If he was less annoying in regard to his classmates, he was more so in his classrooms. He had learned from Gottlieb the trick of using the word "control" in reference to the person or animal or chemical left untreated during an experiment, as a standard for comparison: and there is no trick more infuriating. When a physician boasted of his success with this drug or that electric cabinet, Gottlieb always snorted, "Where was your control? How many cases did you have under identical conditions, and how many of them did not get the treatment?" Now Martin began to mouth it -- control, control, control, where's your control? -- till most of his fellows and a few of his instructors desired to lynch him.

*Arrowsmith* (1925) by Sinclair Lewis, first American to win the Nobel Prize for literature.

**COURSE GOALS:** Understanding and application of the linear regression model. This tool is essential in the study of relationships between two or more economic variables, testing hypothesis of economic behavior and forecasting economic outcomes. Economics and econometrics, unlike most sciences and statistics, is characterized by the unavailability of
controlled environments and repeated experimentation. Consequently, it is that much trickier to discover or test causal relationships, to measure the effects of a particular economic policy or an economic control on economic states, and other similar thought experiments. Econometrics not only provides adequate statistical methods but also clever solutions to overcome many of these obstacles.

**PRE-REQUISITES:** Statistics 13, Math 16A-16B, Econ 100 or 104, and 101 or 105. 102 highly recommended.

Statistics 13 is the most important. Algebra (though not matrix algebra) and some calculus are extensively used. Problem sets will require use of the computer, but no previous experience is assumed.


**COMPUTER SOFTWARE:** EViews. You can purchase the student version at the bookstore. This is NOT required, however. The computer sessions should provide you with enough time to complete the assignments. It is to your benefit (convenience, personal growth, consulting, …) to own your copy.

**ADDITIONAL RESOURCES:** Check the class web page for additional materials such as formula sheet, a brief overview of EViews, interesting web sites for econometricians, etc.

**COMPLEMENTARY LITERATURE:** (these books are on reserve at the library)

- R. J. Larsen and M. L. Marx, *An Introduction to Mathematical Statistics and its Applications*, Prentice Hall. This is an excellent text to review in more depth the statistical concepts presented in class and beyond. This is an undergraduate text, therefore very accessible.
- A. Spanos, *Statistical Foundations of Econometric Modelling*, Cambridge. This is a more advanced book than Larsen and Marx. However, it contains proofs and topics in great detail.
- R. Ramanathan, *Introductory Econometrics with Applications*, Dryden. It is very well written and gives a great number of useful examples. A little hard to navigate.
- W. Greene, *Econometric Analysis*, Prentice Hall. This is an advanced text. In addition to the topics we will cover in class, it contains a number of additional topics that give you a flavor of the discipline. A good resource book.

**COMPUTER ASSIGNMENTS:** Homework problems that require the computer will use the software program EViews (already installed in the computer lab). I will teach a lab session illustrating how the assignments can be completed. Check the lab schedule to
plan times when you can complete your assignment. The day before assignments are due, the T.A. will be available during lab hours to address any lingering questions.

**COURSE GRADING:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework (4/5)</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>Midterms (2)</td>
<td>35%</td>
<td>Tuesday, February 5</td>
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<td>Thursday, February 28</td>
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<tr>
<td>Final</td>
<td>35%</td>
<td>Thursday, March 21, 1:30-3:30</td>
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<tr>
<td>(Comprehensive)</td>
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Homework must be handed on time. There is no credit for late homework. Please contact the T.A. at your convenience if you need special arrangements and rescheduling for midterms and final. All requests must be made by January 17. Make-up exams are not permitted. Consult the web schedule for more details on homework due dates.

**REGRADE POLICY:**

I do not engage in grade bargaining. I try to apply the same standard to everyone, which makes special considerations unfair to your peers. If you feel a question was unfairly graded or there was a mistake, *please submit it in writing* to your T.A. no later than a week after the exam. This allows your T.A. to go over the exam carefully and give your queries due consideration.

**CALENDAR**

**January**

- Wednesday, 9: LAB Instruction
- Wednesday, 16: LAB Assistance
- Thursday, 17: Assignment 1 Due

- Monday, 21: Holiday

- Wednesday, 23: LAB Instruction
- Wednesday, 30: LAB Assistance
- Thursday, 31: Assignment 2 Due
February

Tuesday, 5: Midterm 1

Wednesday, 6: LAB Instruction
Wednesday, 13: LAB Assistance
Thursday, 14: Assignment 3 Due

Monday, 18: Holiday

Wednesday, 20: LAB Instruction
Wednesday, 27: LAB Assistance
Thursday, 28: Assignment 4 Due and Midterm 2.

March

Wednesday, 6: LAB Instruction
Wednesday, 13: LAB Assistance
Thursday, 14: Assignment 5 Due – Last day of classes

Thursday, 21: FINAL EXAM. 1:30 – 3:30

COURSE OUTLINE:

I. STATISTICAL TOOLS FOR ECONOMETRICIANS

1. RANDOM VARIABLES
   
   i. DISCRETE
   ii. CONTINUOUS

2. UNIVARIATE PROBABILITY DENSITY FUNCTIONS
   
   i. DISCRETE PDF AND CDF
   ii. CONTINUOUS PDF AND CDF

3. MULTIVARIATE PROBABILITY DENSITY FUNCTIONS
   
   i. THE JOINT DISTRIBUTION
   ii. THE MARGINAL DISTRIBUTION
   iii. THE CONDITIONAL DISTRIBUTION
   iv. INDEPENDENCE
4. **MOMENTS OF PROBABILITY DISTRIBUTIONS**
   i. **UNIVARIATE**
      a. Population Mean, Median, and Mode
      b. Population Variance
   ii. **MULTIVARIATE**
      a. Conditional Mean
      b. Covariance
      c. Correlation

5. **COMMON DISTRIBUTION FUNCTIONS**
   i. The Normal and the Standard Normal
   ii. The $\chi^2$ Distribution
   iii. The T-Distribution
   iv. The F-Distribution

6. **POPULATIONS, SAMPLES, STATISTICS AND ESTIMATION**
   i. Populations versus Samples
   ii. Moments versus Sample Statistics
   iii. Properties of Estimators
      a. Unbiasedness
      b. Efficiency

7. **HYPOTHESIS TESTING**
   i. Elements of a Test
   ii. Testing the Mean

II. **TWO VARIABLE REGRESSION MODEL**
1. **MODEL ASSUMPTIONS**
   i. Linearity
   ii. Homoscedasticity
   iii. Independence
   iv. Regressor Variation
   v. Normality
   vi. Residual Independence

2. **ESTIMATION**
i. METHOD OF MOMENTS
ii. LEAST SQUARES

3. PROPERTIES OF OLS ESTIMATORS
   i. UNBIASEDNESS
   ii. EFFICIENCY
   iii. GAUSS-MARKOV THEOREM

4. HYPOTHESIS TESTING
   i. CONFIDENCE INTERVALS
   ii. ONE-TAIL TESTS
   iii. TWO-TAIL TESTS

5. GOODNESS OF FIT - THE R²

6. PREDICTION

7. VARIABLE TRANSFORMATIONS
   i. CHANGES OF SCALE
   ii. CHANGES OF ORIGIN
   iii. FUNCTIONAL FORMS

III. MULTIPLE LINEAR REGRESSION MODEL

1. THE MODEL AND ADDITIONAL ASSUMPTIONS
2. ESTIMATION
3. HYPOTHESIS TESTING
   i. JOINT HYPOTHESIS TESTING
      a. SIGNIFICANCE OF SUBSETS OF REGRESSORS
      b. OVERALL SIGNIFICANCE TESTS
      c. TESTS OF LINEAR COMBINATIONS OF PARAMETERS

4. GOODNESS OF FIT
   i. THE R² AND THE ADJUSTED R²
   ii. MODEL SELECTION

5. PREDICTION
   i. POINT FORECASTS
   ii. CONDITIONAL MEAN FORECASTS

6. SPECIFICATION ERRORS
i. OMITTED VARIABLES
ii. IRRELEVANT VARIABLES
iii. MULTICOLLINEARITY

IV. EXTENSIONS

1. DUMMY VARIABLES
   i. MULTIPLE DUMMY VARIABLES IN REGRESSION
   ii. INTERACTIVE DUMMY VARIABLES

2. HETEROSCEDASTICITY
   i. DETECTION
   ii. SOLUTIONS

3. THE MULTIPLE REGRESSION MODEL IN MATRIX NOTATION

4. MAXIMUM LIKELIHOOD ESTIMATION