**Math 321 Differential Equations Schedule**

The course was organized by weeks. The preparatory reading and topics covered in each class are described. The individual assignments and team projects were generally due the middle of the week after they are listed. Some of the class notes, assignments, and projects were described in Jupyter notebooks housed in a CoCalc course; these files can be found in the CoCalc folder.

**August 25 - August 31**

Introduction. Read sections 1.1-4. Section 1.5 is not required but could be useful. The Math 212 Lab01 CoCalc notebook is a good resource for CoCalc beginners.

* To read this text, you should stop at each reading question, attempt to answer it (use paper and a calculator when necessary), and check your answer against the author's answer. Start reading before the first class of the week and finish by soon after the last class of the week.
* Class activities will complement, not substitute, for the reading, problem solving, and concept discussing students engage in outside of class.
* If you do not understand something when reading the text or listening in class, write a question. Ask your classmates or the instructor your accumulated questions.
* The assignment(s) and project related to the topic of the week will appear directly below the recommended reading. These will typically be due the Tuesday after the week the topic is discussed in class.

A01 Assignment

* Exercise 1.4.4 #2, 4, 6, 8, 10, 12 (10 points each). A great Calculus I review!
* X1 (10 points). Consider a change to the Atlantic Cod harvesting model. Instead of assuming, "that the cod are harvested by humans at a rate that is proportional to the number of cod present," assume that the cod are harvested by humans at a constant rate, independent of the number of cod present. Write the new differential equation and the units of the new constant that you use.
* X2 (10 points). State a differential equation model for the populations of Arctic Grayling and Bull Trout for the scenario described on the first day of class. Describe the meaning of each variable and parameter in your model.
* [The following boiler plate was included in each assignment] Each individual student should turn in a complete set of solutions on paper or a pdf document uploaded in Moodle. If computer software is used to obtain an answer, include an organized print out of the computations performed.
* [More boiler plate.] From the syllabus Academic Integrity Policy: "For *open resources* assessments (assignments), you may use any published work, internet resource, or generative artificial intelligence application.  You may look at and discuss another student's written work, but you may not directly copy that work when writing your answers.  You may collaborate with others, but you should independently write your own solutions.  In all cases, an appropriate acknowledgement should be made.  For example, the answer to exercise 1 is based on example 3.17 on page 86 of All Mathematics in a Single Book by D. Housman, the answer to exercise 2 is based upon a query to ChatGPT 4o, I read Ann Classmate’s solution to exercise 3 before writing up my solution independently, Joe Peer and I worked on exercises 4-7 together before I independently wrote my solutions, I completed exercises 8-9 without assistance or collaboration, and I got some help from the student teaching assistant when I got stuck on exercise 10."

P01 Assignment (see CoCalc)

**September 1 - September 7**

First Order Equations Part I. Read sections 2.1-2.

No class on Monday (Labor Day).

A02 Assignment

Second Edition (each exercise is worth 10 points):

* Section 2.1.4 #2, 4, 7, 8, 13, 15
* Section 2.2.6 #2, 4, 8, 10
* Extra: Solve via separation of variables:  u’(t) = sin(t)/u(t), u(0) = -1.

First Edition (each exercise or part is worth 10 points):

* Exercises 2.1.4 #2, 4, 6, 8 (10 points each); 2.1.4 (10 points); 2.1.6 (10 points); 2.2.1 parts (b), (d), (h), (j) solving each via separation of variables (10 points each); and 2.2.2 (10 points)
* Exercise 2.2.1 part (j) is u’(t) = sin(t)/u(t), u(0) = -1.

**September 8 - September 14**

First Order Equations Part II. Read sections 2.3-4. Browse the SIMIODE Textbook Software Code - SAGE page.

A03 Assignment

First Edition:

* Exercise 2.2.8 (10 points).  The supplementary resources has the file chp2-yeast-exer.ipynb containing the data and all of the needed code.  Turn in a print out of just the code containing the $r$ and $K$ values chosen along with the graph showing the data and model.
* Exercises 2.3.2 parts (b), (f), (h) (10 points each) but create each direction field by hand and include a few illustrative solution curves and choose the graph window to best illustrate the direction field and solution curves.
* Exercise X1 (10 points).  The direction field sketched for u’ = cos(u + t) suggests that there are solutions of the form u(t) = b + mt.  Find all such solutions.  The solution to this exercise may cause you to rethink the window to use in the previous exercise.
* Exercise 2.3.3 (d) (10 points), 2.3.5 (b) (10 points)
* 2.4.1 (b) (10 points), 2.4.3 (d) (10 points).

Second Edition:

* Section 2.2.6 #16 (10 points).  The supplementary resources has the file chp2-yeast-exer.ipynb containing the data and all of the needed code.  Turn in a print out of just the code containing the $r$ and $K$ values chosen along with the graph showing the data and model.
* Section 2.3.7 #2, 10, 12 (10 points each) but create each direction field by hand and include a few illustrative solution curves and choose the graph window to best illustrate the direction field and solution curves.
* Section X1 (10 points).  The direction field sketched for u’ = cos(u + t) suggests that there are solutions of the form u(t) = b + mt.  Find all such solutions.  The solution to this exercise may cause you to rethink the window to use in the previous exercise.
* Exercise 2.3.7 #16, 26 (10 points each)
* Section 2.4.4 #2, 9 (10 points each).

P02 Assignment (see CoCalc)

**September 15 - September 21**

Numerical Methods. Read sections 3.1-4 (section 3 need only be skimmed).

A04 Assignment (see CoCalc)

P03 Assignment (see CoCalc)

**September 22 - September 28**

Second Order Equations Part I. Read sections 4.1-2.

A05 Assignment

First Edition:

* Exercise 4.1.2, 4.1.4, 4.2.1b, 4.2.1d, 4.2.1f, 4.2.1j, 4.2.2b, 4.2.3b, 4.2.4b, 4.2.8 (each exercise is worth 10 points).
* Second Edition:
* Section 4.1.5 #2, 4; Section 4.2.8 #2, 4, 6., 10, 12, 20, 28, 34 (each exercise is worth 10 points).
* (Although not part of the assignment, exercise 4.1.1 is a good one to try and check your answer with the student solutions provided in the supplementary materials.)

**September 29 - October 5**

Second Order Equations Part II. Read sections 4.3-4.

[MIT Physics Demo -- Driven Mechanical Oscillator](http://www.youtube.com/watch?v=aZNnwQ8HJHU&NR=1)

[Breaking a Wine Glass With Sound](http://www.youtube.com/watch?v=17tqXgvCN0E&feature=related)

[Tone Generator](https://moodle.goshen.edu/mod/url/view.php?id=640154&forceview=1)

[Memorex Commercial](https://www.youtube.com/watch?v=u3sXpPLFXRw&index=1&list=PL-D6POcagA40HEiHdI6_8XyyVTOXD4kjR) Does this commercial show that the recording tape is of high quality?

A06 Assignment

Each of the following exercises (1st edition / 2nd edition) is worth 10 points.

* Exercise 4.3.1b / 4.3.4 #2 by hand.
* Exercise 4.3.1d / 4.3.4 #4 by hand.
* Exercise 4.3.1f / 4.3.4 #6 by hand.
* Exercise 4.3.1t / 4.3.4 #20 using SageMath, and plot the specific solution over 0 < t < 6.
* Exercise 4.3.2d / 4.3.4 #27 by hand, and plot the specific solution on the interval [0, 100].ExerciseExercise
* Exercise 4.4.1b / 4.4.3 #2 any way you like.
* Exercise 4.4.1d / 4.4.3 #4 any way you like.
* Exercise 4.4.4ab / 4.4.3 #11ab any way you like.
* Exercise 4.4.4cd / 4.4.3 #cd any way you like.
* Extra Exercise: Suppose a singer can break a glass by singing a particular note.  
    
  (a) (4 points) If a play back at the same volume of a taped recording of the singer's note is also able to break a glass, does this show that the tape does a good job of reproducing recorded sound?  
    
  (b) (3 points) Will the singer have to sing a higher or a lower note to break an identical glass that is half full of water?  Explain in terms of our differential equation model.  
    
  (c) (3 points) Suppose both notes are within the singer's range.  Will it be harder or easier to break the glass when it is half full of water?  Explain in terms of our differential equation model.

P04 Assignment (see CoCalc)

**October 6 - October 12**

[Review and Midterm Exam](C18%20Midterm%20Exam%20Prep.docx).

The Laplace Transform Part I. Read section 5.2 (subsection 5.2.7 is optional). The Sage code provided in the supplementary materials uses some code that had been deprecated and is now removed; the video below is a good replacement.

**October 13 - October 19**

No class on Monday or Wednesday.

The Laplace Transform Part I. Read section 5.2 (subsection 5.2.7 is optional). The Sage code provided in the supplementary materials uses some code that had been deprecated and is now removed; the video below is a good replacement.

[Solving ODE using Laplace Transforms in SageMath](https://www.youtube.com/watch?v=WvNdTuvucRM)

A07 Assignment

Each of the following exercises is worth 10 points (1st or 2nd editions).

* Exercise 5.2.1b or 5.2.9 #2
* Exercise 5.2.1d or 5.2.9 #4
* Exercise 5.2.2b or 5.2.9 #7
* Exercise 5.2.2d or 5.2.9 #9
* Exercise 5.2.4b or 5.2.9 #19
* Extra Exercise: Directly from its definition, find the Laplace transform of cos⁡(2t).

Each of the following exercises is worth 20 points.

* Exercise 5.2.5b or 5.2.9 #22
* Exercise 5.2.5d or 5.2.9 #24

V1 Assignment

The syllabus describes conversations in this manner:”Converse with the instructor about how you are developing effective uses of time, texts, classes, internet, artificial intelligence, peers, mentors, and other resources to learn mathematics concepts and enhance problem solving skills. Each conversation will be based upon a recently completed assignment or exam.  Scores for conversation completion will be part of your assignment grade.” [Download the attached file](V1%20First%20Conversation%20Questions.docx) for instructions for scheduling and preparing for this conversation.

**October 20 - October 26**

The Laplace Transform Part II. Skim section 5.1. Read sections 5.3-4.

A08 Assignment

Each of the following exercises is worth 10 points.

* Exercise 5.3.1d and 5.3.2d OR 5.3.6 #4 and #6 (for #4)
* Exercise 5.3.3d OR 5.3.6 #10
* Exercise 5.2.10 OR 5.2.9 #31

Each of the following exercises is worth 20 points.

* Exercise 5.3.5d OR 5.3.6 #18
* Exercise 5.3.6 OR 5.3.6 #19
* Exercise 5.4.4 OR 5.4.8 #9
* Exercise 5.4.6 OR 5.4.8 #11

P05 Assignment (See CoCalc)

**October 27 - November 2**

Linear Systems Part I. Read section 6.1 through Remark 6.1.1, subsection 6.1.2, section 6.2 through Reading Exercise 6.2.3, and section 7.2 through Example 7.3.

A09 Assignment (See CoCalc)

**November 3 - November 9**

Linear Systems Part II. Read the parts of sections 6.1-3 and 7.2 not previously read.

A10 Assignment (See CoCalc)

P06 Assignment (See CoCalc)

**November 10 - November 16**

Linear Systems Part III on Monday.

Nonlinear Systems Part I. Read sections 7.1, 3, and 4.

November 17 - November 23

Nonlinear Systems Part I. Read sections 7.1, 3, and 4.

Nonlinear Systems Part II. Read sections 7.4 & 6. Skim section 7.5.

A11 Assignment

* Exercise 7.1.1b OR 7.1.5 #2 (10 points)
* Exercise 7.1.1d OR 7.1.5 #4 (10 points)
* Exercise 7.3.1b OR 7.3.3 #2 (30 points)
* Exercise 7.3.1d OR 7.3.3 #4 (30 points)
* Exercise 7.4.4 OR 7.4.5 #4 (20 points)

November 24 - November 30

Nonlinear Systems Part II. Read sections 7.4 & 6. Skim section 7.5.

No classes on Wednesday or Friday.

A12 Assignment (See CoCalc)

P07 Assignment (See CoCalc)

**December 1 - December 7**

Nonlinear Systems Part II. Read sections 7.4 & 6. Skim section 7.5.

Review.

Last class on Wednesday.

**December 8 - December 14**

Final Exam.