AC Angewandte Chemie

Hochschule Reutlingen
Reutlingen University

Reutlingen University
School of Applied Chemistry

Course compendium for exchange students

2019/20 winter semester

110011 Biophysical Chemistry

Study Program **Study level and semester**	BWB Bachelor, 2 semester
ECTS Credits	5 Credits
Hours per week / total contact hours	4 / 60
Total hours of study	150
Type/Teaching Method	Lecture, Exercises, Laboratory
Language of instruction	English;German
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Rumen Krastev Email: Rumen.Krastev@Reutlingen-University.DE
Restrictions (falls zutreffend)	None
Prerequisites:	Mathematics and Physics for chemists. Inorganic Chemistry
Course learning objectives:	Acquisition of knowledge in physical chemistry relevant to the life sciences Expertise Mastering the basic skills in Physical Chemistry for the fields of thermodynamic, chemical thermodynamic, phase equilibria, chemical and biological kinetics, mass transport Structure and dynamics of biomolecules Skills Understanding physico-chemical principles and methods Understanding the relationship of chemical structures to the macroscopic properties of the substances Acquisition of experimental skills for physical chemical measurement techniques and evaluation methods • Applications of scientific working methods in physical chemistry • Ability for independent scientific work and experimentation Social skills: Promoting teamwork in exercises and internships
Contents:	Lectures Fundamentals in thermodynamics

	• The first law. System and surrounding. Temperature and 0th law. Work and heat. Internal energy and enthalpy. State functions. Calorimetry. Physical and chemical change. Thermochemistry (Hess's law, Kirhhoff's law). • Ideal gas. Equation of state. Kinetics theory of gases. Real gas. • The second law. Entropy. Direction of spontaneous reactions. Absolute entropy – the third law. Molecular interpretation of the second and the third law. The Boltzmann formula. Gibbs energy. • Biological relevance. Energy conversion in organisms. Molecular interactions in biological systems. Calorimetry of the interaction drug-protein. Phase equilibria. • Thermodynamics of transitions. Phase diagrams. Mixtures. The chemical potential. • Colligative properties – osmosis, Donnan equilibrium, Ebullioscopy and Cryoscopy. • Biological relevance. Phase transitions in biological systems – Lipids, Proteins, DANN. Systems at equilibrium. • The reaction Gibbs energy. Equilibria constant. Standard reaction Gibbs energy. The response of the equilibrium to the conditions. • Proton equilibria. pH. Salt solutions. Buffers. • Biological relevance. Biologically significant buffers. Buffer action of blood. Binding of oxygen to haemoglobin. Biosynthesis of proteins. Oxidation of glucose. Ion and electron transport • Ions in solutions. Activity. Debye-Hückel theory. • Redox reactions. Reactions in electrochemical cells. Types of electrodes. Ion selective electrodes. Nernst equation. Standard potential. Electrochemical work. Electrochemical series. • Biological relevance. Membrane potential. Biological redox reactions. Systems in transition • The rates of reactions. Reaction rate. Rate laws. Rate constants. Reaction order. Reaction mechanisms. Dependence on the concentration. Temperature dependence of the chemical reactions – Arrhenius equation. • Catalytically reactions. Bio catalysis – Enzymatic reactions. Michaelis-Menten mechanism. • Diffusion. 1st and 2nd Fick's law. Diffusion coefficient. Permeability. • Biological relevance. Pharmacokinetics. Protein folding and unfolding. • Structures of bio molecules. Chemical bonds.

	• Fundamentals in structural clarification of biomolecules. Electron microscopy. Spectroscopy.
Textbooks:	1. P. Atkins, J. de Paula Physical Chemistry for the Life Sciences, Oxford University Press. 2. P. Atkins, J. de Paula Atkins' Physical Chemistry, Oxford University Press 3. G. Wedler, H. –J. Freund Lehrbuch der Physikalischen Chemie, Wiley-VCH 4. C. Czeslik, H. Seemann, R. Winter Basiswissen Physikalische Chemie, Vieweg+Teubner Verlag | Springer
Assessment	Written exam 2h

110021 Project Management

Study Program **Study level and semester**	ACB;BWB Bachelor, 2 semester
ECTS Credits	3 Credits
Hours per week / total contact hours	2 / 30
Total hours of study	90
Type/Teaching Method	Lecture, Project, team work, case study
Language of instruction	English;German
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Alexander Schuhmacher Email: Alexander.Schuhmacher@Reutlingen-University.DE
Restrictions (falls zutreffend)	None
Prerequisites:	None
Course learning objectives:	The students shall become familiar with the structure and organization of enterprises in chemical industry, medical devices industry and other branches and be able to understand and apply economical thinking—even without preliminary qualification. Understanding of basic terms and concepts of management Terms and instruments of operational project management are known and can be applied Acquiring and applying of problem solving processes by presentation and case studies Smaller plans can shall be structured, planned, organized and conducted independently
Contents:	Basic terms of project management Project organisation, planning, realization and closure Project controlling, risk, claim and change management
Textbooks:	1. Scheck, H., Scheck, B. (2007): Wirtschaftliches Grundwissen für Naturwissenschaftler und Ingenieure, Wiley-VCH 2. Domschke, W., Scholl, A. (2008): Grundlagen der Betriebswirtschaftslehre: Eine Einführung aus entscheidungsorientierter Sicht, 4. Aufl. Springer, Berlin

	3. Schmalen, H., Pechtl, H (2009): Grundlagen und Probleme der Betriebswirtschaft, 14. Aufl. Schäffer-Poeschel, Stuttgart 4. Wöhe, G. (2005): Einführung in die Allgemeine Betriebswirtschaftslehre, 22. Aufl. Vahlen, München 5. Schierenbeck, H. (2003): Grundzüge der Betriebswirtschaftslehre, 16. Aufl. Oldenbourg, München 6. Haberstock, L. (2008): Kostenrechnung 1: Einführung mit Fragen, Aufgaben, einer Fallstudie und Lösungen, bearb. v. Breithecker, V., 13. Aufl. 7. Kruschwitz, L. (2008): Investitionsrechnung. 12. Aufl. 8. Kuster, J.: Handbuch Projektmanagement, Springer, 2005 9. Gassmann, O.: Praxiswissen Projektmanagement, Hanser, 2004 Seite 71 von 92 10. Litke, H.-D.: Projektmanagement - Handbuch für die Praxis 11. Meier, R.: Projektmanagement, Gabal-Verlag, 2004
Assessment	Graded: Open book exam and case study

110031 Macromolecular Chemistry 1

Study Program **Study level and semester**	ACB;BWB Bachelor, 4 semester
ECTS Credits	4 Credits
Hours per week / total contact hours	2 / 30
Total hours of study	120
Type/Teaching Method	Lecture
Language of instruction	English;German
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Günter Lorenz Email: Guenter.Lorenz@Reutlingen-University.DE
Restrictions (falls zutreffend)	None
Prerequisites:	Organic Chemistry
Course learning objectives:	The students shall adopt basics of organic substances in view of possible applications in engineering and science. Knowledge: Important syntheses and reaction mechanisms for the fabrication of high-molecular organic products Characterization of macromolecular substances Basic knowledge of physical, chemical, and technical aspects of the production of polymers as well as their characteristics and features The participants are able to apply experimental methods for the preparation of simple organic materials Technical skills: Participants are able to apply the learned stuff to questions of medical and pharma industry Social skills: To develop an awareness of possible impacts on the environment of their doings.
Contents:	Basic definitions in macromolecular chemistrty Reactions and polymer generating reactions

	Modification of polymers Polymeric biomaterials
Textbooks:	1. J.M.G. Cowie, Valeria Arrighi, Polymers: Chemistry & Physics of Modern Materials, 3rd ed., CRC Press 2007, ISBN 9780849398131. 2. H.G. Elias, An Introduction to Polymer Science, Wiley 1997, ISBN: 978-3-527-28790-1. 3. Seymour/Carraher´s Polymer Chemistry, Marcel Dekker, Inc., New York, Basel, 7th ed., 2008, ISBN-13: 978-1-4200-5102-5 4. Fried, Joel R.: Polymer Science and Technology, 3rd. ed., Prentice Hall, New Jersey 2014, ISBN-13: 978-0137039555.
Assessment	Graded: exam (2 hours)

110041 Surfaces

Study Program **Study level and semester**	ACB;BWB Bachelor, 6 semester
ECTS Credits	3 Credits
Hours per week / total contact hours	2 / 30
Total hours of study	90
Type/Teaching Method	Lecture
Language of instruction	English;German
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Rumen Krastev Email: Rumen.Krastev@Reutlingen-University.DE
Restrictions (falls zutreffend)	None
Prerequisites:	Basics of Physics, Chemistry, Physical Chemistry, Material Science and Organic Chemistry
Course learning objectives:	Expertise Mastering the basic skills in Chemistry and Physical Chemistry of surfaces. Surfaces and their biological relevance. Surfaces of biomaterials. Structure and dynamics of biologically relevant molecules at surfaces. Skills Understanding principles and methods relevant to surface characterisation. Understanding the relationship of chemical structures to the macroscopic properties of the surfaces Acquisition of experimental skills for measurement techniques and evaluation methods Applications of scientific working methods Ability for independent scientific work and experimentation Social skills: Promoting teamwork in exercises
Contents:	Thermodynamics of interfaces.

	• Fundamental thermodynamic relations. Definition of a surface. Gibbs energy and surface tension. Gibbs adsorption isotherm. • Liquid surface. Curved liquid surface. Young-Laplace equation. Capillary pressure. • Solid surface. Surface energy. Contact angle. Wetting and dewetting. Super hydrophobic surfaces. Adhesion. Work of adhesion. Adhesive effects – glues. • Methods for measurement of the surface tension and the contact angle. • Biological relevance. Liquids in capillaries. Surfaces of typical biomaterials. Adsorption. • Thermodynamics of adsorption. Adsorption models. Measurements with adsorption isotherms. • Adsorption from gas phase. Adsorption from solutions. • Biological relevance. Protein adsorption. Lipid deposition. Surfactants • Types of surfactants. • Self-assembling in surfactant systems – micelles, vesicles, liposomes, bilayer lipid membranes. Phase diagrams of lipid systems. • Biological relevance. Cell membranes. Lipid rafts. Charged surfaces. • Electric double layer. Poisson-Boltzmann equation. Stern layer. Grahame. Equation. • Electro capillary and electro kinetic effects. The zeta potential. Electrophoresis. • Biological relevance. Electrophoresis as a method for characterisation of proteins. IEP. IEP focusing. Application topics • Basic methods for surface modifications. Physical. Chemical. Coatings. • Dispersed systems. Stability of the dispersed systems. Interactions between surfaces – electrostatic, van der Waals. • Friction and lubrication. • Washing process. • Flotation and its application in the biotechnology.
Textbooks:	1. H.-J. Butt Physics and Chemistry of Interfaces, Wiley-VCH 2013. 2. Evans, D.F., Wennestrtöm, H. The Colloidal Domain: Wiley-VCH, 1999.

	3. Adamson, A.W., Gast, A.P. Physical Chemistry of Surfaces: Wiley-Interscience, 1997. 4. P. Atkins, J. de Paula Physical Chemistry for the Life Sciences, Oxford University Press. 5. Lyklema, J. Fundamentals of Interface and Colloid Science, Volume 1-3, Academic Press Inc. 2000 6. Wintermantel, E., Ha, S. W.: Medizintechnik: Life Science Engineering. Interdisziplinarität, Biokompatibilität, Technologien, Implantate, Diagnostik, Werkstoffe, Zertifizierung, Business Springer, Berlin; Auflage: 5., überarb. u. erw. A. 2009
Assessment	Graded: Written exam (1 hour)

110051 Biomaterials

Study Program **Study level and semester**	BWB Bachelor, 4 semester
ECTS Credits	3 Credits
Hours per week / total contact hours	2 / 30
Total hours of study	90
Type/Teaching Method	Lecture and exercises
Language of instruction	English
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Ralf Kemkemer Email: Ralf.Kemkemer@Reutlingen-University.DE
Restrictions (falls zutreffend)	None
Prerequisites:	Basics of Physics, Chemistry, Material Sciences, and Organic Chemistry
Course learning objectives:	Basic knowledge Knowledge of materials for biomedical application in in-vitro and in-vivo applications Understanding of technologies for surface modifications for implants and related methods Knowledge of biomedical implant technologies - applications examples and challenges Technical competences: Students are able to understand surface and polymer chemistry technologies and can transfer these to appropriate application in the biomedical field Students are able to identify technical working principles of complex implants Students are able to understand the complexity of tissue-material interaction and can relate this to material properties Students are able to classify the suitability of different materials classes for specific application Students can name limitation of current technologies in the field Social competences:

	Students get an awareness of ethical aspects in the development of medical products.
Contents:	Material aspects of biomaterials and surface technologies Concept of biocompatibility Seite 13 von 28 Medical products and introduction into regulations Examples and applications of biomaterials Micro and nanotechnology, Interaction of cells/tissue with materials
Textbooks:	1. Narayan R.: Biomedical Materials, Springer Publisher, 2009 2. Ratner B.D. et al.: Biomaterial Sciences, Elsevier Oxford, 2012 3. Scientific publications
Assessment	Exam (1 hour) and presentation

110061 Biomaterials Lab

Study Program **Study level and semester**	BWB Bachelor, 6 semester
ECTS Credits	5 Credits
Hours per week / total contact hours	6 / 90
Total hours of study	150
Type/Teaching Method	Laboratory, Project work etc.
Language of instruction	English
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Ralf Kemkemer Email: Ralf.Kemkemer@Reutlingen-University.DE
Restrictions (falls zutreffend)	Admission capacity for this course is limited to 5 international students
Prerequisites:	Organic Chemistry, Polymer Chemistry, Human Biology, Medical Basics
Course learning objectives:	The lab is organized as a project orientated learning lab. Students will plan, work and present important aspect of their project in teams. Students will learn To develop a research project in the field of biomaterials To write a project proposal and report To understand and apply physical and chemical methods and technologies for surface modifications and characterization To understand and apply in vitro methods for testing of biocompatibility To apply principles of project management To work in a team on a research project To analyse, interpret, visualize and present data To search, read and interpret scientific publications
Contents:	Scientific project management methods, various methods of material sciences, material characterization, cell biology, and related methods. Application of surfaces and surface modifications, technical principles micro and nanotechnology, surface chemistry, interaction of cells with materials.
Textbooks:	1. Scientific publications
Assessment	Lab work (40%) and presentations, project proposal and report (60%)

110071 Instrumental Analysis and Lab

Study Program **Study level and semester**	IP Bachelor, 4 semester
ECTS Credits	6 Credits
Hours per week / total contact hours	4 / 60
Total hours of study	180
Type/Teaching Method	Lecture, Laboratory
Language of instruction	English
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Wolfgang Honnen Email: Wolfgang.Honnen@Reutlingen-University.DE
Restrictions (falls zutreffend)	
Prerequisites:	Knowledge in organic chemistry and basic knowledge in analytical chemistry
Course learning objectives:	This course will expand the student's theoretical and practical knowledge of chromatography, spectroscopy, environmental analysis and ecotoxicological methods To become familiar with instrumental analytic techniques and ecotoxicological methods through theoretical instruction, practical experiments, demonstrations and projects. To become familiar with the development of analytical methods. To become familiar with evaluation procedures and principles of documentation as well as the scientific reporting and presentation of experiment results. To understand the application possibilities in practice as well as the limitations and significance of analytical results.
Contents:	• Basic principles of sample collection and sample preparation techniques • infrared spectroscopy, photometry, thin layer chromatography, gas chromatography, AOX, TOC, atomic absorption spectrometry, ion chromatography, HPLC, GC-FID, GC-ECD, GC-MS, polarography, ecotoxicological methods • development of analytical methods • documentation of experimental results

Textbooks:	1. Douglas A. Skoog, F. James Holler, Stanley R. Crouch: Principles of Instrumental Analysis, Cengage Learning, (2017) 2. Robert Kellner (Editor), Jean-Michel Mermet (Editor), Matthias Otto (Editor), Miguel Valcárcel (Editor), H. Michael Widmer (Editor): Analytical Chemistry: A Modern Approach to Analytical Science, 2nd Edition, Wiley-VCH (2004)
Assessment	Written and oral exam, lab work

110081 Fundamentals in Instrumental Analysis

Study Program **Study level and semester**	ACB;BWB Bachelor, 2 semester
ECTS Credits	5 Credits
Hours per week / total contact hours	4 / 60
Total hours of study	2
Type/Teaching Method	Lecture
Language of instruction	English;German
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Karsten Rebner Email: Karsten.Rebner@Reutlingen-University.DE
Restrictions (falls zutreffend)	None
Prerequisites:	Basics in general and analytical chemistry
Course learning objectives:	Successful students will have a solid knowledge and understanding of modern analytical techniques with particular emphasis on measurement basics. Students will develop a critical insight into the performance validity and applicability of analytical techniques and how to understand and interpret data of advanced analytical methods. This will allow students to realise the fluid and dynamic nature of an analytical technique's development and its future application in the modern laboratory.
Contents:	Introduction: Differentiation of instrumental methods from classical analytical methods / categorization; Formulation of analytical problems, analytical process and analysis planning. Measurement Basics; Signal generation, operational amplifiers, signal measurement and signal processing; Experimental errors, propagation of measurement uncertainty, statistics Sampling and sample preparation of gaseous, liquid and solid samples including digestion, enrichment and extraction procedures. Data evaluation, quantification, presentation of results in final reports; Quality management in analytics, auditing, certification and accreditation. Basics of spectral analytical methods: Properties of electromagnetic radiation and interaction with matter (spectra types); Light sources, spectrographs, monochromators, interferometers, resolving power, luminous intensity and detectors; Atomic spectroscopy - atomization, influence of temperature, equipment, interferences

	Basics of electroanalytical processes: Electrolysis, polarization and overvoltage, Nernst equation, ion mobility, ionic conductivity, limiting conductivity; Construction of an electroanalytical experiment: cell, three-electrode arrangement, regulation and control of the potential or current.
Textbooks:	1. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). Principles of instrumental analysis. Cengage learning. 2. Harris, D. C. (2010). Quantitative chemical analysis. Macmillan. 3. Holler, F. J., & Crouch, S. R. (2013). Applications of Microsoft Excel in Analytical Chemistry. Cengage Learning. 4. De Levie, R. (2001). How to Use Excel® in Analytical Chemistry: And in General Scientific Data Analysis. Cambridge University Press.
Assessment	The final grade is an averaged grade from the written exam (70%) and from coursework (30%) during the semester.

110091 Labor Makromolekulare Chemie

Study Program **Study level and semester**	ACB Bachelor, 6 semester
ECTS Credits	3 Credits
Hours per week / total contact hours	4 / 60
Total hours of study	90
Type/Teaching Method	
Language of instruction	English;German
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Günter Lorenz Email: Guenter.Lorenz@Reutlingen-University.DE
Restrictions (falls zutreffend)	Only after prior arrangement
Prerequisites:	Knowledge in organic chemistry
Course learning objectives:	Promotion of manual skills in the laboratory; Proficiency in the use and correct disposal of organic-chemical hazardous substances; Enhancement of the experimental skills in macromolecular synthesis; Application of evaluation processes and principles of documentation and reporting; students are able to document and present analysis results in a scientific and structured way; Improvement of independent scientific thinking and experimenting
Contents:	Synthesis and characterisation of polymers; important procedures for production and modification of polymers; testing of polymer properties, using spectroscopy, determination of molecular weight, end groups, melting point, and solubility; documentation of the experimental results
Textbooks:	
Assessment	Entrance colloquium, test protocolls and graded exit colloquium

110101 Kunststoffverarbeitung und Rheologie

Study Program **Study level and semester**	ACB;BWB Bachelor, 6 semester
ECTS Credits	6 Credits
Hours per week / total contact hours	4 / 60
Total hours of study	180
Type/Teaching Method	Lecture
Language of instruction	Deutsch
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Ralph Lehnert Email: Ralph.Lehnert@Reutlingen-University.DE
Restrictions (falls zutreffend)	Only for students with sufficient German knowledge
Prerequisites:	Basic knowledge in physics, physical and macromolecular chemistry
Course learning objectives:	Kenntnisse • Es sollen die wichtigsten Verarbeitungs- und Aufarbeitungsmethoden von Kunststoffen und ihren Additiven erläutert werden. Besonders soll auf den Zusammenhang zwischen den allgemeinen Verarbeitungseigenschaften eines polymeren Werkstoffes und seiner chemischen Struktur hingewiesen werden. Überlegungen zur Qualitätssicherung runden die Veranstaltung ab. • Kenntnis der wichtigsten physikalischen und chemischen Eigenschaften von Polymeren • Kenntnis aller viskosimetrischen Kenngrößen. • Kenntnis der wichtigsten instrumentell analytischen Messmethoden. Fertigkeiten • Studierende sind in der Lage, den Einfluss der rheologischen Parameter an ausgewählten anwendungstechnischen Prozessen zu analysieren. • Studierende sind in der Lage Messergebnisse aus der thermischen Analyse zu interpretieren. Fachliche Kompetenz • Erlangung der Methodenkompetenz für rheologische Messtechniken in Theorie und Praxis • Erlernen und Einüben der systematischen Vorgehensweise bei der rheologischen Analyse von Schmelzen, Flüssigkeiten und Festkörpern.

	• Kompetenz zur Bearbeitung und Lösung problemorientierter Beispiele aus dem Bereich der Polymeranalytik. Soziale Kompetenz • Teamfähigkeit
Contents:	Angewandte Rheologie • Rheometrische Größen • Fließ und Viskositätskurven • Geschwindigkeitsgefälle bei Verarbeitungsprozessen • Einflussgrößen auf die Viskosität • Newtonsche und nicht-Newtonsche Flüssigkeiten • Methoden der praktischen Viskositätsbeurteilung • Methoden zur absoluten Viskositätsmessung • Kapillarviskosimeter, Kugelfall- und Rotationsviskosimeter. • Aufnahme und Auswertung von Fließkurven mit praktischen Übungen. • Erkennen von Fehlmessungen. • Bestimmung von Fließgrenzen mit praktischen Übungen. • Bestimmung der viskoelastischer Eigenschaften von Flüssigkeiten und Festkörpern mit praktischen Übungen. • Systematik einer rheologischen Analyse. Kunststoffverarbeitung • Grundbegriffe polymerer Werkstoffe • Synthesen, Reaktionen, Aufbau und Eigenschaften • Kunststoffadditive • Einfärben von Kunststoffen • Mischen und Aufbereiten • Compoundieren • Dosieren • Schüttguttechnik • Qualitätssicherung
Textbooks:	1. Gächter, R.; Müller, H.: Kunststoff-Additive, Carl-Hanser-Verlag Wien, 3. Auflage 2. Handbuch der PVC-Additive, Ciba-Geigy, Marienberg GmbH 3. Rink, G.: Studienbücher Chemie - Einführung in die Kunststoffchemie, Diesterweg Verlag, Salle-Sauerländer 1979

	4. Brockes, A.; Berger-Schunn, A.: Farbmessung in der Textilindustrie, Bayer Farben Revue 5. Huff, K.: Visuelle Abmusterung und praktische Farb-messung in der Kunststoffindustrie, Bayer AG, Technische Redaktion 6. Pahl, Sommer, Streiff, Limper: VDI, Mischen von Kautschuk und Kunststoffprodukten, VDI-Gesellschaft KunststofftechnikBrummer, R.: Rheology Essentials of Cosmetic and Food Emulsions, Springer Berlin, 2005, ISBN 3-540-25553-2 7. Mezger, Th.: The Rheology-Handbook von 2006, Vincentz, ISBN 3-87870-174-8 8. Schramm, G.: Einführung in die Rheologie und Rheometrie, Gebr. Haake, Karlsruhe 9. http://www.rheologie.de/
Assessment	Graded exam (2 hours)

110111 Sicherheit und Umwelttechnik

Study Program **Study level and semester**	ACB Bachelor, 4 semester
ECTS Credits	5 Credits
Hours per week / total contact hours	4 / 60
Total hours of study	150
Type/Teaching Method	Lecture
Language of instruction	Deutsch
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Siegfried Blösl Email: Siegfried.Bloesl@Reutlingen-University.DE
Restrictions (falls zutreffend)	
Prerequisites:	German level B2
Course learning objectives:	Ziel ist es, aufbauend auf dem Modul Physik und Verfahrenstechnik (Modul ACB7), den Studierenden die Fertigkeit zu vermitteln, um geeignete Verfahren zur Wasseraufbereitung, Abwasser- und Abgasreinigung unter Beachtung sicherheitstechnischer Gesichtspunkte zu entwickeln. • Die Studierenden kennen die grundsätzlichen Methoden der Umwelt- und Sicherheitstechnik. • Sie wissen, wie man aus einem Rohwasser ein Wasser für einen speziellen Einsatzzweck herstellt und kennen die grundlegenden Techniken zur Abwasserreinigung und haben die prinzipielle Vorgehensweise bei der Verfahrensplanung verstanden. Wie Abwasser durch produktionsintegrierte Maßnahmen vermieden bzw. verringert werden kann ist ebenfalls bekannt. • Abluftseitig kennen die Studierenden die gängigen Primär- und Sekundärmaßnahmen zur Verringerung bzw. Vermeidung von Emissionen. • Die Studierenden kennen die grundlegenden Techniken zur Abluft-/Abgasreinigung und haben die prinzipielle Vorgehensweise bei der Verfahrensplanung von Abluftreinigungsanlagen verstanden. • Sie kennen die grundlegenden Maßnahmen zur Erhöhung der Sicherheit von Verfahren. Sie kennen vorbeugende Maßnahmen die betriebliche Sicherheit hinsichtlich erhöhen. Hierzu zählen technische Sicherheitseinrichtungen, die betriebliche Sicherheitsorganisation sowie diverse Maßnahmen zur Gefahrenabwehr. • Sie sind in der Lage, Lösungen für Sicherheitsprobleme zu erarbeiten.

	• Es wird ein Verständnis für die gesellschaftliche und wirtschaftliche Bedeutung der Sicherheit- und Umwelttechnik entwickelt.
Contents:	Wasseraufbereitung • Wasservorkommen und Wasserqualität • Grundlegende Wasseraufbereitungsschritte • Adsorption • Wasserhärte, Calcit-Gleichgewicht • Enteisenung, Entsäuerung, Entgasung • Ionenaustauscher • Membranprozesse • Desinfektion des Trinkwassers • Trinkwasseraufbereitungsverfahren • Rein- und Reinstwasser Abwasserbehandlungstechniken • Abwasserarten und Abwasserbeschaffenheit, gesetzliche Anforderungen • Produktionsintegrierte Maßnahmen zur Vermeidung von Abwasser • Physikalische, biologische und chemische Abwasserbehandlung • Verfahren zur weitergehenden CSB-Elimination • Schlammbehandlung Luftreinhaltung/Abgasreinigung • Atmosphäre • Primärmaßnahmen zur Verringerung und Vermeidung luftseitiger Emissionen • Emissionen aus Verbrennungsprozessen • Kondensation* • Absorption • Adsorption • Entstickung von Feuerungsabgasen • Oxidationsverfahren • KfZ-Abgasreinigung • Spezielle Verfahren der Abgasreinigung Sicherheitstechnik • Arbeitssicherheit und Sicherheitsmanagement • Sicherheitsgerichtete Technik

	• Schutz vor gefährlichen Stoffen • Brand- und Explosionsschutz • Sicherheitstechnische Kennzeichnung • Verfahren- und Anlagensicherheit
Textbooks:	Umwelttechnik 1. Görner, Hübner, Umweltschutztechnik, Springer Verlag 2. Bank, Basiswissen Umwelttechnik, Vogel Buchverlag, Würzburg 3. Stefan, Wasseraufbereitung, Chemie und chemische Verfahrenstechnik, VDI 4. Mudrack, Biologie der Abwasserreinigung, Spektrum Akademischer Verlag 5. Janke, Umweltbiotechnik, UTB Sicherheitstechnik 6. Bender, Das Gefahrstoffbuch: Sicherer Umgang mit Gefahrstoffen nach REACH und GHS, Wiley-VCH 7. Blass, Entwicklung verfahrenstechnischer Prozesse, Springer Verlag 8. Lehder, Taschenbuch Arbeitssicherheit, E. Schmidt-Verlag 9. Lehder, Taschenbuch Betriebliche Sicherheitstechnik, E. Schmidt-Verlag
Assessment	Graded exam (2 hours)

110121 Humanbiology

Study Program **Study level and semester**	BWB Bachelor, 1 semester
ECTS Credits	3 Credits
Hours per week / total contact hours	2 / 30
Total hours of study	150
Type/Teaching Method	Lecture
Language of instruction	German
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Petra Groß-Kosche Email: Petra.Gross-Kosche@Reutlingen-University.DE
Restrictions (falls zutreffend)	Only students with sufficient German knowledge
Prerequisites:	
Course learning objectives:	• Die Studierenden können die Bestandteile einer Zelle identifizieren, können Organsysteme benennen und können grundlegende Methoden den verschiedenen Schritten des wissenschaftlichen Arbeitens zuordnen. • Die Studierenden können den Aufbau und die Funktion menschlicher Zellen mit englischsprachigen Fachbegriffen beschreiben. • Die Studierenden können grundlegende physiologische Abläufe im menschlichen Körper (Verdauung, Atmung, etc.) erklären. • Die Studierenden können eine Literaturrecherche mit Hilfe von Datenbanken durchführen und laborvorbereitende Rechenaufgaben lösen. • Die Studierenden können die zugrundeliegenden Mechanismen für wichtige Zellfunktionen (Kommunikation, Migration, Vermehrung, Zelltod) identifizieren. • Die Studierenden können die Funktionsweise von Organsystemen (Herz-Kreislauf, Nervensystem, Lunge, etc.) vereinfachen. • Die Studierenden können numerische Datensätze auswerten und daraus graphische Ergebnisse generieren. • Die Studierenden können den Aufbau einer schriftlichen wissenschaftlichen Arbeit mit den entsprechenden Abschnitten planen.
Contents:	• Aufbau der Zelle • Funktionen der Zellbestandteile

	• Kommunikation zwischen Zellen • Zellvermehrung und Zelltod • Hämatopoetisches System und Immunsystem • Aufbau und Funktion verschiedener Organsysteme mit folgenden Schwerpunkten • Herz-Kreislaufsystem • Nervensystem • Atmung • Ernährung und Verdauung • Ausscheidung • Reproduktion • Wissenschaftliche Dokumentation (Laborjournal, Berichte) • Wissenschaftliche Recherche (Datenbanken) • Wissenschaftliche Veröffentlichungen • Grundlagen Labor (Ausrechnen von Konzentrationen, Verdünnungen, etc.)
Textbooks:	1. Lodisch H., Berk A., Zipursky S.L., Matsudaira P., Baltimore D., Darnell j.E.: Molekulare Zellbiologie; Spektrum Akademischer Verlag 2. Alberts, Bray, Hopkin, Johnson, Lewis, Raff, Roberts, Walter: Lehrbuch der molekularen Zellbiologie; Wiley-VCH 3. Karp G., Beginnen K., Vogel S., Kuhlmann-Krieg S.: Molekulare Zellbiologie, Springer-Lehrbuch 4. Silbernagel S, Despopoulus A: Taschenatlas Pysiologie, Thieme ISBN 978-3-13-567708-8 5. Schmidt RF, Lang F, Heckmann M: Physiologie des Menschen, Springer, ISBN 978-3-662-54121-0 6. Sobotta, J., Welsch, U: Atlas Histologie: Zytologie, Histologie, Mikroskopische Anatomie Urban & Fischer Verlag/Elsevier GmbH ISBN-10: 3437431412 7. Kremer BP, Bannwarth H.: Einführung in die Laborpraxis, Springer, ISBN 978-3-642-54334-0
Assessment	Written exam (2h)

110131 Lab Instrumental Analysis

Study Program **Study level and semester**	ACB Bachelor, 6 semester
ECTS Credits	3 Credits
Hours per week / total contact hours	2 / 30
Total hours of study	90
Type/Teaching Method	Laboratory
Language of instruction	English
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Wolfgang Honnen Email: Wolfgang.Honnen@Reutlingen-University.DE
Restrictions (falls zutreffend)	
Prerequisites:	Knowledge in organic chemistry and basic knowledge in analytical chemistry
Course learning objectives:	To become familiar with instrumental analytic techniques and ecotoxicological methods through theoretical instruction, practical experiments, demonstrations and projects. To become familiar with the development of analytical methods. To become familiar with evaluation procedures and principles of documentation as well as the scientific reporting and presentation of experiment results. To understand the application possibilities in practice as well as the limitations and significance of analytical results.
Contents:	• Basic principles of sample collection and sample preparation techniques • infrared spectroscopy, photometry, thin layer chromatography, gas chromatography, AOX, TOC, atomic absorption spectrometry, ion chromatography, HPLC, GC-FID, GC-ECD, GC-MS, polarography, ecotoxicological methods • development of analytical methods • documentation of experimental results
Textbooks:	1. Douglas A. Skoog, F. James Holler, Stanley R. Crouch: Principles of Instrumental Analysis, Cengage Learning, (2017) 2. Robert Kellner (Editor), Jean-Michel Mermet (Editor), Matthias Otto (Editor), Miguel Valcárcel (Editor), H. Michael Widmer (Editor): Analytical

	Chemistry: A Modern Approach to Analytical Science, 2nd Edition, Wiley-VCH (2004)
Assessment	Lab work

110141 Study Project

Study Program **Study level and semester**	ACB;BWB Bachelor, semester
ECTS Credits	2 Credits
Hours per week / total contact hours	2 / 30
Total hours of study	60
Type/Teaching Method	project work
Language of instruction	English;German
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Ralf Kemkemer Email: Ralf.Kemkemer@Reutlingen-University.DE
Restrictions (falls zutreffend)	
Prerequisites:	
Course learning objectives:	The student can work on a small project independently.
Contents:	Each project is to be discussed on an individual basis.
Textbooks:	
Assessment	Project report

150011 Technology Management

Study Program **Study level and semester**	PAT Master, 1 semester
ECTS Credits	5 Credits
Hours per week / total contact hours	4 / 60
Total hours of study	150
Type/Teaching Method	Lecture
Language of instruction	English
Frequency	winter semester
Course Coordinator/Instructor	Prof. Dr. Alexander Schuhmacher Email: Alexander.Schuhmacher@Reutlingen-University.DE
Restrictions (falls zutreffend)	None
Prerequisites:	Basic understanding of good laboratory practice and project management principles, no further special prerequisites
Course learning objectives:	Innovation & project management: Understanding of innovation strategies and processes. Understanding of the significance of the context of innovation strategy for the daily business of researchers in an R&D organization. Learn how a portfolio of projects is managed efficiently and effectively. Understand the principles of project life-cycle-management. Quality Management Understanding the concepts of quality management Understanding the responsibilities and tasks of QM in daily business
Contents:	Innovation Management Economic relevance of innovation Innovation strategies Innovation processes Open innovation Portfolio management Seite 18 von 28

	Product life-cycle-management Quality Management Basic systems of quality management QM Tools & procedure Normative systems and standards Examples from industry
Textbooks:	1. Gassmann O. et al. (2004) Leading Pharmaceutical Innovation. Springer Verlag 2. Schein EH (1997) Organizational Culture and Leadership. Jossey-Bass Publishers 3. S. Nokes and S. Kelly. Guide to Project Management. FT Press (2003) 4. L. Brwon and T. Grundy (2011) Project Management for the Pharmaceutical Indsutry. Gower Publishing Company 5. R.D. Austin (2004) Managing projects large and small. Havard Business Essentials 6. PMI (2008) The Standard for Portfolio Management. 2nd edition. Project Management Institute 7. A. Schuhmacher, M. Hinder, O. Gassmann (2015) Value Creation in the Pharmaceutical Industry: The Critical Path Towards Innovation, Wiley International
Assessment	Graded: Written exam (2 hours)

150021 Process Engineering and Industrial (Bio)Chemistry

Study Program **Study level and semester**	ACM;BMS;PAT Master, 1 semester
ECTS Credits	5 Credits
Hours per week / total contact hours	4 / 60
Total hours of study	150
Type/Teaching Method	Lecture
Language of instruction	English
Frequency	winter semester
Course Coordinator/Instructor	Prof. Dr. Wolfgang Honnen Email: Wolfgang.Honnen@Reutlingen-University.DE
Restrictions (falls zutreffend)	Admission capacity for this course is limited
Prerequisites:	Knowledge in physics, chemistry, mathematics
Course learning objectives:	Knowledge Knowledge of important fundamentals in chemical engineering Knowledge of the importance of mechanical and thermal unit operations Knowledge of important examples of industrial chemical and bio chemical plants Skills Ability to apply principles of fluid mechanics in calculations for technical processes Ability to understand the physical basis of chemical engineering and to govern methods based on it. Ability to understand the significance of heat and mass transfer and in nature and technology and estimate and calculate heat and mass transfer processes Technical competences Competent application of the mechanical and thermal unit operations, which are important in the assessment of devices or equipment in the process engineering industries

	Competence to interpret such technical systems in the students' future careers or to virtually understand, operate and master complete processes based on the acquired knowledge. Competence to assess critically conventional solutions, to improve or to replace them with new solutions. Social competence Ability to think conceptually Development and strengthening of team and communication skills
Contents:	1. Fundamentals of chemical engineering Mass and energy conservation Fluid mechanics (fluid statics, fluid dynamics, Bernoulli's energy equation and metering of flows with examples) Phase transitions Heat and mass transfer 2. Selection of mechanical and thermal unit operations Mixing and agitation Filtration Heat exchange, in particular heat transfer processes with phase change Distillation Adsorption Absorption Crystallization Drying 3. Selected flowsheets (examples of industrial chemical and bio-chemical plants)
Textbooks:	1. Jess, Andreas; Wasserscheid, Peter: Chemical Technology, An Integral Textbook, Wiley-VCH (2013) 2. McCabe, Warren L.; Smith, Julian C.;Harriott, Peter: Unit Operations of Chemical Engineering, International Edition, McGraw-Hill Higher Education, 7th ed. (2005) 3. Doran, Pauline M.: Bioprocess Engineering Principles, Academic Press, 2. ed. (2012) 4. Katoh, Shigeo; Horiuchi, Jun-ichi; Yoshida, Fumitake: Biochemical Engineering, A Textbook for Engineers, Chemists and Biologists, Wiley-VCH , 2nd, rev. and enl. ed. (2015)
Assessment	Graded: Written exam (2h), presentation

150031 Materials and Applications in Biomedical Sciences

Study Program **Study level and semester**	BMS Master, 1 semester
ECTS Credits	5 Credits
Hours per week / total contact hours	4 / 60
Total hours of study	150
Type/Teaching Method	Lecture
Language of instruction	English
Frequency	winter semester
Course Coordinator/Instructor	Prof. Dr. Rumen Krastev Email: Rumen.Krastev@Reutlingen-University.DE
Restrictions (falls zutreffend)	None
Prerequisites:	Basic understanding of chemistry, biology and biomedical technology, material sciences
Course learning objectives:	Basic knowledge • Knowledge of materials for biomedical application in in-vitro and in-vivo applications • Understanding of technologies for surface modifications for implants and related methods • Knowledge of biomedical implant technologies - application examples and challenges • Understating of drug delivery concepts and application of polymers • Understanding of drug release methods, kinetics and applications Technical competences: • Students will be able to understand surface and polymer chemistry technologies and transfer these to appropriate applications in the biomedical field • Students will be able to identify technical working principles of complex implants • Students will be able to understand the complexity of tissue-material interaction and relate this to material properties

	• Students will be able to classify the suitability of different materials classes for specific applications • Students will be able to name limitations of current technologies in the field Social competences: • Students develop skills in research, reading and interpretation of scientific texts • Students gain an awareness of ethical aspects in the development of medical products.
Contents:	Functional Implants & Surface Technologies Materials and design principles of passive and active implants, examples and applications, surfaces and surface modifications, technical principles of active implants (examples), micro and nanotechnology, surface chemistry, interaction of cells with materials. Drug Release and Delivery Systems Medical devices (active and passive) as drug delivery systems examples and applications Approaches, formulations, technologies, and systems for transporting of active pharmaceutical compounds as needed to achieve the desired therapeutic effect Immobilisation and delivery of “biologicals” e.g. peptides, proteins, antibodies, vaccines and gene based drugs Release based on diffusion, degradation, swelling, and affinity-based mechanisms Current approaches – site and time specific targeting, facilitated pharmacokinetics Example techniques – thin polymer film delivery, acoustic or light targeted delivery, liposomal delivery.
Textbooks:	1. King M.R.: Principles of Cellular Engineering – Understanding the Biomolecular Interface, Academic Press, 2006 2. Ritter A.B., et al.: Biomedical Engineering Principles, CRC Press, 2012 3. Narayan R.: Biomedical Materials, Springer Publisher, 2009 4. Ratner B.D. et al.: Biomaterial Sciences, Elsevier Oxford, 2012 5. Wintermantel E., H. Suk-Woo Ha: Medizintechnik: Life Science Engineering, Springer 2009
Assessment	Graded: Written exam (2h), presentation/assignments

150041 Umweltchemie

Study Program **Study level and semester**	UWS Master, 1 semester
ECTS Credits	3 Credits
Hours per week / total contact hours	2 / 30
Total hours of study	90
Type/Teaching Method	Lecture
Language of instruction	Deutsch
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Wolfgang Honnen Email: Wolfgang.Honnen@Reutlingen-University.DE
Restrictions (falls zutreffend)	German level B1
Prerequisites:	Allgemeine Grundlagen der Chemie
Course learning objectives:	Es werden die folgenden Kenntnisse, Fertigkeiten und Kompetenzen erworben: Die Studierenden kennen die wichtigsten umweltchemischen Grundlagen und Zusammenhänge, insbesondere die in der Lithosphäre, Hydrosphäre und Atmosphäre ablaufenden und für die Umwelt bedeutsamen chemischen Prozesse und haben diese verstanden. Sie diskutieren umweltchemische Themen im Team, bewerten wissenschaftliche Beobachtungen und leiten daraus Handlungsstrategien für den Umweltschutz ab.
Contents:	Die Lehrveranstaltung vermittelt zum einen die wesentlichen Aspekte der Umweltchemie als Teildisziplin der chemischen Wissenschaften, wobei v.a. auf chemische Sachverhalte in der Lithosphäre, Hydrosphäre und Atmosphäre sowie auf die Bedeutung anthropogener Schadstoffeinträge eingegangen wird.
Textbooks:	1. R.A. Hites, J.D. Raff und P. Wiesen: Umweltchemie – eine Einführung mit Aufgaben und Lösungen, Wiley-VCH, 2017
Assessment	Graded: Klausur (60 Minuten)

150051 Umweltanalytik

Study Program **Study level and semester**	UWS Master, 1 semester
ECTS Credits	3 Credits
Hours per week / total contact hours	2 / 30
Total hours of study	90
Type/Teaching Method	Lecture
Language of instruction	Deutsch
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Wolfgang Honnen Email: Wolfgang.Honnen@Reutlingen-University.DE
Restrictions (falls zutreffend)	German level B1
Prerequisites:	Allgemeine Grundlagen der Chemie
Course learning objectives:	Es werden die folgenden Kenntnisse, Fertigkeiten und Kompetenzen erworben: Verstehen der Umweltanalytik als ein Instrument zur objektiven Bewertung von Umweltqualität Verstehen der rechtlichen Rahmenbedingungen der Umweltanalytik Einschätzung der Möglichkeiten und Grenzen der Umweltanalytik
Contents:	Rechtlicher Rahmen der Umweltanalytik Probenahme, Probenvorbereitung Umweltanalytische Verfahren in den Kompartimenten Wasser, Boden und Luft
Textbooks:	1. Schwedt, G.: Taschenatlas der Analytik, Wiley-VCH, 2007 2. Otto, M.: Analytische Chemie, Wiley-VCH Weinheim, 2011 3. Kolb, B.: Gaschromatographie in Bildern, Wiley-VCH Weinheim, 2003 4. Meyer, V. R.: Praxis der Hochleistungsflüssigchromatographie, Wiley-VCH Weinheim, 2009 5. Funk, W., Damann, V. & G. Donnevert: Qualitätssi-cherung in der analytischen Chemie, Wiley-VCH Weinheim, 2005
Assessment	Graded: Klausur (60 Minuten)

150061 Verfahrens- und Anlagentechnik

Study Program **Study level and semester**	UWS Master, 1 semester
ECTS Credits	2 Credits
Hours per week / total contact hours	2 / 30
Total hours of study	60
Type/Teaching Method	Lecture
Language of instruction	Deutsch
Frequency	summer semester;winter semester
Course Coordinator/Instructor	Prof. Dr. Wolfgang Honnen Email: Wolfgang.Honnen@Reutlingen-University.DE
Restrictions (falls zutreffend)	German level B1
Prerequisites:	Allgemeine Grundlagen der Chemie
Course learning objectives:	Es werden die folgenden Kenntnisse, Fertigkeiten und Kompetenzen erworben: Studierende verstehen die Grundlagen technischer Verfahren und Prozesse Studierende lesen und verstehen verfahrenstechnische Fließbilder Studierende verstehen die wichtigsten mechanischen und thermischen Grundoperationen Studierende verstehen großtechnisch bedeutsame Prozesse und die zugehörigen verfahrenstechnischen Anlagen
Contents:	Grundlagen der Verfahrenstechnik Grund-, Verfahrens-, RI-Fließbilder mechanische Grundoperationen thermische Grundoperationen Ausgewählte Beispiele relevanter großtechnischer Prozesse
Textbooks:	1. SCHWISTER, K. (2017): Taschenbuch der Verfahrenstechnik. Hanser Verlag München 2. SCHWISTER, K. (2009): Taschenbuch der Umwelttechnik. Hanser Verlag München

	3. WINNACKER, K. & L. KÜCHLER (1996-2005) : Chemische Technik. 8 Bände, Wiley-VCH 4. ANONYM (2002): Ullmann's Encyclopedia of Industrial Chemistry, 40 vols., 6th ed. Wiley-VCH
Assessment	Graded: Klausur (60 Minuten)

150071 Biomedical Technology and Regenerative Medicine

Study Program **Study level and semester**	BMS Master, 2 semester
ECTS Credits	5 Credits
Hours per week / total contact hours	4 / 60
Total hours of study	150
Type/Teaching Method	Lecture
Language of instruction	English
Frequency	summer semester
Course Coordinator/Instructor	Prof. Dr. Petra Kluger Email: Petra.Kluger@Reutlingen-University.DE
Restrictions (falls zutreffend)	
Prerequisites:	cell biology, physiology, biomaterials, tissue engineering, biomedical engineering
Course learning objectives:	• students get insight into biofabrication technologies for future perspectives in biomedical engineering • students get an overview of the materials and techniques used in Regenerative Medicine; state of the art in various clinical applications and the global market students know: • how to define biofabrication • basic principles for automation, especially for automated cell and tissue culture as well as clinical applications • different biofabrication technologies, their characteristics and their pros & cons • needed properties for a bioink, different materials used as bioink and their limitations • possible applications of these biofabrication technologies in biomedical sciences • how to define regenerative medicine • the characteristics of stem cells and their clinical use

	• different matrix components and their properties as well as the clinical applications of different matrices • the regulatory framework • key facts concerning the global regenerative medicine market • the state of the art in selected applications and the challenges students improve their ability in: • understanding and use new vocabulary • read, summarize and discuss about scientific topics prepare and present these results and short presentation in teams
Contents:	• Definition and short summary of fundamentals • Stem cells (basics and clinical applications) • Matrix (basics and clinical applications) • State-of-the-art clinical applications • Regulatory affairs and market
Textbooks:	1. • Gustav Steinhoff, Regenerative Medicine: From Protocol to Patient, Springer 2013 2. • Anthony Atala, Robert Lanza, James A., Thomson, and Robert M. Nerem, Principles of Regenerative Medicine, Elsevier, 2008 3. • Ratner, B. D., Hoffman A.S. et al. (eds.): Biomaterials Science - An Introduction to Materials in Medicine, Elsevier Academic Press, 2004 4. • Joseph Bronzino and Donald R. Peterson : The Biomedical Engineering Handbook, Fourth Edition: Four Volume Set, Crc Pr Inc; 2015
Assessment	Written exam (2 hours)