BIS388 Philosophy and Science of Quantum Mechanics
Course Syllabus-Winter 2005

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Office Hours: Monday and Tuesday (11-noon), Wed (1-2 PM) and by appointment. It is best to check with me ahead of time, even for a visit during normal office hours, especially if you are making a special trip for that purpose. I am on campus for considerable periods every day (approximately 8-5) and will gladly make appointments outside of the nominal office hours.

Class Times: 8:45-10:50 AM, Tuesday and Thursday, Room UW2-021.

Mid Term Exams: Jan 27 and Feb 24, in class..

Final Exam: March 15, in class

Writing Assignment: Individual papers due on March 11, with preliminary materials due on Jan 25, Feb 8, and Mar 4.

Texts: The New Quantum Universe, 2nd ed, Tony Hey and Patrick Walters, (Cambridge University Press, 2003)
Where Does the Wierdness Go?, David Lindley, (Basic Books, 1996).

Supplementary Material: These journal articles and book chapters are required reading in the course. The following are available electronically on the UWB web site http://eres.bothell.washington.edu/

- Tegmark, Max and Wheeler, John Archibald ì100 Years of Quantum Mysteries,î Scientific American, February 2001, 68-75.
- Scerri, Eric R ì The Evolution of the Periodic System,î Scientific American, September 1998, 78-83.
- Scerri, Eric R ì The Periodic Table and the Electron,î American Scientist, Nov-Dec 1997, 546-553.
- Beller, Mara ì The Rhetoric of Antirealism and the Copenhagen Spirit,î Philosophy of Science, Vol 63, June 1996, 183-204.
- Cassidy, David ì Heisenberg, Uncertainty and the Quantum Revolution,î Scientific American, May 1992, 106-112.
- Kaiser, David ì More Roots of Complementarity: Kantian Aspects and Influencesî Studies in History and Philosophy of Science, Vol 23(2), 1992, 213-239.
- Logan, Jonathon ì A Strange New Quantum Ethicsî , American Scientist, July 2000, vol 88, p356.

Other required articles may be added during the course of the term.

Course Description

BIS 388 Philosophy and Science of Quantum Mechanics
(Charles F. Jackels)

The theory of quantum mechanics is arguably the most significant scientific development of the twentieth century. Much of contemporary technology (e.g. computers, CDís, etc.) depends directly on quantum mechanics, and its concepts have even gained prominent roles in popular culture, especially science fiction literature and movies. In this course we will explore the basic scientific and philosophical concepts of quantum mechanics within the context of its historical development. Our goal will be to gain an understanding of both the scientific method and the general principles of quantum mechanics. Particular attention will be focused on the relationship between observation, concept, and theory and the evolution of that relationship in twentieth-century physics. We will also explore the philosophical implications of duality, uncertainty, and complementarity, which are inherent to modern physics. The applications of quantum mechanics to be discussed will include: radioactivity, nuclear power, photosynthesis, stellar evolution, microelectronics, cryptography, quantum computing, and even time-travel and parallel worlds.

Course Goals
The overall goal of BIS 388 this term is to learn about the scientific method, the formulation of scientific theory, the nature of scientific discovery and the principal concepts and philosophical implications of quantum mechanics by exploring the development of modern quantum theory and several of its applications.

Specific goals include:

- An understanding of classical and modern atomic theories as they were developed in response to the experimental observations of the time.

- An understanding of the basic concepts, consequences, and philosophical implications of quantum theory, with particular emphasis on the interplay of theory and experiment. In addition to the classic experiments, this discussion will include modern "quantum entanglement" experiments that seem to imply "spooky" action at a distance.

- A conceptual understanding of important phenomena that are explained by quantum theory. Examples include atomic structure and spectra, nuclear fission, radio-isotope dating, photosynthesis, quantum cryptography, and time-travel.

- Development of the ability to read and understand papers written for the popular scientific literature that assume a conceptual understanding of quantum mechanics.

- Development of some of the basic graphical, algebraic and numerical skills necessary to effectively read the popular scientific literature, making use of scientific notation and hand-held calculators.

Background
It is *not* expected that students enrolled in this course will have had college level courses in either physics or chemistry. The course content will include those aspects of classical and modern physics necessary to support a conceptual understanding of quantum mechanics.

No particular mathematics background is assumed except the customary familiarity with algebra and scientific notation. It is not necessary that you purchase a calculator for this course, if you can borrow one when doing the homework problems and for an occasional exam question. If you want to purchase one, please select one that handles scientific (exponential) notation. Most of the explicitly numerical work will be during the first half of the course.

If you have not used high school level algebra, scientific notation, or your calculator in years, **do not panic!!** While the class time itself cannot be devoted to reviewing this material, I am most willing to spend time with you working on it during the first few weeks of the term.

Research Papers

There will be one major writing assignment during the course of the term, an 7-10 page independent research paper Your subject definition will start with selection of an approved paper from our reserve shelf. There will be library research involved to further develop the topic, and a primary emphasis of your paper should be on clear and effective presentation of your ideas concerning the quantum mechanics involved in this subject.. *A detailed description of this assignment will be given out during the first week of the course*.

The paper will be expected to provide a clear, effective, and convincing presentation of your ideas in addition to an accurate and effective presentation of the relevant scientific concepts. This assignment will be graded for all the usual aspects of presentation (grammar, spelling, word choice, organization, etc.) as well as for quality of research and effective communication.

During the early phases of this assignment, annotated bibliographies, complete outlines, brief proposals, and rough drafts will be turned in electronically by each person for comment and discussion. Each person will also be expected to work with their writing group using the on-line facility for peer review. With the exception of the rough draft, these required preliminary materials will be graded and will be returned to you (electronically) with my comments. Twenty percent of your paperís final grade will reflect the quality of this preliminary material and your responses to my comments.

All late papers will be penalized 10%, and they will not be accepted more than one week late (March 18, 8:45 AM).

There will be student panel discussions based upon the research topics during the last two weeks of the course.

Study Groups

You will be divided into study groups of several students each. From time to time, discussion questions or problems may be assigned for the group to work on collaboratively. The group may also be called upon to make presentations of these results in class. It is expected that you will use your study group to provide feedback concerning progress on your research paper. *Much of this group interaction and peer review of your papers will be accomplished electronically.*

Class Participation, Homework and Workgroup Problems.

Significant class time will be spent in discussion and student presentation mode. Students or workgroups will be contributing to and leading discussions of the material we have read. Students will be graded based on their participation in these class discussions. If you are missing from class, you cannot make up the participation grade.

There will be several homework problem assignments given during the term. They may take the form of essay questions, quantitative problems, or abstracts of papers to be read. Some of these will be individual efforts, but others may involve a collaborative effort with your class partner. We may have discussions of these problems in class with your study group before they are due. In those cases, you will be expected to prepare a rough draft of the homework, which will not be graded as such (see below), but simply handed in before the discussion of them in class or in workgroups. The final version of the homework (to be graded) will generally be due at the next class meeting following the discussions; *the homework will receive no more than half credit if the rough draft was not handed in before the discussions*. In general, neither rough drafts nor final copies of homework will be accepted late. *An exception to this rule will be made in the case of illness or family emergency (see below).* In some cases you or your group will be asked to make (graded) presentations of the homework or workgroup problems.

The workgroups will be given problems to solve, write-up, and sometimes present in class. There will be several of these "Workgroup Exercises" during the course of the term. In some cases the groups will work on them during class time . Members of the workgroup who are not present for these exercises will receive no credit for them.

The homework assignments, small group projects, panel discussion, and general in-class participation will be graded and contribute 20% to your overall grade. (In some cases only selected problems from a particular assignment will be graded.) *All written assignments will be submitted electronically.*

Back-up Copies
You are responsible for maintaining back-up copies of all assignments. If an assignment should be lost or misplaced during the submission or grading process, it will be your responsibility to provide a copy of that assignment upon request.

Journals
You will be expected to maintain a bound journal with your notes from the papers we read during the course of the term. Each time you read one of these papers or we discuss one in class, you are to enter your notes in the journal. The small blue covered books with numbered pages that cost about $5-6 at the bookstore are one acceptable format. (This is not a loose leaf binder.) You will be allowed to use this journal during the exams when there are questions that may pertain to the readings. This journal will also include your notes from presentations that students may make in class. You may be requested to turn it in with the exam. *It is not meant to contain your general class notes.*

Tests and Final Exam
The two midterm tests will each cover approximately 1/3 of the course material. The final exam will review the entire course as well as more intensively cover the last 1/3 of the course material. Because scientific knowledge is cumulative, the tests and examinations will always have a cumulative nature to them. The tests and exams will be mixtures of quantitative chemical problems, short answer questions and short essay questions. Very few multiple choice questions will be used; there will be no True/False questions. **The exams are always to be completed in ink in standard examination books (green or blue books from the book store).** Buy three exam books ahead of time, so that you do not have to waste your exam time buying them at the book store. Most exam and test questions will be graded primarily for scientific content and your understanding of the concepts involved. Errors in grammar, spelling, etc., will influence these grades to the extent that they make it difficult to understand your reasoning and explanations. If a particular exam question is to be specifically graded for good grammar, style, etc., it will be identified as such on the exam

Attendance: Class & Exams.
Any excuse for missing an exam *other than illness or family emergency* must be cleared with me at least one week ahead of time. If you cannot attend class on an exam day because of illness or emergency, you are expected **before class** to contact me by phone, leave a voice mail message, leave a message for me with the Interdisciplinary Arts and Sciences office, or leave me an e-mail message. Failure to notify me in one of these ways may result in you not receiving consideration for a make-up examination.

Regular class attendance is expected, although roll calls will not be generally taken. If you are not present to participate in class discussion, work group discussion and/or presentation of a ìhomeworkî exercise, that will, of course, affect your grade on that assignment. Missed in-class work *cannot* be made up.

Documented Disabilities
To request academic accommodations due to a disability, please contact Disabled Student Services (DSS) in the Counseling Center, (425)352-5000, (425) 352-5303 (TDD). If you have a documented disability on file with the DSS office, please have your counselor contact me and we can discuss accommodations.

Academic Honesty
The highest standards of academic honesty will be expected in this class. Cheating and plagiarism in any of their forms are unacceptable. At the least, a grade of zero will be assigned to any work that is the product of cheating or plagiarism. Plagiarism is also discussed in the 1993-1995 UW Bothell Catalog:

> "Plagiarism is the use of the creations, ideas or words of someone else without formally acknowledging the author or source through appropriate use of quotation marks, references, and the like. Plagiarizing is stealing someone's work and presenting it as one's own original work or thought. Student work in which

plagiarism occurs will not ordinarily be accepted as satisfactory by the instructor, and may lead to disciplinary action against the student submitting it. Any student who is uncertain whether his or her use of the work of others constitutes plagiarism should consult the course instructor for guidance before formally submitting the course work involved."

Work that is assigned to you alone is to be assisted by no one else. Work that is assigned to you and your partner is to be accomplished by no one except the two of you. The official UWB information on academic integrity is to be found at http://www.uwb.edu/students/policies/integrity.html. Each student is responsible to read and understand that information. *It is your responsibility to clarify with me any uncertainty that may exist on this question. Do not assume that an action is acceptable; ask me to be sure.*

Grades.

The final grade will be determined numerically by averaging your scores with the following weights:

Final Exam	25%	
1st Midterm Exam		15%
2nd Midterm Exam	15%	
Paper	30%	
Homework/Panels/Group Exercises /Participation	15%	

Most grades given during the course of the term will be based on a 100-pt scale. The **official decimal class grades** (0.0 - 4.0) will be determined from a weighted average of your individual grades. A weighted average of 96 will be assigned a decimal grade of 4.0, and a weighted average of 55 will be assigned a decimal grade of 0.7. Intermediate grades will be determined by a linear relationship between these two limits. This scale represents a *minimum* decimal grade. If I judge it to be appropriate, I will give higher grades than those indicated by this scale. Based on past experience, the class GPA will likely fall in the range 2.7-3.2 (a ìBî average).

The following table represents the official UW conversion of standard letter grades to the UW decimal grade scale and the conversion to the 100-pt scale used in this class:

	A Range		B Range			C Range			D Range		
Letter	A	A-	B+	B	B-	C+	C	C-	D+	D	D-
Min Decimal	3.9	3.5	3.2	2.9	2.5	2.2	1.9	1.5	1.2	0.9	0.7
Min 100-pt	95	90	86	82	77	74	70	65	61	57	55

Library Materials:
The reserve shelf for this course will include popular and scholarly monographs on atomic and quantum theory, and copies of selected papers from the scientific literature. Some of you may find it useful to have a high school or introductory college physics text available for explanations of the classical physics concepts that form the foundation for our discussion of twentieth century physics. UWB holdings include some of these books, but you can find a wider selection of them in the UW catalogue. These can be obtained with little effort via the courier service.

The electronic reserve page for the course has a number of journal articles that we will be reading during the course of the term. If you wish hard copies of these articles, you are responsible for printing them. There is a link to the E-Reserve on the course home page.

Use of E-Mail
You will be required to use e-mail as part of this course. Since our personal contact hours are quite limited, this can become a major avenue for our communication. In addition, I will use the class e-mail list, listserve, and web page as means of broadcasting information to the class. It is assumed that class members are reading their e-mail on a daily basis. You may, of course, read your e-mail anywhere of your choosing, but it is required that you will have an

active account of the form UWNetID@u.washington.edu that you check daily or forward. You can set up your account from the UW Web page. There is also a link on our course home page that takes you to UW on-line documentation that explains how to set up an account, how to send e-mail, etc.

There is a web-based U-mail form set up that allows you to send me either identified or anonymous e-mail from the browser. It can be found at URL**:**

http://catalyst.washington.edu/webtools2/umail/index.cgi?owner=jackels&id=1622

and there are links to this Umail form on the course home page.

Class Listproc
A listserver has been set up for the class. Any message sent to this address is rebroadcast to the entire class. You are welcome to use this when you want to communicate with the entire class. Your UWNetID e-mail account is automatically subscribed to this listproc. The e-mail address for this is**:** *bis388a_wi05@u.washington.edu*

Note the single underscore between "bis388a" and "wi05"; it is required.

Use of Class Discussion Board
I have set up a computer discussion board for our use. This is an excellent medium for class discussions. Any class member can post to the bulletin board. It forms a "running" conversation that can be about the lectures, problem assignments, etc. I am using E-Post for this purpose. The bulletin board is found at:
http://catalyst.washington.edu/webtools/epost/register.cgi?owner=jackels&id=9979

A link to this bulleting board will appear on the course web site. When you first access this message board, you will establish a username and password. You can also click on "configure" in order to select the type of e-mail notification to be provided. You can be automatically notified when someone has posted a message to the board.

Electronic Submission of Assignments
Most assignments for this course will be submitted electronically. The E-submit site for this purpose is found at:
https://catalyst.washington.edu/webtools/secure/esubmit/turnin.cgi?owner=jackels&id=2466

Peer Review Site
To assist in peer review of your papers and their preliminary submissions, a peer review site has been set up for the class. We will discuss in class how to use it. It is to be fund at:

http://catalyst.washington.edu/webtools/pr/slogin.cgi?owner=jackels&id=2572

Course Home Page

My personal home page is found at the URL:

http://faculty.washington.edu/jackels

Click on the entry referring to this course and you will find yourself at the course home page:

http://faculty.washington.edu/jackels/bis388.w05/

Tentative Class Schedule (subject to change)

DATE	READING	TOPICS
Jan 4		Introduction; ìThe Quantum Universeî:BOT-1172
Jan 6	Ch 1, Hey and Walters	Intro, waves, particles, duality
Jan 11	Chs 2-3, Hey and Walters	Heisenberg, uncertainty, Schrodinger, waves.
Jan 13	*Paper by Cassidy; Paper by Beller* *Paper by Kaiser*	Complementarity, Copenhagen;
Jan 18		Continuation; Library workshop.
Jan 20	Ch 4, Hey and Walters	Atoms, nuclei, quantum numbers, hydrogen atom
Jan 25	Ch 5, Hey and Walters	Tunneling, nuclear physics, radioactivity, fission, weapons and power. Preliminary Paper submission (**Jan 25**);
Jan 27		Exam #1 (**Jan 27**); Continuation
Feb 1	Ch 6, Hey and Walters *Two papers by Scerri*	Exclusion Principle, elements, periodic table, semiconductors.
Feb 3	Ch 7 Hey and Walters	Co-operation; superfluids
Feb 8	Ch 8 Hey and Walters	Measurement problem, Copenhagen, Many worlds, Decoherence Preliminary Paper Submission (**Feb 8**),
Feb 10	Ch 9 Hey and Walters	Quantum information, computing, teleportation
Feb 15	Chs 10,11,. and 13 Hey and Walters *Paper by Tegmark and Wheeler; Essay by Logan*	Stars, cosmology, afterword
Feb 17	ì Act 1î, Lindley	Background and fundamentals.
Feb 22	*ì* Intermission,î ì Act 2,î Lindley	Philosophical aspects, EPR, Bell, Aspect
Feb 24		Exam #2 (**Feb 24**); continuation
Mar 1	ì Act3,î, Lindley	Measurements, decoherence;
Mar 3		Student Panels Writing Assignment Rough Draft Due (**Mar 4)**
Mar 8		Student Panels
Mar 10		Mindwalk: BOT-621 Writing Assignment Due (**Mar 11**)
Mar 15		Final Examination