MATH/ECE 430 Fourier and Wavelet Analysis with Apps[*]

Instructor: Emily J. King

Spring 2021

Just as you can't become a marathon runner by watching marathons on TV, likewise for science, you have to go through the thought processes of doing science and not just watch your instructor do it.
– Eric Mazur (physicist at Harvard, quoted by Sara Rimer in a New York Times article on changing methods in teaching physics)

This syllabus is filled with critical information. Please carefully read it.

Before the start of the course, please fill out the online questionnaire: `https://docs.google.com/forms/d/e/1FAIpQLSdqqiWDPT_WFb7NdLBQ7G1mXDbQsRYogVabzLpfWJPXxoEiFg/viewform?usp=sf_link`

Contents

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[*]Last updated February 8, 2021.

1 How to Contact Me

Email: emily.king@colostate.edu
Office hours: Tuesdays 1:00–2:00 pm MT, Fridays 11:00–12:00 MT, or by appointment
Gather.town https://gather.town/app/V5k5YRFzl3bzrmeO/DrKingCSU (Password: FFT)
What to call me: Dr. King
Pronouns: she, her, hers

2 Formalities

Lecture times: Tuesdays 8:00–9:15 a.m. MT, Thursdays 11:00 a.m.–12:15 p.m. MT
Lecture locations for MATH 430.001 and ECE 430.001 January 26–April 8: We-

ber 202 (Tuesdays), ENGR 204 (Thursdays)

Online lecture links:

`https://us02web.zoom.us/j/82513990330?pwd=eCtQMUFoMlFaMVVZMOFmZkJBZ3RlUTO9`
Alternatively, call +14086380968 and enter the meeting ID 82513990330 and password
170952. During some online lectures, we will use the following Jamboard
`https://jamboard.google.com/d/1NOr73hnSHrHqGIoRfsQamw052cXdgeacnVIf8YhWRvo/edit?`
`usp=sharing` with Zoom.

3 Course Description

This course concerns the fundamental theory and applications of Fourier and wavelet analysis. Some of the topics include Fourier series/discrete Fourier transform; the fast Fourier transform; continuous Fourier transform; Fourier transforms over various function spaces like L^1, L^2, and tempered distributions; uncertainty principles; the Poisson summation formula; aliasing; wavelet transforms and multiresolution analysis; as well as applications of these topics.

4 Course Materials

The main textbook is *Fourier Analysis and Applications: Filtering, Numerical Computation, Wavelets* by Claude Gasquet and Patrick Witomski and published by Springer-Verlag New York. If you do not need a print version, then you may download it for free from the CSU library. PLEASE ONLY DOWNLOAD IT ONCE AND SAVE IT LOCALLY.

I will also upload supplementary materials to Canvas when necessary.

5 Grading

The breakdown of the course score, with each category explained further below, is 70% for homework and 30% for the final paper and presentation.

If you earn 90% or more of the points, then you will certainly earn at least an 'A-'; if you earn at least 80% of the points, then you will certainly earn at least a 'B-'; and so on. Depending on the actual distribution of the grades, the cut-off scores may be slightly lower. The cut-off scores are completely at my discretion.

Grades will be entered as soon as possible into Canvas.

5.1 Homework (HW) 70%

There will be no quizzes or exams in this course. Rather, the homework assignments will serve as the assessment of the skills learned. **Homework will be due each Friday at 1:00 p.m. MT**, starting on January 29 and ending on May 14 (i.e., during exam week).

5.1.1 Material Covered

The material covered on each assignment will be from the previous week or earlier. E.g., The assignment due on January 29 will cover the material from the lectures held on January 19 and 21. In particular, there will always be two office hours between when the material was presented and when the HW on the material is due. In total, there will be 15 homework assignments. The 5th, 10th, and 15th assignments will be worth twice as many points as the other assignments and will be comprehensive, i.e., cover material since the beginning of the course.

5.1.2 Mandatory HW Discussion Meetings

You will also be required to meet with me (over Zoom or gather.town) for 10 minutes each meeting twice during the semester to discuss your homework solutions. **The first discussion meetings will be by appointment March 8, all day; March 9, 1:00–2:00 p.m.; March 10 all day; March 12, 2:00 p.m.-5:00 p.m.** During those meetings, we will discuss your solutions to HW 1–5. **The second discussion meetings will be by appointment April 20, 1:00–2:00 p.m.; April 21 all day; April 22, 11 a.m.–Noon.** During those meetings, we will discuss your solutions to HW 6–10. These meetings are worth 50 points each. The goal is to have discussions about your solutions, not to be an oral exam. So you should prepare for the meetings by looking over your graded HW solutions.

5.1.3 Types of HW Questions

In addition to standard math questions, where you must work out an exact solution, there will also be a few problems which may be worked out on the computer. You may use Matlab/Octave, Python, or R to work those problems. I will upload information (or links to such information) concerning pertinent commands to Canvas when appropriate. If you do not have experience with any of those languages, let me know.

Each week, you will also be asked to write at least one complete sentence about something that you are still struggling with or something that you learned and found to be interesting.

5.1.4 Grading and Scoring

It is my goal to grade the HW assignments by the start of the Tuesday lecture following the due date. If it looks like it will take longer than that, I will notify you during my weekly

announcements.

Each of the HW assignments except for the 5th, 10th, and 15th will be worth 50 points each. The 5th, 10th, and 15th will be worth 100 points each. The questions asking you to write at least one complete sentence about something that you are still struggling with or something that you learned and found to be interesting will be worth 5 points. Thus these "free" points are worth more than dropping an assignment. The lowest assignment will not be dropped, in part because we will not have any quizzes or exams.

To get full credit, you must justify your answer. This also makes it easier for me to give you partial credit if your final answer is wrong but methods are correct. For the questions where you may use a computer, "showing your work" means giving the commands used.

5.1.5   Submission of Assignments

Each set of HW solutions should be uploaded as a single PDF or DOCX file to Canvas by the deadline. First click on the Assignments tab, and then click on the appropriate assignment from the list. On the next page, there will be a button titled Submit Assignment. Click on that and follow the instructions to upload your HW file. I will also accept physical copies handed in during either of the lectures before the due date.

Last year, I collected information on various methods of creating files for math HW submission, which you may find here:
`https://docs.google.com/document/d/1qnus9qdc3dchnMWdCCKKg4NYOC2RawKPQB7xkwTdkYO/edit?usp=sharing` If you have another method that you would like to share, please let me know so that I may add it to the list.

5.1.6   Collaboration with Other Students / Definition of Cheating

I encourage you to discuss the HW questions not only with me during office hours but also with other students. Discussion with others helps you learn the material better. However, simply copying solutions from other students will be considered academic dishonesty. It is also considered cheating to use Chegg or any other cheating website in any manner while working on your assignments.

5.1.7   Late Assignments

If your HW is submitted x hours late due to circumstances within your control, then you will be docked $30\lceil\frac{x}{24}\rceil$ points for HW 5, HW 10, or HW 15 and $15\lceil\frac{x}{24}\rceil$ points for any of the other HW assignments. Not that $\lceil\ \rceil$ rounds a number up to the next nearest integer, e.g., $\lceil 1.1 \rceil = 2$. This means that you have up to 72 hours after the due date and time to submit for some points. I understand that things may arise that are out of your control that prevent you from submitting your HW on time. In that case, contact me as soon as possible so that I may determine whether or not to accept your HW late without a penalty.

5.2   Final Project 30%

The purpose of the HW is to help you learn the breadth of topics covered in this course. The purpose of the final project is allow you to go deeper in a topic related to this course that you find personally interesting. The final project will be worth 100 points: 35 points for the quality of the written paper, 35 points for the quality of the oral presentation, 10 points for choosing a topic on time, 10 points for providing and receiving constructive feedback to another person about the paper, and 10 points for providing and receiving constructive feedback to another person about the presentation.

5.2.1   Choosing a Topic On-Time, 10 Points

You will need to get approval from me on a topic by **April 1 at 11:00 a.m.** The topic must concern the application of Fourier or wavelet methods to some other field, like image processing, geophysics, or quantum mechanics. The topic may be covered in the lecture, but it need not be. If the topic was covered in the lecture, then the paper must contain additional information not covered in the lecture.

5.2.2   Written Paper, 35 Points

The final paper should be 5–10 pages long; a PDF file, DOCX file, or (link to a) Google Doc; font size 12; and double-spaced. The paper should have an introduction where the topic covered is properly motivated. All material coming from a third party – including images – should be properly cited *where the material appears in the paper*. There should be at least 3 sources listed. The sources should be peer-reviewed journals, (non-textbook) book chapters, or a popular science magazine articles. Sources like Wikipedia will not be considered acceptable but may be used as a starting point to find good sources. The paper should be free or almost free of grammatical and spelling errors.

See the "Online Library Resources" section of `https://lib.colostate.edu/covid-19-library-updates` for more info about using online library resources from off-campus, finding eBooks, finding journal articles, and streaming media options.

The paper must be uploaded to Canvas by **May 7 at 1:00 p.m.** Note that since another student will need to read the paper to give feedback, you need to have the paper completed well before the submission deadline.

I will upload a LATEX template to Canvas in case someone is interested in using it.

5.2.2.1   Grading Rubric
   15 points: Following the basic formatting rules: 5–10 pages long; a PDF file, DOCX file, or (link to a) Google Doc; font size 12; and double-spaced

5 points: Proper citations.

5 points: Proper spelling / grammar. Some typos and small errors are acceptable.

10 points: Overall quality of the write up. The topic should be well-motivated and well-explained. The topic should be somehow related to the course material.

5.2.3 Oral Presentation, 35 Points

The oral presentations of your papers will be held over Zoom during the time scheduled for the final exam, **May 12, 6:20–8:20 p.m.** The order of the talks will be randomly set. Each presentation should be 4–5 minutes long; thus, it will not be possible to cover all of the material of the paper. The plan is for everyone to watch each other's presentations over Zoom, using screenshare to post slides. If this is not possible due to technological issues or the time zone you live in, please let me know as soon as possible so that we may find a workaround.

The presentation should be high energy. You should make slides for the presentation (in whatever format you want: Powerpoint, Beamer, Google Slides, Keynote, Prezi, etc.) You also need to cite sources of images in your slides. The amount of text on each slide should be minimal. You should speak in a clear and strong voice and use vocal inflections to emphasize points.

5.2.3.1 Grading Rubric

15 points: Following the basic formatting rules: 4–5 minutes long; slides

5 points: Proper citations.

5 points: Proper spelling / grammar. Some typos and small errors are acceptable.

10 points: Overall quality of the talk. The talk should be high energy. The slides should be visually appealing with minimal text. You should speak in a clear and strong voice and use vocal inflections to emphasize points.

5.2.4 Providing to and Receiving from Another Person Constructive Feedback About Their Paper, 10 points

Sometime before May 7, you should read a draft of the final paper of at least one other student in the class (MATH 430.001, ECE 430.011, or MATH 430.002). This should be done soon enough that the student has time to incorporate your suggestions into their paper. You should also find another student to read your paper and provide feedback. (This can be the same student whose paper you read.) A form for the feedback will be uploaded to Canvas. You should immediately provide the other student with the feedback, and submit a copy to me over Canvas by **May 7 at 1:00 p.m.**

5.2.5 Providing to and Receiving from Another Person Constructive Feedback About Their Presentation, 10 points

Sometime before May 12, you should watch a practice run of the oral presentation of at least one other student in the class (MATH 430.001, ECE 430.011, or MATH 430.002). This should be done soon enough that the student has time to incorporate your suggestions into their presentation. You should also find another student to listen to your presentation and provide feedback. (This can be the same student whose presentation you watched.) A form for the feedback will be uploaded to Canvas. You should immediately provide the other student with the feedback, and submit a copy to me over Canvas by **May 14 at 1:00 p.m.**

6 Notable Dates

All times are MT.

January 19, 8:00–9:15 a.m.: First meeting of the semester, over Zoom.

January 21, 11:00 a.m.–12:15 p.m.: Second meeting of the semester, over Zoom.

January 26, 8:00–9:15 a.m.: Start of Tuesday in-person meetings for MATH 430.001 and ECE 430.001 in Weber 15.

January 28, 11:00–12:15 p.m.: Start of Thursday in-person meetings for MATH 430.001 and ECE 430.001 in ENGR 204.

January 29, 1:00 p.m: HW 1 due.

February 5, 1:00 p.m.: HW 2 due.

February 12, 1:00 p.m.: HW 3 due.

February 19, 1:00 p.m.: HW 4 due.

March 3, 1:00 p.m.: HW 5 due.

March 8, 8:00 a.m.: HW 6 due.

March 8, all day; March 9, 1:00–2:00 p.m.; March 10 all day; March 12, 2:00 p.m.-5:00 p.m.: Meet (by appointment) for 10 minute discussion of your HW 1–5 solutions.

March 12, 1:00 p.m.: HW 7 due.

March 19, 1:00 p.m.: HW 8 due.

March 26, 1:00 p.m.: HW 9 due.

April 1, 11:00 a.m.: Choice of paper/presentation topic due.

April 2, 1:00 p.m.: HW 10 due.

April 8, 11:00 a.m.-12:15 p.m.: Last in-person class.

April 9, 1:00 p.m.: HW 11 due.

April 10–18: No classes or office hours due to Spring Break

April 20, 8:00–9:15 a.m.: All classes from this point on are remote.

April 20, 1:00–2:00 p.m.; April 21 all day; April 22, 11 a.m.-Noon: Meet (by appointment) for 10 minute discussion of your HW 6–10 solutions.

April 23, 1:00 p.m.: HW 12 due.

April 30, 1:00 p.m.: HW 13 due.

May 6, 11:00–12:15 p.m.: Last lecture of the semester.

May 7, 1:00 p.m.: Final paper due, proof of paper peer feedback due, HW 14 due.

May 12, 6:20–8:20 pm: Final presentations.

May 14, 1:00 p.m.: Proof of presentation peer feedback due, HW 15 due.

7   COVID-19

As required by CSU, this section is copied verbatim from the `https://canvas.colostate.edu/spring-2021-syllabus-language/`.

All students are required to follow public health guidelines in any university space, and are encouraged to continue these practices when off-campus(es). Students also are required to report any COVID-19 symptoms to the university immediately, as well as if they have potentially been exposed or have tested positive at a non-CSU testing location. If you suspect you have symptoms, please fill out the COVID Reporter (`https://covid.colostate.edu/reporter/`). If you have COVID symptoms or know or believe you have been exposed, it is important for the health of yourself and others that you complete the online COVID Reporter. Do not ask your instructor to report for you; if you report to your instructor that you will not attend class due to symptoms or a potential exposure, you are required to also submit those concerns through the COVID Reporter. If you do not have access to the internet to fill out the online COVID-19 Reporter, please call (970)491-4600.

If you report symptoms or a positive test, your report is submitted to CSU's Public Health Office. You will receive immediate, initial instructions on what to do and then you will also be contacted by phone by a public health official. Based on your specific circumstances, the public health official may:

- choose to recommend that you be tested and help arrange for a test

- conduct contact tracing

- initiate any necessary public health requirements or recommendations and notify you if you need to take any steps

If you report a potential exposure, the public health official will help you determine if you are at risk of contracting COVID.

For the latest information about the University's COVID resources and information, please visit the CSU COVID-19 site (`https://covidrecovery.colostate.edu/`).

8 Canvas Information & Technical Support

This section is copied from the CSU syllabus template, which is provided to CSU instructors.

Canvas is the where course content, grades, and communication will reside for this course.

Login: `canvas.colostate.edu`

Support: `info.canvas.colostate.edu`

For passwords or any other computer-related technical support, contact the Central IT Technical Support Help Desk.

(970) 491-7276

`help@colostate.edu`

The Technical Requirements page identifies the browsers, operating systems, and plugins that work best with Canvas.

9 Academic Integrity & CSU Honor Pledge

This section is copied from the CSU syllabus template, which is provided to CSU instructors.

This course will adhere to the CSU Academic Integrity/Misconduct policy as found in the General Catalog and the Student Conduct Code.

Academic integrity lies at the core of our common goal: to create an intellectually honest and rigorous community. Because academic integrity, and the personal and social integrity of which academic integrity is an integral part, is so central to our mission as students, teachers, scholars, and citizens, I will ask that you affirm the CSU Honor Pledge as part of completing your work in this course.

Further information about Academic Integrity is available at CSU's Academic Integrity - Student Resources.

10   Universal Design for Learning/Accommodation of Needs

This section is copied from the CSU syllabus template, which is provided to CSU instructors.

I am committed to the principle of universal learning. This means that our classroom, our virtual spaces, our practices, and our interactions be as inclusive as possible. Mutual respect, civility, and the ability to listen and observe others carefully are crucial to universal learning.

If you are a student who will need accommodations in this class, please contact me to discuss your individual needs. Any accommodation must be discussed in a timely manner. A verifying memo from The Student Disability Center may be required before any accommodation is provided.

The Student Disability Center (SDC) has the authority to verify and confirm the eligibility of students with disabilities for the majority of accommodations. While some accommodations may be provided by other departments, a student is not automatically eligible for those accommodations unless their disability can be verified and the need for the accommodation confirmed, either through SDC or through acceptable means defined by the particular department. Faculty and staff may consult with the SDC staff whenever there is doubt as to the appropriateness of an accommodative request by a student with a disability.

The goal of SDC is to normalize disability as part of the culture of diversity at Colorado State University. The characteristic of having a disability simply provides the basis of the support that is available to students. The goal is to ensure students with disabilities have the opportunity to be as successful as they have the capability to be.

Support and services are offered to student with functional limitations due to visual, hearing, learning, or mobility disabilities as well as to students who have specific physical or mental

health conditions due to epilepsy, diabetes, asthma, AIDS, psychiatric diagnoses, etc. Students who are temporarily disabled are also eligible for support and assistance.

Any student who is enrolled at CSU, and who self-identifies with SDC as having a disability, is eligible for support from SDC. Specific accommodations are determined individually for each student and must be supported by appropriate documentation and/or evaluation of needs consistent with a particular type of disability. SDC reserves the right to ask for any appropriate documentation of disability in order to determine a student's eligibility for accommodations as well as in support for specific accommodative requests. The accommodative process begins once a student meets with an accommodations specialist in the SDC.

11 Copyrighted Course Materials

This section is copied from the CSU syllabus template, which is provided to CSU instructors.

Please do not share material from this course in online, print, or other media. Course material is the property of the instructor who developed the course. Materials authored by third parties and used in the course are also subject to copyright protections. Posting course materials on external sites (commercial or not) violates both copyright law and the CSU Student Conduct Code. Students who share course content without the instructor?s express permission, including with online sites that post materials to sell to other students, could face appropriate disciplinary or legal action.

12 Undocumented Student Support

This section is copied from the CSU syllabus template, which is provided to CSU instructors.

Any CSU student who faces challenges or hardships due to their legal status in the United States and believes that it may impact their academic performance in this course is encouraged to visit Student Support Services for Undocumented, DACA & ASSET for resources and support. Additionally, only if you feel comfortable, please notify your professor so they may pass along any additional resources they may possess.

13 Library & Research Help

This section is copied from text distributed by Jocelyn Boice.

The CSU Libraries Help Desk provides basic research and technical assistance either in person at Morgan Library or by phone at 970-491-1841. The Libraries? Ask Us chat service (`http://lib.colostate.edu/help/ask-us`) offers after-hours help. For in-depth as-

sistance, contact Jocelyn Boice, the librarian supporting the Mathematics Department and this course: `jocelyn.boice@colostate.edu` / 970-491-3882.