

STAT 7270  
Bayesian Inference (A01)  
Fall Term 2022

**Class Time:** M.W.F. 11:30 - 12:20 p.m.  
**Location:** EITC E2 351  
**CRN:** 21206

**Instructor:** Saman Muthukumarana  
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**Office Hours:** Monday 10:00 - 11:30 a.m.  
Thursday 1:00 - 2:00 p.m.

**Calendar Description:** Bayesian decision problems, priors, Jeffrey's Rule, robustness of posteriors, Bayesian justification of ANOVA

**Prerequisite:** consent of instructor.

**Course Website:** The course website is accessible via [UM Learn](#) management system.

**Computing:** This course will expose you to Bayesian Analysis and Computing using R, Python and BUGS computing languages throughout the course. This will also help you to select a suitable computing method for a given problem based on your interest and the scope of the problem.

R is a free software environment for statistical computing and runs on Windows, Linux, UNIX and Mac. You can download your own copy from R Project (CRAN) homepage at <http://www.r-project.org/>. The introductory tutorial for R can be found [here](#). RStudio can be downloaded from <https://www.rstudio.com/>.

Python is freely available and a collection of useful resources for Python beginners, including installation and introductory self-learning resources can be found at <https://www.python.org/about/gettingstarted/>. You can also use Anaconda Navigator <https://docs.anaconda.com/anaconda/navigator/> which will give you a desktop graphical user interface (GUI) with access to Jupyter Notebook and R studio.

You will also have access to Python and R through syzygy at <https://intro.syzygy.ca/>. Syzygy gives you direct interactive computing environment to R and Python with Jupyter notebooks at a single access point. You can log into the syzygy service using your UoM account credentials at <https://umanitoba.syzygy.ca/>.

The BUGS project at the University of Cambridge offers the BUGS language in various forms. It does both Gibbs and Metropolis-Hastings sampling and can be downloaded [here](#).

**Grading Scheme:** The minimum percentage final mark required to receive each of the various letter grades are A+ (90%), A (80%), B+ (75%), B (70%), C+ (65%), C (60%), D (50%). The final course mark will be determined as follows. You will have access to your assignments and mid term marks via UM Learn Grade-book.

UM Learn Assignments (4)	30%
In Class Mid-term Test	30%
Final Exam	40%

**Assignments:** There will be four assignments with written and computing components throughout the term. All assignments must be submitted electronically by their due date using **UM Learn Dropbox**. Make sure to follow the assignment submission guideline and late assignments will not be accepted. You are encouraged to discuss your problems with your classmates, TA and me, but final submission must be developed independently. Assignments will be marked using Brightspace Assignment Grader and specific submission instructions will be posted on UM Learn. Assignments will include problems which require computing and your submission must accompany the code written by you. Your grades for assignments will be returned within two week of the due date.

**Mid-term Test:** The in-class mid-term test is tentatively scheduled on **Nov 14, 2022**. There will be no makeup tests unless it deems required. If you miss the exam due to a legitimate reason, your exam weight will transfer to the final exam. Your answers must be submitted electronically using **UM Learn Dropbox**.

**Final Exam:** The final exam covers all course materials and will be an open-book take-home test. The take-home exam will consist of written and computing components and must be submitted electronically using **UM Learn Dropbox**.

**Class and Computer Lab Attendance:** I will introduce, discuss and demonstrate computer codes in classes to understand the course material. Computer Lab sessions will also provide you with various practical hands-on computing experience on theory and applications. Therefore, I encourage you to attend classes and labs regularly to avoid falling behind. The exams will also resemble in part on problems discussed during classes. The lab sessions will be held on Mondays at 2:30 – 3:45 pm in 311 Machray Hall computer lab.

**Textbook:** You will have access to my lecture notes via course website and there is no required textbook for this course. However, the following textbooks are recommended for reading and the additional material will also be borrowing from journal papers. Note that e-copies of first three books are freely available to download from UoM Library server. For some lectures, specific sections from these books will be assigned as reading assignments.

- *Bayesian computation with R* (Second Edition), Jim Albert, Springer (2009).
- *Applied Bayesian Statistics With R and OpenBUGS Examples*, Mary Kathryn Cowles, Springer (2013).
- *Introduction to Bayesian Statistics* (Third Edition), William Bolstad and James Curran, Wiley (2017).
- *Bayesian Theory* (Second Edition), José M. Bernardo and Adrian F. M. Smith, Wiley Series (1994).
- *Bayesian Data Analysis* (Second Edition), Andrew Gelman, John B. Carlin, Hal S. Stern and Donald B. Rubin, Chapman and Hall/CRC (2003).
- *The Bayesian Choice*, Christian P. Robert, Springer (1994).

**Course Outline:** The course aims to cover the following topics.

- Basic Review and Some History
  - The Role of Statistics in the Scientific Method
  - Main Approaches to Statistics
  - Sufficiency, Likelihood and Conditionality Principles
  - Computing via syzygy
- Introduction to Bayesian Paradigm
  - Likelihood, Prior and Posterior
  - Sequential Bayesian Updating
  - Types of Priors
  - Predictive Distributions
  - Credible Intervals
  - Hypothesis Testing
- Simulation Based Inference
  - Monte Carlo Methods in Bayesian Inference
  - Importance Sampling
  - Markov Chain Monte Carlo - MCMC
  - Gibbs and Metropolis-Hastings Algorithms
  - Assessing Convergence in MCMC
- Bayesian Models with Applications
  - Bayesian Inference for Statistical Distributions
  - Bayesian Regression Models
  - Handling Missing Data in Bayesian Models
- Further Topics
  - Hierarchical Models
  - Model Selection
  - Robustness and Sensitivity Analysis
  - Bayesian Decision-theoretic methods
  - Dirichlet Process
  - Bayesian Computation using BUGS

**Important Dates:** These dates are tentative and subject to change at the discretion of the instructor and/or based on the learning needs of the students but such changes are subject to Section 2.8 of the ROASS Procedure.

Preliminary Schedule	
Date	Task
Sep 7	First class
Sep 12	First Lab
Sep 28	Assignment 1 Due
Oct 19	Assignment 2 Due
Nov 4	Assignment 3 Due
Nov 7 – 10	Fall Term Break
Nov 14	In class Mid-Term Test
Nov 22	Voluntary Withdrawal (VW) Deadline
Dec 7	Assignment 4 Due
Dec 12	Last Class – Review

### Other Important Information:

- **Academic Dishonesty:** It is important that you understand what constitutes academic dishonesty and that you are familiar with the very serious consequences. Links to resources that describe academic dishonesty (including plagiarism, cheating, inappropriate collaboration and examination impersonation, as well as typical penalties) can be found at: <https://umanitoba.ca/student-supports/academic-supports/academic-integrity>.
- **Class Communication:** The University requires all students to activate an official University email account. All communication between your instructor and you as a student must comply with the Electronic Communication with Students Policy. Please click [here](#) for further details. You are required to obtain and use your U of M email account for all communication between yourself and the university.
- **Student Accessibility Services:** If you are a student with a disability, please contact SAS for academic accommodation supports and services such as note-taking, interpreting, assistive technology and exam accommodations. Students who have, or think they may have, a disability (e.g. mental illness, learning, medical, hearing, injury-related, visual) are invited to contact SAS to arrange a confidential consultation. The details can be found at <https://umanitoba.ca/student-supports/accessibility>.
- **Copyrighted Material:** All course notes, assignments, tests, exams, computer codes and solutions are the intellectual property of your instructor. Reproduction or distribution of these materials is strictly forbidden without instructor's consent.
- **Recording of Class Lectures:** Your instructor and the University of Manitoba hold copyright over the course materials, presentations and lectures which form part of this course. No audio or video recording of lectures or presentations is allowed in any format, openly or surreptitiously, in whole or in part without permission from your instructor.
- **Use of Electronics in the Classroom:** It is the general University of Manitoba policy that all technology resources are to be used in a responsible, efficient, ethical and legal manner. A student may use technology in the classroom setting only for educational purposes approved by the instructor and/or the University of Manitoba Student Accessibility Services.
- **ROASS Schedule:** Schedule A of the Responsibilities of Academic Staff with regards to Students (ROASS) policies of the University of Manitoba lists resources and policies for students. It is important that you familiarize yourself with these resources and policies. Schedule A is available at <https://sci.umanitoba.ca/statistics/courses-and-programs/outlines/>.

Minimum technological requirements Students enrolled in this course must have are: access to a computer with the capability of running the required software and programming languages. See the appendix for further details on policies and resources available to you.

## **Appendix For Fall 2022 Course Syllabi**

### **How to succeed in your science courses?**

The Faculty of Science is committed to delivering the high-quality education our students have come to expect. We also want to ensure that you set yourself up for success. We want you to succeed!

#1. **Registration Revision Period:** Use the [Registration Revision Period](#) to evaluate course syllabus. During the registration revision period you will be able to drop/add courses without any financial consequence. Speak directly with instructors if you have any questions specific to their course.

#2. **Evaluate Workload:** Take time to consider the workload associated with the course schedule you are planning. Be realistic about other commitments and distractions that are part of everyday life and make your course selection decisions accordingly. Please consider watching this presentation from the Academic Learning Centre for [Managing Your Time Effectively](#). If you want to discuss anything, talk to an Academic advisor in your faculty – [Academic advising](#).

#3. **Commitment to Study:** For an average course, you should aim to commit at least three hours of studying for every hour of lecture. Make sure you keep up with studying on a consistent basis.

#4. **Reach Out for Help:** If you experience issues learning the course material, reach out to your instructor, teaching assistants, supplemental instruction leaders or [Academic Learning Centre](#) for the course as soon as possible. Most content builds on previous content and deficiencies in understanding will cascade issues throughout the course. For questions about your degree program or if life stresses hinder your academic performance, contact your faculty's academic advisors immediately.

#5. **Learn Efficiently, Learn to Take Notes:** During the pandemic, many lectures were delivered asynchronously so students had a chance to review lecture videos when they did not catch something during the lecture. Lectures are delivered in-person this fall term therefore students will not have the luxury of rewatching a live lecture. Therefore, you may want to review some [note-taking tips](#) offered by the [Academic Learning Centre](#) which can help you learn efficiently.

## **LEARNER SUPPORT**

### **Writing and Learning Support**

The Academic Learning Centre (ALC) offers writing and learning supports to help you throughout your academic program. Make an appointment with an ALC writing tutor who can give you feedback at any stage of the writing process, whether you are just beginning to work on a written assignment or already have a draft. The ALC also has an English as an Additional Language (EAL) specialist available to work with students on improving their English-language academic writing skills.

Consult an ALC learning specialist or attend an academic skills workshop to improve your time management, learning strategies and test-taking strategies. Get support in select courses by making an appointment with an ALC content tutor. The ALC also offers peer-facilitated study groups called Supplemental Instruction (SI) for certain courses that students have typically found difficult. In SI study groups, students ask questions, compare notes, discuss content, solve practice problems, and develop new study strategies in a group-learning format.

In addition to one-to-one and group sessions, you can also find writing and study tip sheets and videos on the ALC website.

Academic Learning Centre services are free for U of M students. For more information, please visit the Academic Learning Centre website at: <http://umanitoba.ca/student/academiclearning/>  
Contact the Academic Learning Centre by calling 204-480-1481 or emailing [academic\\_learning@umanitoba.ca](mailto:academic_learning@umanitoba.ca).

### **University of Manitoba Libraries (UML)**

Research begins at UM Libraries. Learn at the Libraries is a great place to start, with information for students on academic writing, how to search the library, evaluating resources, and writing citations. As the primary contact for all research needs, your liaison librarian can play a vital role when completing academic papers and assignments. Liaisons can answer questions about locating appropriate resources or managing citations, and will address any other concerns you may have regarding the research process. Liaisons can be contacted by email or phone, and are also available to meet with you online. When working remotely, students can also receive help online through Ask Us! chat. For further detail about the libraries' services and collections, visit the Libraries' web site.

### **MENTAL HEALTH SUPPORT**

**For 24/7 mental health support, contact the Mobile Crisis Service at 204-940-1781.**

### **Student Counselling Centre**

Contact SCC if you are concerned about any aspect of your mental health, including anxiety, stress, or depression, or for help with relationships or other life concerns. SCC offers crisis services as well as individual, couple, and group counselling. *Student Counselling Centre:*

<http://umanitoba.ca/student/counselling/index.html>

474 University Centre or S207 Medical Services

(204) 474-8592

### **Student Support Case Management**

Contact the Student Support Case Management team if you are concerned about yourself or another student and don't know where to turn. SSCM helps connect students with on and off campus resources, provides safety planning, and offers other supports, including consultation, educational workshops, and referral to the STATIS threat assessment team.

*Student Support Intake Assistant* <http://umanitoba.ca/student/case-manager/index.html>

520 University Centre, Fort Garry Campus

(204) 474-7423

### **University Health Service**

Contact UHS for any medical concerns, including mental health problems. UHS offers a full range of medical services to students, including psychiatric consultation.

*University Health Service* <http://umanitoba.ca/student/health/>

104 University Centre, Fort Garry Campus

(204) 474-8411 (Business hours or after hours/urgent calls)

### **Health and Wellness**

Contact our Health and Wellness Educator if you are interested in [peer support from Healthy U](#) or information on a broad range of health topics, including physical and mental health concerns, alcohol and substance use harms, and sexual assault.

Health and Wellness Educator <https://umanitoba.ca/student/health-wellness/welcome-about.html>  
[britt.harvey@umanitoba.ca](mailto:britt.harvey@umanitoba.ca)

469 University Centre, Fort Garry Campus  
(204) 295-9032

### **Live Well @ UofM**

For comprehensive information about the full range of health and wellness resources available on campus, visit the Live Well @ UofM site: <http://umanitoba.ca/student/livewell/index.html>

### **HEALTH AND SAFETY**

The University of Manitoba (the “UM”) is committed to maintaining a safe learning environment for all students, faculty, and staff. Should campus operations change because of health concerns related to the COVID-19 pandemic or other campus-wide emergency, it is possible that this course will move to a fully remote delivery format. Should the instructor be required to stay at home for an extended period and an alternate instructor not be available, the course may move temporarily to a remote delivery format.

### **Mask Wearing**

In a face-to-face environment, our commitment to safety requires students to observe all Covid guidelines set by the University (<https://umanitoba.ca/coronavirus> ) While on campus and in class, you must wear masks as stipulated in current University policies, procedures, and guidelines. The University highly recommends the use of KN-95 masks; the minimum requirement is a ATSM Level 2 Medical mask. Both mask types are available at many locations on campus. Students who fail to comply are subject to disciplinary action in accordance with the [Student Discipline Bylaw](#) and the [Non-Academic Misconduct and Concerning Behaviour Procedure](#).

If you do not follow masking requirements, you will be asked to leave the learning space and may only return to the class already in progress when you have complied with this requirement. Repeated issues will result in disciplinary action as previously noted. Students should not eat or drink during class time.

### **Illness**

Remember: STAY HOME IF YOU HAVE SYMPTOMS OR ARE ILL. If you become ill, we highly recommend that you [self-isolate](#); you should notify your instructor by email so you can develop a plan to complete the course learning outcomes while you are absent.

What to do if you become ill while at UM:

1. Leave the classroom, lab, or workspace immediately. Continue to wear your mask while leaving the premises and/or while waiting for transportation.
2. Perform hand hygiene (soap and water or hand sanitizer) and avoid contact with others and minimize contact with the physical environment.
3. Once at home, complete the [MB self-assessment](#) and follow the directions that are provided.
4. Inform your instructor(s) or, if in residence, the appropriate individual. The Instructor will discuss with you arrangements for extensions, deferrals or make-up assignments as required.



5. Please remain off-campus and all UM facilities until cleared to return in accordance with self-assessment, testing results, and UM recommended isolation procedures.
6. Complete the [COVID-19 case reporting form](#)

Recommended transportation options (in order):

1. Drive yourself home.
2. Pick-up by family or friend – remember to keep your mask on and to distance yourself as much as possible, and where possible, open a window to improve ventilation.
3. Pickup by taxi/Uber:
  - Remain masked and perform hand hygiene before entering the vehicle.
  - o Avoid touching the inside of the vehicle
  - o Keep your mask on for the duration of the ride
  - o Where possible, open a window to improve ventilation.
4. Winnipeg Transit buses – We recommend that you do not use Winnipeg Transit in this situation.

### **ACADEMIC ACCOMMODATIONS**

Students who have, or think they may have, a disability (e.g., mental illness, learning, medical, hearing, injury-related, visual) are encouraged to contact [Student Accessibility Services](#) to arrange a confidential consultation. Instructors are notified by Student Accessibility Services what accommodations their registered students require which will help the instructor determine fair, feasible and reasonable academic accommodations without compromising academic standards. This takes time and planning, so reach out at the start of term.

SAS students can write their exams and tests in spaces organized by the SAS Exam Centre however they must register with the SAS Exam Centre a few weeks in advance. Please be sure to do so to receive the accommodations.

### **Medical Notes and Other Documentation**

The Self-Declaration for Brief and Temporary Absences Procedure and Policy will be effective on September 1, 2022 and therefore students will not be required to present medical or other documentation for absences due to extenuating circumstances of 72 hours or less, however [this form](#) must be completed and submitted to the instructor in lieu of the documentation. Please note that further documentation may be requested from students who claim multiple temporary absences or absences for more than 72 hours.

### **Short-Term Academic Accommodations (up to 72 consecutive hours absences)**

As we emerge from the pandemic, the University still has the health and safety of its community at top of mind. Since your classes are held in-person, please make sure you follow the [University's COVID-19 Health and Safety Protocols](#). Notably, exercise [good hand hygiene](#), [stay home if you are ill](#) and you must wear a [mask](#) when attending lecture/labs and on campus.

- Students who miss a lab or assessment due to an extenuating brief or temporary absence should complete a [self-declaration for brief and temporary student absences form](#) and submit it to their instructor **within 48 hours of the end of the brief absence**. The instructor will discuss with the student how the missed work can be made up.
- **Students absent for over 72 hours as a result of medical, compassionate, University scholastic, University athletic or religious event will require official documentation to**

**explain the absence.** Students should reach out to instructors early if absences are anticipated.

- **Personal vacations and work requirements are not considered acceptable absences.**

### **Long-Term Academic Accommodations**

Students with long-term academic accommodations are usually registered with [Student Accessibility Services](#). The long-term academic accommodations are usually to accommodate long term physical or mental illness and accommodations can be in the form of notetaking, interpreting, assistive technology, and assessment accommodations.

### **Final Exams**

Students who have conflicting scheduled exams should contact their faculty's academic advisors as soon as possible. Students who miss their exam due to extenuating circumstances can apply for a deferred exam. Please note that the granting of a deferred exam is not necessarily guaranteed.

### **Missed Lecture Notes**

Students missing lecture notes as a result of absences are responsible for obtaining the missed content on their own accord. Contact a classmate or the course instructor for their notes but please be aware the instructor is not obliged to create notes for students as a result of absences.

### **VOLUNTARY WITHDRAWAL (VW) AND AUTHORIZED WITHDRAWAL (AW) POLICIES**

**VW:** Students have the opportunity to [voluntarily withdraw \(VW\)](#) from this class up to November 22 ([in the event of date discrepancies, please follow the dates on the Important Dates and Deadlines webpage](#)). By then, you will have received feedback to allow you to assess your progress and determine if you are achieving the grade you are aiming for in this course. If you are unlikely to be successful in the course, or not achieving the grade that you are aiming for, you should consider a VW from the course. You should contact your instructor to review your progress in more detail, or you may discuss the VW option with a Faculty academic advisor. Students enrolled in the course after the VW deadline will be assigned a final grade.

**AW:** At times medical or compassionate circumstances arise in a student's life that prevent them from performing as they would in normal circumstances. If you are in this position, please contact a Faculty academic advisor to discuss your [options](#). Be prepared to provide documentation, which supports your situation.

### **PROFESSIONAL CONDUCT**

Students in the University community can freely express their thoughts, opinions, and beliefs however they must observe the [Respectful Work and Learning Environment Policy](#) and treat each other, staff, and faculty with respect. Students who are alleged to have breached the Respectful Work and Learning Environment Policy will be investigated and disciplined according to the [Student Non-Academic Misconduct and Concerning Behaviour Procedure](#).

### **ACADEMIC INTEGRITY**

Academic integrity is taking responsibility for and being honest with your work and respecting the work of others. Since you are a member of the university community, we want you to learn what that responsibility and honesty entails and how we respect the work of others.

The Faculty of Science continues to uphold high standards of academic integrity. We know that you, our students, support us in this and we count on every one of you to do your part. We expect all students to strictly adhere to instructions from their professors regarding what resources can and cannot be used for assessments, to follow other rules the professors wish to set, and to adhere to the academic conduct standards of the University and Faculty.

To aid professors in assuring that all forms of assessments have been administered fairly, the University will be electronically monitoring all tests, quizzes and examinations, included, but not limited to overseeing chatrooms, relevant predatory websites and, in so doing, we will analyze scholastic evidence of individual exams.

Students who transgress academic integrity rules will be investigated and disciplined (if justified) according to the [Student Discipline By-Law](#) and [Student Academic Misconduct Procedure](#).

The list of suggested minimum penalties assessed by the Faculty of Science for acts of academic dishonesty is available on the [Faculty of Science website](#).

### **COPYRIGHT**

All students are required to respect copyright as per Canada's *Copyright Act*. Staff and students play a key role in the University's copyright compliance as we balance user rights for educational purposes with the rights of content creators from around the world. The Copyright Office provides copyright resources and support for all members of the University of Manitoba community.

Please respect copyright. We will use copyrighted content in this course. No audio or video recording of the lectures is allowed in any format, openly or surreptitiously, in whole or in part without permission from the instructor. University guidelines state that copyrighted works, including those created by the course instructor, are made available for private study and research, and must not be distributed in any format without permission. Since it is illegal, do not upload copyrighted works to a learning management system (such as UM Learn), or any website, unless an exception to the Copyright Act applies or written permission has been confirmed.

For more information, see the University's Copyright Office website at <http://umanitoba.ca/copyright>.

### **YOUR RIGHTS AND RESPONSIBILITIES**

As a student of the University of Manitoba you have rights and responsibilities. It is important for you to know what you can expect from the University as a student and to understand what the University expects from you. Become familiar with the policies and procedures of the University and the regulations that are specific to your faculty, college or school.

The [Academic Calendar](#) is one important source of information. View the sections of *University Policies and Procedures* and *General Academic Regulations*.

While all of the information contained in these two sections is important, the following information is highlighted.

- If you have questions about your grades, talk to your instructor. There is a process for term work and final **grade appeals**. Note that you have the right to access your final

examination scripts. See the Registrar's Office website for more information including appeal deadline dates and the appeal form <http://umanitoba.ca/registrar/>

- You are expected to view the General Academic Regulation section within the Academic Calendar and specifically read the **Academic Integrity** regulation. Consult the course syllabus or ask your instructor for additional information about demonstrating academic integrity in your academic work. Visit the Academic Integrity Site for tools and support <http://umanitoba.ca/academicintegrity/>. View the **Student Academic Misconduct** procedure for more information.
- The University is committed to a respectful work and learning environment. You have the right to be treated with respect and you are expected to conduct yourself in an appropriate respectful manner. Policies governing behavior include the: [Respectful Work and Learning Environment](#), [Student Discipline](#) and, [Violent or Threatening Behaviour](#)
- If you experience **Sexual Assault** or know a member of the University community who has, it is important to know there is a policy that provides information about the supports available to those who disclose and outlines a process for reporting. The **Sexual Violence** policy may be found at: <https://umanitoba.ca/governance/governing-documents/governing-documents-university-community#sexual-violence>. More information and resources can be found by reviewing the Sexual Assault site <http://umanitoba.ca/student/sexual-assault/>

For information about rights and responsibilities regarding **Intellectual Property** view the policy: [https://umanitoba.ca/admin/governance/governing\\_documents/community/235.html](https://umanitoba.ca/admin/governance/governing_documents/community/235.html)

For information on regulations that are specific to your academic program, read the section in the Academic Calendar and on the respective faculty/college/school web site <http://umanitoba.ca/faculties/>

Contact an **Academic Advisor** within **YOUR** registered faculty/college or school for questions about your academic program and regulations <http://umanitoba.ca/academic-advisors/>

### **Student Advocacy**

Contact Student Advocacy if you want to know more about your rights and responsibilities as a student, have questions about policies and procedures, and/or want support in dealing with academic or discipline concerns.

<http://umanitoba.ca/student/advocacy/>

520 University Centre

204 474 7423

[student\\_advocacy@umanitoba.ca](mailto:student_advocacy@umanitoba.ca)