Module description of Mechanical Engineering S7 Precision Engineering

Exchange program Autumn 2021 – 2022

Fontys Hogeschool Engineering

Revisions

Rev	Date	Description
01	01-02-2019	Baseline description advanced program

Module : Design Principles for Precision
Code : WACM5
Size : 4 EC (112 hours)

Content of the module

In this mechanical oriented module you will learn which physical phenomena influence the precision, reproducibility and accuracy of a mechanical system. Useful models are introduced to predict and analyse system behaviour. Design concepts are offered to conceive a system that has the potential for optimal behaviour. You will learn how to perform calculations of essential elements of a system to predict the behaviour.
Module objectives:

- Being able to communicate with professionals.
- Design for accuracy (system on target as good as possible).
- Design for precision (system does the same every time).
- Keeping in place an object or machine part.

Main objectives/goals

How to achieve these objectives:

- Understanding the meaning of accuracy and precision
- Knowing the phenomena that influence accuracy and precision
- Make useful models of systems
- Calculate essential elements to predict accuracy and precision
- Choose suitable design concepts

Prerequisite requirement

For this module a sound background knowledge concerning statics and mechanics of materials is required such as:

- statically determined and over determined structures
- moments of inertia, centre of gravity
- Bending of beams and elements (stiffness)
- bending, shear and torque stresses including combined stresses
- to calculate with multi-element construction including working with spring stiffness's of the construction elements
- buckling
- representing constructions using parallel and serial spring elements

Module : Production and Materials for Precision
Code : WAPM13
Size : 4 EC (112 hours)

Content of the module

Modern High Tech designs require ever increasing needs for precision manufacturing technologies not only into the range of µm's but even progressing into the range of nm (nanometres). With conventional processes the limits in precision are found in the micro meter regime by subtractive processes. For higher accuracies Electrical Discharge Machining (EDM) or Electro Chemical Milling (ECM) or working with high energy beams, such as lasers, ion beams or ultrasonic are opening up new possibilities. In particular micro-additive manufacturing is applied e.g. with lasers or electroforming.
This module concentrates on the basic principles of Production and Materials for Precision with some well-chosen examples that illustrate the progress and impact and show how to use these technologies as part of the (precision) design.
In an introduction the evolution of precision manufacturing will be indicated as a function of time in the area of both processing equipment and inspection equipment.
Topics of the module are:

- Micromachining using milling, turning and grinding
- EDM, ECM, laser micro machining and water jet cutting
- Micro additive manufacturing, surface treatments and coatings for performance enhancement
- Ceramics, composites and lightweight metals (Mg, Al, Ti alloys) for precision
- Precision measurement and characterisation methods
- Vacuum conditions, contamination control and wear resistance

Main objectives/goals

Explain the importance and industrial relevance of precision manufacturing and to know which materials are commonly used in precision applications.

- Understand and apply advanced machining and additive methods.
- Understand and apply surface treatments and coatings for performance enhancements.
- Analyse and apply the performance of ceramics, composites and lightweight metals.
- Analyse and evaluate precision measurements.
- Evaluate and apply wear resistance under different conditions.
- Work with contamination control and vacuum conditions.

Prerequisite requirement

In order to follow this module pre knowledge regarding materials (metals and plastics), material properties and production fundamentals is required.

Module : Dynamic Behaviour of High Tech Systems
Code : WADG2
Size : 4 EC (112 hours)

Content of the module

This module is aimed at understanding, designing and controlling of dynamic precision systems. Besides gaining theoretical knowledge part of the module consists of designing of a dynamic and controlled system.
The module consists of two main parts:

- Dynamic behaviour
- Control theory

During the part Dynamic behaviour the student will work on the design of dynamic system. This will for instance be aimed at a hard drive, production- or positioning machine. Design aspects such as bearings, actuator types, material choices and their impact on dynamic and control behaviour will be considered. Design choices will investigated validated using differential equations, Matlab Simulink and Matlab Simscape.
The part control theory is about using techniques to design and implement a controller of a dynamic system.

Main objectives/goals

- Make a validated design of a dynamic precision system.
- Derive the differential equations (DE's) to describe a physical problem.
- Reflect critically on his/her own work and the work of class mates.
- Convert the DE's into a system of first order DE (state space description, SS).
- Convert the mathematical model into a Simulink model, including Simscape.
- Use both Simulink as Matlab to solve the model.
- Interpret the results of the model, analyse the effects of the parameters.
- Design a PID controller to meet the requirements using both the frequency domain and the IMC scheme.
- Design a SVF controller to meet the requirements using pole placement techniques.
- Implement the designed controllers to the physical setup.
- Interpret the results of the implemented controllers.

Prerequisite requirement

For this module pre knowledge is required regarding differential equations, feedback control systems and setting up of transfer functions of control systems, Laplace transformations, basic design and tuning of PI and PID controllers. Also skills in using Matlab Simulink and programming in Matlab are required.

Module	: Finite Element Methods (FEM)
Code	: WACM10
Size	: 4 EC (112 hours)

Content of the module

During the design of complex precision systems, the use of Finite Element Methods is in wide use throughout the high-tech industry. One of the leading high end software suits for this is Siemens NX. In this course, the use of Finite Element Methods analysis using Siemens NX software will be investigated. An assignment at this level is used as an introduction. After that 1D, 2D and 3D elements are introduced and the connecting technique to combine these types of elements. These (combined) elements are used in five different types of solvers or solutions: structural, buckling, eigenfrequencies, fatigue and simple non-linear structural. Three of these are applied in the course and one of the other two must be done by the student himself in the final project. The intention of the module is that all exercises are validated with manual calculations.

Main objectives/goals

- Use different types of meshes
- Use different types of mesh connections
- Find and solve errors in the simulation
- Create a test program to validate a solver/solution process
- Use post processing correctly

Prerequisite requirement

Pre knowledge of and experience in using an advanced CAD program such as Siemens NX, Solidworks of ProMechanica is required. Not only modelling skills but also initial knowledge of and experience in performing static lineair FEM analysis is required. Experience with Siemens NX is advised. If not students need to take into account that learning this software tool is the responsibility of the student in parallel to this course.

Module : Systems Engineering
Code : WASYE7
Size : 4 EC (112 hours)

Content of the module

After several years obtaining insights and methods on technical design processes, you know how to design a well-functioning product or system. Requirements however mainly refer to the functionality of that product. But a well-designed product does not give automatically a guarantee for being successful in the market. The success is very dependent on other influences of the environment, like a growing attention to sustainability, the market, presence of a financial crisis, styling, price, service and quality perception of the consumers. These influences may (strongly) change in time and may make or break the success of a well-functioning product. These influences are difficult to change. A product or system designer however can take the probability of these environmental influences into account. Thus, it is important while focusing on the design criteria to incorporate those taking external influences into account with a wide and strategic view.
This module provides a further introduction into several relevant themes:

- Design & styling
- Marketing
- Safety: CE qualification

Main objectives/goals

The main goals of the topics are to get introduced into the mechanisms of different environmental influences on the market success of a product or system, in order to apply to the engineering design process:

- Design & styling
- Marketing
- Safety: CE qualification
- Durability & Environment
- Quality in design
- The relevance of aspects to the design and design process
- How each aspect can contribute to a successful design
- What are the most important characteristics of each topic
- What are the consequences of the aspects to the design and design process
- How the aspects of each topic can be applied.

Prerequisite requirement

Background knowledge in system engineering is required such as the system engineering V-cycle, methodological design method(s) and requirements management.

Module : Design for Excellence
Code : WADFX
Size : 4 EC (112 hours)

Content of the module

Introducing value of multi-disciplinary approach compared to mono-disciplinary approach.

- Assignment to get familiar with the various “Design for” methodologies and research on DfX approaches.
- Apply the multi-disciplinary approach and best matching DfX approach on the running project.
- Choose the best tool to come to an underpinned decision w.r.t. direction of the project.
- Presentation how the results of the DfX assignment have been achieved.
- Presentation of values and their importance of most important aspects (minimum 5, maximum 8) including underpinning.

Main objectives/goals

Handle multi-disciplinary aspects in development projects

- Underpinned decision making with regard to value and importance of product specifications
- Achieving consensus on final product specification / project results with a team where members have different goals
- Using ”Design for” methodology and tools to facilitate

Prerequisite requirement

No specific background knowledge is required

Module : Research project
Code : WAPRS7
Size : 10 EC (280 hours)

Content of the module

Under the guidance of a project tutor students will work on an industry or social relevant project. Within this project students will need to design an integral solution including the validation of the proposed design.
During the semester students will meet and interact on a weekly / daily basis with the team, tutor and client.

Main objectives/goals

To work effectively and efficient within a team actively applying management and group dynamic methods when needed.

- Planning and organizing your own work and the work of others - phasing and managing the project with respect to quality, logistics, time and costs (QLTC).
- Use and if required modify methods and techniques during all phases of the design process (entire V-cycle process).
- To be able to apply theoretical knowledge in the project in order to come to a design solution according to the set requirements.
- To be able to define the project/research assignment.
- To be able to independently investigate literature sources and acquire new knowledge where required.
- Making a complete design solution including all required documentation.
- Design a prototype with the required functionality, manufacturability and processes at acceptable costs.
- Validate the design regarding the within the project required functionality.
- To be able to translate client requirements into univocal and SMART defined system requirements and able to communicate effectively with stakeholders.
- To be able to reflect actively on the own performance and the performance of team members.
- Assessing the consequences of technical and / or commercial choices on functionality but also manufacturability, reliability, safety and costs.
- To provide oral and written explanations in both English and Dutch language.
- Make a written compact report (technical paper) in the Dutch or English language.
- To make a technical poster in the English language and provide argumentation during a poster session.

Prerequisite requirement

Experience in team cooperation, project management skills, report writing and presentation skills.