NAFEMS Academic Module Approval

# Introduction to the Approval Scheme

Over the years NAFEMS has received requests from academic staff enquiring about the possibility of some form of approval of “modules” offered in their University. This scheme is a response to such requests. NAFEMS recognizes that it has a role to play in working with Universities and other course providers, to help define and deliver the competencies required in the engineering analysis and simulation area. In doing so, our goal is also to raise awareness of NAFEMS in future generations of engineers and scientists.

This Approval Scheme is based on the competencies defined in the **core FEA** and **core CFD** modules in the NAFEMS Professional Simulation Engineer (PSE) Competency Framework. This framework covers the 26 technical areas listed in the table below.

|  |  |
| --- | --- |
| **Core Finite Element Analysis** | **Core Computational Fluid Dynamics** |
| Mechanics, Elasticity and Strength of Materials | Fundamentals of Flow, Heat and Mass Transfer |
| Beams, Membranes, Plates and Shells | Dynamics and Vibration |
| Materials for Analysis and Simulation | Noise, Acoustics and Vibro-Acoustics |
| Composite Materials and Structures | Multi-body Dynamics |
| Fatigue | Multi-Physics Analysis |
| Flaw Assessment and Fracture Mechanics | Multi-Scale Analysis |
| Nonlinear Geometric Effects and Contact | Probabilistic Methods |
| Plasticity | Electromagnetics |
| Buckling and Instability | Management General |
| Thermo-Mechanical Behaviour | Verification and Validation |
| Creep and Time-Dependency | PLM Integration and CAD-CAE Collaboration |
| Optimisation | Simulation Process Data Management |

Table 1 – Technical Areas in the PSE

The framework allows anonymous access to all of these modules via the NAFEMS tracker system, which defines the necessary competencies in these technical areas and is designed to provide the facility to record and manage the development of competencies in individuals and groups of staff in industry.

<http://www.nafems.org/professional_development/competency_tracker/>

A **Professional Simulation Engineer** standard and qualification is also available to industrial users and this is also based on the competency framework.

The competency statements contained in the above modules cover lifelong learning for staff at all levels of practice in engineering analysis and simulation. Although the modules were primarily aimed at supporting self-learning in the work-place, the competency statements form the basis of the NAFEMS Academic Module Approval Scheme, which is applicable to formal provision at both undergraduate and postgraduate levels.

It is not the aim of this scheme to be entirely prescriptive on module content in the engineering analysis and simulation area and diversity in content and methods of delivery is welcomed. However in identifying the competencies inherent in these technical areas it is hoped that module providers will adopt these and in doing so prepare students for industrial use of such application software. As will be seen, the competencies not only cover the lower cognitive areas of Knowledge and Understanding, but also define competencies in the Application, Analysis, Synthesis and Evaluation areas.

Suggested resource material for the development of these competencies are identified in the [NAFEMS competency tracker system](http://www.nafems.org/professional_development/competency_tracker/), with free anonymous access.

Each competency has an associated “level” ( 6 being Bachelor degree level and 7 being Masters as defined in the International Standard Classification of Education) and possible supporting material for the development of the competencies are also identified in the tracker system.

Finally, it should be noted that this scheme is currently aimed at module *Approval*, as opposed to a more rigorous *Accreditation*. This is reflected in the simple process detailed below.

# The Approval Process

The scheme requires a proposing academic member of staff in the host institution to provide a “mapping” of their module to the statements of competence listed in the application form, with an indication of how these are being assessed. Attestation of these by the proposer would automatically give module approval. The proposer is required to complete both the application form and either Appendix 1 or 2 depending upon the content of the module seeking approval. Modules teaching principals of Finite Element Analysis should use Appendix 1 while Computational Fluid Dynamics modules should use Appendix 2.

On approval by the NAFEMS Education and Training Working Group a University can, if they so wish, identify such modules on their web-site or in promotional literature as being “NAFEMS Approved”. The NAFEMS approved logo will be sent to the course contact upon approval in high resolution format. The following statement can be used depending on the content of the course.

*“This course contains modules covering Finite Element Analysis/Computational Fluid Dynamics (delete as appropriate) content that is NAFEMS approved”*

A selection of presentations made at past NAFEMS events will be made available for students on “NAFEMS Approved” courses to access. This will include access to presentations made at past [NAFEMS World Congress](http://www.nafems.org/congress/agenda3/presentations/) events. The approved modules will be held on a NAFEMS register for 5 years, at which time re-approval may be sought.

# Application Form for NAFEMS Module Approval

The following form and either Appendix 1 or Appendix 2 should be completed and returned to [etwg@nafems.org](mailto:etwg@nafems.org) for consideration by the Education and Training Working Group along with a copy of the module descriptor / course syllabus.

|  |  |
| --- | --- |
| **University** | Click here to enter text. |
| **Department** | Click here to enter text. |
| **Course Title** | Click here to enter text. |
| **Application Area** | Choose an item. |
| **Module Duration (weeks)** | Click here to enter text. |
| **Name of Proposing Member of Staff** | Click here to enter text. |
| **Signature** |  |
| **Date** | Click here to enter a date. |
|  | |
| **Is the University a member of NAFEMS?** | Click here to enter text. |
| **Does the proposing member of staff have any association with NAFEMS or other professional bodies? If so please provide details.** | Click here to enter text. |
| **Engineering analysis software used to support the above courses/modules** | Click here to enter text. |

# Appendix 1

# Competence Mapping for FEA Modules

|  |  |  |
| --- | --- | --- |
| **NAFEMS**  **Competency**  **Code** | **Statement of Competence** | **Competence covered?** |
| FEAkn1 | List the various steps in the analysis/simulation process. |  |
| FEAkn2 | Define the meaning of *degree of freedom*. |  |
| FEAkn3 | List the nodal degrees of freedom and the associated force actions for common beam, 2D solid, 2D axisymmetric, 3D solid and shell elements, for the Displacement FEM. |  |
| FEAco1 | Describe the sources of error inherent in finite element analysis, in general terms. |  |
| FEAco2 | Discuss checks that may be used post-solution to check for the presence of inaccuracy. |  |
| FEAco4 | Explain the meaning of *convergence*, including *h* and *p* types. |  |
| FEAco6 | Discuss the need for a consistent set of units in any analysis and illustrate possible pitfalls. |  |
| FEAco28 | Explain why element distortion generally results in poorer results. |  |
| FEAco29 | Discuss the term *flying structure* or *insufficiently constrained structure*. |  |
| FEAco35 | Discuss the terms *Validation* and *Verification* and highlight their importance. |  |
| FEAap1 | Employ an analysis system for the determination of stresses and strains in small displacement, linear elastic problems. |  |
| FEAap2 | Demonstrate effective use of available results presentation facilities. |  |
| FEAap3 | Illustrate the approximate nature of finite element analysis, through examples chosen from your industry sector. |  |
| FEAap4 | Illustrate the various steps in the Displacement Finite Element Method from assumed displacement polynomial to determination of stresses. |  |
| FEAap7 | Employ *symmetric* boundary conditions effectively. |  |
| FEAap10 | Illustrate various physical situations which will result in a Stress Singularity and explain why it is not appropriate to use finite element results at such locations directly. |  |
| FEAap12 | Employ a range of post-solution checks to determine the integrity of FEA results. |  |
| FEAap13 | Conduct validation studies in support of FEA. |  |
| FEAan1 | Analyse the results from small displacement, linear static analyses and determine whether they satisfy inherent assumptions. |  |
| FEAan2 | Compare the results from small displacement, linear elastic analyses with allowable values and comment on findings. |  |
| FEAsy1 | Prepare an analysis specification, including modelling strategy, highlighting any assumptions relating to geometry, loads, boundary conditions and material properties. |  |
| FEAev1 | Select an appropriate idealisation for a component / structure, which is consistent with the objectives of the analyses. |  |

Table A1 – Competencies required for NAFEMS Approved Academic Modules Covering FEA

# Appendix 2

# Competence Mapping for CFD Analysis Modules

|  |  |  |
| --- | --- | --- |
| **NAFEMS**  **Competency**  **Code** | **Statement of Competence** | **Competence covered?** |
| CFDkn1 | State the general transport equation for a general flow variable. |  |
| CFDkn2 | State the Navier-Stokes equations. |  |
| FDkn3 | State the Reynolds Averaged Navier Stokes equations. |  |
| CFDkn3b | State the general energy equation. |  |
| CFDkn4 | List typical boundary conditions for incompressible and compressible flow boundaries. |  |
| CFDkn5 | State the principles of best practice in CFD. |  |
| CFDkn7 | List the main sources of error and uncertainty that may occur in a CFD calculation. |  |
| CFDco2 | Compare and contrast the finite difference, finite volume and finite element discretisation methods. |  |
| CFDco4 | Explain why turbulence models are required and classify the range of models currently available. |  |
| CFDco5 | Review the terms in the differential form of the governing equations for fluid flow and explain their physical significance. |  |
| CFDco5b | Review the available turbulence models for RANS approaches and discuss their strengths, weaknesses and their applicability to a range of different flow conditions. |  |
| CFDco8 | Explain the difference between RANS and LES turbulence modelling approaches. |  |
| CFDco11 | Discuss the issues and conditions of numerical stability in the numerical solution of unsteady flow problems. |  |
| CFDap2 | Demonstrate the ability to apply discretisation techniques for diffusion, convection and source terms of the general transport equation using the Finite Volume and/or Finite Element techniques. |  |
| CFDap3 | Demonstrate the ability to apply boundary conditions correctly for external and internal incompressible flow problems. |  |
| CFDap4 | Demonstrate the ability to select appropriate numerical grids for incompressible and compressible flow problems in complex geometries. |  |
| CFDap5 | Demonstrate the ability to apply Boundary conditions correctly for external and internal compressible flow problems. |  |
| CFDap7b | Employ best practice guidelines for the validation of a CFD model. |  |
| CFDap8 | Demonstrate the ability to prepare a comprehensive report on a CFD analysis. |  |
| CFDan1 | Analyse a fluid engineering problem and identify the limitations of the analysis. |  |
| CFDsy1 | Formulate an analysis strategy identifying, geometry simplifications, physical modelling assumptions, boundary conditions, material properties for laminar and turbulent flow problems. |  |
| CFDsy2 | Construct a strategy for the assessment of fluid flow design concepts using CFD methods. |  |

Table A2 – Competencies required for NAFEMS Approved Academic Modules Covering CFD