University of Iowa

STAT:4560
Statistics for Risk Modeling
Course Syllabus
Fall 2020

MWF, 427 EPB*
11:30 a.m. – 12:20 p.m.

Department of Statistics and Actuarial Science
University of Iowa
241 Schaeffer Hall
Iowa City, Iowa 52242-1409
319-335-0712
https://stat.uiowa.edu

Department of Statistics and Actuarial Science

* We will meet in person in the first thirteen weeks of this semester. All UI courses, including ours, will be delivered virtually after the Thanksgiving Recess.

1 Contact Information

- **Instructor:** Professor Ambrose Lo, PhD, FSA, CERA
  - ▷ *Office:* 368 SH
  - ▷ *Email:* ambrose-lo@uiowa.edu
    (Note: Please put "STAT:4560" in the subject line)
  - ▷ *Personal homepage:* `https://sites.google.com/site/ambroseloyp`
    (Feel free to visit it from time to time for latest updates on my courses and books!)
  - ▷ *Office hours:* 3:30 p.m. – 4:30 p.m., Monday, Wednesday, and Friday. Also available by appointment.
- **Grader:** Mr. Zongyi Xu
  - ▷ *Office:* 348 SH
  - ▷ *Email:* zongyi-xu@uiowa.edu
    (Note: Please put "STAT:4560" in the subject line)
- **Departmental Executive Officer (Chair):** Professor Kung-Sik Chan
  - ▷ *Office:* 241 SH
  - ▷ *Email:* kung-sik-chan@uiowa.edu

2 Course Description and Objectives

Prerequisite: C+ or above in STAT:4101 (Mathematical Statistics II) or STAT:5101 (Statistical Inference II)

Recommendation: Taking STAT:4540 (Statistical Learning) together with STAT:4560

Building upon students' prior exposure to actuarial science and preparation in mathematical statistics, this applied statistics course for B.S. and M.S. in Actuarial Science students covers the theory and applications of linear regression models, generalized linear models, and tree-based models, as required in the **Statistics for Risk Modeling (SRM) Exam** offered by the Society of Actuaries (SOA). Emphasis is placed on the use of these models to select useful variables (a.k.a. features) and make predictions. Practical implementations of these models with real data by means of the R programming language will be demonstrated to give you some hands-on data analysis experience. This is an important way to put the theory we learn in the course into practice. Although the use of R is not strictly required for Exam SRM, it is essential for the **Predictive Analytics (PA) Exam**, which has SRM as the prerequisite.

Structure-wise, this course consists of the following three central strands:

Strand I.	Linear Regression Models	(approx. 9 weeks)
Strand II.	Generalized Linear Models	(approx. 3 weeks)
Strand III.	Decision Trees	(approx. 3 weeks)

Note that this course emphasizes not only the memorization of formulas and doing calculations by hand, but also the conceptual rationale behind the construction of various estimators, hypothesis tests, and predictions. By strongly discouraging the black-box approach adopted by elementary regression courses, this course will inculcate students with a genuine understanding of the mechanics of different predictive models and their relative strengths and weaknesses.

After taking this course, the successful student is expected to:

- Understand the ideas and assumptions underlying the statistical methods covered in the course.
- Apply appropriate statistical methods to real-world problems amenable to such techniques.
- Implement a predictive model using R and interpret the computer output.
- Take and, most importantly, pass Exam SRM in January 2021 with considerable ease.
- Be equipped with the conceptual underpinnings to take Exam PA in December 2021.

3 Exam SRM

Exam SRM is a three and one-half hour computer-based exam consisting of 35 multiple-choice questions. Each question includes five answer choices identified by the letters (A), (B), (C), (D), and (E), only one of which is correct. Offered for the first time in September 2018 by the SOA, this new exam is a replacement of the old Validation by Educational Experience (VEE) Applied Statistics requirement and serves as the formal prerequisite for the new PA exam. The construction of Exam SRM, which revolves around making use of various statistical models to draw inferences and make predictions for the future, is an important step that the SOA takes to incorporate more statistics, most notably predictive modeling, into the modern-day actuarial curriculum. More information about Exam SRM can be found at `https://www.soa.org/education/exam-req/edu-exam-srm-detail.aspx`.

Out of the six topics in the SRM exam syllabus, this course is dedicated to:

Topic 1: Basics of Statistical Learning (7.5-12.5%)

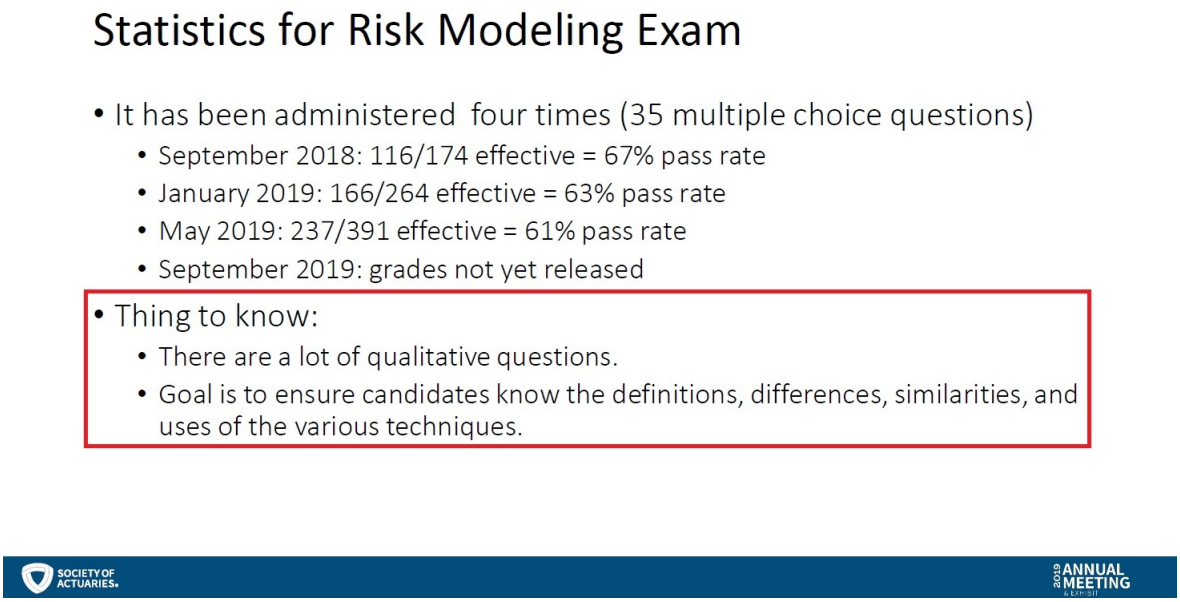
Topic 2: Linear Models (40-50%)

Topic 5: Decision Trees (10-15%)

Together, these topics account for about two-third of the exam syllabus. To learn Topic 4: Principal Components Analysis (2.5-7.5%) and Topic 6: Cluster Analysis (10-15%), consider taking STAT:4540 *Statistical Learning*, in addition to STAT:4560, in this fall semester. (Topic 3: Time Series Models (12.5-17.5%) will be left as self-learning.)

One distinguishing characteristic of Exam SRM compared to other multiple-choice ASA-level exams is that most of the questions in this exam are *conceptual* (a.k.a. qualitative and true-or-false) in nature, testing the uses, motivations, pros and cons, do's and don'ts of, and similarities and differences between different predictive models. As the SOA publicly admitted in the 2019 Annual Meeting & Exhibit,[i]

"there are a lot of qualitative questions [in Exam SRM]."



You are typically given three statements and asked to pick the correct one(s). The generic structure of these questions is as follows:

> Determine which of the following statements about *[...a particular statistical concept/method...]* is/are true.
>
> I. (blah blah blah...)
>
> II. (blah blah blah...)
>
> III. (blah blah blah...)
>
> (A) I only
>
> (B) II only
>
> (C) III only
>
> (D) I, II, and III
>
> (E) The correct answer is not given by (A), (B), (C), or (D).

[i] See Slide 9 of https://www.soa.org/globalassets/assets/files/e-business/pd/events/2019/annual-meeting/pd-2019-10-annual-session-070.pdf.

or

(A) None

(B) I and II only

(C) I and III only

(D) II and III only

(E) The correct answer is not given by (A), (B), (C), or (D).

Do not be under the impression that these conceptual questions are easy. The conceptual items being tested can be tricky and at times controversial: Rather than an absolute "yes" or "no," the statement is more a matter of extent. Sadly, if you get any of Statements I, II, or III incorrect, you will likely be led to an incorrect final answer. By the way, Answer (E) occasionally turns out to be the right answer—it is not a filler!

Logistically, Exam SRM is offered three times every year (in January, May, and September). It is strongly suggested that you take the exam in **January 2021** shortly after you learn the material, do the homework, and study for the quizzes and exams in this course (as the old saying goes, "strike while the iron is hot!"). You will have time to study for Exam SRM because ACTS:4280 *Life Contingencies II*, which prepares you for Exam LTAM, will end in late October. In the unlikely event that you cannot pass the exam in January 2021, you should retake it in May 2021 when your memory is still fresh. The bottom line is:

> You should aim to have at least *four* professional exams under your belt (P, FM, IFM, LTAM, and/or SRM) by the time you graduate.

4 CAS Exam MAS-I

Students who aspire to specialize in property and casualty insurance will take Exam MAS-I (Modern Actuarial Statistics I) of the Casualty Actuarial Society (CAS), Section C (Extended Linear Models; 30-50% of the exam syllabus) of which overlaps substantially with Exam SRM. More information about Exam MAS-I can be found at `https://www.casact.org/admissions/syllabus/index.cfm?fa=MASI&parentID=391`.

5 Textbook

The text of this course is

> *ACTEX Study Manual for SOA Exam SRM* (Fall 2020 Edition), 2020, by Feng, R., Linders, D., **Lo, A. (yours truly)**, ACTEX Learning. ISBN: 978-1-64756-065-2.

This study manual not only addresses all important topics required in the SRM exam syllabus, but also presents lots of intuition for you to understand the subject matter deeply, and a wide variety of examples and practice problems for exam preparation. In this course, we will cover the following chapters in the manual:

> Chapter 1: Simple Linear Regression
>
> Chapter 2: Multiple Linear Regression

Chapter 4: Linear Models from a Statistical Learning Perspective

Chapter 5: Generalized Linear Models

Chapter 8: Decision Trees

These chapters correspond to Topics 1, 2, and 5 of the SRM syllabus. During lectures, the instructor will provide a framework, cover the main ideas, point out subtleties, and go over representative examples with you. You should put down additional details, work out examples together with the instructor, and take supplementary notes to better understand concepts.

6 Grading System

Assessment in this course comprises the following items:

- **Attendance and Attitude:** $\pm\varepsilon\%$[ii]

  You may choose to attend or not to attend classes, but everyone needs to be aware that unexcused absences from classes can adversely affect your final grade. It is also impossible for absentees to get a copy of the course material they miss, inquire about announcements made in class, or seek out-of-class help from the instructor. Likewise, your participation, preparedness, and work ethic may affect your final grade (positively or negatively).

- **Homework Assignments: 10%**

  There will be homework assignments given on a sporadic basis. These assignments may consist of exam-type practice problems, theoretical problems involving derivations, or simple data analysis problems to be completed using R (resources for learning R will be provided). More details will be announced later.

  A note on collaboration: Discussion with other students on homework problems is allowed. However, you should always write up your own solutions.

- **Weekly Quizzes: 25%**

  There will be a total of ten 15-minute quizzes held on Fridays. Please refer to the course schedule on pages 7 and 8. Any exceptions will be announced in class or on ICON (`http://icon.uiowa.edu`). These quizzes are intended to motivate you to study regularly (not just cram before the Midterm and Final Exams!) and will consist of relatively straightforward questions. You will find that the in-text examples and end-of-chapter problems in the SRM study manual are useful in preparing for these quizzes. For students' guidance, illustrative solutions will be posted on ICON shortly after each quiz is given.

  Note that the two quizzes with the lowest score will be dropped when it comes to computing the final grade; accordingly, missed quizzes due to illness cannot be made up under any circumstances.

- **Midterm Examination: 25%**

  There will be a 90-minute Midterm Examination to be held in the evening (6:30 p.m. – 8:00 p.m.) of **November 2, 2020 (Monday)** at 3655 SC covering Chapters 1, 2, and 4 of this course. It will consist of multiple-choice questions similar in style to typical SRM problems.

[ii] In mathematics, ε usually denotes a small positive number.

- **Final Examination: 40%**

  A comprehensive Final Examination will take place in the week of December 14–18, 2020 and will be delivered in a virtual, open-book format due to the special circumstances of this fall semester. The exact date and time will be announced by the Registrar in mid-September. More details about the Final Exam will be given as the exam date approaches.

With the exception of the Final Exam, all quizzes and exams in this course are closed-book. The SRM tables (also available on the real SRM exam) will be provided if needed, and you are not allowed to bring your own formula sheets (the same applies to the real SRM exam as well!). Only calculators listed on Point 9 of the SOA exam rules and regulations/instructions (see `https://www.soa.org/Files/Edu/edu-rules-reg-instructions.pdf`) are permitted.

A note on absence from exams. If, because of illness, you are unable to take any exams (not including quizzes) in this course as scheduled, you should inform the course instructor *within 24 hours* after the exam has ended and explain why you are medically unfit to take the exam on the scheduled date. Otherwise, a zero score will be awarded. Approval for absences for other reasons such as mandatory religious obligations, certain University activities, or unavoidable circumstances should be sought well in advance with documentation provided.

Grading scheme. Plus/minus grades will be given in this course, and undergraduate and graduate students will be treated as two separate groups when it comes to assigning final grades. An *approximate* guide is as follows:

Undergraduate students					
A-	[85,90)	A	[90,95)	A+	[95,100]
B-	[70,75)	B	[75,80)	B+	[80,85)
C-	[55,60)	C	[60,65)	C+	[65,70)
D-	[40,45)	D	[45,50)	D+	[50,55)
F	[0,40)				

Graduate students					
A-	[86.5,91)	A	[91,95.5)	A+	[95.5,100]
B-	[73,77.5)	B	[77.5,82)	B+	[82,86.5)
C-	[59.5,64)	C	[64,68.5)	C+	[68.5,73)
D-	[46,50.5)	D	[50.5,55)	D+	[55,59.5)
F	[0,46)				

These are not completely absolute scales and the instructor reserves the right to adjust the cutoffs, depending on the difficulty of the exams. Note that with this grading scheme you are not "graded on a curve," and so you are not competing with fellow students. Therefore, you are not penalized in any way for working together to better understand concepts and to perform better in this course.

IMPORTANT NOTE

This is *not* an easy course for most students, even if you have prior exposure to regression analysis. Each week you should spend at least 3 hours outside of class meetings reviewing the SRM study manual and working on the end-of-chapter problems. It is fine to work harder, but working less is risky. Let me know if you encounter any problems with your learning.

7 Tentative Teaching and Quiz Schedule

The tentative schedule below will be updated as needed as the semester unfolds.

Teaching Week	Lecture	Date	Topic (Refer to study manual)
Part I: Linear Regression Models			
1	1	August 24, 2020 (Mon)	Course overview
	2	August 26, 2020 (Wed)	Chapter 1
	3	August 28, 2020 (Fri)	Chapter 1
2	4	August 31, 2020 (Mon)	Chapter 1
	5	September 2, 2020 (Wed)	Chapter 1
	6	September 4, 2020 (Fri)	Chapter 1, **Quiz 1**
3	—	September 7, 2020 (Mon)	(University Holiday)
	7	September 9, 2020 (Wed)	Chapter 1
	8	September 11, 2020 (Fri)	Chapter 1, **Quiz 2**
4	9	September 14, 2020 (Mon)	Chapter 1
	10	September 16, 2020 (Wed)	Chapter 2
	11	September 18, 2020 (Fri)	Chapter 2, **Quiz 3**
5	12	September 21, 2020 (Mon)	Chapter 2
	13	September 23, 2020 (Wed)	Chapter 2
	14	September 25, 2020 (Fri)	Chapter 2, **Quiz 4**
6	15	September 28, 2020 (Mon)	Chapter 2
	16	September 30, 2020 (Wed)	Chapter 2
	17	October 2, 2020 (Fri)	Chapter 2, **Quiz 5**
7	18	October 5, 2020 (Mon)	Chapter 4
	19	October 7, 2020 (Wed)	Chapter 4
	20	October 9, 2020 (Fri)	Chapter 4, **Quiz 6**
8	21	October 12, 2020 (Mon)	Chapter 4
	22	October 14, 2020 (Wed)	Chapter 4
	23	October 16, 2020 (Fri)	Chapter 4, **Quiz 7**
9	24	October 19, 2020 (Mon)	Chapter 4
	25	October 21, 2020 (Wed)	Chapter 4
	—	October 23, 2020 (Fri)	(No class due to Exam LTAM!)
Part II: Generalized Linear Models			
10	26	October 26, 2020 (Mon)	Chapter 5
	27	October 28, 2020 (Wed)	Chapter 5
	28	October 30, 2020 (Fri)	Chapter 5
11	—	November 2, 2020 (Mon)	**(No class. Midterm in evening!)**
	29	November 4, 2020 (Wed)	Chapter 5
	30	November 6, 2020 (Fri)	Chapter 5
12	31	November 9, 2020 (Mon)	Chapter 5
	32	November 11, 2020 (Wed)	Chapter 5
	33	November 13, 2020 (Fri)	Chapter 5, **Quiz 8**
Part III: Decision Trees			
13	34	November 16, 2020 (Mon)	Chapter 8
	35	November 18, 2020 (Wed)	Chapter 8
	36	November 20, 2020 (Fri)	Chapter 8, **Quiz 9**

—	—	November 23, 2020 (Mon)	(Thanksgiving Recess—No class!)
	—	November 25, 2020 (Wed)	
	—	November 27, 2020 (Fri)	
14	37	November 30, 2020 (Mon)	Chapter 8
	38	December 2, 2020 (Wed)	Chapter 8
	39	December 4, 2020 (Fri)	Chapter 8, **Quiz 10**
15	40	December 7, 2020 (Mon)	Chapter 8
	41	December 9, 2020 (Wed)	Chapter 8
	42	December 11, 2020 (Fri)	Chapter 8
—	—	December 14–18, 2020	**Final Examination**
⋮	⋮	⋮	⋮
—	—	January 2021	**January 2021 Exam SRM**

More about the Instructor ("Shameless" Self-introduction...)

Professor Ambrose Lo, Ph.D., FSA, CERA, is currently Associate Professor of Actuarial Science with tenure at the Department of Statistics and Actuarial Science, The University of Iowa. He earned his B.S. in Actuarial Science (first class honors) and Ph.D. in Actuarial Science from The University of Hong Kong in 2010 and 2014, respectively. He joined The University of Iowa as Assistant Professor of Actuarial Science in August 2014 and was tenured and promoted to Associate Professor in July 2019. His research interests lie in dependence structures, quantitative risk management as well as optimal (re)insurance. His research papers have been published in top-tier actuarial journals, such as *ASTIN Bulletin: The Journal of the International Actuarial Association*, *Insurance: Mathematics and Economics*, and *Scandinavian Actuarial Journal*.

Besides dedicating himself to actuarial research, Ambrose attaches equal importance to teaching, through which he nurtures the next generation of actuaries and serves the actuarial profession. He has taught courses on financial derivatives, mathematical finance, life contingencies, and statistics for risk modeling. In addition to coauthoring the *ACTEX Study Manual for SOA Exam SRM* (Fall 2020 Edition), he is also the sole author of the *ACTEX Study Manual for CAS Exam MAS-I* (Spring 2020 Edition), *ACTEX Study Manual for SOA Exam PA* (Fall 2020 Edition), and the textbook *Derivative Pricing: A Problem-Based Primer* (2018) published by Chapman & Hall/CRC Press. Although helping students pass actuarial exams is an important goal of his teaching, inculcating students with a thorough understanding of the subject and concrete problem-solving skills is always his top priority. In recognition of his exemplary teaching, Ambrose has received a number of awards and honors ever since he was a graduate student, including the 2012 Excellent Teaching Assistant Award from the Faculty of Science, The University of Hong Kong, public recognition in the *Daily Iowan* as a faculty member "making a positive difference in students' lives during their time at The University of Iowa" for five years in a row (2016 to 2020), and, most recently, the 2019-2020 Collegiate Teaching Award from the College of Liberal Arts and Sciences, The University of Iowa.

UI and the College of Liberal Arts and Sciences
Information for Undergraduates

Absences and Attendance

Students are responsible for attending class and for contributing to the learning environment of a course. Students are also responsible for knowing their course absence policies, which will vary by instructor. All absence policies, however, must uphold the UI policy related to student illness, mandatory religious obligations, including Holy Day obligations, military service obligations, unavoidable circumstances, or University authorized activities. Students may use the CLAS absence form to aid communication with the instructor who will decide if the absence is excused or unexcused. The form is on ICON in the top banner under "Student Tools." More information is at `https://clas.uiowa.edu/students/handbook/attendance-absences`.

Academic Integrity

All undergraduates enrolled in courses offered by CLAS have, in essence, agreed to the College's Code of Academic Honesty. Misconduct is reported to the College, resulting in suspension or other sanctions, with sanctions communicated with the student through UI email. Visit this page for information: `https://clas.uiowa.edu/students/handbook/academic-fraud-honor-code`.

Accommodations for Disabilities

UI is committed to an educational experience that is accessible to all students. A student may request academic accommodations for a disability (such as mental health, attention, learning, vision, and physical or health-related condition) by registering with Student Disability Services (SDS). The student is then responsible for discussing specific accommodations with the instructor. More information is at `https://sds.studentlife.uiowa.edu/`.

Administrative Home of the Course

The College of Liberal Arts and Sciences (CLAS) is the administrative home of this course and governs its add/drop deadlines, the second-grade-only option, and related policies. Other colleges may have different policies. CLAS policies may be found here: `https://clas.uiowa.edu/students/handbook`.

Class Behavioral Expectations

Students are expected to comply with University policies regarding appropriate classroom behavior as outlined in the Code of Student Life. This includes the policies and procedures that all students have agreed to regarding the Steps Forward for Fall 2020 in response to the COVID-19 pandemic. Particularly, all students are required to wear a face covering when in a UI building, including a classroom. In addition, the density of seats in classrooms has been reduced; in some instances, this will allow 6 feet or more between students while other cases, it may be less. Regardless, wearing a face covering and maintaining as much distance as possible are vital to slowing the spread of COVID19. In the event that a student disrupts the classroom environment through their failure to comply with the reasonable directive of an instructor or the University, the instructor has the authority to ask that the student immediately leave the space for the remainder of the class period. Additionally, the instructor is asked to report the incident to the Office of Student Accountability for the possibility of additional follow-up. Students who need a temporary alternative learning arrangement related to COVID-19 expectations should contact Student Disability Services

(https://sds.studentlife.uiowa.edu/fall-2020/covid-19-temporary-learning-arrangements/; +1 319 335-1462).

Class Recordings: Privacy and Sharing

Some sessions of a course could be recorded or live-streamed. Such a recording or streaming will only be available to students registered for the course. These recordings are the intellectual property of the faculty, and they may not be shared or reproduced without the explicit written consent of the faculty member. Students may not share these sessions with those not in the class; likewise, students may not upload recordings to any other online environment. Doing so is a breach of the Code of Student Conduct and, in some cases, a violation of the Federal Education Rights and Privacy Act (FERPA).

Communication and the Required Use of UI Email

Students are responsible for official correspondences sent to their UI email address (uiowa.edu) and must use this address for all communication within UI (Operations Manual, III.15.2).

Complaints

Students with a complaint about an academic issue should first visit with the instructor or course supervisor and then with the Chair of the department or program offering the course; students may next bring the issue to the College of Liberal Arts and Sciences; see this page for more information: https://clas.uiowa.edu/students/handbook/student-rights-responsibilities.

Final Examination Policies

The final exam schedule is announced around the fifth week of classes; students are responsible for knowing the date, time, and place of a final exam. Students should not make travel plans until knowing this information. No exams of any kind are allowed the week before finals with very few exceptions made (for labs, ESL and some world language courses, and off-cycle courses): https://registrar.uiowa.edu/final-examination-scheduling-policies.

Nondiscrimination in the Classroom

The University of Iowa is committed to making the classroom a respectful and inclusive space for people of all gender, sexual, racial, religious, and other identities. Toward this goal, students are invited in MyUI to optionally share the names and pronouns they would like their instructors and advisors to use to address them. The University of Iowa prohibits discrimination and harassment against individuals on the basis of race, class, gender, sexual orientation, national origin, and other identity categories set forth in the University's Human Rights policy. For more information, contact the Office of Equal Opportunity and Diversity (https://diversity.uiowa.edu/eod; +1 319 335-0705).

Sexual Harassment

Sexual harassment subverts the mission of the University and threatens the well-being of students, faculty, and staff. All members of the UI community must uphold the UI mission and contribute to a safe environment that enhances learning. Incidents of sexual harassment must be reported immediately. For assistance, please see https://osmrc.uiowa.edu/.

****END OF COURSE SYLLABUS****