

November 2, 2021

TO: The Faculty of the College of Engineering
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: New Undergraduate Course, BME 36600, Foundations of Biomedical Data Science

The Faculty of the School of Biomedical Engineering has approved the following new undergraduate course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

BME 36600: Foundations of Biomedical Data Science

Term Offered: Fall, Lecture 3, Cr. 3

Concurrent Prerequisites: STAT 35000 or STAT 51100

Major Restriction: Biomedical Engineering only

Description: This course presents foundational data science methods for analysis of complex biological datasets encountered in biomedical engineering research and applications. After a brief (1-2 weeks) introduction and review of mathematical concepts necessary for data science, the course will cover representative areas of regression, supervised machine learning, unsupervised machine learning, model evaluation, and uncertainty quantification. Assignments and exams will focus on practical examples spanning basic science, engineering, and medical applications.

Reason: This course is a new offering that will be required for students who select the new Computational Biomedicine pathway in the BME undergraduate curriculum redesign. Engineering and life science disciplines have seen a growing need for practitioners capable of working with, analyzing, and interpreting large data sets. The highly interdisciplinary nature of biomedical data science typically precludes students from acquiring applicable skills in this area until graduate training. This course aims to teach undergraduate students the foundational concepts and methods for practicing data science in the biomedical engineering disciplines.



David M. Umulis
Dane A. Miller Head and Professor
Weldon School of Biomedical Engineering

DRAFT SYLLABUS

BME 36600 Foundations of Biomedical Data Science (CRN: XXXX)
Fall 2022

This syllabus is subject to change with notice. For the most recent updates see <https://purdue.brightspace.com>

All class materials will be available online:

Brightspace: TBD

In-person class meetings will be held in **MJIS TBD (Brubaker)**
Tuesday and Thursday **TBD**

Instructor: Douglas Brubaker

Graduate TA: TBD

Office Hours: TBD

***Concurrent Prerequisites: STAT 35000 or
STAT 51100***

Catalog Description

This course presents foundational data science methods for analysis of complex biological datasets encountered in biomedical engineering research and applications. After a brief (1-2 weeks) introduction and review of mathematical concepts necessary for data science, the course will cover representative areas of regression, supervised machine learning, unsupervised machine learning, model evaluation, and uncertainty quantification. Assignments and exams will focus on practical examples spanning basic science, engineering, and medical applications.

Learning Outcomes

- At the end of the course, students will be able to identify the appropriate statistical tests to analyze data fitting a given probability distribution.
- At the end of the course, students will be able to propose an analysis plan for large datasets that tests a hypothesis or answers an exploratory analysis question.
- At the end of the course, students will be able to implement the appropriate computational model for their analysis plan and interpret the model results with appropriate consideration of uncertainty.

Textbook

- **Pattern Recognition and Machine Learning**, Christopher M. Bishop

Grading

Assessment Mechanism	Weighting
Participation	10%
Homework	50%
Midterm exam(s)	20%
Final exam	20%

Grade Ranges

Grade	GPA	Value Range
A+, A	4.0	93-100
A-	3.7	90.0-92.9
B+	3.3	87.0-89.9
B	3.0	83.0-86.9
B-	2.7	80.0-82.9
C+	2.3	77.0-79.9
C	2.0	73.0-76.9
C-	1.7	70.0-72.9
D+	1.3	67.0-69.9
D	1.0	63.0-66.9
D-	0.7	60.0-62.9
F	0.0	< 60.0

NOTE: The scale can change per instructor discretion so that a given grade may fall into a lower bin range (i.e. A, A+ could drop down to 83-90) if the instructor deems it necessary. Under no circumstances will the reverse occur.

Course Policies

Grade dispute

If a student believes that a problem was graded incorrectly the student should resubmit, to the instructor, the work and a paragraph describing what error was made in grading. This should be submitted within a week after receiving the disputed grade. The instructor reserves the right to re-grade the entire exam if an error is found. Note that all exams and quizzes are photocopied and archived prior to returning the graded material to the students.

Academic Integrity

Student Honor Pledge - *“As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue.”*

1. Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either

emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information that is submitted provides the greatest opportunity for the university to investigate the concern.

2. Any form of cheating will result in a penalty up to automatic “F” grade for the course. All instances of cheating will be forwarded to the Office of Student Rights and Responsibilities for appropriate disciplinary action.
3. Helping another student to cheat and cheating are considered equal cases of academic dishonesty and will be treated as outlined above.
4. Giving another student an electronic copy of your homework, or access to your computer account constitutes cheating on your behalf if that other student copies or uses any files that become implicated in a cheating case.

For a complete definition of academic dishonesty see <http://www.purdue.edu/ODOS/osrr/integrity.htm>

Use of Copyrighted Materials

All course materials are copyrighted by the instructor and may not be republished or posted for public viewing. Notes taken in class are considered derivative works and may not be republished or posted for public viewing.

Students are expected, within the context of the Regulations Governing Student Conduct and other applicable University policies, to act responsibly and ethically by applying the appropriate exception under the Copyright Act to the use of copyrighted works in their activities and studies. The University does not assume legal responsibility for violations of copyright law by students who are not employees of the University.

A Copyrightable Work created by any person subject to this policy primarily to express and preserve scholarship as evidence of academic advancement or academic accomplishment. Such works may include, but are not limited to, scholarly publications, journal articles, research bulletins, monographs, books, plays, poems, musical compositions and other works of artistic imagination, and works of students created in the course of their education, such as exams, projects, theses or dissertations, papers and articles.

Course Evaluation

During the last two weeks of the course, you will be provided with an opportunity to evaluate this course and your instructor. Purdue uses an online course evaluation system. You will receive an official email from evaluation administrators with a link to the online evaluation site. You will have up to two weeks to complete this evaluation. Your participation is an integral part of this course, and your feedback is vital to improving education at Purdue University. It is strongly encouraged that you participate in the evaluation system.

Nondiscrimination Policies

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the

institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. Purdue's nondiscrimination policy can be found at http://www.purdue.edu/purdue/ea_eou_statement.html.

Grief Absence Policy for Students

Below is the University's Grief Absence Policy for Students:

Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). GAPS Policy: Students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for missed assignments or assessments in the event of the death of a member of the student's family.

See the University's website for additional information:

http://www.purdue.edu/studentregulations/regulations_procedures/classes.html

Accessibility

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

Any student who, because of a disabling condition, has an accommodation from the Disability Resource Center must contact the instructor by the third week of class in order to make necessary accommodations. Students who do not contact the instructor by the third week of class, or as soon as they know they have a disabling condition should it occur during the semester, forfeit their rights to special accommodations.

Mental Health

If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try [WellTrack](#). Sign in and find information and tools at your fingertips, available to you at any time.

If you need support and information about options and resources, please contact or see the [Office of the Dean of Students](#). Call 765-494-1747. Hours of operation are M-F, 8 am- 5 pm.

If you find yourself struggling to find a healthy balance between academics, social life, stress, etc. sign up for free one-on-one virtual or in-person sessions with a [Purdue Wellness Coach at RecWell](#). Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.

If you're struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact [Counseling and Psychological Services \(CAPS\)](#) at 765-494-6995

during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Violent Behavior

Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent Behavior impedes such goals. Therefore, Violent Behavior is prohibited in or on any University Facility or while participating in any university activity.

See the University's full policy for more detail: <https://www.purdue.edu/policies/facilities-safety/iva3.html>

Campus emergency

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.

Description: This course presents foundational methods for analysis of complex biological datasets encountered in biomedical engineering research and applications. The course covers foundational concepts in probability, statistics, and linear algebra necessary for a working knowledge of data science methods. The course will aim to cover representative areas of regression, classification, supervised learning, clustering, unsupervised learning, data-driven modeling, machine learning, model evaluation, and uncertainty quantification. Assignments and exams will focus on practical examples spanning basic science, engineering, and medical applications.

Representative Topics:

- **Mathematical Fundamentals:** Probability, Statistics, Linear Algebra
- **Model Building**
 - Cross-validation (Training and Testing Data)
 - Uncertainty Quantification and performance evaluation
- **Biological Fundamentals For Models**
 - Survey of topics in biology relevant for course examples
 - Biomolecules, Bioelectrics, Biomechanics, Imaging Modalities
 - Measurement Technologies – Uncertainty, fitting to probability distributions
- **Regression Models**
 - Ordinary Least Squares, Multiple Linear Regression
 - LASSO, Ridge, and Elastic Net Regularization
 - Latent Variable Models
 - Principal Component Analysis
 - Partial Least Squares Regression
- **Machine Learning,**
 - Unsupervised Learning
 - Clustering
 - K-means

- Hierarchical Clustering
- Principal Component Analysis
- Non-linear dimensionality reduction
- Autoencoders
- Supervised Learning
 - K-nearest neighbors
 - Support vector machines
 - Random forests
 - Multi-layer perceptron