maximum of 6 credits.
 R: Open only to graduate students in Astronomy and Astrophysics and in Physics.
 Design and setup of experiments in various faculty research areas. Data collection and analysis. Study and practice of theoretical methods.
 QA: PHY 800
- 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.
 QA: PHY 857 PHY 858
- 831*. Statistical Mechanics**
 Spring. 3(3-0)
 Equilibrium statistical mechanics and thermodynamics. Boltzmann transport equations and hydrodynamics. Brownian and Langevin motion.
 QA: PHY 871
- 832*. Topics in Statistical Mechanics(MTC)**
 Fall. 3(3-0) May reenroll for a maximum of 12 credits.
 P: PHY 831.
 Advanced topics in statistical matter physics and nuclear physics.
 QP: PHY 871
- 832A*. Chaos and Nonlinear Dynamics in Statistical Mechanics**
 3(3-0)
 P: PHY 831.
 Application of statistical mechanics principles to nonlinear dynamics and chaos.
 QP: PHY 871
- 832B*. Phase Transitions and Critical Phenomena in Statistical Mechanics**
 3(3-0)
 P: PHY 831.
 Application to critical phenomena. Phase transitions, Landau theory, scaling.
 QP: PHY 871
- 832C*. Linear Response Theory in Quantum Statistical Systems**
 3(3-0)
 P: PHY 831.
 Linear response theory in quantum statistical systems. Applications to magnetism, electrical and optical response functions. Fluctuations.
 QP: PHY 871
- 832D*. Superfluidity and Superconductivity in Statistical Mechanics**
 3(3-0)
 P: PHY 831.
 Applications to superfluidity and superconductivity.
 QP: PHY 871
- 841*. Classical Electrodynamics I**
 Fall. 3(3-0)
 Electrostatics, magnetostatics, time-varying fields and Maxwell's equations. Gauge transformations. Poynting's theorem and conservation laws.
 QA: PHY 847 PHY 848
- 842*. Classical Electrodynamics II**
 Spring. 3(3-0)
 P: PHY 841.
 Plane electromagnetic waves, polarization states, reflection, refraction. Wave guides and resonant cavities. Radiating systems, dipole fields, radiated power. Special theory of relativity.
 QP: PHY 847 QA: PHY 848 PHY 849
- 853*. Advanced Quantum Mechanics**
 Fall. 3(3-0)
 P: 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.
 QP: PHY 839 QA: PHY 867 PHY 868
- 854*. Quantum Electrodynamics**
 Spring of odd-numbered years. 3(3-0)
 P: PHY 853.
 Application of quantum field theory to the interaction of electrons and photons: pair annihilation, Compton scattering. Bound states, renormalization theory.
 QA: PHY 868 PHY 869
- 871*. Condensed Matter Physics**
 Spring. 3(3-0)
 P: PHY 852.
 Structure and vibrations of solids. Electrons in solids, electron gas, Bloch's theorem. Cohesion. Electron states in solids. Electronic properties of solids, electron transport, conductivity, semiconductors. Cooperative phenomena.
 QP: PHY 839 QA: PHY 883

PHYSICS

881*. **Subatomic Physics**
 Fall. 3(3-0)
 P: 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.
 QP: PHY 838 QA: PHY 881

891*. **Elementary Particle Physics**
 Fall. 3(3-0)
 P: 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.
 QP: PHY 867 QA: PHY 927 PHY 928

899*. **Master's Thesis Research**
 Fall, Spring, Summer. 1 to 6 credits.
 May reenroll for a maximum of 24 credits.
 R: Open only to graduate students in Physics.
 QA: PHY 899

972*. **Topics in Condensed Matter Physics(MTC)**
 Fall. 3(3-0)
 P: PHY 831, PHY 852
 Advanced topics in many-body problems, disordered solids, superfluidity and superconductivity magnetism.
 QP: PHY 883 QA: PHY 941

972A*. **Topics in Condensed Matter Physics: Many-Body Problems**
 Fall. 3(3-0)
 P: PHY 871
 Advanced topics in many-body problems, disordered solids, superfluidity and superconductivity, magnetism.
 QP: PHY 883 QA: PHY 941

972B*. **Topics in Condensed Matter Physics: Disordered Solids**
 Fall. 3(3-0)
 P: PHY 871
 Advanced topics in many-body problems, disordered solids, superfluidity and superconductivity, magnetism.
 QP: PHY 883 QA: PHY 941

972C*. **Topics in Condensed Matter Physics: Superfluidity and Superconductivity**
 Fall. 3(3-0)
 P: PHY 831, PHY 852
 Advanced topics in many-body problems, disordered solids, superfluidity and superconductivity, magnetism.
 QP: PHY 883 QA: PHY 941

972D*. **Topics in Condensed Matter Physics: Magnetism**
 Fall. 3(3-0)
 P: PHY 831, PHY 852
 Advanced topics in many-body problems, disordered solids, superfluidity and superconductivity, magnetism.
 QP: PHY 883 QA: PHY 941

972E*. **Topics in Condensed Matter Physics: Physics of Macroscopic Systems**
 Fall. 3(3-0)
 P: PHY 831, PHY 852
 Advanced topics in many-body problems, disordered solids, superfluidity, and superconductivity, magnetism.
 QP: PHY 883 QA: PHY 941

980*. **Advanced Reading in Physics**
 Fall, Spring, Summer. 1 to 3 credits.
 May reenroll for a maximum of 4 credits.
 R: Permission of department.
 QA: PHY 984

982*. **Topics in Nuclear Physics(MTC)**
 Spring. 3(3-0)
 P: PHY 881, PHY 852
 A special topics course in nuclear physics.
 QP: PHY 881 PHY 839 QA: PHY 951 PHY 952

982A*. **Topics in Nuclear Physics: Heavy Ion Reactions**
 Spring. 3(3-0)
 P: PHY 852, PHY 881, PHY 831
 Scattering, particle transfer, resonance reactions, fission, time-dependent Hartree-Fock, Vlasov equation, nuclear transport equations, particle production, nuclear liquid-gas phase transition, quark-gluon plasma.
 QP: PHY 839 PHY 881PHY 871

982B*. **Topics in Nuclear Physics: Nuclear Structure**
 Spring. 3(3-0)
 P: PHY 881, PHY 852
 Special topics course in nuclear structure, nuclear forces, nuclear matter, nuclear-structure models, and few-nucleon systems.
 QP: PHY 881 QA: PHY 951 PHY 952

992*. **Quantum Chromodynamics(MTC)**
 Spring. 3(3-0)
 P: PHY 891
 Current topics in quantum chromodynamics, hadron-hadron interactions, interaction of hadrons with leptons.
 QP: PHY 927 QA: PHY 928 PHY 929

992A*. **Quantum Chromodynamics: Hadron Interactions**
 Spring of even-numbered years. 3(3-0)
 P: PHY 891 R: X
 Current topics in quantum chromodynamics, hadron-hadron interactions, interaction of hadrons with leptons.
 QP: PHY 927 QA: PHY 928 PHY 929

992B*. **Quantum Chromodynamics: Lepton-Hadron Interactions**
 Spring of odd-numbered years. 3(3-0)
 P: PHY 891
 Current topics in quantum chromodynamics, hadron-hadron interactions, interaction of hadrons with leptons.
 QP: PHY 927 QA: PHY 928 PHY 929

999*. **Doctoral Dissertation Research**
 Fall, Spring, Summer. 0(-) May reenroll for a maximum of 99 credits.
 R: Physics
 QA: PHY 999

PHYSIOLOGY PSL

250. **Introductory Physiology**
 Fall, Spring. 4(4-0)
 Function, regulation and integration of organs and organ systems of higher animals emphasizing human physiology.

323*. **Physiology and Hygiene of the Eye**
 Fall of odd-numbered years, , Summer of even-numbered years. 3(3-0)
 R: Not open to Physiology majors.
 Basic anatomy, physiology, and hygiene of the visual system: normal and abnormal visual function, methods of correction, and educational implications.
 QA: PSL 323

410*. **Computational Problem Solving in Physiology**
 Fall, Spring. 3(03-00)
 P: PSL 432.
 Quantitative analysis of physiological data: mathematical models, curve fitting, data analysis and interpretation. Problem solving involving exponential and logistic growth. Cerebral blood flow, convective cooling, oxygen consumption, thermoregulation, o
 QP: PSL 432 QA: PSL 410

431*. **Human Physiology I**
 Fall. 3(03-00)
 P: BS 111, CEM 142.
 Neural function including autonomic nervous system, physiological control systems, endocrinology, reproduction and digestive function.
 QP: BS 210 BS 211 QA: PSL 431

432*. **Human Physiology II**
 Spring. 3(03-00)
 P: PSL 431.
 Continuation of PSL 431. Function and regulation of the cardiovascular, respiratory, and renal systems. Control of tissue blood flow, blood pressure, blood gases, body fluid volume and electrolytes.
 QP: PSL 431 QA: PSL 432

440*. **Topics in Cell Physiology**
 Fall, Spring. 2(02-00)
 P: PSL 432. R: Open only to Physiology majors.
 Critical discussion and evaluation of a selected problem of mammalian cell physiology including cell biophysics, molecular biology of the cell.
 QP: PSL 431 PSL 432

441*. **Topics in Endocrinology**
 Fall, Spring. 2(02-00)
 P: PSL 432. R: Open only to Physiology majors.
 Selected topic on the role of hormones in the regulation of growth, metabolism, differentiation.
 QP: PSL 431 PSL 432

442*. **Topics in Cardiovascular Physiology**
 Fall. 2(2-00)
 P: PSL 432. R: Open only to Physiology majors.
 Selected topic in blood flow physiology.
 QP: PSL 431 PSL 432

443*. **Topics in Respiratory Physiology**
 Fall of odd-numbered years. 2(02-00)
 P: PSL 432. R: Open only to Physiology majors.
 Selected topic in the physiology of gas exchange and lung mechanics.
 QP: PSL 431 PSL 432

444*. **Topics in Renal Physiology**
 Spring of even-numbered years. 2(02-00)
 P: PSL 432. R: Open only to Physiology majors.
 Selected topic in the function of the kidney, regulation of salt and water balance.
 QP: PSL 431 PSL 432

445*. **Topics in Environmental Physiology**
 Spring of odd-numbered years. 2(02-00)
 P: PSL 432. R: Open only to Physiology majors.
 Selected topic in environmental physiology with an emphasis on thermoregulation.
 QP: PSL 431 PSL 432

446*. **Topics in Visual Physiology**
 Fall of even-numbered years. 2(2-00)
 P: PSL 432. R: Open only to Physiology majors.
 Selected topic in the functioning of the visual system in health and disease.
 QP: PSL 431 PSL 432