Circular Engineering

Find another programme

Core courses

Year 1 Core Courses

Faculty of Science and Engineering

Engineering in a Circular Economy

Full course description

This course sets the stage for the pressing need of circular engineers in the modern world that is to face two huge societal challenges: to cope with the scarcity of raw materials and to balance the impact on the environment as wealth continues to increase. In this course, you get an overview of what it entails to become and to be a circular engineer by introducing the concept of circular economy. The circular economy approach addresses material supply challenges by keeping materials in use much longer and by returning materials for new use. The principle is that waste must be minimised and that by the reuse of materials less energy is required to manufacture new products. You are able to explain the concepts of reuse, repair, remanufacture and recycle and their mutual relationship in product design. Furthermore, you can describe state-of-the-art circular design methods that lead to less waste and energy, loss of value and loss of resources and explain issues that rise when implementing such circular economic principles from various perspectives (manufacturer, consumer, government).

Course objectives

At the end of this course, you are able to:
1. Describe and classify various circular economy and design terms, methods, and regulations, such as circularity indicators, value retention strategies, circularity metrics, product life cycle, cradle-to-cradle, circular design, industrial sustainability and ecology, Life Cycle Assessment, energy labels, and carbon footprint.
2. Generate possible circularity improvements in existing product life cycles by studying comparable products that already meet the requirements of circularity.
3. Explain the four steps to perform a Life Cycle Assessment and summarize its value related to sustainability and circular engineering.
4. Explain the impact of existing Life Cycle Assessment reports on a local, national and global scale.
5. Give your own reflection on a circularity

Recommended reading

Mandatory:The following handbooks and resources are used during the course. Only the topics covered during lectures and tutorials need to be studied.

- Reports - published by the Ellen McArthur Foundation:
- - Towards the Circular Economy Vol. 1: an economic and business rationale for an accelerated transition
- - The New Plastics Economy: Rethinking the future of plastics

Circular Engineering

- Book - Life Cycle Assessment: Quantitative Approaches for Decisions that Matter (2014), H. Scott Matthews, Chris Hendrickson, Deanna H. Matthews; available at https://www.lcatextbook.com/
- Article - Morseletto P. (2020), Targets for a Circular Economy. Resources, Conservation and Recycling, 153, 104553; available at https://doi.org/10.1016/j.resconrec.2019.104553
- Selection of literature on circularity and LCA; the sources are defined in the different tasks for this course

Recommended:
The following handbooks and resources are recommended if you are interested in circularity and/or Life Cycle Assessment and desire to have more in-depth information. They are by no means obligatory for the course.

- Handbook on essential concepts of sustainability: Tom Theis and Jonathan Tomkin, Editors, Sustainability: A Comprehensive Foundation. OpenStax CNX. 06.jan.2015 http://cnx.org/contents/1741effd-9cda-4b2b-a91e-003e6f587263@43.5. The book can be read online and is downloadable as PDF or EPUB file Article(s)
- Handbook - General guide for Life Cycle Assessment. European Commission - Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. First edition March 2010. EUR 24708 EN. Luxembourg. Publications Office of the European Union; 2010. The pdf file is available at:http://eplca.jrc.ec.europa.eu/uploads/ILCD-Handbook-General-guide-for-LCA-DETAILED-GUIDANCE-12March2010-ISBN-fin-v1.0-EN.pd
- Other reports on circularity published by the Ellen McArthur Foundation

CEN1001
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
5.0
Instruction language:
English
Coordinator:

- Y. van der Meer

Teaching methods:
Lecture(s), PBL
Assessment methods:
Final paper, Written exam
Faculty of Science and Engineering

Calculus

Full course description

The aim of this course is to enhance the student's mathematical skills in order to become a technically well-educated circular engineer. The student deepens their insight in how calculus tools

are used in modern society, science and business, while also training their technical problem solving skills.

Course objectives

The course-level objectives (CLOs) are:
A. I can compute limits, derivatives, and integrals.
B. I can analyse functions using limits, derivatives, and integrals.
C. I can recognize appropriate tools of calculus to solve unfamiliar problems.
D. I can apply the tools of calculus to solve problems.
E. I can prove basic theorems and properties of calculus.
F. I can communicate about concepts of calculus.

Recommended reading

The following literature is mandatory:

- Hass, J., Heil, C., Bogacki, P., Weir, M. D., & Thomas, G. B. (2020). University Calculus: Early Transcendentals (Fourth edition in SI units). Pearson Education Limited. (ISBN: 9781292317304.)*
- Lecture slides, see electronic learning platform.

*Numerical solutions to the odd-numbered exercises can be found in the book. In order to obtain worked-out solutions for exercises, the student should attend the (mandatory) tutorials and/or engage on the discussion forum. The coordinating team is not expected to provide any worked-out solutions to the exercises in any other format under any circumstance.

The following literature is recommended:

- Hass, J., Heil, C., Weir, M.D. (2019). Thomas' Calculus: Early Transcendentals (Fourteenth edition in SI units). Pearson Education Limited. (ISBN: 9781292253114.)
- Adams, R.A., Essex, C. (20). Calculus: A Complete Course (Tenth edition). Pearson. (ISBN: 9780135732588.)

CEN1002
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
5.0
Instruction language:
English
Coordinator:

- M. Boussé

Teaching methods:
Lecture(s), PBL
Assessment methods:
Assignment, Written exam
Keywords:

Fundamentals of Engineering

Full course description

This course introduces fundamentals of engineering. It provides an overview of various engineering fields with a specific focus on the open-ended and multidisciplinary nature of typical engineering problems and the underlying scientific principles.

The students familiarize with the engineering design cycle, which consists of formulating a problem, setting design requirements, generating several concepts, selecting the optimal solution, realizing it.

The course focusses on underlying scientific principles and laws related to basic engineering fields. Principles and laws in the field of current, force, energy and power that a broad range of engineers need in their basic knowledge portfolio, also including the future circular engineer. Exercises are included in the course to let students apply and calculate on these principles and laws as is expected of engineers.

The course prepares students for later courses in which they continue the development of their circular engineering skills. In this light, students need to perform this with an understanding of the environmental impact, but also the academic environment as well as ethics, safety and sustainability aspects.

Course objectives

At the end of this course, you are able to:

- Understand and explain basic engineering principles more specific:

Laws of Newton, Ohm, mass, momentum, energy and electric charge conservation, Coulomb, Fourier, Hooke, Fick, ideal gas; the principles of Archimedes, Bernoulli

Elementary modelling involving setting of preconditions, identification of most important scientific principle, sources of losses, deviations and errors

- Analyse principles of physics and engineering and perform basic calculations with characteristic examples in each engineering field
- Apply the design engineering cycle to solve a problem
- Reproduce knowledge on the generic engineering design cycle
- Develop teamwork participating as an active member of a team

Recommended reading

Only topics of lectures and tutorials need to be studied.

- Moaveni S. (2020). Engineering Fundamentals: An Introduction to Engineering, SI Edition. Cengage Learning, 6th edition, ISBN 978-0-357-11215-1. (The library has 2 copies in stock that can be consulted in the library only.)

Circular Engineering

- Khandani S (2005), Engineering design process.

CEN1003
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
5.0
Instruction language:
English
Coordinator:

- C. Koopman

Teaching methods:
Lecture(s), PBL, Working visit(s), Work in subgroups
Assessment methods:
Written exam, Assignment
Keywords:
Engineering Design Cycle; Instrumentation Design, Modelling and Engineering
Faculty of Science and Engineering

Linear Algebra

Full course description

Linear Algebra is one of the basic mathematics courses of the BSc Circular Engineering programme, just as is the case for most engineering and natural sciences programmes across the globe. It mostly builds on high school mathematics. It prepares for more advanced mathematics courses as well as for computational techniques and skills, which feature in applied modelling and engineering courses and in the projects.

This course is structured around three central themes: algebra, geometry, and dynamics.

Algebra – The first theme is concerned with the most frequently occurring mathematical problem in practical applications: How to solve a system of linear equations? For this problem, a complete algebraic solution procedure is developed which provides you with a way to deal with such problems systematically, regardless of the number of equations or the number of unknowns.

Geometry – The second theme addresses linear functions and mappings, which can be studied naturally from a geometric point of view. This involves geometric ‘objects’ such as points, lines and planes, and geometric ‘actions’ such as rotation, reflection, projection and translation. One of the main tools of linear algebra is offered by matrices and vectors, for which a basic theory of matrix-vector computation is developed. This allows one to bring these first two themes together in a common framework, in what turns out to be an exceptionally fruitful way. By introducing the notions of vector spaces, inner products and orthogonality, a deeper understanding of the scope of these techniques is developed. This opens up a large array of rather diverse application areas in engineering and the natural sciences.

Dynamics – The third theme surfaces when a dynamic perspective is taken, where the focus is on the effects of iteration, in this case the repeated application of a linear mapping. This gives rise to a

basic theory of eigenvalues and eigenvectors, which have many applications in various branches of science as will be discussed.

Many examples and exercises are provided to clarify the issues and to develop practical computational skills. They also serve to demonstrate practical applications where the results of this course can be successfully employed.

You will gain insight into algebraic and geometric concepts including vectors, matrices, linear transformations, eigenvalues and eigenvectors, inner products and orthogonality. You will learn to perform basic algorithmic calculations (matrices, equations, etc.) and solve more abstract algebraic problems. You will also gain insights into the applications of linear algebra in several engineering and scientific disciplines.

Course objectives

At the end of this course, you are able to:

- Solve linear systems of equations using various methods such as Gaussian elimination, LU factorization, the least-squares method, QR factorization, (pseudo)-inverse matrix, and Cramer's rule.
- Compute matrix factorizations such as the LU factorization, QR factorization, eigenvalue decomposition, and singular value decomposition.
- Solve and compute various linear algebra problems using Matlab.
- Communicate and reason about linear algebra problems algebraically and geometrically by interleaving various definitions, theorems, and properties about vectors and matrices, linear systems and factorizations, eigenvalues and eigenvectors, singular values and singular vectors, linear transformations, orthogonality, determinants, etc. In particular, you are able to provide (counter)-examples and proofs for your reasoning.
- Understand that many, seemingly disconnected, problems from various disciplines reduce to linear algebra problems, i.e., solving a linear system and/or computing a factorization.
- Perform calculations with complex numbers.

Recommended reading

Mandatory

- Lecture slides
- David C. Lay, Steven R. Lay, and Judi J. McDonald (2021). Linear Algebra and Its Applications (Sixth Edition). ISBN: 978-1-292-35121-6.

CEN1004
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
5.0
Coordinator:

Circular Engineering

- M. Boussé

Teaching methods:
Lecture(s), PBL, Work in subgroups, Assignment(s)
Assessment methods:
Written exam, Assignment
Keywords:
Algebra; Geometry; Dynamics
Faculty of Science and Engineering

Chemical Engineering

Full course description

Many daily used products contain materials produced in industrial chemical plants. ‘Chemical engineering’ studies the development, design, operation and improvement of these chemical plants, the chemical and physical processes and their safety, sustainability and economic feasibility.

This course will introduce students to the challenges of the modern chemical engineer, in which basic chemical and physical concepts, like material and energy balances, process design and typical unit operations, will be combined with discussions on sustainability/circularity and the business consequences.

The example of industrial fertiliser production, one of the most important chemical processes in modern societies, will be used to exercise with these topics complimentary to lectures and tutorials. By continually building on prior knowledge, you learn about designing chemical processes while developing a deeper understanding of chemical engineering fundamentals.

Course objectives

At the end of this course, you will be able to:
• Know basic process variables and apply them to solve practical problems
• Calculate energy (changes) for fluid streams, and physical and chemical processes.
• Determine the yield, conversion and selectivity of chemical reaction
• Describe some typical chemical industrial unit operations and do simple design calculations
• Complete energy and mass balances and make process flowsheets for steady state continuous and batch chemical processes
• Discuss about transition of the chemical industry towards a safe, sustainable, and circular industry

Prerequisites

None

Recommended reading

Mandatory:

Circular Engineering

■ Elementary principles of chemical processes 4th edition, R.M. Felder, R.W. Rousseau, L.G. Bullard, 2016

CEN1005
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
5.0
Coordinator:

- T.D. Butterworth

Teaching methods:
Lecture(s), PBL
Assessment methods:
Final paper, Written exam
Keywords:
Chemical Reactions; Chemical Process Design; Sustainability
Faculty of Science and Engineering

Biotechnology

Full course description

This course aims at introducing you to the fields of Biology and Biotechnology. Starting from the definition of life, you will understand its basic characteristics, such as metabolism, growth, reproduction, response to stimuli and communication. You will study the cell as the basic unit of life, will learn the major differences between eukaryotes and prokaryotes, and will understand the classification of organisms to appreciate the principles of the diversity of species and evolution. You will become familiar with population dynamics and understand how it is affected by environmental changes. In addition, a basic understanding of how the genetic information of an organism relates to its phenotype will be gained, laying the basis to comprehend the core concept of biotechnology: the technological application of biological systems. You will become familiar with the major fields of biotechnology and will learn how biotechnological applications have already affected our daily lives.

Course objectives

At the end of this course, you are able to:

- Describe the building blocks of life and their structure-function relationship
- Illustrate how life is organized into hierarchical levels
- Explain the basic concepts of growth, development and reproduction and compare these between unicellular and multicellular organisms
- Describe the mechanisms and strategies that plant organism use to communicate with each other and to respond to the environment
- Explain the most important basic concepts in the fields of ecology and evolution
- Give examples of tools and approaches used in biotechnology
- Explain the relationship between genotype, phenotype and environment

- Provide examples of how biotechnology can contribute to the circular economy
- Present about a scientific topic to an audience of scientific peers.

Recommended reading

Mandatory
Campbell, N. A., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Reece, J. B. (2018). Biology: A global approach (11th ed.). Pearson.

Recommended
Recommended literature and other sources would be at the end of each task. Feel free to approach the coordinator to suggest additional books/articles if you are interested in specific topics and/or desire to have more in depth information.

CEN1006
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
5.0
Coordinator:

- C.M. Padilla Díaz

Teaching methods:
Lecture(s), PBL
Assessment methods:
Assignment, Written exam
Keywords:
Ecology; Evolution; Biotechnological Applications
Faculty of Science and Engineering

Thermodynamics and Engineering Physics

Full course description

Understanding thermodynamics is essential for any engineer as it is key to understanding the functioning of a wide range of mechanical and electronic devices, as well as the principles behind chemical reactions. This course requires the knowledge of Calculus and Linear Algebra as it provides the theoretical frameworks required to mathematically describe the basic concepts of many-particle systems in terms of their macroscopic quantities such as temperature, pressure and volume. The aim of this course is to comprehend the fundamentals of temperature and heat, thermal properties of matter, the laws of thermodynamics, entropy, enthalpy and free energy. These concepts are used to describe the properties gasses, liquids and ideal and non-ideal solids in terms of state functions. Lastly, these fundamental concepts are applied to understand the working mechanisms of basic reactor elements used in chemical engineering, including heaters, coolers, pumps and heat engines. Understanding of the abstract nature of these concepts is essential for further courses.

CEN1007

Circular Engineering

Period 5
10 Apr 2023
9 Jun 2023
Print course description
ECTS credits:
5.0
Coordinator:

- G.J. van Rooij

Teaching methods:
Lecture(s), PBL, Assignment(s)
Keywords:
Thermodynamic Principles; Circular Chemical Processes
Faculty of Science and Engineering

Multivariable Calculus

Full course description

Multivariable Calculus is an intermediate level mathematics course that builds on the prerequisite courses Calculus and Linear Algebra. It is an essential course within the programme as it allows you to understand fundamental engineering concepts, such as electromagnetism and mass transfer, of which several are discussed in the parallel course Thermodynamics and Engineering Physics. You get familiar with differentiation and integration of functions involving multiple variables. Considerable attention is devoted to vector calculus, differential equations, constrained optimization and numerical approximation techniques. Differentiation and integration of vector fields is primarily focused in 3-dimensional Euclidean space.

CEN1008
Period 5
10 Apr 2023
9 Jun 2023
Print course description
ECTS credits:
5.0
Coordinator:

- P. Diomede

Teaching methods:
Lecture(s), PBL
Keywords:
Integration Techniques; Dynamical Systems; Mathematical Argumentation
Elective courses

Year 2 Electives

Faculty of Science and Engineering

Organic Chemistry

Full course description

The course builds on the knowledge obtained during the course Chemical Engineering and Chemistry and Biology Laboratory Skills and is recommended for courses within the Circular Chemical Engineering concentration. This course focuses on the basic concepts in the field of organic chemistry (i.e. structure & bonding and nomenclature). Furthermore, a logical review is provided of the reactivity of the most important functional groups, as applied in a selection of fundamental organic reactions. The second part of the course focusses on the understanding of material properties based on their chemical structure which is essential for the design of (recyclable) materials in a circular economy. Therefore, this course provides the theoretical basis on why and how atoms come together to form bonds, certain molecular structures and the properties of such (macroscopic) materials. Different types of materials are discussed in terms of their molecular and microstructure and the resulting macroscopic material properties. Finally, the course elaborates on the concepts of green chemistry and how, combined with reactor design (i.e. batch or flow-chemistry), the (organic) chemistry can be optimised to reduce use of toxic solvents and chemicals while maximising reaction efficiency.

CEN2001
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
5.0
Coordinator:

- H. Diliën

Faculty of Science and Engineering

Differential Equations

Full course description

The course builds upon the first year Calculus, Linear Algebra and Multivariable Calculus courses and offers mathematical tools that are applied and occasionally elaborated upon in courses such as Solid State Physics, Quantum Physics and Plasma Physics. You are introduced to difference and differential equations, providing you with the tools to model processes of change. Particularly, first order difference and differential equations are described for typical natural processes as well as the determination of solutions, set for higher order linear recurrences having constant coefficients.

CEN2002
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
5.0

Biochemistry

Full course description

This course introduces you to the basic concepts of biochemistry, a discipline that links biology and chemistry by studying chemical reactions and their organisation in living cells and organisms. The course explores the structure, function and interactions of biomacromolecules (such as proteins, carbohydrates, lipids and nucleic acids), and provides insights into the mechanisms of action of enzymes, enzyme kinetics and inhibition. During the course, you learn to describe the 6 different classes of enzymes (oxidoreductases, transferases, hydrolases, lyases, isomerases and ligases) and to indicate examples of the biological functions of these enzymes inside a living organism. Moreover, you understand the concepts of primary and secondary metabolism, the main metabolic pathways resulting in the generation of ATP, and you are able to reflect on the physiological importance of secondary metabolites for the producing organisms and their potential and utility in the bio-based economy.

CEN2003
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
5.0
Faculty of Science and Engineering

Imaging Engineering

Full course description

This course provides you with overview of specialized imaging techniques, such as computed tomography (CT), magnetic resonance imaging (MRI), radiography, nuclear imaging (SPECT, PET), ultrasound, (mass) spectrometry, optical computed tomography, electron microscopy, fluoroscopy and contrast enhanced imaging. Attention is paid to the underlying physical and chemical principles of the imaging techniques, including imaging optics, as well as the methods of data collection for image reconstruction. You learn to perform basic calculations with the fundamental equations of the various techniques. Furthermore, you are able to recognise typical artefacts, noise, distortions of the images and relate them to the underlying principles as well as indicate measures or propose alternative techniques to overcome these.

CEN2005
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
5.0
Coordinator:

Circular Engineering

- S.P.M. van Nuffel

Faculty of Science and Engineering

Remake, Reuse, Repair, Recycle

Full course description

You are introduced to the circular economy for materials and the four main pathways that can be followed to make products more circular: Remake, Reuse, Repair and Recycle. We start by baselining with the current end-of-life and (potential) recycling schemes and will move on to how these can be improved or how products could be moved to more circular schemes. You are instructed in technical aspects like material selection for product (re)design and performance, but are also taught to think beyond the typical engineering boundaries and look towards value chains, business models and consumer experience.

Topics covered in this course are:

- The Circular Economy (refreshing from year 1) and the different Rs
- Current-day disposal and recycling of different material types and waste streams: schemes, value chains and technologies
- Remake – how do I redesign a product to be more circular?
- Reuse - how do I design products and services for effective reuse?
- Repair – how do I switch from product to service?
- Recycle – how do I make a product better fit for high quality recycling?
- Environmental balance of the 4 Rs
- Impact of legislation and other non-technical factors
- Industrial case studies

In the tutorials we get to work with actual case studies from Dutch companies, introduced and guided by guest lecturers from the industry. All types of products and materials will be handled in the course, but for the tutorial case

Course objectives

At the end of this course, we expect you to be able to:

- Understand and explain to others the basics of the circular economy for technical materials
- Analyze a product’s current fit to the circular economy and select one of the 4 R pathways to improve this, taking most recent developments into account.
- Justify your choice with up-to-date technical and scientific arguments.
- Connect non-engineering aspects (such as economic/ environmental cost, societal impacts) to an engineering challenge and as such grasp the extent

Recommended reading

For context, it is recommended to explore the Ellen MacArthur Foundation Learning Hub (https://archive.ellenmacarthurfoundation.org/explore). Topics of particular interest include:
o What is the Circular Economy

Circular Engineering

o The Circular Economy in detail
o Fashion and the Circular Economy
o Plastics and the Circular Economy
o Circular Design
o Systems and the Circular Economy

Literature related to the lectures and industrial cases will be distributed during the relevant sessions.

CEN2006
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
5.0
Coordinator:

- K.J.P. Ragaert

Teaching methods:
Lecture(s), PBL
Assessment methods:
Final paper, Written exam
Faculty of Science and Engineering

Energy Systems

Full course description

The course begins with a review of the concept of system thinking as introduced in the Y1 course Engineering in a Circular Economy with a translation towards the energy system followed by delving deep into the complexity of the energy system and potential future challenges.
During the course, you are introduced to the concept of energy systems and energy sources, including those based on fossil fuels, nuclear-, wind-, geo-, tidal- and solar power. Furthermore, you are introduced to the concept of exergy and accordingly, evaluate the different methods to provide energy. A quantitative analysis of the efficiency, sustainability and viability of renewable energy options is obtained by performing basic calculations on the various energy systems. The course concludes with an introduction to energy policies and both the technical and societal limits of the covered energy systems, including safety considerations and issues of social acceptance.
At the end of the course, you will be able to evaluate effects of energy sources and systems on the environment, the economy and society.

Course objectives

At the end of this course, we expect you to be able to:

- Describe and discuss the production, storage and use of energy in the contemporary global economy
- Quantitatively compare energy sources and appraise their utility and impacts within the

energy system and on the surroundings/environment
- Assess the appropriateness of integrated energy sources and produce evidenced proposals for energy systems using current academic insights to solve energy circularity challenges

Recommended reading

- T. Bradford (2019), The Energy System; Technology, Economics, Markets, and Policy, The MIT Press (hardcopy available with tutor and library)
- D. Mc Kay (2008), Sustainable Energy- without the hot air, www.withouthotair.com

CEN2008
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
5.0
Coordinator:

- C. Koopman

Teaching methods:
PBL, Lecture(s)
Assessment methods:
Assignment, Final paper, Written exam
Faculty of Science and Engineering

Sustainable Food Production

Full course description

This course builds upon the Life Cycle Assessment project and the course Engineering in a Circular Economy. The aim of this course is to give you insights into the current challenges of sustainability in food production ecosystems. You gain a deeper understanding of the role of food in health and the economy, on the pressures on maintaining an adequate food supply and the factors that can affect future food availability. You apply some of the tools and methods used in sustainability assessment (Life Cycle Assessment, Cradle-to Cradle), and use them to analyse several existing more complex case studies where these tools were applied. Issues of scale (case studies at global, regional and local level), stakeholders (who to involve) and future- proofing (scenario studies) are addressed. The role and impact of biotechnology on sustainable food production is evaluated and consumer acceptance of GMOs and key innovations such as the CRISPR genome editing tools in food production is also discussed.
CEN2009
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
5.0
Coordinator:

Circular Engineering

- K.J.P. Verhees

Faculty of Science and Engineering

Polymeric Materials

Full course description

You are introduced to polymer chemistry and polymer physics. The physicochemical characteristics of polymers, dependent on their molecular structure, govern the polymers' macroscopic behaviour
and, therefore, their applications, processing, and recycling. First, the basic concepts in polymer science are explained, including polymer structures and classifications. Then, polymer synthesis
and the resultant molar mass are studied. Afterwards, the thermo-mechanical behaviour of polymeric materials is considered, as well as polymer viscoelasticity. Subsequently, the translation
from intrinsic materials characteristics to macroscopic properties. Finally, concepts of polymer processing, (bio)degradation, and recycling are studied.

Course objectives

At the end of this course, we expect you to be able to:

- Identify the main characteristics of polymers.
- Explain how polymers are synthesized and differentiate their molecular structures.
- Recognize the main physical properties of polymers
- Describe the viscoelastic phenomenon and the flow behaviour of polymers.
- Correlate polymer structures with their properties and applications.
- Distinguish the main processing and recycling methodologies.

Recommended reading

Mandatory

- Rudin, Alfred. Elements of Polymer Science & Engineering: An Introductory Text and Reference for Engineers and Chemists. Elsevier, 1999.
- Nicholson, John W. The Chemistry of Polymers. Royal Society of Chemistry, 2006.
- Davis, Fred J., ed. Polymer chemistry: a practical approach. Oxford University Press on Demand 2004.
- Subramanian, Muralisrinivasan. Basics of polymers: fabrication and processing technology. Momentum Press, 2015.
- Van Krevelen, Dirk Willem, and Klaas Te Nijenhuis. Properties of polymers: their correlation with chemical structure; their numerical estimation and prediction from additive group contributions.Elsevier, 2009.

Recommended:

- Han, Chang Dae. Rheology and processing of polymeric materials: Volume 1: Polymer Rheology. Oxford University Press on Demand, 2007.

Circular Engineering

- Schramm, Gebhard. A practical approach to rheology and rheometry. Karlsruhe: Haake, 1994.
- Odian, George. Principles of polymerization. John Wiley & Sons, 2004.
- Hiemenz, Paul C., and Timothy P. Lodge. Polymer chemistry. CRC press, 2007.

CEN2013
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
5.0
Coordinator:

- R. Fiorio

Teaching methods:
PBL, Lecture(s)
Assessment methods:
Assessment
Faculty of Science and Engineering

Fluid Mechanics

Full course description

Students are introduced to the study of fluids in rest and motion. The course starts with an introduction to fluids, their different properties, and their behaviours. This is followed by a deep discussion of fundamental principles of fluid flow within conservation laws, focusing on the equations of motion. Attention is also paid to the mechanics of non-Newtonian fluids, such as polymer solutions and melts, emphasizing sustainable polymer processing and recycling. Throughout the course, practical examples illustrate the significance of fluid mechanics in process design and aid students in translating theory into practice.

The main topics covered in this course are:

- Introduction to the Fluid Mechanics
- Fluids and their properties
- Mechanics of fluids: stress and flow
- Conservation laws: mass, energy, and momentum balance
- Constitutive equations
- Applications of momentum balance in designing processes
- Introduction to complex fluids: solutions, gels, and polymers
- Viscoelastic materials
- Introduction to rheology
- Polymer processing: extrusion and injection molding
- Mechanical recycling

Course objectives

At the end of this course, we expect students to be able to:

Circular Engineering

- Understand fluid properties and behavior
- Analyze processes that involve fluid flow
- Improve fluid transport efficiency
- Implement Fluid Mechanics principles in Circular Engineering

Recommended reading

Transport Phenomena, 2nd Edition; R. B. Bird, W. E. Stewart, E. N. Lightfoot; Wiley 2002.

CEN2007
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
5.0
Coordinator:

- A. Gooneie

Teaching methods:
PBL, Lecture(s)
Assessment methods:
Assignment, Written exam
Faculty of Science and Engineering

Sustainable Agronomy

Full course description

The course teaches you how various biotechnological concepts introduced in Biotechnology and Plants and Microbes courses can help to reduce the pressure of agriculture on natural resources and the environment. This course is specifically interesting for students preparing for the Sustainable Biotechnology concentration in year 3. This course explores concepts of sustainability in the context of agriculture and horticulture production systems: how can we meet the ever-increasing need of society for food, feed, textiles and biobased materials despite the challenges posed by global climate change and urbanization, and while reducing the pressure on natural resources and the environment? You learn what the main factors are affecting agronomy sustainability in general. In particular, the course focusses on those aspects that can be influenced or addressed using biotechnology. By building on the knowledge acquired in previous courses, you reflect on how biotechnology can aid in reducing the pressure of agriculture on natural resources and the environment. You deepen your understanding of plant–microbe interactions and how these can be exploited and promoted for sustainable agriculture. You learn the importance of biodiversity, its conservation and the utilization of wild gene pools. You understand how classical and new breeding technologies can be applied to e.g. increase the yield per hectare to reduce the use of land; make plants resistant to pathogens or produce bio-pesticides to reduce environmental pollution and increase food quality; develop drought-tolerant crops to reduce the use of water.

CEN2015
Period 5
10 Apr 2023

Circular Engineering

9 Jun 2023
Print course description
ECTS credits:
5.0
Coordinator:

- C.M. Padilla Díaz

Faculty of Science and Engineering

Data Science and Analysis

Full course description

The course builds on the knowledge obtained during the course Basic Programming Skills and is valuable to students choosing any of the three concentrations in year 3. Within the modern world and in science, abundant streams of data are generated. This course focuses on methods to pre-process, analyse and interpret relevant information. Items that are introduced are datamining, pre-processing, databases, explore data, datatypes, labelling, machine learning and data visualizations. You apply these techniques in computer assignments that are executed with MATLAB. Furthermore, data management is an essential aspect to conduct responsible research. You learn to understand the general rules of appropriate data management and define roles and responsibilities regarding data management. You study scientific literature on this topic with a focus on an engineering and natural sciences point of view. Subsequently, you are required to develop and implement a communication plan dealing with data management issues.

CEN2016
Period 5
10 Apr 2023
9 Jun 2023
Print course description
ECTS credits:
5.0
Coordinator:

- M.C. Popa

Faculty of Science and Engineering

Circular Business Development

Full course description

This course builds upon the course Engineering in a Circular Economy and Life Cycle Assessment Project has a link to the second-year courses Remake, Reuse, Repair, Recycle, Reversed Engineering and Refurbishing Skills and Management Skills. You are encouraged to apply the concepts of the circular economy as previously introduced. You work in teams to solve 4 cases each being representative for one of the four Rs. You approach each case by searching and studying relevant background information and example solutions applied in similar products. You need to quickly familiarize yourself with the case and study business aspects that are new to them such as business models, investment, financing, product pricing, servicing and marketing. To this end, you are guided

to relevant databases, books and journal papers. To solve the cases, you select and apply one of the circular economy business models which should encompass all economic aspects such as resources, logistics, savings on energy and waste streams, financing and product pricing. Where possible the full footprint is worked out. You should support your solution by a solid line of reasoning, basic calculations, experimental or computational evidence.

CEN2018
Period 5
10 Apr 2023
9 Jun 2023
Print course description
ECTS credits:
5.0
Coordinator:

- N.M.P. Bocken

Faculty of Science and Engineering

Heat and Mass Transfer

Full course description

This course introduces you to fundamental concepts of heat and mass transfer needed to enter the concentration in Circular Chemical Engineering. It builds on the core course Thermodynamics and Engineering Physics. You learn to argue why mass and heat transport play a crucial role in the field of process technology and especially in the context of circularity for certain types of reactors and purification systems. You learn how to calculate heat and mass flows using mathematical descriptions and how to optimise these flows for minimal losses as essential in a circular economy. For example, you are able to calculate the amount of power needed to keep a tank reactor at fixed temperature (based on the heat capacity of water), how much water is required to maintain the reactor temperature and the heat lost to the environment.

Prerequisites

PREREQUISITE for the Concentration Circular Chemical Engineering in Year 3.

CEN2019
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
5.0
Coordinator:

- G.J. van Rooij

Faculty of Science and Engineering

Genetics and Cell Biology

Full course description

In this course, you gain fundamental knowledge on prokaryotic and eukaryotic cell function and the principles of genetics needed to enter the concentration Sustainable Biotechnology. This course builds on the core course Biotechnology and relates to the second-year courses Plants and Microbes and Genetics Skills. You look into more detail into the structure and function of the different cellular components and organelles, and understand how the flow of information from nucleic acids to protein is achieved and regulated. You gain knowledge on the organisation of the genetic material, and the transmission of hereditary characteristics. You deepen your understanding of the function of genes as determinants of the intrinsic properties of a species (genotype- phenotype relationship) and appreciate the importance of model organisms and mutants. The processes of cell growth and differentiation are described, along with the concepts of pluripotency and totipotency.

Prerequisites

PREREQUISITE for the Concentration Sustainable Biotechnology in Year 3

CEN2020
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
5.0
Coordinator:

- K.J.P. Verhees

Faculty of Science and Engineering

Electronics Engineering

Full course description

In this course, you learn the fundamentals of electronics needed to enter the concentration in Engineering Physics for Sustainable Manufacturing and extend the knowledge you obtained in Physics and Electronics Laboratory Skills. You explore the role of different components and devices, learn the laws governing their behaviours and develop an understanding of basic circuitry, further explored in the concentration course Advanced Electronics and Sensor Technology. You perform calculations using Ohm’s and Kirchhoff’s laws, resistances, voltages, DC and AC currents, capacitors, inductors, diodes, junctions and transistors. You also apply the basics of digital electronics (logic gates and Boolean algebra). You look at how combinations of discrete devices can be used to build up more complex circuitry and have the opportunity to see how electronics can be used to build up the technology, which we are most familiar with today, from flat-screen TVs and smartphones. Nearly everything we use in this day and age relies on electronics. Throughout this course, you learn to appreciate how the technology around functions. You execute reversed engineering strategies to understand the inner workings of typical electronic devices.

Circular Engineering

Prerequisites

PREREQUISITE for the Concentration Engineering Physics in Year 3.

CEN2021
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
5.0
Coordinator:

- B.R.N. van Grinsven

Faculty of Science and Engineering

Biobased Materials

Full course description

This course exploits the development of biobased materials involving chemistry of biobased building blocks, the technical processes, principles of circularity and environmental and societal implications. This course builds upon the first-year courses Engineering in a Circular Economy, and has a link to the second-year courses Organic Chemistry, Remake, Reuse, Repair, Recycle, Reversed and Refurbishing Engineering Skills and Polymer Processing Skills. The aim is to create a critical, but also technologically creative and inventive circular attitude towards biobased materials. This is fed by the increasing critical attitude of society towards plastics as they contribute to oil depletion, global warming and pollution of the oceans. You are introduced to renewable bio-based equivalent or alternative monomers and polymers to close carbon cycles timely via various circular concepts and learn how to use biobased resources. You should be able to recognise the challenges and possibilities with respect to polymeric materials in the transition towards a biobased circular economy and society. Typically, the technological solutions are often multidisciplinary in nature, demanding engineering at the interface of chemical engineering, biotechnology and materials engineering. Added to this, societal, economic, and ethical aspects need to be taken into account along the new value chain specific to biobased materials.

CEN2022
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
5.0
Coordinator:

- Y. van der Meer

Faculty of Science and Engineering

Quantum Physics

Full course description

You use the knowledge obtained in the course Differential Equations to understand the fundamental principles, equations and theories behind quantum mechanics. The course is organised around the following topics: basic logic in classical and quantum mechanics, the time evolution of quantum systems; quantum entanglement and the nature of reality, quantum computing, relativistic quantum mechanics, the Klein-Gordon and the Dirac equation and Feynman path integrals and the Schwinger–Dyson equations.

CEN2024
Period 5
10 Apr 2023
9 Jun 2023
Print course description
ECTS credits:
5.0
Third year courses

Year 3 Circular Chemical Engineering

Faculty of Science and Engineering

Chemical Eng. Thermodynamics & Kinetics

Full course description

This course builds upon the first-year course Thermodynamics and Engineering Physics and uses the knowledge of the mathematical courses. In circular and sustainable process engineering, the word symbiosis encompasses the output of one process being the input of another process that traditionally are non-related. Traditionally, chemists and chemical engineers work with pure or refined resources, but inclusion of the circular concepts and symbioses impact process design. In this course, you link concepts in process design, including (i) flow sheet design and topology (using ASPEN software), and (ii) economic and environmental simulation and optimization of reactor, separation and energy conversion unit sequences following extended hierarchical Douglas methodologies to fundamentals of thermodynamics and kinetics. Gibbs free energy and chemical potential are introduced in the context of phase equilibrium, chemical reaction equilibria and rates in ideal and heterogeneous systems. Additionally, concepts in power generation and refrigeration cycles are introduced and analysed.

CEN3001
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
5.0
Teaching methods:

Circular Engineering

Lecture(s), PBL
Faculty of Science and Engineering

Reactor Engineering

Full course description

This course builds on the first-year courses Chemical Engineering, Basic Programming Skills and the mathematical courses. You are introduced in the creation and analysis of mole balances for the three elementary reactor models being the perfectly-mixed Batch reactor, the Continuous Stirred Tank Reactor (CSTR) and Plug-Flow Reactor (PFR). Besides a profound understanding of rate laws, stoichiometry, reaction rates and order, conversion and selectivity and function of temperature and pressure are pivotal. Numerical analysis to the design and performance of the reactors and their comparison is adopted for simple and more complex reaction chemistries such as gas reactions, recycle reactors, serial CSTR and autocatalytic reactions.

CEN3002
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Industrial Process Design Skills

Full course description

In this skills course, teams of students operate at the pilot plants of the Brightlands Chemelot Campus and use knowledge from courses such as Chemical Engineering, Engineering in a Circular Economy, Thermodynamics and Engineering Physics, Basic Programming Skills as well as the second-year elective courses. You no longer merely optimise these plants from an economic perspective, but also consider environmental and social criteria for optimization. You propose a strategy for developing a pilot process for the fabrication of biofuel from algae, which must result in technologically viable solutions and also demands the combination of process analysis and simulations, mole and energy balances and product life cycle analysis.

SKI3101
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
2.5
Teaching methods:
Lecture(s), Training(s), Work in subgroups, Skills

Circular Engineering

Faculty of Science and Engineering

Chemical Separations

Full course description

The course integrates insights from with the mathematical courses, Chemical Engineering, Basic Programming Skills and Heat and Mass Transfer and introduces you to various separation techniques used in the field of chemical engineering. You learn when and how to use these techniques by studying key concepts and by performing design calculations. One example is the evaporative separation in distillation towers. These towers are designed to separate liquid mixtures based on a difference of volatility and with the McCabe-Thiele method you can calculate the size of the column to separate the liquids. Similar approaches studied are absorption techniques, liquid-liquid extractions, crystallization or precipitation and filtration. Lastly, you are required to analyse strengths and weaknesses of the separation techniques and convert this knowledge to criteria such as economics, feasibility, product stability, reliability and sustainability and circularity and use these for the selection of separation methods in sustainable chemical processes.

CEN3003
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Chemical Plant Design

Full course description

This course builds on the previous courses of the Circular Chemical Engineering concentration as you learn how to integrate aspects of energy efficiency, sustainability and circularity in designing a process and plant design of the future. The course provides an overview of project steps required to obtain a chemical plant design and is structured accordingly. First, you learn how to translate a process objective to a process flowsheet including the selection, specification and chemical engineering design of equipment. From various design options, you then select an optimal process design by considering investment and operating costs, safety, environment, energy efficiency, flexibility, circularity etc. Lastly, you learn how to translate the chosen process design into a plant design, in which aspects of sustainability and circularity should also be taken into account.

CEN3004
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:

Circular Engineering

5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Unit Operations Skills

Full course description

In this skills course, you are introduced to the various unit operations used in the field of chemical engineering. Through examples from textbooks and the infrastructure existing on the Brightlands Chemelot Campus, you evaluate the four basic unit operations including fluid mechanics, heat and mass transfer, equilibrium stages and operations involving particulate solids. Starting from process flow diagrams in combination with visits of real life production plants, you discuss various components including cooling towers, refrigerators/heat pumps, distillation towers (boiling/condensation), mixing and emulsification processes and their typical equipment design and operation.

SKI3102
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
2.5
Teaching methods:
Lecture(s), Training(s), Work in subgroups, Skills
Faculty of Science and Engineering

Circular Process Design and Control

Full course description

This course follows up on the core course in Chemical Engineering as well as the previous concentration courses in Reactor Engineering, Chemical Separations and Unit Operation Skills. Combining all knowledge, insights and experiences, you are required to address sustainability issues of existing reactor design and the accompanying industrial challenges in upgrading/updating existing production plants. To this end, you are provided with relevant background information on state-of- the-art reactor design and process intensification technology, based upon which you could select an approach for your assignment. Subsequently, teams of students perform a technical and economic evaluation for a real-life application, such as the production of biofuel from algae on the Brightlands Chemelot Campus and blend in sustainability and/or circularity requirements. You set up design criteria, use ASPEN software for the calculation of the relevant separation techniques and the corresponding energy and mass balances and diverge to find optimal settings of the process by calculating different scenarios. You evaluate your work and discuss weaknesses and strengths of your approach.

CEN3005
Period 4

Circular Engineering

6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Ethical and Philosophical Reflections

Full course description

In preparation of the bachelor thesis and your future studies or career, this course provides you with the main theoretical approaches within ethics, philosophy of science, as well as the relevant rules and regulations in the field of circular engineering. You develop the skills required to apply and reflect on these topics. Typical questions that are addressed are: what is the role of observation in science? What is a scientific explanation? What roles do theories and experiments play in science? Are there boundaries to genetic modifications? How can we approach multinationals that break environmental laws? What would you do if you would find out that your company is performing illegal dumping of waste or provides misleading information of the circularity or footprint of their products? You study typical ethical dilemmas, search representative examples that are related to the posed questions and discuss your findings with your peers.

CEN3006
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Gene Technology

Full course description

In this course, you integrate the knowledge acquired in the courses Biotechnology, Genetics Skills and Genetics and Cell Biology, and learn how genetic modification of living organisms can be achieved in practice. This course introduces you to the most advanced approaches to alter the genetic makeup of an organism, including gene insertion, activation, repression and modification. You learn the principles of modern recombinant DNA technologies to generate expression vectors and the most efficient techniques to transform plants and microbes. You are be able to illustrate the two main cellular DNA repair pathways – homologous recombination and non-homologous end joining – which form the basis for understanding the application and potential of genome editing technologies such as the CRISPR/Cas 9 system. You are also able to define genetically modified organisms. You apply your knowledge to a case for which you need to review existing gene

technologies and select the one most suited for the case. This has to be argued based on a solid line of reasoning using the set criteria.

CEN3010
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Biological Separations

Full course description

This course builds on knowledge introduced in the course Plants and Microbes, further explored in Plant Biology Skills, and aims at giving an overview of the different techniques available for the separation, recovery and purification of specific biosynthetic products from natural or recombinant sources, such as plant biomass or microbial cultures. The typical five stages in downstream processing are studied: 1. Solid- liquid separation (flotation, flocculation, filtration, centrifugation, distillation); 2. Release of intracellular products (cell disruption by physical, chemical, enzymatic methods or combinations thereof); 3. Concentration (dialysis, evaporation, liquid-liquid extraction, filtration, precipitation, adsorption); 4. Purification (chromatography), and; 5. Formulation (crystallization, drying, use of stabilising agents and additives, sterilization). In addition, the principles of biomass upgrading and biorefinery technologies are also studied. Particular attention is given to the concepts of recovery, recycling and upgrading of waste materials, in which new trends as well as commercially viable examples are discussed.

CEN3011
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Biotechnology Skills

Full course description

In this skills course, you deepen and apply the theoretical knowledge learned in the previous years and in the Gene Technology and Biological Separations courses by performing a set of interconnected experiments involving different techniques. Experiments include: cloning of an insert

into an expression plasmid, bacterial transformation, selection of positive clones by check PCR and restriction digestion of the plasmid; extraction and isolation of a recombinant protein from a bacterial culture using affinity chromatography, SDS-PAGE and Western blot analysis of the purified protein; Design of guide RNA for CRISPR/Cas9-mediated genome editing and detection of indels using different techniques such as T7E1 assay and RFLP. Furthermore, you are introduced to the concepts of Standard Operating Procedure (SOP) and Good Laboratory Practice (GLP), and their importance in ensuring the quality and reproducibility of the results both in academic and industrial settings.

SKI3103
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
2.5
Teaching methods:
Lecture(s), Training(s), Work in subgroups, Skills
Faculty of Science and Engineering

Plant Biotechnology

Full course description

The course builds on the biotechnological knowledge obtained in year 1, some principles introduced in elective courses such as Plants and Microbes and Genetics and Cell Biology and the technological background acquired in Gene Technology. This course starts with a thorough introduction into plant disease resistance. You learn to understand the difference between pre-formed disease resistance and pathogen-induced responses; you are able to describe the difference between diseases resistance, tolerance and susceptibility and their genetic basis (R genes and R proteins); you learn what type of defence-activating compounds are produced by the plant. You are introduced to plant biotechnology on genetically-modified organisms (GMO). In this way, you get familiar with trans-genesis approaches such as the expression of genes from microbes to induce plant resistance to insects or the expression of resistance genes from other plant species to obtain microbial resistance in the host plant. In addition, other techniques such as cis-genesis (expression of genes of the same species modify endogenous processes) and targeted mutagenesis are introduced.

CEN3012
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Bioreactors

Full course description

This course links to various concepts introduced in the course Plants and Microbes and provides you with a general understanding of the use of bioreactors within the field of biotechnology. You acquire a deep knowledge of cell culture growth parameters and kinetics and gain an overview of the available technologies for their cultivation. You learn the principles of fermentation, the influence of nutrient availability, temperature, pH and O2 concentration on cell growth and how an equal distribution of these can be achieved within a bioreactor. You learn the principles of the three operation modes of bioreactors, and understand the differences in design and function between the most widely used bioreactor types for submerged fermentation. Distinctions between bioreactors for microbial vs. plant cell cultures are be highlighted and photobioreactors used to culture algae are also be described. The difference between bioreactors to produce metabolites, chemicals, proteins or biomass on the one hand and bioreactors that are designed to remove pollutants (e.g. denitrification) is also discussed. You are requested to study two methods commonly used to increase cell biomass inside a reactor and compare them based upon a number of set criteria: the use of membranes and the immobilization of cells. The approach of integrating different microorganisms in a single process configuration and considerations on the properties of the microorganisms required to implement this in a bioreactor is covered. Scaling up aspects from a shake flask to a bench-top to a large-scale fermenters is be studied. Finally, the use of disposable bioreactors and the socio- economic importance of bioreactors in our rapidly developing economy is discussed.

CEN3013
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Microbiology and Fermentations Skills

Full course description

In this skills course, you expand and apply the theoretical knowledge on the growth of microbes and cell cultures obtained in the previous years and in the Bioreactors course. You are introduced to the 12 principles of green chemistry and experiment with fermentation as an ideal technique to perform environmentally sustainable chemistry. In order to do so, you learn how to identify, characterise and maintain a microbial culture for fermentation purposes; you gain practice with media preparation, differential staining and microscopy. You perform serial dilutions and learn how to calculate the colony forming units/ml of samples from the plate counts. You apply the Monod equation to calculate the maximum growth rate for a specific microorganism and the minimum amount of substrate needed to achieve it. You also practice extraction of natural products from the bacterial culture, and the purification and characterization of metabolites. As a separate topic, you also experiment how

bacteria produce biofilms and how different surfaces can influence biofilm formation.

SKI3104
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
2.5
Teaching methods:
Lecture(s), Training(s), Work in subgroups, Skills
Faculty of Science and Engineering

Biotechnology for Sustainable Processe

Full course description

This course aims at completing and integrating the insights acquired during the programme and especially of the previous courses in the concentration Sustainable Biotechnology. In this course, you analyse known industrial examples of sustainable manufacturing practices as case studies. For example, you identify the potential impact of protein or metabolic engineering on the overall improvement of a production process, you understand the importance of using dedicated software for flow sheeting and process simulation to solve mass and energy balances of bioprocesses, and you see how waste and bleed streams can be effectively recycled. As a major part of this course, you have to propose a biotechnology-based approach to increase the sustainability of a process of your choice.
CEN3014
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Ethical and Philosophical Reflections

Full course description

In preparation of the bachelor thesis and your future studies or career, this course provides you with the main theoretical approaches within ethics, philosophy of science, as well as the relevant rules and regulations in the field of circular engineering. You develop the skills required to apply and reflect on these topics. Typical questions that are addressed are: what is the role of observation in science? What is a scientific explanation? What roles do theories and experiments play in science? Are there boundaries to genetic modifications? How can we approach multinationals that break environmental laws? What would you do if you would find out that your company is performing illegal dumping of waste or provides misleading information of the circularity or footprint of their

products? You study typical ethical dilemmas, search representative examples that are related to the posed questions and discuss your findings with your peers.

CEN3006
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Mechanical Physics

Full course description

This course elaborates on statics and strength of materials as introduced in the course Fundamentals of Engineering. Statics is the analysis of physical loads that are exerted on a product, system or component when these systems are in equilibrium. With this precondition, Newton's law to calculate (unknown) reaction forces can be applied and you learn to perform such calculations on 2-dimensional engineering problems. Once all loads on a system are known, analysis of the stresses or deformations of the system can be performed, needed in order to assess weak points that could lead to material failure. You learn how such an analysis helps in the dimensioning and selection of materials when designing new systems. Overall, you learn to calculate stress distribution, maximum stress and its location, as well as deformation and point of failure of elementary components. In addition to loads, other physical phenomena such as temperature, corrosion, time (aging) can influence the stresses and deformations in materials are studied as well.

CEN3020
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Sensors, Instrumentation and Measurement

Full course description

Sensors systems are part of many aspects in daily life. They are present in almost every home, office or industrial plant and play an essential role in optimizing and automizing industrial processes to increase efficiency, decrease pollution and create a more sustainable and circular economy. In this course, the elements of measurement systems are further explored: transducers, amplifiers, filters

and analog-to- digital converters. The different sources of error (noise, interference, offset, non-linearity, aliasing) that limit the performance of such systems are discussed. Methods of analytically determining the corresponding detection limits are presented, and in particular how errors can be referred to the input of a system and represented by equivalent voltage/current sources. Several techniques for mitigating measurement errors are studied in detail, such as the use of feedback, filtering, synchronous modulation, chopping, auto-zeroing, dynamic element matching etc. In order to fully exploit an instrument's potential, you need to be aware of its limitations, correctly interpret the measurement results and be able to arrive at well-balanced decisions relating to the purchasing, repairing, expansion or replacement of electronic equipment. You learn how to identify the correct instrumentation to address specific circularity and sustainability issues in problem-based learning sessions, analysing for example, how waste-stream monitoring and feedback loops can reduce the waste production in an industrial process line.

CEN3021
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Mechanical Design Skills

Full course description

This course provides you with basic skills to perform computer aided design (CAD). You use theoretical knowledge introduced in Mechanical Physics to complete 3D designs in CAD. First, you are familiarized with the 3D CAD software package. You follow a computer tutorial with exercises to build 3D designs of simple products, assign dimensions, tolerances and materials. Subsequently, your skills are deepened by preparing for and making a design with 3D-printing and by performing a structural and thermal analysis of a component using the theoretic knowledge of the course Mechanical Physics.

SKI3105
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
2.5
Teaching methods:
Lecture(s), Training(s), Work in subgroups, Skills
Faculty of Science and Engineering

Materials and Production Engineering

Full course description

In this course, materials science and production engineering are introduced by exploring how the the microstructure of a material relates to its physical properties, which in turn allows you to explore its production and manufacturing possibilities. You first learn to understand the atomic structure and interatomic bonding in materials and to understand phase diagrams. Subsequently, the material classes (metals, ceramics, polymers, composites) are introduced. You learn to analyse characteristic material properties which are primary relevant to production (density, elasticity, strength, toughness, durability, melting point, specific heat, thermal expansion and reflectance/absorbance). Finally, you are introduced to conventional and some advanced manufacturing techniques. As an integral part of this course, there is a visit to the machine workshop of Maastricht University. In addition to an exam, you execute a group assignment related to the process of turning bulk materials into value-added products and accompanying footprint, you perform a material selection and generate a fabrication plan at conceptual level for a basic product and discuss circularity aspects.

CEN3022
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Advanced Electronics and Sensor Technolo

Full course description

This course builds on the knowledge obtained in the concentration course Sensors, Instrumentation and Measurements and provides a deeper understanding of advanced electronics and sensor technology by focusing on three major topics in (bio)medical sensors. First, you are acquainted with applications using surfaces as carrier to generate a sensing principle. Aspects such as the physical and biochemical properties of surfaces and their relation to chemical or biologic activity are discussed, as well as physical and chemical principles that underlay these interactions and methods to study them (e.g. optics, thermodynamics and chemical bond formation). In addition, you acquire an overview of the state-of-the-art technologies which are involved in the detection of biomolecules, metabolites, and organic/inorganic contaminants. You are able to describe the different technical layouts and physical working principles of different types of bio(mimetic) sensors, focusing mainly on electrochemical, optical and physical readout techniques to identify individual molecules.

CEN3023
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
5.0

Circular Engineering

Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Advanced Electronics Skills

Full course description

In this skills training, you learn how to bring the theoretical knowledge from the course Advanced Electronics and Sensor Technology into practice. The course is split into three, two-week long advanced- level projects covering the following topic areas: digital electronics for computing which covers the basics of binary number systems, Boolean algebra, and logic devices. You build a digital clock to provide an appreciation of how digital devices can perform different functions. A similar device will be built using the Arduino microcontroller to better understand how an integrated microcontroller can achieve the same functions of many discrete logic components and understand how microcontrollers can contribute to optimize the efficiency of industrial processes and thereby contribute to their sustainability. Analogue electronics with bioengineering applications in which you build an ECG generator and measurement unit using analogue components with the aim of better understanding analogue electronics and their potential applications in biomedical engineering. You gain a more detailed insight into the charging and discharging characteristics of biological and technological capacitors as well as understanding the function of amplifiers, filters and counters. Finally, you acquire hands-on experience with electrochemical impedance measurements and learn how this technology can be used for biosensor technology that can be used to monitor industrial processes and make them more sustainable by e.g. decreasing their impact on the environment my reducing waste production. You also learn how advanced electronics and sensors can be used to analyse re-used materials and screen them for defects. You work in small teams on a different project every two weeks.

SKI3106
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
2.5
Teaching methods:
Lecture(s), Training(s), Work in subgroups, Skills
Faculty of Science and Engineering

Product and Process Design for Sustainab

Full course description

In this course, you integrate the insights you have obtained during the first semester of the final year to solve two circular engineering case studies. Teams of students apply their knowledge and skills of circular engineering to develop an actual solution for one of two themes: a) Redesign of a consumer product to fulfil the requirements of repair and reassemble at component level, or; b) Optimization of the process control of an existing processing plant for energy and water use efficiency. You follow the engineering design cycle from analysis of the existing systems, defining

circular engineering requirements, diverging to generate several conceptual solutions, selecting the most promising and developing that into a working functional solution. Finally, you evaluate the performance of the solution quantitatively and discuss the results.

CEN3024
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Faculty of Science and Engineering

Ethical and Philosophical Reflections

Full course description

In preparation of the bachelor thesis and your future studies or career, this course provides you with the main theoretical approaches within ethics, philosophy of science, as well as the relevant rules and regulations in the field of circular engineering. You develop the skills required to apply and reflect on these topics. Typical questions that are addressed are: what is the role of observation in science? What is a scientific explanation? What roles do theories and experiments play in science? Are there boundaries to genetic modifications? How can we approach multinationals that break environmental laws? What would you do if you would find out that your company is performing illegal dumping of waste or provides misleading information of the circularity or footprint of their products? You study typical ethical dilemmas, search representative examples that are related to the posed questions and discuss your findings with your peers.

CEN3006
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
5.0
Teaching methods:
Lecture(s), PBL
Skills

Year 1 Skills

Faculty of Science and Engineering

Academic Skills and Project Management

Full course description

This skills course is vital preparation for study on the BSc Circular Engineering Programme. This skills course will provide the basis of important aspects in a student's study skillset. Students will learn effective study techniques based on academic work in this area, they will learn methods for finding and evaluating information sources and develop their knowledge of the concept of uncertainty, probability and bias. Students will learn the importance of academic integrity as applied to university work specifically and academic study and technical work generally. Students will learn skills related to a variety of methods of assessment including the oral presentation of information.

Course objectives

At the end of this course, you are able to:
1. Identify and explain evidence-based study methods and recognise an effective study plan.
2. Describe methods for finding information sources and assess the quality of information obtained from those sources.
3. Understand the reasons for integrity and ethics in academic study and demonstrate the use of techniques such as paraphrasing and reference citation when presenting academic work for assessment.
4. Describe and demonstrate effective methods for presenting data and information orally and in writing.

Recommended reading

EdLab Web resources for study smart.
https://www.studysmartpbl.com/

SKI1101
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
2.5
Coordinators:

- L.J.B.M. Kollau
- G.J. Phillips

Teaching methods:
Lecture(s), Training(s), Work in subgroups, Skills
Assessment methods:
Assignment, Presentation
Keywords:
Academic Research and Writing; Project Management
Faculty of Science and Engineering

Basic Programming Skills

Full course description

In this course you will learn how to use the engineering software package MATLAB© environment (Mathworks Inc.) to perform mathematical computations and plot data. In parallel, you will get acquainted with basic programming, creating and running scripts, making m-files, and debugging.

A direct relation is with the course Linear Algebra, as you will perform matrix calculations with MATLAB. By learning to work with MATLAB, you will be able to solve many technical or mathematical problems also in other courses of this programme.

Course objectives

At the end of this course, you will be able to:

- Write scripts/functions with MATLAB syntax/code, using vectors, matrices, various loops, simple calculations, indexing and various preselected built-in MATLAB functions.
- Visualise data with MATLAB syntax/code including titles, axes, legends, line styles based on prescribed 2D drawings and/or equations of one variable with built in MATLAB functions
- Fit basic curves and numerical analysis with built-in MATLAB functions
- Debug and optimize performance of MATLAB code

Recommended reading

Mandatory

- The MATLAB Manual: Pekalska E., Babuska R. (2014-2015), Introduction to Matlab, Delft University of Technology, Delft, The Netherlands.

Recommended

Please find some other website that introduce MATLAB as well. Perhaps the wording is a bit more intuitive for you. Be aware that the MATLAB Manual is leading in terms of assessment material.

- Griffiths D. F., An introduction to MATLAB, University of Dundee, Dundee, Scotland, 2006. (link)
- The Mathworks, Getting started with MATLAB, The MathWorks, Inc. Natick, USA.

Software

MATLAB (Mathworks Inc.)

Internet, e.g. MATLAB Central

SKI1102
Period 2
31 Oct 2022
23 Dec 2022
Print course description

Circular Engineering

ECTS credits:
2.5
Coordinator:

- L.J.B.M. Kollau

Teaching methods:
Training(s), Assignment(s), Skills
Assessment methods:
Assignment, Written exam
Keywords:
Coding; Scripting; Debugging; MATLAB
Faculty of Science and Engineering

Physics and Electronics Laboratory Skills

Full course description

This skills training is strongly related and therefore complementary to the course Fundamentals of Engineering. You perform physical experiments representative for each of the engineering domains that are studied on a theoretical level in the Fundamentals of Engineering course. You gain a deeper understanding of the fundamental physical principles and understanding that laws and mathematical descriptions are models of the real world. Special attention is paid to an appropriate statistical analysis of the scientific results. You train your interpretative skills by comparing your experimental measurements with theoretical calculations using statistical methods, MATLAB and reporting strategy. Furthermore, you learn to highlight sources of error and when to use theory or experiments to solve engineering problems.

SKI1103
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
2.5
Coordinator:

- B.R.N. van Grinsven

Teaching methods:
Training(s), Assignment(s), Skills
Keywords:
Laws of Physics; Experiments; Statistical Analysis; Scientific Reporting
Faculty of Science and Engineering

Chemistry and Biology Laboratory Skills

Full course description

This skills training focuses on translating the basic concepts of chemistry and biology to laboratory work. You learn to work in a safe manner taking into account rules and regulations, with respect for

yourself, others and the environment such as handling chemicals, safe use of equipment and usage of safety gear. You learn basic skills such as the accurate measurement of volumes, chemical lab techniques, basic spectroscopic analysis, biological sample preparation and analysis. Special attention is paid to a proper statistical analysis. You are provided with two tasks in which you are assessed on your capability to work safely, accurately, log and report your findings.

SKI1104
Period 5
10 Apr 2023
9 Jun 2023
Print course description
ECTS credits:
2.5
Coordinator:

- L.J.B.M. Kollau

Teaching methods:
Lecture(s), Work in subgroups, Skills
Keywords:
Laws of Physics; Experiments; Statistical Analysis; Scientific Reporting

Year 2 Elective Skills

Faculty of Science and Engineering

Statistics Skills

Full course description

The knowledge obtained in this course can benefit engineers from any concentration. In this skills training, theoretical statistical models are introduced and you apply this knowledge by analysis of cross- sectional or longitudinal data on the computer. In this way, you are trained to identify which statistical model is most appropriate to apply to a given empirical question. Accordingly, you are provided with four types of datasets derived from experiments related to circular engineering topics. You are introduced to the statistical software package SPSS. With this background, you need to formulate a research question that could be answered for each dataset. Subsequently, you need to determine the appropriate statistical analysis and execute the analysis using the SPSS software and report on your findings. This way, you are introduced and trained to work with different statistical models using the SPSS software.

SKI2101
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
2.5
Coordinator:

- M.C. ten Thij

Bioinformatics Skills

Full course description

This course builds upon the first year Basic Programming Skills course and is particularly useful for students leaning towards the Sustainable Biotechnology concentration. It offers in-depth insights in bioinformatics topics by studying simulations that are executed in a MATLAB/SIMULINK environment. The focus is not on programming, but rather on using existing models such as population and infectious disease (outbreak) modelling, Malthusian modelling, evolutionary stability of Mendel's law on segregation or applying a Bioinformatics Toolbox to perform a DNA sequence alignment using classification. By modifying important parameters in these models, you gain deeper insights in the underlying principles and learn how to apply computer models to derive answers for complex engineering problems. You complete computer assignments which includes a report discussing the variations in parameters.
SKI2102
Period 5
10 Apr 2023
9 Jun 2023
Print course description
ECTS credits:
2.5
Faculty of Science and Engineering

Genetics Skills

Full course description

This skills training aims at providing a basic introduction to the most common techniques and methods used in modern genetics and is strongly related to the courses Genetics and Gen Technology. This training is a particular useful preparation for the Sustainable Biotechnology concentration in year 3 and consists of two parts. In the first part focusing on "wet lab"-skills, you learn how to isolate the total genomic DNA from eukaryotic tissue (plant leaves) and plasmid DNA from prokaryotes (bacteria), how to analyse the extracted DNA by agarose gel electrophoresis, how to quantify it, and how to determine its quality. Subsequently, you learn how to manipulate the DNA extracted, amplify a plant gene via polymerase chain reaction (PCR) and perform a restriction digestion and ligation of plasmid DNA. You isolate RNA from plant leaves and perform a reverse transcription reaction to generate copy DNA (cDNA). The second part of the course on "genomes and genomics" is taught in a computer landscape, integrating theoretical information with practical in silico training. You learn how to retrieve specific sequences from a given database, how to find regions of similarity between biological sequences using the different BLAST alignment tools, how to identify the regulatory elements of a DNA sequence and the correct ORF, and how to predict the subcellular localization of a given gene product and the possible post-translational modifications of a protein.

SKI2105
Period 4
6 Feb 2023

Circular Engineering

7 Apr 2023
Print course description
ECTS credits:
2.5
Coordinator:

- K.J.P. Verhees

Faculty of Science and Engineering

Advanced Programming Skills

Full course description

This course is built as a follow up course to Basic Programming Skills in year 1 where MATLAB, an engineering software, is introduced. In this course, you learn how to use the open-source programming and scripting language Python. This will be achieved by assignments you work on collectively during the skills sessions, guided by the tutor. The assignments you work on are not problems that have ready-made answers; several approaches are possible. By discussing with your peers during these sessions, you learn different approaches for solving the same problem.
While developing skills in Python, you have to apply this knowledge by using common data analysis techniques, like visualization, smoothing, and fitting to generic and specific functions. After you become sufficiently fluent in data treatment scripting, you will start using a Raspberry Pi. You work in small groups, sharing a Raspberry Pi, and choose a project to work on for 3 weeks. Alternatively, you work on 3 smaller projects over the course of the 3 weeks. The projects chosen should be close to a topic in engineering in a sustainable economy, and they have to contain a data acquisition component. The addition of data acquisition to your skillset enables you to tackle nearly all practical challenges engineering in general has to offer.

Course objectives

At the end of this course, we expect you to be able to:
■ Write scripts/functions with Python syntax/code, using targeted at data processing and visualization.
■ Fit advanced curves, numerical and statistical analysis with Python.
■ Write a simple program to run on the Raspberry Pi.
■ Use the Raspberry Pi to control a given sensor.

Recommended reading

■ Python Data Science Handbook: Essential Tools for Working with Data (2016), Jake VanderPlas, O'Reilly Media, USA.

SKI2106
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
2.5

Circular Engineering

Coordinator:

- L.J.B.M. Kollau

Teaching methods:
PBL, Skills
Assessment methods:
Portfolio, Presentation, Take home exam
Faculty of Science and Engineering

Organic Chemistry Skills

Full course description

This course follows up on Chemistry and Biology Laboratory Skills and is closely connected to the course Organic Chemistry. You convert your theoretical knowledge on chemical reactivity and green chemistry to laboratory experiments. The course is specifically interesting for those opting for the concentration Circular Chemical Engineering. This skills training focuses on the development of a clear understanding of the synthesis and purification of organic chemical compounds. You are trained in safe handling of organic reagents and safe execution of organic experiments, commonly used organic synthetic laboratory techniques, synthetic chemistry of various organic reaction types (e.g. nucleophilic substitutions and eliminations, electrophilic reactions and radical chemistry), organic reactions in batch and in flow reactors, purifications and separations in chemistry and spectroscopy and characterization of organic compounds.
SKI2107
Period 4
6 Feb 2023
7 Apr 2023
Print course description
ECTS credits:
2.5
Faculty of Science and Engineering

Plant Biology Skills

Full course description

In this course, you learn to dissect plant organs and learn more about the correspondence between the morphological and physiological aspects of a plant throughout its lifecycle. You learn how to make protoplasts from intact tissues by enzymatic digestion of the cell wall and test the effect of osmotic pressure on intact plants, protoplasts and cells. You observe the differences between plant cell types from various organs as well as protoplasts under the microscope. You also become familiar with plant cell cultures techniques used to propagate plants and genetically manipulate plants. You understand how a plant suspension culture can be established starting from a differentiated tissue and learn how from a single cell of a differentiated leaf tissue a completely new plant can be regenerated.

Course objectives

At the end of this course, we expect you to be able to:

- Identify plant organs and tissues and understand their structure-function relationship
- Manipulate and isolate protoplasts from different plant tissues for different purposes while following complex laboratory protocols
- Understand how small plants (plantlets) can grow under different medium requirements from different types of protoplasts by using diverse laboratory protocols
- Explain the agronomic purpose of propagating and genetically manipulating plants by to a scientific audience
- Provide examples of how plant cell cultures can contribute to the circular economy and agriculture

Recommended reading

Mandatory:
The following concepts from the Biotechnology course (CEN1006) have to be checked in order to fully comprehend new concepts introduced in this course. Therefore, please read again the listed chapters from the following book:

Campbell, N. A., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Reece, J. B. (2018). Biology: A global approach (11th ed.). Pearson.
 Concept 19.1: DNA sequencing and DNA cloning are valuable tools for genetic engineering and biological inquiry
 Concept 19.3: Cloned organisms and stem cells are useful for basic research and other
 applications
 Concept 19.4: The practical applications of DNA-based biotechnology affect our lives in many ways

During the course, please read from Campbell et al. (2018) the following chapters: See the manual.

Recommended:

- Wang, K., & Zhang, F. (2022). Protoplast Technology (1st ed.). Humana New York. https://doi.org/10.1007/978-1-0716-2164-6
- Neumann, K.-H., Kumar, A., & Imani, J. (2020). Plant Cell and Tissue Culture – A Tool in Biotechnology. In Plant Cell and Tissue Culture – A Tool in Biotechnology (2nd ed). Springer Nature. https://doi.org/10.1007/978-3-030-49098-0
- Collin H.A. & Edwards, G.S. (1998). Plant Cell Culture. Springer

SKI2108
Period 1
5 Sep 2022
28 Oct 2022
Print course description
ECTS credits:
2.5
Coordinator:

- C.M. Padilla Díaz

Teaching methods:

Circular Engineering

PBL, Skills
Assessment methods:
Portfolio, Presentation, Written exam
Faculty of Science and Engineering

Polymer Processing Skills

Full course description

In this skills course, both the processing and mechanical analysis of polymer materials is explored. The course builds upon the first year courses Engineering in a Circular Economy, Fundamentals of Engineering, Chemical Engineering and has a strong link to the second year courses Organic Chemistry, Biobased Materials and Polymeric Materials Science and Engineering. Generally, four different elements are discussed and tested: basic melt-behaviour of materials (rheology), compounding of pure polymer materials and their blends (extrusion) followed by injection molding, mechanical testing and thermal reprocessing (recycling). Mechanical testing is conducted through tensile testing and impact testing. Different techniques for constructing composite materials are addressed and their potential for recycling is investigated. Similarly, techniques for the development of thermosetting composites and coatings are explored together with their potential for recycling or reprocessing. Finally, you are requested to make use of the learned skills to design and create a polymer product which can be used for different applications after recycling and present on your findings in a final presentation.

SKI2110
Period 2
31 Oct 2022
23 Dec 2022
Print course description
ECTS credits:
2.5
Coordinator:

- A. Gooneie

Faculty of Science and Engineering

Signal Processing and Control Skills

Full course description

This course builds upon several first year courses such as Calculus, Linear Algebra, Physics and Electronics Laboratory Skills and Basic Programming Skills. In the first year courses, the focus was on data acquisition and introduction of software and basic mathematical tools. In this course, you are introduced to signal processing and control theory such as the relation between continuous and discrete signals, theory of Nyquist, elementary filter techniques, noise, moving average, low and high band pass, Fourier and Laplace transformation, open vs closed control systems and Bode diagrams of 1st and 2nd order systems. Each theoretical aspect is supported by a computer assignment to be performed with MATLAB/SIMULINK software, where datasets of actual measurements need to be processed and visualised. The final test is a signal processing assignment that is performed using MATLAB/SIMULINK and is documented in a report that discusses the

problem solving strategy and the results.

SKI2112
Period 5
10 Apr 2023
9 Jun 2023
Print course description
ECTS credits:
2.5
Projects

Year 1 Projects

Faculty of Science and Engineering

Life Cycle Assessment Project

Full course description

In the projects, typically (inter)personal skills are trained. In this project, teams of students are challenged to analyse the sustainability of products and production processes introduced by staff members from research groups or company representatives.

The LCA theory for this project was provided in course CEN1001, Engineering in a Circular Economy. In order to be able to execute the Life Cycle Assessment (LCA) project, students are introduced in instruction sessions to the project topic and what is expected from the LCA project. Teams of students will perform a (simplified) LCA study and will report their results at the end of the project.

The completion and success depend on working, thinking, acting, and learning as a team and sharing tasks and responsibilities with peers. The results are orally presented, documented in a report; individual and peer reflections are given on (inter)personal skills development.

Course objectives

At the end of this course, you are able to:
1. Demonstrate understanding of the environmental implications of the project topic and feasible engineering solutions by searching and studying additional literature;
2. Describe the four stages of life cycle assessment (LCA) and explain the important aspects in performing an LCA in each stage;
3. Apply the knowledge of the four stages of LCA on a circular engineering topic by performing a basic or partial LCA study and explaining the meaning of the results obtained from the LCA study performed;
4. Communicate on the project process and results by written text, illustrations, and oral presentation;
5. Reflect on your share and that of peers in team performance, your personal development including leadership, and the results of the project.

Prerequisites

None

Recommended reading

Mandatory

- Handbook on Environmental Assessment of Products, by Kirsten Pommer and Pernille Bech (Danish Technological Institute), Henrik Wenzel and Nina Caspersen and Stig Irving Olsen (Technical Knowledge Center of Denmark), 2000, Danish Environmental Protection Agency
- Book: Life Cycle Assessment: Quantitative Approaches for Decisions that Matter (2014), H. Scott Matthews, Chris Hendrickson, Deanna H. Matthews; available at https://www.lcatextbook.com/
- As part of the project, students will get information on the project topic. Students are expected to search for additional information. All information sources that are used (literature, books, patents, interviews) should be properly referred by a bibliography (see Library of Maastricht University for help and guidelines to cite).

Recommended
The following handbooks and resources are recommended if you are interested in Life Cycle Assessment and desire to have more in-depth information. They are by no means obligatory for the course.

- Handbook - General guide for Life Cycle Assessment. European Commission - Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. First edition March 2010. EUR 24708 EN. Luxembourg. Publications Office of the European Union; 2010. The pdf file is available at: http://eplca.jrc.ec.europa.eu/uploads/ILCD-Handbook-General-guide-for-LCA-DETAILED-GUIDANCE-12March2010-ISBN-fin-v1.0-EN.pdf
- Information available at the website of the European platform on Life Cycle Assessment : http://eplca.jrc.ec.europa.eu/?page_id=86
- Book - Jolliet, O., Saade-Sbeih, M., Shaked, S., Jolliet, A., Crettaz, P. (2016). Environmental Life Cycle Assessment. Boca Raton: CRC Press, https://doi.org/10.1201/b19138

Software

- MS Word
- MS Excel
- MS PowerPoint
- LCA calculation tools (internet & MS Excel)

PRO1110
Period 3
9 Jan 2023
3 Feb 2023
Print course description
ECTS credits:

Circular Engineering

5.0
Coordinator:

- Y. van der Meer

Teaching methods:
Research, Working visit(s), Work in subgroups, Project-Centered Learning
Assessment methods:
Final paper, Presentation
Keywords:
Life Cycle Assessment; Environmental Impact; Research Project; Project Management
Faculty of Science and Engineering

Design Project

Full course description

You choose one of three projects that each cover one of three concentrations: Circular Chemical Engineering, Sustainable Biotechnology and Engineering Physics for Sustainable Manufacturing. After the end of the second year, you have performed one project related to each of the three concentrations, in your own preferred sequence. The aim of these three projects is to facilitate the integration of acquired knowledge and skills by addressing real-life circular engineering problems in collaboration with one of the Brightlands Campuses. By working in a team to execute the project, you also train your (inter)personal skills. You are introduced to a real-life case and provided with relevant background information in instructional sessions. The case consists of an existing product or process control system that needs to be modified to meet requirements of sustainability and circularity. The teams follow the engineering design cycle to solve the case at a conceptual level using basic calculations, scientific information and a solid line of reasoning. Considering the scope of the assignment, the completion and success depend on working, thinking, acting and learning as a team, sharing tasks and responsibilities among peers. This way of organising projects means that you not only execute the project, but also own and design it. The results are orally presented, documented in a report and individual reflections are written on (inter)personal skills development.

Course objectives

At the end of this course, you are able to: - Apply the design engineering cycle, circular economy concepts and design aspects (such as scarcity of materials, reuse, repair, remanufacturing and recycle, reduction of waste, water and energy consumption, life-cycle assessment), and emerging technologies to solve a simple problem in the circular engineering domain - Demonstrate understanding of societal and environmental implications of the project topic and feasible engineering solutions by searching and studying additional literature - Adapt to the professional, cultural and societal merits of the working environment of the representatives that offer the real-life design projects - Communicate on the project process and results by written text, illustrations and oral presentation - Reflect on your share and that of peers in team performance, your personal development including leadership, and the results of the project

Prerequisites

None

Circular Engineering

PRO2110
Period 6
12 Jun 2023
7 Jul 2023
Print course description
ECTS credits:
5.0
Coordinator:

- G.J. Phillips

Teaching methods:
Research, Working visit(s), Work in subgroups, Project-Centered Learning
Keywords:
Research Project; Project Management; Circular Chemical Engineering; Sustainable Biotechnology; Engineering Physics for Sustainable Manufacturing

Year 2 Projects

Faculty of Science and Engineering

Design Project

Full course description

You choose one of three projects that each cover one of three concentrations: Circular Chemical Engineering, Sustainable Biotechnology and Engineering Physics for Sustainable Manufacturing. After the end of the second year, you have performed one project related to each of the three concentrations, in your own preferred sequence. The aim of these three projects is to facilitate the integration of acquired knowledge and skills by addressing real-life circular engineering problems in collaboration with one of the Brightlands Campuses. By working in a team to execute the project, you also train your (inter)personal skills. You are introduced to a real-life case and provided with relevant background information in instructional sessions. The case consists of an existing product or process control system that needs to be modified to meet requirements of sustainability and circularity. The teams follow the engineering design cycle to solve the case at a conceptual level using basic calculations, scientific information and a solid line of reasoning. Considering the scope of the assignment, the completion and success depend on working, thinking, acting and learning as a team, sharing tasks and responsibilities among peers. This way of organising projects means that you not only execute the project, but also own and design it. The results are orally presented, documented in a report and individual reflections are written on (inter)personal skills development.

PRO2111
Period 3
9 Jan 2023
3 Feb 2023
Print course description
ECTS credits:
5.0
Coordinator:

- P.P.M. Aarts

Circular Engineering

Teaching methods:
Research, Working visit(s), Work in subgroups, Project-Centered Learning
Faculty of Science and Engineering

Design Project

Full course description

You choose one of three projects that each cover one of three concentrations: Circular Chemical Engineering, Sustainable Biotechnology and Engineering Physics for Sustainable Manufacturing. After the end of the second year, you have performed one project related to each of the three concentrations, in your own preferred sequence. The aim of these three projects is to facilitate the integration of acquired knowledge and skills by addressing real-life circular engineering problems in collaboration with one of the Brightlands Campuses. By working in a team to execute the project, you also train your (inter)personal skills. You are introduced to a real-life case and provided with relevant background information in instructional sessions. The case consists of an existing product or process control system that needs to be modified to meet requirements of sustainability and circularity. The teams follow the engineering design cycle to solve the case at a conceptual level using basic calculations, scientific information and a solid line of reasoning. Considering the scope of the assignment, the completion and success depend on working, thinking, acting and learning as a team, sharing tasks and responsibilities among peers. This way of organising projects means that you not only execute the project, but also own and design it. The results are orally presented, documented in a report and individual reflections are written on (inter)personal skills development.

PRO2112
Period 6
12 Jun 2023
7 Jul 2023
Print course description
ECTS credits:
5.0
Teaching methods:
Research, Working visit(s), Work in subgroups, Project-Centered Learning
Thesis

Bachelor Thesis

Faculty of Science and Engineering

Bachelor Thesis

Full course description

All students write a proposal in period 3, before they start their thesis. As part of drafting the proposal, all students are further introduced into scientific methodology of translating research questions in hypothesis. Detailed attention is paid to correct formulation. In addition, if applicable to the research topic, sample size calculation and the meaning of significance levels and statistical power are addressed for the most common statistical models (t-test, ANOVA, Mann- Whitney U, Kruskal Wallis, Pearson correlation, ICC and Kappa). The thesis coordinator approves the topic and

location of the thesis and safeguards overall quality. Bachelor Thesis Research and Design: The bachelor thesis project is the final proof-of-capability for BSc Circular Engineering students. The individual project enables you to realise your academic profile through an integrated piece of research or research-based design. The size of the thesis allows you to contribute to the circular engineering discipline by a) either conducting an entire scientific cycle which consists of an analysis of lacking knowledge, formulating a hypothesis, formulating a research plan, executing experiments and reporting, or b) conducting an research-based engineering design cycle which consists of formulating a problem, setting of design requirements based on scientific evidence, generating several concepts and performing an evidence-based selection of the most optimal solution and reporting. Bachelor Thesis and Thesis Defence: You summarise and present the results in your bachelor thesis. As a form of public defence, you give an oral public presentation on your thesis work, in which you motivate your research plan in light of identified problem statements and research questions to be addressed. You carefully disclaim the approaches you took, the methods used for the data collection and processing and the results you obtained. You critically analyse your work in a discussion section and conclude the thesis within a final chapter that also contains a reflection of your work and the value of your work for society.

BTH3010
Period 3
9 Jan 2023
3 Feb 2023
Semester 2
6 Feb 2023
7 Jul 2023
Period 5
10 Apr 2023
9 Jun 2023
Period 6
12 Jun 2023
7 Jul 2023
Print course description
ECTS credits:
0.0