MFIN 706
Computational Finance

DeGroote School of Business
McMaster University

COURSE OBJECTIVE

The objective of MFIN 706 is to introduce key computational methods and practical resources that are widely used in contemporary finance professions. The coursework focuses on hands-on data analysis applications and coding. Additionally, the students gain perspectives on the latest developments in the Fintech sector.

INSTRUCTOR AND CONTACT INFORMATION

Instructor Name: Mehmet Beceren, Ph.D.

Email: becerenm@mcmaster.ca

Office Hours: TBA

TA: Michael Milewski milewsmr@mcmaster.ca

COURSE DESCRIPTION

Method and Scope: The course is designed to guide the students through a set of practical problems and projects that are done on a computer programming environment. There is no requirement for prior coding experience, however students are expected to dedicate time to build programming and data analysis skills throughout the term. Mathematical and financial concepts will be briefly discussed and explained in class. Then, related programming and data resources will be presented.

The key learning method will be hands-on work with data analysis and coding tools. Students are expected to employ computational resources to deliver solutions to selected problems in areas such as risk analysis, portfolio construction, strategy back-testing, optimization, derivative pricing and scenario simulation. There will be weekly assignments and a term project.

Students are also expected to raise their level of knowledge on recent developments in global financial markets. It is important for the Master of Finance students to develop a background on the policy, political economy and market developments.

Quantitative methods become more powerful when they are combined with the understanding of the qualitative (social, political historical etc.) context.

COURSE DESCRIPTION

Topics of study will cover common quantitative methods used in portfolio construction, iterative optimization, numerical simulation methods, measures of risk, derivative pricing, option trading, factor-based risk models, quantitative strategy back-testing, yield curve fitting, interest rate models, and credit risk models, along with selected topics from machine learning algorithms, Robo-Advisory infrastructure and Asset-Liability Management practices. The lectures will also touch on recent developments in Fintech sector.

This course is designed to improve applied quantitative skills of students. Open-source coding will be the primary tool of learning. The focus will be to develop data analysis and programming capabilities. MFIN 706 students will have an opportunity to use their theoretical knowledge and computer skills to work on various projects.

Timely, neat, and coherent work will be rewarded in a 'business-like' setting. Untidy, unclear, and delayed delivery will not be accommodated.

The main programming tools will be **R – RStudio (primary) and Python – Jupyter Notebooks (secondary)**.

R programming language provides a free, open-source development environment with many powerful tools. MS Excel will also be handy. Bloomberg and Refinitiv (if available) will be used as data sources, and market information platform. An account for Wharton Research Database (WRDS) through the library will be set up to access historical financial data as well.

Additionally, current developments in global financial markets and topical business cases will be mentioned and discussed during lectures.

COURSE MATERIALS AND READINGS

There is no required textbook.

Suggested reference text books are as follows.

- **R Programming and Its Applications in Financial Mathematics** *by Shuich Ohsaki, J. Ruppert-Felsot, D. Yoshikawa, CRC Press, 2018*
- **Computational Finance – An Introductory Course with R**, *by Argimiro Arratia, Atlantis Press*
- **Active Portfolio Management**, *by Richard Grinold and Ronald Kahn, MaGraw Hill*
- **An Introduction to Statistical Learning with Applications in R**, *by Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani*
- **Handbook of Financial Risk Management**, *by N.H Chan, H.Y. Wong*
- **Python for Finance Cookbook,** *by Eryk Lewinson, 2020*
- **Mastering Pandas for Finance,** *by Michael Heydt, 2015*

- **Financial Risk Management and Financial Institutions** *by John C. Hull, John Wiley & Sons*

EVALUATION

Weekly 7 Assignments *(with different weightings according to difficulty level)*	**65%**
Term Project	**35%**
Total	**100%**

Missed tests/exams not approved by the MFIN Program Office will receive a grade of zero. Late assignments will be penalized 50% for each day they are late. Your final grade will be calculated as follows:

www.mcmaster.ca/policy/Students-AcademicStudies/UndergraduateExaminationsPolicy.pdf

Grade Conversion

At the end of the course your overall percentage grade will be converted to your letter grade in accordance with the following conversion scheme:

Letter Grade	Percent	Points
A+	90-100	12
A	85-89	11
A-	80-84	10
B+	75-79	9
B	70-74	8
B-	60-69	7
F	00-59	0

Approximate Course Program:

Broad Topic and Week	Specific Topics of Discussion
Week # 1 **Introduction: Computational Applications, Course Logistics, Fintech Overview, Simple Numerical Simulations**	Programming and Data Logistics: RStudio IDE tips and examples, Python/Anaconda/Spyder/ Jupyter Notebooks Fields of Computational Finance: Summary of key topics and discussion of projects Simulations of single and multiple correlated stochastic processes Robo-Advisory infrastructure and examples
Week # 2 **Stochastic Processes and Simulation Examples, Robo-Advisory Examples**	Robo-Advisor Examples: Wealthfront, OpenInvest, Wealthsimple Robo-Advising Process: From data feed to client front-end processes Examples of stochastic process simulations

	Single-factor and multi-factor models in asset pricing Estimation of risk exposures and covariance matrices Factor-based investment products and portfolio selection Back-testing simple factor models and rule-based portfolios
Week # 3, 4 **Quantitative Investing, Strategy Design, Hedge Fund Applications**	Back-testing simple factor models and rule-based portfolios Quantitative portfolio strategies and hedge fund examples: AQR, Bridgewater, Renaissance etc. Uses and abuses of back-testing and computational strategies in asset management ML applications in factor research and quantitative investing practices Reliability and over-fitting issues in forecasting
Week # 4, 5 **Machine Learning Applications in Alpha-Modeling, Statistical Learning and Pattern Recognition Basics**	Stochastic Interest Rate Models & Yield Curve Models Yield Curve Analysis: PCA, curve fitting and simulation examples Mid-term team project discussions
Week # 5,6 **Interest Rate and Yield Curve Models**	Stochastic Interest Rate Models & Yield Curve Models Yield Curve Analysis: PCA, curve fitting and simulation examples Mid-term team project discussions
Week # 6 **Credit Risk**	Credit Risk, Correlation Risk, Default Risk and Bond Portfolio Simulations Options and Derivatives Review
Week #7 **Numerical Methods in Equity Option Pricing**	Numerical Methods in Equity Option Pricing and Trading Delta & Gama Hedging Examples Exotic Options Swaps and Swaption Pricing Examples Structured products examples
Week #8	

Portfolio Optimization Index Tracking	Optimization basics: Newton's method and iterative search routines Optimization with nonlinear risk and allocation constraints Curve fitting and index tracking examples
Week #9 **Numerical Simulations of Multi-Asset Portfolio Risk, Short-Term & Long-Term Scenario Projections**	Short-term scenario examples with Multi-Asset Portfolios Monte-Carlo techniques, Var-Cov Assumptions Asset-Liability Management and Long-Term Economic Scenarios
Week #11 **Discussion on AI and Fintech Developments**	Term-End Project Discussions Review of Statistical Learning, Big Data and Fintech Limits of Big Data and the Importance of Human Context
Week # 12 **Project Presentations and Conclusion**	Presentations and conclusion

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COMMUNICATION AND FEEDBACK

Students who wish to correspond with instructors or TAs directly via email must send messages that originate from their official McMaster University email account. This protects the confidentiality and sensitivity of information as well as confirms the identity of the student. Emails regarding course issues should NOT be sent to the Administrative Assistant.

Students who have concerns about the course content, evaluation methods, or delivery should first reach out to the course instructor. If your concern remains unresolved after speaking with the instructor, you may then reach out to the relevant Area Chair for further consideration.

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at:

www.mcmaster.ca/academicintegrity

Students are responsible for being aware of and demonstrating behaviour that is honest and ethical in their academic work. Such behaviour includes:

- following the expectations articulated by instructors for referencing sources of information and for group work;
- asking for clarification of expectations as necessary;
- identifying testing situations that may allow copying;
- preventing their work from being used by others (e.g., protecting access to computer files); and
- adhering to the principles of academic integrity when conducting and reporting research.

AUTHENTICITY/PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software.

All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ONLINE ELEMENT

All courses use some online elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course.

Students may be required to use the Respondus LockDown Browser and Respondus Monitor. The Respondus LockDown Browser is a downloadable program that allows a student to take an Avenue to Learn quiz in a secure environment. Quizzes can be set to use LockDown Browser or LockDown Browser.

For more details about McMaster's use of Respondus Lockdown Browser please go to https://avenuehelp.mcmaster.ca/exec/respondus-lockdown-browser-and-respondus-monitor/

The available information is dependent on the technology used. Continuation in a course that uses online elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

ONLINE PROCTORING

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate,

respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the *Code of Student Rights & Responsibilities* (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx, Teams, or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

ATTENDANCE

Arriving late or missing class disrupts the learning experience for both you and your peers. Punctuality and attendance are crucial to maintaining a respectful, professional and productive environment for everyone, including our faculty.

Instructors may use Top Hat in their course in a variety of ways, including to capture attendance in their classes. Attendance is recorded by submitting a unique 4-digit code displayed in your physical classroom using your personal device.

MISSED ACADEMIC WORK

Missed Examinations / Tests / Class Participation

Students can apply for relief from missed term work if they have or are going to miss an evaluated portion of their course. Please contact the Program Administrator for more information.

Reasons for missing course work can include:

- Health-related or extenuating circumstances
- Work-related commitments (for part-time students only)
- Representing the University at an academic or varsity event
- Religious obligations
- Conflicts between two (or more) overlapping scheduled mid-term exams.

Requesting Relief for Missed Term Work

When students miss regularly scheduled term work which contributes 10% or less to the final grade, the activity necessary to compensate for the missed work will be determined by the course instructor. The compensatory activities assigned will vary with the nature of the course and the missed requirement. They include, but are not restricted to, an alternative assignment, a rescheduled midterm exam, or re-weighting the marks for the missed component to other mark components. For missed work which exceeds 10% of the course grade, Petition For Relief For MFin Missed Term Work and McMaster University Student Health Certificate or other supporting documentation must be submitted to the Program Administrator at mfin@mcmaster.ca within five (5) business days of missing the work or mid-term exam.

Missed Final Examinations

Students must be available for the duration of the posted exam period regardless of their personal exam schedule. This is to ensure student availability throughout the entire exam period in the event that an exam must be rescheduled due to unforeseen circumstances (university closure, power outage, storm policy, etc.). A student who misses a final examination without valid reason will receive a mark of 0 on the examination.

Students who have missed a final exam for a valid reason can apply to the Program Office to write a deferred examination by submitting an Application for Deferring a Final Exam and McMaster University Student Health Certificate or other supporting documentation. The application must be made within five days of the scheduled exam.

Deferred examination privileges, if granted, are normally satisfied during the examination period at the end of the following semester. In select cases, the deferred examination may be written at a time facilitated by the Program Office and agreed to by the course instructor.

Requests for a second deferral or rescheduling of a deferred examination will not be considered.

ACADEMIC ACCOMMODATION FOR STUDENTS WITH DISABILITIES

Student Accessibility Services (SAS) offers various support services for students with disabilities. Students are required to inform SAS of accommodation needs for course work at the outset of term. Students must forward a copy of such SAS accommodation to the instructor normally, within the first three (3) weeks of classes by setting up an appointment with the instructor. If a student with a disability chooses NOT to take advantage of an SAS accommodation and chooses to sit for a regular exam, a petition for relief may not be filed after the examination is complete. The SAS website is:

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to the Program Office **normally within 10 working days** of the beginning of term in which they anticipate a need for accommodation. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

POTENTIAL MODIFICATION TO THE COURSE

The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes.