TMS | ONLINE COURSE

VERIFICATION, VALIDATION, AND UNCERTAINTY QUANTIFICATION IN THE COMPUTATIONAL MODELING OF MATERIALS AND STRUCTURES

Applying Recommended Practices and Expert Techniques

August 22-24, 2022 • This course will include six, half-day, virtual modules, with supporting materials.

COURSE MODULES

Module 1: How to Design and Implement Robust Verification and Validation Practices
This module will instruct attendees on why V&V is critical for computational modeling of materials and structures and how to design and implement V&V practices. We will discuss the six process steps in any V&V approach, as outlined in the TMS V&V study report. We will also work through the process of planning the six process steps for materials applications.

Module 2: Code and Solution Verification
This module will instruct attendees on how to carry out code and solution verification. We will begin with how to carry out code verification by comparing to analytical and manufactured solutions. We will then learn how to carry out solution verification to estimate the discretization error in a simulation that will be validated.

Module 3: Computational Uncertainty Quantification
This module will cover the quantification of uncertainty in computational models. Sources of model uncertainty can be considered in three groups:

- Model form assumptions and simplifications that arise in deriving the mathematical model form;
- Uncertainty regarding model parameters, which are typically unmeasurable and are inferred from measured quantities; and
- Solution approximation errors that arise in numerical solutions of the model equations, such as finite element discretization, reduced-order models, etc.

The module will discuss computational techniques to quantify the above sources of uncertainties, and relate these techniques to model verification, validation and calibration. Next, the module will discuss methods to aggregate and propagate the different uncertainty sources through the computational model in order to quantify the uncertainty in the model prediction. The module will also discuss uncertainty sensitivity analysis, i.e., how to quantify the relative contributions of different uncertainty sources towards the overall uncertainty in the model output. Several engineering examples will be used to illustrate the uncertainty quantification techniques.

Learn more about the curriculum and the team of 9 expert instructors and register:
www.tms.org/VVUQ2022

Module 4: Quantifying Experimental Uncertainties for Validation Assessments
This module will cover the quantification of uncertainty in experimental data. Sources of experimental measurement uncertainty relate to:

- Physical differences among nominally identical members of a manufactured ensemble;
- Non-repeatability of measurements that arises from changes in temperature, pressure, humidity, bolt-preload, boundary conditions, initial conditions, and nonlinearities in system behavior;
- Sensor imperfections and miscalibrations that yield noisy outputs;
- Data limitations that lead to variability and uncertainty in system statistics;
- Failure to measure all factors that influence a behavior;
- Errors and poor parameter choices in data analysis.

The module will provide examples on how to quantify the contributions of different factors towards the overall uncertainty in experimental data.

Module 5: Designing Validation Experiments: Combining Modeler and Experimentalist Perspectives
This module will present a discussion of the preliminary calculations and design of validation experiments aspects of the Verification & Validation in Computational Modeling of Materials and Structures study. This experiment-design stage comes early in the VV&UQ process and requires a close collaboration between modelers and experimentalists. The primary objective in this stage is to design an experiment wherein the quantities of interest (QoIs) to serve as a validation basis are defined. The discussion of the main concepts are complemented with a few examples from several current in-practice cases to provide context. The module will conclude with a presentation of transitioning from validation to materials qualification.

Module 6: Regulatory Agency Perspectives, Examples and Lessons Learned
This module will give the perspective of the importance and utility of VVUQ and provide examples in certain commercial sectors from the point of view of three different regulatory agencies: the Federal Aviation Administration (FAA), the U.S. Nuclear Regulatory Commission (NRC), and the US Food and Drug Administration (FDA). The instructors will discuss their experiences reviewing modeling and simulation, regulations regarding modeling and simulation, and approaches commonly used to assess the credibility of simulations.