Syllabus

Indiana Wesleyan University

PHYS-504: Quantum Mechanics I – Online course

Session dates: 1/21/19 – 3/17/19

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Instructor: TBD

Course Description

This course reviews special relativity and provides an introduction to quantum mechanics. It covers applications in nuclear and particle physics and develops key aspects of quantum theory via various extensions of the Stern-Gerlach experiment. The course emphasizes the matrix mechanics approach to quantum mechanics. Use of software applications for visualization and problem solving is a key aspect.

Note: This course is designed for those seeking the credentials required by many regional accrediting bodies in order to be able to teach advanced placement, concurrent early college, and community college physics courses.

Credit Hours: 3
Prerequisite Courses: PHYS-501 or equivalent (recommend PHYS-502, PHYS-503 or equivalents)
Prerequisite Skills and Knowledge: Prerequisites: a bachelor's degree with a physics major or state certification (in any state) to teach physics at a secondary school level.

Course Outcomes

Upon successful completion of this course, you should be able to:

1. Demonstrate how Einstein's special relativity postulates lead to the Lorentz transformation and solve relativity problems involving time, length, simultaneity, and paradoxes.
2. Solve problems in relativistic motion and dynamics by using the conservation of relativistic energy and momentum.

3. Describe various applications of nuclear physics using the radioactivity of nuclei and the phenomena of fission and fusion with the binding energy curve.
4. Describe some of the fundamental properties of quantum mechanics in terms of generalized versions of the Stern-Gerlach experiment.
5. Explain the importance of Hermitian operators, commutation relations, eigenvectors, and eigenvalues in quantum mechanics and apply the statistical interpretation of quantum mechanics to determine the outcomes of measurements.
6. Evolve the quantum state of a system forward in time.
7. Examine the integration of faith and science in the major developments of physics during the 20th century.

Course Textbook

Helliwell, T. M. (2010). *Special relativity*. Sausalito, CA: University Science Books.

Griffiths, D. J. (2018). *Introduction to quantum mechanics* (3rd ed.). Cambridge, England: Cambridge University Press.

Course Technology

Each student will need to purchase a temporary site license for Mathematica Online. This can be arranged through Indiana Wesleyan.

For submitting solutions to assigned problems from the text, students may use Microsoft Equation Editor, LatEx, or another text/equation editor and submit a PDF or scans of work written on paper.

IWU Diversity Statement

IWU, in covenant with God's reconciling work and in accordance with the biblical principles of our historic Wesleyan tradition, commits to build a community that reflects Kingdom diversity.

We will foster an intentional environment for living, teaching, and learning, which exhibits honor, respect, and dignity. Acknowledging visible or invisible differences, our community authentically values each member's earthly and eternal worth. We refute ignorance and isolation and embrace deliberate and courageous engagement that exhibits Christ's commandment to love all humankind. (2016)

Grading Scale

NOTE: In graduate-level courses, a grade of C- or below will require the course to be repeated.

Grade	Quality Points Per Credit	Percentage	Score
A	4.0	95%–100%	950–1000
A-	3.7	92%–94.9%	920–949
B+	3.3	89%–91.9%	890–919
B	3.0	85%–88.9%	850–889
B-	2.7	82%–84.9%	820–849
C+	2.3	79%–81.9%	790–819
C	2.0	75%–78.9%	750–789
C-	1.7	72%–74.9%	720–749
D+	1.3	69%–71.9%	690–719
D	1.0	65%–68.9%	650–689
F	0.0	0%–64.9%	0–649

Grading Policies

Your grading policy for your course is dependent on your school and program. Your grading policies can be found in the IWU Catalog.

Letter Grade Equivalencies

NOTE: In graduate-level courses, a grade of C- or below will require the course to be repeated.

Grade	Description of Work
A	Clearly stands out as excellent performance. Has unusually sharp insights into material and initiates thoughtful questions. Sees many sides of an issue. Articulates well and writes logically and clearly. Integrates ideas previously learned from this and other disciplines. Anticipates next steps in progression of ideas. Example "A" work should be of such nature that it could be put on reserve for all cohort members to review and emulate. The "A" cohort member is, in fact, an example for others to follow.

B	Demonstrates a solid comprehension of the subject matter and always accomplishes all course requirements. Serves as an active participant and listener. Communicates orally and in writing at an acceptable level for the degree program. Work shows intuition and creativity. Example "B" work indicates good quality of performance and is given in recognition for solid work; a "B" should be considered a good grade and awarded to those who submit assignments of quality less than the exemplary work described above.
C	Quality and quantity of work in and out of class are average. Has marginal comprehension, communication skills, or initiative. Requirements of the assignments are addressed at least minimally.
D	Quality and quantity of work are below average. Has minimal comprehension, communication skills, or initiative. Requirements of the assignments are addressed at below-acceptable levels.
F	Quality and quantity of work are unacceptable and do not qualify the student to progress to a more advanced level of work.

Course Module Summary

Module	Optional Devotion*	Discussion*	Dropbox*	Total Points per Module
Module One	1/0	1/20	2/90	110
Module Two	1/0	1/20	3/120	140
Module Three	—	1/30	2/90	120
Module Four	1/0	1/20	1/60	80
Module Five	1/0	1/20	2/100	120
Module Six	1/0	1/20	3/130	150
Module Seven	—	1/30	2/100	130
Module	1/0	1/20	3/130	150

Eight				
End-of-Course Survey				10 extra credit
TOTAL	6/0	7/160	13/600	1000

* Number of Activities/Sum Point Totals

Module One Outline

Title	Type	Due Dates	Time	Points
1.1 Stress	Devotional	Suggested: Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	30 minutes	0
1.2 Reading	Reading	Complete prior to assignments.	4:30 hours	0
1.3 Einstein's Postulates	Discussion	Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	2 hours	20
1.4 The Special Theory of Relativity Assessment	Dropbox	Due by the end of the module.	2 hours	30
1.5 Time Dilation and Length Contraction Application Problems	Dropbox	Due by the end of the module.	5 hours	60
		Totals	**14 hours***	**110**

* These times are only estimates. Actual assignment completion times will vary.

Module Two Outline

Title	Type	Due Dates	Time	Points
2.1 Hard to Fathom	Devotional	Suggested: Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	30 minutes	0
2.2 Reading	Reading	Complete prior to assignments.	4:30 hours	0
2.3 The Relativity of Simultaneity	Discussion	Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	2 hours	20
2.4 Simultaneity, Paradox, and Lorentz Transformation Assessment	Dropbox	Due by the end of the module.	2 hours	30
2.5 Simultaneity and Paradox Application Problems	Dropbox	Due by the end of the module.	5 hours	60
2.6 Einstein's Postulates and Lorentz Transformation: Student Video	Dropbox	Due by the end of the module.	2 hours	30
		Totals	**16 hours***	**140**

* These times are only estimates. Actual assignment completion times will vary.

Module Three Outline

Title	Type	Due Dates	Time	Points
3.1 Reading	Reading	Complete prior to assignments.	3 hours	0
3.2 Being Still	Discussion	Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	2 hours	30
3.3 Relativistic Momentum and Energy Assessment	Dropbox	Due by the end of the module.	2 hours	30
3.4 Relativistic Motion Application Problems	Dropbox	Due by the end of the module.	5 hours	60
		Totals	**12 hours***	**120**

* These times are only estimates. Actual assignment completion times will vary.

Module Four Outline

Title	Type	Due Dates	Time	Points
4.1 Being Unique	Devotional	Suggested: Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	30 minutes	0
4.2 Reading	Reading	Complete prior to assignments.	1:30 hours	0
4.3 Nuclear Physics Applications	Discussion	Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	2 hours	20
4.4 Nuclear Physics Assessment	Dropbox	Due by the end of the module.	2 hours	30
4.5 Fission and Fusion: Student Video	Dropbox	Due by the end of the module.	2 hours	30
		Totals	**8 hours***	**80**

* These times are only estimates. Actual assignment completion times will vary.

Module Five Outline

Title	Type	Due Dates	Time	Points
5.1 Unique Gifts	Devotional	Suggested: Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	30 minutes	0
5.2 Reading	Reading	Complete prior to assignments.	6 hours	0
5.3 Stern-Gerlach Experiment	Discussion	Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	2 hours	20
5.4 Schrödinger Equation Assessment	Dropbox	Due by the end of the module.	2 hours	30
5.5 Schrödinger Equation Application Problems	Dropbox	Due by the end of the module.	5 hours	70
		Totals	**15:30 hours***	**120**

* These times are only estimates. Actual assignment completion times will vary.

Module Six Outline

Title	Type	Due Dates	Time	Points
6.1 Character	Devotional	Suggested: Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	30 minutes	0
6.2 Reading	Reading	Complete prior to assignments.	2:30 hours	0
6.3 Hermitian Operators	Discussion	Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	2 hours	20

6.4 Quantum Mechanics Methods Assessment	Dropbox	Due by the end of the module.	2 hours	30
6.5 Wave Function Application Problems	Dropbox	Due by the end of the module.	5 hours	70
6.6 Quantum Mechanics and Chemistry: Student Video	Dropbox	Due by the end of the module.	2 hours	30
		Totals	**14 hours***	**150**

* These times are only estimates. Actual assignment completion times will vary.

Module Seven Outline

Title	Type	Due Dates	Time	Points
7.1 Reading	Reading	Complete prior to assignments.	0 hours	0
7.2 Restoring Your Soul	Discussion	Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	2 hours	30
7.3 Formalism Assessment	Dropbox	Due by the end of the module.	2 hours	30
7.4 The Uncertainty Principle Application Problems	Dropbox	Due by the end of the module.	5 hours	70
		Totals	**9 hours***	**130**

* These times are only estimates. Actual assignment completion times will vary.

Module Eight Outline

Title	Type	Due Dates	Time	Points
8.1 Future Plans	Devotional	Suggested: Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	30 minutes	0
8.2 Reading	Reading	Complete prior to assignments.	4:30 hours	0
8.3 Angular Momentum and Spin	Discussion	Initial post due by the end of the fourth day of the module; two responses due by the end of the module.	2 hours	20
8.4 Quantum Mechanics in 3-D Assessment	Dropbox	Due by the end of the module.	2 hours	30
8.5 3-D Schrödinger Equation Application Problems	Dropbox	Due by the end of the module.	5 hours	70
8.6 Stern-Gerlach: Student Video	Dropbox	Due by the end of the module.	2 hours	30
8.7 End-of-Course Survey	Quiz	Due by the end of the module.	30 minutes	10 extra credit
		Totals	**16:30 hours***	**150**

* These times are only estimates. Actual assignment completion times will vary.

Course Assignments

COURSE TOTALS	**105 hours***	1000

* This time is only an estimate. Actual assignment completion times will vary.

Course Development Resources

Cronin, J. A., Greenberg, D. F., & Telegdi, V. L. (1979). *University of Chicago graduate problems in physics with solutions*. Chicago, IL: The University of Chicago Press.

G, D. R. (n.d.). *Light speed!* Retrieved October 4, 2018, from http://lightspeed.sourceforge.net/

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Franklin, A., & Perovic, S. (2015). Appendix 5: Right experiment, wrong theory: The Stern-Gerlach experiment. In *Stanford Encyclopedia of Philosophy*. Retrieved from https://plato.stanford.edu/entries/physics-experiment/app5.html

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Morrison, M. A. (1990). *Understanding quantum physics: A user's manual, Vol. 1*. Upper Saddle River, NJ: Prentice-Hall Inc.

Newbury, N., Newman, M., Ruhl, J., Staggs, S., & Thorsett, S. (1991). *Princeton problems in physics with solutions*. Princeton, NJ: Princeton University Press. doi:10.2307/j.ctv3f8r5s

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Reinhart, A. (n.d.). *Relativity simulator*. Retrieved October 4, 2018, from https://www.refsmmat.com/jsphys/relativity/relativity.html

Society of Nuclear Medicine and Molecular Imaging. (n.d.). *Latest news*. Retrieved October 4, 2018, from http://www.snmmi.org/NewsPublications/index.aspx

McCulley, F. (n.d.). *Milliken oil drop lab*. Retrieved October 5, 2018, from https://www.thephysicsaviary.com/Physics/Programs/Labs/MillikanOilDropLab/index.html

McCulley, F. (n.d.). *Photoelectric effect lab*. Retrieved October 5, 2018, from https://www.thephysicsaviary.com/Physics/Programs/Labs/PhotoelectricEffect/index.html

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PhET Interactive Simulations, University of Colorado Boulder. (2018). *Stern-Gerlach experiment*. Retrieved from https://phet.colorado.edu/en/simulation/legacy/stern-gerlach

PhET Interactive Simulations, University of Colorado Boulder. (2018). *Quantum tunneling and wave packets*. Retrieved from https://phet.colorado.edu/en/simulation/legacy/quantum-tunneling

PhET Interactive Simulations, University of Colorado Boulder. (2018). *Models of the hydrogen atom*. Retrieved from https://phet.colorado.edu/en/simulation/legacy/hydrogen-atom

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Expectations, Policies, and Important Student Information

School/Division	Link
DeVoe School of Business Division of Liberal Arts School of Services and Leadership	View School/Division Expectations, Policies, and Student Information
School of Educational Leadership	View School/Division Expectations, Policies, and Student Information
Wesley Seminary @ IWU	View School/Division Expectations, Policies, and Student Information
Nursing – Undergraduate	View School/Division Expectations, Policies, and Student Information
Nursing – Graduate	View School/Division Expectations, Policies, and Student Information