Physics 581 Class Schedule – Winter 2012

	Monday	Tuesday	Wednesday	Thursday	Friday
January	2	3 Start of classes	4 Lecture 1 Ch 1: Periodic arrays of atoms **HW 1 assigned**	5	6 Lecture 2 Ch 1: Fundamental types of lattices; indices for xtal planes
	9 Lecture 3 Ch 1: Simple structures; direct imaging; nonideal structures; crystal structure data	10	11 Lecture 4 Ch 2: Diffraction of waves by crystals **HW 1 due; HW 2 assigned**	12	13 Lecture 5 Ch 2: Scattered wave amplitude
	16 **MLK Day Holiday**	17	18 Add/drop deadline Lecture 6 Ch 2: Fourier analysis of basis	19	20 Lecture 7 Ch 2: Fourier analysis, cont.; Brillouin zones
	23 Lecture 8 Ch 3: Crystals of inert gases **HW 2 due; HW 3A assigned**	24	25 Lecture 9 Ch 3: Ionic; covalent; metals; hydrogen bonds; atomic radii	26	27 Lecture 10 Ch 3: Analysis of elastic strains; elastic compliance and stiffness constants **HW 3A due; HW 3B assigned;** **Begin Exam 1 (Ch 1, 2, 3A)**
February	30 Lecture 11 Ch 3: Elastic compliance and stiffness constants, cont.; Elastic waves in cubic crystals	31 **Exam 1 due**	1 Lecture 12 Ch 3: Elastic waves in cubic crystals, cont.; Ch 4: Vibrations of crystals with monatomic basis	2	3 Lecture 13 Ch 4: Vibrations of crystals with monatomic basis , cont. **HW 3B due; HW 4 assigned**
	6 Lecture 14 Ch 4: Two atoms per primitive basis	7	8 Lecture 15 Ch 4: Quantization of elastic waves; phonon momentum	9	10 Lecture 16 Ch 4: Inelastic scattering by phonons
	13 Lecture 17 Ch 5: Phonon heat capacity: density of states **HW 4 due; HW 5 assigned;**	14	15 Lecture 18 Ch 5: Phonon heat capacity: Debye model	16	17 Lecture 19 Ch 5: Phonon heat capacity: Einstein model; anharm. crystal interactions; thermal cond.
	20 **Presidents Day Holiday**	21 Monday Instruction Lecture 20 Ch 5: Thermal cond., cont.; Ch 6: Energy levels in 1D	22 Lecture 21 Ch 6: Effect of temperature on the Fermi-Dirac distribution; Free electron gas in 3D **HW 5 due; HW 6 assigned**	23	24 Lecture 22 Ch 6: Free electron gas in 3D, cont.; Heat capacity of the electron gas
March	27 Lecture 23 Guest Lecturer (Colton out of town)	28	29 Lecture 24 Guest Lecturer (Colton out of town)	1	2 Lecture 25 Ch 6: Electrical cond. & Ohm's law; Thermal cond. of metals
	5 Lecture 26 Ch 6: Motion in magnetic fields; *Quantum mechanics review*	6	7 Lecture 27 Ch 7: Bloch functions **HW 6 due; HW 7 assigned** **Begin Exam 2 (Ch 3B, 4, 5, 6)**	8	9 Lecture 28 Ch 7: Kronig-Penney model; Empty lattice approximation
	12 Lecture 29 Ch 7: Wave eqn of electron in a periodic poten. ("Central Eqn") **Exam 2 due**	13	14 Lecture 30 Ch 7: Central equation, cont.	15 Withdraw deadline	16 Lecture 31 Ch 7: Number of orbitals in a band; Nearly free electron model ("Perturbation Theory")
	19 Lecture 32 Ch 7: Perturbation theory, cont.; Ch 7 wrap-up	20	21 Lecture 33 Ch 8: Eqns of motion (effective mass, holes, band gap); intrinsic carrier concentration **HW 7 due; HW 8 assigned**	22	23 Lecture 34 Ch 8: Intrinsic carrier concentration, cont.; impurity conductivity
	26 Lecture 35 Ch 8: Impurity conductivity, cont.; *Bandgap engineering* (skipping rest of Ch 8)	27	28 Lecture 36 Ch 17: p-n Junctions; heterostructures semiconductor lasers; LEDs	29	30 Discontinuance deadline Lecture 37 Ch 15: Excitons; *Maxwell Eqns* **HW 8 due; HW 9 assigned** **Begin Exam 3 (Ch 7, 8, 17)**
April	2 Lecture 38 *Maxwell Eqns, cont.*; Ch 15: Optical reflectance	3 **Exam 3 due**	4 Lecture 39 *Lorentz model of dielectrics*	5	6 Lecture 40 Ch 14: Polaritons
	9 Lecture 41 Ch 14: Dielectric function of the electron gas; plasmons	10	11 Last day of classes Lecture 42 *Semester Review* **HW 9 due; Final assigned**	12 Reading Day	13 Reading Day
	16 Begin Final Exams	17	18 **Final exam due**	19 End Final Exams/Graduation	20 Graduation

Reading assignments indicate the chapter and section the topic is in Kittel. Topics not found in Kittel are listed in *italics* and may involve handouts posted to the website.

Physics 581 – Winter 2012
Solid-State Physics

Instructor: Dr. John S. Colton, john_colton@byu.edu
Office: N335 ESC
Instructor Office Hours: 3-4 pm MWF, Underground Lab under the skylight
Research Lab: U130 ESC, phone 801-422-5286
Website: http://www.physics.byu.edu/faculty/colton/courses/phy581-Winter11/
You can navigate there via www.physics.byu.edu → Courses → Class Web Pages → Physics 581 (Colton).

TA: Tyler Park, tylerdpark@gmail.com
TA Office Hours: 1-3 pm MWF, N306 ESC (Tyler's office)

Prerequisites: Everyone should have had Physics 222 or equivalent. Integral and differential calculus are also certainly required, as will be some matrix analysis (linear algebra). Multivariable calculus will also likely be needed. Some statistical thermodynamics (Physics 360) may also be helpful.

Textbooks:

- *Introduction to Solid State Physics*, by Charles Kittel (8th edition). Required textbook. This is the standard textbook used in solid state physics classes across the country, and will be the dominant source for my lectures and homework problems. We'll cover the first eight chapters, along with some other odds and ends.
- *Solid State Physics for Advanced Undergraduate Students*, by Harold Stokes. Optional textbook. Dr. Stokes is a faculty member of our department. He taught Phys 581 for many years and wrote this textbook for it. There are a few reasons why I chose Kittel's textbook over Stokes' book, but it is still a good reference. In many cases I found Stokes' explanations easier to understand than Kittel's. Plus it's published very inexpensively through BYU Academic Publishing. It might be available in the bookstore; if not, ordering information can be found here: http://stokes.byu.edu/textbooks.html

Course Objectives: Students who successfully complete this course will learn the basics of the physics of solids. Specifically, students should be able to:

- Explain and use the following concepts and topics: crystal structure, reciprocal lattice, crystal binding, macroscopic elastic properties, phonons, the free electron model, band structure, and semiconductors.
- Show their understanding by solving problems in those areas using a variety of mathematical tools.

I also hope that as you learn more about the physical laws governing the universe, your appreciation for the order, simplicity and complexity of God's creations will increase. I sincerely believe that one can come to know the Creator better by studying His creations. I have been struck by these two quotes; hopefully they will be as meaningful to you as they are to me.

Brigham Young:

> Man is organized and brought forth as the king of the earth, to understand, to criticize, examine, improve, manufacture, arrange and organize the crude matter and honor and glorify the work of God's hands. This is a wide field for the operation of man, that reaches into eternity; and it is good for mortals to search out the things of this earth.

Steve Turley (former BYU Physics Department chair):

> My faith and scholarship also find a unity when I look beneath the surface in my discipline to discover the Lord's hand in all things (see D&C 59:21). It is His creations I study in physics. With thoughtful meditation, I have found striking parallels between His ways that I see in the scriptures and His ways that I see in the physical world. In the scriptures I see a God who delights in beauty and symmetry, who

is a God of order, who develops things by gradual progression, and who establishes underlying principles that can be relied on to infer broad generalizations. I see His physical creations following the same pattern.

Student Email Addresses: I may periodically send class information via email to your email address that is listed under Route-Y. If that is not a current address for you, please update it.

Mathematica: Some of the homework problems will require numerical calculations and plots. Mathematica is the program I recommend for this, but you can use other similar programs if you have access to/experience with them. Mathematica is found on many computers on campus: in the ESC, in the TMCB, in the library, and perhaps in other locations. To gain access to the computer labs in the ESC (rooms N337 and N212) you will need to (a) get the door codes from Diann Sorenson (room N281), and (b) get a Physics Dept computer account, see here: http://www.physics.byu.edu/ComputerSupport/ComputerAccounts.aspx

If you are not familiar with Mathematica and would like to become more so, here are two resources for you:

(1) My *Basic Commands of Mathematica* document, written for Physics 123 students: http://www.physics.byu.edu/faculty/colton/courses/PHY123resources/basic%20commands%20of%20mathematica.nb. (That document must be opened with Mathematica, not a word processor.)
(2) The Physics 230 *Introduction to Mathematica* manual, available here: http://www.physics.byu.edu/Courses/Computational/phys230.aspx

Grading: If you hit these grade boundaries, you are guaranteed to get the grade shown. I may make the grading scale easier than this in the end if it seems appropriate, but I will not make it harder. Because students are not graded relative to each other, it is to your advantage to learn collaboratively.

A	93%	B+	84%	C+	73%	D+	60%
A-	89%	B	80%	C	69%	D	56%
		B-	77%	C-	64%	D-	50%

Grades will be determined by the following weights:

- Homework: 35%
- 3 Midterm Exams: 45%
- Final Exam: 20%

Homework: Homework assignments will be given out on a quasi-weekly basis, typically one assignment per chapter. They will be due by 5 pm on the day indicated on the schedule. Turn in assignments to the slot labeled "Physics 581" in the boxes near room N375 ESC. Half credit will typically be given for work turned in late.

Midterm Exams: Two midterm exams will be given, currently planned to be take-home (as opposed to in the Testing Center).

Final Exam: A comprehensive final exam will be given, also currently planned to be take-home.

Advice from last year's students: In an end-of-the-semester survey last year, I asked outgoing students, "If you could give one piece of advice to next year's students, what would that be?" Here are their responses, in no particular order.

- Go to class and pay attention.
- READ THE BOOK! I could have learned much more had I read the book and paired this with the lectures.
- Read for understanding.
- Read the text book, work through the examples, use Dr. Stokes' book as a reference.

- I would highly recommend the students to purchase or use Dr. Stokes' book on solid state. I used it on most of my homework assignments and I found that it presents the material in a much more accessible format.
- Read over the *Mathematica* document on the website early on to avoid lots of frustrations.
- Learn *Mathematica.*
- It is a hard class, which requires a lot of study, but you will like it at the end.

BYU Policies:

Prevention of Sexual Harassment: BYU's policy against sexual harassment extends to students. If you encounter sexual harassment or gender-based discrimination, please talk to your instructor, or contact the Equal Opportunity Office at 378-5895, or contact the Honor Code Office at 378-2847.

Students with Disabilities: BYU is committed to providing reasonable accommodation to qualified persons with disabilities. If you have any disability that may adversely affect your success in this course, please contact the Services for Students with Disabilities Office at 378-2767. Services deemed appropriate will be coordinated with the student and your instructor by that office.

Children in the Classroom: The serious study of physics requires uninterrupted concentration and focus in the classroom. Having small children in class is often a distraction that degrades the educational experience for the entire class. Please make other arrangements for child care rather than bringing children to class with you. If there are extenuating circumstances, please talk with your instructor in advance.