Colonnade Program Course Proposal: Explorations Category

Following the Colonnade Implementation committee's request, the Department of Physics and Astronomy submits the following materials for the Exploration course and lab: **PHYS 180/181** Introductory Modern Physics, this is the first course of the physics sequence and is taken mostly by physics, geology and metrology majors.

1. **What course does the department plan to offer in Explorations? Which subcategory are you proposing for this course?** (Arts and Humanities; Social and Behavioral Sciences; Natural and Physical Sciences)

The Department of Physics and Astronomy plans to offer PHYS 180/181 Introductory Modern Physics and Lab in the Natural and Physical Sciences subcategory within the Explorations Category.

2. **How will this course meet the specific learning objectives of the appropriate subcategory.** Please address **all** of the learning outcomes listed for the appropriate subcategory.

The overall objective of PHYS 180 and 181is to provide a survey of the physics revolution responsible for the invention of devices such as laptop computers, fiber optics, and nuclear power. The course follows the change in physical theory from the 1870's through the 1920's, from the ideas of geometrical optics and thermodynamics through the theories of relativity and the basic concepts behind quantum mechanics. The laboratory component emphasizes quantitative reproducible testing of an idea: hypothesis testing.

Students who complete PHYS 180/181 will be able to:

- Frame the debate between the Continuum Hypothesis and Atomic Hypothesis
- Apply the scientific method of hypothesis testing
- Describe the quantization of charge and motion of cathode rays
- Use Newton's laws deterministically to find the outcome of an experiment
- Understand the debate between the Aether Hypothesis vs. the Vacuum Hypothesis to explain speed of light measurements
- Understand the role of Special Relativity to fundamentally change our understanding of space and time and alter the scientific notion of simultaneity and energy
- Describe the development of the nuclear model of the atom in terms of the debate between various atomic models
- Understand that quantum mechanics replaces strict determinism with probabilistic outcomes and the developments of bonding and the transistor
- Understand aspects of radioactive half life.

How these course objectives fulfill the Colonnade Program's four objectives for the Natural and Physical Sciences subcategory of the Explorations Category:

Colonnade Learning Objective 1: Demonstrate an understanding of the methods of science inquiry.

Objective 1 is met by the following course objectives:

- Quantitative reproducible hypothesis testing is the cornerstone of the scientific method and the core of this class via the laboratory explorations that are closely coupled to the development of scientific thought related to modern physics in the lecture.
- Several topics are developed from the great scientific debates that centered on the not so gentle overthrow of long term entrenched thinking:
    a. Development of atomism vs. the ancient intuitive continuum ideas
    b. Development of relativity theory vs. the entrenched aether ideas
    c. Development of the nuclear atom vs. the long term notions of a molecular medium
    d. Development of quantum theory vs. classical theory

Colonnade Learning Objective 2: Explain basic concepts and principles in one or more of the sciences.

Objective 2 is met by the following course objectives:

- Demonstrate Boyle's gas law
- Understand the debate between the Aether Hypothesis vs. the Vacuum Hypothesis to explain speed of light measurements
- Understand the role of Special Relativity to fundamentally change our understanding of space and time and alter the scientific notion of simultaneity and energy
- Describe the development of the nuclear model of the atom in terms of the debate between various atomic models
- Apply the scientific method of hypothesis testing
- Use Newton's laws deterministically to find the outcome of an experiment
- Understand how quantum tunneling is related to radioactive half life
- Understand that quantum mechanics replaces strict determinism with probabilistic outcomes and the developments of bonding and the transistor
- Differentiate between alpha, beta and gamma nuclear radiation

Colonnade Learning Objective 3: Apply scientific principles to interpret and make predictions in one or more of the sciences.

- Use hydrolysis of water as atomic ratios test
- Apply the basic principles of chemical stoichiometry in the lab
- Measure and describe cosmic ray tracks in a cloud chamber
- Measure several quantum atomic spectra
- Measure quantum tunneling of microwave photons

Colonnade Learning Objective 4. Explain how scientific principles relate to issues of personal and/or public importance.

- Understand the role of Special Relativity to fundamentally change our understanding of space and time and alter the scientific notion of simultaneity and energy: shift in fundamental understanding or the nature of time.
- Differentiate between alpha, beta and gamma nuclear radiation: impact and understanding of nuclear materials widely used in medicine and power generation.
- Understand that quantum mechanics replaces strict determinism with probabilistic outcomes and the developments of bonding and the transistor: basic concept of structure of materials and the economic and social impact of small, fast and efficient electronic devices.

3. Syllabus statement of learning outcomes for course. NOTE: In multi-section courses, the same statement of learning outcomes must appear on every section's syllabus.

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4. Brief description of how the department will assess the course for these learning objectives.

Outcomes 1 and 2 are assessed through three of the specially designed laboratory investigations where students must develop hypothesis testing. These labs are designed so the first three focus on formative assessment of hypothesis testing and the last 3 labs focus on global summative assessment where the hypothesis testing is encoded in the quantitative outcome of empirical testing of the underlying principle.

Outcomes 3 and 4 are assessed through group presentations in the lab section of the course.

Outcome 5 and 6 are assessed through a presentation to the class selected in consultation with the instructor to connect the scientific principles to a topic of public importance. The combination of public speaking, organizing a presentation and coupling scientific principles to a community topic of interest: i.e. energy characterization and measurement applied to energy needs in a town or state and how that is related to resources.

Assessment consists of written homework, in class quizzes and topical exams several times per semester with a cumulative final exam and weekly lab reports written in a formalized scientific style.

5. How many sections of this course will your department offer each semester?

The Department of Physics and Astronomy will offer one course of 20 students per semester.

6. Please attach sample syllabus for the course.

Introductory Modern Physics
PHYS 180

1. **Instructor:** Physcs
2. **Class Meetings:** MWF 12:40-1:35 PM, TCCW 201
3. **Office Hours:** MWF: 1:40PM -2:40 PM
4. **Textbook:** *Modern Introductory Physics*, C. H. Holbrow, J.N.Lloyd, J.C. Amato Springer-Verlag, New York, 1999
5. **Readings From:** The Feynman Lectures on Physics, Vol. I-III, R.P. Feynman, R. Leighton, M. Sands, Ad. Wes., NY, 2001, we will be especially interested in the Feynman description of the world of physics, and *The New World of Mr. Tompkins*, G.Gamow, R.Stannard, Cambridge University Press, 2005.
6. **Corequisites:** PHY 181, Wed. 10:20 AM, TCCW 205
7. **Course Description:** This course is a basic study of modern physics in the areas of relativity and quantum mechanics as applied to a wide range of phenomena. The fundamental ideas of atomic structure and quantization will be explored within the context of isolated systems; these ideas include Dalton's Law, Boyle's Law, Newton's Laws, Heisenberg's Uncertainty Principle, de Broglie Waves, Einstein's Photon and Bohr's Atomic Model. How these fundamental ideas are altered with the introduction of the axioms of special relativity will be studied along the lines of Einstein and Dirac. The interpretation of quantum mechanics with relativistic interactions will be briefly introduced. The relationship between these results, conservation laws, and thermal fields will be examined when constrained by causal structure and quantum rules. Some issues associated with the epistemological foundations of quantum theory will be examined, especially in light of the combined effects of relativity and quantum mechanics within the context of Quantum Electrodynamics- QED- as formulated by Feynman, Schwinger and Tomonaga. A constant and unrelenting curiosity coupled with scientific skepticism are important characteristics of a student in this setting.

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    6. Understand that quantum mechanics replaces strict determinism with probabilistic outcomes and the developments of bonding and the transistor

8. **General Education D-I and lab PHYS 181 D-I DL**: This course fulfills the requirements for General Education Goal #8 to develop an understanding of the scientific method and a knowledge of natural science and its relevance in our lives. The ideas of this goal will be apparent through the use and analysis of the scientific method in the classroom and laboratory setting as well as through the chronological development of several of the concepts of modern physics and how they impacted society at large; principle among these will be the development of the atomic bomb by Oppenheimer, the transistor by Bardeen, and the integrated circuit chip by Kilby.
9. **Attendance:** Consistent with the WKU policy you are responsible for the content and conduct of each and every class. Chronic tardiness or missing of more than three classes will significantly reduce your grade independent of your current average; any unexcused absences beyond this will be grounds for failing the class. Please be courteous with respect to others speaking, the use of computers and cell phones.
10. **Homework:** Each chapter and topical unit requires a significant homework and reading assignment to be completed on time and in a formal style. Group discussion is encouraged to help understand material but you must hand in your own work at the beginning of the due date class period. Mastery of homework material is expected and students will be asked to discuss and develop these skills during the class period, this will include summaries of readings. Late homework is not accepted.
11. **Presentations and Directed Readings:** each group student will formally write up one modern physics problem selected in consultation with the instructor as a report and present as a PowerPoint presentation to the class. The report grade is 50 points and must include a quiz problem. Reading summaries will be presented by students directly from the textbook on relevant sections for discussion.
12. **Quizzes:** Unannounced in-class quizzes will be given that are similar to the homework assignments. They will be averaged with the homework and normalized to one exam grade.
13. **Exams:** There will be three one hour exams, of 100 points, and a comprehensive final exam, of 150 points.
14. **Grades:** Instantaneous grade values are calculated on a weighted percentage basis. You may check your grade at any time. The final term grade is based upon the percentage of total points with cutoff grades determined by weighting functions by:

$$G(t) = \sum_{i=1}^{N} w_j \frac{(HW_i + Q_i)}{N} + \left(\frac{Re}{50}\right)100 + \sum_{k=1}^{3} \frac{E_k}{3} + \left(\frac{FE}{150}\right)100$$

    where at any time t if $G(t) > 90\%$ the resulting grade is in the A range and if $G(t) < 50\%$ the resulting grade is in the F range. Homework is weighted with a sharp discontinuity that gives an F grade to any student who does not hand in the homework independent of the exam average, **late homework is not accepted.**
15. **Students with disabilities: Student Disability Services**
    In compliance with university policy, students with disabilities who require academic and/or auxiliary accommodations for this course must contact the Office for Student Disability Services in Downing University Center, A-200. The phone number is 270 -

745- 5004. Please DO NOT request accommodations directly from the professor or instructor without a letter of accommodation from the Office for Student Disability Services.

16. **Safety:** review emergency exits and procedures during the first class period.
17. **Academic Honesty:** Students are expected to adhere to the WKU standards of integrity and honesty with regards to cheating and plagiarism. All work you turn in must be your own, WKU uses *TERM PAPER©* to check against web resources for plagiarism, any violations will be handled by the Judicial Board.
18. **Final Exam:** Thursday, May 12, 2011, from 1:00 PM-3:00 PM.
19. **Assignments:** Homework each week following the table below.

Homework for PHYS 180/181

Due Date	Chapter		Page	Problem	Points
Fri. Jan. 28	Ch. 1	Units Scale	p. 8	6,7, 9	30
2-2	Ch.2	Vectors	p.47	3,8,10,13	40
2-7	Ch. 3	Molecules	p.65	1,9,12	30
2-16	Ch. 4	Gases	p.88	6,9,10,12	40
2-28	**EXAM I**	100			
2-25	Ch. 5	Atoms	p.122	2,12,15,21	40
	EOS	**Application**	**Presentation**	**Group**	
3-6	Ch. 6	Electric	p. 157	2,8,9,10	40
3-20	Ch. 7	Magnetic	p.180	1,4,6	30
3-27	Ch. 8	Atomic Charge	p.218	4,10,16	30
3-30	**Exam II**	100			
4-1	Ch. 9	Waves	p.268	1,4,8	30
4-3	Ch. 10	SR	p.307	1,5,8	30
4-10	Ch. 11	$E=mc^2$	p.329	1,3,6	30
4-10	Ch. 12	Photons	p.349	3,4,8	30
4-13	**Exam III**	100			
4-20	Ch. 13	X-Rays	p.378	3,6,9	30
4-25	Ch. 14	De Broglie	p.402	1,3,7,9	40
	Report	**Presentation**	**50 pts**	**Individual**	
4-27	Ch. 15	Heisenberg	p.422	4,5,6	30
4-30	Ch. 16	Half-Life	p.456	5,8,11	30
5-6	Ch. 17	Bohr	p. 489	1,2,9	30
5-6	**Ch. 17**	Spectra	p. 491	4,5	20
May 12, 2011 Thursday	**Final Exam**	**150**	**1:00-3:00 PM**		**560**

Laboratory Topics and Class Material

The laboratory experiments develop the critical aspects of empiricism required for science. The detailed use of the scientific methods of hypothesis testing and empirical feedback needed to develop a better understanding of natural phenomena will be aggressively pursued. The essential concepts of lab overlap heavily those developed in class along the lines of the textbook by Holbrow, Lloyd and Amato: *Modern Introductory Physics.*

	Date	**Lab**	**Topic**	**Chapter in Holbrow**	**Due Date**
1.	**1-26**	Measurement and Error	Lab format, uncertainty	Chapter 1	1-30
2.	**2-2**	The Invention of Vectors: Force Table	Vector components: the analysis of motion in 2-d as two separate 1-d problems	Chapter 2	2-6
3.	**2-9**	Molecules and Atoms: Electrolysis of Water	Dalton's Law: a test that atoms stoichiometrically combine in simple ratios to produce molecules	Chapter 3	2-13
4.	**2-16**	A Gas of Atoms: Boyle's Law	Equation of State: the gas laws leading to the ideal gas law and van deer Waals equation of state	Chapter 4	2-20
5.	**2-23**	The Atomic Scale: Oleic Acid	Atomic Size- test of the atomic hypothesis vs. the continuum hypothesis	Chapter 5	2-27
6.	**3-2**	Electrostatic Fields and Forces	Faraday Pail and Capacitors- collecting charge as predicted by Franklin	Chapter 6	3-6
7.	**3-16**	Magnetic Fields and Forces	Lorenz Force Law- a vector cross product force	Chapter 7	3-20
8.	**3-23**	Electric Charge-Millikan Oil Drop	Charge of an electron- evidence of quantization	Chapter 8	3-27
9.	**3-30**	Electromagnetic Waves and Interference-Microwaves	Waves and superposition- Young's wave concept	Chapter 9	4-3
10.	**4-6**	Photon Energy and Planck's Constant	Microwave photons and energy from h and LEDs	Chapter 10	4-10
11.	**4-13**	Atomic Solid-Bragg Diffraction	Atomic Structure-microwwave interference yields atomic crystal structure	Chapter 12	4-17
12.	**4-20**	Quantum Tunneling and Radioactive Half-Life	Microwave tunneling and Gamow Half-Life	Chapter 13	4-25
13.	**4-27**	Bohr Atom and Atomic Spectra	Bohr Model-electron orbits describe emission and absorption	Chapter 17	4-31
14.	**5-4**	Final	Private problems		5-8

Please send your proposal to: robert.dietle@wku.edu