

**Faculty of Engineering****DEPARTMENT OF CHEMICAL & BIOCHEMICAL ENGINEERING****CBE 4484A – Processes for Green Products**  
**Course Outline 2023****Description**

This course describes what are green chemicals and products and the main current or potential processes used to produce green chemicals and products. The student should be aware of the issues associated with the production of products from fossil resources, be aware of the current processes that are used on a commercial scale to produce green chemicals and products, their advantages and drawbacks. The students should develop an understanding of the opportunities to transform wastes into resources that can generate both economical and environmental benefits.

**Prerequisites**

CBE 2207A/B or GPE 2214A/B, CBE 2224A/B or GPE 2218A/B, CBE 3315A/B or GPE 3315A/B.

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

**Corequisites**

None

**Contact Hours**

0.5 course.

At present, plans are to offer in-person lectures. This may change depending on how COVID-19 infection rates evolve. Pre-recorded versions of the lectures will be made available on OWL for students who do not attend in-person. They will be close but not identical to the in-person lectures. Uploading the lectures to public sites such as YouTube or sharing them with people who are not registered in GPE 4484 or CBE 9334 is NOT ALLOWED.

*In the event of a COVID-19 resurgence during the course that necessitates the course delivery moving away from face-to-face interaction, all remaining course content will be delivered entirely online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading*

*scheme will not change. Any remaining assessments will also be conducted online at the discretion of the course instructors.*

**Instructors**

Dr. Franco Berruti; email: [fberruti@uwo.ca](mailto:fberruti@uwo.ca)

Dr. Cedric Briens; email: [cbriens@uwo.ca](mailto:cbriens@uwo.ca)

**Undergraduate Assistant**

(TEB 477) Telephone: 519-661-2111 ext: 82131 email: [cbeundergraduate@uwo.ca](mailto:cbeundergraduate@uwo.ca)

**Required Text**

None

**Reference Text**

None

**Course Notes**

Course notes and recorded lectures will be available on Owl. Uploading the lectures to public sites such as YouTube or sharing them with people who are not registered in GPE 4484 or CBE 9334 is NOT ALLOWED.

**Units**

SI units will be used in lectures and examinations.

**General Learning Objectives**

- Be introduced to the possible future processes to produce green fuels and chemicals, their advantages and drawbacks.
- Gain knowledge to integrate various processes in a bio-refinery.
- Be aware of the socio-economic and environmental impacts of the various processes.

**Specific Learning Objectives****Introduction: Why we need Green Products. Biomass resources (Cedric Briens)**

At the end of this topic, students should:

- be aware of the environmental and political drivers behind the development of green products.
- have a general knowledge of the processes used to produce fuels, chemicals, and products from fossil resources.
- be aware of the environmental issues associated with these processes.

**Biomass/BioFuels Combustion (Cedric Briens)**

At the end of this topic, students should:

- know the processes used for the combustion of wood and residues from agricultural, food

processing, and municipal waste operations, as well as the processes for the combustion of fuels derived from these feedstocks.

- be aware of the environmental and logistic issues associated with these processes.

### **Biomass Gasification (Cedric Briens)**

At the end of this topic, students should:

- know the processes used to gasify wood and residues from agricultural, food processing, and municipal waste operations.
- be aware of the environmental and logistic issues associated with these processes.

### **Pyrolysis to Biochar, Bio-oil, and Gas (Cedric Briens)**

At the end of this topic, students should:

- understand the processes that are used to pyrolyze biomass.
- be aware of the technical and environmental issues of using raw bio-oils and biochar.

### **Processing and Refining of Bio-oils and Biochar (Cedric Briens)**

At the end of this topic, students should:

- understand how bio-oil can be stabilized and cleaned.
- know how bio-oil can be upgraded into valuable products.
- understand the various applications of biochar.
- know how to transform biochar into higher-value products.

### **Biodiesel and Renewable Jet Fuel (Cedric Briens)**

At the end of this topic, students should:

- know the processes that are used to produce biodiesel.
- know the processes that are used to produce renewable jet fuel.
- understand the social, economic, and political problems associated with the various production schemes.

### **Processes for Green Carbon and Hydrogen (Cedric Briens)**

At the end of this topic, students should:

- know the different types of green carbon.
- know how to produce green carbon and hydrogen from fossil sources and waste plastics.
- know how to produce green carbon and hydrogen from renewable sources.

### **Bioethanol and Biobutanol (Franco Berruti)**

At the end of this topic, students should:

- know the processes that are used to produce bioethanol, including biochemical and thermochemical methods.
- know the processes that are used to produce biobutanol, including biochemical and thermochemical methods.
- understand the social, economical and political problems associated with the various production schemes.

**Biogas by Fermentation** (Franco Berruti)

At the end of this topic, students should:

- know the various fermentation processes that can be used to transform agricultural, industrial and municipal waste into biogas.
- understand the various issues associated with the purification and use of biogas as a feedstock for the production of high value chemicals and products.

**Syngas and Hydrogen Production. Syngas Conversion to Clean Chemicals** (Franco Berruti)

At the end of this topic, students should

- understand the processes that are used to generate syngas.
- know the processes that are used for hydrogen production from syngas.
- 
- know the main processes that are used to convert syngas to chemicals.

**Biorefining: Product Separation and Purification** (Franco Berruti)

At the end of this topic, students should:

- understand the processes that are used to extract and purify green chemicals and products, with a stress on green processes.
- know the characteristic features of currently produced and novel biomaterials and the processes that are used to produce them.

**Green Chemistry Separations: Extraction and Purification of Green Chemicals from Renewable Resources** (Franco Berruti)

At the end of this topic, students should:

- know the major green chemicals that are obtained from renewable resources.
- understand the processes that are used to produce chemicals from renewable resources.

**Economics and Social Impact. Government Policies** (Franco Berruti)

At the end of this topic, students should:

- know how to evaluate the economics and social impact of green chemicals.
- be aware of the major, relevant government policies.

**Circular Economy of Waste Plastics** (Franco Berruti)

At the end of this topic, students should:

- know the circular economy principles can be applied to waste plastics.
- understand the processes that are used to produce valuable chemical products from waste plastics.

**Evaluation**

The final course mark will be determined as follows:

Mid-term exam on chapters covered by Cedric Briens	30%
Final exam on chapters covered by Franco Berruti	30%

Project 40% of which:

1 <sup>st</sup> report	10%
2 <sup>nd</sup> report	10%
draft of final report	10%
final report	10%

**Each Examination will be in-person, open book and 1 hour. It will be in essay format, with 4 questions in each exam.**

### **Notes**

**More information will be provided separately for the project.**

### **Repeating All Components of the Course**

In accordance with Senate and Faculty Policy, students who have failed an Engineering course (i.e. <50%) must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment or test marks from previous years.

Previously completed assignments and laboratories cannot be resubmitted for grading by the student in subsequent years.

### **Use of English**

In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for the improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

### **Cheating**

University policy states that cheating is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning (see Scholastic Offence Policy in the Western Academic Calendar).

### **Plagiarism**

Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence (see Scholastic Offence Policy in the Western Academic Calendar).

The University of Western Ontario has software for plagiarism checking. Students may be required to submit their work in electronic form for plagiarism checking.

### **Conduct**

Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others.

### **Sickness and Other Problems**

Students should immediately consult with the instructor or Department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented. The student should seek advice from the Instructor or Department Chair regarding how best to deal with the problem. Failure to notify the Instructor or Department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation

### **Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled**

If, on medical or compassionate grounds, you are unable to write term tests or final examinations or complete course work by the due date, you should follow the instructions provided by the Faculty of Engineering. You should understand that academic relief will not be granted automatically on request. You must demonstrate to the Undergraduate Services Office that there are compelling medical or compassionate grounds that can be documented before academic relief will be considered. Different regulations apply to term tests, final examinations and late assignments.

For further information, please consult the University's medical illness policy at:

[https://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/accommodation\\_medical.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf)

The Student Medical Certificate is available at

[https://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/medicalform.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf)

### **Absences from Final Examinations**

If you miss the Final Exam, please contact the Academic Counselling office of your Faculty of Registration as soon as you are able to do so. They will assess your eligibility to write the Special Examination (the name given by the University to a makeup Final Exam).

You may also be eligible to write the Special Exam if you are in a "Multiple Exam Situation" (e.g., more than 2 exams in 23-hour period, more than 3 exams in a 47-hour period).

**Note:** missed work can only be excused through one of the mechanisms above. Being asked not to attend an in-person course requirement due to potential COVID-19 symptoms is not sufficient on its own.

### **Notices**

Students are responsible for regularly checking their Western email and notices posted on Instructors' doors.

**Consultation**

Students are encouraged to discuss problems with their teaching assistant and/or instructor in tutorial sessions. Office hours will be arranged for the students to see the instructor and teaching assistants. Other individual consultation can be arranged by appointment with the appropriate instructor.

<b>Graduate Attribute</b>	<b>Indicator</b>	<b>Assessment tool</b>	<b>Assessment Level</b>
Problem Analysis	PA2: Demonstrate ability to formulate a strategy to solve an engineering problem	Project report #1	A: Applied
Impact on Society	IESE2: Demonstrate understanding of the concept of sustainable design and development	Exam question	A: Applied

**Accreditation (AU) Breakdown**

Engineering Science 100%

**STATEMENT ON GENDER-BASED AND SEXUAL VIOLENCE**

Western [is committed to reducing incidents of gender-based and sexual violence](#) and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced gender-based or sexual violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts, [here](#). To connect with a case manager or set up an appointment, please contact [support@uwo.ca](mailto:support@uwo.ca).

**INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED**

If, on medical or compassionate grounds, you are unable to write term tests or final examinations or complete course work by the due date, you should follow the instructions listed below. You should understand that academic relief will not be granted automatically on request. You must demonstrate to your department (or the Undergraduate Services Office) that there are compelling medical or compassionate grounds that can be documented before academic relief will be considered. Different regulations apply to term tests, final examinations and late assignments. Please read the instructions carefully.

**A. GENERAL REGULATIONS & PROCEDURES**

1. All first-year students will report to the Undergraduate Services Office by submitting the [Academic Consideration Request Form](#), for all instances.
2. If you are an upper year student and you are missing a test/assignment/lab or examination you will report the absence by submitting [Academic Consideration Request Form](#). Absences worth LESS THAN 10% of your mark, will be processed by your department office. If your course work is worth 10% OR MORE of your final grade, your request will be processed by the Undergraduate Services Office.
3. Check the course outline to see if the instructor has a policy for missed tests, examinations, late assignments or attendance.
4. Documentation must be provided as soon as possible. If no one is available in your department office or the Undergraduate Services Office, leave a message clearly stating your name & student number and reason for your call. The department telephone numbers are given at the end of these instructions.
5. If you decide to write a test or an examination you should be prepared to accept the mark you earn. Rewriting tests or examinations or having the value of a test or examination reweighted on a retroactive basis is not permitted.

**B. TERM/MIDTERM TESTS**

1. If you are in first year and you are unable to write a midterm/term test, contact the Undergraduate Services Office, SEB 2097 PRIOR to the scheduled date of the test.
2. If you are an upper year student and you are unable to write a midterm/term test, inform your instructor PRIOR to the scheduled date of the test and request relief through the [Academic Consideration Request Form](#). If the instructor is not available, leave a message for him/her at the department office. If the test is worth LESS THAN 10% of your mark, your request for relief will be processed by your department office. If the test is worth MORE THAN 10% of your final grade your request for relief will be processed by the Undergraduate Services Office.
3. Be prepared to attach supporting documentation to the Department Chair and/or the Undergraduate Services Office through the online form (see next page for information on documentation).
4. Discuss with the instructor if and when the test can be rescheduled. The approval of the Chair or the



Undergraduate Services Office is required when rescheduling midterm/term tests.

### C. FINAL EXAMINATIONS

1. If you are unable to write a final examination, contact the Undergraduate Services Office PRIOR TO THE SCHEDULED EXAMINATION TIME to report your absence using the [Academic Consideration Request Form](#) and request permission to write a Special Final Examination. If no one is available in the Undergraduate Services Office, leave a message clearly stating your name & student number.
2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, headache, sleeping in, misreading timetable and travel arrangements.
3. In order to receive permission to write a Special Examination, you must obtain the approval of the Chair of the Department **and** the Associate Dean and in order to apply you must submit an "[Application for a Special Exam](#)" form. The Undergraduate Services Office will then notify the course instructor(s) and reschedule the examination on your behalf.

**PLEASE NOTE: It is the student's responsibility to check the date, time and location of the Special Examination.**

### D. LATE ASSIGNMENTS

1. Advise the instructor if you are having problems completing the assignment on time (**prior** to the due date of the assignment).
2. Be prepared to submit the [Academic Consideration Request Form](#) and provide documentation if requested by the instructor (see reverse side for information on documentation).
3. If you are granted an extension, establish a due date. The approval of the Chair of your Department (or the Assistant Dean, First Year Studies, if you are in first year) is not required if assignments will be completed prior to the last day of classes.
4.
  - i) Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean, Undergraduate Studies. Documentation is mandatory.
  - ii) A Recommendation of Incomplete Form must be filled out indicating the work to be completed and the date by which it is due. This form must be signed by the student, the instructor, the department Chair and the Associate Dean, Undergraduate Studies.

### E. SHORT ABSENCES

If you miss a class due to a minor illness or other problem, check your course outlines for information regarding attendance requirements and make sure you are not missing a test, laboratory or assignment. Cover any readings and arrange to borrow notes from a classmate.

### F. EXTENDED ABSENCES

If you are absent more than one week or if you get too far behind to catch up, you should consider reducing your workload by dropping one or more courses. (Note drop deadlines listed below). You are strongly encouraged to seek advice from your Academic Counsellor in the Undergraduate Services Office.

### G. DOCUMENTATION

If you consulted an off-campus doctor or Student Health Services regarding your illness or personal problem, **you must provide the doctor with a Student Medical Certificate** to complete at the time of your visit and then bring it to the Department (or the Undergraduate Services Office). **This note must contain the following information: severity of illness, effect on academic studies and duration of absence. Regular doctor's**

**notes will not be accepted; only the Student Medical Certificate will be accepted.**

**In Case of Serious Illness of a Family Member:** Provide a Student Medical Certificate to your family member's physician to complete and bring it to the Department (or the Undergraduate Services Office if you are in first year).

**In Case of a Death:** Obtain a copy of the death certificate or the notice provided by the funeral director's office. You must include your relationship to the deceased and bring it to the Department (or the Undergraduate Services Office if you are in first year).

**For Other Extenuating Circumstances:** If you are not sure what documentation to provide, ask the Departmental Office (or the Undergraduate Services Office if you are in first year) for direction.

**Note: Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).**

## H. **ACADEMIC CONCERNS**

1. You need to know if your instructors have a policy on late penalties, missed tests, etc. This information may be included on the course outlines. If not, ask your instructor(s).
2. **You should also be aware of attendance requirements in some courses. You can be debarred from writing the final examination if your attendance is not satisfactory.**
3. If you are in academic difficulty, check out the minimum requirements for progression in the calendar. If in doubt, see your Academic Counsellor.

**Calendar References:** Check these regulations in your 2023 Western Academic Calendar available at [www.westerncalendar.uwo.ca](http://www.westerncalendar.uwo.ca).

### **Absences Due to Illness:**

[https://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page\\_135](https://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_135)

### **Academic Accommodations for Students with Disabilities:**

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page\\_10](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_10)

### **Academic Accommodations for Religious or Holy Days:**

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page\\_16](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_16)

### **Course Withdrawals:**

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=6&SelectedCalendar=Live&ArchiveID=#Page\\_75](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=6&SelectedCalendar=Live&ArchiveID=#Page_75)

### **Examinations:**

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=5&command=showCategory&SelectedCalendar=Live&ArchiveID=#Page\\_135](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=5&command=showCategory&SelectedCalendar=Live&ArchiveID=#Page_135)

### **Scheduling of Term Assignments:**

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=5&SelectedCalendar=Live&ArchiveID=#SubHeading\\_78](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=5&SelectedCalendar=Live&ArchiveID=#SubHeading_78)

### **Scholastic Offences:**

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page\\_20](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_20)

### **Student Medical Certificate:**

<https://www.eng.uwo.ca/files/undergraduate/student-medical-certificate.pdf>

**Engineering Academic Regulations:**

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=4&SelectedCalendar=Live&ArchiveID=#Page\\_86](http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=4&SelectedCalendar=Live&ArchiveID=#Page_86)

**Note:** These instructions apply to all students registered in the Faculty of Engineering regardless of whether the courses are offered by the Faculty of Engineering or other faculties in the University.

**Add Deadlines:**

“F”)	First term half course (i.e. “A” or
	September 15, 2023
suffix)	Full courses and full-year half course (i.e. “E”, “Y” or no
	September 15, 2023
“G”)	Second term half course (i.e. “B” or
	January 16, 2024

**Drop Deadlines:**

“F”)	First term half course without penalty (i.e. “A” or
	November 13, 2023
suffix) November 30, 2023	Full courses and full-year half courses without penalty (i.e. “E”, “Y” or no
“G”) March 7, 2024	Second term half or second term full course without penalty (i.e. “B” or

**Contact Information:**

Undergraduate Services Office:	SEB 2097	Phone: 519-661-2130	E-mail:
<a href="mailto:engugrad@uwo.ca">engugrad@uwo.ca</a>			
Chemical & Green Process Engineering:	TEB 477	Phone: 519-661-2131	E-mail:
<a href="mailto:cbeugrad@uwo.ca">cbeugrad@uwo.ca</a>			
Civil Engineering:	SEB 3005	Phone: 519-661-2139	E-mail:
<a href="mailto:civil@uwo.ca">civil@uwo.ca</a>			
Computer, Electrical, Mechatronic Systems & Software Engineering	TEB 279	Phone: 519-661-3758	E-mail:
<a href="mailto:eceugrad@uwo.ca">eceugrad@uwo.ca</a>			
Integrated Engineering	ACEB 2410	Phone: 519-661-6725	E-mail:
<a href="mailto:engceli@uwo.ca">engceli@uwo.ca</a>			
Mechanical Engineering:	SEB 3002	Phone: 519-661-4122	E-mail:
<a href="mailto:mmeundergraduate@uwo.ca">mmeundergraduate@uwo.ca</a>			