

Curriculum proposal

BSc in Engineering Science

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		Semester			
		Track	ECTS	1	2
Year 1	Math	30	Engineering mathematics 1	Engineering mathematics 2	
	Physics	30	Physics - mechanics	Physics - electromagnetics & optics	
	Electronics	30	Programming		
	Materials & mechanics	30	Molecular engineering	Engineering mechanics	
	Engineering	30	System design lab	Engineering design	
	Soft skills	30		Technical writing & presentation	
		ECTS:	30	30	

		Semester			
		Track	ECTS	3	4
Year 2	Math	30	Data science	Differential equations	
	Physics	30		Solid-state physics	
	Electronics	30	Electrical engineering + lab	Electronic devices & circuits	
	Materials & mechanics	30	Solid-state materials	Molecular engineering lab	
	Engineering	30	CAD design		
	Soft skills	30	Project management	BOK	
		ECTS:	30	30	

		Semester			
		Track	ECTS	5	6
Year 3	Math	30		Control systems	
	Physics	30	Thermodynamics	Semiconductor physics	
	Electronics	30	Signals & systems	Instrumentation + lab	
	Materials & mechanics	30	Advanced molecular engineering		
	Engineering	30	Microsystems + lab	Rapid manufacturing	
	Soft skills	30	Design project	BOK	
		ECTS:	30	30	

		Semester			
		Track	ECTS	7	8
Year 4	Electives	60	Specialization & elective courses + BSc thesis		
			ECTS:	30	30

		Lab course	
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Figure 1: Summary of the BSc Engineering Science core curriculum & electives

1 Math track

Responsible: Pastewka

1.1 Engineering mathematics 1

Semester: 1	ECTS: 6	Lab: no	Possible instructors: ?
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- Mengen
- Zahlenbereiche
- Konvergenz
- Differentiation
- Integration

1.2 Engineering mathematics 2

Semester: 2	ECTS: 6	Lab: no	Possible instructors: ?
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- Lineare Algebra
- Funktionen mehrerer Variablen
- Grundlagen der Tensoranalysis

1.3 Data science

Semester: 3	ECTS: 6	Lab: no	Possible instructors: ?
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- Grundlagen der Statistik
- Frequentistischer Wahrscheinlichkeitsbegriff
- Bayesscher Wahrscheinlichkeitsbegriff
- Stochastische Prozesse (Wiener Prozess, Langevin Gleichung, Fokker-Planck-Gleichung)
- Bayes-Inferenz
- Gaußsche Prozesse (nichtparametrische Inferenz)
- neuronale Netze

1.4 Differential equations

Semester: 4	ECTS: 6	Lab: no	Possible instructors: ?
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- Partielle Differentialgleichungen
- Funktionenräume
- spektrale Methoden

- Methode der finiten Elemente
- nichtlineare Probleme
- Analyse und Visualisierung

1.5 Control systems

Semester: 6 **ECTS:** 6 **Lab:** no **Possible instructors:** Diehl

- State-Space Modeling of Dynamical Systems
- Input-Output System Models
- Stability and Characteristic Polynomial
- Linear Time Invariant Systems (Step-Response, BIBO Stability, Transfer Function, Bode- and Nyquist-Plot)
- Feedback Control Architectures
- Stability of Controlled Systems
- PID Control
- Frequency Domain Control Design
- State Space Control Design (Controllability, Pole Placement, LQR)
- State Estimation (Observability, Luenberger Observer, Kalman Filter)

2 Physics track

Responsible: Paul

2.1 Physics – mechanics

Semester: 1	ECTS: 6	Lab: no	Possible instructors: ?
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- Massepunkt
 - Orts-, Geschwindigkeits-, Beschleunigungsvektoren
 - Arbeit, Energie, Impuls, Leistung, Erhaltungssätze
 - Reibung
 - Gravitation, Coulomb
 - Trägheitskräfte (Zentrifugalk., Coriolis-K.)
- Starrer Körper
 - Translation, Rotation
 - Trägheitsmoment, Drehmoment, Drehimpuls
 - Drehimpulserhaltung
 - Statische und dynamisches Gleichgewicht
 - Bewegungsgleichungen
 - Kreisel
- Schwingungen und Wellen
 - Grundgleichung
 - Überlagerung, 1D, mehr-D
 - freie Schwingung, gedämpfte Schwingung
 - erzwungene Schwingung
 - Wellengleichung
 - Elastische Wellen, Seilwellen, Wasserwellen
 - Überlagerung von Wellen
 - Energie von Wellen
 - Streuung, Beugung, Absorption, nichtlineare Phänomenen (Schockwellen)
 - Einfaches Pendel
 - Gekoppelte Pendel
 - Schwingungen von Balken und Platten

2.2 Physics – electromagnetics & optics

Semester: 2 ECTS: 6 Lab: no Possible instructors: ?

- Elektrizität
 - Elektrostatik
 - Dielektrika: Verschiebungsdichte, Polarisierung, Energiedichte
- Elektrodynamik
 - Magnetfeld
 - Kräfte auf Ladungsträger und Ströme im Magnetfeld
 - Erzeugung von Magnetfeldern
 - Induktion
 - Wechselströme
 - Maxwell-Gleichungen
 - Ebene elmag. Wellen
 - Dipolstrahlung
 - Wellenleiter
- Geometrische Optik
 - Reflexion, Brechung, Snellius-Gesetz, Totalreflexion
 - Optische Elemente
 - Elektronenoptik
- Wellenoptik
 - Kohärenz
 - Interferenz
 - Beugung am Gitter
 - Spalt- und Lochblende
 - Auflösungsvermögen: Rayleigh
 - Fresnellinsen
 - Fabry-Perot, DBR
 - Lichtpolarisation
 - Absorption von Licht
 - Dispersion von Lichtpulsen
- Strahlungsenergie
 - Strahlungsspektrum
 - Wärmestrahlung
 - Schwarzkörperstrahlung, Stefan-Boltzmann
 - Von IR bis UV

2.3 Solid-state physics

Semester: 4 **ECTS:** 6 **Lab:** no **Possible instructors:** ?

- Aufbau der Festkörper
 - Übersicht über Atomaufbau und Orbitale
 - Gitteraufbau, Gittervektoren, Basisvektoren
 - Kristallebenen, Miller-Indizes
 - Bravais-Gitter
 - Wichtigste Kristallstrukturen (sc, bcc, fcc, hcp)
- Strukturaufklärung
 - Bragg-Streuung
 - Reziprokes Gitter
 - Laue-Bedingung, Ewald-Konstruktion
 - Röntgen-, Neutronen- Elektronen-Streuung
 - Laue-Methode, Debye-Scherrer-Methode
- Bindung der Festkörper
 - Lennard-Jones-Potenzial
 - van der Waals, Dispersions-Kräfte
 - Ionische Bindung, Madelung
 - Metallische Bindung
 - Kovalente Bindung
- Schwingungszustände des Festkörpers
 - Masse-Feder-Modell
 - Longitudinale und transverse Schwingungen
 - Schwingungsquanten, Phononen
 - Bose-Einstein-Verteilung
 - Schwingungsenergie des Festkörpers und spezifische Wärme
 - Einstein-Modell der spezifischen Wärme
 - Debye-Modell der spezifischen Wärme
 - Wärmeleitung durch Gitterschwingungen
- Elektronen im Festkörper
 - Schrödingergleichung und Blochzustände
 - Bandstruktur

- Quasifreie Elektronen
- Elektronen im periodischen Potenzial: Bänder und Bandlücken
- Fermiverteilung, Fermifläche
- Spezifische Wärme der Elektronen
- Elektrische Leitung im Metall
- Wiedemann-Franz-Gesetz
- Halbleiter: Valenz-/Leitungsband, direkte/indirekte Bandlücke Elektronen/Löcher, intrinsischer HL, Dotierung)
- Lichtabsorption im HL
- Magnetismus
 - Magnetisches Moment, Magnetisierung
 - Dia-/Para-/Ferromagnetismus
 - Langevinscher Diamagnetismus
 - Langevinscher Paramagnetismus
 - Bandmagnetismus nach Pauli
 - Ferromagnetismus

2.4 Thermodynamics

Semester: 5	ECTS: 6	Lab: no	Possible instructors: ?
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- Wärmeenergie, Temperatur, spezifische Wärme
- Kinetische Gastheorie
- Wärmekraftmaschinen
- Wärmeleitung, Diffusion
- Entropie, Enthalpie, freie Energie
- Aggregatzustände, Gibbssche Phasenregel

2.5 Semiconductor physics

Semester: 6	ECTS: 6	Lab: no	Possible instructors: ?
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- This and that

3 Electronics track

Responsible: Zappe, Diehl

3.1 Programming

Semester: 1	ECTS: 6	Lab: no	Possible instructors: ?
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- This and that

3.2 Electrical engineering

Semester: 3	ECTS: 6	Lab: yes	Possible instructors: Stieglitz/Kuhl
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- Basic circuit elements (R,C,L, diodes)
- Sources
- dc network analysis
- Fourier analysis
- ac network analysis, frequency response, & switching
- Feedback networks
- Digital systems
- Electrical power, electromagnetism & transformers
- Electromechanics

3.3 Electronic devices & circuits

Semester: 4	ECTS: 6	Lab: yes	Possible instructors: Zappe
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- Bipolar transistors & MOSFETs
- Bipolar circuit analysis
- Bipolar single-stage, differential, multi-stage & power amplifiers
- Filters, signal generators & current sources
- Op amps
- MOSFET circuit analysis
- MOS digital logic circuits
- Digital memory
- Microelectronics & integrated circuits
- Circuit simulation

3.4 Signals & systems

Semester: 5	ECTS: 6	Lab: no	Possible instructors: Diehl
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- Signals & spectral analysis
- Impulse & frequency response, transfer functions
- Fourier analysis & FFT
- Time and transform-domain representations
- Sampling, convolution, deconvolution, quantizing
- Noise, filtering & compression
- Probabilistic models; stochastic processes
- Correlation functions, power spectra, spectral factorization

3.5 Instrumentation

Semester: 6	ECTS: 6	Lab: yes	Possible instructors: Rupitsch
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- Sensors & signal types
- Sampling & measurement error
- Fourier transforms, impulse response, transfer functions, linear time-invariant systems
- Measurement concepts, filters, A/D & D/A conversion
- Analog & digital measurement systems
- Example measurement systems
 - Position, velocity & rotation measurement
 - Temperature, force & pressure measurement

4 Materials & mechanics track

Responsible: Rühle, Rapp

4.1 Molecular engineering

Semester: 1	ECTS: 6	Lab: no	Possible instructors: Rapp/Rühle
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- Atommodelle
- Chemische Bindung
- Phasen
- Stöchiometrie
- pH-Werte
- Massentransport
- Elektrochemie
- Analytische Verfahren (IR,NMR...)

4.2 Engineering mechanics

Semester: 2	ECTS: 6	Lab: no	Possible instructors: Woias
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- This and that

4.3 Solid-state materials

Semester: 3	ECTS: 6	Lab: no	Possible instructors: Paul
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- This and that

4.4 Molecular engineering lab

Semester: 4	ECTS: 6	Lab: yes	Possible instructors: Rühle
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- Analysis
- Synthesis
- Project-oriented connection to engineering problem

4.5 Advanced molecular engineering

Semester: 5	ECTS: 6	Lab: no	Possible instructors: multiple
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- Polymere / Soft Matter
 - concepts in soft matter / polymers

- smart, responsive materials
 - bioinspired materials
 - light weight composites
- Molecular Bioengineering
 - Biosensors
 - Biomaterials
 - Bioengineering: From biointerfaces to Regenerative Medicine
- Molecular Engineering for sustainable solutions
 - Energy conversion and storage
 - Water purification
 - From Cradle to cradle: Materials Cycles
 - biobased Materials; Biodegradation
- Computational
 - skalenübergreifende Modellierung

5 Engineering track

Responsible: Woias

5.1 System design lab

Semester: 1	ECTS: 6	Lab: yes	Possible instructors: Rupitsch
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- This and that

5.2 Engineering design

Semester: 2	ECTS: 6	Lab: no	Possible instructors: Woias
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- This and that

5.3 CAD design

Semester: 3	ECTS: 6	Lab: no	Possible instructors: ?
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- This and that

5.4 Microsystems

Semester: 5	ECTS: 6	Lab: yes	Possible instructors: Wallrabe/Zengerle
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- This and that

5.5 Rapid manufacturing

Semester: 6	ECTS: 6	Lab: no	Possible instructors: ?
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- Stereolithographie
- 3D-Druck mittels FDM (Fused Deposition modeling)
- Lasermikrobearbeitung
- CAM (Computer-Aided Manufacturing)

6 Soft skills track

Responsible: ?

6.1 Technical writing & presentation

Semester: 2	ECTS: 6	Lab: no	Possible instructors: Hanemann
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- This and that

6.2 Project management

Semester: 3	ECTS: 6	Lab: no	Possible instructors: Wallrabe
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- This and that

6.3 BOK

Semester: 4	ECTS: 6	Lab: no	Possible instructors: external
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- This and that

6.4 Design project

Semester: 5	ECTS: 6	Lab: yes	Possible instructors: all labs
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- This and that

6.5 BOK

Semester: 6	ECTS: 6	Lab: no	Possible instructors: external
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- This and that