

MAHARISHI UNIVERSITY OF MANAGEMENT



CS 435

Algorithms:

Discovering the Hidden Dynamics of Natural Law

PROFESSOR Emdad Khan, PhD

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COURSE TITLE:**Algorithms:***Discovering the Hidden Dynamics of the Laws of Nature*

Prof. Emdad Khan, PhD

SYLLABUS**“He who in action sees inaction and in inaction sees action is wise among men”***--Bhagavad-Gita IV v18*

GOAL OF THE COURSE

The Objectives of the Course

Student will

- Develop skill in designing algorithms and learn to represent algorithms in an implementation-neutral algorithm language
- Learn tools for evaluating efficiency of an algorithm, both empirically and analytically
- Develop the ability to demonstrate the correctness of an algorithm
- Develop discriminative ability in making the optimal selection of a data structure and/or an algorithm in a particular setting
- Learn a core of classical algorithmic solutions to both practical and theoretical problems.
- Become acquainted with techniques for improving efficiency of an algorithmic solution.
- Become acquainted with the self-referral transcendental foundation of all computation both on a theoretical and experiential level

STUDENT LEARNING CHART

OBJECTIVES This is what you'll learn to do*	LEARNING ACTIVITIES This is how you'll learn it	ASSESSMENTS This is how you'll show you've learned
1. Develop skills in designing algorithms and learn to represent algorithms in an implementation-neutral algorithm language (1, 4, 7)	By working individually, in teams and practicing the techniques to understand, analyze and design key algorithms using pseudocode	Lab works and results from the midterm exam
2. Learn tools for evaluating / improve efficiency of an algorithm, both empirically and analytically (6, 7, 8)	By practicing the techniques using counting primitive operations, big-Oh, big Omega, Big Theta and b. worst-case complexity c. average case complexity in homework as well as in labs	Lab works and results from the midterm exam
3. Develop the ability to demonstrate the correctness of an algorithm (4, 5, 7)	By practicing the Proof of Correctness techniques in classroom, labs and homework	Lab works and results from the midterm exam
4. Develop discriminative ability in making the optimal selection of a data structure and/or an algorithm in a particular setting (4, 5, 7)	By practicing the techniques of using & analyzing of various Data Structures in various algorithms in classroom, labs and homework	Lab works and results from the midterm & final exams
5. Learn a core of classical algorithmic solutions to both practical and theoretical problems. (5, 9)	By practicing the techniques like Sorting, Searching, Dynamic Programming and Graph Algorithms in classroom, labs and homework	Lab works and results from the midterm & final exams

6. Learn the definition and analysis of Hard problems (1, 3, 4)	By practicing the techniques in classroom, labs and homework	Lab works and results from the final exam
7. Learn the connections between the Science of Consciousness and Algorithm (1, 3, 4, 9)	By doing Wholeness of the Lessons, Main Points, Unity Charts and associated explanations in classroom	Results from the final exam

*The numbers in parentheses refer to the MUM Essential Learning Outcomes that are best supported by this course objective. They appear in **boldface** in the list below.

1. Development of consciousness
2. Health
3. Holistic thinking
4. Creativity
5. Critical thinking
6. Communication
7. Problem solving
8. Teamwork and leadership
9. Local and global citizenship

OFFICE HOURS, CONTACT INFORMATION, AND BIOGRAPHICAL SKETCH

Dr. Emdad Khan

- Email: ekhan@mum.edu
- Phone: 408-532-9630 (home), 472-7000 ext 2215 (office)
- Office: McLaughlin – Room 14
- Office hours: Mondays 3:15 – 4:15 (Everyday after lab in the class)

Short Bio:

Dr. Khan's research areas include Natural Language Processing, Big Data, Intelligent Agent, Artificial Intelligence, Machine Learning, Human Computer Interaction and their applications, especially, in the areas of Internet / Intelligent Internet and Biological Systems. Dr. Khan also

focuses on multi-disciplinary education with emphasis on innovation and entrepreneurship to help global development — economic, social, cultural and more with emphasis on increased peace & prosperity!

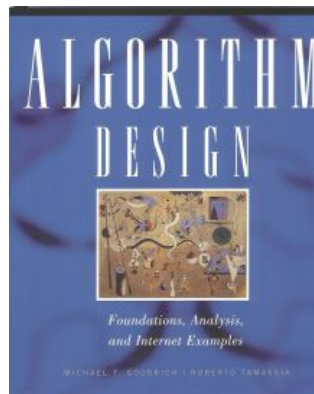
See <https://www.mum.edu/academic-departments/computer-science/faculty-profiles/emdad-khan/> for details.

TEXTS AND OTHER REQUIRED CLASS MATERIALS

Textbooks

The strongly recommended to use following Text Books:

1. ***Algorithm Design: Foundations, Analysis, and Internet Examples***, by Michael Goodrich and Roberto Tamassia, available through Amazon Books and Barnes and Noble.



Lessons	Corresponding Sections from Textbook (and Other Resources)
Math Review	Section 1.3
1 - Introduction to Algorithms	Halting Problem: The Halting Problem Knapsack Problem: Section 5.3.3 and p. 614
2 - Introduction to Analysis of Algorithms	Sections 1.1, 1.2, 1.6. Also, p. 27.
3 - Average Case Analysis	p. 11 and Section 1.3.4
4 - More Average Case Analysis	Section 1.5
5 - Merge Sort	Section 4.1, Section 2.3.1
6 - Quick Sort	Section 4.3
7 - Lower Bound on Comparison-Based Algorithms and Radix Sort	Sections 4.4, 4.5
8 - Data Structures	Sections 2.1, 2.2, 2.5
GCD Algorithm	Section 10.1.2

9 – Binary Search Trees and Enhancements	Sections 3.1, 3.2
10 - Red-Black Trees	Section 3.3.3
11 - Heaps and Priority Queues	Section 2.4
12 - Introduction to Graph Theory	Section 6.1, Resource: Graph Tutor
13 - Implementing Graph Algorithms	Sections 6.1.1, 6.2, 6.3.1, 6.3.3
14 - Weighted Graphs	Sections 7.1.1, 7.3.1
15 - Hard Problems and Approximation Algorithms	Sections 13.1-13.4, Sections 5.3.1, 5.3.3

(Recommended 2nd Text Book):

2. *Introduction to Algorithms*, Cormen, Leiserson, Rivest, Stein - Third edition (2009). It has everything in it. And it's inexpensive considering it spans more than 1000 pages.

[You can download the latest version (3rd edition) free]

Do Labs in Groups

You will need to know how to do every homework problem yourself, but you will have the opportunity to work in a group consisting of 2-3 people. One way to do homework assignments that I do NOT recommend is to split up the assignment between group members and then combine results. This approach is almost entirely without value – better to just skip the assignment completely. The group is there for you to *discuss* homework that you have done, or to get ideas for you to work out solutions. It is not intended as a means of skipping problems.

I will assign labs every day; labs are due on the day (indicated on the calendar) on which solutions are presented to class.

Labs are submitted in paper form, in a packet, with a cover page to indicate the Lab number and group members. These submissions will be used to compute your Group Lab score.

Guidelines for Lab submission

1. Your work for a particular Lab should be submitted *as a group*.
2. Each problem in a Lab should be worked out on a *separate page* – two problems should never be worked on the same page, even if they are short.
3. If a problem asks you to write code, work it out in a development environment, but then include a hard copy of your code in your group submission, bundled with other work you have done for that problem.
4. Each hard-copy submission should have a cover page with the following information:
 - *Assignment Number*
 - *Group Name* (like “Group 1”, “Group 2” etc)
 - *All names and student ID’s of the members of the group*

Math Quiz and Study

“Lesson 0” (in the lessons folder) serves as a math review. There is a MathReview.pdf document that reviews the main mathematical points that you should know as a pre-requisite for this course. Some of the most important points from that document are discussed in the lecture for Lesson 0, in the document MathReviewLecture.pdf. A math quiz has been placed in the lessons/Lesson 0 folder; you will submit answers to this quiz as a group (like other labs). The MathReview.pdf document will provide you with the information you will need to work through the problems on the quiz. This quiz should be done and submitted sometime before the second Friday of the course. In preparing your submission, please follow the same guidelines as for the other labs.

Reference Materials**Data Structures And Algorithm Analysis In Java**

Mark Allen Weiss

Addison-Wesley

ISBN: 0-201-35754-2

We have used this textbook in previous Algorithms classes.

Data Structures, Algorithms, and Applications in Java

Sartaj Sahni

McGraw-Hill

<http://www.mhhe.com/engcs/compsci/sahnijava/>

Website offers Java code for many algorithms

Assignments for Algorithms

Lesson	Assignment	Suggested Reading
1	Lab 1	mathReview/MathReview.pdf articles/computability-theory.pdf, articles/intro-computation.pdf
2	Lab 2	Sections 1.1, 1.2, 1.3, 1.6 of the book. Optional: 4.1.2, 5.2 of the book.
3	Lab 3	Section 1.3.4 of the book
4	Lab 4	Section 1.5 of the book
5	Lab 5	Section 4.1 of the book
6	Lab 6	Sections 4.3, 4.7 of the book
7	Lab 7	Sections 4.4, 4.5, 4.6 of the book
8	Lab 8	Sections 2.1, 2.2, 2.5 of the book
9	Lab 9	Sections 2.3, 3.1, 3.2, 3.4 of the book
10	Lab 10	Section 3.3.3 of the book
11	Lab 11	Section 2.4 of the book
12	Lab 12	Sections 6.1, 6.2 of the book
13	Lab 13	Sections 6.3.1, 6.3.3 of the book
14	Lab 14	Sections 7.1.1 and 7.3.1 of the book
15	Lab 15	Sections 13.1 – 13.4 of the book

In-Class Exercises

From time to time, there will be in-class exercises, as time allows. These will be exercises that you will work out in your group. Groups will have the opportunity to present their solutions to these exercises, but for each problem, only one presentation will be permitted. If a group presents a correct solution in a sufficiently complete and understandable way, they will be awarded 5 Lab credits. No one is required to participate in these in-class exercises.

Course Overview Chart CS 435 - Algorithms: Discovering the Hidden Dynamics of the Laws of Nature						
Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1 Theme: How to analyze algorithms	AM: Lesson 1: <i>Introduction: Solving Problems with Algorithms</i> PM: Lab 1	AM: Lesson 2: <i>Intro to Analysis Of Algorithms.</i> PM: Lab 2	AM: Lesson 2 (continued) PM: Lab 2	AM: Lesson 3: <i>Average Case Analysis</i> PM: Lab 3 Labs 1, 2 are due Review Solutions	AM: Lesson 4: <i>More Average Case Analysis</i> PM: Lab 4	AM: Lesson 5: <i>MergeSort</i>
2 Theme: Sorting Algorithms	AM: Lesson 6: <i>QuickSort</i> PM: Lab 6 Labs 3-4 are due Review Solutions	AM: Lesson 7: <i>Lower Bound on Comparison-Based Algorithms And RadixSort</i> PM: Lab 7 <i>End of course material for Midterm Exam</i>	AM: Lesson 8: <i>Data Structures</i> PM: Lab 8 Labs 6, 7 are due, Review Solutions	AM: Review for Midterm PM: Study for midterm	<i>Midterm Exam</i>	AM: Lesson 9: Binary Search Trees and Enhancements
3 Theme: Data Structure and Graphs	AM: Lesson 10: <i>Red-Black Trees</i> PM: Lab 10 Review MidTerm Solutions	AM: Lesson 11, 11A: <i>Heaps and Priority Queue, Dynamic Prog.</i> PM: Lab 11 Labs 8, 10 are due Review Solutions	AM: Lesson 12: Dynamic Programming (Contd) / Introduction to Graph Theory. PM: Lab 12	AM: Lesson 13 <i>Implementing Graph Algorithms</i> PM: Lab 13	AM: Lesson 13 (contd) Weighted Graphs – Shortest Path Algorithms PM: Lab 13 (contd) Labs 10 – 12 are due Review Solutions	AM: Lesson 14: <i>Weighted Graphs – Minimum Spanning Tree Algorithms</i>
4 Theme: Hard Problems	AM: Lesson 15 <i>Hard Problems</i> PM: Lab 15	AM: Lesson 15 <i>Hard Prob. (con)</i> PM: Labs 13, 15 are due Review solutions & review for Final Exam	AM: Review for Final exam PM: Study for final	Final Exam		

EVALUATION PLAN

Your class grade represents your performance on the course objectives as measured by assignments and exams, as well as your classroom participation, as measured by attendance and punctuality.

How are grades calculated

Grading

Your final grade will be a combination of your scores on Exams, Group Homework, and Professional Etiquette. Professional Etiquette will be evaluated with a qualitative score (Excellent, Good, Not So Good), which is an evaluation of your attendance and professional manner in class (including appearance); this score will play a role in determining how borderline grades will be decided. (Example: Your combined score for Exams, Homework, and Class Participation has put you within 1 point of an A-. If your Professional Etiquette score is Excellent, you would probably get the A-. If your Professional Etiquette score is Not So Good, you would probably get a B+.)

Evaluation Modality	Value
Combined Exam Scores	92%
Group Homework	8%
Professional Etiquette	tiebreaker

There will be two exams in the class. The following table lists the value and content of each exam:

Exam Number	Exam Content	Value
1	Lessons 1 – 7	46%
2	Lessons 8 - 15	46%

Honors assignment (or extra credit)4 Points**What do grades mean?**

A	90–100	Excellent	Meets the course objectives at an exceptionally high level
B	80–89	Good	Meets the course objectives at the expected level
C	70–79	Fair	Meets the course objectives at a basic level
NC	below 70	No credit	Does not meet the course objectives

More Details on Grading:

Range	Letter Grade
93-100	A
90 - 92	A-
87 - 89	B+
83 - 86	B
80 - 82	B-
77 - 79	C+
73 - 76	C
67 - 72	C-
0 - 66	NC

REVIEW ACTIVITY

We'll frequently use the following activity at the end of a class to review the lesson:

- At the end of the lesson, please write down in your own words what you think is the lesson's most important point. (one sentence)
- Relate this main idea to the growth of your own creative potential or the knowledge of full development of consciousness you've gained. (one sentence)
- Draw a diagram or illustration that integrates the two points.

- One participant: Draw your picture on the board and present your review to the class. Others: Share your review with a neighbor.

• DAILY SCHEDULE

On Monday–Friday, classes begin at 10:00 a.m. and end at 3:15 p.m. with an hour for lunch. On Saturdays, class meets from 10 AM to noon. For more detail, please see the recommended daily schedule below.

This daily schedule of all courses is designed to help you **master specific fields of** knowledge while also cultivating higher states of consciousness for success and fulfillment in life.

The more rested you are, the more you'll learn. I recommend you aim to be in bed by 10:00 p.m., so you're rested and fresh each morning. If you haven't finished your homework by then, then instead of staying up late to finish it, get a good night's rest and finish it in the morning before class.

You are also encouraged to participate in physical activity daily.

MORNING	
	Group program for Meditators and Sidhas
10:00 AM – 12:15 PM	Class lecture, discussion, activities, labs
12:15 PM– 12:30 PM	In-class group Transcendental Meditation practice
12:30 – 1:30 PM	Lunch and walk
AFTERNOON	
1:30 – 2:55 PM	Continuation of morning class, projects, exercises, in-class reading, labs
2:55 – 3:15 PM	In-class group Transcendental Meditation practice for Meditators and Rising Sidhas
3:00 – 4:30 PM	Group program for Sidhas
EVENING	
	Dinner
7:00 – 9:00 PM	Homework (2 hours per evening)

9:30 PM	Rest
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COURSE POLICIES

This section is meant to remind you of the policies in effect for this course. Most of these are University-wide policies, explained in more detail in either the Student Handbook or the University Catalog's Academic Policy section, available online at <https://students.mum.edu/student-handbook/> or <https://students.mum.edu/catalogs> . If you're unsure how a policy works, feel free to discuss it with me after class.

Development of consciousness component for each class

The Development of Consciousness component in each class includes:

- A 15-minute group meditation in the classroom before lunch, Monday–Saturday.
- At the end of class Monday–Friday:
 - **Meditators** stay for a 20-minute group meditation with class. This is part of each class — five group meditations per week. Because group meditation is part of each class, attendance will be recorded in the same way it is for other parts of the class day.
 - **Sidhas** are excused at 2:45 pm to attend early or evening program in the Domes or flying halls on campus at least 5 times a week. This is part of the homework for each class.
- A group TM-checking before lunch sometime during the course.

All students are encouraged to do their 20-minute morning meditation each day before they come to class. One option is to attend the group meditation in Dalby Hall before breakfast. The 15-minute group meditation before lunch is a special bonus available to students here. Students who practice the TM-Sidhi program are encouraged to join group practice in the Golden Domes as often as possible.

Attendance

Students are expected to attend all class sessions. Much of the value of a university course comes from your class experiences. These experiences can't be made up in other ways or evaluated through quizzes, papers, or exams. For this reason, we highly value attendance at MUM.

Absences are either excused or unexcused:

- An *excused absence* is defined as an absence due to illness or family emergency, including childcare, or medical appointments that cannot be scheduled outside of class hours.
- All other absences are *unexcused*.

Whether the absence is excused or unexcused, you're responsible for all readings and all written assignments during any time you miss. In the interest of efficiency, please arrange to find out adjustments in assignments and other announcements from other classmates rather than from me, if possible. I'll be happy to give you any handouts you missed while absent.

Contact me before class if you will be absent

- In the rare event you must miss class or are sick, please contact me as soon as possible (contact information above) or send a message with a friend. If you keep me informed, I will know how you're doing and how to plan for each class.
- If you miss class without notifying me, I will assume the absence is unexcused.
- Please schedule doctor's appointments and other appointments for outside of class time.

Consequences of absences

- Unexcused absences may result in your course grade being reduced by 3 percentage points for each session missed (morning or afternoon).
- Repeated unexcused absences are a violation of the MUM Code of Student Behavior. In addition to academic consequences, students with repeated unexcused absences are subject to disciplinary actions.
- If you miss more than 6 sessions of a standard 4-unit course, even for illness or family emergency, it's likely you won't have completed enough of the coursework to be eligible for course credit. I may ask you to withdraw from the course.

Punctuality

Students are expected to arrive on time, just as in the professional world. We ask that you arrive a couple minutes early, so everyone is seated and settled when the class begins.

Punctuality also extends to returning from lunch and breaks on time.

- **Consequences of arriving late or leaving early** — A class grade may be reduced by one percentage point for every 20 cumulative minutes late (up to two points per session). This policy also applies to leaving class early.
- **If you do arrive late**, please look for the Attendance/Punctuality Registry posted in the classroom to record your late minutes (with academic honesty).

Turning in assignments late

Late homework (department policy) — Unless illness or family emergency prevents you from turning in work, you need to hand in all assignments on the day they're due. You may turn in homework one day late for a reduced grade, but not after that. Please do not turn in assignments after the end of the course without prior arrangement (see "Incomplete work" below).

"Incomplete work" at the end of the course

At the end of the course, I'll evaluate the work you've turned in according to the grading or evaluation plan announced at the start of the course. If you weren't able to complete assigned work by the end of the course *due to illness, family emergency, or other circumstances beyond your control*, you may petition me to turn in that work late for credit using a "Late Work Contract" (available at the Enrollment Center or downloadable from the MUM website — search "Late Work Contract.") For further details, please see the MUM Catalog under "Late Work Policy" in "General Policies."

Academic honor code

Personal integrity, honesty, and honor are essential qualities of a capable student, a good citizen, and a developing leader. Our Academic Honor Code sets forth the standards of academic honesty and personal integrity expected of all students for all writing assignments and exams. Abiding by the Academic Honor Code will also help you avoid questions of academic impropriety. For the full Honor Code, see the MUM Catalog and Student Handbook.

Computers and cell phones

Please turn off all cell phones at the start of class, to avoid disruptions and focus fully on the class. We'll discuss when classroom use of computers is appropriate.

Respectful classroom interaction

We enjoy a uniquely harmonious and supportive atmosphere at MUM. We honor diversity of every kind, including diversity of culture, ethnic, religion, race, gender and sexual orientation, and viewpoint. We do not tolerate racism, harassment, or abusive or disrespectful language or behavior. While we welcome all points of view, we ask that you maintain an open and supportive attitude toward your fellow classmates and university staff.

Standards of appearance

The MUM faculty seek to create a coherent, focused, and dignified atmosphere on campus and in class that supports giving and gaining knowledge. In that spirit, we encourage neat, dignified, and modest clothing appropriate to the occasion. Torn, stained, sloppy, immodest, or revealing clothing is not appropriate. Students from other cultures and traditions are welcome to wear traditional dress, provided the appearance is neat and modest.

END-OF-COURSE FEEDBACK

Please give us your feedback about the course. Near the end of the course, you should receive an email from Sonja Gobec, Director of Evaluations, that gives you a one-step login link. If you don't receive this email, you can request access by emailing Sonja at evaluations@mum.edu or go to [Smartevals.com/mum](https://smartevals.com/mum) and log in there.

- Your Username: your student ID in 000-00-0000 format.
- Your Password: your birth date in MM/DD/YY format.

How it works

- The information you enter on the online form is collected and sorted by an outside company, Gap Technologies.
- Gap Technologies prepares a report for each class that averages the numerical scores and lists your text responses anonymously.

- Your instructor receives the report *only after* turning in grades.

We're committed to continuously improving the curriculum. We value and need your feedback.

SERVICES

Student Support Services

In addition to the normal support you receive from me and your classmates, you can take advantage of extensive on-campus support services for both academic and personal support you may need at any time.

To access these services, please stop by the Student Life department (Dreier 105) between 10 a.m. and 4 p.m., Monday–Friday, or call the department administrator at 641-472-1225 for referral to the appropriate person.

Writing Center

This is an especially valuable resource for all students, for anything you may be writing.

- Location — Arts Center room 112.
- Hours — Monday–Friday 3:30 – 6 p.m. or by appointment.

To schedule an appointment, please stop by or email writingcenter@mum.edu. For questions, comments, concerns, or further information, please contact Leah Waller at ext. 5031 or lwaller@mum.edu.

