School of Mathematical Sciences

✓ New  ❌ Revised  COURSE: COS-MATH-646 Combinatorics

1.0 Course Designations and Approvals:

<table>
<thead>
<tr>
<th>Required Course Approvals:</th>
<th>Approval Request Date</th>
<th>Approval Grant Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Unit Curriculum Committee</td>
<td>04/17/14</td>
<td>04/17/14</td>
</tr>
<tr>
<td>College Curriculum Committee</td>
<td>04/28/14</td>
<td>04/28/14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Optional Course Designations:</th>
<th>Yes</th>
<th>No</th>
<th>Approval Request Date</th>
<th>Approval Grant Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Education</td>
<td>✓</td>
<td></td>
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<tr>
<td>Writing Intensive</td>
<td>✓</td>
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<tr>
<td>Honors</td>
<td>✓</td>
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2.0 Course information:

Course Title: Combinatorics
Credit Hours: 3
Prerequisite(s): Permission of instructor
Co-requisite(s): None
Course proposed by: School of Mathematical Sciences
Effective date: August 2014

<table>
<thead>
<tr>
<th>Contact Hours</th>
<th>Maximum Students/section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>3</td>
</tr>
<tr>
<td>Lab</td>
<td></td>
</tr>
<tr>
<td>Workshop</td>
<td></td>
</tr>
<tr>
<td>Other (seminar)</td>
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</table>

2.1 Course Conversion Designation: (Please check which applies to this course)

✓ Semester Equivalent (SE) to: 1016-767

☐ Semester Replacement (SR) to:

☐ New

2.2 Semester(s) offered:

☐ Fall  ✓ Spring  ☐ Summer

☐ Offered every other year only  ☐ Other
2.3 Student Requirements:

Students required to take the course:
Applied and Computational Mathematics graduate students in the Discrete Mathematics concentration

Students who might elect to take the course:
Graduate students and advanced undergraduate students in mathematics, physics, computer science, imaging science, and engineering.

3.0 Goals of the course: (including rationale for the course, when appropriate)

3.1 To provide a rigorous introduction to concepts in combinatorics
3.2 To provide a foundation for further study in applied mathematics
3.3 To identify possible thesis topics

4.0 Course description: (as it will appear in the RIT Catalog, including pre- and co-requisites, semesters offered)

COS-MATH-646 Combinatorics
This course introduces the fundamental concepts of combinatorics. Topics to be studied include counting techniques, binomial coefficients, generating functions, partitions, the inclusion-exclusion principle and partition theory. (Permission of instructor) Class 3, Credit 3 (S)

5.0 Possible resources: (texts, references, computer packages, etc.)

5.1 J. Van Lint & R. Wilson, A Course in Combinatorics, Cambridge, Cambridge, UK.
5.2 R. A. Brualdi, Introductory Combinatorics, Prentice Hall, Upper Saddle River, NJ.
5.3 M. Bóna, Introduction to Enumerative Combinatorics, McGraw-Hill, Columbus, OH.
5.4 D. West, Combinatorial Mathematics, (available from author).

6.0 Topics: (outline) Topics with an asterisk(*) are at the instructor’s discretion, as time permits

6.1 Basic Counting Techniques
   6.1.1 Pigeonhole principle
   6.1.2 The Erdős-Szekeres theorem, basic Ramsey theory
   6.1.3 Permutations & combinations of sets and multisets
   6.1.4 Bijective proofs

6.2 Binomial Coefficients
   6.2.1 The binomial theorem
   6.2.2 The multinomial theorem
   6.2.3 Binomial identities
   6.2.4 Unimodality and log-concavity of binomial coefficients
   6.2.5 Lattice paths, Catalan and Delannoy numbers
   6.2.6 The ballot problem
6.3 Partitions
   6.3.1 Compositions
   6.3.2 Set partitions
   6.3.3 Stirling numbers of first, second kind and Bell numbers
   6.3.4 Integer partitions
   6.3.5 Euler’s identity
   6.3.6 Ferrer’s diagrams

6.4 Inclusion Exclusion
   6.4.1 Inclusion exclusion principle
   6.4.2 Derangements
   6.4.3 Rook polynomials
   6.4.4 Forbidden positions
   6.4.5 Möbius inversion

6.5 Generating Functions
   6.5.1 Generalized binomial coefficient
   6.5.2 Ordinary generating functions
   6.5.3 Exponential generating functions
   6.5.4 Products of generating functions
   6.5.5 Compositions of generating functions
   6.5.6 Solving homogeneous and nonhomogeneous recursions

6.6 Pólya-Redfield counting*
   6.6.1 Symmetry groups
   6.6.2 Burnside’s lemma
   6.6.3 Pólya’s method of enumeration

6.7 Optional Topics*
   6.7.1 Dilworth’s theorem
   6.7.2 Erdös-Ko-Rado theorem
   6.7.3 Latin squares
   6.7.4 Block designs and projective planes

7.0 Intended learning outcomes and associated assessment methods of those outcomes:
<table>
<thead>
<tr>
<th>Learning Outcomes</th>
<th>Assessment Methods</th>
</tr>
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<tbody>
<tr>
<td>7.1 Use the basic vocabulary and definitions of combinatorics</td>
<td>✓</td>
</tr>
<tr>
<td>7.2 Apply techniques of combinatorics to solve applied problems</td>
<td>✓</td>
</tr>
<tr>
<td>7.3 Establish relationships between concepts in combinatorics by writing formal,</td>
<td>✓</td>
</tr>
<tr>
<td>rigorous mathematical proofs</td>
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</tbody>
</table>

8.0 Program goals supported by this course:

8.1 To develop students’ understanding of the mathematical framework that supports engineering, science, and mathematics.

8.2 To develop critical and analytical thinking.

8.3 To develop an appropriate level of mathematical literacy and competency.

8.4 To provide an acquaintance with mathematical notation used to express physical and natural laws.

9.0 General education learning outcomes and/or goals supported by this course: Not applicable

10.0 Other relevant information: (such as special classroom, studio, or lab needs, special scheduling, media requirements, etc.)

None.