Outline of the On-Line Differential Equations Class

To be successful in an on-line class, you must put in the appropriate amount of time and you must fully engage the material during that time. If you hope to simply do the homework, look at some examples when you are stuck, and then pass the tests, then this class is probably not for you.

Time. In a face-to-face class, you would spend 225 minutes in class each week, plus you would spend time coming and going to class, and finally you would spend further time studying outside of class. In this class, you are *expected* to study for this amount of time and to *not* "charge" homework against it. (Remember that we are partially counting the time spent reading the text as "class time". If that makes the "class periods" take longer, remember that in other classes you may have been *supposed* to read the text, while in this class it is *expected*.) If you can finish certain topics faster than you would have in a regular class, that's great. But you may need to use this saved time for other topics that take longer. The outline below sets up 26 study sessions to get you through the material. Each session is estimated to take about 75 minutes, but I would not recommend working next to a stopwatch. Some will take less time, some will take more. Overall, 26 classes at 75 minutes each, plus three exams and a final are the time you spend in class on a regular schedule.

Fixed dates. The dates for the "class period" in which you study are *suggested*. I took a regular Monday-Wednesday-Friday schedule as guidance. Adjust this study schedule as appropriate. Speed it up, if you want to, but do not fall behind. Last minute cramming usually results in failure.

The dates for the exams are fixed.

Exams will be given in class, face-to-face, on the dates indicated in the outline.

Studying mathematics. The primary way to transmit abstract content is reading and thinking. But reading abstract content can be frustrating, because it is different from reading blogs or novels. Abstract content takes more time to read and it must often be read multiple times, as you figure out why the steps are true. It is important to *do* the mathematics as you read it. Basically you want to invent it for yourself, with the book guiding you. Here are the details on how I want you to proceed.

1. For most topics, there is a discovery activity. You should first try to do the discovery activity by simply following the directions. After you have executed all directions, ask yourself "What does this mean?", "Why should this work for all equations of a certain type?".

2. After you have primed your brain in this fashion, read the text section on the topic. Try to connect back to what you have already worked out. The more you can connect your thoughts to it, the better the material will stick.

3. Once you have read the section, do the assigned practice problems. The practice may drag on for too long, which is similar to a class that does not quite stop on time. In this case, use your own discretion when to stop practicing.

4. Watch the video to reinforce what you have just learned.

5. Finally, do the homework. Ideally, you want to give yourself a break between studying and homework, and you want to do the homework "closed book". In this fashion, you must recall the essentials as you do the homework. That makes homework a bit slower than possible. But because your brain has to retrace the connections that you made while studying, the connections will be reenforced. As a consequence, you will know the material better and studying for exams will be easier.

Now, it may be that you get stuck in the discovery activity. This is normal. If mathematics was easy to discover, everyone would simply invent it and classes would not be necessary. So when you are stuck, start reading the text. But keep in mind how far you had gone in the discovery activity. Some things will look familiar. In the ideal situation, you will identify where you got stuck and how you can get past the problem. As soon as you can do that, get back to the activity. (Learning by doing works best.) You may need to switch between the activity and the text multiple times, but you should complete

the activity. After that, continue with step 2 (and the following steps) above. Yes, you should re-read everything you have read while you were looking to get unstuck. Because you are no longer stuck, you will hopefully pick up a few more details. Plus, the additional reinforcement should help with a topic that apparently was hard for you.

I cannot guarantee that the above approach will work for you. But it's the best way I can think of to keep you connected to the mathematics without actually being in the room with you. You may ultimately find that certain steps work better in a different order. But the basic premise of actively engaging the content will remain. As you find better ways to study, you will become more adept in mathematics and you will become a more mature learner.

No interruptions. Treat each day's task list like a class: No distractions, no interruptions. Study in a place where you will have at least 75 minutes' worth of privacy, turn off the cell phone, do not check e-mail. Just like you would pay attention in class, you should pay attention to your own thoughts as they are guided through the material.

Pacing yourself. I have found that after reading and learning a lot, I am often in the mood to write something. Essentially, after I have absorbed a lot, I feel like my brain needs to produce something. When I was a student, it was efficient to do writing assignments after reading assignments. So after a day's task list, it may be a good idea to work on a writing project or a lab report. This can only be an example. But listen to what your subconscious tries to tell you. Look for tasks that need to be accomplished anyway and continue working.

Remember to put a gap between learning about differential equations and the corresponding differential equations homework. You may also want to put a gap between your reading and watching the video. The videos are supposed to reinforce and clarify the main points. So if discovery and reading go well, do some practice problems. Then watch the video later and then do homework.

Homework. Homework will be administered through webwork at

`http://webwork.latech.edu/webwork2`

To make sure you recall what you learned, it is best to attempt the homework "closed book". Just print out the problems, get some paper and solve as many as possible. When you get stuck, approach it like the discovery activities. Resolve as much as possible without using other resources, even if it means being stuck a little longer. Then do a focused search to resolve your problem and get back to your task as fast as possible.

Homework problems in this document. The assigned homework problems in this document will not be collected or graded. Consequently I tried to keep the enclosed homework sections short enough to serve as review problems before tests or the final exam. Instead of re-working homework problems that you already have solved (which seems to be an astoundingly common practice), you may want to solve the enclosed problems as you prepare for a test. In this fashion, residual memory will not make the problems look easier than they should, and consequently you will prepare better.

Technical issues. The addresses for the tegrity videos are all of the form

`http://www2.latech.edu/~schroder/videos/DE/`⟨`name`⟩`.exe`

You should probably go to the directory and download the executables. That way you only need to look up the name in your directory to access the video. The installation is quicker from the hard drive than from the web page, too. Plus, you can watch the videos anywhere, without being dependent on a web connection.

The tegrity player works best with Internet Explorer being the default browser. So you may want to adjust this setting when you watch the videos.

Personal Request. If you find typos in the text, problems with the videos (typos, misspeaks), or if you think something is missing or could be done better, please let me know. Typos will be fixed, videos can be re-shot, and I will consider new ways of transmitting the content. Just remember that we cannot put an example for every situation you are likely to encounter into a 350 page book. (Even 3500 pages would not be enough for that.)

Day	Instructions	Homework
1 (Wed. 12-3)	**Introduction** 1. Read the preface. 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/start.exe` 3. Read Module 1. *Note.* The main purpose of this session is to familiarize you with how to verify that a function solves a differential equation (the informal part of Definition 1.2) and with the general idea of modeling with differential equations.	Section 1, # 5, 11, 20 Section 1.2, # 1 Section 1.5, # 1, 2
2 (Fri. 12-5)	Day 1 was a lot of reading. Now we start working. **Topic: Separable differential equations** 1. Work the discovery part in the left column of the activity on page 331. 2. Read pages 13-16, stop before Example 2.6. 3. Work the practice part in the right column of the activity on page 331. This may get a little lengthy. Stop after about 20 minutes. 4. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/separable.exe` 5. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/separable_IVP.exe` 6. Read pages 16-19. This finishes the section, and it gives you a few more examples of models and a "trick of the trade" when an integral is not solvable in closed form.	Section 2.1, # 1, 6, 8, 14, 19, 26
3 (Mon. 12-8)	Day 2 gave a thorough introduction to one class of differential equations, but the big idea is summed up on page 14. This class and the next one will go through more types of differential equations, but a bit more rapidly. **Topic: Linear Differential Equations** 1. Work the discovery part in the left column of the activity on page 333. 2. Read Section 2.2 (pages 22-23). 3. Work the practice part in the right column of the activity on page 333. This may get a little lengthy. Stop after about 10 minutes. 4. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/linear_first_order.exe` **Topic: Bernoulli Equations** 1. Work the discovery part in the left column of the activity on page 335. 2. Read Section 2.3 (pages 23-25). 3. Work the practice part in the right column of the activity on page 335. This may get a little lengthy. Stop after about 10 minutes. 4. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/Bernoulli_eqns.exe`	Section 2.2, # 1, 5, 9 Section 2.3, # 2, 5, 9

Day	Instructions	Homework
4 (Wed. 12-10)	**Topic: Homogeneous First Order Differential Equations** 1. Work the discovery part in the left column of the activity on page 337. 2. Read Section 2.4 (pages 26-27). 3. Work the practice part in the right column of the activity on page 337. This may get a little lengthy. Stop after about 10 minutes. 4. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/homog_first_order_eqns.exe` **Topic: Exact Differential Equations** 1. Work the discovery part in the left column of the activity on page 339. 2. Read Section 2.5 (pages 27-29). 3. Work the practice part in the right column of the activity on page 339. This may get a little lengthy. Stop after about 10 minutes. 4. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/exact_eqns.exe`	Section 2.4, # 1, 5 Section 2.5, # 2, 4, 10, 11
These first four classes may have been a bit intense, but they should have gotten you into the right routine. There will be fewer activities and more reading from here on. Use what you have learned so far and read actively and precisely.		
5 (Fri. 12-12)	**Topic: Homogeneous Linear Differential Equations With Constant Coefficients** These differential equations should not be confused with the much less frequent homogeneous first order equations. 1. Read sub-module "Before Module 3", at least Sections B3.1 and B3.2 (pages 37-44). These sections give the real-life background for the differential equations we want to solve. 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/spring_mass_systems.exe` 3. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/LRC_circuit.exe` 4. Work the discovery part in the left column of the activity on page 341. 5. Read pages 51-57, stop before Physical Verification 3.14. 6. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/linear_const_coeff.exe` 7. Work the practice part in the right column of the activity on page 341. This may get a little lengthy. Stop after about 10 minutes. 8. Finish reading Section 3.1.	Section 3.1, # 1, 4, 5, 7, 10
6 (Mon. 12-15)	**Topic: Homogeneous Linear Differential Equations With Constant Coefficients (Focus on Initial Value Problems and Design)** 1. Read Section B3.3 (pages 45-46). Read Section B3.4 (pages 47-49). This will remind you why linear differential equations are important. In either section, do not get discouraged if you don't understand every single detail. 2. Read Section 3.2 (pages 58-61). 3. Read Section 3.3 (pages 63-65).	Section 3.2, # 1, 9, 14, 21 Section 3.3, # 2, 7

Day	Instructions	Homework
7 (Wed. 12-17)	**Topic: Undetermined Coefficients** 1. Work the discovery part in the left column of the activity on page 343. 2. Read pages 67-70, stop before Example 3.25. 3. Work the practice part in the right column of the activity on page 343. This may get a little lengthy. Stop after about 10 minutes. 4. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/undet_coeff.exe` 5. Finish reading Section 3.4. 6. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/undet_coeff_sol_hom.exe`	Section 3.4, # 1, 2, 8, 11, 15, 16, 20
8 (Fri. 12-19)	(Exam preparation) 1. Read Sections 2.7 and 2.8 (pages 33-35). 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/recognition_and_review.exe` 3. Review homogeneous and inhomogeneous constant coefficient equations as necessary.	Section 2.8, # 9, 16, 20, 36
9 (Mon. 1-5)	**Exam 1: First order equations and constant coefficient equations. (Modules 2 and 3 up to Section 3.4, inclusive.)**	
10 (Wed. 1-7)	(Finishing up the elementary methods.) **Topic: Variation of Parameters** Variation of Parameters is basically one large formula. We want to see is how to apply it, which is not hard, except for the computations. 1. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/VP_simpler_int.exe` 2. Read Section 3.5 (pages 76-82). Do not be intimidated by the proof of Theorem 3.31 or by Example 3.33. It's o.k. to not fill in every detail there. 3. If you are interested in an example with *really* nasty integrals, watch the video `http://www2.latech.edu/~schroder/videos/DE/Variation_of_Parameters.exe` **Topic: Cauchy-Euler Equations** 1. Read Section 3.6 (pages 82-85). 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/Cauchy-Euler.exe`	Section 3.5, # 2, 9, 17 Section 3.6, # 2, # 7
This concludes our exploration of "elementary" (that is, calculus-style) methods to solve differential equations. For the rest of the course we will focus on more "advanced" methods that require transformations or infinite series representations.		

Day	Instructions	Homework
11 (Fri. 1-9)	The theory part for this module will be a bit deep, but once we are past Section 6.1 we can focus on solving initial value problems. **Topic: Laplace Transforms** 1. Work the discovery part in the left (and most of the right) column of the activity on page 355. 2. Read the introduction to Module 6 and Section 6.1 up to Theorem 6.8 (pages 139-143). If you are not familiar with induction, then there is no need to read the proof of Theorem 6.8. 3. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/LT_intro.exe` 4. Work the practice part in the right column of the activity on page 355. This may get a little lengthy. Stop after about 10 minutes. 5. Finish reading Section 6.1 (pages 143-147). This part will show you a few techniques and also fill in the remaining theory. 6. Read Section 6.2 (pages 149-153). If you can follow the solution process for initial value problems here, then you have achieved the main purpose of this first section. The underlying idea will not change throughout the rest of the module. 7. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/Laplace_IVP.exe`	Section 6.1, # 4, 12, 19, 21, 28 Section 6.2, # 2, 3, 13
12 (Mon. 1-12)	**Topic: Solving Systems with Laplace Transforms** 1. Read Section B6.1 (pages 135-137) to get an idea where systems come from. 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/LT_systems.exe` 3. Read Section 6.3 from page 155 to page 156. Stop before Example 6.28. 4. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/multi_loop_circuits.exe` 5. Read Example 6.28 (pages 156-157). 6. Read Section B6.2 (pages 137-138) and Example 6.29 if you are interested in an example of a higher order system. (We will stick with first order systems in this course.)	Section 6.3, # 1, 8, 12a, 12b, 13
Although we will give an indication how the Laplace transform formulas come about, we will mainly solve initial value problems and we will use the Laplace transform table on page 310 when we do so.		
13 (Wed. 1-14)	**Topic: Laplace Transforms of Damped Oscillations and of Products with t.** 1. Read Section 6.4 from page 162 to page 165. Stop Example 6.38. 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/Laplace_damp_trig.exe` 3. Finish reading Section 6.4 (pages 165-167).	Section 6.4, # 3, 14, 16, 21, 24, 26, 34

Day	Instructions	Homework
14 (Fri. 1-16)	**Topic: Laplace Transforms of Unit Step Functions.** 1. Read Section 6.5 from page 170 to page 175. Stop after Example 6.51. 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/Laplace_step.exe`	Section 6.5, # 4, 12, 16
15 (Wed. 1-21)	**Topic: Laplace Transforms of Dirac Delta Functions.** 1. Finish reading Section 6.5 (pages 175-179). 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/LT_Dirac.exe`	Section 6.5, # 13, 29
16 (Fri. 1-23)	**Topic: Convolutions and Periodic Functions.** 1. Read Section 6.6 from page 182 to page 185. Stop after Example 6.65. Do not be intimidated by the derivation of the convolution formula. 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/LT_convol.exe` 3. Finish reading Section 6.6 (pages 185-188). 4. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/LT_periodic.exe` 5. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/LT_int_eq_fixed.exe`	Section 6.6, # 2, 3, 7, 13, 15, 25

Day	Instructions	Homework
17 (Mon. 1-26)	Laplace transforms will need some more time to sink in and they are the last time we work with constant coefficient differential equations. Review them (and Sections 3.5 and 3.6) for the test. After the test, we will tackle equations with non-constant coefficients. We will not go into details on partial differential equations, but the videos below can give you an idea of the origin of the equations for which we need series solutions. **Topic: Overview on Partial Differential Equations** 1. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/sepvar_legendre.exe` 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/sepvar_Bessel.exe` 3. You can read Module 7 and the sub-module "Before Module 7" if you are interested, but there will be no test items on partial differential equations or separation of variables.	
18 (Wed. 1-28)	**Exam 2: Laplace transforms, Variation of Parameters, Cauchy Euler equations. (Module 6 and Sections 3.5 and 3.6.)**	
The background on series is from B. Schröder, *Single Variable Calculus with Precalculus* (the text from MATH 240 in the freshman year). Off campus students will receive the relevant sections electronically.		
19 (Fri. 1-30)	**Topic: Taylor Polynomials.** 1. Read Section 16.1, Taylor Polynomials. 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/taylor_series.exe` If only we could make the degree of polynomials infinite, we might be able to represent functions as "infinite polynomials". The next section gives a vehicle for infinite summations. **Topic: Series of Numbers** 1. Read Section 19.1, Series of Numbers.	Section 16.1, # 1c, 2b, 4b, 5a Section 19.1, # 1b, 4c
20 (Mon. 2-2)	**Topic: Convergence Tests.** For our purposes, the most relevant test will be the ratio test. 1. Read Section 19.2, Convergence Tests.	Section 19.2, # 2a, 2b
21 (Wed. 2-4)	**Topic: Power Series.** 1. Read Section 19.3, Power Series. 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/power_series_overview.exe`	Section 19.3, # 1c, 2a, 3a
With series finished, we get back to the differential equations text.		

Day	Instructions	Homework
22 (Fri. 2-6)	**Topic: Series Solutions for Differential Equations.** 1. Do the activity on page 359. 2. Read the start of Module 8 from page 231 to page 234, stop after Solution Method 8.2. 3. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/series_solutions.exe` 4. Finish reading Section 8.1 (pages 234-240). 5. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/series_sol_roc.exe`	Section 8.1, # 7, 17, 34, 38
23 (Mon. 2-9)	**Topic: Background on Legendre Polynomials.** This section can be seen as another example of series solutions and pattern recognition in the series. The physical background is quite sophisticated. It should not be a problem if not every detail is understood here. 1. Read Section 8.2 (pages 243-247). 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/legendre_poly.exe`	Section 8.2, # 11
24 (Wed. 2-11)	**Topic: The Method of Frobenius.** 1. Do the activity on page 361. 2. Read Section 8.3 from page 249 to page 252. Stop before Theorem 8.22. 3. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/Frobenius.exe` 4. Finish reading Section 8.3 (pages 252-254). 5. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/frobenius_problem.exe`	Section 8.3, # 2, 5, 13
25 (Fri. 2-13)	(Finishing series solutions, getting ready for the test.) **Topic: Bessel Functions.** 1. Read Section 8.4 (pages 256-besselexersec) as another example of the method of Frobenius. Do not be intimidated if you don't understand all the background. **Topic: Reduction of Order.** 1. Read Section 8.5 (pages 260-263). The proof of Theorem 8.31 and Exercise 8.33 are getting a bit technical. No need to check details. 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/reduction_of_order.exe`	Section 8.4, # 6 Section 8.5, # 2, 5
26 (Mon. 2-16)	**Exam 3: Series, series solutions, Frobenius, reduction of order. (Module 8, and Sections 16.1, 19.1, 19.2 and 19.3 in B. Schröder, *Single Variable Calculus with Precalculus*.)**	

Day	Instructions	Homework
27 (Wed. 2-18)	**Topic: Theory of Linear Differential Equations.** This topic could be expanded significantly in a theory class. For our purposes, we need to understand linear independence and determinants. It's a lengthy module, but it's best to just push through it. 1. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/theory_lin_eq.exe` 2. Read Module 5 (pages 117-134). 3. Do the activity on page 353.	Section 5.1, # 3 Section 5.2, # 2, 6 Section 5.3, # 2 Section 5.4, # 2, 6 Section 5.5, # 6
28 (Fri. 2-20)	(Deliberately high intensity session so that the last day before the final is not too bad.) **Topic: Diagonalizable Systems.** 1. Read the start of Module 9 from page 269 to page 271. Stop after Example 9.4. 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/translate_to_first_order.exe` 3. Continue reading from page 271 to page 275. Stop before Definition 9.16. 4. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/matrix_multiplication.exe` 5. Continue reading from page 275 to page 283. Stop before Example 9.29. 6. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/diagonalizable_systems.exe` 7. Do the activity on page 363. 8. Finish reading Section 9.3 (pages 283-288). 9. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/diagonalizable_complex_ev.exe`	Section 9.1, # 2, 6 Section 9.2, # 2, 7, 10 Section 9.3, # 5, 10, 16
29 (Fri. 2-27)	**Topic: Non-Diagonalizable Systems.** 1. Read Section 9.4 (pages 290-292). 2. Watch the video at `http://www2.latech.edu/~schroder/videos/DE/nondiagonalizable_systems.exe` **Topic: Shape of the Trajectories.** 1. Read Section 9.5 (pages 292-295).	Section 9.4, # 2, 6 Section 9.5, # 1, 3, 6, 8, 12, 16
30 (Mon. 3-2)	**Final Exam: Cumulative. Special focus on Module 9.**	