



## Course Curriculum for the for Interdisciplinary Certificate in Artificial Intelligence/Machine Learning (AI/ML) in Medical Physics

Students must complete a total of at least 16 units of coursework, including at least four units from each of three (3) fields: Medical Physics, AI/Machine Learning and Statistics and Data Analysis. Example courses from each field are listed here (Complete course listings are enclosed).

- (a) Medical Physics (PBMED 205, PBMED M219, PBMED 200A, PBMED M248, PBMED 203)
- (b) AI / Machine Learning (PBMED M209, PBMED 210, STAT M231A, BIOINFO M226)
- (c) Statistics and Data Analysis (PBMED 217, BIOENGR M228)

### Descriptions of Courses by Field

#### Medical Physics course options

1. **PBMED 200A. Physics and Chemistry of Nuclear Medicine** - Units: 4.0; Offered Winter Quarter  
Lecture, three hours; discussion, one hour. Nuclear structure, statistics of radioactive decay, nuclear radiations and their interaction with matter, nuclear decay processes, nuclear reactions, and compartment models. Physical and chemical properties of radioactive preparations used in nuclear medicine. Basic principles of nuclear medicine imaging, SPECT, and PET. S/U or letter grading.
2. **PBMED 203. Physics of Radiation Therapy** - Units: 4.0; Offered Spring Quarter  
Lecture, three hours; discussion, one hour. Requisite: course 216. Radiation quantities and units. Radiation dosimetry, clinical applications in treatment planning. Methods of measuring radiation quantities. Calibration of radiation therapy equipment. Letter grading.
3. **PBMED 205. Physics of Diagnostic Radiology** - Units: 4.0; Offered Fall Quarter  
Lecture, three hours; laboratory, one hour. Production of X rays, basic interactions between X rays and matter, X-ray system components, physics principles of medical radiography, radiographic image quality, fluoroscopy, image intensifiers, special procedures, X-ray protection. Laboratory experiments illustrate basic theory. S/U or letter grading.
4. **PBMED M219. Principles and Applications of Magnetic Resonance Imaging** - Units: 4.0; Offered Winter Quarter  
(Same as Bioengineering M219.) Lecture, three hours; discussion, one hour. Basic principles of magnetic resonance (MR), physics, and image formation. Emphasis on hardware, Bloch equations, analytic expressions, image contrast mechanisms, spin and gradient echoes, Fourier transform imaging methods, structure of pulse sequences, and various scanning parameters. Introduction to advanced techniques in rapid imaging, quantitative imaging, and spectroscopy. Letter grading.
5. **PBMED M248. Introduction to Biological Imaging** - Units: 4.0; Offered Spring Quarter  
(Same as Bioengineering M248 and Pharmacology M248.) Lecture, three hours; laboratory, one hour; outside study, seven hours. Exploration of role of biological imaging in modern biology and medicine, including imaging physics, instrumentation, image processing, and applications of imaging for range of modalities. Practical experience provided through series of imaging laboratories. Letter grading.



## Machine Learning Course Options

1. **PBMED M209. Signal and Image Processing for Biomedicine** - Units: 4.0; Offered Fall Quarter (Same as Bioengineering M209.) Lecture, three hours. Preparation: basic calculus or linear algebra and undergraduate probability. Mathematics and statistical fundamentals prevalent in biomedical physics studies. Notion and basic descriptions of linear shift-invariance and point spread functions in continuous and discrete time. Sampling theory and Fourier analysis. Signal representation of vector spaces, projection theorem, and least-squares approximations. Discussion of signal subspace methods, correlation and independence, principal component analysis, and independent component analysis. Basic ideas in inverse problems and optimization. Application in medical and signal processing. Development of geometric and informatics intuitions behind mathematics and statistics. Light derivations and MATLAB programming. S/U or letter grading.
2. **PBMED 210. Computer Vision in Medical Imaging** - Units: 4.0; Offered Winter Quarter  
The AI of the future will be capable of human-like thinking. New approaches in Cognitive AI combine data-driven machine learning with human knowledge and reasoning to increase real-world reliability and trustworthiness. In this course you will learn the building blocks of machine learning, deep learning, and image processing. You will gain insights into their limitations and explore Cognitive AI solutions that improve performance in critical real-world decision making. You will have the opportunity to build a working system for computer vision in medical imaging and gain practical experience using AI packages and open software platforms.
3. **BIOINFO M226. Machine Learning in Bioinformatics** - Units: 4.0; Offered Winter Quarter (Same as Computer Science M226 and Human Genetics M226.) Lecture, four hours; outside study, eight hours. Enforced prerequisite: Computer Science 32 or Program in Computing 10C with grade of C- or better. Recommended: one course from Biostatistics 100A, 110A, Civil Engineering 110, Electrical Engineering 131A, Mathematics 170A, or Statistics 100A. Familiarity with probability, statistics, linear algebra, and algorithms expected. Designed for engineering students as well as students from biological sciences and medical school. Biology has become data-intensive science. Bottleneck in being able to make sense of biological processes has shifted from data generation to statistical models and inference algorithms that can analyze these datasets. Statistical machine learning provides important toolkit in this endeavor. Biological datasets offer new challenges to field of machine learning. Examination of statistical and computational aspects of machine learning techniques and their application to key biological questions. Letter grading
4. **STATS M231A. Pattern Recognition and Machine Learning** - Units: 4.0; Offered Fall Quarter (Same as Computer Science M276A.) Lecture, three hours; discussion, one hour. Designed for graduate students. Fundamental concepts, theories, and algorithms for pattern recognition and machine learning that are used in computer vision, image processing, speech recognition, data mining, statistics, and computational biology. Topics include Bayesian decision theory, parametric and nonparametric learning, clustering, complexity (VC-dimension, MDL, AIC), PCA/ICA/TCA, MDS, SVM, boosting. S/U or letter grading.



## Statistical/Data Analysis

1. **PBMED 217. Statistics and Data Analysis in Biomedical Physics** - Units: 4.0; Offered Winter Quarter (typically 2<sup>nd</sup> year for PBM students)  
Lecture, four hours. Requisites: Mathematics 31A, 31B, 32A, 32B, 33A, 33B. Introduction to computer-based statistical concepts, data analysis, and experimental design within biomedical physics research. Standard statistical packages and various statistical computing algorithms on relevant data sets within radiological sciences. Letter grading.
2. **BIOENGR M228. Medical Decision Making & Reasoning** – Units: 4.0; Offered Winter Quarter (Same as Information Studies M255. Introduction to biostatistics and study design. Discussion on meta-analysis methods and concepts such as odds ratio are described. Understanding basic statistical and probabilistic models, including, Bayesian statistics. Materials are presented in the context of how healthcare decision-making processes are conducted.



**Example Courses of Study (NOTE; this schedule does not include Poster or Oral Presentation Requirements)**

These examples are meant to be illustrative and not comprehensive; many other combinations exist.

**Example #1**

| Quarter               | Course    | Medical Physics | AI/Machine Learning | Statistics and Data Analysis |
|-----------------------|-----------|-----------------|---------------------|------------------------------|
| Fall Quarter Year 1   | PBMED 205 | X               |                     |                              |
| Winter Quarter Year 1 | PBMED 210 |                 | X                   |                              |
| Spring Quarter Year 1 | PBMED 203 | X               |                     |                              |
| Winter Quarter Year 2 | PBMED 217 |                 |                     | X                            |

**Example #2**

| Quarter               | Course    | Medical Physics | AI/Machine Learning | Statistics and Data Analysis |
|-----------------------|-----------|-----------------|---------------------|------------------------------|
| Fall Quarter Year 1   | PBMED 205 | X               |                     |                              |
| Winter Quarter Year 1 | PBMED 219 | X               |                     |                              |
| Fall Quarter Year 2   | PBMED 209 |                 | X                   |                              |
| Winter Quarter Year 2 | PBMED 217 |                 |                     | X                            |

**Example #3**

| Quarter               | Course     | Medical Physics | AI/Machine Learning | Statistics and Data Analysis |
|-----------------------|------------|-----------------|---------------------|------------------------------|
| Fall Quarter Year 1   | PBMED 205  | X               |                     |                              |
| Spring Quarter Year 1 | PBMED M248 | X               |                     |                              |
| Winter Quarter Year 2 | PBMED 210  |                 | X                   |                              |
| Winter Quarter Year 2 | PBMED 217  |                 |                     | X                            |

**Example #4**

| Quarter               | Course     | Medical Physics | AI/Machine Learning | Statistics and Data Analysis |
|-----------------------|------------|-----------------|---------------------|------------------------------|
| Fall Quarter Year 1   | PBMED 205  | X               |                     |                              |
| Fall Quarter Year 2   | PBMED M209 |                 | X                   |                              |
| Winter Quarter Year 2 | PBMED 210  |                 | X                   |                              |
| Winter Quarter Year 2 | PBMED 217  |                 |                     | X                            |