Course Details

Course Title & Number: BIOE 4620 Remediation Engineering (Fall 2018)
Class Times & Days of Week:
Lectures: MWF 1:30 - 2:15
Tutorials: M 2:30 - 4:30
Location for classes/labs/tutorials:
Lectures: Room E2-351 EITC Bldg
Tutorials: Room E2-351 EITC Bldg
Pre-Requisites: SOIL 4060, CIVL 2790 or BIOE2790.

Course Description:
(Formerly 034.462) The theoretical basis for the engineering design of different remediation technologies to treat contaminated soil and groundwater will be introduced. Methods for site characterization, monitoring of progress in remediation, and modeling of the remediation process will be presented. Different methods such as soil washing, air sparging, bioremediation, phytoremediation, constructed wetlands, electrokinetic remediation, reactive barriers will be discussed. Prerequisite: CIVL 2790 (or 023.279) or MECH 2262 (or MECH 2260 or 025.226). (4 Credit hours)

Instructor Information

Instructor(s) Name: Dr. (Ranjan) R. Sri Ranjan, P.Eng., Professor
Office Location: E1-346 EITC
Office Hours or Availability: By appointment
Office Phone No. 204-474-9344
Email: Sri.ranjan@umanitoba.ca

Teaching Assistant: Ms Xueke Jia
Office Location: E1-309 EITC
Office Phone No. 204-963-8488
Email: Jiax34@myumanitoba.ca (Email is the best way to contact)

Textbook, Readings, Materials

Required textbook
Course hand-outs will be available through the Campus Copy Centre.

Supplementary material

Additional Materials
The following journals provide recent research information on the topics covered in this course:
Canadian Biosystems Engineering Journal
Transactions of the ASABE
Applied Engineering in Agriculture
Biosystems Engineering
Journal of Soil and Water Conservation
Course Philosophy

Students’ Learning Responsibilities
Students are expected to study the material covered during the lecture and make additional notes. They are expected to review the material already covered before they come to the next class. The assignments are due on the designated dates. This course relies heavily on your knowledge of basic concepts in soil physics. You are encouraged to review soil physics from any textbook, i.e., many books by Daniel Hillel are available in the library. Please respect both us as instructors and your classmates by **turning off your cell phone during class time.** Laptops/iPads may be used during lectures only if you are using it in connection with this course.

Why this course is useful?
The course covers and overview of groundwater hydrology and contaminant transport. Then it uses these concepts to design different types of remediation systems for cleaning-up contaminated soil and groundwater. If you plan a career in Environmental Engineering dealing with remediating contaminated sites, this course will equip you with the tools necessary for your career.

Who should take this course?
Students interested in the Environmental Engineering focus area.

How this course fits into the curriculum
Soil and groundwater remediation is a major part of the responsibilities of an engineer working in the environmental area. Knowledge gained through this course will provide a key component of the environmental stream.

Course Policies

Late Assignments
10% per day will be deducted for late assignments. Assignments **will not be accepted** after the marked assignments of others have been returned to the class.

Missed Assignments
Zero marks for missed assignments.

Missed Exams
There is **NO make-up examination** for a missed mid-term! If missed, and the student has a valid medical certificate or compassionate reason (e.g., death of an immediate family member), marks assigned to the mid-term will be added to marks assigned for the final examination. Students who miss the examination without a valid reason will receive a grade of zero (0) for the mid-term examination.

In case of a missed final examination, a student will be assigned an F no paper grade for the course unless an acceptable medical certificate or a confirmable compassionate reason is provided in which case a supplementary examination will be allowed.

Instructional Methods
The lecture will consist of discussion of concepts using Keynote slides with additional descriptive notes in class. The slides will be available through the Campus Copy Centre as course handouts for students to take additional notes during the lecture.
Description of Examinations
All tests/examinations will consist of two parts. Part A will be closed book/notes testing your ability to recall concepts. Part B will be open book/notes/assignments testing your ability to solve a field problem, and quantify inputs and outputs to help design a remediation system.

Description of Assignments
Assignments are usually problem-solving type questions to provide practice for what was discussed in class. We will briefly review the assignments at the beginning of the class and get you started on problem solving. You are expected to complete the assignment and submit by the due date.

Assignment Due Dates
Deadlines are a reality in the world of engineering; we expect assignments to be completed and uploaded on time to the UMLearn portal. Assignments submitted after the due date will be docked 10% per day. All assignments must be submitted to pass the course. Assignments are given on Mondays. They are due to be uploaded to the UMLearn portal as .pdf file by 4:30 pm on the following Thursday. The assignments are designed to be completed in less than four hours. Your papers can be scanned in the library.

Academic Integrity
Plagiarism or any other form of cheating in examinations, term tests or academic work is subject to serious academic penalty. Cheating in examinations or tests may take the form of copying from another student or bringing unauthorized materials into the exam room. Exam cheating can also include exam impersonation. A student found guilty of contributing to cheating in examinations or term assignments is also subject to serious academic penalty. Students should acquaint themselves with the University’s policy on plagiarism, cheating, exam impersonation and duplicate submission.

Use of Third Party Detection and Submission Tools
Electronic detection tools may be used to screen assignments in cases of suspected plagiarism.

Group Work Policies:
Students are all owed to discuss laboratory results with lab partner or others but the final report must be independently written. Copying or joint production of reports (except for group projects) will result in both reports receiving a zero mark.

General Guidance Resources on Campus
Students are encouraged to familiarize themselves with the resources available to them by visiting the Student Affairs website at http://umanitoba.ca/student/index.html The site contains helpful general information as well as links to webpages for the Aboriginal Student Centre, the International Centre for Students, the Academic Learning Centre, Student Advocacy & Accessibility, the Student Counselling & Career Centre, and University Health Service. Please make use of these resources to enhance your academic learning and life as a student.

Important Dates

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>October 8:</td>
<td>No class – Thanksgiving Day</td>
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<tr>
<td>November 12-16:</td>
<td>No class – Fall term break</td>
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<td>November 19:</td>
<td>Last date for Voluntary Withdrawal for fall term courses.</td>
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Course Goals

The intent of this course is:
The theoretical basis for the engineering design of different remediation technologies to treat contaminated soil and groundwater will be introduced. Methods for site characterization, monitoring of progress in remediation, and modelling of the remediation process will be presented. Different methods such as soil washing, air sparging, bioremediation, phytoremediation, constructed wetlands, electrokinetic remediation, reactive barriers will be discussed.

Intended Learning Outcomes

At the conclusion of the course, the student should be able to:
1. Explain the principles associated with the design of remediation systems.
2. Analyze an existing field scenario to determine the most appropriate remediation strategy.
3. Use models to predict the outcomes from a remediation strategy.
4. Design and evaluate remediation systems for specified scenarios.
5. Summarize and present the results of the design process in an oral presentation and formal report.
6. Apply what was learned in the classroom to novel situations in the workplace.

Expected Level of Development in Course **

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>KB</th>
<th>PA</th>
<th>IN</th>
<th>DE</th>
<th>ET</th>
<th>IT</th>
<th>CS</th>
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*Attributes:*
- KB: A knowledge base for engineering
- PA: Problem analysis
- IN: Investigation
- DE: Design
- ET: Use of engineering tools
- IT: Individual and team work
- CS: Communication skills
- PR: Professionalism
- IE: Impact of engineering on society/environment
- EE: Ethics and equity
- EP: Economics and project management
- LL: Life-long learning

**Expected Level of Development:**
- I – Introductory
- D – Developed
- A – Advanced
All courses in the Biosystems Engineering program are expected to contribute, in some way, to the development of one or more of the 12 graduate attributes that have been identified by the Canadian Engineering Accreditation Board. The 12 graduate attributes have been defined below for your information. While there are likely some aspects of many of these attributes that can be found in this course, the attributes being emphasized in this course are: 1) A Knowledge Base for Engineering, 2) Problem Analysis, 4) Design, 5) Use of engineering tools 6) Individual and team work, 7) Communication Skills, 8) Professionalism 9) Impact of Engineering on Society and the environment, 11) Economics and Project Management, and 12) Life-long learning.

Graduate Attributes
1. **A Knowledge Base for Engineering**
   Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

2. **Problem Analysis**
   An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.

3. **Investigation**
   An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.

4. **Design**
   An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

5. **Use of Engineering Tools**
   An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

6. **Individual and Team Work**
   An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

7. **Communication Skills**
   An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

8. **Professionalism**
   An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

9. **Impact of Engineering on Society and the Environment**
   An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

10. **Ethics and Equity**
    An ability to apply professional ethics, accountability, and equity.

11. **Economics and Project Management**
    An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.

12. **Life-long Learning**
    An ability to identify and address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.
## Course Evaluation

<table>
<thead>
<tr>
<th>Assessment Element</th>
<th>Value</th>
<th>Attributes Covered</th>
<th>Indicators being assessed</th>
<th>Level *</th>
</tr>
</thead>
</table>
| Tutorial/Lab                | 20%   | Problem Analysis (10%) Design (10%)                   | **PA.3** – Analyzes and solves complex engineering problems.  
**DE.3** – Designs a component based on real-life scenario. | A       |
| Mid-term Tests              | 25%   | Knowledge base (10%) Problem Analysis (5%) Design (10%) | **KB.3** – Recalls and defines, and/or comprehends and applies information, principles and concepts in engineering design.  
**PA.3** – Analyzes and solves complex engineering problems.  
**DE.3** – Designs a component based on real-life scenario. | A       |
| Project Presentation/Report | 5%    | Design (2%) Communication (3%)                        | **DE.3** – Designs a component based on real-life scenario.  
**CS.3** – Make an oral presentation and submit a report. | A       |
| Final Examination           | 50%   | Knowledge base (20%) Problem Analysis (10%) Design (20%) | **KB.3** – Recalls and defines, and/or comprehends and applies information, principles and concepts in engineering design.  
**PA.3** – Analyzes and solves complex engineering problems.  
**DE.3** – Designs a component based on real-life scenario. | A       |

*Level of Development of Graduate Attributes (I = Introductory; D = Intermediate; A = Advanced)

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### Tutorials (20%)

Each **Monday** we will have a tutorial, which is due at 4:30 pm on the following **Thursday**. Students will lose 10% of their mark per additional late day. Once the marked assignments are posted to UMLearn no further submissions will be allowed. Students will be given questions in order to practice their problem solving skills. During tutorials, students will have two hours to work on the questions, asking questions of the TA/instructor when needed. Please upload a clearly scanned .pdf file to the UMLearn site for grading. Scanners are available in the Engineering Library.

### Midterm Tests (2 X 12.5%)

Two 50 minute Midterm tests will be administered during the lecture period on October 3 and November 28, 2018. Part A of the midterm will be closed-book; Part B is open book/notes.

### Final exam (50%)

A cumulative final exam worth 50% of your grade will be administered during the final examination period. Part A of this exam will be closed-book; Part B is open book/notes.

### Assessment method

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<thead>
<tr>
<th>Assessment</th>
<th>Value</th>
<th>Letter Grade</th>
<th>Percentage out of 100</th>
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<tbody>
<tr>
<td>Tutorials</td>
<td>20%</td>
<td>A+</td>
<td>92-100</td>
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<tr>
<td>Project Reports/Presentation</td>
<td>5%</td>
<td>A</td>
<td>85-91</td>
</tr>
<tr>
<td>Two Midterm Tests</td>
<td>25 %</td>
<td>B+</td>
<td>78-84</td>
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<tr>
<td>Final Exam (comprehensive)</td>
<td>50 %</td>
<td>B</td>
<td>72-77</td>
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<td></td>
<td>100 %</td>
<td>C+</td>
<td>66-71</td>
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<td>Less than 50</td>
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Course Outline

Principles of flow and contaminant transport
- Overview of terminology
- Darcy’s law, Chemical partitioning and reactions

Site characterization
- Saturated and unsaturated flow measurement, Water content determination
- Non-intrusive methods for delineating the contaminated area

Pump-and-Treat method
- Placement of injection and recovery wells
- Above ground treatment protocol

Air sparging/bio-venting
- Siting of access wells and treatment protocol

Electrokinetic Remediation
- Conditions suitable for electrokinetic remediation
- Siting of electrodes and design of treatment protocol

Bioremediation
- Conditions necessary for successful bioremediation
- Design protocol for maintaining an active system

Phytoremediation
- Selection of plant species appropriate to the different sites.
- Protocol for establishing the phytoremediation process
- Design of vegetative covers for waste containment

Constructed wetlands
- Selection of plant species
- Design of wetlands for treating effluents

Vegetative filter strips

Reactive walls and barrier technologies
- Chemical reactions within the reactive wall and barriers
- Design protocol for creating and maintaining the reactive walls and barriers

Assessing and monitoring remediation

Laboratories
There will be 12 labs covering topics on site characterization, laboratory and field methods, and design of pump-and-treat, air sparging, bioremediation, phytoremediation, electrokinetic remediation, reactive barriers.