Dave Kaplan

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# Class Meeting times, place: Tuesday and Thursday 2:00 PM – 3:50 PM Science East room 2270

# Office Hours: Tentatively M 2:00 PM – 2:50 PM, R 4:00 PM – 4:50 PM and see below on this page

This document: January 9, 2024

### Physics 251-002 Waves

#### Syllabus and Information

# Spring, 2024

# Thank you for coming to Physics 251 and WELCOME!

Physics 251 is a one-semester 4 credit hour course in which we will discuss aspects of the physics of oscillations, waves and the associated mathematical techniques. The material discussed in Physics 251 is quite helpful as background for more advanced courses in physics.

I love teaching the physics of oscillations and waves! I have taught such courses many times and have thought about the subject for many years. Yet, each time I teach it, I gain new insights. There’s a lot of really interesting material that we’ll be discussing in the course, and I think that you will really like it. If you feel at any point you need help or advice, please don’t hesitate to ask!

**Texts**: 1. Excerpts from Physics of Waves by D. H. Kaplan (under development for publication). This will be the text from which most of the reading assignments are planned. The relevant parts of this text manuscript will be made available to you on-line through the SIUE Blackboard system. Instructions for accessing those parts are indicated below.

1. A Student’s Guide to Waves by D. Fleisch and L. Kinnaman (Cambridge University Press). Reading assignments will also be made from this text. This book is available for undergraduate students through the SIUE Textbook Rental Service.

**Prerequisites for our course:** Grade ofC or better in Phys 152 or Phys 142.

**Co-requisite**: Math 250 (Calculus III) or successful completion of it.

**Office Hours**: Tentatively M 2:00 PM – 2:50 PM, R 4:00 PM – 4:50 PM, and also, if I am available for it, by appointment (call 618 -650-2479 to set and confirm a time). If you cannot make it in-person to an office hour (or at another time), I might be available via Zoom during the office hour.

**Please Note:** *There will likely be other material placed on-line for you within the SIUE Blackboard system Coursework area – e.g., “Class Notes sets,” that you’ll be responsible for. Not everything in the assigned reading will be gone over in class sessions, and not everything in class sessions will be in the assigned reading; you will be responsible for and may be tested on both. Those and also other material that you will be responsible for and may be tested on are listed in the section “*Concerning your responsibility for Material in our course” on pages 2 and 3 of this document.

Assigned excerpts from the Kaplan (K) text manuscript, HW assignments/solutions and any posted “class notes packets” can be accessed in the Blackboard website Coursework (CW) area (access via the left-hand navigation bar for our course). The K-text chapters can be accessed in the folder “K-Waves Text Chapters for Students Spring 2024” within the CW area. The homework assignments will be in the folder called “Homework assignments” in the CW area.

This Syllabus and Information document will be posted on the Blackboard (BB) website for our course in the “About This Course” area. Updates to it will be announced and may also be posted on the P251 BB Websi

2

**To access Zoom Sessions if necessary**: Navigate to the SIUE Blackboard website for our course. In the left-hand tool-bar, click on the icon called “Zoom Meetings”. A page will open that lists upcoming Zoom meetings that are scheduled along with the link to join. If you cannot attend a class session in person due to an absence for a serious reason that I excuse (see section on excused absences later in this document) and you notify me of it (e.g., by email) reasonably in advance, you may also be able to attend on Zoom by using the link that I than send you via email. Either way, to enter the Zoom session, you will be required to provide your SIUE login credentials.

**Weekly Folders on-line**: As we go along, within the Coursework area of the SIUE Blackboard website for our course there will be set up a series of weekly folders (called “Week of January 8”, “Week of January 15,” etc.) that will contain information for you pertaining to that week for our course. It is planned that weekly reading assignments and also hand written “Class Notes sets” will be placed within these weekly folders as we progress through the course. Updates to the reading assignments may occur as each week progresses; it’s planned that those updates will be made in files called “Reading Assignments and Reminders Week of …” that will also be in the appropriate weekly folders. As well, video links may be posted in the appropriate weekly folders.

Please Note: If you attend class and feel ill, I encourage you to wear a face mask.

***Let Me Know How It’s Going:***

Office hours are tentatively as listed on page 1. Changes to these office hours may be announced in class or posted. Feel free to contact me at any reasonable time during the course, though - the worst that will happen is that I will be busy and will ask you to reschedule a time with me. Please do try to contact me at least a few times during the semester to let me know how it’s going for you. That’s important because different people learn in different ways.

Please always feel free to discuss things with me about the course. I welcome your suggestions on how to improve it. Also, please feel free to interrupt the class presentation at any point to ask questions. Asking questions is part of how you learn. I bet that if you have a question, someone else has the same question but is too shy to ask it. Don’t be.

***Learn Steadily:***

Please try to not let work pile up – try to study physics every dayif possible. I know that you have lots of other things to do, but, as you know, physics is not a “memorizing” subject - it is an “understanding” one, and the understanding is of a sort that comes only gradually and with repetitive exposure to and rereading of a topic, and not with last-minute “cramming.”

**Concerning your responsibility for Material in our course**:

As mentioned above, assigned readings in the text will be communicated to you as we progress through the semester via classroom announcements and/or via weekly files posted within the Weekly folders within the SIUE Blackboard website for our course. Again, likely, there will also be written material (“Class Notes” and perhaps more) placed on-line for you (within SIUE Blackboard). Both the classroom presentations and the associated posted “Class Notes” will supplement the assigned material in the text; often considerably (further explanations, other worked examples, etc.). As well, any audio/visual presentations I post or show in class likely will also supplement the text.

So, *not everything in the assigned reading from the textbook will be discussed in the written posted “class notes” and not everything in the written posted class notes is discussed within the assigned reading from the textbook.* As well, the possible audio/visual may include elucidation (e.g., further examples, explanations, demonstrations) that is not discussed in either the textbook or the posted class notes. So:

3

**Concerning your responsibility for Material in our course, continued:**

**Important**: Unless I announce otherwise: *You will be responsible for and may be tested on:*

1. *All assigned material from our class textbooks.*

1. *All material in the posted “Class Notes” plus other posted material (including all Audio/*

*Visual postings if there are any)*

1. *All physics and math material discussed during class sessions.*
2. *In addition, you will be responsible for knowing, understanding and understanding how to use the formulae on the appropriate list of “Primary Formulas” that I plan to post for you in advance of each exam and quiz, including the Final Exam.* For each exam and for each quiz, the Primary formulas will be those that I consider most basic regarding the material that you will be responsible for. I do not intend to provide you with any of the Primary Formulas with or during any of the exams or quizzes in our course. The formulas on the list of Primary formulas for each exam or quiz will be made available to you at least three calendar days before that exam or quiz. For more information about Primary Formulas, see pp. 12-13 of this document.

Please note that for protection of your privacy, I will not discuss grades or exam or quiz solutions via e-mail or via telephone. Nor will I discuss exam and/or quiz solutions until the grades on the exam or quiz have been communicated to the class as a whole. For more about policies for exams and quizzes, see pages 12 through 14 of this document.

**Some Other Requirements:**

* Completion of all course exams, including the Final Exam and completion of all quizzes.
* Completion of all assigned Homework Assignments. Homework will be assigned frequently throughout our course, mostly or exclusively through Pearson “Mastering Physics” system (see pages 12 through 14of this document).
* Attendance: Lack of attendance due to too many unexcused absences from class may result in a lowering of your course grade independent of your exam and quiz scores (see page 15 of this document).

* You are required to be aware of the contents of this Syllabus and Information document and any updates to it. This Syllabus and Information document will be posted under the About This Course link in Blackboard. Updates to be announced as necessary and may be posted through Announcements in Blackboard.
* You are required to be aware of all updates I communicate to the class on reading assignments and all updates to homework due dates and exam dates.
* You are required to be aware of all announcements made during class sessions (whether or not you attended those class session(s)) and all announcements posted on-line for you.
* Technology requirements: Technical requirements for students can be found in this [ITS Knowledge Base article](https://kb.siue.edu/104656). You should be able to:
* Use a word processor, such as MS Word.
* Attach files to emails or course areas
* Navigate websites and course materials
* Reach out to tech support staff when issues arise and troubleshoot to resolve problems

Additional guidance for can be found on the [Online at SIUE site](https://www.siue.edu/online/planning-preparation/index.shtml).

## 4

## **More on Technical Support**

You are expected to have reliable Internet access on a regular basis. It is your responsibility to address any computer problems that might occur. Generally, such problems are not an excuse for delays in meeting expectations or for missing course deadlines; any exception to this is at my decision. Contact ITS at [618-650-5500](mailto:618-650-5500) or at [help@siue.edu](mailto:help@siue.edu) with any technical concerns. You can also check the functionality of University systems, including Blackboard, at the [ITS System Status page](https://status.siue.edu/), or search the [ITS Knowledge Base](http://kb.siue.edu) for various how-to and troubleshooting guides.

Tips for taking online assessments (should a modality change for course delivery occur):

* Set up a wired (Ethernet) Internet connection on your computer
* Do not use a mobile device, such as a phone or tablet
* Be prepared to complete the assessment in the allotted time

If you find that you need additional support, please let me know.

**Other Resources**

* Physics “Tutor Lab”: The physics department maintains a “Tutor Room” staffed with advanced student tutors who are available to help your understanding of physics concepts. Some physics tutors may also do sessions via Zoom. Please note that tutors are not to do your homework problems for you, so please do not ask a tutor to do this.
* [Lovejoy Library Resources](http://www.siue.edu/lovejoylibrary/) and also [The Writing Center](http://www.siue.edu/lss/writing/index.shtml)
* SIUE [Tutoring Resource Center](https://www.siue.edu/lss/tutoring-resource-center/) and SIUE [Academic Success Sessions](http://www.siue.edu/retention/sass/index.shtml)
* SIUE [Academic Advising](http://www.siue.edu/advising/) . Also, there are [Financial Aid](https://www.siue.edu/financialaid/) possibilities and [Campus Events](http://www.siue.edu/events/).
* **SIUE Counseling Services/Cougar Care**: Students have many different responsibilities outside of those for our course and handling all of these simultaneously may be very demanding. As your health is very important, should the need arise, please do not hesitate to contact an SIUE counseling service: [Counseling Services](https://www.siue.edu/counseling/)/SIUE **Cougar Care**: To make an appointment visit [cougarcare.siue.edu](http://cougarcare.siue.edu/) or call [618-650-2842](tel:618-650-2842)

## **Services for Students Needing Accommodations**

Students needing accommodations because of medical diagnosis or major life impairment will need to register with Accessible Campus Community & Equitable Student Support (ACCESS) and complete an intake process before accommodations will be given. Students who believe they have a diagnosis, but do not have documentation, should contact ACCESS for assistance and/or appropriate referral. The ACCESS office is located in the Student Success Center, Room 1203. You can also reach the office by emailing us at [myaccess@siue.edu](mailto:myaccess@siue.edu) or by calling [618-650-3726](tel:618-650-3726).

If you feel you would need additional help in the event of an emergency situation, please notify your instructor to be shown the evacuation route and discuss specific needs for assistance.

## **Diversity and Inclusion**

SIUE is committed to respecting everyone’s dignity at all times. In order to learn, exchange ideas, and support one another, our virtual and physical classrooms must be places where students and teachers feel safe and supported. Systems of oppression permeate our institutions and our classrooms. All students and faculty have the responsibility to co-create a classroom that affirms

Diversity and Inclusion statement continued on next page 🡪

5

inclusion, equity, and social justice, where racism, sexism, classism, ableism, heterosexism, xenophobia, and other social pathologies are not tolerated. Violations of this policy will be enforced in line with the SIUE Student Conduct Code.

The [Inclusive Excellence, Education, and Development Hub](https://www.siue.edu/diversity/the-hub/) is an excellent resource for students for support and community. Any person who believes they have experienced or witnessed discrimination or harassment can contact Lindy Wagner, Assistant Vice Chancellor for Inclusive Excellence, Education and Development at (618) 650-3179 or [linwagn@siue.edu](mailto:linwagn@siue.edu). There is also an online form for reporting campus climate concerns at: <https://cm.maxient.com/reportingform.php?SIUEdwardsville&layout_id=10>.

## Pregnancy and Newly Parenting Policy

This policy and procedure are established to ensure the protection and equal treatment of pregnant students, students with pregnancy-related medical conditions including as a result of the termination of pregnancy, and students who become new parents including parents adopting or fostering to adopt for the first 12 weeks a child is in the home, in accordance with Federal and State guidelines and regulations. "New Parents" refers to a parent who has recently welcomed a newborn or adopted a child or is fostering to adopt a child and needs support to mitigate the disruption in academic progress within the first 12 weeks of parenting or a parent that needs support due to medical necessity attributed to pregnancy or delivery of a child; care of newborn; or lactation within the first year of child's life or legal adoption/fostering. Visit [Policies & Procedures - Student Rights and Conduct - Newly Parenting Policy - 3C15](https://www.siue.edu/policies/3c15.shtml) to view the full policy and learn how to request accommodations through the Office of Equal Opportunity, Access, and Title IX Coordination (EOA).

**Special Accommodations:**

Services for Students Needing Accommodations

Students needing accommodations because of medical diagnosis or major life impairment will need to register with **Accessible Campus Community & Equitable Student Support (ACCESS)** and complete an intake process before accommodations will be given. Students who believe they have a diagnosis, but do not have documentation, should contact ACCESS for assistance and/or appropriate referral. The ACCESS office is located in the Student Success Center, Room 1203. You can also reach the office by emailing us at myaccess@siue.edu or by calling 618-650-3726.

If you feel you would need additional help in the event of an emergency situation, please notify your instructor to be shown the evacuation route and discuss specific needs for assistance.

6

**About Our Course:**

In our course, I plan to show you some really neat things in physics and physical mathematics that are very interesting and will also be very helpful to you in subsequent physics courses. I want to tell you that I’ve had much fun in my life learning and doing physics. Much of it is very beautiful. In this course I hope to convey to you at least some of the great joy and excitement that I have felt about it.

**Some Main Objectives of the Course**:

To provide you with an introductory treatment of the physics of waves and oscillations.

To familiarize you with the idea of a governing differential equation in physics and its role in predicting possible future behaviors of a dynamical system.

To familiarize you with the governing differential equation for simple harmonic oscillation and different forms of its general solution.

To familiarize you with the role of physical initial conditions in predicting the specific future behavior of a dynamical system, especially as regards oscillating systems and waves. In concert with this, to familiarize you with mathematical parameters appearing in the general solution of the simple harmonic oscillator (sho) governing differential equation and their completeness over

physical initial conditions. To familiarize you with how to match these parameters to any allowable physical initial conditions.

To provide you with an introduction with examples to the wide range of systems to which, in idealization, versions of the sho governing differential equation apply and to help you recognize analogies and isomorphisms and between these situations. (“The same equations have the same solutions.”)

To deepen your understanding of the role of approximation in physics and, in particular, to familiarize you with basic technique for approximating solutions for intrinsically nonlinear oscillation situations by linearization and by power-series expansion.

To provide a solid introduction to situations involving simultaneous coupled oscillations in a system and especially to the concept of normal modes of coupled oscillations.

To provide you with a basic understanding of the mathematical completeness of the normal mode solutions for a discrete system over all realizable initial conditions. (“The most general solution is an arbitrary simultaneous superposition of all normal modes.”)

To introduce (or reintroduce) you to the Classical Wave Equation (CWE) and familiarize you with solutions of it in one dimension. The CWE, a basic general governing equation for both traveling and standing waves in many systems (waves on stretched string, sound waves, EM waves, …), is one of the most important governing equations of physics.

To familiarize you with properties of standing waves on a stretched string and their role as normal modes. To provide an understanding of the shapes of the standing waves, why only certain frequencies of standing waves are allowed in a system subject to boundary conditions (“frequency quantization”) and the relation of these frequencies to the boundary conditions of the system, especially for cases of rigidly bound ends and free ends. This is a critically important paradigm that has direct analogs across many areas of physics (quantum mechanics, astrophysics, and more).

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7

**Some Main Objectives of the Course, continued:**

To familiarize you with the completeness concept for normal modes on a stretched string. (Again, “the most general solution is an arbitrary simultaneous superposition of all normal modes.”)

An important topic in our course is that of Fourier analysis: Thus, some further objectives are:

To provide you with an intuitive and physical quantitative introduction to important concepts of Fourier analysis and completeness of the Fourier basis functions and Fourier synthesis in one dimension re Fourier series, including the “complex exponential form” of Fourier series.

To apply Fourier analysis to predict the motion of a bound stretched string subject to initial conditions obeying the bound end boundary conditions.

To introduce you to and illustrate the very important Fourier Bandwidth Theorem. (The Fourier Bandwidth Theorem is fundamental to many areas of more advanced physics (e.g., quantum mechanics, nuclear physics, particle physics, …) as well as to modern communication broadcast and reception theory.

As time permits: To introduce you to further application of Fourier analysis in the context of classical physics (e.g., physics of music).

To familiarize you with general concepts (e.g., phase velocities) concerning rigidly traveling waves, especially as regards the most important case: sinusoidal traveling waves, but also including more general rigidly traveling shapes. To introduce you to some examples of traveling wave propagation in media – for example, on a stretched string and in air as sound waves.

As time permits: To introduce you to concepts involving energy transfer by traveling waves between media, including partial reflection/partial transmission and the concept of characteristic impedance.

As time permits: To introduce you to concepts pertaining to the synthesis of multiple harmonic traveling waves, leading to the concepts of wave packets and “group velocity” and also Fourier sine and Fourier cosine transforms and also complex exponential Fourier Transform concepts.

Other objectives for our course will become clear as we progress through it.

***Emphasis and Philosophy of the course:***

The emphasis of the course will be on learning new physics (in particular, the physics associated with oscillations and wave phenomena), on learning, understanding and applying important mathematical technique and on trying new ideas, and on training you to think independently as a physicist. It will also be on having a good time while working hard and exploring things. I am particularly concerned with providing physicists, engineers and other scientists with a first-rate background for graduate study and for professional work in the twenty-first century. The physics is very interesting. I plan to provide a solid course in it.

8

**Overview of the Course (Tentative)**:

A quick walk through the topics to be included in the course would look, time permitting and *tentatively*, as follows:

1. In the first part of the course: A qualitative/semi-quantitative brief overview of some of the main concepts and applications of Wave physics. Part of this may be through early reading assignments in Chapter 1 of the “K” text manuscript that you’ll carry out in parallel with our classroom discussions on other material beginning with that of chapter 2 of that text. Thus, after the first hour or so of the course, our class lectures/discussions will pick up with:
2. We will review and extend your exposure to aspects of simple harmonic oscillation and show you how to match constants appearing in the general solution to the harmonic oscillator governing differential equation to the physical initial conditions. (K text chap. 2)

1. A number of diverse examples of simple harmonic motion in nature will be presented (including some examples and applications that will probably be new to you) with a theme of picking off the oscillation frequency directly from the governing differential equation of motion. Some important analogies between physically different oscillating systems will be pointed out, which will allow you to begin “reasoning by analogy” between seemingly disparate systems. (K text, chap. 2 and first sections of chap. 3.)
2. I plan to next show you how to use power series expansion techniques to approximate and linearize intrinsically nonlinear equations that describe the oscillations of real physical systems. This powerful technique opens the door to dealing with the physics of some real world phenomena. It will be applied to (as time permits) several systems, including a physical model for predicting an approximation to a fundamental radiation frequency from diatomic molecules. (K text, chap. 3)
3. I plan to then then introduce you to one of the central concepts of modern physics (and of branches of modern engineering) - that of normal modes. In this part of the course, initially we will spend considerable time gaining an intuitive understanding of the normal modes of selected paradigm discrete systems of masses and springs. We will also look at the interesting and important phenomenon of “beats” and energy exchange between the moving parts of a system in the interesting situation when two modes that are close in frequency are simultaneously excited. (The concept of beats between modes has applications in many areas of modern physics and communications engineering, including, e.g., to neutrino oscillations in particle and astrophysics.) (K text, chap. 6)

1. Following that, we will study the normal modes of one of the most important continuous one-dimensional systems (the “stretched string”). We will derive the all-important Classical Wave Equation (CWE) governing wave motion on the string. From the CWE, we will be able to derive the “Helmholtz” (or “mode-shape”) equation that governs the shapes of the normal modes. We will see that the normal modes on an “ideal” stretched string subject to boundary conditions are standing waves, and will see exactly how the boundary conditions require the very important result that only certain frequencies can exist for standing waves on a bound string. We will see how to identify those frequencies. (This general concept has application in many areas of physics including quantum physics). Here, we’ll also consider simultaneous superpositions of normal modes on a string. (K text chap. 8, parts of chaps 9 and 10; also F&K text, chap. 1, sect. 1.4 and 1.5 (on complex numbers) and chapter 2, section 2.1 and part of sect. 2.2.

Continued on next page 🡪

9

**Overview of the Course (Tentative), continued:**

1. Next, I plan to provide you with a solid quantitative and physically intuitive introduction to what is arguably the single most important mathematical technique in much of physics - that of Fourier analysis. Examples will be provided, and time permitting, among them some that could lead us naturally into a discussion of some very interesting aspects of the physics of music. Also, in this part of the course, the Fourier Bandwidth Theorem, so central to all branches of modern physics (especially to quantum theory, in which it appears as the “uncertainty principle” and to signal propagation and reception in electrical engineering) will be introduced and illustrated in an elementary way. (K text, chap. 11 and part of chap. 12, F&K text chap. 3, sect. 3.3).
2. I plan to next discuss rigidly traveling waves: formulae for rigidly traveling waves, wave (phase) velocities on ideal stretched strings, Time permitting we will discuss propagation and wave velocity of sound waves in air and discuss the amazing range of sensitivity of the human ear. (K text, parts of chapter 13, F&K text section 4.3).
3. Time permitting, we will next discuss energy carried by waves, including energy flux by plane and spherical waves of sound, “characteristic impedance” of a medium as an important parameter controlling the energy flux and (time permitting) partial reflection/partial transmission of waves at interfaces between media. (K-text, chapter 15, F&K text section 4.4).
4. The plan is that you will next learn about the propagation of superpositions of traveling waves of differing frequencies, which will lead us to discussion of traveling groups of waves and their group velocity. This will lead us naturally to the very important Fourier integral and (to the extent that time permits) real Fourier sine and cosine transform concepts. Then with those and with the Fourier bandwidth theorem, you’ll be ready to understand the basis of radio and television broadcast (modulation and bandwidth), which, time permitting, we discuss next. (K text, chapter 17 and possibly F&K text sections 6.4 and 6.5).
5. Then, complex exponential Fourier series (K text, chapter 12, sections 12.9 and 12.10, and complex exponential Fourier transforms (K text chapter 17, also F&K text, sections 3.3 and 3.4)

As I say, the above listing is *tentative* – it may be reordered as we go through, parts may be omitted, other material may be added – we will see how things go.

I found this material fantastic when I first learned it. I still do! I hope that you will also.

10

***Tentative Syllabus:***

*Text material will be supplemented in class sessions and with posted “Class Notes sets” and possibly with other posted material. You are responsible for the sum of assigned text readings, all class lecture/discussion material, all material posted on-line and handouts, unless I indicate otherwise. The listing below is tentative.* Coverage may be extended to additional topics (time permitting). On the other hand, certain sections or even entire chapters or parts listed below may be deleted from your responsibility– I’ll determine this as we go along.The items on the exact list of text sections that you are responsible for each exam will be announced before that exam.

For convenience, I think of the course as consisting of parts as listed below with references:

(K = text manuscript by D. Kaplan, F&K = text by Fleisch and Kinnaman). *Actual reading assignments are not necessarily those listed below, but will be posted online in each “weekly folder” as we go through the course. Listed time durations listed are only rough guides, may vary.*

## Part I: Overview of Aspects of Wave Physics: K chapter 1.

## (One half class session plus student reading spread through parts of the course.)

## Part II: Simple Harmonic Motion, Linearization and approximate harmonic motion, application.

## systems. K chap. 2 and sections 3.1 thru 3.3, of chap. 3, About weeks.

*Higher order approximation for oscillations, binomial expansion approximations,*

*applications*: K chapter 3, sects. 3,4, 3.6. 3.7 and 3.11. About 1 week.

*Part III: Normal Modes and coupled oscillations of discrete systems, examples, energy*

*exchange between moving parts: K chapter 6; handouts. About 2 weeks.*

*Part IV: Classical Wave Equation and Normal Modes for Stretched String and one dimensional*

*Systems, Normal Mode Superpositions on stretched string and Initial Value Problem: K chap. 8, selections from K chaps 9, 10; F&K parts of chapter 2. About 2 weeks.*

*Part V:*  *Introduction to Fourier synthesis and analysis of repetitive functions, more on Initial Value Problem on stretched string via Fourier analysis, Classical Bandwidth Theorem: K chaps. 11 and part of chap 12, F&K chapter 3, section 3.3. About 2*½ *weeks.*

*Part VI: Traveling waves, phase velocities, complex function form of traveling sinusoidal waves,*

*reflection at bound and free ends, standing waves as superpositions of traveling waves, energy and intensity carried by waves, characteristic impedance, traveling waves in two and three dimensions, applications to sound waves. As time permits: partial reflection/partial transmission and refraction at change of impedance. K part of chapter 13, F&K chap. 4, sects. 4.3, 4.4. If time permits: selections from chapter K, chap. 16, F&K sect. 4.5. About 2*½ - 3 *weeks.*

*Part VII: Traveling pulses and wave groups, group velocity, Classical Bandwidth theorem*

*applied to non-repetitive pulses, applications. Fourier integral and Fourier sine and*

*cosine transform analysis of nonrepetitive functions and wave pulses, complex*

*Fourier transform, applications: excerpts from K chap.17, possibly F&K chap.6, sects.*

*6.3 thru 6.5. About weeks, as time permits.*

Please remember again - you are responsible, not only for the assigned text sections, but also for all class session material, all material posted on-line for you and all handout material, and, on quiz(es) and exams, the associated “Primary Formulas.” Please also note that it is your responsibility to keep your reading synchronized with the class presentations. If you are ever unsure of what you should read to prepare for the next class session, please ask.

**Please Note**: Posted “Class Notes” are meant to help you and highlight aspects of the subject as time permits in class sessions. They are not meant as a replacement for the text reading assignments.

11

**A Relevant Note**:

The material is challenging and expansive and thus it will require steady work. New physics is rarely easy, and the material of this course is no exception to that. Understanding comes only through repetitive visiting and working through the material. *Please understand that this is normal for everyone* – please do not get too discouraged if the subject seems quite difficult and you have to fight to learn. Your own satisfaction in understanding what you had time to work through is something that you can take pride in.

**Course Policies**

1. **Course Attendance Policy**:

*I urge you to attend all of our class sessions unless illness or unavoidable serious other responsibilities (see section on “Excused Absences” below) cause you to miss some.* I am here to help your learning. As I say, lectures will supplement the text and unless otherwise indicated by me as we go along, you will be responsible for all physics material discussed in all class sessions. Some of the material covered in class lectures is not in the text, or is only somewhat superficially covered in it. Thus, it’s not good to miss a class unless it is really necessary.

I do not allow students to “add” (i.e., register in) the course after the first week of class sessions. If you do register in the course after the first class session, you are still responsible for all material covered and for all announcements made in class and for all posted assignments for the class made before your registration.

**If you are absent from class for any reason, authorized (“excused absences,” see below) or not, you are still responsible for material covered in class on the day of absence and for all assignments due or assigned during that class or on any day during your absence.**

**Grade Penalty for excessive absence**:

If, over the course of the semester, you miss more than nine of our class sessions (excluding “excused absences” as per list of excused absences below) your final Course Composite Score (see section on Grades below in this document) may be lowered on that account alone by up to 3% (out of 100%) per missed class session beyond the ninth unexcused missed class session.

### Excused Absences

An absence from class is considered an “excused absence” as per the above policy of possibly being dropped from the course, **only** if it meets at least one of the following criteria:

1. Absence due to required participation in Official University business. If official University business requires you to miss a class or exam, you must present appropriate University documentation authorizing your required participation in this University business to me in advance. If official University business requires you to miss more than nine classes [15% of our total number of class sessions], then any additional classes missed due to University business after the ninth are *not* considered excused absences. For more information about absences due to University business, consult SIUE University policy 1i8.
2. If University approved valid religious observance requires you to miss a class or an exam.
3. A *serious* and *temporary* situation for which I grant excused absence. Medical situations

require documentation.

12

## **Policy on Withdrawal From The Course**:

To withdraw from the course, *you* must initiate the paperwork with the registrar’s office. I cannot do this for you.You must also observe University rules and deadlines in this regard. **It is your responsibility to be knowledgeable about these rules** **and** **to be aware of these deadlines.** I cannot change them for you.

**Withdrawal from the Course After the University Deadline for “W” Grade:**

After the University deadline for the grade of W, there is a period (“WG” period) during which, if you drop the course, you will receive a grade of either WP or WF. In accordance with university guidelines, that is determined as follows:

After the “W” deadline but before the close of the WG period:

At the time that I electronically or otherwise sign the completely filled-out university drop form:

If you are passing the course at that time, you will receive the grade of WP.

If you are failing the course at that time, you will receive the grade of WF.

Note: I do not sign or consider as received add/drop forms that are not completely filled out.

Cessation of attendance without required paperwork: If you cease attending the course without submitting the required withdrawal paperwork to the University, you will receive the grade of UW, subject to the following: In the event of unauthorized cessation of attendance in the course that does not result in the grade of WR or NS or I, the grade that is the grade earned for the entire course will result only if it is “D” or better, counting all missed exams and unsubmitted assignments as zeroes and then subject to a further possible grade penalty if there are more than nine unauthorized absences that are not approved “excused absences” (as per list above on page 11). If a serious illness prevents you from attending and completing the course, let me know about it and I will consider the situation and make a decision concerning it. If you are in doubt, I also recommend consulting with me about it.

## **Policies for Examinations and Quizzes:**

For *tentative* dates for our course exams including the Final Exam, see page 19 in this document. Date(s) of the quiz(zes) will be announced at least three calendar days in advance of each quiz.

## a. **Policies for Examinations and quizzes during in-person (“f2f”) course modality:**

The following policies will apply for exams and quizzes that occur while our course is in live in-person mode. (If a modality change requires that exams and quizzes occur while our course is in online mode, I or the physics department will inform you of the policies that will then apply.)

Unless otherwise indicated in advance by me, all quizzes and exams in our course will be of a “closed-book, closed notes” nature.

The list of relevant text sections and material that you will be responsible for on each quiz or exam will be communicated to you in advance of that quiz or exam.

**“Primary Formulae” you will need to know for exams and quizzes**

Unless I announce otherwise, in advance of each exam or quiz (including our Final Exam), pertaining to the material that you are responsible for, I plan to make available to the class a list

13

of formulae and/or equations that are considered very basic (“Primary Formulae”) for that exam or quiz. I expect that you will know, understand and understand how to use those Primary Formulae, as I do not intend to provide you with them along with or during the quiz or exam. No assurance is made that *all* necessary formulas/equations needed for the exam or quiz will appear on the associated list of Primary Formulae – you are responsible for knowing and understanding the content of our course that is within the lines of responsibility for each exam or quiz (including necessary prerequisite material). Each such list of Primary Formulae is provided to you in advance as an aid, not as a replacement for understanding the course material.

The list of Primary Formulas for each exam and for each quiz will be made available to you at least three calendar days before that exam or quiz.

*Further Policy During In-person Modality Quizzes and Exams:*

Unless I indicate otherwise, calculators are allowed during a quiz or exam, but the use of a calculator program during a quiz or exam is not allowed and is considered academic dishonesty.

**Use of a cell phone, smart watch, ipod, personal music device, computer or computer “tablet,” or wearing headphones or earbuds during any examination or quiz is forbidden. All such devices must be turned off and put away during any quiz or exam.** Thus, during examinations and quizzes, cell phones cannot be left on the desk top or table top on which you are taking the exam or quiz. The same is true for smart watches, headphones, “ear buds,” ipods, personal music devices, computers and computer “tablets.” If it is announced that, for a certain exam or quiz, a calculator is not allowed, it cannot be left out on the desk top or table top during the exam or quiz, and must be put away.

**Please Note**: Due to issues that have been experienced throughout the University, if you leave the exam room during the exam, you will be required to leave any phone, ipad, ear buds and headphones that you have with you on the instructor’s classroom desk. Thus, please ensure that any needs are dealt with before beginning your quiz or exam. If you have a persistent medical condition related to this, please contact SIUE ACCESS concerning accommodation for it.

**Missed Exam or Quiz Policies:**

It is my general policy that a missed course exam or quiz counts as a zero – **I do not intend to give any make-up quizzes or exams unless official university business, absence from class due to U.S. federal or state military requirement that you be away from the University, a University approved valid religious observance or another serious reason** (the decision on which ismine, perhaps in consultation with the physics department Chair) **intervenes**.

Allowing a make-up for missing an exam or quiz due to a medical condition will be subject to my decision and will normally require a note from and signed by a physician explaining when you can return to take the exam.

If official University business requires you to miss a scheduled quiz or exam, you must contact me about it in advance and you must present to me appropriate University documentation authorizing your required participation in this University business to me in advance. For more information about missing class requirements due to University business, you can consult SIUE University policy 1i8.

If an unavoidable situation or significant illness arises, please let me know about it as soon as possible before the scheduled exam time; I will make the judgment.

*I plan no early (i.e., before the scheduled time for the class) exams for individual students.* That applies even in situations involving authorized missing of an exam or quiz during the day and time scheduled for the class to take that exam or quiz.

14

**Authorized “make-up” quizzes and Exams**: Unless I specifically authorize otherwise, an exam or quiz missed due to required participation in official University business or due to valid University recognized religious observance on the scheduled day of the exam or quiz, must be “made up” very promptly, otherwise a grade of zero (on that exam or quiz) may result. Thus, if you miss a quiz or exam for one of those reasons, you must contact me about it as soon as possible in advance, so that we can arrange a “make up” quiz or exam.

Exams or quizzes missed for any other reason (e.g., a medical condition) that I specifically authorize must be made up very promptly after the quiz or exam is administered to the class, per

agreement with me. Please note that I will only authorize a delay in taking an exam or quiz for situations that I judge to be sufficiently serious and/or appropriate. If in doubt, ask me. The judgement and decision on this is mine. For these situations, according to my judgement, documentation may be required.

Unless I specifically authorize otherwise, an exam or quiz missed for any other reason will result in a grade of zero on that exam or quiz.

**Please note:** Generally, I do not discuss exam and/or quiz solutions until the grades on the exam or quiz have been communicated to the class as a whole. Also, for the protection of your privacy, I will not discuss grades or exam or quiz solutions via e-mail, via telephone or during an office hour with more than one student present.

***Final Exam***: Unless announced otherwise, **the final exam will be comprehensive** (will range over the entire course.) More on the Final Exam toward the end of the present document.

## **Academic integrity**

It is necessary that you adhere to good standards of conduct at all times. I know that you will do this. I also know that you will work honestly at all times during this course. In case of a violation of this, consequences will be in line with University policy and the University student academic code. Students are reminded that the expectations and academic standards outlined in the [Student Academic Code (3C2)](https://www.siue.edu/policies/3c2.shtml) apply to all courses, field experiences and educational experiences at the University, regardless of modality or location.

Plagiarism is the use of another person’s words or ideas without crediting that person. Plagiarism and/or cheating may lead to failure on an assignment, in the class, or dismissal from the University, per the [SIUE academic dishonesty policy](http://www.siue.edu/policies/1i6.shtml). Students are responsible for complying with University policies about academic honesty as stated in the [University Student Academic Conduct Code](http://www.siue.edu/policies/3c2.shtml). Information on University policy on plagiarism can be found at web site <http://www.siue.edu/policies/1i6.shtml>. Information on the Student Academic Code and academic misconduct can be found at <http://www.siue.edu/policies/3c2.shtml>, and also at <http://www.siue.edu/policies/3c1.shtml>.

Unless expressly allowed by the instructor, the use of artificial intelligence (AI) tools and applications (including ChatGPT, DALL-E, and others) to produce content for course assignments and assessments is a violation of SIUE’s academic policy and is prohibited.

Please note that you are not allowed the use of a cell phone, smart watch, ipod, personal music device, headphones or “ear buds” during any class session. In addition, use of a computer or computerized “tablet” during any quiz or exam (including during the Final Exam) is not permitted. During all quizzes and exams, cell phones and similar devices must be turned off or placed into “silent mode” and put away.

15

**Intellectual Property Policy**

Much of the material for this course is created by the instructor (David Kaplan) for his use and that of his students. All such materials created by the instructor, whether explicitly otherwise stated as copyright or not, are © David H. Kaplan, 2024. This includes, but is not limited to, manuscript materials, written “Class Notes,” Audio/Visual files, handout packets and quizzes and examinations created by, distributed or posted on-line by the instructor. Dissemination of these materials without prior, explicit, written consent of the instructor is prohibited.

Further, recording of lectures, including but not limited to electronic recording of video or sound during lectures, without prior explicit written consent of the instructor is prohibited. Recording of Zoom meetings without the consent of the instructor and the participants is likewise prohibited. Recording by students and/or dissemination by students of images of other students or their

utterances in class is also prohibited. Violation of these rules may result in disciplinary action within the university, or possibly even legal action outside of the university. Recording and/or

dissemination of images, sounds, or events in the classroom may also violate University regulations (<http://www.siue.edu/policies/3c1.shtml>) and/or State and/or Federal privacy laws and may be subject to penalties through those agencies. So, please be careful regarding these issues. If you have any questions on this, please ask me.

***Classwork:***

You will note (see below) that your class participation *may* affect your course grade. This underscores the importance of keeping up in class and actively participating. Participation does not so much mean knowing the answers as it means asking questions about things that you feel uncertain or unclear about, but that display that you have kept up with the required reading and generally taking and displaying an active interest in learning the material of the course. Extensive experience shows that it is much easier to succeed in a course in which you keep up with the class discussions. As noted above, this will generally require steady studying outside of class.

***Homework****:*

**A. Reading Assignments**:

Reading assignments will be communicated to you regularly in class sessions. As mentioned above, the plan is that, as we go along, they will also be included in on-line weekly folders in the Coursework area of the SIUE Blackboard website for our course. I recommend multiple readings of reading assignments separated in time over several days.

**B. Homework Problems to be Submitted:**

Homework Problems will be assigned frequently and will count in your course grade (see below). *Late* *homework assignments will not be accepted after the due date and time unless I specifically authorize an exception* (which must be for a good reason). Even if I authorize acceptance of late homework, there may be a point penalty for the late submission.

For reasons of efficiency and pragmatism, if there is no grader assigned by the department for our course, it is likely that I will not be able to grade every homework problem on every assignment that you submit. In that case, only a percentage of the homework problems on each homework set will be selected to be graded and only those will count in your grade. The percentage that is selected for grading likely will vary from assignment to assignment and will range from about 20% to 100%. However, not attempting all of the homework problems can put not only your homework grade, but also your examination grades at risk. I urge you to seriously attempt all assigned homework problems. Some homework problems may require only 15 minutes, others may require significantly more thought.

16

**A Tip for Success in the Course Concerning Homework**:

Good success in our course means learning and understanding the material. It’s fine and often a help to learning to *study* with other people in a group, but ultimately, there is really only one road toward understanding physics and that is thinking through it on your own at your own rate. It is all too frequent that even advanced students incorrectly convince themselves that they understand material that they have not worked through in detail on their own. We are all prone to think or assume, after looking at or hearing someone else’s solution to a problem, that we would have, or at least could have, gone through the same reasoning all the way to the correct conclusion. **All too** **often, that assumption is incorrect.**

For this reason, I urge that, before consulting anyone else, you make a serious effort to work through every assigned homework problem in detail **yourself**. If a homework question seems unclear after significant thought, I recommend asking me about it – it is possible that there is a “typo” in the question statement, etc.

Above all, I urge: **do not attempt to do a homework problem before you have studied the relevant material.** Many problems that arise can be traced to that.

17

***Quizzes, Exams and Grades****:* ***Tentative Plan***

Here is the ***tentative*** plan: Over the course of the semester there will be required: one quiz (more than one if I deem it necessary), three midterm exams, a final exam that is comprehensive over the course, and required homework assignments. Your course grade will be determined from your final “Course Composite Score” determined from these as indicated below. The date(s) of the quiz(zes) will be announced in class at least three calendar days in advance of each quiz. Your final Course Composite Score will be a percentage (maximum 100%).

In the determination of your Course Composite Score: A missed quiz or exam counts as a zero score for that quiz or exam unless I specifically authorize a “make-up” quiz or exam for you. A homework set that is not submitted or submitted after the due date will (unless specifically authorized by me) count as a zero score on that homework set. If I authorize acceptance of late homework, there may be a point penalty for the late submission. Authorization of a make-up exam or quiz will require a serious reason (by *my* judgement). If an unavoidable situation arises, let me know about it as soon as possible before the scheduled quiz/exam time. I will then make a judgment (possibly in consultation with the department Chair). If in doubt, ask me.

The date for (each) quiz will be communicated to you at least three days before that quiz.

The tentative dates for the three midterm exams are listed on page 19 of this document.

***Determination of Your Final Course Composite Score (Tentative)***

Your score on the quiz (assuming there is only one) will count for 3% of your final Course Composite Score. [If it is necessary to have more than one quiz, the quizzes together may count more than 3% and the percentages listed below, which assume one quiz, may then change accordingly. In that case, the new percentages will be announced in class.]

Your score on each of the three midterm exams will count as % of your final course composite score. Thus, taken together, the average of your scores on all three midterm exams will count as 53% of your final composite score.

Your score on the final exam will count as 24% of your course composite score.

Your scores on all of the required written homework assignments will count as 20% of your course composite score.

I will let you know about any changes in the above weighting scheme.

*Formula for the course composite score:*

You can calculate your course composite score as follows:

Let *q* be your average percentage score (maximum 100%) on the quizzes.

Let *m* be your average percentage score (maximum 100%) on the midterm exams.

Let *h* be your average percentage score (maximum 100%) on the homework.

Let *f* be your percentage score (maximum 100%) on the final exam. Then:

Final composite score = (.03\**q*) + (.53\**m*) + (.20\**h*) + (.24\**f*).

18

*Example*: Let’s say your quiz average is 82%, your midterm average is 85%, your homework average is 80% and your score on the final exam is 87%. Then your final

composite score is

(.03\*82) + (.53\*85) + (.20\*80) + (.24\*87) = 84.4

*Possible bonus*: If, in my judgement, you consistently showed very good informed (i.e., reflective of that you have kept up with the assigned reading and understand it) participation, and/or showed consistent significant improvement as the semester progresses, at my decision, you *may* receive a bonus of up to 4% added to your course composite score at the end of the course when the grades are determined. *Whether or not this occurs and the extent of it is completely my decision.*

*Minimum Letter Grades*:

If your composite percentage score (after possible adjustment as indicated above) is in a range indicated in the table below you will receive a grade of at least that indicated for that range:

Composite Percentage Minimum Course Letter Grade

in range

100% – 90% A

<90% – 80% B

<80% - 70% C

<70% - 60% D

below 60% F

However, at my decision, for the class, the minimum scores necessary to achieve one or more of the letter grades *may* be lower than those listed in the table above. (The minimum required scores for each letter grade will not be raised above those in the table, however.) Thus, after I determine your Course Composite Score as outlined above, your course letter grade *may* be higher than indicated in the table. *Whether or not this occurs and the extent of it is completely at my decision.*

More on next page 🡪

19

***Tentative*** *Dates for Midterm Exams:*

The dates for the midterm exams are *tentatively* (see below)as follows:

Exam I – Thursday February 15, 2024

Exam II – Thursday March 14, 2024

Exam III – Thursday April 18, 2024

One or more of these tentative dates may be changed, but consider them firm unless I announce otherwise. If an exam date is changed, the new date for the exam will be announced in advance in class. Also, the items on the list of relevant text sections (and other material) that you will be responsible for on each exam will be announced in class in advance of that exam.

As indicated above, the date(s) of the quiz(zes) will be announced at least 3 calendar days in advance.

***Final Exam****:*

The Final Exam will be comprehensive (*i.e*., range over the entire course).

The tentative date for the final exam as of this writing is:

Thursday May 2, 2024 Noon – 1:40 PM.

20

***Other Books:***

At this level, you may find it helpful to consult books other than your texts. Some that I’ve found helpful in teaching Waves courses (listed roughly in order of increasing level):

The Wave Watchers Companion by Gavin Pretor-Pinney (Perigee Books). A delightful overview (with no math) of wave phenomena. Although written for the general public, generally correct and not oversimplified. Available in inexpensive paperback.

Physics, 5th Ed., by R. Resnick, D. Halliday and K. Krane (Wiley). Chapter 17, 18 and 19 of this well known University physics text offer excellent, but brief overview treatments of some of the main topics of our course.

Six Ideas That Shaped Physics: Unit E: Electric and Magnetic Fields by Thomas Moore (McGraw-Hill). Chapters E15 and E16 offer clear but brief introductions to waves in general and to electromagnetic waves. At the level of our course but quite restricted in coverage.

Introduction to Wave Phenomena by A. Hirose and K. Lonngren (Wiley). A very clear straightforward treatment that emphasizes traveling waves, esp. EM and cable waves. CWE derived as a continuum limit. No coupled oscillations, little on Fourier analysis. Very good basic treatment of EM waves and EM radiation, some basic optics. Relatively easy to read.

Vibrations and Waves (M.I.T. Introductory Physics Series) by A. P. French. A nice short book with many insights. Well written and at about the level of our course, but more restricted in coverage and in places wanders significantly from our curriculum. Very little on electromagnetic waves. In my opinion, a linear combination of French’s book with that of Hirose and Lonngren (above) would make a good more inclusive basic text on the subject.

The Feynman Lectures on Physics, Vol I by R. P. Feynman, R. Leighton and M. Sands. The master speaks – and, as always, very lucidly. Only a few chapters are directly concerned with waves, but they are excellent.

Waves Berkeley Physics Series Vol. 3 by F. S. Crawford (McGraw-Hill). Classic text from the 1960’s, but used copies probably still available. At the level of our course. Parts correspond fairly closely to our course; includes much additional material and many delightful “Home Experiments.” Emphasizes intuition and packed with insights and analogies. Quite readable and very beautiful in many places, but in other places an overreliance on intuition makes it challenging for a typical 2nd year physics student to understand what’s being said, an issue that’s exacerbated in places by the lack of a sufficient number of diagrams to illustrate. Despite these “flaws in the gem,” one of the most beautiful and enthusiastically written physics texts ever written. Recommended.

The following four books are all at about the same level, slightly higher than that of our course:

Vibrations and Waves in Physics, by Iain Main (Cambridge University Press): Excellent treatment, very good choice of topics, but moves fairly rapidly and thus a bit terse for a second-year course. Many good insights. Good, careful (but a bit brief) treatment of characteristic impedance (based on the force method) and partial reflection. Nice basic coverage of surface waves on water. A good book to read through following our course – one of my favorite books on waves.

Waves and Oscillations A Prelude to Quantum Mechanics by W. F. Smith (Oxford). Very good with readable, friendly and informal tone, but moves faster than our course and is terser. Emphasizes a mathematical formulation for normal modes that parallels that of quantum mechanics with good elementary coverage of the vector space and Hilbert space aspects of normal mode theory. Good treatment of characteristic impedance and partial reflection emphasizing isomorphisms between quantities in different physical systems. Would be very good to read right after our course.

21

The Physics of Vibrations and Waves, 6th Ed. by H. J. Pain (Wiley). A quite complete (except for waves on water) coverage – almost encyclopedic. Lots of good physics in this book. Strong on transmission lines and electromagnetic waves. At the 3rd year level, though parts of it are readily accessible to second-year students.

Oscillations and Waves An Introduction by Richard Fitzpatrick (CRC Press). Very good treatment, readable, but moves rapidly – a lot covered in its 268 text pages. Very clear and nice to read through as a review plus more if you’ve already had a course like ours. At a brisk 3rd year level.

Wave Phenomena by Dudley H. Towne (Dover). At the 3rd − 4th year level. Generally very good, careful and authoritative coverage with a special emphasis on acoustics and optics (the latter, as of the late 1960’s). Final part very good on some aspects of Fourier methods.

Physics of Waves by W. Elmore and M. Heald (Dover). A pretty complete, fairly high-level, careful physical and mathematical coverage of the subject without vector space/Hilbert space aspects. Excellent on acoustics, EM waves, optics (as of 1969). At the senior undergrad to first-year graduate level. Generally an excellent book.

Vibration and Sound, by Phillip Morse (Amer. Inst. of Physics): An older classic (1st edition, 1936). Very complete on traditional mathematical techniques applied to wave motion (especially acoustics). At the 4th year undergrad to first-year graduate level.

**Math Topics**: For aspects of basic Fourier analysis, I particularly recommend:

Mathematical Methods for the Physical Sciences by Mary Boas (Wiley), chapter 7 (very readable, starts “from scratch”) and also section 15.4 (Fourier Transforms),

Mathematics for Physicists by Susan Lea (Thomson), esp. chapter 4 on Fourier Series (starts at the beginning, but at junior-senior level) and chapter 7 on Fourier transforms; for the latter she assumes some proficiency with contour integration of complex-valued functions. Generally excellent book for a one-semester course on “math methods” for physics.

Optics, 4th Ed. by Eugene Hecht (Addison-Wesley), chapters 7 & 11 (also, see below), and

Fourier Series and Boundary Value Problems 4th Ed. by R. Churchill and J. Brown (McGraw Hill).

Further mathematical coverage of solutions of the Classical Wave Equation is frequently included in books on differential equations – e.g., those by Boyce and DiPrima and by Farlow.

**Applications to Physics of Music and Sound:**

Physics: Foundations and Applications, vol. I (sections on physics of music) by R. Eisberg and R. Lerner (McGraw-Hill). Excellent on aspects of physics of music. At the level of Phys. 251.

The Science of Sound, 3rd Edition, by Rossing, Moore and Wheeler (Wiley). At the noncalculus level. Very good and almost encyclopedic on the physics of musical instruments.

The Physics of Sound, 3rd Ed. by R. Rerg and D. Stork. Excellent. Similar to book by Rossing et al (above) but less encyclopedic. Very good choice for noncalculus “Physics of Music” course.

Musical Acoustics by D. Hall. Similar to Berg and Stork (above) with slightly different emphases.

**Application of Wave/Fourier technique to Optics**: The following are at the 3rd/4th year level:

Principles of Physical Optics by C. A. Bennett (Wiley). Nice book. Succinct, very clear.

Introduction to Modern Optics, 2nd Ed. by Grant R. Fowles (Holt, Rinehart, Winston).

Optics, 4th Ed. by E. Hecht (Addison-Wesley). Excellent classic at the 3rd/4th year undergrad level.

## Now let’s enjoy our course!