Hochschule
Bonn-Rhein-Sieg
University of Applied Sciences

Module Handbook
„Forensic Sciences“
Bachelor of Science (B.Sc.)

Department of Natural Sciences
University of Applied Sciences Bonn-Rhein-Sieg

Stand: 05.10.2022

Compulsory modules

Elective courses

Module	**General Chemistry**
Semester	1st Semester
Course leader	Dr. Ulf Ritgen
Lecturer	Dr. Ulf Ritgen, Antje Thielen
Language	English
Assignment to curriculum	**Compulsory course, 1st semester of Forensic Science**
Course units / Lesson hours per week (SWS)	The course consists of a lecture, an accompanying tutorial (exercises) and a laboratory course (experiments). Lecture: 2 lesson hours per week (SWS) Tutorial: 2 lesson hours per week (SWS); max. group size: 60 Laboratory course: 2 lesson hours per week (SWS); max. group size: 24
Student workload:	Contact hours / Private study Lecture: 30 / 30 Tutorial: 30 / 30 Laboratory course: 30 / 60 Total: 90 / 120 **Total (contact hours + private study): 210 hours**
Credits	7 ECTS
Prerequisites according to Examination Regulations	None
Recommendations	None
Learning Outcomes	The students are able to • compare the fundamental atom / matter models, • classify and safely handle substances, • classify chemical reactions with respect to their reaction type and explain the corresponding processes and observable phenomena, • recognise the effect of various parameters to the law of mass action, and • plan, conduct, and protocol basic chemical experiments, regarding material requirements, setup of apparatuses, and operation by • applying the models according to the respective task/problem, • using their knowledge about the characteristic properties of various classes of materials, • setting up reaction equations (including substance balance and charge balance), based on predefined information regarding reactants and/or products, • applying Le Chatelier's principle to predict expectable outcomes/observations, • actively applying their knowledge about the theoretical background of the experiments performed, the lab-specific hazards when handling

	dangerous materials and laboratory apparatuses, and the general precations for laboratory safety, and • documenting both performing the experiment and any observations in a laboratory journal in order to • explain chemical facts and concepts from both laboratory and "everyday life" systematically and using the proper terminology, • familiarise themselves autonomously with more complex facts and concepts of chemistry and related disciplines, based on the background knowledge gained within this module, • interpret, manipulate, and evaluate experimentally obtained data and present them both orally and in writing.
Summary content:	Lecture: atomic models (Bohr, Rutherford), atomic spectra the periodic table of the elements, orbitals, the Aufbau principle chemicals bonds (ionic, covalent, metallic, coordinative); intermolecular interactions chemical reactions and the dynamic equilibrium, the law of mass action, fundamentals / laws of thermodynamics acids and bases, the pH value (and corresponding calculations), buffer systems solubility and the solubility product redox reactions, electrochemical potentials, galvanic cells, the Nernst equation Laboratory course: Introduction to laboratory safety introductory experiments on the law of mass action, acid/base titrations, electrochemistry, coordination complexes
Assessment:	successful participation in the practical course, documented by lab reports and/or post-lab quizzes (non-graded) final modular examination in writing (120 min) - graded
Teaching style:	Lecture: presentation slides; blackboard/whiteboard (analogue or digital) Tutorial: exercise collections, blackboard/whiteboard (a/d) Laboratory course: written laboratory instructions and operating procedures, introductory videos, and presentations slides (a/d) seminar accompanying the laboratory course, especially covering interpretation, manipulation, and evaluating data.
Literature	D.D. Ebbing, S.D. Gammon, "General Chemistry", 11th ed. Houghton Mifflin S. Ortanderl, U. Ritgen, "Chemie - das Lehrbuch für Dummies", 2. Aufl., Wiley-VCH (in German).

Module:	**Structure and Characteristics of Materials**
Semester:	1st semester
Course leader:	Dipl.-Ing. (FH) Irina Marschall, Prof. Dr. Michael Heinzelmann
Lecturer:	Dipl.-Ing. (FH) Irina Marschall, Prof. Dr. Michael Heinzelmann
Language:	German
Assignment to curriculum:	**Compulsory course, 1st semester of Forensic Science** **Compulsory course, 1st semester of Chemistry with Material Science**
Course units/Lesson hours per week (SWS):	The course consists of: Lecture: 2 lesson hours per week Exercise: 2 lesson hours per week; max. group size: 30 Laboratory course: 2 lesson hours per week; max. group size: 20
Student workload:	Contact hours / Private study Lecture: 30 / 30 Tutorial: 30 / 45 Laboratory course: 30 / 45 Total: 90 / 120 **Total (contact hours + private study): 210 hours**
Credits	7 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	None
Learning outcomes:	The students will be able to • describe and understand the basic structures of materials and how they develop, • explain how the macroscopic characteristics of materials relate to their respective microscopic structures, • identify the relevant basic material properties in different applications, • and conduct basic material tests to characterize structures as well as mechanical and physical characteristics by • knowing the different atomic compositions of materials, • understanding how the atomic composition of a material influences the macroscopic behaviour, • understanding how the most common experiments in materials testing work, in order to • determine materials properties • select the best possible material for a given application, and • conduct failure analyses

Summary indicative content:	Lecture: • Terms and definitions • The texture and structure of metallic and polymer materials • Crystal lattices • Slip planes • Imperfections • Macromolecules and principles of synthesis methods • Homo-polymers and copolymers • Blends, bonding types and characteristics • Structural formula and property spectrum • Texturing in metallic and polymer materials • Introduction to the mechanics of solids: elasticity, elastic-plastic material performance, fatigue, toughness, abrasion and wear, thermal material performance, creep deformation and creep fracture, methods of mechanical material testing Tutorial: Exercises and case studies relating to the content of the lecture Laboratory course: Experiments to characterize the structure and determine important physical and mechanical characteristics of metals, and polymers (e.g. determination of density, electric conductivity, heat conductivity, coefficient of thermal expansion and glass temperature, microstructure characterization, tests to determine corrosive properties and corrosion/insulation rating, tests to identify plastics and polymerization, tensile and bending tests)
Assessment:	Modular examination - graded. Written final examination (90 min): 100%.
Teaching style:	Lecture: computer projector, overhead, blackboard Tutorial: compilation of exercises, blackboard, overhead, computer projector Laboratory course: written experiment instructions
Indicative bibliography/Sources:	Ashby / Jones: Werkstoffe 1, Spektrum Akademischer Verlag Schwab: Werkstofkunde und Werkstoffprüfung, Wiley Hornbogen, Eggler, Werner: Werkstoffe Hellerich, Harsch, Haenle: Werkstoff-Führer Kunststoffe, Thieme- Verlag Hornbogen, Warlimont: Metalle

Module:	**Mathematik**
Semester:	**1st semester**
Course leader:	Prof. Dr. Draber and Prof. Dr. Oligschleger
Lecturer:	Prof. Dr. Draber and Prof. Dr. Oligschleger
Language:	German
Assignment to curriculum:	**Compulsory course in the 1st semester of Forensic Sciences**
Course units/Lesson hours per week (SWS):	The course consists of a lecture and accompanying exercises Lecture: 4 SWS Exercises: 2 SWS group size: 20
Student workload:	Contact hours / Self-study Lecture: 60 / 60 Exercises: 30 / 30 Total: 90 / 90 **Total : 180 hours**
Credits	6 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	Bridging course Mathematics
Learning outcomes:	The students are able to • solve given problems and mathematical tasks with basic methods of differential and integral calculcus and apply analytical and numerical procedures in mathematics and related fields • recognize the elementary functions, derivatives and integration methods and procedures to be used in practical questions and carry out basic calculations yourself by • using the presented functions, analytical methods and numerical procedures confidently • knowing, distinguishing and assessing the presented methods and procedures in order • to be able to safely and independently use suitable mathematical functions, analytical and numerical methods in the laboratory and everyday work and to be able to carry out corresponding calculations
Summary indicative content:	<u>Lecture:</u> • Quantities, real numbers and intervals, complex numbers, linear and quadratic equations, binomial theorem. • Functions and curves: definition and representation, understanding as a mapping, general functional properties, polar coordinates, consequences: limit value and continuity of a function, polynomials, fractional rational functions, power functions, trigonometric functions and arc functions, exponential functions and logarithmic functions, logarithmic representations (logarithmic paper). • Differential calculus: derivation as a tangent slope, derivation of the elementary functions, derivation rules, higher derivatives, linearization of a function, characteristic curve points and extreme value problems, curve discussion, numerical zero point search. • Integral calculus: integration as the inverse of the derivative, definite integral as area, indefinite integral, fundamental theorem of differential and integral calculus, important integrals, calculation of certain integrals, integration rules and methods, substitution, partial

	integration, numerical integration, some applications of integral calculus. • Power series, Taylor series: Infinite series, power series, Taylor series, limit value rule from de L'Hospital. Exercise: • Exercise sheets for the subject areas are worked on and discussed on a weekly basis
Assessment:	written exam (120 min)– graded
Teaching style:	Lecture: blackboard, overhead projector, beamer; lecture slides; textbooks Exercise: blackboard; slides; textbooks
Indicative bibliography/ Sources:	Lothar Papula, Mathematik für Ingenieure und Naturwissenschaftler, vieweg Verlag, Braunschweig Wiesbaden. Band 1,2 und 3. Manfred Brill, Mathematik für Informatiker, Hanser Verag, München, Wien, 2. Auflage, 2005 K. Gieck, R. Gieck, Technische Formelsammlung, Gieck Verlag, Germering, 1995, 30. erweiterte Ausgabe. Alan J. Cann, Maths from Scratch for Biologists, John Wiley& Sons.

Module:	**Criminalistics: Material Evidence and Crime Scene Investigation**
Semester:	1st semester
Course leader:	Prof. Dr. Eßmann
Lecturer:	Chief of the Criminal Devision M. Mohr, Detective Chief Superintendent G. Prüfling (retd)., Detective Chief Superintendent N. Wirschem
Language:	German
Assignment to curriculum:	**Compulsory course in the 1st semester of Forensic Sciences**
Course units / Lesson hours per week (SWS):	Lecture: 1 lesson hour per week Tutorial: Laboratory course: 1 lesson hour per week, max. group size: 20
Student workload:	**Contact hours** / **Private study** Lecture: 15 / 30 Tutorial: Laboratory course: 15 / 30 **Total: 30 / 60** **Total (contact hours + private study: 90 hours**
Credits:	3 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	None
Learning outcomes:	The students are able to • recover and document material evidence which is admissible in court • process material evidence systematically by applying • the principles of forensic sciences to the recovery and analysis of material evidences analysis from crime scenes • the guidelines of proper documentation to the traces recovered from crime scenes • the rules, how material evidence is introduced at trials in order to • assess the results of a forensic crime scene investigation in the context of a court hearing • present the results of their own forensic analysis in court
Summary indicative content:	Lecture: • The importance of a crime scene and of material evidence in criminal proceedings • The role of the expert witnesses in criminal proceedings • Forms of evidence, kinds of traces and methods of analysis • Evidence collection and evidence security • Case study Laboratory course: • Searching for and recovering evidence that is admissible in court • Independent analysis and documentation of this evidence • Defence and discussion of the results

Assessment:	Modular examination - ungraded. Active participation will be demonstrated by preparing a lab report and a case study.
Teaching style:	L: overhead projector, computer projector, blackboard P: written experiment instructions; PC
Indicative bibliography/Sources:	• R. Weihmann: Lehr- und Studienbrief Kriminalistik, VdP- Verlag, 2006 • Versuchsvorschriften und Sicherheitshinweise des FB Angewandte Naturwissenschaften • P. White (ed), Crime Scene to Court, The Essentials of Forensic Science, The Royal Society of Chemistry, London, 2004 • M. Benecke, Dem Täter auf der Spur. So arbeitet die moderne Kriminalbiologie - Forensische Entomologie und Genetische Fingerabdrücke, Lübbe Verlag, 2006 • B. Herrmann, K.S. Saternus, Biologische Spurenkunde, Bd.1, Kriminalbiologie 1; Springer Verlag, Berlin, 2007

Module:	**Computing Sciences**
Semester:	1st Semester
Course leader:	Prof. Dr. Ulrich Eßmann
Lecturer:	Prof. Dr. Ulrich Eßmann
Language:	English
Assignment to curriculum:	**Compulsory course in the 1st semester of Forensic Sciences** **Compulsory course in the 1st semester of Applied Biology**
Course units / Lesson hours per week (SWS):	Lecture: 2 lesson hours per week Tutorial: 2 lesson hours per week, max. group size: 30
Student workload:	Contact hours / Private study Lecture: 30 / 15 Exercise: 30 / 45 Lab work: 0 / 0 Total: 60 / 60 **Total (contact hours + private study): 120 hours**
Credits:	4 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	None
Learning outcomes:	The students are able to • analyse scientific data and prepare a visual presentation of the results • characterise scientific data with the measures of exploratory data analysis • apply numerical algorithms to the analysis of data sets and can implement these algorithms in a high-level programming language by using • spread sheets programs for the preparation of professional tables and graphs • functions of spread sheet programs for the calculation of the measures of descriptive statistics • spreadsheet programs to represent the data in professional tables and graphs • Python for the analysis of scientific data and the implementation of algorithms with the data structures of Python in order to • analyse scientific data and present them visually and characterise the data with the measures of descriptive statistics
Summary indicative content:	Lecture and tutorial: • Structure and mechanisms of spreadsheet programs • Calculations and functions in spreadsheet programs • Statistical measures for the characterisation of experimental distributions • numerical mathematics with mit spreadsheet programs • Basic concepts and structure of Python programs • Data structures and control structures in Python
Assessment:	The students provide evidence of active participation in the tutorial relating to the lecture by solving exercises in class and/or by taking a written test at the end of the semester.
Teaching style:	**Lecture**: computer projector presentation, notes on the blackboard

	Tutorial: notes on the blackboard, work sheets, practical computer exercises
Indicative bibliography/ Sources:	**Microsoft Excel** • Joseph E. Billo, Excel for chemists, Wiley, New York 2011 (has a lot of tips and tricks relevant for scientists) **Python** • https://www.python-kurs.eu/kurs.php (Deutsch und English) • Martin Jones, Python for Biologists, CreateSpace Independent Publishing Platform, 2015 • https://www.tutorialspoint.com/python/index.htm • https://www.w3schools.com/python/

Module:	**English for Forensics**
Semester:	1. Semester
Course Leader:	Peter Kapec
Lecturers:	Peter Kapec et al.
Language:	English
Assignment in Curriculum:	**Compulsory Course in 1st Sem. Naturwissenschaftliche Forensik**
Course Units/Credit hours:	Exercise: 3 credit hours; max. group size: 20
Students workload:	Contact hours Private study Exercise:: 45 45 **Total Sum: 90 hours**
Credits	3 ECTS
Prerequisites according to examination regulations:	None
Recommendations:	The course assumes that students have achieved a minimum CEF B1 level.
Learning outcomes:	The students will be able to • discuss, describe and give presentations about Forensics and other natural sciences, in English by • using grammatically correct language, accurate pronunciation and relevant technical vocabulary, and by conducting research, accessing information from English-language scientific journals and other sources in order to • be able to use English as a means of communication in their future projects and academic careers.
Summary indicative content:	• Introduction to the Periodic Table • Forensics • The History of Forensics • The Language of Mathematics and Numbers • Collecting Evidence • Analysing Evidence • Analysing the Body • Review of the Main Tenses • Forensics Vocabulary • Pronunciation Practice
Assessment:	Passing of module – graded Attendance requirement of at least 75% Type portfolio: • written final examination (120 min, weighting 50%) • scientific presentation (15 min, weighting 50%)
Teaching style:	Script, videos, examination preparation
Indicative Bibliography/Sources:	Script: English for Forensics

Module	**Analytical Chemistry**
Semester	2nd Semester
Course leader	Dr. Ulf Ritgen
Lecturer	Dr. Ulf Ritgen, Antje Thielen
Language	German
Assignment to curriculum	**Compulsory Course 2nd Semester of Forensic Science** **Compulsory Course 2nd Semester of Sustainable Chemistry with Material Science**
Course units / Lesson hours per week (SWS)	The course consists of a lacture, an accompanying tutorial (exercises) and a laboratory course (experiments). Lecture: 2 lesson hours per week (SWS) Tutorial: 2 lesson hours per week (SWS); max. group size: 60 Laboratory course: 2 lesson hours per week (SWS); max. group size: 24
Student workload:	Contact hours / Private study Lecture: 30 / 30 Tutorial: 30 / 30 Laboratory course 30 / 60 Total: 90 / 120 **Total (contact hours + private study): 210 hours**
Credits	7 ECTS
Prerequisites according to Examination Regulations	None
Recommendations	Participation in the Module General Chemistry and Allgemeine Chemie respectively
Learning Outcomes	The students are able to • Comprehend and reproduce the individual analytical processes, beginning with sampling and sample preparation up to independently implementing the respective determination method • Describe and explain the process using proper terminology • analyse, interpret, evaluate and present the analytical data obtained and • plan, perform, and record basic experiments with respect to setup, material requirements, and scheduling by • recognising and applying the various (electro-)chemical methods to the individual task at hand, • determining chemical compositions using fundamental (electro-)chemical analytical methods and validate the data obtained considering statistical and other sources of error regarding plausibility and accuracy, including taking appropriate steps for further analytical endeavours, to • Independently determine the chemical composition of selected samples based on laboratory instructions and operating procedures,

	• and assess potential working place hazards, including drawing necessary consequenses to ensure safety.
Summary content:	Lecture: Fundamentals of quantitative analytical chemistry; concepts, principles, and tools; standards; statistical considerations gravimetry based on aqueous solutions volumetry: acid/base titrations and precipitations titrations, complexometry; redox titrations electrogravimetry, coulometry conductometry potentiometry; electrodes (primary, secondary, tertiary cells); selected techniques selected special electrodes (incl. glas electrode); potentiometric pH determination; ion-sensitive electrodes Practical course: Practical performance (including protocolling, interpretation, and evaluation) of various analytical methods covered in the lecture: conductometric titrations; ion-sensitive electrodes in their application; selected gravimetric methods; auto-indicating and indicator-dependent redox systems (permanganometry, iodometry).
Assessment:	Portfolio exam: lab report + final examination in writing (120 min) – graded.
Teaching style:	Lecture: presentation slides; blackboard/whiteboard (analogue or digital) Tutorial: exercise collections, blackboard/whiteboard (a/d) Laboratory course: written laboratory instructions and operating procedures, introductory videos, and presentations slides (a/d) seminar accompanying the laboratory course, especially covering interpretation, manipulation, and evaluating data (a/d).
Literature:	D.C. Harris, Lehrbuch der Quantitativen Analyse, 8. Aufl., Springer 2014 (dazu Arbeitsbücher: U. Ritgen, Analytische Chemie I, Springer 2019 und U. Ritgen, Analytische Chemie II, Springer 2020). G. Schwedt, T.C. Schmidt, O.J. Schmitz, Analytische Chemie – Grundlagen, Methoden und Praxis, 3. Aufl., Wiley-VCH 2016. M. Otto, Analytische Chemie, 5. Aufl., Wiley-VCH 2019. G. Jander, K.-F. Jahr, Maßanalyse, 18. Aufl., de Gruyter 2012. U. Ritgen, Analytische Chemie für Dummies, Wiley-VCH **2021**.

Module:	**Microscopy**
Semester:	2nd semester
Course leader:	Dipl.-Ing. (FH) Irina Marschall
Lecturer:	Dipl.-Ing. (FH) Irina Marschall
Language:	German
Assignment to curriculum:	**Compulsory course in the 2nd semester of Forensic Sciences**
Course units/Lesson hours per week (SWS)	The course consists of: Lecture: 1 lesson hours per week Tutorial: 1 lesson hours per week Laboratory course: 1 lesson hours per week
Student workload:	Contact hours / Private study Lecture: 15 / 15 Tutorial: 15 / 30 Laboratory course: 15 / 30 Total: 45 / 75 Total (contact hours + private study): 120 hours
Credits:	3 ECTS
Prerequisites according to Examination Regulations	None
Recommendations:	Pass in the modular examination for the course entitled "Structure and Characteristics of Materials"
Learning outcomes:	The students will be able to • describe the basic functional principles of various microscopes • explain the areas of application of a wide variety of microscopes • understand the use of the different microscopes and their application in material science tasks • explain basic microscopic experiments • characterize the structure and properties of the materials by describing • the applications of standards to the evaluation of microscopic examinations of technical materials • the interpretation of sample images from the field of materials science • the basic principles of the most important applications of microscopy to materials science in order to • scientifically examine different materials • perform forensic and scientific tasks • use the microscopic methods that are most suitable for the various materials • carry out microscopic analysis independently

Summary indicative content:	Lecture: • terms and definitions • different types of microscopes • systematic approach to microscopy • methods of investigation based on light microscopy • methods of investigation based on electron microscopy • preparation methods for light and electron microscopy Tutorial: • tasks and forensic case studies relating to the lecture Laboratory course: • conduct investigations using light and electron microscopes • practical applications of various preparation techniques • conduct forensic investigations of defined microscopic specimen slides • identification of common textile fibers • scientific photography for analysis and documentation • basic image processing and image capture
Assessment:	Modular examination – graded Written final examination (60 min)
Teaching style:	Lecture: notes on the blackboard, computer projector Tutorial, laboratory course: Learning by Doing (example exercises under supervision)
Indicative bibliography/Sources:	Schade, Karl-Heinz; Lichtmikroskopie: Technologie und Anwendung; verlag moderne industrie; Landsberg / Lech; 1993; ISBN 3-478-93107-X Kern, Martin, Jörg Trempler: Beobachtende und messende Mikroskopie in der Materialkunde: Ein Leitfaden für die Praxis; Brünne-Verlag; Berlin; 2007; ISBN 978-3-9809848-6-7 Gottfried W. Ehrenstein: Mikroskopie; Lichtmikroskopie, Polarisation, Rasterkraftmikroskopie, Fluoreszenzmikroskopie, Rasterelektronenmikroskopie; Carl Hanser Verlag München; 2020; ISBN: 9783-3-446-46201-4

Module:	**Physics/Statistics 1**
Semester:	**2nd semester**
Course leader:	**Prof. Dr Sebastian Chmel**
Lecturer:	Prof. Dr. Silke Draber, Prof. Dr. Christin Oligschleger, Prof. Dr. Sebastian Chmel, Prof. Dr Sebastian Chmel
Language:	English
Assignment to curriculum:	**Compulsory course in the 2nd semester of Forensic Sciences**
Course units/Lesson hours per week (SWS):	The course consists of a lecture, an accompanying tutorial (exercises) and a laboratory course (experiments). Lecture: 2 SWS Physics + 1 SWS Statistics Tutorial: 1 SWS Physics + 1 SWS Statistics Laboratory course: 1 SWS Physics; group size: 24 (as a rule, 2 hours per experiment)
Student workload:	Contact hours / Private study Lecture: 45 / 30 Tutorial: 30 / 30 Laboratory course: 15 / 30 Total: 90 / 90 **Total : 180 hours**
Credits	6 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	Module Mathematics (1st semester)
Learning outcomes:	Physics: The students are able to: • explain the fundamental phenomena and principles of mechanics, mechanics of liquids and thermodynamics, and to describe these phenomena mathematically. • At the end of the tutorial, the students will be able to develop solutions to simple problems from the areas mentioned above. by • developing solutions for simple exercises out of the areas mentioned above and discuss about physical questions competently • Understanding and analysing or explaining profoundly experiments and equipment with the help of physical concepts out of mechanics and thermodynamics • conducting and evaluating simple experiments in a team, especially conduct ingstatistical analyses of the experimental data and determining possible sources of error. in order to • be able to plan and conduct safe and autonomously physical measurements in laboratory and everyday work • be able to develop adjustments or new concepts in laboratory and everyday work on the basis of the profound understanding, especially in case of possible difficulties (lost data, defect sensors etc.) • to act in natural science setting confidently with proper basis knowlegde • to evaluate and develop scientific arguments on the basis of physical basics

	• to learn the ropes in new scientific and/or forensic issueswith enough physical basics. • understand and use methods and thinking in natural sciences Statistics: Lecture and tutorial: The students are able to: • solve given problems and tasks with basic methods and technics of statistics • recognise in practical issues, which methods have to be applied, and to perform basic calculations. by • using the methods and techniques confidently • knowing, distinguishing and esvaluating the methods and techniques in order to • use statistical methods confidently and autonomously in laboratory and everyday work and persorm related calculations
Summary indicative content:	**Physics:** Lecture: Mechanics (kinematics and dynamics, forces, work and energy, momentum, mechanics of liquids and gases) Thermodynamics (definition of temperature, physical changes of solids and liquids due to temperature changes, ideal gases, kinetic theory of gases, First and Second Law of Thermodynamics, equation of states for real gases and vapors, heat conduction, material transport) Tutorial: • The concepts acquired during the lecture are applied to concrete situations to enhance the students' understanding of the principles involved. Laboratory course: • In small groups (as a rule, two students per experiment setup), the students conduct a range of experiments in the various subject areas of the module. (The types of experiments can vary within the framework of the study programme reforms). The experiments, taken from the subject areas of mechanics (translational motion with air tracks, density determination of liquids) and thermodynamics (e.g. temperature measurement, determination of heat capacities and enthalpies), are aimed at practising quantitative experimental work, including statistical analyses and error analyses (random versus systematic errors, error propagation, linear regression). In addition, the students widen the expertise acquired during the lecture and the tutorial by applying it to concrete practical examples. **Statistics:** Lecture: Samples; parameters of samples; error propagation: random and systematic errors, regression and correlation; linear regression; fitting of parametric functions; direct least square minimisation Probability calculus: combinatorics; probability experiments; probability; calculation of probabilities; conditional probabilities; probability density; definition of probability density; distribution functions; parameters of probability distributions; normal distribution, complex numbers

	Tutorial: • The concepts acquired during the lecture are applied to concrete situations to enhance the students' understanding of the principles involved.
Assessment:	Modular examination – graded The written examination (120 min) comprises all branches of the module. Successful participation in the laboratory course is a prerequisite for passing the modular examination.
Teaching style:	Lecture: blackboard, demonstration experiments, computer demonstrations (simulation animations) Tutorial: written compilation of exercises, blackboard Laboratory course: written experiment instructions, videos
Indicative bibliography/ Sources:	Physics: College physics, Urone, Brooks/Cole, Pacific Grove, CA Fundamentals of Physics, Halliday, Resnick, Walker: 6th Ed. Wiley, New York 2001 R. Feynman, Lectures on Physics, Massachusetts 1963 K. Weltner, Mathematics for physicists and engineers: fundamentals and interactive study guide [CD-ROM included], Berlin 2009 (englische Version des deutschen Lehrbuches und Leitprogrammes) J. Rybach, Physik für Bachelors, 2. Aufl., Leipzig 2010 J. Orear, Physik, dt. Ausgabe, München 1982 W. Demtröder, Experimentalphysik 1 - Mechanik und Wärme, Berlin 2013 Statistics: Mathematik für Ingenieure und Naturwissenschaftler, L. Papula, Band 3, 2. Auflage Experimental Methods, Les Kirkup, Wiley, Brisbane 1994 Primer of Biostatistics, S. A. Glantz: 5th Ed., McGraw-Hill, New York 2002 Introduction to Statistics for Forensic Scientists, David Lucy, Wiley, 2006

Module:	**Fundamentals of Biology**
Semester:	2nd semester
Course leader:	Prof. Richard Jäger
Lecturer:	Prof. Richard Jäger
Language:	English
Assignment to curriculum:	**Compulsory course in the 2nd semester of Forensic Sciences**
Course units/Lesson hours per week (SWS):	The course consists of: Lecture: 2 lesson hours per week Exercise: 2 lesson hours per week Laboratory course: 2 lesson hours per week; max. group size: 18
Student workload:	Contact hours / Private study Lecture: 30 / 30 Exercieses: 30 / 30 Lab work: 30 / 60 Total : 90 / 120 **Total (contact hours + private study): 210 hours**
Credits:	7 ECTS
Prerequisites according to Examination Regulations:	none
Recommendations:	none
Learning outcomes:	The students are able to • explain the molecular basis of important cellular and physiological functions • calculate the frequencies of combined genotypes based on the parental genotypes • carry out and evaluate basic molecular-biological analyses by • applying knowledge about the basics of cellualr processes • understanding the biosynthesis, structure and function of proteins and nucleic acids • applying the combinatorics resulting from meiosis and karyogamy • learn how to perform basic DNA-analystical technquies such as agarose gel electrophoresis and PCR, serological assays and forensic enzyme assays in order to • apply and document basic bioanalytical techniques • be prepared for learning advanced forensic DNA analytical methods
Summary indicative content:	Lecture: • Introduction to the biology of cells and organisms. • The cell: cell organelles, biomembranes, energy metabolism, enzymes. • Proteins: structure and function

	• Nucleic acids: Biosynthesis, transcription and translation, human chromosomes the cell cycle, mitosis • Fundamentals of genetics: meiosis, polymorphisms, Mendelian genetics, sex-linked and mitochondrial inheritance • human biology: tissues, cell types, immunology Laboratory course: • Microscopic analysis of cells from human blood and the mucosa of the mouth • forensic identification of saliva and blood, blood group analysis • Bradford assay, SDS-PAGE and Western blot of immunoglobulins • restriction digest, PCR analysis, agarose gel electrophoresis of DNA
Assessment:	Written examination (120 min) – graded Requirements: Successful participation in practical course, documented by a laboratory report
Teaching style:	Lecture: Power Point presentation, textbook Laboratory course: written experiment instructions, textbooks
Indicative bibliography/ Sources:	John M. Butler: Fundamentals of Forensic DNA Typing (Elsevier) William Goodwin, Adrian Linacre, Sibte Hadi: An Introduction to Forensic Genetics, 2nd Edition (Wiley-Blackwell)

Module:	**Metals and Alloys**
Semester:	2nd semester
Course leader:	Prof. Dr.-Ing. Christian Dresbach
Lecturer:	Prof. Dr.-Ing. Christian Dresbach and Prof. Dr.-Ing. Michael Heinzelmann
Language:	German / English
Assignment to curriculum:	**Compulsory course in the 2nd semester of B.Sc. Forensic Sciences** **Compulsory course in the 4th semester of B.Sc. Sustainable Chemistry and Materials**
Course units/ Lesson hours per week (SWS):	The course consists of: Lecture: 2 lesson hours per week Exercise: 2 lesson hours per week Practical course: 2 lesson hours per week
Student workload:	Contact hours / Private study Lecture: 30 / 30 Exercise: 30 / 45 Practical course: 30 / 45 Total: 90 / 120 **Total (contact hours + private study): 210 hours**
Credits	7 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	Successful completion of the module "Structure and Characteristics of Materials"
Learning outcomes:	The students are able to • evaluate comparatively technical materials by considering aspects of sustainability, • explain the relations between microstructure and mechanical properties of metals, • put the material properties into context of chemical composition, manufacturing process and heat treatment of metal alloys by means of • comparing material properties in the context of application, • evaluating phase and transformation diagrams, • performing and interpreting mechanical-technological investigations, • analysing and evaluating the microstructure in order to • identify appropriate metallic materials for sustainable applications, • modify metallic materials for specific applications, • perform technical failure analyses and evaluations.
Summary indicative content:	Lecture: • Crystal structure and microstructure of metals and alloys • Mechanical properties of metals • Microstructural hardening mechanisms • Phase diagrams • Iron-carbon diagram

	• Heat treatment of metals • Manufacturing and joining technologies of metallic components • Economic and ecological aspects in material selection • Failures in metals during manufacturing, processing and application Exercise: • Exercises and examples regarding the content of the lecture Practical course: • Determining and comparative discussing of mechanical-technological, chemical-technological and metallographic properties of metal alloys
Assessment:	Written examination (20 min) – graded Requirements: Successful participation in practical course
Teaching style:	Lecture/Exercise: power point presentation, whiteboard/blackboard, videos, textbooks, written task collection, learning games Practical course: written experimental instructions, guided lab courses
Indicative bibliography/Sources:	Ashby &. Jones: "Werkstoffe 1, Eigenschaften, Mechanismen und Anwendungen", herausgegeben von Michael Heinzelmann, Elsevier / Spektrum Akademischer Verlag, 2006 english version: Ashby & Jones: Engineering Materials 1, 5th edition, 2019 Ashby &. Jones: „Werkstoffe 2, Metalle, Keramiken und Gläser, Kunststoffe und Verbundwerkstoffe", herausgegeben von Michael Heinzelmann, Elsevier / Spektrum Akademischer Verlag, 2006 english version: Ashby & Jones: Engineering Materials 2, 4th edition, 2013 Gottstein: „Materialwissenschaft und Werkstofftechnik", 4. Auflage, Springer Vieweg, 2014 Bargel & Schulze: „Werkstoffkunde", 12. Auflage, Springer Vieweg, 2018 Hornbogen et al.: „Werkstoffe", 11. Auflage, Springer, 2017 Läpple: „Wärmebehandlung des Stahls", Europa Lehrmittel, 11. Auflage, 2014

Module:	**Organic Chemistry**
Semester:	3rd semester
Course Leader:	Prof. Dr. Margit Schulze
Lecturer:	Dr. Kai Jakoby, Prof. Dr. Margit Schulze
Language:	English
Assignment to curriculum:	**Compulsory Course 3rd semester BSc Forensic Sciences**
Course units/ Lesson hours per week (SWS)	Lecture: 2 SWS Exercises: 2 SWS Laboratory Course: 1 SWS (max. group size: 16)
Student workload:	Contact hours / Private study Lecture: 30 / 30 Exercises: 30 / 50 Laboratory Course: 15 / 25 Total: 75 / 105 **Total (contact hours + private study): 180 hours**
Credits	6 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	General Chemistry (1st sem.), Analytical Chemistry (2nd sem.)
Learning Outcomes:	The students are able to • identify and name the most common families of organic compounds and describe their physical porperties and their chemical reactivity, • present and predict typical organic reaction pathways including all the steps of the reaction mechanism and all the relevant stereochemical aspects, • explain how to analyze organic samples based upon the expected physical and chemical properties of compounds. • outline and comment on oxidative, hydrolytic and pH-dependent transformation processes of organic samples. by • exemplifying important relationships between chemical structure and properties based upon functional groups, • applying the concept of nucleophile and electrophile, • explaining the influence of resonance on the stability, reactivity, acidity and basicity of organic molecules, • describing suitable wet chemical tests for the identification of classes of compounds in organic samples, • performing fundamental laboratory techniques for the synthesis, the purification and the analysis of organic substances, in order to • evaluate the results of the forensic analysis of organic samples and draw onclusions from them, • to interpret the properties of organic samples and to recognize relevant chemical conversions.

Summary indicative content:	Lectures and Exercises: • Fundamental principles of organic chemistry (such as theory of chemical bonds and molecular structure), • Introduction into important classes of organic substances with a special focus on their physical and chemical properties (such as volatility, polarity, solubility, acidity / basicity, nucleophilicity) and on stereochemical aspects. • Presentation of typical chemical reactions of organic compounds including reaction mechanisms Laboratory Work: • Basic techniques of organic synthesis (such as heating under reflux, recrystallization, liquid-liquid extraction), • Basic techniques of analytical organic chemistry (such as determination of melting points and optical purities)
Assessment:	Written modular Examination (120 min) – graded. Requirements: Successful participation in the laboratory course, documented by a laboratory report.
Teaching style:	Lectures: Power Point Presentation, Document Visualizer, Whiteboard or Blackboard Exercises: Written Compilation of Exercise Problems, Whiteboard or Blackboard, Document Visualizer Lab Course: Written Experimental Instructions, Tablet PCs, Interactive Smartboard
Indicative Bibliography / Sources	1. Paula Y. Bruice, Organic Chemistry, Pearson Prentice Hall, 8th edition, 2017. 2. John McMurry, Fundamentals of Organic Chemistry, Brooks / Cole Cengage Learning, 7th edition, 2011. 3. R.G. Engel et al., Introduction to Organic Laboratory Techniques, Brooks / Cole Cengage Learning, 3rd ed., 2011.

Module:	**Solid Mechanics**
Semester:	3rd semester
Course leader:	Prof. Dr Michael Heinzelmann
Lecturer:	Prof. Dr Michael Heinzelmann
Language:	German
Assignment to curriculum:	**Compulsory course in the 3rd semester of Chemistry with Material Science** **Compulsory course in the 3rd semester of Forensic Sciences**
Course units/Lesson hours per week (SWS):	The course consists of: Lecture: 2 lesson hours per week Tutorial: 4 lesson hours per week; max. group size: 30
Student workload:	Contact hours / Private study Lecture: 30 / 30 Tutorial: 60 / 60 Total: 90 / 90 **Total (contact hours + private study): 180 hours**
Credits:	6 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	Basic lecture in Mathematics
Learning outcomes:	The students are able to determine • reaction forces and moments, • interior forces and moments, and • stresses and strains for elementary load cases as tension/compression, bending, torsion, and cylindrical pressure vessels and to compute equivalent stresses from these values by applying the basic principles of materials mechanics such as • free body diagrams • the equilibrium equations of statics • the direction dependence of stresses and strains as described by Mohr's circle in order to • carry out failure analyses, • calculate the load-carrying capacity and the deflection of structural components, and • evaluate and interpret mechanical materials testing results

Summary indicative content:	Lecture: • Basic terms and definitions • Static equilibrium at a point • Static equilibrium on a rigid body • Section sizes • Line loads • Calculation of the centre of gravity • Friction, stress tensor and Mohr's circle • Strain tensor • Material Law • Tensile stress/compressive stress, bending stress, torsion • Thin-walled containers under internal pressure • Superimposed stressing by mechanical loads • Euler bending Exercises: Exercises and case studies relating to the contents of the lecture
Assessment:	Modular examination – graded Written final examination (120 min) 100%
Teaching style:	Lecture: notes on the blackboard, tutorials on YouTube Tutorial: notes on the blackboard, compilation of exercises on the internet
Indicative bibliography/Sources:	Heinzelmann, Lippoldt: Technische Mechanik in Beispielen und Bildern, Spektrum Akademischer Verlag

Modulbezeichnung:	**Physics 2 and Statistics 2**
Studiensemester:	3. Semester
Modulverantwortliche(r):	Prof. Dr. Sebastian Chmel
Dozent(in):	Prof. Dr. Sebastian Chmel, Dr. Robin Janßen
Sprache:	Englisch
Zuordnung zum Curriculum	**Pflichtfach 3. Sem. Naturwissenschaftliche Forensik**
Lehrform/SWS	Die Lehreinheit besteht aus Vorlesungen, begleitenden Übungen und Experimenten. V: 2 SWS Physics 2+ 1 SWS Statistics 2 Ü: 1 SWS Physics 2s + 1 SWS Statistics 2: max. 30 P: 1 SWS; Gruppengröße: max. 24 (i.d.R. 2 Stud. pro Versuch)
Arbeitsaufwand:	Präsenzstunden / Eigenstudium V: 45 / 45 Ü: 30 / 45 P: 15 / 30 Summe: 90 / 120 **Summe total: 210 Stunden**
Kreditpunkte	7 ECTS
Voraussetzungen nach Prüfungsordnung	Keine
Empfohlene Voraussetzungen:	Erfolgreiche Teilnahme an den Modulen Mathematics und Physics/Statistics 1
Angestrebte Lernergebnisse:	Physics 2 (Vorlesung/Übung/Laborpraktikum): Die Studierenden können • die grundlegenden Phänomene und Prinzipien in den Teilgebieten Elektrizitätslehre, Magnetismus, Schwingungen und Wellen und Optik erläutern und mathematisch beschreiben. • quantitativ die Resultate naturwissenschaftlicher Experimente beschreiben und die Grenzen der Experimente auf Grund der inhärenten Fehlerquellen erkennen indem sie: • Lösungen für einfache Aufgaben aus den oben genannten Bereichen entwickeln und über physikalische Fragestellungen kompetent diskutieren • Experimente und Apparaturen mit Hilfe von physikalischen Konzepten aus der Elektrodynamik, der Optik, der Theorie der Schwingungen und Wellen verstehen und analysieren bzw. fundiert erläutern. • einfache Experimente im Team durchführen und auswerten, d.h. experimentelle Ergebnisse statistisch analysieren und Fehlerbetrachtungen durchführen um • im Labor- und Arbeitsalltag sicher und selbständig physikalische Messungen planen und durchführen zu können. • auf der Grundlage eines soliden Verständnisses im Labor- und Arbeitsalltag Anpassungen vornehmen oder neue

	Konzepte entwickeln zu können - insbesondere bei etwaigen Schwierigkeiten (verlorene/nicht verfügbare Daten, defekte Messgeräte o.a.) • sich im naturwissenschaftlichen Umfeld mit ausreichendem Basiswissen sicher bewegen zu können. • auf der Basis von physikalischen Grundkenntnissen wissenschaftliche Argumentationen beurteilen und entwickeln zu können • sich mit genügend physikalischem Grundlagenwissen in neue naturwissenschaftliche und/oder forensische Fragestellungen und Messverfahren einzuarbeiten • naturwissenschaftlich-technische Methoden und Denkweisen nachvollziehen und selbstständig anwenden zu können <u>Statistics (Vorlesung/Übung):</u> Die Studierenden können • verschiedene Verteilungsfunktionen nennen, erläutern und auf die grundlegenden Fragestellungen der schließenden Statistik anwenden • wichtige statistische Test verschiedene Methoden zur Stichprobennahme und den grundlegenden Ablauf der Datenanalyse erläutern. indem sie: • grafische Analysemethoden und statistische Tests anwenden um • im Labor- und Arbeitsalltag sicher und selbständig geeignete statistische Methoden einsetzen und entsprechende Berechnungen durchführen zu können
Inhalt:	<u>Physics 2</u> Vorlesung: • Schwingungen und Wellen (Mathematische Beschreibung, Überlagerung von Schwingungen und Wellen, Interferenz); • Optik (Huygens'sches Prinzip, Geometrische Optik, Wellenoptik, Beugung, Interferenz, Gitter, Dispersion, Polarisation); • Elektrizität (Ladungen, elektrisches Feld, Elektrostatik, elektrisches Potential, elektrischer Strom, Ohmsches Gesetz, Gleichstromkreise); • Magnetismus (bewegte elektrische Ladungen, Induktion, Selbstinduktivität, Magnetismus in Materie, Wechselstromkreise); • Anwendungen in der physikalischen Messtechnik Übungen: • Die in der Vorlesung erlernten Konzepte werden in den Übungen auf konkrete Anwendungsfälle angwandt und das Verständnis vertieft. Praktikum: • In Kleingruppen (in der Regel 2 Studierenden pro Versuchsstand) wird an ausgewählten Versuchen (die Art der Versuche können sich im Rahmen der Studiengangsreformen ändern) aus den unterschiedlichen Themengebieten des Moduls Versuche zur Schwingungslehre (Parameter zur Beschreibung einer Welle), Optik, Wellenoptik und Elektrizitätstslehre das quantitative experimentelle Arbeiten einschließlich der statistischen Analyse,

	sowie der Fehlerbetrachtung (zufällige und systematische Fehler, Fehlerfortpflanzung, lineare Regression) eingeübt. • Zusätzlich wird der Stoff aus der Vorlesung und Übung praktisch vertieft. <u>Statistics 2 (Vorlesung und Übung)</u> Vorlesung: • Spezielle Verteilungen: Binomialverteilung, Poissonverteilung, F-Verteilung, t-Verteilung, Chi-Quadrat-Verteilung • Testverfahren: F-Test, t-Test, Ausreissertest, Prüfung der Form einer Verteilung (Chi-Quadrat-Test) • Grafische Analysemethoden anhand verschiedener Diagrammtypen (Histogramm, Boxplot, Scatterplot, Quantilplot, usw.) Übungen: • Die in der Vorlesung erlernten Konzepte, Methoden und Tests werden auf konkrete Fälle angewandt und dadurch das Verständnis vertieft.
Studien-/Prüfungsleistungen:	Schriftliche Modulprüfung (120 min) – benotet Die Prüfung umfasst die einzelnen Teilbereiche des Moduls. Die erfolgreiche Teilnahme an den Laborübungen ist Voraussetzung zum Bestehen der Modulprüfung.
Medienformen:	V: Tafel, Präsentation, Demonstrationsversuche, Simulationsanimationen, Televorlesung, Lehrvideos Ü: schriftliche Aufgabensammlung, Tafel P: schriftliche Versuchsanleitungen, Anleitungsfilme
Literatur	Physics 2: - Fundamentals of Physics, Halliday, Resnick, Walker, Wiley, 2001 - R. Feynman, Lectures on Physics, Massachusetts 1963 - K. Weltner, Mathematics for physicists and engineers: fundamentals and interactive study guide [CD-ROM included], Berlin 2009 (englische Version des deutschen Lehrbuches und Leitprogrammes) - K. Weltner, Mathematik für Physiker, 2 Bände, 14. Auflage, Berlin 2008 - K. Weltner, Leitprogramm Mathematik für Physiker, 2 Bände, Berlin 2012 - J. Rybach, Physik für Bachelors, 2. Aufl., Leipzig 2010 - J. Orear, Physik, dt. Ausgabe, München 1982 - Gerthsen, Physik, Springer-Verlag, Berlin Messtechnik: - H.-R. Tränkler, Taschenbuch der Messtechnik, Verlag R. Oldenbourg, München - J. Niebuhr, G. Lindner: Physikalische Messtechnik mit Sensoren, Oldenbourg Verlag - J. Hoffmann, Taschenbuch der Messtechnik, Fachbuchverlag Leipzig Statistics - Fahrmeir, Künstler, Pigeot, Tutz: Statistik, Der Weg zur Datenanalyse. Springer-Verlag, 2007. - Papula: Mathematik für Ingenieure und Naturwissenschaftler Band 3. Vieweg+Teubner Verlag; Auflage: 6., überarb. u. erw. Aufl. 2011.

Module:	**Forensic Biology**
Semester:	3rd semester
Course leader:	Prof. Richard Jäger
Lecturer:	Prof. Richard Jäger
Language:	English
Assignment to curriculum:	**Compulsory course in the 3rd semester of Forensic Sciences**
Course units/Lesson hours per week (SWS):	The course consists of: Lecture: 2 lesson hours per week Exercise: 2 lesson hours per week Laboratory course: 2 lesson hours per week; max. group size: 18
Student workload:	Contact hours / Private study Lecture: 60 / 60 Lab work: 30 / 60 Total : 90 / 120 **Total (contact hours + private study): 210 hours**
Credits:	7 ECTS
Prerequisites according to Examination Regulations:	none
Recommendations:	Fundamentals of Biology
Learning outcomes:	The students are able to • explain the methods and field of application of forensic DNA analysis of human and non-human species • establish DNA profiles from forensic traces • calculate population frequencies of DNA profiles and probabilities of paternity by • understanding and applying methods of extracting and quantitating DNA from from forensic traces • understanding and applying the common PCR-based forensic analytical methods • being familiar with the currently used forensic STR systems (German, EU, and US) • evaluating and interpreting STR profiles from single sources • performing biostatistical calculations using population databses in order to • successfully carry out the different steps of a forensic DNA-analysis • be able to statistically evaluate and present the results of forensic DNA analyses
Summary indicative content:	Lecture: Application of forensic DNA profiling; identifying biological evidence; DNA isolation methods; short history of forensic biology; STR systems and their analysis via multiplex PCR and capilaary electrophoresis; population genetics, databses and calculation of random match probabilities; qPCR; profiling mtDNA; paternity testing; Y-STRs; forensic species determination (Cytb, COI, STRs)

	Practical course: DNA isolation from blood or buccal swabs; quantitation using real-time PCR; multiplex PCR analysis of STR loci using capillary electrophoresis; mtDNA-based determination of meat species; specific detection of human DNA using Alu PCR
Assessment:	Written exam (120 min) – graded Successful participation in the laboratory course , documented by a laboratory report, is a prerequisite for passing the final examination.
Teaching style:	Lecture: Power Point presentation, textbook Laboratory course: written experiment instructions, textbooks
Indicative bibliography/ Sources:	John M. Butler: Fundamentals of Forensic DNA Typing (Elsevier) William Goodwin, Adrian Linacre, Sibte Hadi: An Introduction to Forensic Genetics, 2nd Edition (Wiley-Blackwell)

Module:	**Law**
Semester:	**3rd semester**
Course leader:	VRLG Glasner
Lecturer:	VRLG Glasner
Language:	German
Assignment to curriculum:	**Compulsory course in the 3rd semester of Forensic Sciences**
Course units/Lesson hours per week (SWS):	The course consists of a lecture. Lecture: 4 lesson hours per week
Student workload:	Contact hours / Private study Lecture: 60 / 60 Total: 60 / 60 **Total (contact hours + private study): 120 hours**
Credits:	4 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	None
Learning outcomes:	The students are able to… • use the relevant legal sources of information • discriminate between civil law, administrative law and criminal law • apply the terms and definitions of criminal law to facts of a case • orientate themselves in the preliminary proceedings and the main proceedings of a crime procedure • explain the interrelations between law and forensic laboratory work by… • understanding of the differences between natural and legal sciences • knowing and applying the basic terms and processes relating to criminal law • being familiar and understanding selected areas of delicts and of facts of cases in criminal law and supplementary penal provisions • recognizing and learning how to solve typical problems in these areas of delicts that are related to questions of natural sciences • understanding the process of criminal procedures and the principles of taking evidence • being able to distinguish repressive from preventive police work • understanding the prerequistes of civil liability of the forensic expert • taking part in a real-world trial in order to • understand the importance and function of scientific methods in court preceedings • understand the role und responsibility of the scientific expert in court proceedings • understand the requirements for contents of a forensic expert report

Summary indicative content:	• Legal sources ofinformation and fields of law • Driving under the influence of alcohol • Systematic structure of legislation on road traffic offences • Systematic structure of legislation on narcotics • Structure of the Code of Criminal Procedure • Murder and manslaughter • sexual offenses and assaults • robbery and predatory extorsion • burglary and theft • property damage and arson offences • Criminal law, administrative offences, police law • Legal consequences of criminal offences • The criminal investigation procedure • The formal structure of the criminal sentence • the main proceedings of a crime procudure, principles of evidence-takingand the role of the scientific expert's report • structure of a sentence and case study • excursion: participation at a criminal hearing • expert liability • forms of action of the state
Assessment:	Modular examination – graded Written examination (120 min)
Teaching style:	Lecture: overhead, computer projector, blackboard
Indicative bibliography/Sources:	Nomos-Gesetzestexte Zivilrecht, Öffentliches Recht, Strafrecht (texts on civil law, public law and criminal law; translator's comment) Various court judgements (Federal High Court - Bundesgerichtshof, BGH; Higher Regional Court - Oberlandesgericht, OLG; Federal Constitutional Law - Bundesvefassungsgericht, BVerfG)

Module Title:	**Instrumental Analysis**
Semester:	Semester 4
Module supervisor:	Prof. Dr. Michaela Wirtz
Lecturer:	Prof. Dr. Michaela Wirtz
Language:	German and English
Reference:	**Mandatory module of the courses Forensic Sciences and Chemistry with Material Science (4th semester)**
Module Delivery/SPW (Semester Periods per Week):	This is a lecture based module supplemented with exercises and practicals. L: 3 SPW E: 1 SPW; max. 30 students per group P: 2 SPW; max. 24 students per group
Indicative Student Workload:	Contact Hours / Non-Contact Hours (Preparation and Follow-Up) L/E: 60 / 60 P: 30 / 60 Total 90 / 120 **Sum Total 210 Hours**
ECTS Points:	7
Prerequisites for Module (acc. examination regulations):	None
Corequisites for Module:	General Chemistry (1st semester); Analytical Chemistry (2nd semester); Physics/Statistics (2nd semester); Organic Chemistry (Fundamentals of Organic Chemistry and Biochemistry).
Learning Outcomes:	Students will be able to • Select suitable modern, instrumental techniques and methods for an analytical question, e.g. in a forensic context, and combine them into a procedure, • Estimate the basic validity of procedures on the basis of certain basic analytical parameters with regard to practical applications, • Discuss sustainability aspects of the methods with focus on ecologics and economics, • Interpret measurement results from analytical procedures, evaluate them sophisticatedly and present them in the context of the problem at hand, by • Acquiring detailed knowledge of the principles, techniques and methods of instrumental analyses (with a focus on chromatography, coupling techniques, molecular spectroscopy) in the lecture and learning to apply this to concrete problems with forensic nature in a networked manner in the exercises, • Learning to discuss the advantages and disadvantages of the techniques and methods, their deviation / error tendencies, their basic validity, sustainable developments in ecology, economy and efficiency in lecture and exercise, supported by the practical course, • Learning to link the theoretical knowledge with practical applications and to apply selected methodologies in the practical work,

	• Evaluating, interpreting and reflecting on the data collected in the practical experiments within the framework of the research question, to • Be able to select and optimise a valid, effective and sustainable method in scientific and economic forensic-analytical laboratory practice, • Classify and present the obtained data in the scientific and economic context of the research question and the set framework conditions, • Study advanced forensic-analytical and quality assurance methods (forensic analysis, forensic damage assessment, forensic QA), • Be able to familiarize oneself with new analytically relevant questions and to be able to deal with them successfully across disciplines.
Indicative Module Content:	<u>Lecture and exercise:</u> Analytical process; basic process parameters (e.g. limit of detection, limit of registration, limit of quantification), calibration rates and precision determination methods, resolution, reproducibility/ recovery, linear - dynamic range). Basic principles and theories of chromatography (plate theory, fundamental equation/ Purnell equation, dynamic theory); liquid chromatography (basics and execution techniques such as TLC, SC, SPE, (U)HPLC, SFC, system components, functions, performance spectrum); sustainable developments – "green solutions"; gas chromatography (basics and execution techniques, such as GC with packed columns, capillary gas chromatography, system components, functions, performance spectrum, automated sample preparation - SPME, stat. and dyn. headspace, other sorptive techniques); "green solutions" Mass spectrometry (for liquid, gas and solid phase; basics and principles, ionisation techniques -EI, CI, ESI, APCI, MALDI-, ion acceleration, analysers, e.g. quadrupole - single and triple quad-, ToF- detectors), coupling techniques (GC-MS, LC-MS) Molecular spectroscopy (basics and principles, vibrational spectroscopy -IR, nuclear magnetic resonance spectroscopy). <u>Practical course:</u> Experiments in chromatography, mass spectrometry/ coupling techniques and molecular spectroscopy (e.g. GC, GC-MS, HPLC, HPLC-MS, TLC, IR, NMR).
Assessment Plan:	Successful partcipation in the practical courses (performing and evaluation) and final module examination Type portfolio: • Experimental protocol of one practical course (5-10 pages) weighting 20 % • written final examination (90 min) weighting 80%
Media:	L: PowerPoint presentations, board/ whiteboard, digital content (e.g. screenshots, podcasts, videos), textbooks P: practical course instructions, digital platforms/ content (Articulate courses, videos), textbooks

Indicative Bibliography:	• D. Skoog, F.J. Holler, S. R. Crouch: Principles of Instrumental Analysis, Cengage Learning, Boston MA, 2018, 7th edition • D. Skoog, F.J. Holler, S. R. Crouch: Instrumentelle Analytik; Springer Spektrum, 6. Auflage 2013 • M. Otto: Analytische Chemie; Wiley-VCH, 5.Auflage 2019 • H. Hug: Instrumentelle Analytik, Theorie und Praxis; Verlag Europa-Lehrmittel, 4. Auflage 2020 • M.H. Gey: Instrumentelle Analytik und Bioanalytik, Springer Berlin, 4. Auflage 2021 • M.Z. Haile: Introduction to Instrumental Methods of Analysis: Classical Separation Techniques and Chromatography, LAP Lambert Academic Publishing, 2020 • J. H. Gross: Mass spectrometry, Springer Verlag, 2017 • L. D. Field, S. Sternhell, J. R. Kalman: Organic Structures from Spectra; 2020, Wiley Verlag • M. Hesse, H. Meier, B. Zeeh: Spectroscopic methods in organic chemistry; Thieme Verlag, 2008

Module:	**Biochemistry and Molecular Biological Methods**
Semester:	4th semester
Course coordinator:	Prof.'in Angelika Muscate-Magnussen/ Prof. Oskar Schnappauf
Lecturer:	Prof.'in Angelika Muscate-Magnussen/ Prof. Oskar Schnappauf
Language:	English
Assignment to curriculum:	**Compulsory course in the 4th semester of Forensic Sciences**
Course units/Credit hours (SWS):	The course consists of: Lecture: 1 SWS Biochemistry + 1 SWS Molecular Biological Methods Exercise: 1 SWS Biochemistry + 1 SWS Molecular Biological Methods Laboratory course: 1 SWS Biochemistry + 1 SWS Molecular Biological Methods; max. group size: 16
Student workload:	Contact hours / private study Lecture: 60 / 60 Lab work: 30 / 60 Total: 90 / 120 **Total (contact hours + self study): 210 hours**
Credits:	7 ECTS
Prerequisites according to Examination Regulations:	none
Recommendations:	Organic Chemistry, Instrumental Analysis, Fundamentals of Biology, Forensic Biology
Learning outcomes:	<u>Biochemistry:</u> Students are able to - explain the molecular basis of important cellular and physiological functions - comprehend the basic principles of biochemistry, also with regard to special forensic applications, and recognize correlations - create workflows for the purification of metabolites and proteins and perform and evaluate basic protein analytical procedures by - transferring structure-function relationships of nucleic acids, carbohydrates, lipids and proteins and small molecules to biomedical issues - applying the principles of reaction mechanisms of organic chemistry to biochemical problems, especially in the field of enzymology and metabolic regulation In order to - make themselves understood in interdisciplinary biomedical teams using basic vocabulary - independently determine inhibitory mechanisms based on Michaelis-Menten kinetic data - be able to apply and document simple bioanalytical laboratory procedures

	Molecular Biological Methods: The students are able to... • explain the molecular-biological methods used to analyse the function and the expression of genes by... • understanding how expression vectors are constructed • being familar with transfection methods • analyzing gene expression on the RNA level in order to... • understand forensic RNA analysis and modern methods of experimental toxicology • be able to perform RNA analysis
Content:	Biochemistry: Lecture: • Cells - structure and function -, organelles. • Biomolecules under physiological conditions, buffers, intra- and intermolecular forces. • Proteins: Amino acids - structure and function -, peptides, proteins, proteoforms, posttranslational modifications, enzymes, Michaelis-Menten kinetics, enzyme inhibition, regulation, catalytic mechanisms, classification of enzymes and proteins. • Advanced protein and metabolite analysis by electrophoretic, chromatographic and mass spectrometric methods, sample preparation methods • Carbohydrates and lipids: structure and function, cell membranes, membrane proteins, membrane channels and pumps • Metabolic pathways including glycolysis and gluconeogenesis, citrate cycle, oxidative phosphorylation, fatty acid metabolism, amino acid metabolism - concepts and basic patterns, metabolic energy, signal transduction • Selected case studies in forensic pathobiochemistry. Exercise: • Biochemical calculations, data analysis and interpretation using problems and case studies. Lab course: • Various methods of protein determination, enzyme kinetics studies using the enzyme alkaline phosphatase, enzyme purification using ion exchange FPLC. Molecular Biological Methods: Lecture: • Molecular cloning methods • expression vectors • transfection and transduction of cells • RNA interference and CRISPR-Cas • reverse transcription and RNA analysis Lab course: • transfection of mammalian cells with a reporter construct • RNA extraction and expression analysis using RT-PCR

Assessment:	Modular examination – graded Written exam (120 min) – 100% of overall grade Successful participation in the laboratory course is a prerequisite for passing the final examination.
Teaching formats:	Lecture: Power-Point-Präsentation; Self Assessment Tools wie Kahoot, Quiz Academy, LEA-Quiz; eboards wie Padlet; Videoanimationen; textbooks Laboratory course: written experiment instructions, textbooks, videos
Textbooks/ Sources:	• Berg, J.M. et al. (2019): Biochemistry, WH Freeman, 9th ed. • Löffler/Petrides: Biochemie und Pathobiochemie (2014), Springer • von der Saal, K. (2020): Biochemie, Springer Spektrum • Brown, T.A. (2016) Gene Cloning and DNA analysis: An introduction, Wiley-Blackwell

module	**Pharmacology and Toxicology**
semester:	4th semester
course leader	Prof. Ulrike Bartz
lecturer:	Prof. Ulrike Bartz
language:	English
assignment to curriculum	**Compulsory course in the 4th semester of Forensic Sciences**
course units/lesson hours per week	The course consists of a lecture, exercises and a laboratory course (experiments). Lecture: 3 lesson hours per week Exercise: 1 lesson hour per week Laboratory course: 2 lesson hours per week; max. group size: 16
student workload	Contact hours / Private Lecture & exercise: 60 / 60 Laboratory course: 30 / 60 Total: 90 / 120 **Total (contact hours + private study): 210 hours**
credit points	7 ECTS
prerequisites according to examination regulations	none
recommended passed modules	General Chemistry, Organic Chemistry
learning outcomes	The students are able • to describe the characteristics of compounds in the body relating to Pharmacokinetics (PK) and Pharmacodynamics (PD) • to discuss and interpret PK profiles of different dosage forms; oral dosing (single/multiple doses), intravenous dosing (bolus and infusion) • to derive potential metabolites (urine/plasma) after exposure with a xenobiotic • to interpret analytical data from biological samples (e.g. urine) in the context of forensic science or doping analytics by means of • applying principles of PK and PD • using knowledge about Phase I/II metabolisation reactions and their mechanisms in order to • to apply bioanalytical methods and together with the relevant documentation • and to learn about advanced instrumental techniques in the context of forensic toxicology
content:	<u>Lecture:</u> • general anatomy and physiology, gastro-intestinal tract, liver, kidneys. • (L)ADME, PK Phase, PD Phase • mechanisms of absorption and distribution in the body, distribution spaces, cumulation, protein binding (plasma, tissues)

	• pharmacokinetic parameters (e.g. kel, ka, elimination half life, clearance, AUC, bioavailability) • zero order und first order kinetics, mathematical calculations regarding pharmacokinetics, compartment models, single/multiple dosing • biotransformation reactions (phase I/II) • involved enzyme/enzyme systems, especially P450 enzymes, polymorphisms (ultrarapid/rapid/intermediate/slow metabolizers) • glutathione-pathway for detoxification of electrophiles • first pass effect, enterohepatic circulation • linear kinetics, nonlinear kinetics, Michaelis Menten kinetics • bioactivation (Pro-Drug), biotoxification, detoxification • processes of elimination: hepatic, biliary, renal • pharmacodynamics (mode of action), ligand-receptor-interaction, agonism, antagonism (dose-response curves) • competitive, noncompetitive. antagonists • receptor up/downregulation • structure activity relationships <u>Exercise:</u> • calculations and different plots in PK • calculation of pharmacokinetic parameters • construction of metabolisation pathways <u>Lab course with protocols:</u> • Urinary analysis (HPLC after SPE; Phase I und Phase II Metabolites; biomarker identification via GC-MS after SPE & derivatisation • 3 PK experiments (one compartment model)
examination	Type portfolio: • Experimental protocol of one practical course (weighting 30 %) • oral exam (30 min; weighting 70%)
teaching style:	L: power point presentation, overhead, whiteboard, textbook P: practical course description, textbooks, videos
literature (newest edition)	Drug actions - Basic Principles and therapeutic aspects E. Mutschler/H. Derendorf; MedPharm Scientific Publishers Pharmacokinetic Processes, mathematics and applications Peter G. Welling Wiley Science Applied Biopharmaceutics and Pharmacokinetics L. Shargel/A.Yu; McGraw-Hill Medical Publishing Division Pharmakokinetik kompakt: Grundlagen und Praxisrelevanz Hartmut Derendorf, Thomas Gramatte, Hans Günter Schäfer, Alexander Staab, Wissenschaftl. Verlagsgesellschaft Stuttgart Further literature will be provided at the beginning of the module

Module:	**Forensic Quality Assurance**
Semester:	4th semester
Course leader:	Prof. Dr Ernst-Jürgen Pomp
Lecturer:	Prof. Dr Ernst-Jürgen Pomp
Language:	German
Assignment to curriculum:	**Compulsory course in the 4th semester of Forensic Sciences**
Course units/Lesson hours per week (SWS):	The course consists of a lecture, an accompanying tutorial (exercises) and a laboratory course (experiments). Lecture: 4 lesson hours per week Tutorial: 1 lesson hour per week; max group size: 30 Laboratory course: 1 lesson hour per week; max. group size: 18
Student workload:	Contact hours / Private study Lecture: 60 / 15 Tutorial: 15 / 30 Lab work: 15 / 45 Total: 90 / 90 Total (contact hours + private study): 180 hours
Credits:	6 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	General Chemistry (1st semester), Analytical Chemistry (2nd semester), Physics/Statistics (2nd semester), Instrumental Analysis (3rd semester)
Learning outcomes:	Students are able to • understand the aspects of international Quality Assurance (QA) and Quality Management (QM) systems like Good Documentation Practice (GDocP), Good Laboratory Practice (GLP) and the ISO norm 17025. by • applying knowledge of current, international laws, guidances and norms in the area of toxicological and forensic chemistry. in order to • be familiar with the international required QA and QM systems in the area of research & development and toxicological investigation in the Life Science area (Safety aspects of e.g. pharmaceuticals, biocides or chemicals) and the Quality Management systems in test laboratories in the area of supervisory authorities (criminalistics, environmental and consumer protection) • to be capable to work under these regulatory requiremts in an analytical laboratory.

Summary indicative content:	**Lecture:** • Research and development of new substances and evalution of the toxicological risk of substances in the life science area (pharmaceuticals, vaccines, biocides, chemicals) • Quality assurance systems and their interfaces, including the aspects of safety, efficacy and quality of new items • Legal foundations and requirements of Good Laboratory Practice, including ethical and sustainable aspects • Organisation and responsibilities • Standard operating procedures (SOPs) • Study plan (amendmends and deviations) • Realisation of studies (sample chain) • Qualification of equipment and equipment documentation • Method development, method validation and their documentation (DIN, Guidance for Industry, Ph. Eur., OECD etc.) • Documentation (raw data, evaluation, reporting), Good documentation practice • Computerized systems part 1: Principles, legal basis, case studies, "V-model" • Computerized systems part 2: Qualification of analytical equipment („Life-cycle Modell"); GAMP 5, CFR 21 part 11, WHO Gudance), open/closed/hybrid systems, Laboratory Information- and Data management- systems (LIMS) • Validation of computerized systems: AIQ (Analytical instrument Qualification), CSV (Computerized System Validation) • Digitalisation in industry (Industry 4.0), big data, data integrity, data governance, remote methods • Data archiving • Inspections and certification • Multi-site testing (Globalisation of studies and projects) • Accreditation of test laboratories according to ISO 17025 • Quality policy and quality management handbook • Independence and impartiality • Personal skills (staff training and staff qualification) • Technical skills (acquisition of qualifications, quality rule cards, validation, round robin tests, measuring inaccuracies), documentation • Findings that can be used as evidence in court (expert assessment and court proceedings), accreditation bodies • Method validations (DIN - German Industrial Standard, Guidance for Industry, PharmEU, OECD, etc.) • Accreditation according to DAkkS, ILAC • Applied statistics **Tutorial:** • Drawing up a Quality management handbook (QMH) • Drawing up Standard Opteration Procedures (SOP) • Good Documentation Practice, reviewing raw data (double check)

	• Planning the review of methods and evaluation systems (computer validation) • Alternative: Drawing up an equipment test (user requirement specification) **Laboratory course:** • Checking analytical instruments for performance qualification • Implementation, evaluation, reporting and statistical assessment within the framework of a method validation • Participation at a round robin test • Documentation of laboratory experiments according to the principles ofGood documentation practice
Assessment:	Modular examination – graded Written final examination (120 min): 100% Tutorial and laboratory course: passed
Teaching style:	Lecture: PowerPoint, overhead, blackboard Tutorial: written compilation of exercises, overhead, blackboard Laboratory course: written experiment instructions, Podcasts and webinars on LEA
Indicative bibliography/ Sources:	1) G.A. Christ, GLP Handbuch für Praktiker, GIT Verlag; 2) Anhang 1 zum Chemikaliengesetz, Quelle: www.bfr.bund.de; 3) GLP Inspektorenhandbuch, Quelle: www.bfr.bund.de; 4) OECD Konsensdokumente, Quelle: www.bfr.bund.de; 5) BLAC Dokumente Nr. 1-3, Quelle: www.bfr.bund.de; 6) ISO 17025, Beuth Verlag; 7) W. Bosch, M. Wloka, Allgemeine Anforderungen an die Kompetenz von Prüf- und Kalibrierlaboratorien, DIN e.V.; 8) K. Söhngen, Das Qualtätssicherungshandbuch im Labor, Springer Verlag; 9) G. Linß, Qualitätsmanagement für Ingeneure, Fachbuchverlag Leipzig; 10) S. Kromidas, Qualität im analytischen Labor, VCH; 11) W. Funk, V. Dammann, G.Donnevert, Qualitätssicherung in der Analytischen Chemie, Wiley VCH Verlag; 12) V. Neitzel, Praktische Qualitätssicherung, VCH; 13) N. Hochheimer, Das kleine QM-Lexikon, Wiley VCH; 14) Th. Schneppe, Qualitätsmanagement und Validierung in der pharmazeutischen Praxis, EDITIO CANTOR VERLAG.

Module:	**Forensic Microscopy**
Semester:	4th semester
Course leader:	Dipl.-Ing. (FH) Irina Marschall
Lecturer:	Dipl.-Ing. (FH) Irina Marschall
Language:	German
Assignment tocurriculum:	**Compulsory course in the 2nd semester of Forensic Sciences**
Course units/Lesson hours per week (SWS)	The course consists of: Lecture: 1 lesson hours per week Tutorial: 1 lesson hours per week Laboratory course: 1 lesson hours perweek
Student workload:	Contact hours / Private study Lecture: 15 / 15 Tutorial: 15 / 30 Laboratory course: 15 / 30 Total: 45 / 75 **Total (contact hours + private study): 120 hours**
Credits:	3 ECTS
Prerequisites according to Examination Regulations	None
Recommendations:	Pass in the modular examination for the course entitled "Microscopy"
Learning outcomes:	The students will be able to • understand the use of the different microscopes and their application in forensic tasks • describe the functional principles of various microscopic detection methods • explain the areas of application of a wide variety of microscopes in the identification of evidence by describing • the applications of standards to the evaluation of microscopic examinations of materials • the interpretation and evaluation of sample images from the field of materials science and forensic • the basic principles of the most important applications of forensic microscopy in order to • scientifically examine different materials • perform forensic and scientific tasks • use the microscopic methods that are most suitable for the various materials • carry out microscopic analysis independently • identify and assign common textile fiber samples • use scientific photography and documentation • perform basic image processing and image capture

	• apply methodical approach to the investigation and analysis of traces
Summary indicative content:	Lecture: • different types of microscopes and microscopic examinations • EFTM, IR and Raman-Spectroscopy, comparative microscopes, digital microscopes • systematic approach to microscopy • various methods of investigation based on electron microscopy • Application and approach to forensic analysis • preparation methods and documentation Tutorial: • tasks and forensic case studies relating to the lecture Laboratory course: • conduct investigations using light and electron microscopes • practical applications of various preparation techniques • conduct forensic investigations of defined microscopic specimen slides • identification of common textile fibers • scientific photography for analysis and documentation • basic image processing and image capture
Assessment:	Modular examination – graded Written final examination (60 min); seminar presentations
Teaching style:	Lecture: notes on the blackboard, computer projector Tutorial, laboratory course: Learning by Doing (example exercises under supervision)
Indicative bibliography/Sources:	Kern, Martin: Mikroskopische Technik für die industrielle Anwendung: Präparation, Digitale Fototechnik, Mikroskopie, Bildverarbeitung; Brünne-Verlag; Berlin; 2003; ISBN 3-9804762-4-3 Kern, Martin, Jörg Trempler: Beobachtende und messende Mikroskopie in der Materialkunde: Ein Leitfaden für die Praxis; Brünne-Verlag; Berlin; 2007; ISBN 978-3-9809848-6-7 Barbara p. Wheeler, Lori J. Wilson: Practical Forensic Microscopy: A Laboratory Manual: Experiments, Application Experiments, Instrumental Microscopy; Wiley-Blackwell-Verlag; England; 2008; ISBN: 978-0-470-031176-6

Module:	**Forensic Analysis**
Semester:	5th semester
Course leader:	Prof. Dr Ernst-Jürgen Pomp
Lecturer:	Prof. Dr Ernst-Jürgen Pomp
Language:	English
Assignment to curriculum:	**Compulsory course in the 5th semester of Forensic Sciences**
Course units/Lesson hours per week (SWS):	The course consists of a lecture, a tutorial (exercises) and a laboratory course (experiments). Lecture: 3 lesson hours per week Tutorial: 1 lesson hour per week; max. group size: 30 Laboratory course: 2 lesson hours per week; max. group size: 12
Student workload:	Contact hours / Private study Lecture: 45 / 30 Tutorial: 15 / 45 Laboratory course: 30 / 45 Total: 90 / 120 Total (contact hours + private study): 210 hours
Credits:	7 ECTS
Prerequisites according to Examination Regulations:	None
Reommendations:	Analytical Chemistry (2nd semester), Instrumental Analysis (4th semester), Forensic Quality Assurance (4th semester), Law (4th semester)
Learning outcomes:	The students are able to • apply the principles of chemical and forensic laboratory investigation methods. by • acquiring current knowlegde about chemical and bioanalytical methods for the investigation of forensic samples (narcotics, alcohol, pharmaceutical drugs and chemical poisons) • investigating samples according to the relevant national laws, guidances and norms • describing analytical tasks relating to samples of various origins within their forensic context. in order to • deal with these tasks with respect to handling, preparation and measuring of such samples. • use high-end analytical techniques for the investigation of forensic traces. • acquire the analytical skills necessary to independently determine which testing parameters are required to solve a given task. • report the related findings in an appropriate way.

Summary indicative content:	**Lecture:** • Qualitative and quantitative analysis of drugs of abuse, especially based on standard matrices (blood, serum, urin), using current analytical methods • Sample-taking: Representative samples, sample-taking plans, prevention of contaminations, sample transport, volatile analytes, sample preservation, appropriate sample storage • Sample preparation: Purification, loss, quenching, recovery, internal standards • Identification and quantification: Limit of detection and limit of quantification, concentration range, use of a second technique for confirmation of results and legal evidence) • Quality assurance: Statistical evaluation, interpretation, documentation and presentation of analytical data **Topics: (Case studies)** • Abuse of alcohol: Legal situation, breath alcohol, blood alcohol, fusel alcohols, methods, legal evaluation and consequences • Abuse of finshed medicinal products: E.g. barbiturates, benzodiazepines, analgesics • Abuse of narcotics: Soft, hard and synthetic drugs, new psychotropic substances • Chemical intoxication: Combustion products, fumigants, heavy metal poisining **Tutorial:** • Drawing up sampling plans and experimental instructions • Preparation of calibration and quality control standards, correction factors, calibration models • Selecting suitable sample preparation techniques and analytical methods for forensic tasks • Method optimization • Statistical models for the evaluation of legal enforceability of results (Valistat) • Troubleschooting. **Laboratory course:** Experiments on current issues of forensic analysis: • Alcohol analysis (Enzymatic-UV, Headspace-GC) • Identification of pharmacologically active substances (ELISA, HPLC) • Identification of drugs of abuse like narcotics/pharmaceuticals (Screening by data base („Pragst“) • Drug screening of narcotics, identification of “active” and “passive” consumption by metabolites (GC-MS) • Identification of environmental toxins (Polarography)

Assessment:	Modular examination – graded Written final examination (120 min): 100 % Tutorial and laboratory course: passed
Teaching style:	Lecture: PowerPoint, overhead, blackboard Tutorial: written compilation of exercises, overhead, blackboard Laboratory course: written experiment instructions, Podcasts and webinars on LEA
Indicative bibliography/Sources:	1) Forensische Medizin für Studium und Praxis, Maudrich Verlag 2) The Analysis of controlled substances, Wiley & Sons 3) Forensic Chemistry, Pearson International Education 4) Toxikologie und Analytik der Rauschgifte, UTB Hüthig Verlag 5) Rauschgifte, GOVI Verlag 6) Advances in Forensic Applications of Mass Spectrometry, CRC Press 7) Haaranalytik, Deutscher Ärzte Verlag

Module:	**Polymers and Composites**
Semester:	5th semester
Course leader:	Prof. Dr. Mandy Gieler
Lecturer:	Prof. Dr. Mandy Gieler
Language:	German / English
Assignment to curriculum:	**Compulsory course in the 5th semester of B.Sc. Sustainable Chemistry and Materials** **Compulsory course in the 5th semester of B.Sc. Forensic Sciences**
Course units/ Lesson hours per week (SWS):	The course consists of: Lecture: 2 lesson hours per week Exercise: 2 lesson hours per week; group size: max. 30 Practical course: 2 lesson hours per week; group size: max. 18
Student workload:	Contact hours / Private study Lecture: 30 / 30 Exercise: 30 / 45 Practical course: 30 / 45 Total: 90 / 120 **Total (contact hours + private study): 210 hours**
Credits	7 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	Successful completion of the module "Structure and Characteristics of Materials"
Learning outcomes:	The students are able to • derive the basic properties of a polymer from its molecular structure, • propose possibilities of property modification and optimization with respect to material's application, • apply testing methods and corresponding evaluation techniques to determine predefined material properties, • select and explain processing methods of polymers considering their final application fields by means of • discussing the relationships between molecular structure of a polymer and its properties in specific applications, • applying knowledge on the effects of chemical modification and processing on the property spectrum of polymers, • identifying part-relevant material properties and choosing adequate testing methods, • choosing appropriate processing techniques with respect to part geometry and production quantities in order to • execute application-related material selections in combination with testing and documenting relevant polymer properties, • manufacture plastic parts in a sustainable and cost-efficient manner.

Summary indicative content:	Lecture: • Criteria of application-oriented material selection • Morphology and structure-property relationships • Rheological, mechanical, thermal, electric, optical and chemical properties of polymers and corresponding testing methods • Introduction to polymer blends and composites • Processing techniques for thermoplastic polymers and composites • Sustainability aspects, circular economy and introduction to methods in eco-balance assessment Exercise: Solving technical problems related to topics discussed in lectures Practical course: Lab-scale experiments on processing and testing of thermoplastic polymers and preparation of respective testing protocol: • Extrusion and injection molding • Rheology • Differential Scanning Calorimetry • Morphology and material damage • Tensile test and impact testing • Chemical resistance testing
Assessment:	Written examination (120 min) – graded Successful participation in practical course
Teaching style:	Lecture: Powerpoint presentations, blackboard/whiteboard, videos Exercise: Written set of exercises, interactive presentation of results on blackboard Practical course: Written experimental instructions, guided lab courses
Indicative bibliography/Sources:	E. Baur, G. Harsch, M. Moneke, Werkstoff-Führer Kunststoffe: Eigenschaften - Prüfungen – Kennwerte, 11th edition, München : Hanser, 2019. H. Domininghaus, Die Kunststoffe und ihre Eigenschaften, 6th edition, Berlin Heidelberg : Springer-Verlag, VDI-Buch, 2005. G. Menges, E. Haberstroh, W. Michaeli, E. Schmachtenberg, Menges Werkstoffkunde Kunststoffe, 6th edition, München : Hanser, 2011. W. Kaiser, Kunststoffchemie für Ingenieure: Von der Synthese bis zur Anwendung, 5th edition, München : Hanser, 2021. C. Hopmann, W. Michaeli, Einführung in die Kunststoffverarbeitung, 8th edition, München : Hanser, 2017. G. W. Ehrenstein, Faserverbund-Kunststoffe: Werkstoffe, Verarbeitung, Eigenschaften, 2nd edition, München : Hanser, 2006.

Module:	**Forensic Material Evidence and Failure Analysis**
Semester:	5th semester
Course leader:	Prof. Dr. Johannes Steinhaus
Lecturer:	Prof. Dr. Johannes Steinhaus
Language:	German
Assignment to curriculum:	**Compulsory course in the 5th semester of Forensic Sciences**
Course units/Lesson hours per week (SWS)	The course consists of: Lecture: 2 lesson hours per week Tutorial: 2 lesson hours per week Laboratory course: 2 lesson hours per week
Student workload:	Contact hours / Private study Lecture: 30 / 30 Tutorial: 30 / 45 Laboratory course: 30 / 45 Total: 90 / 120 **Total (contact hours + private study): 210 hours**
Credits:	7 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	Successful completion of the modules "Structure and Characteristics of Materials", "Solid Mechanics" as well as "Metals and Alloys"
Learning outcomes:	The students are able to • identify materials and know suitable analytical techniques for that purpose. • identify and compare material evidence and tool marks • forensically investigate and compare the cause of a material evidence • describe and completely document technical failures. • realise construction, material or processing based part properties and anomalies. • evaluate the actual condition of a failed part. • choose, plan and conduct necessary investigations. • identify failure mechanisms and their impact on the failure case. • forensically investigate and evaluate the cause of a technical failure, and finally to develop remedial measures. by means of • a written description of the material evidence or technical failure including an extensive photographic documentation. • knowing, choosing and applying suitable investigation methods for material evidence analysis • the evaluation of constructive, material or processing related part properties and anomalies. • a comparison of the actual condition of a failed part with the virgin state. • evaluating the applicability of possible analytical methods to identify the failure cause and design a proper sample preparation and action plan. • Evaluating the different failure mechanisms (machanical, corrosion, thermal, etc.) and their impact on the failure case. • destinguishing possible root causes for a technical failure by the

	exclusion principle with respect to primary and secondary failure effects. In order to • independently conduct a forensic material evidence investigation with respect to evidence identification and comparison. • independently conduct a forensic failure analysis with respect to failure clarification, writing a proper report and finding damage prevention actions. • be able to evaluate the quality of a failure analysis report.
Summary indicative content:	Lecture: • Terms and definitions • Analytical techniques and procedures for material evidence investigations • Failure mechanisms and typical manifestations • Differences in failure mechanisms with respect to the various material species • Systematic approach to failure analysis Tutorial: • Presentation and discussion of typical cases of material evidence and failure from the forensic practice, e.g. with a focus on insurance fraud, plagiarism and accidents in transportation Laboratory Course: • Conduction of material evidence and failure analyses on sample parts using various light-, FTIR and electron microscopy methods as well as EDX element analysis
Assessment:	Written modular examination (90 min) – graded Prerequisite: completion of the laboratory course
Teaching style:	Lecture and Tutorial: Power Point presentations (beamer, smartboard), blackboard/smartboard, videos Laboratory course: Tutorial videos and lab instructions prior to the practical laboratory tasks using various types of microscopes
Indicative bibliography/ Sources:	• Braun D. et al. (2012) Erkennen von Kunststoffen – Qualitative Kunststoffanalyse mit einfachen Mitteln. Hanser Verlag • D. Baldwin et al. The Forensic Examination and Interpretation of Tool Marks. John Wiley & Sons, 2013. Online ISBN:9781118374078 • Forensic Examination of Fibres. Ed. J. Robertson. 3rd Edition. CRC Press, 2017. eBook ISBN9781315156583 • Neidel, Andreas et al.; Handbuch Metallschäden; 2. Auflage; Hanser; ISBN 978-3-446-42775-4; e-book-ISBN 978-3-446-42966-6 • Systematische Beurteilung technischer Schadensfälle; Hrsg. Günter Lange; Deutsche Gesellschaft für Metallkunde e. V.; Informationsgesellschaft Verlag; Oberursel; 1997; ISBN 3-88355-070-1 • Werkstoffprüfung, Schadensanalyse und Schadensvermeidung; G. Lange und M. Pohl; Wiley-VCH Verlag; Weinheim; 2001; ISBN 3- 527-30538-6 • Scanning Electron Microscopy of Plastics Failure - Rasterelektronenmikroskopie von Kunststoffschäden; G.

	Ehrenstein, L. Engel, H. Klingele, H. Schaper, Hanser Verlag, 2010; eISBN: 978-3-446-42665-8 • Ehrenstein, Gottfried W.; Kunststoff-Schadensanalyse: Methoden und Verfahren; Carl Hanser Verlag; München; Wien; 1992; ISBN 3-446-17329-3 (Nachdruck 2. Halbjahr 2006)

Module	**Practical training**
Semester	6. Semester
Course Leaders	Professors of the Department Natural Sciences
Lecturer	Professors of the Department Natural Sciences
Langauge	German/English
Assignment to curriculum	**Compulsory course in Applied Biology, Chemie mit Materialwissenschaften, Naturwissenschaftliche Forensik, Semester 6**
Course units/credit hours	Three-month internship in a laboratory, research facility or the R&D department of a company
Students' workload	3 months (540 h)
Credits	18 ECTS
Prerequisites according to examination regulations	None
Recommended prerequisites	Successful participation in the modules of semester 1- 5
Learning Outcomes	Students will be able to: work increasingly independently on scientific projects and evaluate and critically interpret the data obtained in the process by conducting experiments on a given problem independently and under supervision dealing with problems and setbacks in experimental work in a solution-oriented manner applying previously acquired technical and analytical knowledge and methodological skills in a more complex context. establishing interdisciplinary links organizing their daily work in the laboratory independently and assume responsibility as part of a team evaluating acquired data in the context of the project's research question and the current literature in order to Apply and further develop learned skills in professional, scientific and business laboratory practice.
Inhalt:	The students independently search for a place in a working group whose research topic is of interest to them. During the three-month practical phase, they are integrated into the work processes of the research group. They apply the knowledge and skills they have acquired during their studies in practice and learn new methods and techniques. They assume responsibility for the project they have taken on and further develop their social skills as a team member. At the end of the practical phase, the students have obtained the results and data sets required for the bachelor thesis. During the practical phase, students are accompanied by a lecturer from the department.
Assessment	This module is ungraded. This module is ungraded. Prerequisites for passing the module examination are: 1. regular attendance at the internship site 2. proof of completion of the practical semester (certificate / report from the company) 3. successful participation in the final evaluation discussion with the supervisor.
Teaching style	Doesn't apply
Literature	Research reports, reviews, textbook material according to the research topic.

Module	**Bachelor thesis**
Semester	6
Course leader	The Lecturers of the Department
Lecturer	The Lecturers of the Department
Language	English/German
Assignment in Curriculum	**Compulsary course Semester 6 in B.Sc. Applied Biology, Nachhaltige Chemie und Materien, Naturwissenschaftliche Forensik**
Course Units/Credit hours	Written work completed within two months.
Students' workload	Two months (360 h)
Credits	12 ECTS
Prerequisites according to examination regulations	Students will be admitted to the final thesis if they have a maximum of two modules from semester 1-5 not finished successfully yet. Students will be admitted to the final examination "colloquium" if they have successfully finished all modules from semester 1 and 5 as well as their practical training.
Recommendations	None
Learning Outcome	Students will be able to: work within a defined period of time on a scientific task related to their study program using methods, skills and competencies aquired during their study program, present and defend their own scientific data, results or findings both in written form (Bachelor thesis) and in oral form (colloquium) by processing the experimental data usually obtained during the practical phase in an appropriate form compiling, interpreting and discussing these in the form of a scientific publication (Bachelor thesis) using appropriate scientific literature to evaluate their data addressing critical questions about the quality or validity of their results with professional competence and comprehensive knowledge of the literature. In order to present and communicate scientific results appropriately and to specific target groups in their further academic or professional life.
Content:	Final thesis: The students write up the data, observations, and findings, which they usually will have obtained in the preceding practical phase, in the form of a written final paper (Bachelor thesis). This document, prepared within two months, is submitted to the first and second supervisor for evaluation. The supervisors will assess the paper regarding the quality of the presentation, processing of the data obtained, problem-solving approaches and their implementation. The interpretation of the results and their comparison with existing literature will also be evaluated. Colloquium: Students give a presentation on the topic of their thesis. To prepare for this final oral examination students perform in advance an extensive literature research and prepare a presentation. The talk gives an in-depth insight into the theory, methods and results of the thesis and allows an outlook on future research approaches. The 20 minutes talk is to be given in free speech. Afterwards, there will be a discussion on the content of the presentation, the Bachelor thesis and on related topics.
Assessment	Both, Bachelor thesis and Colloquium, are graded. The final thesis is passed if the grade is at least "sufficient" . The grade of the final thesis is included with 25% in the final Bachelor grade. The colloquium is passed if the grade is at least "sufficient. The grade of the colloquium is included with 10% in the final Bachelor grade.
Medienformen**:**	Does not apply.

Elective courses:

Module	**Inorganic Chemistry for Forensic Scientists**
Semester	5th Semester
Course leader	Dr. Ulf Ritgen
Lecturer	Dr. Ulf Ritgen
Language	German
Assignment to curriculum	**Elective Course 5th Semester Forensic Science**
Course units / Lesson hours per week (SWS)	The course consists of a lecture and an accompanying tutorial (exercises) Lecture: 2 lesson hours per week (SWS) Tutorial: 1 lesson hour per week (SWS);
Student workload:	Contact hours Private study Lecture: 30 30 Tutorial: 15 15 Total: 45 45 **Total (contact hours + private study): 90 hours**
Credits	3 ECTS
Prerequisites according to Examination Regulations	none
Recommendations	Participation in the modules General Chemistry, Analytical Chemistry, and Organic Chemistry
Learning Outcomes	The students are able to • Understand and explain reactions taking place in aqueous and selected non-aqueous media and predict the outcome even of reactions not covered in the lecture, • Explain (using proper terminology) laboratory and industrial methods of synthesising importanc inorganic compounds and the principles/concepts behind it and • identify reactions involving environmentally damaging reactants and/or products and evaluate and communicate the concomitant dangers, by • drawing conclusions from trends and tendencies within the periodic table, • recognising chemical connections and similarities, • combining the principles of General Chemistry and Inorganic Chemistry with their knowledge of (mainly) the main group elements' chemical behaviour and applying it to new problems and/or insights to be gained, • recognising similarities in geometrical structure and electron density distribution of both inorganic and organic compounds and using them to prognosticate chemical behaviour and • assess hazards posed by substances used within laboratory or industry processes based on internationally accepted Ordnances of Hazardous Substances, to

	• independently develop solution approaches to interpret chemical reactions and/or processes, • explain the connection between theoretical concepts and every-day phenomena to both experts and interested laypersons using appropriate terminology and • be able to make themselves acquainted independently with specific fields of chemistry, including interdisciplinary topics.
Summary content:	Lecture / Exercise: Trends within the Periodic Table (diagonal relationship, charge density distribution, etc.), general nomenclature Bond models: Valence bond (incl. VSEPR), fundamentals of molecular orbital theory, multi-centre bonds, mesomerism / resonance Coordinate compounds; various form of isomerism (incl. stereo isomerism) selected aspects of the chemistry of main group elements (e.g. modifications, allotropy, polymorphism), natural occurrence, preparation similarities in geometrical structure and/or electron density distribution in selected organic and inorganic compounds; introduction to organo-element/organometallic chemistry important industrial-scale processes (chlorine-alkali electrolysis, preparing and doting ultra-pure semiconductor material, HABER-BOSCH process, CLAUS process, FRASCH process), including environmental / sustainability aspects
Assessment:	final modular examination in writing – non-graded
Teaching style:	Lecture: presentation slides; blackboard/whiteboard (analogue or digital) Tutorial: exercise collections, blackboard/whiteboard (a/d)
Literature:	M. Binnewies et al., "Allgemeine und Anorganische Chemie", 3. Aufl., Springer Spektrum. E. Riedel, C. Janiak, "Anorganische Chemie", 8. Aufl., DeGruyter, Holleman/Wiberg, Lehrbuch der Anorganischen Chemie, 103. Auf., DeGruyter. S. Ortanderl, U. Ritgen, "Chemie - das Lehrbuch für Dummies", 2. Aufl., Wiley-VCH.

Module Title:	**Special Insights into Applied Instrumental Analytics** (German title: Besondere Einblicke in Angewandter Instrumenteller Analytik)
Semester:	Semester 5
Module supervisor:	Prof. Dr. Michaela Wirtz
Lecturer:	Prof. Dr. Michaela Wirtz, external practitioners/ experts will be involved in the delivery of material.
Language:	German and English
Reference:	**Elective module of the courses Forensic Sciences and Chemistry with Material Science (5th semester)**
Module Delivery/SPW (Semester Periods per Week):	This is a lecture based module supplemented with seminars. L: 2 SPW S: 1 SPW; max. 20 students per group
Indicative Student Workload:	Contact Hours / Non-Contact Hours (Preparation and Follow-Up) L: 30 / 20 S: 15 / 25 Total 45 / 45 **Sum Total 90 Hours**
ECTS Points:	3
Prerequisites for Module (acc. examination regulations):	None
Corequisites for Module:	Proficiency in instrumental analytical chemistry
Learning Outcomes:	Students will be able to • Grasp special requirements and challenges of economically relevant analytical questions • Work in small groups and coordinate across groups • Independently research, analyse, evaluate, and present literature related to Sustainability or analytical automation context by • In-lecture and seminar-based classes, learning about in-depth analytical focus, method development and optimisation that is needed for advanced analytics (e.g. concerning more complex problems, analytical ecology and economy, speed optimisation, digitisation automation principles). • Learning to organise oneself independently in small groups and to coordinate the professional and organisational aspects within and outside of the group to • Initiate, Develop and optimise analytical methods with special challenges or future requirements for professional, scientific and, in particular, economic laboratory practice. • Be sensitive for sustainability aspects in method choice and developments. • Develop an understanding of working in project teams in one's profession. • Have an understanding of the relevance and requirements of smart laboratories and of the "principles of green chemistry"
Indicative Module Content:	The contents of the course are variable. Emphasis is placed on

	applied industrial analytical techniques and methods with special challenges, e.g. within validity and the development of appropriate sample preparation techniques, within the use of simulation software to predict separation results in chromatography, and deeper within sustainability developments (e.g. in SFC, fast-GC, fast LC), smart labs. As part of the seminar-based teaching, students will also examine the modern requirements of smart laboratories.
Assessment Plan:	Module examination – marked Component: Presentation (weighting 100%)
Media:	PowerPoint presentations, board/ whiteboard, digital content (e.g. videos), web-based research, scientific papers/ journal articles
Indicative Bibliography:	• Scientific journal articles • Further (reading) material as required

Module:	**Cybercrime**
Semester:	5th Semester
Course leader:	Dr. Özgür Bulut
Lecturer:	Dr. Özgür Bulut
Language:	German (also special terminological terms and definitions in English)
Assignment to curriculum:	**Elective course in the 5th semester of Forensic Sciences**
Course units/Lesson hours per week (SWS):	The course consists of Lecture (L): 1 SWS Exercises (E): 1 SWS Laboratory course (LC): 1 SWS; max. number of participants: 20
Student workload:	Contact hours private studies L: 15. 15 E: 15 15 LC:15 15 Total: 45 45 **Total (contact hours + private study): 90 hours**
Credits	3 ECTS
Prerequisites according to Examination Regulations:	none
Recommendations:	The students should bring their own computer/laptops
Learning outcomes:	Students are able to • understand the general concepts of Cybercrime, • understand the statistical analysis and interpretation of forensic results, • be familiar with Computer & Mobile Forensic Investigation, • be familiar with Internet Crimes, • be familiar with forensic video-image analysis, • have an overview on current developments in cybercrime, • understand the role of cybercrime expert in a forensic investigation, by applying • methods for obtaining and evaluating digital evidences/data from forensic images, • the basic forensic digital data analysis methods, • the knowledge of current forensic digital examinations systems (softwares and hardwares), • the evaluation and interpretation of artifacts, • the knowledge of known journals for literautre acquisition, in order to • be able to successfully carry out digital forensic analysis,

	• be able to evaluate and present analysis results of digital data, • understand and prepare the basic requirements of a research project.
Summary indicative content:	Definition and introduction to cybercrime Recent Developments and Trends in Cybercrime Mobile Forensics – Android & iOS Systems Computer & Mobile Forensic Investigations Cybercrime Case Studies on all Aspects Internet Crimes Social Engineering – Phishing/Smishing/Vhishing Forensic Video (CCTV)-Image Examinations Seminars on Topics of (current) Interest General & Technical Aspects of Cybercrime Cyber Attack Tools and Methods
Assessment:	Oral presentation and the corresponding handout of the presentation (%50) Report writing (%50)
Teaching style:	Powerpoint presentations, Working on case studies, Electronic documents (including presentations, exercises and internship tasks) Current literature and scientific publications
Indicative bibliography/ Sources:	Holt, Thomas J., Adam M. Bossler, and Kathryn C. Seigfried-Spellar. Cybercrime and digital forensics: An introduction. Routledge, 2017. Baggili, Ibrahim. "Digital Forensics and Cyber Crime." Second International ICST Conference, Abu Dhabi, United Arab Emirates. 2010. Casey, Eoghan. Digital evidence and computer crime: Forensic science, computers, and the internet. Academic press, 2011. McGuire, Mike, and Samantha Dowling. "Cyber crime: A review of the evidence." Summary of key findings and implications. Home Office Research report 75 (2013). McQuade, Samuel C. Understanding and managing cybercrime. Boston: Pearson/Allyn and Bacon, 2006.

Module:	**Introduction to Digital Forensics for Non-Computer Scientists**
Semester:	5th Semester
Course leader:	Prof. Dr.-Ing. Norbert Jung
Lecturer:	Prof. Dr.-Ing. Norbert Jung
Language:	German (also English-language technical literature in the original)
Assignment to curriculum:	**Elective course in the 5th semester of Forensic Sciences**
Course units/Lesson hours per week (SWS):	The course consists of Lecture (L): 1 SWS Exercises (E): 1 SWS Laboratory course (LC): 1 SWS, max. number of participants: 16
Student workload:	Contact hours private studies Total: 45 45 **Total (contact hours + private study): 90 hours**
Credits	3 ECTS
Prerequisites according to Examination Regulations:	none
Recommendations:	Basic mathematical knowledge, fundamentals of Computer Science, as described in the curriculum.
Learning outcomes:	Students are able to • without in-depth knowledge of computer science, after successful active participation in this introductory course • apply basic procedures and lead criminal acts committed with data processing systems in a way that can be used in court by applying • knowledge gained from exercises and practicals tools for exemplified examples • and be familiar with well-known journals for literature acquisition, in order to • contribute to the clarification of these criminal acts, • be able to statistically evaluate and present results, • understand the basic requirement of a research project
Summary indicative content:	• Definition of terms and introduction to digital forensics • Basic procedure and boundary conditions for forensics • Introduction to information security and the internal workings of computers • Evidence of "hacking • Use of tools for securing data sets and for analysis of secured data sets
Assessment:	Written modular examination – ungraded The active participation in the practical course is a prerequisite for the participation in the final examination.
Teaching style:	L: Presentations and blackboard writing in the exercises; electronic documents (e.g. presentations)

	E: Exercises and practical tasks (will be provided in the e-learning platform) LC: written lab instructions, textbooks
Indicative bibliography/ Sources:	• BSI-Grundschutzhandbuch (https://www.bsi.bund.de/DE/Themen/ITGrundschutz/itgrundschutz_node.html) • Dan Farmer, Wietse Venema: Forensic Discovery, Addison-Wesley Professional, 2005 • Cory Altheide, Harlan Carvey: Digital Forensics with Open Source Tools, Syngress Verlag, 2011 • Claudia Eckert: IT-Sicherheit Konzepte – Verfahren – Protokolle, Oldenbourg-Verlag, 2014

Module:	**Forensic Anthropology**
Semester:	5th Semester
Course leader:	Dr. Özgür Bulut
Lecturer:	Dr. Özgür Bulut
Language:	English
Assignment to curriculum:	**Elective course in the 5th semester of Forensic Sciences**
Course units/Lesson hours per week (SWS):	The course consists of Lecture (L): 1 SWS Exercises (E): 1 SWS Laboratory course (LC): 1 SWS; max. number of participants: 30
Student workload:	Contact hours private studies L: 15. 15 E: 15 15 LC:15 15 Total: 45 45 **Total (contact hours + private study): 90 hours**
Credits	3 ECTS
Prerequisites according to Examination Regulations:	none
Recommendations:	none
Learning outcomes:	Students are able to • be familiar with core concepts and basic forensic anthropological techniques in death investigations, • understand the role of the forensic anthropologist in death scene investigations, • understand the biological profile of the human skeleton, • be familiar with trauma analysis and craniofacial identification, • demonstrate knowledge of the stages of body decomposition and what variables affect its rate, how to estimate the post-mortem interval, in addition to identifying taphonomic indices on bone. by applying • methods for obtaining and evaluating osteological data from the human skeleton and bone models, • the forensic osteological analysis methods, • the knowledge of traditional and contemporary anthropological tools (softwares and hardwares), • the evaluation and interpretation of sexual and age markers on the skeleton • the knowledge of known journals for literautre acquisition, in order to • be able to successfully carry out anthropological analysis, • be able to evaluate and present analysis results of osteological data, • understand and prepare the basic requirements of a research project.

Summary indicative content:	• Definition and introduction to Forensic Anthropology • Basic consepts of human skeleton • Excavation, documentation and handling of skeletal remains • Initial evaluation of the skeleton: human or not? • Age, sex, stature & ancestry determination from the skeleton • Trauma analysis: blunt- sharp- ballistic trauma (postmortem-perimortem-antemortemtrauma) • Craniofacialsuperimposition • Craniofacial identification: facial reconstruction • Forensic facial identification • Practical case studies
Assessment:	Oral presentation and the corresponding handout of the presentation (%50) Report writing (%50)
Teaching style:	Powerpoint presentations, Working on case studies, Electronic documents (including presentations, exercises and internship tasks) Current literature and scientific publications
Indicative bibliography/ Sources:	Dupras TL, Schultz JJ, Williams LJ, Wheeler SM. Forensic recovery of human remains: archaeological approaches. CRC Press; 2016 Apr 19. Klepinger, Linda L. Fundamentals of forensic anthropology. Vol. 1. John Wiley & Sons, 2006. White, Tim D., Michael T. Black, and Pieter A.Folkens. Human osteology. Academic press, 2011. Pickering, Robert B., and David Bachman. The use of forensic anthropology. crc press, 1996. Iscan, Mehmet Yasar, and Maryan Steyn. The human skeleton in forensic medicine. Charles C Thomas Publisher, 2013. Wilkinson, C., 2004. Forensic facial reconstruction. Cambridge University Press. Wilkinson C. Computerized forensic facial reconstruction. Forensic Science, Medicine and Pathology, 2005. 1(3): p. 173-177 Bulut, O, Sipahioglu S, Hekimoglu B. "Facial soft tissue thickness database for craniofacial reconstruction in the Turkish adult population." Forensic science international, 242 (2014): 44-61.

Module:	**Case studies from Forensic Toxicology**
Semester:	5th Semester
Course leader:	PD Dr. rer. nat. Cornelius Heß
Lecturer:	PD Dr. rer. nat. Cornelius Heß
Language:	German
Assignment to curriculum:	**Elective course in the 5th semester of Forensic Sciences**
Course units/Lesson hours per week (SWS):	The course consists of Lecture (L): Exercises (E): max. number of participants: 20
Student workload:	Contact hours private studies L: 20. 20 E: 20 20 LC:5 5 Total: 45 45 **Total (contact hours + private study): 90 hours**
Credits	3 ECTS
Prerequisites according to Examination Regulations:	none
Recommendations:	none
Learning outcomes:	The students are able to • explan the most important analytical methods for the detection of xenobiotics and their application in forensically relevant matrices (blood, urine, saliva, hair, post-mortem materials) • explain the possible statements of analysis results in these matrices • explain potential questions within forensic toxicology based on case studies • critically read the literature and understand their application to concrete forensic-toxicological case studies • understand the structure and style of forensic-toxicological reports • explain the procedures involved in court proceedings by • presenting case studies and providing background information and literature to be applied directly to the case studies • Attending a court case with a forensic-toxicological background, the case of which has been intensively discussed before and after in order to • be able to carry out toxicological-analytical laboratory work successfully

	• be able to process simple and complex reports in forensic toxicology • critically examine publications
Summary indicative content:	The elective subject "Case Studies from Forensic Toxicology" is intended to give students an understanding of typical questions and approaches to preparing expert reports in the subject of forensic toxicology in Institutes of Forensic Medicine in German speaking countries. Reports on a total of 6-7 case studies are jointly developed. These include an expert opinion on cannabis and driving ability, on the temporal estimation of the time of (stimulant) consumption, on a knockout drug case, on hair analysis, on a case of lethal poisoning, on alcohol recalculation and on the assessment of postmortem findings especially regarding the use of New Psychoactive Substances. The dates each include a short presentation by the lecturer PD Dr. rer. nat. et med. habil. Cornelius Hess on the relevant topic, the (prepared) critical presentation of 2-4 publications, which are intended to bring the students closer to the special question of the report, and the presentation of the case study. A potential report will then be discussed. In addition to getting to know typical questions of forensic toxicology, critical reading of the scientific literature should also be learned. It is also planned (if time permits) to use one of the appointments to attend a (prepared and followed-up) court appointment in the Bonn/NRW/Rhineland-Palatinate area, which deals with a forensic-toxicological issue.
Assessment:	Written modular examination – graded The active participation in the practical course is a prerequisite for the participation in the final examination.
Teaching style:	L: Power Point presentation, textbooks current literature E: current literature LC: court case
Indicative bibliography/ Sources:	Will be provided in the course

Module Name:	**Human Biology and Histology**
Semester:	5th Semester
Reponsible person:	Prof. Dr. Christopher Volk
Lecturer:	Prof. Dr. Christopher Volk
Language:	German
Curricular assignment:	**Elective course in the 5th semester of Forensic Sciences**
Mode of teaching:	The module consists of lecture and practical course L: 2 SWS P: 1 SWS; max. 18 participants
Workload (hours)	Classes / Self-study L: 26 / 26 P: 12 / 16 Sum : 38 / 42 Sum total: 80 hours
Credits:	3 ECTS
Prerequesites according to examination rules:	None
Recommended prerequisites:	Basic knowledge of cell biology
Learning outcomes:	The students are able to • Prepare histological specimen for microscopy • Evaluate microscopical specimen of different tissues and organs and can identify basic structures • Understand functions of the different tissues and organs and connect these functions to the morphological structures by • Learning the basic characteristcs of the different tissues and the connected cellular structures in the lecture, followed by the composition of individual organs from these tissues, thus realising how these structures are responsible for the functions of the organs. • Practicing the technical skills for the preparation of microscopical specimen (cutting, staining) in the course as well as analysing and documenting specimen from different organs under the microscope. to • Reach a profund knowledge of the different organ systems of the human body and their structural and functional properties. • Apply the acquired skills in research and routione labs, e.g. in clinical diagnostics.
Content:	• Preparation of histological specimen: fixation and embedding of tissue samples, making of thin sections by microtome and cryotome, different staining techniques, artefacts, discussion of different light microscopic and electron microscopic techniques. • Cell Biology: Discussion of the different compartments of the cell • General Histology: Introduction of the different basic tissue types (Epithelia, connective tissue, muscle and nerve tissue) • Explanation of the most important organs and organ systems including macroscopical and microscopical as well as functional aspects. Especially covered are: Digestive tract: Oral cavity and associated structures, pharynx, oesophagus, stomach, small and large intestine, liver, pancreas;

	Cardiovascular system: the heart as central pump, organisation of blood vessels, different components of blood; Respiratory tract: nasal cavity, trachea, lungs, gas exchange; Urinary tract: Kidney, mechanisms of urine production, efferent tract, control of micturition; Reproduktve system: female and male sex organs, oogenesis and spermatogenesis; Endokrine system: General operation principle of hormones, detailled discussion of hypothalamus, pituitary gland, adrenal gland and thyroid gland; Nervous system: Structure and function of central and peripheral nerve system, meninges, cerebrospinal fluid, organisation of the spinal chord, discussion of the different parts of the brain with a special focus on functional aspects.
Assessment:	Successful participation in the lab course, documented by a lab report or a short presentation
Examination:	No exam, not graded
Media:	L: Power Point-presentations, black/ whiteboard, digital contents for follow-up (lecture files, videos), textbooks P: Script for the practical course, PowerPoint-presentations.
Literature:	– W. Pawlina, M.H. Ross, Histology: A Text and Atlas. Wolters Kluwer, 8. Auflage 2019 – A.L.Mescher, Junqueira´s Basic Histology: Text and Atlas. McGraw-Hill, 16. Auflage 2021 – R. Lüllmann-Rauch, E. Asan, Taschenlehrbuch Histologie. Thieme, 6. Auflage 2019. – U. Welsch, W. Kummer, T. Deller, Histologie - Das Lehrbuch. Elsevier, 5. Auflage 2018 – U. Welsch, Sobotta Atlas Histologie. Elsevier, 7. Auflage 2005

Module:	**Sensory Evaluation Methods in Quality Control**
Semester:	3rd semester
Course leader:	PD Dr. Michaela Schmitz
Lecturer:	PD Dr. Michaela Schmitz
Language:	English
Assignment to curriculum:	**Elective course in the 5th semester of Forensic Sciences, Chemistry with Material Sciences, Biology**
Course units/Lesson hours per week (SWS):	The course consists of: Lecture: 1 lesson hour per week Laboratory course: 2 lesson hours per week; max. group size: 20
Student workload:	Contact hours Private study Lecture: 15 15 Lab work: 30 30 Total : 45 45 **Total (contact hours + private study): 90 hours**
Credits:	3 ECTS
Prerequisites according to Examination Regulations:	none
Recommendations:	Fundamentals in quality control
Learning outcomes:	<u>Lecture</u>: At the end of the lecture, the students will: • be familiar with sensory perception of humans as a measuring too,l • be familiar with sensory profiles of foods, cosmetics and articles of daily use, • be able to integrate sensory evaluation methods in quality control, • be able to conduct basic sensory evaluation methods and are familiar with different capabilities of each sensory test for each quality control problem. <u>Laboratory course:</u> The students will: • be able to deepen the knowledge of the lecture by experimental methods, • be able to conduct sensory test methods with group of test persons in dependence on DIN standard, • be able to analyse real sensory problems in quality control, and can apply specific test methods for specific problems in quality control.
Summary indicative content:	<u>Lecture:</u> Human observers as good measuring instruments; sensory perception; optical, olfactory, gustatory, haptic and auditive sensory impressions; sensory profiles of foods, cosmetics and articles of daily use; special methods in sensory evaluation: Determination of threshold limit value; discrimination tests; descriptive analysis; hedonic tests; special techniques in sensory evaluation:

	determination of minimum durability, consumer tests and their operating requirements. Practical course: • Development of sensory tests for threshold limit values • Development of discrimination tests • Realization of descriptive tests • Development of hedonic tests
Assessment:	Modular examination – graded Laboratory work (oral examinations and lab reports): 30%; Written final examination: 70% Active participation in the laboratory course is a prerequisite for admission to the final examination. The final examination must be passed independently from the practical part.
Teaching style:	Lecture: Power Point presentation Laboratory course: Description of sensory tests in a power point presentation, realization of the standardized tests (DIN) with test person groups
Indicative bibliography/ Sources:	Lawless, H.T. and Heymann, H. 1998: Sensory evaluation of Food: Principles and Practices. New York: Chapman & Hall. Ney, K.H. 1987: Lebensmittelaromen. Springer Verlag. Frede, W. 2009: Handbuch für Lebensmittelchemiker. Kessler, W. 2007: Multivariate Datenanalyse. Wiley-CH-Verlag. DIN-Normen: DIN 10950-DIN 10970.

Module:	**Like CSI?! – Forensic Genetics in everyday working life**
Semester:	5th Semester
Course leader:	Dr. René Pflugradt, Sonja Uerlings
Lecturer:	Dr. René Pflugradt, Sonja Uerlings
Language:	German
Assignment to curriculum:	**Elective course in the 5th semester of Forensic Sciences**
Course units/Lesson hours per week (SWS):	The course consists of Lecture (L): 1 SWS Exercises (E): 1 SWS Laboratory course (LC): 1 SWS; max. number of participants: 20
Student workload:	Contact hours private studies L: 15. 15 E: 15 15 LC:15 15 Total: 45 45 **Total (contact hours + private study): 90 hours**
Credits	3 ECTS
Prerequisites according to Examination Regulations:	none
Recommendations:	Successful participation in the module Forensic Biology (3rd Semester)
Learning outcomes:	Students are able to • explain the most important fields of application and methods of forensic nucleic acid analysis (different methods for DNA extraction - in particular differential lysis, DNA analysis for individualization, RNA analysis for contextualization), • recognize and secure relevant DNA-containing biological traces in the case context, • process basic biological traces and obtain and evaluate DNA profiles • statistically evaluate DNA profiles from single sources and mixtures (probalities for identity, inclusion and exclusion as well as likelihood ratios) and • locate, understand and classify current research literature/areas, by applying • methods for obtaining and quantifying DNA from forensic samples, • the basic PCR-based forensic DNA analysis methods, • the knowledge of current forensic STR systems (German, EU and US systems) • the evaluation and interpretation of electropherograms of STR profiles • different calculation methods and current software for biostatistical evaluation of DNA profiles and

	• the knowledge of known journals for literautre acquisition, in order to • successfully perform DNA analytical laboratory work • being able to statistically evaluate and present (complex) DNA analytical results, • understand the basic requirements of a research project
Summary indicative content:	Lecture: Fields of application of routine forensic DNA analysis; identification of DNA-containing biological traces in the context of the case; presentation of different sampling techniques; interpretation and evaluation of (mixed) DNA profiles; population genetics; databases and biostatistical calculations with and without the application of different statistical software; insights into current research areas in forensic DNA analysis Exercise: Biostatistical evaluation of DNA profiles using different software applications, evaluation of the results of the practical course Laboratory course: Processing of relevant case studies (so-called mock samples) from sample collection, DNA extraction, multiplex PCR up to capillary electrophoretic analysis
Assessment:	Written modular examination – graded The active participation in the practical course is a prerequisite for the participation in the final examination.
Teaching style:	L: Power Point presentation, textbooks current literature E: various statistical software LC: written lab instructions, textbooks
Indicative bibliography/ Sources:	• John M. Butler: Fundamentals of Forensic DNA Typing (Elsevier) • John M. Butler: Advanced Topics in FORENSIC DNA TYPING: METHODOLOGY (Elsevier) • John M. Butler: Advanced Topics in FORENSIC DNA TYPING: INTERPRETATION (Elsevier) • Ulbrich, W., Anslinger, K., Bäßler, G. et al. Gemeinsame Empfehlungen der Projektgruppe „Biostatistische DNA-Berechnungen“ und der Spurenkommission zur biostatistischen Bewertung von DNA-analytischen Befunden. Rechtsmedizin 26, 291–298 (2016). • Gill, P., Gusmão, L., Haned, H. et al. DNA commission of the International Society of Forensic Genetics: Recommendations on the evaluation of STR typing results that may include drop-out and/or drop-in using probabilistic methods. Forensic Sci Int Genet. 6, 679-688 (2012).

Module:	**Thermal Analysis**
Semester:	4th/5th semester
Course leader:	Prof. Dr. Mandy Gieler
Lecturer:	Prof. Dr. Mandy Gieler
Language:	German
Assignment to curriculum:	**Elective course in the 4th/5th semester of B.Sc. Sustainable Chemistry and Materials** **Elective course in the 5th semester of B.Sc. Forensic Sciences**
Course units/ Lesson hours per week (SWS):	The course consists of: Lecture: 1 lesson hour per week Exercise: 2 lesson hours per week Practical course: 0 lesson hours per week
Student workload:	Contact hours / Private study Lecture: 15 / 15 Exercise: 30 / 30 Practical course: 0 / 0 Total: 45 / 45 **Total (contact hours + private study): 90 hours**
Credits	3 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	None
Learning outcomes:	The students are able to • define the essential thermo-analytical properties of polymers and assess their application-related relevance, • explain the principles of corresponding measurement techniques including sample preparation procedures by means of • in the lectures getting to know common methods of thermal analysis, their advantages and limitations as well as their application fields, • in the exercises deriving fundamental thermal charecteristics of materials from typical measurement curves and applying problem-appropriate evaluation methods, • in the course of laboratory tours and experiment demonstrations getting to know sample preparation steps, execution of measurements and evaluation of measurement curves in order to • measure and critically assess relevant thermo-analytical properties of polymers, • select adequate analytical methods to solve predefined (research) tasks, • draw conclusions on material type based on given measurement data, • perform an application-oriented material selection.
Summary indicative content:	• Terms, definitions and physical basics of thermal analysis • Differential Scanning Calorimetry (DSC)

	• Thermogravimetric Analysis (TGA) • Thermomechanical Analysis (TMA) • Dynamic-mechanical Analysis (DMA) • Dielectric Analysis (DEA)
Assessment:	Written examination– graded
Teaching style:	Lecture: Powerpoint presentations, blackboard/whiteboard, videos Exercise: Set of exercises
Indicative bibliography/Sources:	• G. W. Ehrenstein, G. Riedel, P. Trawiel, Praxis der thermischen Analyse von Kunststoffen, 2nd edition, München : Hanser, 2003. • G.W. H. Höhne, W.F. Hemminger, H.-J. Flammersheim, Differential scanning calorimetry, 2nd edition, Berlin : Springer, 2003.

Module:	**Troubleshooting in analytical chemistry**
Semester:	5rd semester
Course leader:	PD Dr. Michaela Schmitz
Lecturer:	PD Dr. Michaela Schmitz
Language:	English
Assignment to curriculum:	**Compulsory optional course in the 5rd semester of Forensic Sciences, Chemistry with Material Sciences**
Course units/Lesson hours per week (SWS):	The course consists of: Lecture: 0.5 lesson hour per week Laboratory course: 2.5 lesson hours per week; max. group size: 20
Student workload:	Contact hours Private study Lecture: 7.5 15 Lab work: 37.5 30 Total : 45 45 **Total (contact hours + private study): 90 hours**
Credits:	3 ECTS
Prerequisites according to Examination Regulations:	None
Recommendations:	Fundamentals in instrumental analytics
Learning outcomes:	Lecture: At the end of the lecture, the students will: • be familiar with the single parts of analytical instruments and with the assembly of them, • be able to solve analytical problems in photometry, DC, GC, HPLC, • be able to adapt sample preparation to each single analytical method. • be able to install a device (e.g. GC) for the measurement of special compounds Laboratory course: The students will: • be able to deepen the knowledge of the lecture by examples in analytics, • be able to install single parts of an analytical device (e.g. column or liner), • be able to find and solve analytical problems in a practical application, • be able to adapt the measuring device for different applications.
Summary indicative content:	Lecture: Photometry, buildup, troubleshooting, methods of optimization, enzymatical/immunological measurement process, microplates; chromatography: DC, GC, HPLC -buildup-, optimization/columns/ detectors/gradients; troubleshooting: how to approach problems in a sytematic manner?

	Practical course: • troubleshooting at different measuring devices • buildup and modification of the devices for special analytical methods • problems in photometry (enzymology and immunology) and troubleshooting • defects in chromatography (DC, GC, HPLC)-and troubleshooting • sample preparation-cause of mistakes
Assessment:	Modular examination – graded Laboratory work (oral examinations and lab reports): 50%; Written final examination: 50% Active participation in the laboratory course is a prerequisite for admission to the final examination. The final examination must be passed independently from the practical part.
Teaching style:	Lecture: Power Point presentation Laboratory course: Conduction of tasks concerning troubleshooting
Indicative bibliography/ Sources:	Meyer, V.: Praxis der Hochleistungs-Flüssigkeitschromato-graphie. Wiley-VCH. Meyer, V.R.: Fallstricke und Fehlerquellen der HPLC in Bildern The troubleshooting and maintenance guide for gas chromatography. Wiley VCH Kromidas, St.: HPLC-richtig optimiert. Wiley-VCH. Kromidas, St.: Practical Problem Solving in HPLC Kromidas, St.: More Practical Problem Solving in HPLC