Non-linear Analysis with Patran & MSC Nastran

1. Program overview

Title: Non-linear analysis with Patran & MSC Nastran – online course.

Director: Professor Juan José Benito Muñoz.

Department: Construction & Manufacturing Engineering (UNED University).

2. Eligibility and requirements

A degree is required, although university students in the last year of their course may be admitted with proof of their academic status.

Basic knowledge of linear static structural analysis with Patran & MSC Nastran is required, which may have been acquired through:

- Completion of the *Introductory course to FEM with Patran & MSC Nastran*, also available in ICAEEC.
- Completion of the Expert module of the Mechanical branch of the *International Master's in Theoretical & Practical Application of the Finite Element Method and CAE Simulation* of UNED – Ingeciber.

3. Presentation and objectives

The objective of this course is to introduce attendees to non-linear analysis using *Finite Elements*, allowing them to acquire the basic skills to enable them to use this method in their profession.

This course originated as a collaboration project between UNED and Ingeciber, S.A., a company specializing in Computer-Aided Engineering (CAE).

4. Content

The course consists of two subjects:

a. Non-linear analysis with Patran & MSC Nastran
b. Practical Application Exercises with Patran & MSC Nastran

The documentation for both subjects is in English.

The content of each subject is detailed below:

- **Nonlinear analysis with Patran & MSC Nastran**

1. Introduction to MSC Nastran
2. Nonlinear versus Linear Analysis
   - 2.1. FEM Quantities in Linear Analysis
   - 2.2. Nonlinear Analysis
   - 2.3. Contact and Constraint Changes
   - 2.4. Geometric Nonlinearity
   - 2.5. Material Nonlinearity
   - 2.6. SOL400 Input File
   - 2.7. Documentation
3. Nonlinear Solution Strategies
   - 3.1. Iterative Solution Methods
   - 3.2. Analysis Convergence
   - 3.3. Advancing Schemes
   - 3.4. Load Incrementation Control
   - 3.5. Iteration Parameters
   - 3.6. Nonlinear Output Control
   - 3.7. Restarts
   - 3.8. General Guidelines &Limitations
4. Contact in MSC Nastran SOL400
   - 4.1. What is Contact Analysis?
   - 4.2. Contact Bodies
   - 4.3. Contact Pairs/Tables
   - 4.4. Contact Detection
     - 4.4.1. Node to Segment
     - 4.4.2. Segment to Segment Contact Advantages
   - 4.5. Special Features
     - 4.5.1. Contact Interference
     - 4.5.2. Stress Free Initial Contact
     - 4.5.3. Glued Contact
     - 4.5.4. Contact with Shells

4.5.5. Friction

4.5.6. Convergence and Controls with contact

5. Nonlinear Materials
   - 5.1. Large Strain Elastic-Plastic Material
   - 5.2. Nonlinear Elastic Material
   - 5.3. Advanced Hyperelastic Material
   - 5.4. Composite Failure
   - 5.5. Gasket Material
   - 5.6. Crack Materials
   - 5.7. Creep Material
   - 5.8. Table Input for nonlinear materials
   - 5.9. Guidelines and Limitations
6. Advanced Nonlinear Elements
   - 6.1. SOL400 – Advanced Elements
   - 6.2. Advanced Composite Elements
   - 6.3. Advanced Incompressible Elements
   - 6.4. Nonlinear Connector Elements
   - 6.5. Nonlinear Kinematic Elements
   - 6.6. Additional Results Output
7. Advanced Topics
   - 7.1. Analysis Chaining
   - 7.2. SPC and MPC Changes
   - 7.3. Restart
   - 7.4. Automated Bolt Preload Modeling
8. Contact Post Processing
   - 8.1. Contact Results Output
   - 8.2. Plot the Contact Status

A. Contact Pairs (Appendix)

B. Nonlinear Transient Dynamics (Appendix)

- Review of Transient Analysis
- User Interface
- General Features

- Integration Schemes
- Mass Specification
- Damping
- Load Specification
- Initial Conditions
- Case Study
- Hints and Recommendations
- Glued Contact - Status

Various exercises are also proposed:

1. Linear and Nonlinear Analysis of a Cantilever Beam
2. Rubber Door Seal
3. Deformable to Rigid Contact
4. Interference Fit
5. Contact Pairs
6. Plastic Deformation
7. Solid Shell Composites Modeling
8. Delamination of a Composite Solid Shell Beam
9. Restart
10. Bolt Modeling
11. Normal Modes Analysis of a Pre-stiffened Blade
12. Dynamic Collapse of a Cylinder

- **Practical Application Exercises with Patran & MSC Nastran.**

The objective of this subject is to complete the concepts explained previously in the first subject through a number of exercises that must be completed using Patran & MSC Nastran.
The exercises represent a review of the concepts introduced in the subjects taken till now, as well as the orderly use of Patran & MSC Nastran.
These exercises will be delivered to the tutor in order to get feedback and recommendations.
The exercises will be similar to the following ones:

These exercises are as follows:

- Non-linear analysis of a flat square membrane structure
- Linear and non-linear buckling analysis of a thin walled cylindrical structure

- Material non linearity: A simply supported circular plate subjected to a cyclic load
- Elastic-plastic nonlinear analysis of a sphere
- Contact analysis

5. Schedule

35 hours of study. The course lasts from 1 to 6 weeks with full flexibility since no specific delivery date is indicated.

6. Methodology

Distance learning methodology, including pre-prepared study materials and bibliography, tutorials, audiovisual resources and practical application exercises.

7. Teaching materials

Attendees will receive the teaching guide and the corresponding materials for the course. Furthermore, in order to complete the practical exercises and training, the educational version of Patran & MSC Nastran will be provided by the course.

Additional training material for the course developed by ICAEEC.

The course uses a virtual classroom as a training facility where study tools can be found, and also as the main communication channel with the attendees.

Other tools will also be used including audiovisual resources as well as other complementary documentation.

8. Attendee services

The teaching staff will respond to attendee inquiries via telephone, email, or in person. Phone tutorships will be available within the following hours:

Monday to Friday during office hours and always subject to tutor's availability.

9. Evaluation and grading criteria

Attendee evaluation will be performed through the practical application exercises.

10. Certification

Certification will consist of a diploma from ICAEEC & Ingeciber indicating successful completion of the subject by the attendee as well as the grade obtained in the practical application exercises.

11. Teaching staff

Professor J. J. Benito (director). Construction & Manufacturing Engineering Department (UNED).

Mr. Ronald Siat (coordinator & tutor). Ingeciber, S.A.

12. Fees

Tuition fees are 450,00 €.

Current and former attendees of the UNED *Master's in Theoretical and Practical Application of the Finite Element Method and CAE Simulation* are eligible for a 33% discount.

13. Validation

Attendees who pass this course can request validation of the application and practical subjects of the mechanical branch of the Non-linear Analysis with Patran & MSC Nastran specialized module from the academic board of UNED *Master's in Theoretical and Practical Application of the Finite Element Method and CAE Simulation*.