COLONNADE PROGRAM COURSE PROPOSAL

FOUNDATIONS CATEGORY (QR)

Quantitative Reasoning

MATH 109, 116, or other approved courses. (3 hours)

Quantitative Reasoning courses teach students to interpret, illustrate, and communicate mathematical and/or statistical ideas. Students will learn to model and solve problems. Students with a Math ACT of 26 or higher will receive 3 hours credit for this requirement.

Students will demonstrate the ability to:

1. Interpret information presented in mathematical and/or statistical forms.
2. Illustrate and communicate mathematical and/or statistical information symbolically, visually and/or numerically.
3. Determine when computations are needed and execute the appropriate computations.
4. Apply an appropriate model to the problem to be solved.
5. Make inferences, evaluate assumptions, and assess limitations in estimation modeling and/or statistical analysis.

Please complete the following and return electronically to colonnadeplan@wku.edu.

1. What course does the department plan to offer in ***Foundations: Quantitative Reasoning***?

   PHIL 215: Symbolic Logic

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

   See next page.

Learning Outcomes	How the Course Meets Them
Quantitative Reasoning courses teach students to interpret, illustrate, and communicate mathematical and/or statistical ideas. Students will learn to model and solve problems.	In this course students learn a formal, symbolic language and a logical system (a polyadic first-order system with functions and identity), and they learn how to use that system to interpret, illustrate, and communicate mathematical ideas. They learn first-order languages of arithmetic and set theory and they learn how to interpret and illustrate a variety of numerical properties and theorems in first-order logic (FOL). They learn how to use FOL to model the notions of logical truth and logical consequence as well as model mathematical reasoning and proofs, and they apply these models in order to solve a variety of problems (demonstrating that various arguments are valid or invalid; resolving putative paradoxes; etc.). Thereby students learn that mathematical reasoning and mathematical proofs—computations on and transformations of strings of symbols—can be used to solve a variety of problems, including problems concerning the validity and invalidity of arguments that they previously wouldn't have recognize as being amenable to mathematical analysis. They also learn how to perform mathematical induction both on the natural numbers and on complexity (e.g., on the recursively or inductively defined notion of a well-formed formula).
Students will demonstrate the ability to:	
1. Interpret information presented in mathematical and/or statistical forms.	In this course students learn to use FOL to interpret information presented in mathematical form. Specifically, students learn how to: • interpret information presented in a Boolean algebra • interpret information and axioms presented in set theoretical notation • interpret the truth-functional form of Venn and Euler diagrams • interpret and use recursive and inductive definitions • interpret mathematical concepts in FOL; e.g., taking s( ) to be the successor function, students learn how to interpret zero's property of being the first natural number in FOL as $\forall x \neg(0=s(x))$ • use FOL to symbolically interpret the mathematical and syntactic form of information that does not superficially appear to be mathematical; e.g., taking b( ) to be the behind function, students learn how to interpret Pia's property of being at the front of the queue in FOL as $\forall x \neg(p=b(x))$; thereby students learn the deep structural connections inherent to all information of predicational form, and they learn how to symbolically and mathematically interpret it.

2. Illustrate and communicate mathematical and/or statistical information symbolically, visually and/or numerically.	A fundamental goal of this course is to teach students a formal, symbolic language that they use to illustrate and communicate mathematical information. Specifically, students learn how to • symbolically illustrate and communicate assumptions, arguments, theorems, logical truths, equivalences, functions, etc., in FOL • symbolically illustrate and communicate truth-functional reasoning in a Boolean algebra • symbolically and visually illustrate and communicate syntactic proofs both in Fitch format and axiomatic format • illustrate truth functions visually with Venn diagrams • communicate and prove propositionally valid inferences visually via relational properties of Venn diagrams • symbolically illustrate and communicate numbers and number-theoretic information in first-order set theory • symbolically illustrate and communicate arithmetic and set theory with recursive definitions • symbolically illustrate and communicate transfinite arithmetic and the cardinality of sets.
3. Determine when computations are needed and execute the appropriate computations.	In this course students learn how to perform computations on strings of symbols both in a Boolean algebra (e.g., with De Morgan's, distribution, etc., laws) and in first-order syntactic proofs. Students learn how to apply these techniques of FOL to problems in order to determine when and which computations are needed, and they learn how to execute the appropriate computations. For example, they learn how to execute the following computations: • $\neg$Intro, $\neg$Elim, $\vee$Intro, $\vee$Elim, $\wedge$Intro, $\wedge$Elim, $\rightarrow$Intro, $\rightarrow$Elim, $\leftrightarrow$Intro, $\leftrightarrow$Elim, $\forall$Intro, $\forall$Elim, $\exists$Intro, $\exists$Elim, De Morgan's, double negation, $\wedge$Distribution, $\vee$Distribution, LE Wffs, De Morgan's for Quantifiers, etc.
4. Apply an appropriate model to the problem to be solved.	In this course students learn a variety of modeling techniques: they learn how to model propositional as well as quantified structures and they learn how to apply the appropriate model to the problem at hand. For example, they learn how to • use propositional and first-order models and countermodels • use Venn diagrams to model truth-functional inferences • determine whether a Venn diagram can model inferences in various problems • use a truth-functional-form algorithm to determine whether a problem can be solved most efficiently with

	a propositional or first-order model or countermodel.
5. Make inferences, evaluate assumptions, and assess limitations in estimation modeling and/or statistical analysis.	Given that this is a course in logical reasoning, a rigorous training in making inferences and evaluating assumptions is the very essence of the course. Specifically, students learn how to • make inferences in mathematical proofs using reductio ad absurdum, proof by cases, conditional reasoning, contrapositive, universal and existential generalization and instantiation, mathematical induction, etc. • make inferences in syntactic proofs using Fitch Intro and Elim rules and using axioms • make inferences in chain proofs using De Morgan's, double negation, distribution, etc., laws • evaluate assumptions and show when a conclusion does or does not follow from a set of assumptions • identify hidden assumptions in arguments • relate formal and informal proof methods with soundness and completeness metatheorems • assess the limitations of syntactic systems for modeling second-order (e.g.) inferences • use estimation to analyze the complexity measure of quantified sentences and arguments.

3. In addition to meeting the posted learning outcomes, how does this course contribute uniquely to the *Foundations* category (i.e., why should <u>this course</u> be in Colonnade)? Discuss in detail.

Students can easily have a narrow conception of the use and value of quantitative reasoning: they just need it to figure out how much to tip a restaurant server or figure out how far ahead in the polls some candidate is. This course offers a unique foundations experience because it not only teaches students quantitative and mathematical reasoning, but it also teaches them the ubiquity and import of this reasoning for solving problems that they wouldn't have even recognized as quantitative or mathematical. In the course students learn a formal logical system (a formal, symbolic language, a deductive apparatus, and a semantics) that they use to solve a variety of problems. This system allows them to symbolically and quantitatively interpret and represent mathematical properties and arguments as well as non-mathematical properties and arguments; thereby students learn that the transformations and computations that they make on discrete mathematical objects (e.g.) can also be made on symbols with non-mathematical interpretations. Here is an example: say I am going to host a party for my favorite literary characters, and I tell you that I am going to invite either Romeo and Juliette or Edward and Bella. Students can easily recognize that it deductively follows from this that I am going to invite Romeo or Edward. What students don't initially realize, however, is that this reasoning can be modeled symbolically, and that the same operations used in discrete mathematics can be used to prove that this conclusion follows validly from the premise. This course teaches students a variety of formal quantitative models and proof methods, and teaches students how to assess a problem, select an appropriate model, and compute a solution (e.g., showing that a certain sentence is a theorem, or showing that two theorems are equivalent, or showing that it follows that Romeo or Edward is coming to my party). Thereby students get a rigorous training in quantitative reasoning, and they also learn the applicability and importance of quantitative reasoning to all areas of their lives.

FOL is also of foundational importance to mathematics, since set theory is an axiomatized first-order theory. In this course students also learn the language and several axioms of set theory, and they prove several celebrated results: (i) Russell's paradox, and (ii) that the cardinality of the natural numbers is the same as the cardinality of the rational numbers, but the cardinality of the natural numbers is less than the cardinality of the real numbers. Thereby students learn basic results about infinite sets and different sizes of infinity as well as elements of transfinite arithmetic.

For these reasons this course offers a rigorous and uniquely valuable Foundations experience in quantitative reasoning.

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

Learning Outcomes	**Syllabus Statement**
Quantitative Reasoning courses teach students to interpret, illustrate, and communicate mathematical and/or statistical ideas. Students will learn to model and solve problems.	In this course students learn a formal, symbolic language and a logical system (a polyadic first-order system with functions and identity), and they learn how to use that system to interpret, illustrate, and communicate mathematical ideas. They learn how to use first-order logic (FOL) to model the notions of logical truth and logical consequence as well as model mathematical reasoning and proofs, and they apply these models in order to solve a variety of problems (demonstrating that certain arguments are valid or invalid; resolving putative paradoxes; etc.).
Students will demonstrate the ability to:	Students will demonstrate the ability to:
1. Interpret information presented in mathematical and/or statistical forms.	1. Interpret information presented in mathematical form: they learn how to interpret mathematical concepts in FOL, and they learn to use FOL to symbolically interpret the mathematical and syntactic form of information that does not superficially appear to be mathematical. Thereby students learn the structural connections inherent to all information of predicational form, and they learn how to symbolically and mathematically interpret it.
2. Illustrate and communicate mathematical and/or statistical information symbolically, visually and/or numerically.	2. Use a formal, symbolic language to illustrate and communicate mathematical information. Furthermore, students learn how truth functions can be illustrated visually with Venn diagrams, and they learn how to communicate and prove propositionally valid inferences visually via relational properties of Venn diagrams.

3. Determine when computations are needed and execute the appropriate computations.	3. Perform computations on strings of symbols both in a Boolean algebra and in first-order syntactic proofs. Students learn how to apply these techniques of FOL to problems in order to determine when and which computations are needed, and they learn how to execute the appropriate computations.
4. Apply an appropriate model to the problem to be solved.	4. Use a variety of symbolic modeling techniques and apply an appropriate model to the problem to be solved; specifically, they learn how to model propositional as well as quantified inferences, theorems, etc., and they learn how to apply the appropriate model to the problem at hand.
5. Make inferences, evaluate assumptions, and assess limitations in estimation modeling and/or statistical analysis.	5. Make inferences and evaluate assumptions both informally and formally, via syntactic inference rules. They learn how to show when a conclusion does and does not follow from a set of assumptions and how to identify hidden assumptions in arguments. Furthermore, they learn the relationship between formal and informal methods.

5. Give a brief description of how the department will assess the course beyond student grades for these Colonnade learning objectives.

A. The department will use several questions, added to the final exam, in order to assess how well the course's learning objectives are being met. The questions will require students to
    a. Interpret information presented in mathematical and/or statistical forms.
    b. Illustrate and communicate mathematical and/or statistical information symbolically, visually and/or numerically.
    c. Determine when computations are needed and execute the appropriate computations.
    d. Apply an appropriate model to the problem to be solved.
    e. Make inferences, evaluate assumptions, and assess limitations in estimation modeling and/or statistical analysis.
B. At the end of each semester the answers of 30% of the students in each section of the course will be selected at random for assessment.
C. At the beginning of the next semester a faculty member will assess each answer. The names of the students and of the instructors for the sections will be eliminated before the assessment takes place.
D. Answers will be given one of four designations:
    a. Excellent: The student has demonstrated proficiency in all outcomes.
    b. Good: The student has demonstrated proficiency in most outcomes.
    c. Fair: The student has demonstrated proficiency in some outcomes.
    d. Poor: The student has demonstrated proficiency in no outcomes.
E. The results will be tabulated and given to the Department Head.
F. The Department Head will convene the relevant faculty to review the results and to determine what steps, if any, need to be taken in order to improve the instruction in the course.

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

   Two per semester.

7. Please attach sample syllabus for the course. PLEASE BE SURE THE PROPOSAL FORM AND THE SYLLABUS ARE IN THE SAME DOCUMENT.

   See attachment on following pages.

Philosophy 215: Symbolic Logic
Spring 2014
Ian Schnee
Western Kentucky University

Contact Info
Instructor: Ian Schnee
Email: ian.schnee@wku.edu
Office: Cherry Hall 319C
Office Hours: Monday and Wednesday from 11:15 to 12:15 (or by appointment!)

Overview
What makes an argument good? How do you show that someone has reasoned invalidly? In this course we will study arguments and reasoning both informally as well as with the tools and techniques of formal deductive logic. We will learn the syntax and semantics of propositional and first-order logic (polyadic with identity and functions), and we will use them to explicate the intuitive notion of a valid argument. Topics include syntax, semantics, pragmatics, consistency, proof, logical consequence, logical equivalence, logical truth, analyticity, logical form, sets, infinity, truth functionality, truth tables, quantification, relations, functions, interpretations, models, soundness, and completeness. We will also consider, as time allows, the history of logic, philosophical applications of logic (e.g., its applications to computability theory, philosophy of language, and epistemology), and metalogic (theorems about logical systems themselves).

Warning
This is a difficult and fast-paced course! We have a problem set due nearly every week. Furthermore, all the material is cumulative, so you must keep up with the work all semester in order to succeed. That doesn't mean that this class will be all work and no fun: I think this is the most fun class on campus (of course, I am biased). But you must know what you are getting in to if you take this course.

Prerequisites
None.

Books and Readings
There is one book for the course: *Language, Proof and Logic (2nd Edition)*, by Barker-Plummer, Barwise, and Etchemendy: ISBN 978-1-57586-632-1. (The book comes with software; you don't have to buy any software separately.)

Note that the text/software package has a one-time registration ID. Make sure that what you buy includes the unused software and DO NOT BUY IT USED OR SECONDHAND—it won't work and you will not be able to take this course! I only recommend that you buy the book in one of two ways:

(1) Directly from the publisher by electronic download (cost: $55). Go to: http://ggweb.stanford.edu/store. You will get a pdf of the textbook, plus all the software and manuals. You save money this way but you don't get a physical copy of the text. Or:

(2) In person at the university bookstore or some other local shop, like Textbook & Supply. If you buy it in person then you will know that what you are getting is still shrink-wrapped in the box, which is what you want. If you buy it online somewhere other than the publisher, and it says the book is in "new" condition, someone still might have used the registration codes and hence what you bought is a "new" book but worthless to you. The book/software in hard copy costs roughly $70. If you try to save money by getting it much cheaper from a 3rd party then you might cause misery for yourself.

Buy the book as soon as possible (BEFORE classes start): we will have a problem set due on Friday of the first week of class, and you need your own copy of the book and software to do the problem sets!

Grading and Course Requirements

There are four components of your grade:

1. Homework and Quizzes : 30%
2. First Midterm (closed note/book/computer*): 20%
3. Second Midterm (closed note/book/computer*): 20%
4. Final exam (closed note/book/computer*): 30%

Homework assignments will have two parts, one part is called "written" and the other part is called "electronic." In fact, though, both parts will be submitted online with the program Submit (which is part of the software package that comes with the textbook). For directions on how to submit homework and manage your workflow for the course please see both the video on Blackboard, "Submitting Homework," as well as the extensive directions on the first problem set. Problem sets will start to be due the first week! In general, problem sets will be due each **Friday by 9 p.m.**

In-class quizzes (usually unannounced) will be used at the discretion of the professor.

There are two midterms and a final exam. The midterms will be done in class on assigned days. The final exam will be done at the end of term in our assigned two-hour time slot. They will all be done closed book/closed note with no computer* (* unless allowed by Disability Services).

Learning Outcomes

In this course students learn a formal, symbolic language and a logical system (a polyadic first-order system with functions and identity), and they learn how to use that system to interpret, illustrate, and communicate mathematical ideas. They learn how to use first-order logic (FOL) to model the notions of logical truth and logical consequence as well as model mathematical reasoning and proofs, and they apply these models in order to solve a variety of problems (demonstrating that certain arguments are valid or invalid; resolving putative paradoxes; etc.).

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1. Interpret information presented in mathematical form: students learn how to interpret mathematical concepts in FOL, and they learn to use FOL to symbolically interpret the mathematical and syntactic form of information that does not superficially appear to be mathematical. Thereby students learn the structural connections inherent to all information of predicational form, and they learn how to symbolically and mathematically interpret it.
2. Use a formal, symbolic language to illustrate and communicate mathematical information. Furthermore, students learn how truth functions can be illustrated visually with Venn diagrams, and they learn how to communicate and prove propositionally valid inferences visually via relational properties of Venn diagrams.
3. Perform computations on strings of symbols both in a Boolean algebra and in first-order syntactic proofs. Students learn how to apply these techniques of FOL to problems in order to determine when and which computations are needed, and they learn how to execute the appropriate computations.
4. Use a variety of symbolic modeling techniques and apply an appropriate model to the problem to be solved; specifically, students learn how to model propositional as well as quantified inferences, theorems, etc., and they learn how to apply the appropriate model to the problem at hand.
5. Make inferences and evaluate assumptions both informally and formally, via syntactic inference rules. Students learn how to show when a conclusion does and does not follow from a set of assumptions and how to identify hidden assumptions in arguments. Furthermore, they learn the relationship between formal and informal methods.

Help Is Out There

There are many resources at WKU that provide all manner of academic aid and inspiration. E.g., check out the free help at The Learning Center: www.wku.edu/tlc.

Student Disability Services

In compliance with university policy, students with disabilities who require accommodations (academic adjustments, and/or auxiliary aids or services) for this course must contact the Office for Student Disability Services in Downing University Center A-200 (phone 270-745-5004; TTY 270-745-3030). Per university policy, please DO NOT request accommodations directly from the professor or instructor without a letter of accommodation from the OFSDS.

Academic Integrity

Plagiarism and other forms of cheating will not be tolerated; students caught doing either will receive an F for the course.[1] It is your duty to know and understand the university's policy on student conduct and discipline.

See the helpful page at http://www.wku.edu/~jan.garrett/dptengpl.htm as well as http://www.wku.edu/undergraduatecatalog, especially p. 29. All cases of plagiarism, cheating, etc., will be reported to the Dean and the Office of Judicial Affairs for disciplinary action.

NOTE: Collaboration on homework is allowed, in the following sense: students may work together on the problem sets, but each student must do his or her own work and work entirely on his or her own electronic files! Simply copying from another student is cheating, not collaborating. The exams will be done strictly individually, closed computer, closed book, and closed note.

ANOTHER NOTE: Under no circumstances may students share electronic files for homework or any other graded material. Students must always use their own files from their software CD or computer for homework, etc. Be warned: sharing files will be detected by the ingenious Grade Grinder and will be considered cheating, resulting in an F for the course.

Laptop Policy

Using a laptop in class is a privilege, not a right (unless authorized by Student Disability Services—see above). Students may use laptops for taking notes only. Students using a laptop for any other reason, such as doing homework, email, Facebook, or playing World of Warcraft during lecture, will lose the privilege of using a laptop in class. Any cell phones I see or hear will be confiscated and auctioned on eBay.

If you want to use a laptop in class you must sit in the front.

Schedule

We will cover Parts I and II of the textbook, plus supplemental material and some of Part III.

Week 1: Introduction and Chapter 1 (Atomic Sentences)
Problem Set #1 due Friday, January 31.

Week 2: Chapter 2 (The Logic of Atomic Sentences)
Problem Set #2 due Friday, February 7.

Week 3: Chapter 3 (The Boolean Connectives)

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[1] From the Undergraduate Catalogue: "**Academic Dishonesty—**Students who commit any act of academic dishonesty may receive from the instructor a failing grade in that portion of the coursework in which the act is detected or a failing grade in the course without possibility of withdrawal" (my underlining; p. 29).

Problem Set #3 due Friday, February 14.

Week 4: Chapter 4 (The Logic of Boolean Connectives)
Problem Set #5 due Friday, February 21.

Week 5: Review and Test
Monday, February 24: Midterm #1 (covering Ch. 1-4)
NO CLASS Friday, February 28: I will be away at a conference
No problem set due this week because of the midterm

Week 6: Chapter 5 (Methods of Proof for Boolean Logic)
Problem Set #5 due Friday, March 7.

Spring Break: Saturday, March 8–Sunday, March 16

Week 7: Chapter 6 (Formal Proofs and Boolean Logic)
Problem Set #6 due Friday, March 21.

Week 8: Chapters 7 (Conditionals) and 8 (The Logic of Conditionals)
Problem Set #7 due Friday, March 28.

Week 9: Review and Test
Wednesday, April 2: Midterm #2 (covering Ch. 1-8)
No problem set due this week because of the midterm

Week 10: Chapter 9 (Introduction to Quantification)
Problem Set #8 due Friday, April 11.

Week 11: Chapter 10 (The Logic of Quantifiers)
Problem Set #9 due Friday, April 18.

Week 12: Chapter 11 (Multiple Quantifiers) and parts of Chapter 14 (More About Quantification)
Problem Set #10 due Friday, April 25.

Week 13: Chapter 12 (Methods of Proof for Quantifiers) and parts of Chapter 15 (First-Order Set Theory)
Problem Set #11 due Friday, May 2.

Week 14: Chapter 13 (Formal Proofs and Quantifiers), and parts of Chapter 16 (Mathematical Induction)
Problem Set #12 due Friday, May 9.

Final Exam (covering Ch. 1-14): Our final exam will be in our assigned slot during the Final Exam Period (May 12–16)