Nature of Computation

CS 212 L2
Fall Semester 2021

"Those who can imagine anything, can create the impossible." - Alan Turing

Course Information

Class Location: GF-E121
Class Meeting Time(s): Mon Thurs (11:30 AM-12:45 PM)

Course Prerequisites: CS 113,CS/MATH 113
Hardware/Software Prerequisites (if any): Computer with mic, camera, and Internet connection, a LATEX compiler, Zoom, a recent web browser
Content Area: This course is part of CS Kernel. It is required for a CS major and can be counted toward a CS minor. For other students, it can be counted as either a Free Elective, University Elective, CS Elective, or CS requirement.

Instructor Information

Instructor: Waqar Saleem
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Office Hours: Tue, Wed 11-13h

Instructor: Asma Sanam Larik
Title: NA
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Office Hours: NA

Instructor: Muhammad Abdullah Zafar
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Office Hours: na

Instructor: Asma Larik
Office Location: C-212
Email: asma.larik@sse.habib.edu.pk
Office Hours: Monday 12:30 PM to 01:30 PM

Course Description

Computation is a complex process involving the mathematical notion of computing and the hardware that realizes it. This course concerns itself with the former. Can we mathematically defne what it means to compute? Such a definition leads to an identification of problems that can be computed. More interestingly, it disqualifies certain problems, i.e. these problems are not computable. Can we ascertain beforehand for a given problem if it is computable? Are some computable problems easier than others? And for the problems that are computable, can we define machines that can compute them?

These are some of the questions whose answers we seek in this course as we dive deep into the heart of computation.

Course Aims

This course sets the theoretical foundations of computation. Where most CS courses introduce programming techniques or explore novel application areas that benefit from computation, this course examines the nature of computation itself. Students gain an appreciation of the theoretical underpinnings of computer science and the richness of the intellectual tradition that hides just below the surface of application programs. This is a mathematically intensive course and builds upon the mathematical formalism and proof techniques laid forth in CS 113.

Course Learning Outcomes (CLOs)

By the end of the course, students will be able to:

CLO	Description	Cognition
1. Languages & Automata	Categorize languages as regular, non-regular, context free, or non-context-free, and where applicable, design automata that accept these languages	Cog-6
2. Computability	Explain computability in terms of the Church-Turing thesis	Cog-2
3. Decidability	Justify the decidability of a given computational problem	Cog-5
4. Complexity	Describe the complexity of a given computational problem	Cog-5
5. Collaboration	Collaborate fruitfully on the solution, research, and presentation of problems, proofs, and techniques related to the above topics	Aff-3

Mode of Instruction

The course will be a blend of asynchronous and synchronous content. We have 2 classes per week. The first class each week will be replaced by asynchronous videos which will made available on Canvas. The second class will be a synchronous session in which we will discuss the content

presented in the videos. You are expected to come well prepared for the synchronous sessions after watching all uploaded asynchronous content.

All course resources (asynchronous videos, recorded sessions, reference books, articles and all other support material) will be made available through Canvas or the library.

Engagement, Net-etiquettes and Participation Rules

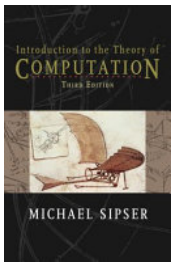
People, not boxes: In order to maintain a healthy class environment, you are encouraged to keep your camera on during synchronous online sessions. In case of extenuating circumstances that prevent you from doing so, you must communicate them to your instructor beforehand over Canvas.

Names: Please make sure that your name on Zoom is the same as it appears on Canvas. We might not be able to mark your attendance otherwise.

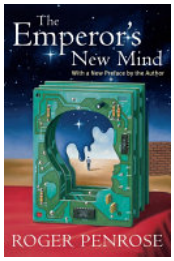
Communication: All official course communication will take place over Canvas. It is your responsibility to stay up to date with it.

Discussion forum: Assessments will be accompanied by corresponding discussion threads on Canvas. For topics of tangential relevance to the course, or other interesting topics or content relating to the course, you are encouraged to use the course discussion forum on Yammer.

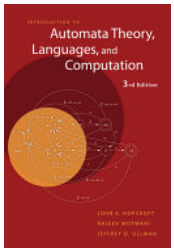
Required Texts and Materials



Introduction to the Theory of Computation
ISBN: 9781133187790
Edition: 3rd
Authors: Michael Sipser
Publisher: Cengage Learning
Publication Date: 2012-06-27



The Emperor's New Mind
ISBN: 9780192861986
Authors: Roger Penrose
Publisher: Oxford Paperbacks
Publication Date: 1999-03-04



Introduction to Automata Theory, Languages, and Computation
Authors: John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman
Publisher: Pearson
Publication Date: 2007-01-01

Assessments

Assessment	Weightage	Frequency
Homework	30%	4
Quizzes	35%	
Weekly Feedback	15%	
Recitation	5%	
Creative Expression	15%	1

Late Submission Policy

Please respect deadlines. Submit your work by the indicated time. Incomplete work will receive partial credit, late work will receive no credit.

Please observe the deadline prescribed for each assessment. There is no late submission policy. It is better to submit partial work on time and receive partial credit than to submit complete work late and receive no credit. In order to avoid last minute emergencies, e.g. power failure close to the deadline, start your work early and aim to finish it in advance of the deadline. We will mostly be using automated tools which time-stamp your submission or simply block submission after the deadline. Please be mindful of deadlines and discuss with your instructor beforehand if you foresee any issues.

Academic Integrity

Each student in this course is expected to abide by the Habib University Student Honor Code of Academic Integrity. Any work submitted by a student in this course for academic credit will be the student's own work.

Scholastic dishonesty shall be considered a serious violation of these rules and regulations and is subject to strict disciplinary action as prescribed by Habib University regulations and policies. Scholastic dishonesty includes, but is not limited to, cheating on exams, plagiarism on assignments, and collusion.

a. Plagiarism: Plagiarism is the act of taking the work created by another person or entity and presenting it as one’s own for the purpose of personal gain or of obtaining academic credit. As per University policy, plagiarism includes the submission of or incorporation of the work of others without acknowledging its provenance or giving due credit according to established academic practices. This includes the submission of material that has been appropriated,// bought, received as a gift, downloaded, or obtained by any other means. Students must not, unless they have been granted permission from all faculty members concerned, submit the same assignment or project for academic credit for different courses.
b. Cheating: The term cheating shall refer to the use of or obtaining of unauthorized information in order to obtain personal benefit or academic credit.
c. Collusion: Collusion is the act of providing unauthorized assistance to one or more person or of not taking the appropriate precautions against doing so.

All violations of academic integrity will also be immediately reported to the Student Conduct Office.

You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else, in the form of an e-mail, an e-mail attachment file, a diskette, or a hard copy.

Should copying occur, the student who copied work from another student and the student who gave material to be copied will both be in violation of the Student Code of Conduct.

During examinations, you must do your own work. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

Penalty for violation of this Code can also be extended to include failure of the course and University disciplinary action.

For this course, collaboration is allowed in the following instances: Homework assignments and Creative Expression.

Final Exam Policy

Final Exam is not included in assessments.

Grading Scale

Letter Grade	GPA Points	Percentage
A+	4.00	[95-100]
A	4.00	[90-95)
A-	3.67	[85-90)
B+	3.33	[80-85)
B	3.00	[75-80)
B-	2.67	[70-75)
C+	2.33	[67-70)
C	2.00	[63-67)
C-	1.67	[60-63)
F	0.00	[0, 60]

Note: [a, b) is a range of numbers from a to b where a is included in the range and b is not.

Week-Wise Schedule (Tentative)

Fall 2021 Weekly Schedule*

Week	Description	Topic(s)	Reading	Assessments & Activities
Week - 1 August 30 – September 3	Sessions & Add / Drop period	**Introduction** Course syllabus CS 113 Recap	Syllabus Chapter 0	Buddy preference form out
Week - 2 September 6 – 10	Sessions Last day to Drop Course(s): **September 18, 2021** Last day to Add Course(s): **September 10, 2021**	**Finite Automata** Deterministic Finite Automata Regular Operations	Chapter 1	Buddy preference form due Buddy allocation out

Week	Description	Topic(s)	Reading	Assessments & Activities
Week - 3 September 13 – 17 & 18	Sessions	**Finite Automata** Non-deterministic Finite Automata Equivalence of NFA and DFA Closure under regular operations	Chapter 1	HW 1 out Creative Expression topics out
Week - 4 September 20 – 24	Sessions	**Regular Expressions** Regular expressions Equivalence with FA	Chapter 1	
Week - 5 September 27 – October 1 & 2	Sessions Arbaeen/Chehlum Imam Hussain†‡: **September 28, 2021**	**Nonregular Languages** Nonregular languages Pumping lemma for RLs	Chapter 1	HW 1 due SEL: Weeks 1 to 4 out Creative Expression meetings 1
Week - 6 October 4 – 8	Sessions	**Context-Free Languages** Context-free grammars Chomsky normal form	Chapter 2	HW 2 out Creative Expression meetings 1
Week - 7 October 11 – 15	Sessions & Mid Term Examinations	**Pushdown Automata** Pushdown automata Equivalence with CFG	Chapter 2	
Week - 8 October 18 – 22	Sessions & Mid Term Examinations 12th Rabi-ul-Awwal†‡: October 19, 2021	**Non-Context-Free Languages** Non-context-free languages Pumping lemma for CFLs	Chapter 2	HW 2 due
Week - 9 October 25 – 29	Sessions	**Church-Turing thesis** Turing machines	Chapter 3	HW 3 out SEL: Weeks 5 to 8 out
Week - 10 November 1 – 5 & 6	Sessions	**Church-Turing thesis** Variants of Turing machines Definition of "algorithm"	Chapter 3	Creative Expression meetings 2
Week - 11 November 8 – 12	Sessions	**Decidability** Decidable languages Decidable problems	Chapter 4	HW 3 due Creative Expression meetings 2
Week - 12 November 15 – 19 & 20	Sessions Last Day to Withdraw from Course(s): **November 19, 2021**	**Undecidability** The diagonalization method An undecidable language A Turing-unrecognizable language	Chapter 4	HW 4 out
Week - 13 November 22 – 26	Sessions	**Time Complexity** Standard notation Analyzing algorithms Complexity models	Chapter 7	Creative Expression meetings 3 SEL: Weeks 9 to 12 out
Week - 14 November 29 – December 3 & 4	Sessions	**Time Complexity** P and NP classes The Cook-Levin theorem **Conclusion** Reflections on the course	Chapter 7	Creative Expression meetings 3

Week	Description	Topic(s)	Reading	Assessments & Activities
Week - 15 December 6 - 10	Sessions			
December 7 – 11 & 13 – 15, 2021	End Term Examinations Days§			Creative Expression sessions

Notes:

* The University reserves the right to correct typographical errors or to adjust the Academic Calendar at any time it deems necessary.

† Subject to the sighting of the new moon.

‡ No Class(es).

Attendance Policy

For the period when the course is online, you are expected to watch all the asynchronous videos and attend all the synchronous classes. Attendance will be marked. However, you may notify your instructor on Canvas beforehand or up to an hour later if you miss a class. Otherwise, you will be marked absent. Note that simply logging on or sitting idly in class does not count as being present. You will be marked present if we can recall your participation after class. As described in Section 7, attendance lower than 85% will impact your SEL and cause you to be reported to OAP. This policy will be updated once classes resume in person.

Program Learning Outcomes (For Administrative Review)

Upon graduation, students will have the following abilities:

- PLO 1: Analysis: Analyse a given situation and reduce it to one or more problems that can be solved via computer intervention.
- PLO 2: Design: Design one or more computer-based solutions of a given problem and select the solution that is best under the circumstances.
- PLO 6: Self-learning: Research, learn, and apply requirements needed to implement a solution for a given high level problem description.
- PLO 8: Communication and Teamwork: Work effectively in inter-disciplinary teams.

Program Learning Outcomes (PLOs) mapped to Course Learning Outcomes (CLOs)					
	CLOs of the course are designed to cater following PLOs: **PLO 1: Analysis** **PLO 2: Design** **PLO 6: Self-learning** **PLO 8: Communication & Teamwork**				
	Distribution of CLO weightages for each PLO				
	CLO 1	**CLO 2**	**CLO 3**	**CLO 4**	**CLO 5**
PLO 1	25%	25%	25%	25%	
PLO 2	25%	25%	25%	25%	
PLO 6					100%
PLO 8					100%

Mapping of Assessments to CLOs

Assignments	CLO #01	CLO #02	CLO #03	CLO #04	CLO #05

Recording Policy

As per HU's teaching policy during Covid-19, all synchronous and synchronous sessions will be recorded and uploaded on our Video Management System (Panopto). Link to the folder of recordings will be available to all students.

Accommodations for Students with Disabilities

In compliance with the Habib University policy and equal access laws, I am available to discuss appropriate academic accommodations that may be required for student with disabilities. Requests for academic accommodations are to be made during the first two weeks of the semester, except for unusual circumstances, so arrangements can be made. Students are encouraged to register with the Office of Academic Performance to verify their eligibility for appropriate accommodations.

Inclusivity Statement

We understand that our members represent a rich variety of backgrounds and perspectives. Habib University is committed to providing an atmosphere for learning that respects diversity. While working together to build this community we ask all members to:

- share their unique experiences, values and beliefs
- be open to the views of others
- honor the uniqueness of their colleagues
- appreciate the opportunity that we have to learn from each other in this community
- value each other's opinions and communicate in a respectful manner
- keep confidential discussions that the community has of a personal (or professional) nature
- use this opportunity together to discuss ways in which we can create an inclusive environment in this course and across the Habib community

Office Hours Policy

Every student enrolled in this course must meet individually with the course instructor during course office hours at least once during the semester. The first meeting should happen within the first five weeks of the semester but must occur before midterms. Any student who does not meet with the instructor may face a grade reduction or other penalties at the discretion of the instructor and will have an academic hold placed by the Registrar's Office.

Assessments and Grading

We will use multiple types of assessments in this course. Several of them will require collaboration with one or more buddies from your class. Your score in each assessment category will contribute differently to your eventual grade.

Quizzes: Every week's content will be accompanied by several short quizzes on Canvas. These will be released by the end of the week and you will typically be allowed unlimited attempts on them over the following week. Quizzes may not be released in some weeks depending on other concurrent course work at the time.

Quizzes will be attempted individually.

Homework Assignments: These will be larger problem sets comprising more challenging and lengthier questions. You will have at least two weeks to attempt each. Release and submission of homework assignments will take place through GitHub and typesetting will be done using LATEX. Homework assignments will be attempted in teams and you will submit feedback on the your buddies' contribution along with your team's solution to the problem set. Further instructions will be contained in the assignment prompt.

Weekly Feedback: A short questionnaire will be released on Canvas every Friday to ask you to reflect on the course and relate your experience with the course content that week. You will have till Sunday midnight to attempt the weekly feedback. Weekly feedback is to be provided individually.

Creative Expression: We will unbridle our creativity to express our ideas about topics relating to theoretical computer science. These will be shared early in the semester and you will meet your instructor several times in the semester to report on your chosen topic and creative expression. You will share your final expression with the class at the end of the semester. Creative expression will be attempted in teams and you will submit feedback on your buddies' contribution after the session. Further instructions will be contained in the assessment prompt.

Recitation: Recitations will be held weekly and will provide practice and insight into the course topics currently under discussion. You are required to attend and actively participate in your recitation.

Recitations will be scored individually.

SEL: Your Student Engagement Level (SEL) score will be released every four weeks. It is based on your attendance in the synchronous sessions and the successful submission of all the assessments over that period. Note that your SEL score is independent of your score in the assessments. Your SEL score is binary, 0 or 1. If your attendance and submissions over the SEL period are 85% or above, your score will be 1, otherwise it will be 0, in which case you will be reported to OAP. SEL does not contribute to your grade directly. But if you are missing classes and missing submissions, your grade will inevitably suffer. SEL score is computed for you individually.

Team Work: You will submit your buddy preference based on which you will be assigned your buddies early in the semester. Do your part in the team. Your contribution to team assessments will be assessed through your buddies' feedback and, where applicable, through GitHub. It will be factored into your score.

Format and Procedures

This is a mathematically intensive course and builds upon the formalism and proof techniques covered in CS 113. You are encouraged to be attentive in lectures and do the assignments and readings in a timely manner. The instructors will make all efforts to closely follow the course textbook

so that you have a ready reference. Make sure to avail course staff's student hours (see Section 12) immediately if you feel yourself falling behind.

This is a 3 credit hour course. The rule of thumb for out-of-class time for a course is at least 2 hours of work outside class for every credit hour. This may vary based on your comfort with mathematics and capacity to absorb and apply abstract ideas. You must attend your weekly recitation which will provide deeper insight into the topics covered that week through practice problems.

Time Journal You are encouraged to maintain a journal to record the time that you spend on this course. This includes the time you spend watching asynchronous videos, attending live sessions, doing any background work, attempting the home- work, filling the weekly feedback form, completing any other required forms, and so on. In short, any activity that you perform related to this course.

Consultation Please utilize the student hours of the course staff in order to discuss course related matters and queries.

Viva Submission of homework assignments is in teams and may be followed up by a team viva called by the instructor. A viva will be called as necessary and need not apply to all groups or all assessments.

Contesting marks Concerns regarding a score can be reported up to a week after its release. Concerns raised later cannot be entertained.

Grace marks Requests for grace marks for whatever reason will not be entertained and each such request will result in a penalty of 1% from your overall score.

Behavior You are expected to maintain a behavior betting Yohsin and acknowledging

the classroom as a place of learning, exploration, and experimentation. The Uni-

versity's standard policies on attendance, inclusivity, student hours, and academic

integrity apply in this course. These are described further below.

Saturdays Classes are scheduled for ve Saturdays this semester in order to make up

for the missing week. We will accommodate these classes through our regular

asynchronous videos and no extra sessions will be held on Saturdays.