This course provides an introduction to the analysis of time-to-event data. Emphasis will be placed upon analyzing real health science data examples using SAS. Topics covered include: estimation of summary survival statistics based upon censored or truncated data employing the Kaplan-Meier procedure, tests of hypothesis for survival curves using the log rank procedure, Cox proportional hazards regression, analysis for censored or truncated data with extensions to time-dependent covariates and model building, inference for parametric regression models / accelerated failure time models.

**Prerequisites:** EPIB 650 *Biostatistics I* and EPIB 651 *Biostatistics II* or permission of instructor.

**Course Learning Objectives:**

Upon completing this course, the student will be able to:

1. Understand and distinguish analytical methods of time-to-event data from other types of measurements.
2. Understand the concepts of censoring and truncation.
3. Describe and calculate basic functions of survival time and understand their relationships.
4. Apply some common parametric survival distributions (e.g., exponential, Weibull, log normal, log logistic, gamma, etc.).
5. Construct likelihood functions for survival data.
7. Conduct nonparametric log-rank tests for comparing survival curves.
8. Use the Cox proportional hazards model to analyze survival data.
9. Assess the fit of the proportional hazards model.
10. Use parametric regression models / accelerated failure time models to analyze survival data.
11. Use SAS to conduct an appropriate survival data analysis.

**Program Competencies Addressed in this Course:**

The following competencies for the *Master of Public Health with concentration in Biostatistics* are addressed in this course:

1. Describe basic concepts of probability, random variables, and commonly used statistical probability distributions.
2. Distinguish among the different measurement scales or types of variables and select appropriate descriptive statistical methods for summarizing public health data.
3. Select appropriate inferential statistical methods to answer research questions relevant to public health research.
4. Conduct descriptive and inferential statistical analyses that are appropriate to different basic study designs used in public health research.
5. Interpret results of statistical analyses found in public health studies.
6. Critically review and summarize statistical analyses presented in public health literature.
7. Use a basic software package to describe, explore, and summarize data as well as perform the basic conventional statistical procedures.
8. Identify limitations in public health studies.
9. Communicate results of statistical analyses to lay and professional audiences.

**Required Texts and Other Readings:**

**Required:**

**Recommended:**

**Course Requirements:**

**Homework:**
There will be nine homework assignments in this class, and each of them will be due at the beginning of the due date class. **Late homework will NOT be accepted without a reasonable and advance notice.** You may discuss the homework problems with other students. **However, the final work you turn in must be your own.**

**Exam:**
Exams will be in class, closed book and closed note. You are allowed to bring ONE letter-size sheet of your summary (both sides) to the midterm exam; and TWO letter-size sheets of summary (both sides) to the final exam. The final exam will be comprehensive. A calculator is required for both exams.

**As a general rule, make-up exams and advance exams will NOT be given.** Exceptions to this rule are evaluated on a case-by-case basis. Students must submit the request before the exam takes place with valid supporting document. No post-exam request will be considered except the student is hospitalized during the exam period.

**Course Website:**
Course announcements, lecture notes, data sets, SAS programs, and homework assignments will be distributed on the ELMS (Enterprise Learning Management System). Please check it on a regular basis. Lecture notes will be posted before class. You may wish to print these notes prior to each lecture and use them as an outline for taking notes during the class. You can access the website by following these directions:
• Direct your URL to [https://myelms.umd.edu/login](https://myelms.umd.edu/login).
• Enter your Directory ID and Password.
• Click “Courses” on the ELMS home tab.
• Click “EPIB653-0101: Applied Survival Data Analysis – Spring 2015”.

Course Policies:

**Email – The Official University Correspondence:**
Verify your email address by going to [www.my.umd.edu](http://www.my.umd.edu).

All enrolled students are provided access to the University’s email system and an email account. *All official University email communication will be sent to this email address* (or an alternate address if provided by the student). Email has been adopted as the primary means for sending official communications to students, so email must be checked on a regular basis. Academic advisors, faculty, and campus administrative offices use email to communicate important and time-sensitive notices.

**Students are responsible for keeping their email address up to date or for redirecting or forwarding email to another address.** Failure to check email, errors in forwarding email, and returned email (from “full mailbox” or “unknown user” errors for example), will not excuse a student from missing University announcement, messages, deadlines, etc. Email addresses can be quickly and easily updated at [http://www.my.umd.edu](http://www.my.umd.edu) or in-person at the Student Service Counter on the first floor of the Mitchell Building.

For technical support for University email: [www.helpdesk.umd.edu](http://www.helpdesk.umd.edu) or call 301-405-1400.

**Absence Policy:**
In accordance with University policy if you are absent for a single (1) lecture due to illness or some form of personal or family emergency, this absence will be considered “excused” and the instructor will accept a note from you attesting to the date of the illness/incident, along with an acknowledgement that the information is true. Whenever feasible, you should try to contact the instructor in advance.

Multiple or prolonged absences, and absences that prevent attendance at a major scheduled grading event (like an exam or test) will require written documentation from an appropriate health care provider/organization.

A link to pull information on the new policy covering absences from class can be found at [http://www.president.umd.edu/policies/v100g.html](http://www.president.umd.edu/policies/v100g.html).

**Course Evaluations:**
The University, the School of Public Health, and the Department of Epidemiology and Statistics are committed to the use of student course evaluations for improving the student experience, course and curriculum delivery, and faculty instruction. Your evaluations help instructors improve their courses; help deans and department chairs decide on merit pay for faculty, renewal of contracts, and support tenure and promotion decisions; and help current and future students decide on classes. Your participation in the evaluation of courses through CourseEvalUM is a responsibility you
hold as a student member of our academic community. Your feedback is confidential and important to the improvement of teaching and learning at the University as well as to the tenure and promotion process. CourseEvalUM will be open for you to complete your evaluations starting about two weeks prior to the last day of the term before exams begin. Please go directly to the website (www.CourseEvalUM.umd.edu) to complete your evaluations. By completing all of your evaluations each semester, you will have the privilege of accessing online evaluation reports for the thousands of courses for which 70% or more students submitted their evaluations. You can access results at www.CourseEvalUM.umd.edu, the same link you use to submit your evaluations. Click View Past Results instead.

Grading Procedures:

Grade of this course will be determined as follows:

- Homework: 30%
- Midterm Exam: 30%
- Final Exam: 40%

Course Outline / Course Calendar:

<table>
<thead>
<tr>
<th>Session Number</th>
<th>Date</th>
<th>Topic(s)</th>
<th>Reading Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>01/28/2015</td>
<td>Introduction; Basic Concepts (I)</td>
<td>Chapters 1 &amp; 2</td>
</tr>
<tr>
<td>2</td>
<td>02/04/2015</td>
<td>Basic Concepts (II); Common Parametric Models for Survival Data; Censoring and Truncation</td>
<td>Chapters 2 &amp; 3 and Sections 4.1 – 4.4 Homework 1 (Due date: 02/11/2015)</td>
</tr>
<tr>
<td>3</td>
<td>02/11/2015</td>
<td>Likelihood Construction; Kaplan-Meier and Nelson-Aalen Estimators for Right-Censored Data (I)</td>
<td>Sections 4.1 – 4.4 and 5.4 Homework 2 (Due date: 02/18/2015)</td>
</tr>
<tr>
<td>4</td>
<td>02/18/2015</td>
<td>Kaplan-Meier and Nelson-Aalen Estimators for Right-Censored Data (II); Estimates of the Mean and Median Survival Time; Cohort Life Table</td>
<td>Sections 4.1 – 4.5, 5.4, 7.1 and 7.3 Homework 3 (Due date: 02/25/2015)</td>
</tr>
<tr>
<td>5</td>
<td>02/25/2015</td>
<td>Test for Two or More Samples</td>
<td>Sections 4.6, 7.1, 7.3 and 7.4 Homework 4 (Due date: 03/04/2015)</td>
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<tr>
<td></td>
<td>Date</td>
<td>Topic</td>
<td>Sections</td>
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</tbody>
</table>
| 6 | 03/04/2015 | Tests for Trend; Stratified Tests                                    | Sections 4.6, 7.4, 7.5, 8.1 and 8.2
Homework 5 (Due date: 03/11/2015) |
| 7 | 03/11/2015 | Estimators of the Survival Function for Left-Truncated and Right-Censored Data; Proportional Hazards Models with Fixed Covariates (I); Review for Midterm Exam | Sections 4.6, 8.1, 8.2, 8.5 and 8.6
Homework 6 (Due date: 04/01/2015) |
| 8 | 03/25/2015 | Midterm Exam                                                          |                                                                          |
| 9 | 04/01/2015 | Proportional Hazards Models with Fixed Covariates (II)                | Sections 8.5 – 8.8, 9.1 and 9.2
Homework 7 (Due date: 04/08/2015) |
| 10| 04/08/2015 | Proportional Hazards Models with Fixed Covariates (III)               | Sections 8.6 – 8.8, 9.1 and 9.2
Homework 8 (Due date: 04/22/2015) |
| 11| 04/15/2015 | Proportional Hazards Models with Time-Dependent Covariates            | Sections 9.2, 9.3 and 11.1 – 11.4                                        |
| 12| 04/22/2015 | Stratified Proportional Hazards Models; Regression Diagnostics (I)     | Sections 11.1 – 11.4
Homework 9 (Due date: 04/29/2015) |
| 13| 04/29/2015 | Regression Diagnostics (II); Inference for Parametric Regression Models / Accelerated Failure Time Models (I) | Sections 11.5, 11.6 and 12.1 – 12.4                                      |
| 14| 05/06/2015 | Inference for Parametric Regression Models / Accelerated Failure Time Models (II); Review for Final Exam | Sections 12.1 – 12.4                                                    |
| 15| 05/15/2015 | Final Exam                                                            |                                                                          |

* This is a tentative schedule, and the actual materials covered in each lecture might not be exactly the same.

**Required Session Outline**

**Session 1**

**01/28/2015**

Topics: Introduction; Basic Concepts (I)

Learning Objectives for Session 1 [Relevant Program Competencies: #1, #2, #3, #8]
- Understand and distinguish analytical methods of time-to-event data from other types of
- Understand the concepts of censoring and truncation.
- Describe and calculate basic functions of survival time and understand their relationships.

Reading: Chapters 1 & 2

<table>
<thead>
<tr>
<th>Session 2</th>
<th>02/04/2015</th>
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</thead>
<tbody>
<tr>
<td>Topics: Basic Concepts (II); Common Parametric Models for Survival Data; Censoring and Truncation</td>
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<tr>
<td>Learning Objectives for Session 2 [Relevant Program Competencies: #1, #2, #3, #6, #8]</td>
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<tr>
<td>- Understand and distinguish analytical methods of time-to-event data from other types of measurements.</td>
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<td>- Describe and calculate basic functions of survival time and understand their relationships.</td>
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<tr>
<td>- Apply some common parametric survival distributions (e.g., exponential, Weibull, log normal, log logistic, gamma, etc.).</td>
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<tr>
<td>Reading: Chapters 2 &amp; 3 and Sections 4.1 – 4.4</td>
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<tr>
<td>Homework 1 (Due date: 02/11/2015)</td>
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<tr>
<th>Session 3</th>
<th>02/11/2015</th>
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<tbody>
<tr>
<td>Topics: Likelihood Construction; Kaplan-Meier and Nelson-Aalen Estimators for Right-Censored Data (I)</td>
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<tr>
<td>Learning Objectives for Session 3 [Relevant Program Competencies: #3, #4, #5]</td>
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<tr>
<td>- Construct likelihood functions for survival data.</td>
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<tr>
<td>- Obtain and interpret Kaplan-Meier and Nelson-Aalen estimators.</td>
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<tr>
<td>Reading: Sections 4.1 – 4.4 and 5.4</td>
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<tr>
<td>Homework 2 (Due date: 02/18/2015)</td>
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<table>
<thead>
<tr>
<th>Session 4</th>
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<tbody>
<tr>
<td>Topics: Kaplan-Meier and Nelson-Aalen Estimators for Right-Censored Data (II); Estimates of the Mean and Median Survival Time; Cohort Life Table</td>
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</tr>
<tr>
<td>Learning Objectives for Session 4 [Relevant Program Competencies: #2, #3, #4, #5, #6, #7, #9]</td>
<td></td>
</tr>
<tr>
<td>- Obtain and interpret Kaplan-Meier and Nelson-Aalen estimators.</td>
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<tr>
<td>- Use SAS to conduct an appropriate survival data analysis.</td>
<td></td>
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<tr>
<td>Reading: Sections 4.1 – 4.5, 5.4, 7.1 and 7.3</td>
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<td>Homework 3 (Due date: 02/25/2015)</td>
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<thead>
<tr>
<th>Session 5</th>
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<tbody>
<tr>
<td>Topic: Test for Two or More Samples</td>
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<tr>
<td>Learning Objectives for Session 4 [Relevant Program Competencies: #3, #4, #5, #7]</td>
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<tr>
<td>- Conduct nonparametric log-rank tests for comparing survival curves.</td>
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<td></td>
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<tr>
<td>Reading: Sections 4.6, 7.1, 7.3 and 7.4</td>
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<tr>
<td>Homework 4 (Due date: 03/04/2015)</td>
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<table>
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<tr>
<th>Session 6</th>
<th>03/04/2015</th>
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<tbody>
<tr>
<td>Topics: Tests for Trend; Stratified Tests</td>
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<tr>
<td>Learning Objectives for Session 6 [Relevant Program Competencies: #3, #4, #5, #7]</td>
<td></td>
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<tr>
<td>- Conduct nonparametric log-rank tests for comparing survival curves.</td>
<td></td>
</tr>
<tr>
<td>- Use SAS to conduct an appropriate survival data analysis.</td>
<td></td>
</tr>
</tbody>
</table>
## Session 7  (Due date: 03/11/2015)

**Topics:** Estimators of the Survival Function for Left-Truncated and Right-Censored Data; Proportional Hazards Models with Fixed Covariates (I); Review for Midterm Exam

**Learning Objectives for Session 7** [Relevant Program Competencies: #2, #3, #4, #5, #6, #7]
- Understand the concepts of censoring and truncation.
- Describe and calculate basic functions of survival time and understand their relationships.
- Obtain and interpret Kaplan-Meier and Nelson-Aalen estimators.
- Use the Cox proportional hazards model to analyze survival data.
- Use SAS to conduct an appropriate survival data analysis.

**Reading:** Sections 4.6, 8.1, 8.2, 8.5 and 8.6

**Homework 6** (Due date: 04/01/2015)

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## Session 8  (Due date: 03/25/2015)

**Midterm Exam**

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## Session 9  (Due date: 04/01/2015)

**Topic:** Proportional Hazards Models with Fixed Covariates (II)

**Learning Objective for Session 9** [Relevant Program Competencies: #3, #4, #5, #7, #9]
- Use the Cox proportional hazards model to analyze survival data.
- Use SAS to conduct an appropriate survival data analysis.

**Reading:** Sections 8.5 – 8.8, 9.1 and 9.2

**Homework 7** (Due date: 04/08/2015)

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## Session 10  (Due date: 04/15/2015)

**Topic:** Proportional Hazards Models with Fixed Covariates (III)

**Learning Objective for Session 10** [Relevant Program Competencies: #3, #4, #5, #7, #9]
- Use the Cox proportional hazards model to analyze survival data.
- Use SAS to conduct an appropriate survival data analysis.

**Reading:** Sections 8.6 – 8.8, 9.1 and 9.2

**Homework 8** (Due date: 04/22/2015)

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## Session 11  (Due date: 04/22/2015)

**Topic:** Proportional Hazards Models with Time-Dependent Covariates

**Learning Objectives for Session 11** [Relevant Program Competencies: #3, #4, #5, #7, #9]
- Use the Cox proportional hazards model to analyze survival data.
- Use SAS to conduct an appropriate survival data analysis.

**Reading:** Sections 9.2, 9.3 and 11.1 – 11.4

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## Session 12  (Due date: 05/06/2015)

**Topics:** Stratified Proportional Hazards Models; Regression Diagnostics (I)

**Learning Objective for Session 9** [Relevant Program Competencies: #3, #4, #5, #6, #7, #9]
- Use the Cox proportional hazards model to analyze survival data.
- Assess the fit of the proportional hazards model.
- Use SAS to conduct an appropriate survival data analysis.

**Reading:** Sections 11.1 – 11.4
### Session 13
**Date:** 04/29/2015

**Topic:** Regression Diagnostics (II); Inference for Parametric Regression Models / Accelerated Failure Time Models (I)

**Learning Objective for Session 13** [Relevant Program Competencies: #3, #4, #5, #6, #7]
- Use the Cox proportional hazards model to analyze survival data.
- Assess the fit of the proportional hazards model.
- Use SAS to conduct an appropriate survival data analysis.

**Reading:** Sections 11.5, 11.6 and 12.1 – 12.4

### Session 14
**Date:** 05/06/2015

**Topic:** Inference for Parametric Regression Models / Accelerated Failure Time Models (II); Review for Final Exam

**Learning Objective for Session 14** [Relevant Program Competencies: #3, #4, #5, #6, #7, #9]
- Use parametric regression models / accelerated failure time models to analyze survival data.
- Use SAS to conduct an appropriate survival data analysis.

**Reading:** Sections 12.1 – 12.4

### Session 15
**Date:** 05/15/2015

**Final Exam**

<table>
<thead>
<tr>
<th>Assessment Activity</th>
<th>Learning Objectives Assessed with the Activity</th>
<th>Relevant Program Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework 1</td>
<td>#1, #2, #3, #4</td>
<td>#1, #2, #3</td>
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<tr>
<td>Homework 2</td>
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<td>Homework 5</td>
<td>#7, #11</td>
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<td>Homework 6</td>
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<tr>
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<td>Homework 8</td>
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<td>#3, #4, #5, #7</td>
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<td>Homework 9</td>
<td>#8, #9, #11</td>
<td>#3, #4, #5, #7</td>
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<tr>
<td>Midterm Exam</td>
<td>#1, #2, #3, #4, #5, #6, #7, #11</td>
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<tr>
<td>Final Exam</td>
<td>#1, #2, #3, #4, #5, #6, #7, #8, #9, #11</td>
<td>#1, #2, #3, #4, #5, #7</td>
</tr>
</tbody>
</table>
Critical University Policies:

Religious Observances:
The University System of Maryland policy provides that students should not be penalized because of observances of their religious beliefs; students shall be given an opportunity, whenever feasible, to make up within a reasonable time any academic assignment that is missed due to individual participation in religious observances. **It is the student’s responsibility to inform the instructor in advance of any intended absences for religious observance.**

Special Accommodations / Disability Support Services:
If you have a documented disability and wish to discuss academic accommodations for test taking or other needs, you will need documentation from Disability Support Service (301-314-7682). If you are ill or encountering personal difficulties, please let the instructor know as soon as possible. You can also contact Learning Assistance Services (301-314-7693) and/or the Counseling Center (301-314-7651) for assistance.

Academic Integrity:
The University’s code of academic integrity is designed to ensure that the principle of academic honesty is upheld. Any of the following acts, when committed by a student, constitutes academic dishonesty:

- **CHEATING**: intentionally using or attempting to use unauthorized materials, information, or study aids in an academic exercise.
- **FABRICATION**: intentional and unauthorized falsification or invention of any information or citation in an academic exercise.
- **FACILITATING ACADEMIC DISHONESTY**: intentionally or knowingly helping or attempting to help another to violate any provision of this code.
- **PLAGIARISM**: intentionally or knowingly representing the words or ideas of another as one's own in any academic exercise.

For more information see: [http://www.shc.umd.edu/code.html](http://www.shc.umd.edu/code.html).

The Honor Pledge is a statement undergraduate and graduate students should be asked to write by hand and sign on examinations, papers, or other academic assignments. The Pledge reads:

*I pledge on my honor that I have not given or received any unauthorized assistance on this assignment/examination.*

The University of Maryland, College Park has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity or the Student Honor Council, please visit [http://www.shc.umd.edu](http://www.shc.umd.edu).

Inclement Weather / University Closings:
In the event that the University is closed for an emergency or extended period of time, the instructor will communicate to students regarding schedule adjustments, including rescheduling of examinations and assignments due to inclement weather and campus emergencies. Official closures and delays are announced on the campus website (http://www.umd.edu) and snow phone line (301-405-SNOW), as well as local radio and TV stations.