***Discrete Structures***

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| **COURSE No.:** | PBM 763 |
| **PROGRAM:** | BITL, BBA (elective) |
| **INSTRUCTOR:** | Kalvis Apsītis, Jānis Lazovskis |
| **CLASS DAYS & TIME:** | **Spring 2021 Semester: Mondays, Tuesdays, Wednesdays, Fridays.** January 4 till April 9, 2021.  (Consultation Week: April 12-16, 2021). |
| **OFFICE LOCATION & HOURS:** | Near Room 423 by appointment |
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**TEXTBOOK**

**The Textbook:** Kenneth H.Rosen. Discrete Mathematics and Its Applications, 8th Edition. McGraw-Hill Education. 2019.

**Class Website:** <http://linen-tracer-682.appspot.com/discrete/index.html> (hosting may change – the permanent URL will be announced to the students).   
It contains presentations and descriptions of assignments.   
**Reading Assignments:** Class Website also links to some math papers and other supplementary material.

**COURSE OBJECTIVES**

At the end of this course, students will be able to prove statements about the mathematical properties of sets, numbers and discrete structures (various data models typically stored in the memory of a computer). They will communicate the rules to manipulate this discrete data. This course prepares for advanced algorithms used in computer networks, data encryption, financial transactions, Internet search and social media. The course can strengthen creative thinking and general problem solving capabilities.

**COURSE OVERVIEW**

The course provides foundational material for further studies in computer science. It covers large number of interrelated topics – Boolean and predicate logic, proofs, set theory, integer arithmetic (in particular, number theory and divisibility), recurrence relations, counting methods, discrete probabilities, graphs and trees.

In order to achieve the course objectives, we will use these methods and tools:

1. **Class Participation: 4\*14 sessions, 90 minutes each.** The scope of this course requires regular work and diligent practice. It is not easy to catch up after missing a few classes. Due to the epidemic we expect that some class sessions are hybrid and/or remote. Two out of four class sessions are for all participants (same meeting room or remote session). During another two sessions the class is split into two parts; both instructors will teach them in parallel and will switch places.

Attendance is not graded, but we expect active participation in the following activities:

* 1. Work with examples provided in the class. Every concept in mathematics is taught by looking at the “typical representatives” of this concept; examples in this course are as important as the theory itself.
  2. Complete multiple-choice or short answer tests. They are not graded just like other classroom activity, but can provide instant feedback and give early indication about the difficulties.
  3. Read some theory topics before the class session itself (flipped classroom).
  4. Participate in problem solving when working in groups; contribute the knowledge that other people in the team might not have (e.g. because of different reading assignments).

1. **Solving mathematical problems (12 Homeworks):** The key ability developed in this class is reasoning in written English. In this class we suggest that you typeset your homework in LaTeX using APA style guidelines. You should expect about one homework per week. A homework consists of 3 types of problems:
   1. 2-3 problems ask you to solve a typical example (for example, apply a procedure covered in a class to a particular case).
   2. 1-2 problems ask you to prove general statements or solve cases where there is no single obvious method. Instructors try to assist by giving hints and encouraging creative problem solving techniques.
2. **Solving mathematical problems (Midterm and Final Exam):** Problems in midterm and final exams are similar (regarding their style and scope) to the homeworks.
3. **Individual Assignment:** Discrete structure results are not found just in textbooks; they may appear as academic papers and some technology solutions. You can study some topic, to prepare slides and give a 10-minute technical talk for your half of the class. We can negotiate that everybody can prepare a different topic matching his/her interests and abilities.

Topics may include an important application area for a discrete math topic, some important algorithm, doing math with proof assistants (such as Coq) or processing data (interactive environments such as Python/Jupyter or R/RStudio).

**COURSE REQUIREMENTS**

In order to get a satisfactory grade, you need to get the total evaluation that matches the minimum grade requirements defined for your study program.

1. **Class Participation** should match the expectations of your study program. If you expect to miss more 1 class per week and there are difficulties following the material, we should resolve the situation as early as possible (since it is easy to miss material that is crucial for understanding the next topics).
2. **Homeworks** should be submitted electronically (typically, on the day preceding the class, where they are discussed). class on the due date and should be submitted electronically. These will include several sets of math problems - mostly proofs or applying your theory knowledge in specific contexts.  
   Late homework submissions are not allowed and they earn no credit.
3. **Midterm and Final Exams.** Both exams are “closed book, closed notes” – you rely on your memory and understanding. Relevant definitions and notation will be included in the problems themselves, if necessary.  
   Make-up exams for the mid-term and the final are generally not given. If there are extenuating circumstances and you must miss an exam the instructor must be notified ahead of the exam time. The only time a make-up exam can be taken is during the week following the date of the exam. If a student does not notify the instructor of an absence or misses the make-up exam deadline, the exam will not be included in the final grade.
4. **Individual Assignments** should be presented on the day they were scheduled.

**GRADING**

Grading for the course is as follows:

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| --- | --- |
| ***Assignments*** | ***Points*** |
| Homeworks | 600 |
| Midterm | 150 |
| Final | 200 |
| Individual Assignment | 50 |
| TOTAL | 1000 |

Final grades are calculated on the following basis.

> 949 = 10

850-949 = 9

750-849 = 8

650-749 = 7

550-649 = 6

450-549 = 5

350-449 = 4

< 350 = failing

Your grades will be updated regularly in ORTUS (E-studijas RTU). Please check to see that your grades are recorded correctly.

**ACADEMIC INTEGRITY**

To strengthen ethics within Riga Business School and the business community the RBS policy is to take steps to avoid cases of academic fraud. Be aware that any student who turns in written work that is not original with incorrectly referenced sources (i.e. plagiarized) will be subject to the RBS sanctions policy on Academic Fraud (see the policy on the online assistant). The same consequences apply to academic dishonesty on tests and quizzes.

To find information on what plagiarism is and how to avoid it please visit the links at:  
<http://www.uottawa.ca/plagiarism.pdf>  
<http://www.socialsciences.uottawa.ca/pdf/plagiarism2.pdf>  
<http://www.sass.uottawa.ca/writing/plagiarism.pdf>

This short presentation on research and plagiarism will also help learn to correctly reference sources and provides good advice on research:  
<http://library.acadiau.ca/tutorials/plagiarism/>

During the Discrete Structures class, you should be aware of the following integrity guidelines in particular:

* **Homeworks:** Discussing your assignments is encouraged as long as you do not take any notes or copies of the work of other people. At the moment when you write your proofs, you should not interact with others and use only your notes and any other notes and papers. Results from external sources can be referred to in your solution, if they are properly quoted (APA guidelines tell how to do citations).
* **Problems completely solved online:** We try to give you problems that are variations of the textbook stuff. But occasionally you may find that the homework problem is completely solved in some online resource. Please do NOT copy the solution (even if properly quoted and referenced), since you will not learn from such practice. Instead, please inform the instructor(s) that a homework problem might be compromised, and then we can try to find a fix together.
* **Exams:** Both exams will be proctored and are closed book and closed notes. You can use only paper and pen.  
  If exams are done remotely they can be open book and open notes (no collaboration of any kind is allowed). To save your time we suggest that you write your exam solutions on grid paper (size A4) and send us photographs of your handwriting.

**CLASS SCHEDULE**

A schedule of topics is listed below. Specific readings and assignments will be defined later.

| Spring 2020 | Topic | Pre-class preparation | Deliverables and Activities |
| --- | --- | --- | --- |
| Week1 04.01-08.01 | Introduce propositions, Boolean logic, predicates and quantifiers. | Ch1 "Logic and Proofs" (1.1, 1.3, 1.4) | Typesetting mathematics. |
| Week 2 11.01 - 15.01 | Write human-readable proofs. (Also formalize word problems?) | Ch1 "Logic and Proofs" (**1.5, 1.6,** 1.7, 1.8) | HW01 |
| Week 3 18.01 - 22.01 | Introduce sets and functions. Compare set cardinalities. Use proof assistants. | Ch2 "Sets, Functions" (2.1, 2.2, 2.3) | HW02 |
| Week 4 25.01 - 29.01 | Generalize sets, functions to sequences, folding expressions (long sums, products), filtering by predicate, matrix operations. | Ch2 "Sets, Functions" (2.4, 2.5, 2.6) | HW03 |
| Week 5 01.02 - 05.02 | Introduce algorithms, prove the existence of unsolvable problems. Introduce asymptotic growth notations. Define poly-time and infeasible problems. | Ch3 "Algorithms" (3.1, 3.2, 3.3) | HW04 Individual Assignments. Part 1: presentations on proofs, logic, math creativity. |
| Week 6 08.02 - 12.02 | Use results about divisibility and primes, number representation, modular arithmetic, apply algorithms on integers. | Ch4 "Number Theory" (4.1, **4.2,** 4.3, 4.4, **4.5**) | HW05 |
| Week 7 15.02 - 19.02 | Use mathematical induction, recursion, invariants, (well ordering principle? axiom of choice?) | Ch5 "Induction and Recursion" (5.1, 5.2, 5.3) | HW06 |
| Week 8 22.02 - 26.02 | Introduce relations, their properties and possible representations. | Ch9 "Relations" (9.1, 9.2, 9.3) | Midterm Exam |
| Week 9 01.03 – 05.03 | Manipulate equivalence and (partial) order relations. | Ch9 "Relations" (9.4, 9.5, 9.6) | HW07 Individual Assignments. Part 2: presentations on number theory, relations. |
| Week 10 08.03 - 12.03 | Apply rules of multiplication (also addition, division etc.) to count some finite sets or structures. Appply permutation, combination, etc. formulas (also their variants with repetitions) | Ch6 "Counting" (6.1, 6.2, 6.3, 6.4, 6.5) | HW08 |
| Week 11 15.03 - 19.03 | Discrete Probability. Assigning probabilities. Bayes theorem. Descriptive statistics | Ch7 "Discrete Probability" (7.1, 7.2, 7.3, 7.4) | HW09 Individual Assignments.  Part 3: presentations on counting and probabilities. |
| Week 12 22.03 - 26.03 | More counting. Recurrences. Inclusion-exclusion. | Ch8 "Advanced Counting" (8.1, 8.2, 8.3, 8.5) | HW10 |
| Week 13 29.03 - 02.04 | Graphs. Representing graphs. Cycles. Shortest paths. | Ch10 "Graphs" (10.1, 10.2, 10.3, 10.4, 10.5) | HW11 |
| Week 14 05.04 - 09.04 | Define and traverse trees, write prefix, infix, postfix expressions, introduce spanning trees in a graph. | Ch11 "Trees" (11.1, 11.3, 11.4) | HW12.  Individual Assignments. Part 4: presentations on graphs. |
| Consultation Week 12.04 - 16.04 | Reviewing all the topics. Feedback on the individual assignments and presentations. | N/A | N/A |
| Exam Session 19.04 - 23.04 | Final Exam not scheduled yet. | N/A | Final Exam |