Advanced mathematics
BMETE90MX33 3 hours / 3 credits
Heat equation on an interval. The wave equation on an interval The wave equation on the line. Convolution Fourier transform. The fundamental subspaces of a matrix. Orthogonal projection to a subspace. Power method. Singular value decomposition. Pseudoinverse.
Literature:
Howard Anthon, Robert C. Busby (2003) Contemporary Linear Algebra, Wiley.
T.W. Körner (1988) Fourier Analysis, Cambridge.
T.W. Körner (1993) Excercises for Fourier Analysis, Cambridge.

Physics laboratory
BMETE11MX22 1 hour / 1 credit
Measurement of the eigenmodes of a vibrating string by an oscilloscope. Study of the excited vibration of a mass on a spring with the help of a computer controlled ultrasonic distance detector. Basic measurements in optics (lenses, prism, polarization, diffraction). Measurement of submicron expansions (thermal expansion, magnetostriction) by Michelson interferometer. Measurement of specific heat and the heat of fusion in a stainless steel vacuum flask. Study of a solar collector model system.

Numerical methods
BMEEOFTMKT2 3 hours / 3 credits
The aim of this course is to introduce numerical techniques that can be used on computers employing Matlab system, as well as to provide understanding of how these methods work and aid in choosing the proper algorithm. The topics cover linear and non-linear equations, optimization, numerical integration and differentiation, interpolation, regression and ordinary differential equations resulted mainly from civil engineering problems.
Literature:
Press W.H. (1995) Numerical Recipes in C, Cambridge University Press.
Chapra S.C. and Canale (R.P) (1998) Numerical Methods for Engineers, McGraw-Hill Won Y.Y. (2005) Applied Numerical Methods using MATLAB, Wiley- Interscience.

Database systems
BMEEOFTMKT3 2 hours / 2 credits
This course will present the base theory, management and analysis of Database Systems which play increasing role in the field of civil engineering practice, the science and the everyday life. It will cover the evaluation factors of database systems and the theoretical, logical, physical and non-structured models of database architectures. Introduce the planning, modeling, retrieving and analysis techniques of data bases. Cover the national/international practice used in infrastructural, environmental, technical data bases, data warehouses.
Literature:
Date, C.J. (2003): An Introduction to Database Systems, Addison Wesley; 8th edition
Rigaux, Scholl, Voisard (2002.): Spatial Databases with Application to GIS, Academic Press
Ullman J. D., Widom J.. (2008): Database Systems, Prentice-Hall, 2nd edition

Advanced mechanics
BMEEOTMMST9 4 hours / 4 credits
Basic variables of non-linear continuum mechanics, equations of kinematics. Definition of strain, small and large strains, strain tensors. Definition of stress, stress tensors. Thermodynamic conditions of material models, stress and strain pairs, the most important material models for elasto-plastic and time-dependent materials. Basic equations of continuum mechanics, strong and

weak forms. Different work and energy theorems, applications. Basic solution methods of equations of continuum mechanics, displacement and force methods, stress functions. Basic mechanical equations of beams, plates and shells.
Literature:
Bojtár: MSc Mechanics, *Lecture notes, TUB, 2011.*
Fung, Y. C. - Pin Tong: Classical and Computational Solid Mechanics, *World Scientific, 2007.*
Ibrahimbegovic, A. : Nonlinear Solid Mechanics, *Springer, 2009.*
Holzapfel, G. A. : Nonlinear Solid Mechanics, *Wiley, 2000.*

Finite element method I.
BMEEOTMMST0 2 hours / 2 credits
Foundations of the error principles in mathematics. Theoretical grounds of the Galerkin and Ritz methods. Application of the general Galerkin and Ritz methods. Special approximations, general idea of the finite element technics. Basic steps of the general finite element analysis. Geometrical and mathematical finitization. Calculation of elementary matrices. Compilation technics, boundary conditions. Estimation of numerical errors. Locking problems. Mixed variational methods in finite element solutions. Boundary element method, finite strip technics, and method of finite volumes.
Literature:
Bojtár I. - Gáspár Zs. : The Basic Ideas of the Finite Element Method, *Lecture notes, TUB, 2010*.
Fish, J. - Belytschko, T. : First Course in Finite Elements, *Wiley, 2008.*
Akin, J. E. : Finite Elements for Analysis and Design, *Academic Press, 1995.*
Zienkiewicz, O. C. - Taylor, R. L. : The Finite Element Method: The Basis + Solid Mechanics, *Butterworth, 2000.*

FEM modelling of structures
BMEEOHSMB01 5 days / 2 credits
The aim of the course is to demonstrate the finite element modelling possibilities in the structural design. Finite element model development; static system and FEM model relationship. Demonstration of the advanced finite element analysis: possible finite elements and analysis methods. Modelling of structures with truss-, surface- or volume elements. Finite element model verification and model refinement possibilities (convergence study, adaptive mesh generation).
Literature:
Introduction to Finite Element Methods (ASEN 5007) - Fall 2010, Department of Aerospace Engineering Sciences, University of Colorado at Boulder, course syllabus available on internet.
ANSYS Mechanical APDL Programmer's Manual, Ansys Inc., Canonsburg PA 15317.

Management accounting and controlling
BMEGT35M410 3 hours / 4 credits
The main issues of ‘window dressing’ and their interpretation through financial ratio analysis and interpretation. The cost volume profit analysis and its relationship with costing and pricing decision-making. The operational and capital budgetary process in an international context and its advisory role through the process of variance analysis. The best international accounting practice both at the functional, planning and strategic stages. The wider developmental strategic and ethical international issues concerned with managerial accounting.
Literature:
Power Point presentations of the sessions and handouts distributed in the classroom.
Williams, Haka, and Bettner (2007) Financial and Managerial Accounting: The Basis for Business Decisions (14th Edition). McGraw Hill.
Drury (2004): Management and Cost Accounting (6th Edition), Thomson Publishing

Engineering ethics
BMEGT41M004 2 hours / 2 credits
The purpose of this course is to help future engineers be prepared for confronting and resolving ethical issues that they might encounter during their professional careers. It gives an overview of the moral problems engineers face in their different social roles, and it provides conceptual tools and methods necessary for pursuing those issues. Topics include engineering professionalism; social roles of engineers; ethical theories; ethical decision making techniques; social impacts of engineering, professional organizations; code of ethics of engineering societies. Case studies are discussed in a practice oriented approach. The primary goal is to stimulate critical and responsible reflection on moral issues surrounding engineering practice.
Literature:
Fleddermann, C.B. 2007. *Engineering Ethics* (3rd ed.) Upper Saddle River, N.J.:Prentice Hall.
Code of Ethics; American Society of Civil Engineers, http://www.asce.org/Leadership-and-Management/Ethics/Code-of-Ethics/

Decision supporting methods
BMEEPEKMST4 2 hours / 2 credits
The aim of the course is to familiarize students with some practically used or usable mathematical models in the field of construction management, scheduling and tendering process. The course covers a wide variety of topics dealing with least cost scheduling problems, multi attribute decision models, learning curves. There are two computational modeling tasks as homework assignments. Final grades will be based on the two assigned tasks 15-15% and test 70%.
Literature:
Levente Mályusz: Decision Support Methods, www.ekt.bme.hu.
Ravindra K. Ahuja, Thomas L. Magnanti, James B. Orlin: Network Flows: Theory, Algorithms, and Applications, Prentice Hall 1993.
Miklós Hajdu: Network Scheduling Techniques for Construction Project Management, Kluwer 1997.

Material models and plasticity
BMEEOTMMB04 3 hours / 5 credits
The effect of microstructure of materials on macro-behaviour. Micro- and phenomenological models. Thermodynamic conditions in generation of material models, conditions of stability and definiteness. Models of elastic and irreversible behaviour: plastic and fracturing physical states, basic ideas of continuum damage mechanics. Description of complex material behaviour. Numerical and experimental aspects of material modelling. The main emphasis is placed on the fundamental relations and theorems of the incremental theory of plastic bodies and on the principles and methods of incremental and limit analysis, optimal design, and shakedown analysis of bar structures. In additions, however, the elasto- plastic analysis of prismatic bars under torsions and thick-walled cylinders and spheres subjected to internal pressures, as well as the theory and application of plane strain and plane stress problems of plasticity are also discussed.
Literature:
Bojtár I.: Material models of mechanics, *Lecture notes, TUB, 2011.*
Kaliszky S. - Lógó J. - Nédli P.: Calculation load bearing capacity and optimal design of frames, *Lecture notes, TUB, 1998.*
Kaliszky S.: Plasticity -Theory and Engineering Applications, *Akadémiai Kiadó, Budapest, 1989.*
Ashby, M. F. - Jones, D. R. H.: Engineering materials 1-2, *Elsevier, 2006.*
Lemaitre, J.: Handbook of materials behavior models I-III., *Academic Press, 2001.*
Cohn, M. - Maier, G., eds.: Engineering Plasticity by Mathematical Programming, *Pergamon Press, New York, 1979.*

Finite element method II.
BMEEOTMMB05 3 hours / 3 credits
Different types of mechanical non-linearity. Eulerian and Lagrangian descriptions. Basic equations of 1D and 3D finite element models. Different types of numerical solutions to non-linear finite element problems, the question of stability and convergence. Large displacement analysis at Bernoulli-Navier and Timoshenko beams. Non-linear analysis of classical and Reissner-Mindlin plate bending problems and shells. Analysis of structures with elasto-plastic materials. The return-mapping algorithms. Analysis of time-dependent problems. Special problems of non-linear geotechnics. New trends in non-linear mechanics.
Literature:
Bojtár I. - Gáspár Zs. : The Nonlinear Finite Element Method, *Lecture notes, TUB, 2011.*
Belytschko, T. - Liu, W. K. - Mora, B. : Nonlinear Finite Elements for Continua and Structures, *Wiley, 2000.*
Wriggers, P. : Nonlinear Finite Element Methods: *Springer, 2008.*

Structural reliability
BMEEOHSMST5 2 hours / 2 credits
Fundamentals of probability theory. Generalized reliability problem. Deterministic and probabilistic measures of structural reliability. Uncertainties in reliability assessment. Risk assessment. Integration and simulation methods. Monte Carlo simulation, second-moment concepts, second-order methods. Reliability index. Idealization of structural systems. Stochastic models for load effects and load combinations. Stochastic models for material strength. Resistance modelling. System reliability. Calibration and selection of safety levels. Reliability concept in Eurocode. Test-based design according to Eurocode.
Literature:
Melchers, R.E.: *Structural reliability analysis and prediction,* 2nd edition, John Wiley & Sons, Chichester, England, 1999.
Madsen, H.O., Krenk, S., Lind, N.C.: *Methods of structural safety,* Dover Publications, Mineola, New York, 2006.
Marek, P., Brozzetti, J., Gustar, M. (editors): *Probabilistic assessment of structures using Monte Carlo simulation - Background, excercises and software,* Tereco, Institute of Theoretical and Applied Mechanics, Czech Academy of Sciences, Prague, 2001.

Structural dynamics
BMEEOTMMB02 4 hours / 5 credits
Dynamic effect of impulse loads for one-degree-of-freedom systems in elastic and plastic states. Calculation of natural circular frequencies of beams. Free vibration of beams. Excitation of beams by moving force. Exact dynamic stiffness matrices of beam systems. Dynamic stiffness matrices in the case of application of finite element method. Calculation of vibration equations using the modal analysis and numerical integrations. Dynamic interaction of structure and soil in the case of rigid foundation. Calculation of machine foundations. Dynamic calculation of structures in the case of support movements. Earthquake analysis. Dynamic effects of wind loads. Aerodynamical instability, galloping. Dynamical calculation of beams in case of moving mass points.
Literature:
Kolousek: Dynamics in Engineering Structures. Butterworths, 1973.
Chopra, A.K., Dynamics of Structures, Theory and Applications to Earthquake Engineering, Pearson Prentice Hall, 2007

Stability of structures
BMEEOTMMB03 4 hours / 5 credits

Failure modes, quasi-static loading process, modelling of structures. The mathematical background of stability of elastic structures in the case of small displacements (linear operators, eigenvalue problems, solution methods, etc). Useful theorems for the determination of approximate value of the critical load of bifurcation (the Southwell, Dunkerley, Foppl-Papkovich, Melan summation theorems). Two- and three-dimensional buckling of columns and beams. Buckling of plates and plated structures. Buckling of shells. Post-critical states and utilization of post-critical reserve.
Literature:
Timoshenko, S.P., Gere, J.M.: Theory of elastic stability. McGraw-Hill, New York, 1961.

Numerical methods for structures
BMEEOTMMB06 2 hours / 3 credits
Fundaments of Discrete Element Modeling. Overview of the mathematical principles of DEM. Theoretical fundaments of the most important modeling methods: UDEC, PFC, DDA, CD, mixed techniques. Interpretation of the results with the help of microstructural state variables. Fundamentals of the semi-analytical Finite Strip Method. FSM application to stability analysis of thin-walled prismatic columns and beams. Introduction to Spline Finite Strip Method.
Literature:
V.M. Sharma, K.R. Saxena, R.D. Woods (eds): Distinct Element Modelling in Geomechanics. Balkema, 1999
Cheung, Tham: Finite Strip Method. CRC Press. 1997

Structural analysis theory
BMEEOTMMB07 2 hours / 3 credits
Basics of Mathematics. Numerical analysis of trusses (state equation, static/kinematic characterization, force and displacement method). Frames: characteristics of a general bar element (of curved axis and variable cross section); basic relationships, stiffness matrix, reduced load vector, special (eccentric, elastic, partial) connections, solution with the displacement method. Special cases: planar frames, grillages, beams on elastic foundation, filled frames. Higher-order theories: suspension bridges, bar networks.
Literature:
Dawe, D.J.: Matrix and finite element displacement analysis of structures. Clarendon Press, Oxford, 1984.
Menon, D.: *Advanced Structural Analysis,* Alpha Science, UK, 2009.
Kovács, F., Lengyel, A.: Structural analysis theory. *Lecture notes, TUB* (in preparation)

Seismic design
BMEEOHSMC03 2 hours / 3 credits
Characterization of seismic events: origin, occurrence, influence, load effect, damages. Fundamentals of structural dynamics. Idealization of structures and structural behaviour. Time-history analysis of a SDOF system, earthquake response of linear systems. Response spectrum analysis, lateral force method of analysis. Earthquake response of non-linear systems. Linear and non-linear analysis methods for dissipative systems. Fundamentals of dissipative structural design. MDOF systems. Modal response spectrum analysis. Torsional effects. Analysis and design according to Eurocode 8. Seismic modelling and analysis of structures. Soil-structure interaction: effects, modelling, analysis. Analysis and seismic design of foundations. Embedded structures, water-immersed structures. Capacity design of dissipative structures. Local and global ductility, failure mechanism. Non-dissipative and dissipative steel, RC and composite structures for buildings. Design of bridges, nondissipative and dissipative bridge structures.

Literature:
Chopra, Anil K.: Dynamics of Structures: Theory and Applications to Earthquake Engineering. Prentice-Hall, 1995.
Mazzolani, F. M., - Piluso, V.: Theory and Design of Seismic Resistant Steel Frames. E & FN Spon, 1996.
Paulay, Th., Priestley, M.J.N.: *Seismic design of reinforced concrete and masonry buildings*, Wiley, 1992.

Conceptual design
BMEEOHSMB08 2 hours / 3 credits
Conceptual Design has to rationally define the basic procedures to get sound structural arrangements not only safe but also economical, aesthetical and of good quality. To reach this goal the engineers can proceed by means of modern engineering concepts using computer- aided methods of analysis in order to quickly obtain reliable information for dimensioning the structural organism. The main topics of the lessons ensure these capabilities: review of the historical development, evaluation system and activities of the Structural Design Software (SDS); 3D-based analysis using the general beam-column finite element method; ConSteel as an integrated design software; modeling with eccentric structural elements; design studies (conceptual design of buildings and bridges); up-to-date methods of global stability analysis.
Literature:
Fraser, D.R.: *Conceptual Design and Preliminary Analysis of Structures,* Pitman Publishing, 2010.
SPECIALTY CONFERENCES on "CONCEPTUAL DESIGN OF STRUCTURES" (e.g. Singapore, 29-30 August 2001)

FEM based structural design
BMEEOHSMB09 2 hours / 4 credits
Application of finite element analysis for structural design. Advanced design methods in Eurocode standards. Characteristics and types of advanced structural analysis. Verification and calibration of finite element models. FEM modelling of plated structures. FEM-based fatigue and stability analysis. Design based on virtual experiments. Multi-level finite element models.
Literature:
Dunai, L.: Computational steel structures technology. Teaching Material, Budapest University of Technology and Economics, TEMPUS-JEP-12116-97, 2001.

Geotechnical design
BMEEOGTMCT1 3 hours / 4 credits
Limit states, determination of actions, safety factors. Determination of soil physical parameters based on in situ test results. Design of shallow foundations based on in situ test results. Design of pile foundations based on in situ test results. Determination of negative skin friction of piles. Design of stone columns. Analysis of bridge abutment backfills; calculation and measurement of settlements. Design of vertical drains. Design of underpinning existing structures. Retaining structures for deep excavations; jet columns and pile columns. Dewatering of excavations.

Numerical modelling in geotechnics
BMEEOGTMC05 2 hours / 3 credits
Basic principles. Introduction to geotechnical modelling. Spreadsheet applications to engineering calculations: stress calculation, shallow foundation design, pile design, beam on elastic foundation, seepage. Geotechnical calculations using finite element programs: shallow foundation, slope stability and retaining structure.
Basic principles. Introduction to geotechnical modeling. Spreadsheet applications to engineering

calculations: stress calculation, shallow foundation design, pile design, beam on elastic foundation, seepage. Geotechnical calculations using finite element programs: shallow foundation, slope stability and retaining structure.
Literature:
Look, B.: Spreadsheet Geomechanics, 1994.
Das, B.M.: Principles of Geotechnical Engineering, 2002.

Extreme actions on structures
BMEEOHSMB10 2 hours / 3 credits
Extreme loads on structures. Robustness of structures. Stochastic models for load effects and load combinations. Performance-based design. Reliability-based approaches.
Wind load effects. Turbulent wind, gust wind load. Response analysis, equivalent static load, stochastic model for wind load. Aerodynamic analysis of structures. Aeroelasticity. Blast load effects. Characterization and influence of blast loads, probability and hazard. Blast load effect modelling, dynamic and equivalent static analysis. Non-linear approaches. Design of structures exposed to fire. Fire models and analysis. Material and element behaviour at high temperature. Thermal analysis of structural elements. Element resistance calculation. Local and global analysis. Application of performance-based design in earthquake and fire engineering.
Literature:
Hegedűs, I., Horváth, L., Vigh, L.G.: *Lecture notes.* (in preparation)
Madsen, H.O., Krenk, S., Lind, N.C.: *Methods of structural safety,* Dover Publications, Mineola, New York, 2006.

Fracture mechanics and fatigue
BMEEOHSMB11 3 hours / 4 credits
The origins of cracks and crack propagation on microstructure level. Complex stress functions for analysis of stress singularities: Kolosov-Mushelisvili-Westergaard solutions. The "K" stress-intensity factor. The Griffith energy condition, the "G" energy parameter. Path-independent integrals, the "J" parameter. Numerical and laboratory experiments to measure fracture parameters and crack propagation in the case of quasi-static and cyclic loads. Analysis of different materials (concrete, wood, etc.). Applications of fracture mechanics for civil engineering structures. Simple and complex structural integrity assessment methods. Fracture mechanical background of the EUROCODE at fatigue design and material toughness properties. Advanced methods to avoid brittle fracture. Estimation of fatigue life of real steel structures.
Literature:
Bojtár I.: Fracture mechanics, *Lecture notes, TUB, 2011.*
Horváth L.: Applied fracture mechanics on fatigue design and to avoid brittle fracture, *Electronic Lecture Notes, TUB, in preparation.*
Mushelisvili, N.: Some basic problems of mathematical theory of elasticity, *P. Nordhoff, 1953.*
Anderson, T. L.: Fracture mechanics, *CRC Press, 1995.*
Ainsworth, R. A. - Schwalbe, K. H.: Fracture of Materials from Nano to Macro, *Elsevier/Pergamon Press, 2007*
Background documents in support to the implementation, harmonization and further development of the EUROCODES, *Scientific and Technical Reports of the Joint Research Centre, European Commission.*