

X.T. Bi

**CHBE 370  
FUNDAMENTALS OF SUSTAINABLE ENGINEERING**

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**Course Website:** UBC Canvas

**COURSE OUTLINE**

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**1. Principles of sustainability and sustainable engineering (week 1)**

- Introduction to principles of sustainability, green chemistry, green engineering, sustainable engineering, pollution prevention, end-of-pipe treatment and systems thinking
- **Term paper guidelines**

**2. Environmental policies, laws and regulations (week 2)**

- Regional, national and global Air, water, soil and climate policies, laws and regulations

*Assignment #1*

**3. Life-cycle assessment (LCA) (weeks 3-4)**

- Methodologies of life-cycle assessment
- Applications of life-cycle assessment
- Audit and inventories  
Process emissions, Fugitive emissions, Secondary emissions

**Case study 1: Life-cycle assessment of alternate fuel engine vehicles.**

*Term paper proposal due*

**4. Environmental impacts and health risks (weeks 5-6)**

- Environmental impacts assessments
- Health risk assessments
- Integrated impact assessments

**Case study 2: Carbon footprint of British Columbia wood pellets**

*Assignment #2.*

*Quiz #1*

**5. Environmental cost and total cost analysis (weeks 7-8)**

- Environmental cost, external cost and total cost
- Cost-benefit and cost-effectiveness analysis (environmental fees, penalties, carbon taxes, clean incentives, green subsidies)

**Case study 3: Cost-benefit and cost effectiveness analyses of BC AirCare program and residential heating.**

*Assignment #3*

**6. Sustainability indicators for processes/products evaluation (weeks 8-9)**

- Sustainability indicators and ranking criteria
- Evaluation and ranking methods
  - ✓ Multi-objective (environmental-economic-social) optimization
  - ✓ Pareto analysis, multiple perspectives
  - ✓ stakeholder consideration

**Case study 4: Evaluation and ranking of biomass residues to biofuels pathways in British Columbia**

*Assignment #4*

**7. Sustainable engineering in practice (weeks 10-12)**

- Pollution prevention for unit operations
- Pollution prevention for industrial processes and products
  - ✓ Sustainable design of processes
  - ✓ Process water use/reuse
  - ✓ Fugitive emissions
  - ✓ Zero discharge
- Pollution prevention for industrial complexes and communities
  - ✓ Industrial symbiosis
  - ✓ Circular economy
  - ✓ Water-food-energy nexus

**Case study 5: A multi-scale approach for regional animal waste management**

*Quiz #2*

**8. Summary (week 12)**

**Term paper presentations (recorded videos) and peer review**

**Term paper submission**

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*During this pandemic, the shift to online learning has greatly altered teaching and studying at UBC, including changes to health and safety considerations. Keep in mind that some UBC courses might cover topics that are censored or considered illegal by non-Canadian governments. This may include, but is not limited to, human rights, representative government, defamation, obscenity, gender or sexuality, and historical or current geopolitical controversies. If you are a student living abroad, you will be subject to the laws of your local jurisdiction, and your local authorities might limit your access to course material or take punitive action against you. UBC is strongly committed to academic freedom, but has no control over foreign authorities (please visit <http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,33,86,0> for an articulation of the values of the University conveyed in the Senate Statement on Academic Freedom). Thus, we recognize that students will have legitimate reason to exercise caution in studying certain subjects. If you have concerns regarding your personal situation, consider postponing taking a course with manifest risks, until you are back on campus or reach out to your academic advisor to find substitute courses. For further information and support, please visit: <http://academic.ubc.ca/support-resources/freedom-expression>*

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**Course schedule:** 3 credit course, two 1.5-hour lectures per week plus one 2-hour tutorial every other week, starting week 2.

**Marking scheme:** 20% for 4 assignments, 10% for term project proposal, 10% for term project presentation, 30% for term paper, 30% for two quizzes

**Assignment deadlines:** completed assignments must be submitted online to the Canvas course website before 4:30 pm on the date they are due. Late assignments are penalized 10% of the maximum possible mark for each day or part day they are overdue. Assignments submitted after seven calendar days beyond the due date will not be marked and will automatically receive a score of 0%.

### Course materials

#### **Recommended textbooks**

1. **Bakshi, B.R. Sustainable Engineering: principles and practice. Cambridge University Press, Cambridge, UK. 2019.**
2. Gerardo Ruiz Mercado Heriberto Cabezas, Sustainability in the Design, Synthesis and Analysis of Chemical Engineering Processes. Butterworth-Heinemann, 2016. (**Accessible from UBC**)
3. Allen, D.T. and D.R. Shonnard, Sustainable Engineering: concepts, design and case studies. Prentice Hall, Upper Saddle River, NJ. 2012.
4. Wimmer, W. and Kauffman, Joanne. Handbook of Sustainable Engineering. First edition, Springer Publishing, 2011. ISBN: 978-1-4020-8939-8
5. Azapagic, A., S. Perdan and R. Clift, Sustainable Development in Practice: case studies for engineers and scientists, John Wiley and Sons, Chichester, 2004.
6. Baumann, H. and A.-M. Tillman, The Hitch-hiker's Guide to LCA, Studentlitteratur, Lund, 2004.
7. Graedel, T. E., B.R. Allenby, Industrial Ecology, Prentice Hall, 2nd Edition, 2002.

#### **Important Journals on green and sustainable engineering**

1. International Journal of Life Cycle Analysis
2. Journal of Cleaner Production
3. Journal of Industrial Ecology
4. Journal of Clean Products and Processes