

## Course Details

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<b>Course Title &amp; Number:</b>	BIOE 4620 Remediation Engineering (Fall 2020)
<b>Class Times &amp; Days of Week:</b>	Lectures: MWF 1:30 - 2:15 Tutorials: M 2:30 - 4:30
<b>Location for classes/labs/tutorials:</b>	Virtual Lecture using Webex accessed through UMLearn Virtual Tutorials using Webex accessed through UMLearn
<b>Pre-Requisites:</b>	SOIL 4060, CIVL 2790 or BIOE2790.

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### 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

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<b>Instructor(s) Name:</b>	Dr. (Ranjan) R. Sri Ranjan, P.Eng., Professor
<b>Office Location:</b>	Virtual contact scheduled through WebEx
<b>Office Hours or Availability:</b>	By appointment
<b>Office Phone No.</b>	204-474-9344
<b>Email:</b>	Sri.ranjan@umanitoba.ca
<b>Teaching Assistant:</b>	Ms Sarah Currie
<b>Office Location:</b>	via email
<b>Office Phone No.</b>	204-963-8488
<b>Email:</b>	curries4@myumanitoba.ca (Email is the best way to contact)

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### Textbook, Readings, Materials

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#### Required textbook

Course hand-outs will be posted to the UMLearn

#### Supplementary material

- Suthersan, S. S., J. Horst, M. Schnobrich, N. Welty, and J. McDonough. 2017. Remediation Engineering (p. iv). CRC Press. Kindle Edition. 2017. Remediation Engineering: Design Concepts, Second Edition
- Fetter, C. W., T. Boving, and D. Kremer. 2018. Contaminant Hydrogeology, Third Edition (Kindle Edition)
- Domenico, P.A. and F.W. Schwartz. 1998. Physical and Chemical Hydrogeology. Second Edition. John Wiley & Sons. (ISBN: 0-471-59762-7)
- Hillel, D. 2003. Introduction to Environmental Soil Physics.

#### 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
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## 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 **muting your microphone during the virtual session, unless you are asking a question.**

### Why this course is useful?

The course covers an 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 due to illness or compassionate reason (e.g., death of an immediate family member), marks assigned to the mid-term tests and quizzes 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 class handout containing mini-slides will be available through UMLearn for students to take additional notes during the lecture.

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**Description of Examinations**

All tests/examinations will be done through UMLearn using Respondus Monitor. Please ensure you have a good internet connection and a webcam that should be active during the examination.

**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 allowed 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**

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October 12:	No classes – Thanksgiving Day
November 9 - 13:	No classes – Fall term break
November 23:	Last date for Voluntary Withdrawal for Fall term courses.

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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 \*\***

Learning Outcome	Attribute*											
	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
1	A											
2		A		D								
3					D							A
4												
5				A	A	A	A	A				A
6									A			A

**\*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

**The University of Manitoba**  
**Department of Biosystems Engineering**

**Supplemental Course Information for BIOE 4620**

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.

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**Course Evaluation**

Assessment Element	Value	Attributes Covered	Indicators being assessed	Level *
<b>Tutorial/Lab</b>	20%	Problem Analysis (10%) Design (10%)	<b>PA.3</b> – Analyzes and solves complex engineering problems. <b>DE.3</b> – Designs a component based on real-life scenario.	A
<b>Two Mid-term Tests</b>	25%	Knowledge base (10%) Problem Analysis (5%) Design (10%)	<b>KB.3</b> – Recalls and defines, and/or comprehends and applies information, principles and concepts in engineering design. <b>PA.3</b> – Analyzes and solves complex engineering problems. <b>DE.3</b> – Designs a component based on real-life scenario.	A
<b>Project Presentation</b>	5%	Communication (5%)	<b>CS.3</b> – Make an oral presentation of the remediation plan	A
<b>Project Report</b>	10%	Design (5%) Communication (5%)	<b>DE.3</b> – Designs a remediation plan based on real-life scenario. <b>CS.3</b> – Submit a written report.	
<b>Final Examination</b>	40%	Knowledge base (10%) Problem Analysis (15%) Design (15%)	<b>KB.3</b> – Recalls and defines, and/or comprehends and applies information, principles and concepts in engineering design. <b>PA.3</b> – Analyzes and solves complex engineering problems. <b>DE.3</b> – Designs a component based on real-life scenario.	A

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

<b>Tutorials (20%)</b>	
Each <b>Wednesday</b> we will have a tutorial, which is <b>due Five days later at 4:30 pm on Monday</b> . 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.	
<b>Midterm Tests (2 X 12.5%)</b>	
Two 50 minute Midterm tests will be administered during the lecture period on <b>October 9</b> and <b>November 27, 2020</b> .	
<b>Project Presentation and Report (5% + 10%)</b>	
This is a group project where the presentations are individually marked and report marked as a group based on contributions made by each member of the group. The contribution of each member is determined by the group and stated in the Report.	
<b>Final exam (40%)</b>	
A cumulative final exam worth 35% of your grade will be administered during the final examination period.	
<b>Assessment method</b>	
Tutorials	20%
Project Reports/Presentation	15%
Two Midterm Tests	25 %
Final Exam (comprehensive)	<u>40%</u>
	100 %
Letter Grade	Percentage out of 100
A+	92-100
A	85-91
B+	78-84
B	72-77
C+	66-71
C	60-65
D	50-59
F	Less than 50

## 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

## Tutorials/Laboratories

There will be 11 Tutorial labs covering topics on site characterization, laboratory and field methods, and design of pump-and-treat, air sparging, bioremediation, phytoremediation, electrokinetic remediation, reactive barriers. There will be a group Design Project.

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