

## Quantitative Investment Management

**Course Description.** The rapid growth in financial technology over the past three decades, and the parallel growth in computational power and the Internet as a distribution channel, has had profound implications for financial investments. This course covers the most important innovations in quantitative investment management within an integrative framework in which individual financial planning, corporate financial strategy, risk management, and proprietary trading can be analyzed quantitatively and implemented efficiently. The course contents are loosely divided into the four sectors of the economy that comprise the domain of financial technology (see the flowchart on page 3): (1) the household sector; (2) the nonfinancial corporate sector; (3) the financial intermediaries sector; and (4) the capital markets sector. We will develop the most important ideas of modern investment analysis in the context of sector-specific applications, e.g., elicitation of risk preferences and retirement planning in the household sector, corporate and financial risk management in the nonfinancial corporate sector, asset allocation and stock selection in the financial intermediaries sector, and trading technology and transactions costs control in the capital markets sector. We will also examine several non-standard approaches to financial analysis, e.g., chaos theory, neural networks, and technical analysis.

Each topic will be motivated by specific industry-driven issues in the investment process, and lectures and group projects will develop in detail the key analytical tools that comprise modern investment technology. These tools include: (1) portfolio optimization; (2) Monte Carlo simulation; and (3) financial econometrics. Each of these techniques will be covered in some depth—along with its implementation on PC's and various Internet platforms—however, the emphasis will be on financial *applications*, not on methodology. To ensure that the focus of the course is properly directed towards the practical application of these quantitative methods, the material will be presented in a unique way: the entire course will be devoted to solving successively more complex versions of a single problem: how should a rational investor decide to allocate his wealth among a collection of risky investments? By starting with a relatively simple static version of this problem (basic portfolio theory), and then adding more realistic features incrementally (dynamics, trading costs, securities with nonlinear payoffs, etc.), the motivation for each quantitative method will become apparent before the method is introduced.

**Course Materials.** The following materials will be used in this course (required texts are indicated by asterisks):

- Lo\*, 2004, *15.408 Lecture Notes*, MIT Graphic Arts.
- Bodie, Kane, and Marcus\*, 2001, *Investments* (5<sup>th</sup> Edition), Irwin McGraw.
- Bernstein, 1993, *Capital Ideas*, Free Press.
- Bernstein, 1996, *Against The Gods*, John Wiley & Sons.

**Prerequisites.** This course is intended primarily for graduate students participating in the Sloan/EECS Financial Technology Option (FTO), hence the prerequisites include 15.407 and the other requirements of the FTO curriculum. Some basic computer literacy will be assumed—projects will make use of standard web browsers, Excel, and Matlab (though prior exposure to these languages is not expected). Students without these prerequisites may enroll only with the permission of the instructor.

**Course Requirements and Grading.** Course requirements include: regular attendance and class preparation/participation in lectures and recitations (10 percent), three group projects (25 percent), a mid-term (25 percent) and a final (40 percent) examination. *The closed-book mid-term examination will be given during the first half of class on Tuesday April 13<sup>th</sup>, and the closed-book final examination will be given during the MIT-scheduled final examination date—please reserve these dates immediately and schedule your interviews and travel plans accordingly.*

**Class Preparation and Participation.** Class preparation and participation are important components of this course. Students are expected to come to each class well prepared to discuss the materials assigned (see the attached *15.408 Schedule of Classes and Assignments*). Assignments marked “Review” refer to material already covered in one of the prerequisites such as 15.407—students without such prerequisites should read this material thoroughly. Assignments marked “Read” should be read thoroughly with the expectation that it will be required for class discussion. In addition, there may be short assignments distributed in each class for discussion during the following class. Such assignments are to be treated like “case-study” assignments that require considerable advance preparation, and students should expect to be “cold-called” in class to present the results of their analyses.

**Group Projects.** There are three group projects that will provide students with additional opportunities to apply the methods covered in the lectures to new investment problems. Each project covers a broad application area and involves both quantitative analysis and industry research. Students will be assigned to project groups based on computer skills, industry experience, etc. so that each group will have a good balance of quantitative expertise and institutional background. The three projects and their distribution and due dates are:

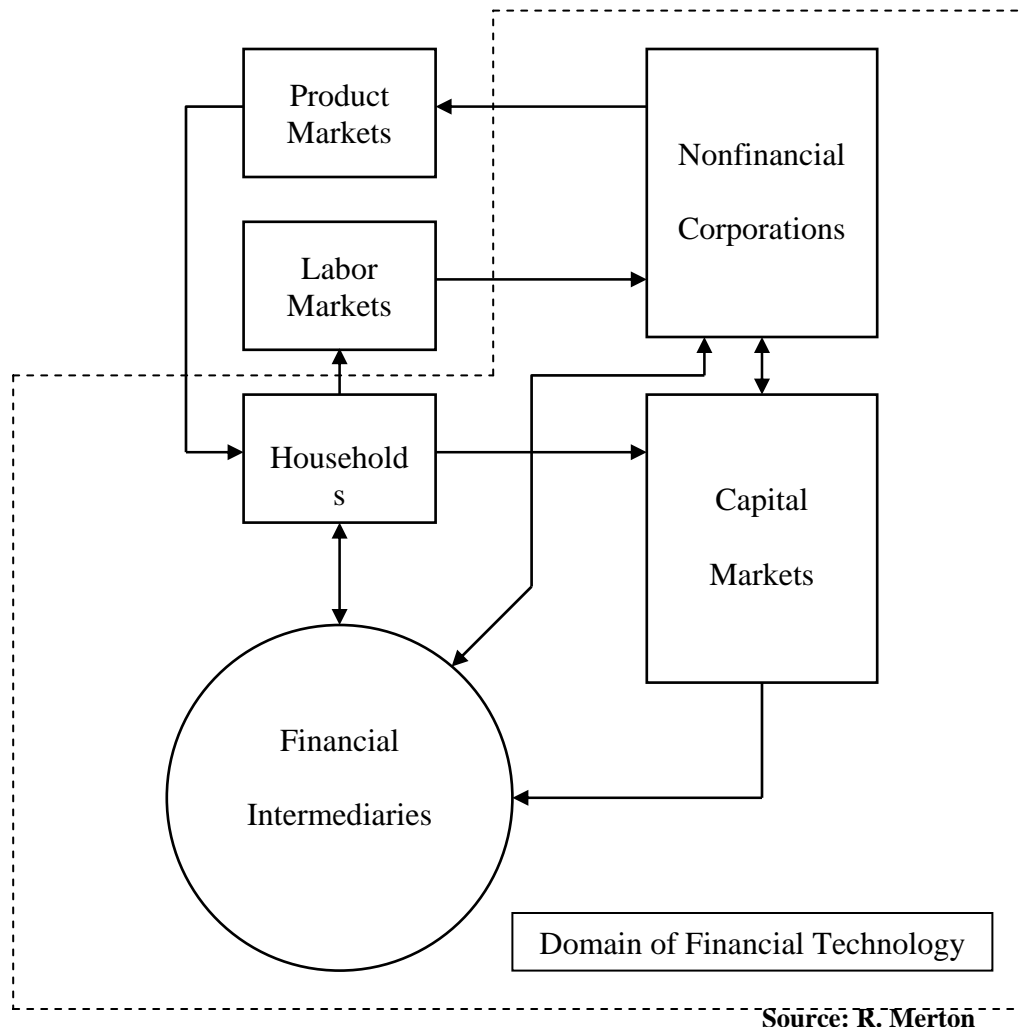
<u>Project</u>	<u>Topic</u>	<u>Distributed</u>	<u>Due</u>
A	Risk Preferences and Life-Cycle Investing	February 3	March 2
B	Corporate and Financial Risk Management	March 2	March 30
C	Portfolio Management and Trading Technology	March 30	May 4

*Projects are due at the start of class on the due date. Projects submitted after the due date will be subject to a 25% grade-deduction for each day they are late. There will be no exceptions to this policy, so please plan your interview and travel schedules accordingly.*

**Other Resources.** If you are planning for a career in the investments area, there are several additional resources that you should keep in mind:

- Association of Investment Management Research (AIMR, [www.aimr.org](http://www.aimr.org))
- International Association of Financial Engineers (IAFE, [www.iafe.org](http://www.iafe.org))
- Securities Training Corporation (STC, [www.stcusa.com](http://www.stcusa.com))
- *Financial Analysts Journal*
- *Journal of Portfolio Management*
- *Pensions and Investments*
- *RISK*

**Non-Disclosure Agreements.** If you register for this course, you will be required to submit project reports, examinations, and other written materials. If you fail to submit any of these required materials for any reason other than documented incapacitating medical conditions, you will receive no credit for such materials in the computation of your course grade. Any conflicts arising from non-disclosure and patent-assignment agreements that you have signed will be your responsibility to manage, and no special dispensations will be granted to any student in such circumstances.



## 15.408 Schedule of Classes and Assignments

<b>Class 1a: Course Overview, and Mathematical Preliminaries</b> <ul style="list-style-type: none"><li>• Read course syllabus thoroughly</li><li>• Read Merton (2003)</li><li>• Read Bodie, Kane, and Marcus (BKM) Chapters 1–5</li><li>• Review BKM Appendix A.1–A.2</li><li>• Project A distributed (due Tuesday March 2<sup>nd</sup>)</li></ul>	<b>T: February 3</b>
<b>Class 1b: Household Preferences For Risk and Expected Return</b> <ul style="list-style-type: none"><li>• Read BKM Chapters 6–8</li><li>• Read Kahneman and Tversky (1982), Bodie (2003)</li></ul>	
<b>Class 2a: Life-Cycle Investing and Risks in the Long Run</b> <ul style="list-style-type: none"><li>• Read Bodie (1995), Bodie and Crane (1997)</li><li>• See BKM Chapter 26</li></ul>	<b>T: February 10</b>
<b>Class 2b: Market Equilibrium and the Informational Role of Prices</b> <ul style="list-style-type: none"><li>• Read BKM Chapters 9-10</li></ul>	
<b>No Class: Monday Schedule</b>	<b>T: February 17</b>
<b>Class 3a: Market Efficiency, Part I (Trading Lab)</b> <ul style="list-style-type: none"><li>• Read BKM Chapter 12-13</li><li>• Prepare CRL trading exercise</li></ul>	<b>T: February 24</b>
<b>Class 3b: Market Efficiency, Part II</b> <ul style="list-style-type: none"><li>• Read Farmer and Lo (1999)</li></ul>	
<b>Class 4a: Corporate Preferences For Risk and Expected Return</b> <ul style="list-style-type: none"><li>• Read Finnerty (1988, 1992), Tufano (1996)</li></ul>	<b>T: March 2</b>
<b>Class 4b: Risk Management</b> <ul style="list-style-type: none"><li>• Read Lo (1999)</li><li>• Project A due, Project B distributed (due Tuesday March 30<sup>th</sup>)</li></ul>	
<b>Class 5a: Financial Intermediation</b> <ul style="list-style-type: none"><li>• Read Mishkin (2000) Chapters 1–3</li></ul>	<b>T: March 9</b>
<b>Class 5b: Introduction to Asset Management</b> <ul style="list-style-type: none"><li>• Read BKM Chapters 26</li><li>• Read Ambachtsheer (1994)</li></ul>	
<b>SIP Week (please attend “Risk Management for Hedge Funds”)</b>	<b>March 15–19</b>
<b>Spring Break</b>	<b>March 22–26</b>

- Class 6a: The CAPM and APT, Part 1: Theory and Evidence** **T: March 30**
- Read BKM Chapters 9–13
  - Read Black (1993)
  - Project B due, Project C distributed (due Tuesday May 4<sup>th</sup>)
- Class 6b: The CAPM and APT, Part 2: Current Trends**
- Read Jagannathan and McGratten (1995)
- Class 7a: Security Analysis and Stock Selection** **T: April 6**
- Read BKM Chapters 17–19, 27
  - Read Treynor and Black (1973)
- Class 7b: Asset Allocation**
- Review BKM Chapter 6–8, 26
  - Read Samuelson (1990)
- In-Class Mid-Term Examination** **T: April 13**
- Class 8: Introduction to Fixed Income Securities**
- Read BKM Chapter 14
- Patriot’s Day: No Class** **T: April 20**
- Class 9a: Basic Fixed-Income Analytics** **T: April 27**
- Read BKM Chapter 15–16
- Class 9b: Models of the Yield Curve**
- Read Yan (2001)
- Class 10a: Introduction to Credit-Sensitive Securities** **T: May 4**
- Review BKM Chapter 16
  - Project C due
- Class 10b: Models of Credit and Default**
- Read Carty (2000), Kao (2000)
- Class 11a: Technical Analysis, Neural Networks, and Fringe Finance** **T: May 11**
- Read Pruitt and White (1988), Lo (1994a,b), Lo, Mamaysky, and Wang (2000)
- Class 11b: Course Summary and Future Trends**
- Review lecture notes

## 15.408 Readings

1. Ambachtsheer, K., 1994, "The Economics of Pension Fund Management," *Financial Analysts Journal* 50, 21–31.
2. Black, F., 1993, "Beta and Return," *Journal of Portfolio Management* 20, 8–18.
3. Bodie, Z., 1995, "On the Risk of Stocks in the Long Run," *Financial Analysts Journal* 52, 18–22.
4. Bodie, Z., 2003, "Thoughts on the Future: Life-Cycle Investing in Theory and Practice", *Financial Analysts Journal* 59, 24–29.
5. Bodie, Z. and D. Crane, 1997, "Personal Investing: Advice, Theory, and Evidence," *Journal of Portfolio Management* 53, 13–23.
6. Bookstaber, R., 1999, "A Framework for Understanding Market Crisis," in *Risk Management: Principles and Practices, AIMR Conference Proceedings*, Charlottesville, VA: Association for Investment Management and Research 3, 7-19.
7. Bookstaber, R., 2000, "Understanding and Monitoring the Liquidity Crisis Cycle," *Financial Analysts Journal* 56, 17-22.
8. Carty, L., 2000, "Corporate Credit-Risk Dynamics," *Financial Analysts Journal* 56, 67–81.
9. Farmer, D. and A. Lo, 1999, "Frontiers of Finance: Evolution and Efficient Markets," *Proceedings of the National Academy of Sciences* 96, 9991–9992.
10. Finnerty, J., 1988, "Financial Engineering in Corporate Finance: An Overview," *Financial Management* 17, 14–33.
11. Finnerty, J., 1992, "An Overview of Corporate Securities Innovation," *Journal of Applied Corporate Finance* 4, 23–39.
12. Jagannathan, R. and E. McGrattan, 1995, "The CAPM Debate," *Federal Reserve Bank of Minneapolis Quarterly Review* 19, 2–17.
13. Kahneman, D. and A. Tversky, 1982, "The Psychology of Preferences," *Scientific American* 246, 160–173.
14. Kao, D., 2000, "Estimating and Pricing Credit Risk: An Overview," *Financial Analysts Journal* 56, 50–66.
15. Lo, A., 1994, "Data-Snooping Biases in Financial Analysis," in H. Russell Fogler, ed.: *Blending Quantitative and Traditional Equity Analysis*. Charlottesville, VA: Association for Investment Management and Research, 59–66.
16. Lo, A., 1994, "Neural Networks and Other Nonparametric Techniques in Economics and Finance," in H. Russell Fogler, ed.: *Blending Quantitative and Traditional Equity Analysis*. Charlottesville, VA: Association for Investment Management and Research, 25–36.

17. Lo, A., 1999, "The Three P's of Total Risk Management," *Financial Analysts Journal* 55, 13–26.
18. Lo, A., Mamaysky, H. and J. Wang, 2000, "Foundations of Technical Analysis: Computational Algorithms, Statistical Inference, and Empirical Implementation," *Journal of Finance* 55, 1705–1765.
19. Merton, R., 2003, "Thoughts on the Future: Theory and Practice in Investment Management", *Financial Analysts Journal* 59, 17–23.
20. Merton, R., 1994, "Influence of Mathematical Models in Finance on Practice: Past, Present, and Future," *Philosophical Transactions of the Royal Society of London A* 347, 451–463.
21. Mishkin, F., 2000, *The Economics of Money, Banking, and Financial Markets*, 6<sup>th</sup> Edition, Reading, MA: Addison Wesley Longman. (Chapters 1-3), 3-63.
22. Pruitt, S. and R. White, 1988, "The CRISMA Trading System: Who Says Technical Analysis Can't Beat the Market?" *Journal of Portfolio Management* Spring, 55–58.
23. Samuelson, P., 1990, "Asset Allocation Could Be Dangerous to Your Health," *Journal of Portfolio Management* Spring, 5–8.
24. Tufano, P., 1996, "Who Manages Risk? An Empirical Examination of Risk Management Practices in the Gold Mining Industry," *Journal of Finance* 51, 1097–1137.
25. Treynor, J. and F. Black, 1973, "How to Use Security Analysis to Improve Portfolio Selection," *Journal of Business* 46, 66-86.
26. Yan, Y., 2001, "Dynamic Models of the Term Structure," *Financial Analysts Journal* 57, 60–76.