To whom it may concern

Torstein Ørbeck Eliassen

Torstein Ørbeck Eliassen, born March 1st 1997, is a student in NTNU's 5-year Master's Programme in Cybernetics and Robotics. This is a five-year integrated master's degree of 300 ECTS, with no intermediate bachelor's degree. Normally the master´s degree is given after two years of study (120ECTS), following the completion of a bachelor's degree (180 ECTS).

Within the Norwegian Education system, a Bachelor's degree is awarded after three years of full-time study (180 ECTS). Ørbeck Eliassen will after his first three years at the 5-year Master's Programme in Cybernetics and Robotics have achieved 180 ECTS. Regarding extent and level of the study, this should be considered equivalent to a Bachelor's degree.

Please find on the next pages an overview of the subjects Ørbeck Eliassen will have completed after his first three years of the 5-year Master's Programme in Cybernetics and Robotics. The overview shows the subjects, the subjects' content, and references to complete course descriptions in English.

Regards
NTNU – Faculty of Information Technology and Electrical Engineering

Roger Midtstraum
Vice Dean for Education

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NTNU

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The following information contains a table, showing course content for the subjects in the three first years of the 5-year Master's Programme in Cybernetics and Robotics. The first column consist of the different course codes. By clicking them the entire course description will appear.

All courses are given 7,5 Credits, eccept from the course HMS0002, which is a mandatory course regarding Health, Safety and Environment. This course is not given any credits.

1st Year		Course content
HMS0002	Health, Safety and Environment (HSE) course for 1st year students	Fire protection-theory and practical exercises using fire extinguishing equipment - Fire/evacuation routines at NTNU - First aid-theory and practical exercises in heart-lung resuscitation and the use of heart starter
TDT4110	Information Technology, Introduction	The course consists of two parts: ICT theory (1/3) and an introduction to procedure-oriented programming in Python (2/3). ICT theory Principles of computer operations. Digital representation. Algorithms. Network and communication. Procedure-oriented programming: Variables and data types. Input and output. Control structures: Sequence, conditional program flow and repetitions. Structuring and modularization of programs; functions and modules. Data structures: Lists, tables, text strings, sets, tuples and dictionaries. Persistent storage of data, file input and output, and exceptions. Numerics, simulation, and estimations. Representations of numbers, simple processing and visualization of measured data, and iterative solution of simple equations.

		Recursion, sorting and searching. Formulation of algorithms as pseudo code or in flow diagrams. Python as a programming environment.
TFE4101	Electrical Circuits and Digital Design	The course gives an introduction to electrical concepts and analog circuit theory as a base for understanding both electrical and computer engineering. It also provides a foundation for understanding and designing simple circuits and systems built with digital electronic circuit elements. Examples and exercises provide skills learning for using basic laboratory equipment and training laboratory work and report writing. Themes are: Conventions, circuit elements, Ohm´s law, Kirchhoff´s laws, simple resistive circuits, techniques of circuit analysis, capacitance, inductance, and first order RC-circuits (natural and step response). Simplified properties, function and use of diodes and MOSFET transistors. Number systems, binary arithmetic. Boolean algebra, logic gates, simplification methods, combinational logic and simple memory components, flip flops, counters, shiftregisters, and simple arithmetic circuits. Time delay, performance, area, and power consumption for simple digital circuits.
TMA4100	Calculus 1	Limits, continuity, differentiation, and integration of functions of one variable. The intermediate value theorem, the mean-value theorem, extreme values, transcendental functions, implicit differentiation, related rates, indeterminate forms, Newton's method. Techniques of integration and numerical integration. Riemann sums, the definite integral, and the fundamental theorem of calculus. Area, volume, arclength, area of surfaces of revolution. Sequences, series, and power series. Taylor series, Taylor's formula. First order separable and linear differential equations. Euler's method. Examples of mathematical modelling and from applications to science, technology, and economy.
TTK4100	Computerized Control, Introduction	The basics and terminology of control theory. Introduction to differential equations. Mathematical models of some simple and well known physical

		processes are derived and presented. Control and simulations of these models will be demonstrated. Modeling with block diagrams. Introduction to Simulink. Introduction to dynamical systems.
TDT4102	Procedural and Object-Oriented Programming	Basic and practice-oriented programming in C++. The course covers most of the elements in the programming language and selected parts of the standard library. Through the exercises, the students will get extensive experience in the construction, debugging and testing of software.
TMA4105	Calculus 2	Curves in space. Functions of several variables. Taylor's theorem in two dimensions, extremal values in several variables, Lagrange multipliers. Double and triple integrals, line and surface integrals. Vector calculus. The theorems of Green, Stokes, and Gauss.
TMA4115	Matematikk 3	Complex numbers and the complex exponential function. Second order linear differential equations. Systems of linear equations, Gauss-Jordan elimination, reduced echelon form, matrix algebra, determinants. Vector spaces, subspaces, linear dependence and independence. Inner products, orthogonality, orthogonal projections, Gram-Schmidt orthogonalization, and the method of least squares. Eigenvalues and eigenvectors, diagonalization, symmetric matrices and quadratic forms. First order systems of differential equations.
TTK4101	Instrumentation and Measurements	Analog signals, filtering, sampling, analog signal amplifiers, current loop. Transmission lines and line termination. scaling and calibration. Basic measurement principles based on resistance, capacitance, light, magnetism etc.. Instrumentation for selected physical process variables. Selected control elements.

2nd Year		**Course content**
TDT4160	Computers and Digital Design	The course will contain terminology, principles and concepts for construction and operation of different kinds of modern computers and other computer related equipment. Basic methods, analysis and design of of sequential logic and finite state machines. Principles of how computers (and other digital machines) are constructed from combinatoric and sequential logic logic blocks. Short historic overview into the evolution of computer technology. Architecture (organization), operation and realization of computers and computer systems. Construction of computers on different levels, instruction format, address modes, processor architecture and types, Hardware and software interface, connection of components, interrupt, busses, storage hierarchy, and cache. Examination of central computer technical equipment (peripheral units). Short introduction to distributed systems, embedded systems, parallel computers, new technologies and new applications.
TFY4115	Physics	Main topics: Mechanics, thermodynamics. Detailed content: Mechanics: Point particle dynamics. Statics and dynamics of rigid bodies. Conservation of energy, linear momentum and angular momentum. Oscillations. Principles of continuum mechanics. Thermodynamics: 1. and 2. law of thermodynamics. Temperature, internal energy, entropy. Kinetic gass theory. Heat transport (conduction, convection and radiation).
TMA4120	Calculus 4K	Complex functions, complex integration, Laurent series and calculation of residues. The Laplace transform with applications to solving ordinary differential equations and integral equations. Fourier series and the Fourier transform with applications to solving linear partial differential equations.
TTK4240	Industriell elektroteknikk	**Industrial Electrotechnics**
EXPH0004	Examen philosophicum for Science and	At NTNU there are four ex.phil.variants. The variants have a common part

	Technology	constituting about 2/3 of the course and a variant part constituting about 1/3. The variants constitue an integral unit. The course provides a wider perspective on university studies at NTNU through an introduction to the philosophy and history of science and philosophy of science, ethics and political philosophy of relevance to students of science and technology. The common part draws lines from Antiquity's worldview to discussions in our own time. It takes up different views of nature, man, knowledge, science, crafts/art, ethics, politics, rationality and argumentation from both a historical and systematic perspective. The variant part focuses on ethics both as systematic theory and in an applied perspective with particular focus on the relationship between science/technology and ethics.
TMA4245	Statistics	Descriptive statistics. Probabilities for an event and stochastic variables. Independent and dependent stochastic variables. Conditional probability. Univariate and multivariate probability distributions. The most important classes of univariate probability distributions. Extreme variables. Point estimation, interval estimation and hypothesis testing for one and two sample data. Simple linear regression.
TTK4105	Control Systems	Linear differential equations. State space representation. Transition matrix, decoupling, canonical forms. Linear approximations of nonlinear processes; linearisation. Block diagrams. Laplace transformation. Root loci. Responses for some typical processes--time- and frequency response. Stability of feedback systems, stability criteria. Frequency domain based synthesis of feedback systems: Servo control, process control with rejection of disturbances. P, PI, PID controllers, other serial controllers. Cascade control. Feedforward control. Basics of discrete (digital) control of continuous systems and digital filters.

TTK4235	Embedded Systems	The Unified Modeling Language (UML) as a general-purpose, developmental, modeling language in the field of software engineering, that is intended to provide a standard way to visualize the design of a system. Programmable logic Controllers (PLC). System analysis and design, with emphasis on event driven systems. The state machine formalism. The C programming language: Pointers and complex data structures (arrays and structs). Register-level operations, bits in input and output registers, program development based on C. Advanced programming, coding style and netiquette. Programming microcontrollers: the Micro:Bit board, an ARM-based embedded system designed by the BBC for use in computer education. Sampling and digitizing of analog signals.

3rd Year		**Course content**
TDT4120	Algorithms and Data Structures	Methods for analysing the efficiency of algorithms, divide and conquer techniques, recursive solution methods. Methods for ordering, searching and sorting. Data structures for efficient retrieval of data, dynamic programming and greedy algorithms. Data structures for implementing graphs and networks, as well as methods for traversals and searches. Algorithms for finding the best path(s) and matchings, spanning trees and maximum flow. Theory of problem complexity. Algorithms are expressed in a language-independent manner.
TIØ4252	Technology Management	The course ensures that students encounter different challenges associated with managing a modern technology enterprise. Central themes are: a) understanding of organisations, including change and development processes around technology; b) understanding of economy including basic understanding of accounting, investments and economy management. In addition, there are themes on entrepreneurship and ethical behaviour in the engineering profession.
TMA4145	Linear Methods	Linear and normed spaces. Completeness, Banach spaces and Banach's fixed point theorem. Picard's theorem. Linear transformations. Inner product spaces, projections, and Hilbert spaces. Orthogonal sequences and approximations. Linear functionals, dual space, and Riesz' representation theorem. Spectral theorem, Jordan canonical form, and matrix decompositions.
TTK4115	Lineær systemteori	Theory for linear multivariable systems, state space models, discretization, canonical forms and realizations, Lyapunov stability, controllability and observability, state feedback, LQ control, state estimation, the Kalman filter, descriptions of stochastic processes and random signals.
TTK4145	Real-time Programming	Programming formalisms for real-time systems; POSIX, Ada, Java and Go. Threads/processes, synchronization and communication. Shared variable-based synchronization and resource control. Fault Tolerance, availability and consistency. Message-based synchronization, CSP and formal methods.

		Exercises and project.
TTK4130	Modelling and Simulation	The course gives an introduction to methods for modeling and simulation of physical processes, for use in control applications. 1. Models, model properties and modeling tools: The student will know the most common model classes, and have knowledge of some central model properties that are useful for control systems, and know principles for, and have some practical exposure of, high level modeling tools (both block-oriented (Simulink) and equation/object-oriented (Modelica/Dymola)). 2. Numerical simulation: The student should be able to simulate a state-space model in a computer. This entails implementation of simple explicit ODE methods, and to know principles of state-of-the-art ODE solvers (e.g. as implemented in Matlab). 3. Rigid body dynamics: The student should be able to write down equations of motion for simple systems of rigid bodies, which gives a basis for modeling of mechanical systems such as robots, marine vessels, cars, and airplanes. 4. Balanse laws/fluid systems: The student should learn the principles of balance laws, and use them to formulate simple models of process systems (e.g. new energy, oil- and gas production, chemical process industry).
TTK4135	Optimization and Control	The course treats optimization. The candidates learn to formulate optimization problems and solve these through appropriate algorithms and software. Optimality conditions like the Karush-Kuhn-Tucker (KKT) conditions are discussed and conditions for global and local conditions are analyzed. Key optimization classes of problems including linear programming (LP), quadratic programming (QP) and nonlinear programming (NP) are studied and applied in different settings. The course includes advanced control of dynamic systems with emphasis on Model Predictive Control (MPC).

	Elective subject – the students can choose between 10 different subjects.	
TKP4120	Process Engineering	
TTK4175	Instrumentation Systems	
TTM4100	Communication - Services and Networks	
TTT4275	Estimation, Detection and Classification	
MEDT4165	Signal Processing in Ultrasound Imaging	
TDT4145	Data Modelling, Databases and Database Management Systems	
TET4120	Electric Drives	
TET4180	Power System Stability and Control	
TMA4165	Differential Equations and Dynamical Systems	
TTT4235	Space Technology II	