COMPUTER AIDED ENGINEERING – 3ème année cycle ingénieur Estia

Second diplôme : Master of science « Computational and Software Techniques in Engineering » de l'Université de Cranfield

Option in Computer Aided Engineering (CAE)

Course details : MODULES

C PROGRAMMING (PRE-REQUISITE)

Aim
The module aims to cover all the main elements making up the C programming language and to provide many illustrative examples of their use in practice. Use is made of 'hands-on' workshops which enable the student to gain confidence with the language and form a preparation for the practical assignment which forms a major part of the course. An Ansi-standard C compiler and development environment is employed.

Syllabus
Variables, operators and expressions
Statements and flow control
Functions
Pointers and arrays
Strings
Structures and other derived types
Dynamic memory
Allocation
Input and output.

MODULE COMPUTATIONAL METHODS

Module Leader
Dr Irene Moulitsas

Aim
The module aims to provide an understanding of a variety of computational methods for integration, solution of differential equations and solution of linear systems of equations.

Syllabus
The module explores numerical integration methods; the numerical solution of differential equations using finite difference approximations including formulation, accuracy and stability; matrices and types of linear systems, direct elimination methods, conditioning and stability of solutions, iterative methods for the solution of linear systems.

MODULE C++ PROGRAMMING

Module Leader
Dr Irene Moulitsas

Aim
Object oriented programming (OOP) is the standard programming methodology used in nearly all fields of major software construction today, including engineering and science and C++ is one of the most heavily employed

languages. This module aims to answer the question 'what is OOP' and to provide the student with the understanding and skills necessary to write well designed and robust OO programs in C++. Students will learn how to write C++ code that solves problems in the field of computational engineering, particularly focusing on techniques for constructing and solving linear systems and differential equations. Hands-on programming sessions and assignment series of exercises form an essential part of the course.
An introduction to the Python language is also provided.

Syllabus
The OOP methodology and method, Classes, abstraction and encapsulation;
Destructors and memory management, Function and operator overloading, Inheritance and aggregation, Polymorphism and virtual functions, Stream input and output;
Templates, Exception handling, The C++ Standard Library and STL.

MODULE COMPUTER GRAPHICS

Module Leader
Dr Karl Jenkins

Aim
Computer graphics is a key element in the effective presentation and manipulation of data in engineering software. The aim of this module is to provide an in depth overview of the mathematical and software principles behind 2D and 3D visualisation, the viewing pipeline, and practical implementation in the widely used OpenGL graphics library. Representative GUI based 2D and 3D OpenGL applications using the Windows environment are used. Reference is also made to the programming model employed in OpenGL-ES, the version of OpenGL created for embedded devices and the basis for Android and iPhone apps. Hands-on exercises and an assignment supplement the learning process.

Syllabus
- Mathematical principles behind 2D and 3D visualisation, Matrix transformations, The viewing pipeline, Modelling, viewing and projection, OpenGL graphics library, GLSL and shader programming.
- Development of CG applications using OpenGL, GLSL and Qt, UI
- WebGL, OpenGL-ES.

MODULE MANAGEMENT FOR TECHNOLOGY

Aim
The importance of technology leadership in driving the technical aspects of an organisations products, innovation, programmes, operations and strategy is paramount, especially in today's turbulent commercial environment with its unprecedented pace of technological development. Demand for ever more complex products and services has become the norm. The challenge for today's manager is to deal with uncertainty, to allow technological innovation and change to flourish but also to remain within planned parameters of performance. Many organisations engaged with technological innovation struggle to find engineers with the right skills. Specifically, engineers have extensive subject/discipline knowledge but do not understand management processes in organisational context. In addition, STEM graduates often lack interpersonal skills.

Syllabus
Engineers and Technologists in organisations: The role of organisations and the challenges facing engineers and technologies.
People management: Understanding you. Understanding other people. Working in teams. Dealing with conflicts.
The Business Environment: Understanding the business environment; identifying key trends and their implications for the organisation.
Strategy and Marketing: Developing effective strategies; Focusing on the customer; building competitive advantage; The role of strategic assets.
Finance: Profit and loss accounts. Balance sheets. Cash flow forecasting.Project appraisal.
New product development: Commercialising technology. Market drivers. Time to market. Focusing technology. Concerns.
Business game: Working in teams (companies), students will set up and run a technology company and make decisions on investment, R&D funding, operations, marketing and sales strategy.

Negotiation: Preparation for Negotiations. Negotiation process. Win-Win solutions.
Presentation skills: Understanding your audience. Focusing your message. Successful presentations. Getting your message across.

MODULE GEOMETRIC MODELLING AND DESIGN

Module Leader
Dr Karl Jenkins

Aim
The aim of this module is to provide the student with the knowledge and practice of the mathematical techniques and the principal algorithms used for the construction and implementation of parametric curve, surface and solid geometry. The material covered here forms the basis of free-form modelling as used in all major CAD/CAM systems and, more generally, in the fields of visualisation and computer graphics. Hands-on programming exercises and a modelling assignment form part of the course.

Syllabus
Wireframe, surface and solid geometry, Polynomial and spline interpolation, B-spline curve and surface interpolation and approximation, Some advanced modelling techniques, Solid model representation schemes, Boundary representation models.

MODULE CAE APPLICATIONS AND PLM

Module Leader
Dr Karl Jenkins

Aim
The aim of the CAE Solid Modelling module is to introduce students to key concepts, techniques and applications of a 3D Solid Modelling system. Use is made of structured computer based workshops which employ an industry standard system (CATIA) for 3D Solid Modelling. Introductory lectures are reinforced by the 'hands-on' approach through a series of part, assembly and surface modelling exercises covering the major workbenches available in the CAD system.

Syllabus
- Introduction to CATIA CAE Solid Modelling Software,
- Some benefits of using solid modelling and the CAE approach,
- Different construction methods for 3D geometrical models,
- Parametric and variational design,
- Production of drafting setup details from 3D geometrical parts,
- Modifying parts and features,
- Part, Assembly and Surface Modelling workbenches

MODULE ADVANCED ENGINEERING ANALYSIS

Module Leader
Dr Karl Jenkins

Aim
The numerical solutions of partial differential equations are used for simulating physical systems and phenomena and for the investigation of a wide range engineering applications. These numerical solutions may used in engineering design optimisation to explore the implications of design changes. The aim of this course is to provide the student with the mathematical background to the discretisation of partial differential equations using finite element and finite difference approaches, and an insight into methods for their solution along with the vital numerical techniques for the analysis of the solution and numerical errors.

Syllabus
- Introduction to Simulation, Finite Element Methods, Finite Difference Methods,
- Numerical Solution to Partial Differential Equations: Parabolic, Elliptic, Hyperbolic

- Stability Analysis and Truncation Errors, Case Studies

MODULE COMPUTATIONAL ENGINEERING (FLUIDS)

Module Leader
Dr Karl Jenkins

Aim
To introduce the techniques and tools for modelling, simulating and analysing realistic computational engineering problems for industrial applications with practical hands on experience of commercial software packages used in industry.

Syllabus
- Introduction to Computational Engineering
- Fundamental equations
- The Computational Engineering Process
- Fluid Simulation for Computer Graphics
- Modelling techniques
- Practical sessions

MODULE CAE ADVANCED APPLICATIONS

Aim
This course covers more advanced aspects of CAE, the aim being to introduce students to key concepts and techniques in the use of CAE application software tools. Use is made of structured computer based workshops which employ industry standard systems for CAD through to Engineering Analysis.

Syllabus
Introduction to I-DEAS CAE Finite Element Analysis (FEA) Simulation software
CAE FEA Pre- and Post- Processing
Free mesh and Mapped mesh techniques
Quality checks on nodes and elements
Finite element and geometry based boundary conditions
Utilising solids based modelling geometry for downstream CAE FEA
CAE linear statics analysis using the I-DEAS CAE FEA Simulation software
Case Studies.

MODULE ADVANCED GRAPHICS

Module Leader
Dr Karl Jenkins

Aim
High performance computer graphics are used in many areas of software application development, and are fundamental to games, entertainment, CAD and scientific visualisation. The aim of this module is to introduce students to the advanced techniques used in the generation of computer graphics. Building on the basic methods of the Introductory course, students will learn how to generate more realistic effects, such as the use of lighting and surface details to create realistic representations of computer generated graphical objects and display them to the screen.

Syllabus
Surfaces and Tessellation, Geometric and Raster Algorithms, Light, Illumination and Shading, Texture Mapping, Bump Mapping, Displacement Mapping, Environment Mapping, Introduction to Virtual Reality.

MODULE APPLICATIONS OF COMPUTATIONAL ENGINEERING DESIGN OPTIMISATION - GROUP PROJECT

Module Leader
Dr Karl Jenkins

Aim
This module aims to provide the student with the mathematical, programming and computational skills used in solving a practical engineering design optimisation problem so that they can undertake a group project.
Syllabus
Specification of optimisation problem - design parameters, objective function, constraints
Geometry construction – curve/surface fitting, product data exchange, CAD modelling
Algorithm implementation - monte carlo (or other) archiving strategy, quality measure extraction

MODULE DÉVELOPPEMENT RAPIDE D'APPLICATIONS

Responsable : Sébastien BOTTECCHIA

Pré Requis
- Modélisation orientée objet.
- Programmation orientée objet,
- Méthodes d'analyse et de conception.

Learning Outcomes
- Être capable de mettre en application différentes connaissances liées à la programmation.
- Être capable de développer une application métier en utilisant des outils professionnels

Contenu
À partir d'un cahier des charges métier (en lien avec l'option), il s'agit de mettre en œuvre les phases suivantes :
- Analyse s'appuyant sur des méthodologies connues
- Conception à l'aide d'une démarche basée sur UML
- Réalisation du programme (programmation-objet de la solution avec Visual Studio)

Un outil professionnel utilisé par de nombreuses SSII tel que Visual Studio dispose de fonctionnalités permettant de faciliter le développement. Seront notamment abordés :
- Conception UML de manière graphique
- Génération de code (squelette) à partir d'un diagramme UML
- Utilisation des assistants de génération d'IHM.

MODULE DÉMARCHE DE RÉSOLUTION DE PROBLÈMES

Responsable : Véronique PILNIERE
Intervenants : V.Pilnière, E.Villeneuve, J.Lartigau, S.Bottecchia, G.Terrasson, C.Merlo, J.Chatenoud

Pré Requis
Expériences professionnelles

Learning Outcomes
- Approfondir les démarches de résolution de problèmes
- Appliquer une démarche et méthodologie rigoureuses

Contenu
Ce module se décline sur des thématiques particulières en fonction du parcours de l'étudiant (option choisie).
Démarche de résolution de problème : de l'identification du problème (besoin) à sa résolution.

MODULE : PROJETS 3A

Pré Requis

- Outils et méthodes de gestion de projet.
- Connaissances techniques liées au sujet du projet (mécanique, conception, électronique, informatique…)

Learning Outcomes

- Être capable de satisfaire la demande des parties prenantes d'un projet, en particulier d'un client, en faisant preuve de responsabilité, d'engagement, d'organisation.
- Être capable de choisir les outils et méthodes adéquats en faisant preuve d'autonomie.
- Être capable de réaliser un projet technique pluridisciplinaire, en équipe, en respectant les normes/réglementations et les principes de propriété intellectuelle.