CSCI 310-01: Advanced Algorithms

TR 9:55 am-11:10am in HWW 217A
Fall 2020

Instructor: Dr. Kris Ghosh, HWE 315, *ghoshk@cofc.edu*
Office hours: TBD

Catalog description: A course that covers algorithms, focusing on computational complexity, approximation, classification, and optimization. Algorithms covered include evolutionary and genetic algorithms, gradient descent techniques, discrete optimization, branch-and-bound, dynamic and stochastic programming, combinatorial optimization, and approximation algorithms.

Course objective: To expose students to a variety of techniques for designing and analyzing algorithms as illustrated on problems that have practical, pedagogical and theoretical origins.

Textbook:
The Design and Analysis of Algorithms, 3rd edition, Anany Levitin, Pearson, 2012, ISBN 13: 978-0-13-231681-1.

References:
1.Algorithms Design by Jon Kleinberg and Eva Tardos.
Through Open Text book
2. Discrete Mathematics, Oscar Levin http://discrete.openmathbooks.org/dmoi3.html
3. Foundations of Combinatorics with Applications by E,Bender and Williamson.
http://www.math.ucsd.edu/~ebender/CombText/
4.Book of Proof, Richard Hammack Third Edition.
http://www.people.vcu.edu/~rhammack/BookOfProof/

Other resources: Can be found in the library or online. Reading different explanations or views of the same technique may be helpful. Additional Material will be uploaded in the Reading section on OAKS.

Class policies:
- Attend every class and arrive on time (including online). Stay until the end of class, if you know you must leave early, please let me know before class, unless an emergency arises.
- Participate in class discussions inside and out of the classroom or online class. Students will be asked to present problems in-class or online on Zoom.
- Due to social distancing requirements, this class will include a variety of online and technology enhanced components to reinforce continuity of learning for all enrolled students. Before the drop/add deadline, students should decide whether the course plan on the syllabus matches their own circumstances.
- Video of the online-lectures will be made available for the students.
- Students are expected to study assigned materials before coming to class or online.
- Students are expected to have the camera on the laptop to be switched on. Students not abiding by this policy will be awarded no points.

- The course treats Zoom just like a classroom. For any meeting that you attend, be sure to: Participate from a quiet space (e.g., your room) where can you listen and speak. If you participate from a more public space (e.g., a classroom, conference room, dining hall, or the like), just be sure you won't be approached or disturbed by others while there. Be sure to participate with your camera turned on, using horizontal video*.

Exercises/homework:
- Homeworks, programming assignments, and exams will be independent efforts, unless specified otherwise. If in doubt, ask the instructor.

Grading:

Midterm Exams (2 Exams) (2 × 20%)	40%
Final Exam *(Comprehensive)*	25%
Homework Assignments	15%
Quizzes (Pop/Announced)	10%
Attendance	5%
Participation and Scribes	5%

- Top 70% of the total Quizzes will be considered for final grades. For example, if there are 9 quizzes, then top 6 quiz scores will be considered.
- There will be 3 tests (2 Midterms and Final), tentative dates for the midterms will be posted. Tests will be online only if the school has online learning.
- Cumulative final exam, scheduled by CofC (Check the schedule for finals)
- There will no makeup quizzes. There has to be documentation for makeup exams.
- Assignments will be accepted electronically **only**.
- Attendance will be taken everyday. The weight of attendance on the final grade is: 5%: 0 absences · 4%: 1 absence · 3%: 2 absences · 0%: 3+ absences
- Online attendance: We will use Zoom this semester to connect remotely with students in the class. In order to join our class remotely, you will need to register.
- Discussion will include presenting homework problems or problems assigned by instructor. It may include individual or group presentations.
- Students will be selected at least a day before the lectures for taking scribes for the lecture.
- Participation will be evaluated by the questions asked and presentation of the solution of assigned problems.

*https://cs50.harvard.edu/college/2020/spring/zoom/

The grade-score table.

A	90-100
B+	85-89

B	80-84
C+	75-79
C	70-74
D+	65-69
D	60-64
F	0-59

Learning outcomes:

- Analyze the **time complexity of a non-recursive algorithm** using a general analysis framework that includes: 1) identify the input size (n), 2) identify the basic operation, 3) determine if a best-case, worst-case, or average-case condition exists, 4) setup a sum expressing the number of times the basic operation is executed, and 5) find closed form solution using summation identities and report time complexity *using Big-O, Big-Theta, and Big-Omega notation*.

- Analyze the **time complexity of a recursive algorithm** using a general analysis framework that includes: (1) identify the input size (n), (2) identify the basic operation, (3) determine if a best-case, worst-case, or average-case condition exists, (4) setup a recurrence relation, with appropriate initial condition, for the number of times the basic operation is executed, and (5) find closed form solution by solving recurrence relation (using a backward or forward substitution technique, or in the case of divide-and-conquer algorithms using the master theorem) and report time complexity *using Big-O, Big-Omega, and Big-Theta notation*.

- Define and analyze basic **complexity theory** concepts such as Class-P, Class-NP, and NP-completeness. This include analyzing classic backtracking (such as subset sum and Hamiltonian) and branch-and-bound (such as knap sack and traveling salesman) problems and how complexity theory can approximate these NP-hard problems.

- Review the **Graph ADT** and then design, write a program, test the program, and analyze the program for the following concrete data structures: (1) undirected graph (2) directed graph.

- Write programs that perform the following **dynamic programing algorithms** on List or Graph data structures: (1) Longest common subsequence and (2) all pairs shortest path (Floyd and/or Warshall). For each algorithm analyze the time complexity using Big-O, Big-Theta, or Big-Omega.

- Write programs that perform the following **divide-and-conquer**: (1) Strassen's matrix multiplication or (2) convex hall. For each algorithm analyze the time complexity using Big-O, Big-Theta, or Big-Omega.

- Write programs that perform the following **greedy algorithms**: (1) For each algorithm analyze the time complexity using Big-O, Big-Theta, or Big-Omega.

- String Algorithms: (I) Naïve Pattern Matching Algorithms (2) Knuth-Morris-Pratt Algorithm (3) Boyer-Moore String Matching Algorithm. Analyze the time complexity of each algorithm.

- Approximation Algorithms: (1) The Traveling Salesman Problem (2) Bin Packing or The Steiner Tree Problem. Analyze the time complexity.

- Randomized Algorithms: (1) Randomized Linear Search or QuickSort (2) Monte Carlo and Las Vegas Algorithm. Analyze the time complexity

Disability Accommodation:

Any student who feels that he or she may need an accommodation because of a disability should contact me individually to discuss your specific needs. Please contact the College of Charleston, Center for Disability Services http://disabilityservices.cofc.edu/ for additional help.

How to report an Absence:

Student should come to 67 George Street to discuss absences and fill out the appropriate forms. Student will need documentation for health, personal and emergency situations. Athletic Teams or School-sponsored trips will have documented list of students participating on letterhead as early in the semester as we get the information from the organization. We would like all information on scheduled outings to reach at least two full weeks in advance. We will then turn the information back to the coach or advisor.

Academic Integrity:

Lying, cheating, attempted cheating, and plagiarism are violations of our Honor Code that, when identified, are investigated. Each incident will be examined to determine the degree of deception involved. Incidents where the instructor determines the student's actions are related more to a misunderstanding will be handled by the instructor. A written intervention designed to help prevent the student from repeating the error will be given to the student. The intervention, submitted by form and signed both by the instructor and the student, will be forwarded to the Dean of Students and placed in the student's file.

Cases of suspected academic dishonesty will be reported directly by the instructor and/or others having knowledge of the incident to the Dean of Students. A student found responsible by the

Honor Board for academic dishonesty will receive a XF in the course, indicating failure of the course due to academic dishonesty. This grade will appear on the student's transcript for two years after which the student may petition for the X to be expunged. The student may also be placed on disciplinary probation, suspended (temporary removal) or expelled (permanent removal) from the College by the Honor Board.

Students should be aware that unauthorized collaboration--working together without permission--is a form of cheating. Unless the instructor specifies that students can work together on an assignment, quiz and/or test, no collaboration during the completion of the assignment is permitted. Other forms of cheating include possessing or using an unauthorized study aid (which could include accessing information via a cell phone or computer), copying from others' exams, fabricating data, and giving unauthorized assistance.

Research conducted and/or papers written for other classes cannot be used in whole or in part for any assignment in this class without obtaining prior permission from the instructor.

Students can find the complete Honor Code and all related processes in the Student Handbook at http://studentaffairs.cofc.edu/honor-system/studenthandbook/index.php.

Tentative Schedule

Topics	Duration
Algorithm Analysis	1 week
Non Recursive and Recursive Analysis	2 week
Search and Sorting	2 weeks
Dynamic Programming	1.5 week
Graph Algorithms	2 weeks
P,NP and Approximation Algorithms	2 weeks
String Algorithms	1.5
Approximation Algorithms	1 week
Randomized Algorithms	1 week.

IX. Disability Accommodation:
Any student who feels that he or she may need an accommodation because of a disability should contact me individually to discuss your specific needs. Please contact the College of Charleston, Center for Disability Services http://disabilityservices.cofc.edu/ for additional help.

X. How to report an Absence:
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XI. Academic Integrity:

Lying, cheating, attempted cheating, and plagiarism are violations of our Honor Code that, when identified, are investigated. Each incident will be examined to determine the degree of deception involved. Incidents where the instructor determines the student's actions are related more to a misunderstanding will be handled by the instructor. A written intervention designed to help prevent the student from repeating the error will be given to the student. The intervention, submitted by form and signed both by the instructor and the student, will be forwarded to the Dean of Students and placed in the student's file.
Cases of suspected academic dishonesty will be reported directly by the instructor and/or others having knowledge of the incident to the Dean of Students. A student found responsible by the Honor Board for academic dishonesty will receive a XF in the course, indicating failure of the course due to academic dishonesty. This grade will appear on the student's transcript for two years after which the student may petition for the X to be expunged. The student may also be placed on disciplinary probation, suspended (temporary removal) or expelled (permanent removal) from the College by the Honor Board.
Students should be aware that unauthorized collaboration--working together without permission-- is a form of cheating. Unless the instructor specifies that students can work together on an assignment, quiz and/or test, no collaboration during the completion of the assignment is permitted. Other forms of cheating include possessing or using an unauthorized study aid (which could include accessing information via a cell phone or computer), copying from others' exams, fabricating data, and giving unauthorized assistance. Research conducted and/or papers written for other classes cannot be used in whole or in part for any assignment in this class without obtaining prior permission from the instructor. Students can find the complete Honor Code and all related processes in the Student Handbook at http://studentaffairs.cofc.edu/honor-system/studenthandbook/index.php.

XII. Honor Code and Academic Integrity:

Lying, cheating, attempted cheating, and plagiarism are violations of our Honor Code that, when identified, are investigated. Each incident will be examined to determine the degree of deception involved.

Incidents where the instructor determines the student's actions are related more to misunderstanding and confusion will be handled by the instructor. The instructor designs an intervention or assigns a grade reduction to help prevent the student from repeating the error. The response is recorded on a form and signed both by the instructor and the student. It is forwarded to the Office of the Dean of Students and placed in the student's file. Cases of suspected academic dishonesty will be reported directly by the instructor and/or others having knowledge of the incident to the Dean of Students. A student found responsible by the Honor Board for academic dishonesty will receive a XXF in the course, indicating failure of the course due to academic dishonesty. This status indicator will appear on the student's transcript for two years after which the student may petition for the XX to be expunged. The F is permanent.

Students can find the complete Honor Code and all related processes in the *Student Handbook* at http://deanofstudents.cofc.edu/honor-system/studenthandbook/index.php

XIII. Disability/Access Statements:

1. The College will make reasonable accommodations for persons with documented disabilities. Students should apply for services at the Center for Disability Services/SNAP located on the first floor of the Lightsey Center, Suite 104. Students approved for accommodations are responsible for notifying me as soon as possible and for contacting me one week before accommodation is needed.

2. This College abides by section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act. If you have a documented disability that may have some impact on your work in this class and for which you may require accommodations, please see an administrator at the Center of Disability Services/SNAP, 843.953.1431 or me so that such accommodation may be arranged.

Statement on "Religious Accommodation for Students"
([Faculty/Administration Manual VIII.A.10](#))

The College of Charleston community is enriched by students of many faiths that have various religious observances, practices, and beliefs. We value student rights and freedoms, including the right of each student to adhere to individual systems of religion. The College prohibits discrimination against any student because of such student's religious belief or any absence thereof.

The College acknowledges that religious practices differ from tradition to tradition and that the demands of religious observances in some traditions may cause conflicts with student schedules. In affirming this diversity, like many other colleges and universities, the College supports the concept of "reasonable accommodation for religious observance" in regard to class attendance, and the scheduling of examinations and other academic work requirements, unless the accommodation would create an undue hardship on the College. Faculty are required, as part of their responsibility to students and the College, to ascribe to this policy and to ensure its fair and full implementation.

The accommodation request imposes responsibilities and obligations on both the individual requesting the accommodation and the College. Faculty members are expected to reasonably accommodate individual religious practices. Examples of reasonable accommodations for student absences might include: rescheduling of an exam or giving a make-up exam for the student in question; altering the time of a student's presentation; allowing extra-credit assignments to substitute for missed class work or arranging for an increased flexibility in assignment dates. Regardless of any accommodation that may be granted, students are responsible for satisfying all academic objectives, requirements and prerequisites as defined by the instructor and by the College.

2020 – 2021 Religious Holidays[1]

Date	Holiday	Religion
September 18 2020	Rosh Hashanah[2]	Jewish
September 28, 2020	Yom Kippur[2]	Jewish
October 2 – October 9, 2020	Sukkot[2]	Jewish
October 9, 2020	Shemini Atzeret[2]	Jewish
October 19 - October 26, 2020	Navaratri	Hindu
October 19, 2020	Birth of Baha'u'llah	Baha'i
January 7, 2021	Christmas[3]	Orthodox Christian
February 17, 2021	Ash Wednesday (Beginning of Lent)	Christian
February 25-26, 2021	Purim[2]	Jewish
March 15, 2021	Great Lent Begins	Christian
March 20, 2021	Naw-Ruz	Baha'i
April 2, 2021	Good Friday	Christian
March 26 - April 3, 2021	Passover[2]	Jewish
April 12-May 11, 2021	Ramadan	Muslim
April 30, 2021	Good Friday (Orthodox)[3]	Orthodox Christian
April 20 and 28, 2021	Ridvan	Baha'i

[1] The previously included Islamic holiday of Eid al-Adha falls outside the regular academic year and is therefore not listed here.

[2] All Jewish holidays begin at sunset on the evening before the date given.

[3] Orthodox Christian holidays begin at sunset on the evening before the date given.

Center for Student Learning:

The Center for Student Learning's (CSL) academic support services provide assistance in study strategies, speaking & writing skills, and course content. Services include tutoring, Supplemental Instruction, study skills appointments, and workshops. Students of all abilities have become more successful using these programs throughout their academic career and the services are available to you at no additional cost. For more information regarding these services please visit the CSL website at http://csl.cofc.edu or call (843) 953-5635.

Financial Challenges:

If a student has difficulty affording groceries or getting sufficient food to eat every day, or who lacks a safe and stable place to live, and believes this may affect their performance in the course, please contact the Dean of Students for support. Furthermore, please notify Professor ABC if you are comfortable in doing so. This will enable the student to assist with identifying available resources.

Weather:

If the College of Charleston closes and members of the community are evacuated due to inclement weather, students are responsible for taking course materials with them in order to continue with course assignments consistent with instructions provided by faculty. In cases of extended periods of institution-wide closure where students have relocated, instructors may articulate a plan that allows for supplemental academic engagement despite these circumstances.