## QUOTA DI PARTECIPAZIONE

La quota di partecipazione al corso, comprensiva di materiale didattico, pranzi e coffee break è di: 200,00 Euro (+IVA 20%) *(Costo per i soci NAFEMS 180,00 Euro +IVA 20%)*.

## SCHEDA DI ISCRIZIONE

Nome e Cognome _____

Azienda/Ente _____

Indirizzo _____

Comune _____ CAP _____ Prov. _____

Tel _____ Fax _____

P. IVA _____

Email _____

Data _____ Firma _____

Si prega di inviare la scheda di prenotazione **via fax al numero 035-362970, allegando copia del bonifico bancario** di Euro 240,00 (IVA compresa) *(Euro 216,00 IVA compresa per i soci Nafems)* effettuato a favore di TCN S.Cons.a r.l. via Malfatti, 21 - 38100 Trento sul c/c 03/304330, ABI 08304, CAB 01804 della CASSA RURALE DI TRENTO Ag. Via Don Sordo.
IBAN: IT35 S 08304 01804 000003304330 - BBAN: S 08304 01804 000003304330
La fattura verrà inviata dopo lo svolgimento del corso.
***L'iscrizione ed il pagamento del corso (tramite carta di credito o bonifico bancario) possono esser effettuate anche collegandosi all'indirizzo web: www.consorziotcn.it.***

*E' fissato il numero massimo di 25 partecipanti al corso.*
**L'attestato di partecipazione è valido con riferimento all'iniziativa europea dell'albo degli analisti certificati.**

## SEDE

CRF S.C.p.a. - Strada Torino 50 - 10043 Orbassano (TO) - Italy - Sala C
AUTOSTRADE - A21-A6 Piacenza-Savona
Tangenziale direzione Milano - Uscita Orbassano
A4 Milano-Venezia - A5 Aosta - A32 Frejus
Tangenziale direzione Piacenza-Savona - Uscita Orbassano
TRENO - Dalla stazione Centrale di Porta Nuova è raggiungibile in
TAXI (15 km)
AEREO - Aeroporto Caselle.
PULLMAN - Linea 5 (direzione Orbassano)
***Per maggiori informazioni sulla sede del corso visitare il sito www.consorziotcn.it***

## PER ULTERIORI INFORMAZIONI

**Segreteria Organizzativa** - Sig.ra Mirella Prestini
**Consorzio TCN**
Via Galimberti, 8/A - 24124 Bergamo
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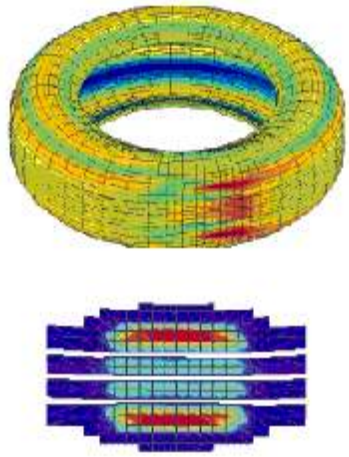
**CORSI DI FORMAZIONE 2005**

**MMCATA06-05**

# Computational Methods for Rolling Contact Phenomena



Orbassano (TO) - Luglio 13, 2005

**Il corso è inserito nel programma di formazione 2005 del Consorzio TCN (Tecnologie per il Calcolo Numerico). Fondato dal CRS4 (Cagliari), dal Centro Ricerche Fiat (Orbassano), dall'ITC-IRST (Trento) e dalla EnginSoft (Trento), il Consorzio ha l'obiettivo di promuovere attività di Alta Formazione per preparare, attraverso percorsi formativi mirati, le risorse chiave per assicurare la competitività delle imprese, sfruttando le potenzialità offerte dalle nuove tecnologie. Www.consorziotcn.it**

# Computational Methods for Rolling Contact Phenomena

## MMCATA06-05

*Level: Specialized Course*
*Type: Theoretical and Applied*
*Instructor's Information: Prof. Dr.-Ing. Udo Nackenhorst, Institut für Baumechanik und Numerische Mechanik, Department of Civil Engineering, University of Hannover*

### INTRODUCTION

Rolling contact is of interest in many technical applications. Examples are car tires, railways, roller bearings etc. Questions arise from wear, fatigue and deterioration of wheels and rails, safety, comfort and durability of tires until to the high frequency dynamic behaviour of rolling wheels related to rolling noise generation. The physical mechanisms on these questions often are not well understood yet. One reason is that detailed phenomena taking place in the contact region are not observable by measurements in general, for example it is impossible to measure the contact-stress and slip distribution for example in wheel-rail contact under high speed conditions. Analytical methods are limited to linear elastic cases and rather simple contact geometries. Therefore, reliable and efficient numerical methods are needed for improving the performance of rolling systems.
This course gives an introduction into computational approaches based on the finite element method for the numerical analysis of rolling contact problems. The state of the art of computational rolling contact analysis will be demonstrated illustratively by industrial applications ranging from 3D wheel-rail contact over large deformation tire-road contact including inelastic material properties up to high frequency noise radiation of rolling tires. The participants will be introduced into the theoretical foundations and key-features will be investigated interactively on simple examples.

### COURSE OBJECTIVES

Topic of this course is the finite element modelling of rolling contact problems. The state of the art of computational methods with emphasis to industrial problems such like tires or railway systems will be taught.
A first step for the general understanding will be the discussion of the physical phenomena observed on deformable bodies in rolling contact by use of analytical solutions available for simple geometries. With this basic knowledge computational approaches based on the finite element method shall be learned. In contrast to quasi-static as well as impact problems rolling is occupied by large rigid body motions, which is treated numerically efficient by use of a special relative kinematics, the so called Arbitrary-Lagrangian-Eulerian (ALE) description. The participants will be introduced into the continuum mechanics of the ALE-approach and its finite element approximation. Special emphasis will be laid onto the “non-classical” contributions within this approach, like inertia-effects, the treatment of inelastic material properties as well as local frictional contact and the transient dynamic behaviour of rolling bodies.
The capabilities as well as advantages and disadvantages of alternative numerical approaches, like boundary element methods, pure Lagrangian finite element methods (explicit vs. implicit) will be discussed. Hints on limitations of commercial finite element codes with respect to rolling contact analysis will be given.
Goal of this course is to familiarize the participants with the physical, mathematical and numerical specialities for the treatment of industrial rolling contact problems. They will be introduced to judge the problems nature for choosing suitable computational approaches and the details behind.

### INTENDED AUDIENCE

Engineers (and other scientists, see prerequisites) seeking on solutions for optimizing rolling contact behaviour of industrial products by use of computational methods.
Post-graduate students for a basic introduction and evaluating their own research project in this field.

### PREREQUISITES

The participants should be familiar with:

- basics of continuum mechanics: balance laws, large deformation theory.
- basics of constitutive theory: plasticity, visco-elasticity, friction.
- finite element methods for implicit non-linear static solutions (Newton-methods)
- basics of computational contact mechanics (TCN-COURSE GZ/PW)
- numerical (FE) treatment of transient dynamic problems (explicit vs. implicit)

### DIDACTIC MATERIALS

The course will be taught by use of Power-Point presentations. Photocopies of the slides will be supplied to the participants.

### COURSE PROGRAM

| | |
|---|---|
| 09.30 | Welcome |
| 09.45 | Introduction. Finite Element Analysis of Rolling Contact with Industrial Applications |
| 10.15 | Basic Phenomena of Rolling – Analytical Investigation |
| 11.15 | Coffee Break |
| 11.30 | The Arbitrary Lagrangian Eulerian (ALE) Description of Rolling |
| 12.30 | Aspects of Finite Element Implementation |
| 13.30 | Lunch |
| 14.00 | Reliability: Error estimates and model adaptivity |
| 15.00 | Treatment of inelastic material properties and frictional contact |
| 16:00 | Coffee Break |
| 16.15 | Transient dynamic analysis of rolling bodies |
| 17.00 | Discussion on future developments |
| 17.30 | Conclusion |