



## Erasmus Mundus

### Mechanical background

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### FINAL PROGRAM

#### Inertial properties of bodies in the space

- The elementary relations of Mass Geometry, Center of mass, Moment of inertia
- Mass moment of inertia, parallel axis theorem, principal axes, inertia ellipsoid

#### Elements of Continuous Mechanics

- Hooke's Law, tensile stress, relative strain, Young's modulus (tensile, elastic modulus)
- Stress strain curve for Ductile and Fragile materials
- Bending – flexure, Euler – Bernoulli Model, Torsion of a beam

#### Kinematic of the point mass

- Describe the expressions of velocity and accelerations of a point

#### Kinematic of the rigid body

- Velocity and Acceleration of two points fixed on the same rigid body
- The theorem of relative motions, Coriolis acceleration
- Existence and uniqueness of the center of velocities (instant center of rotation)
- Existence and uniqueness of the center of accelerations

#### Kinematic structure of Mechanisms (systems of rigid bodies)

- Lagrangian Coordinates and Equations for the modeling of the kinematic constraints
- Evaluation of the degrees of freedom of a mechanism

#### Kinematic Analysis of Mechanisms

- The problem of configuration analysis of a mechanism: graphical and analytic solution (method based on the constraint equations)
- Kinematic analysis of mechanisms: graphical methods, with examples
- Kinematic Analysis by means of the constraint equations (first and second order)

#### Static Force Analysis

- the equations of static balance for the concentrated mass and for the rigid body
- Rigid body under the action of only 2, 3 and 4 forces
- The “free body” method for the solution of the static force analysis of mechanisms

#### Dynamic of the point mass

- The basic laws of dynamics
- Range of a projectile



#### Dynamic of the rigid body

- The basic equations of the Dynamic of the rigid body
- Inertial forces and moments
- Application of the free body method to the dynamic balance of mechanisms
- Application of the principle of the virtual works to the dynamic balance of mechanisms

#### Dynamic Analysis and Simulation of Multi-Body systems MBS

- Redundant Lagrangian coordinates: (absolute angles , natural coordinates, Reference Point Cartesian Coordinates)
- Dynamic simulation of planar MBS by means of the Lagrange multipliers method
- Inverse and direct dynamic problems: examples

#### Power, Work, Energy and Efficiency

- The basic definitions of energy, work and power
- The efficiency of the mechanical systems

#### Fluid mechanics

- Surface tension: pressure inside a drop and rise in a capillary tube
- The principles of fluid static
- Viscous fluids and lubricants: viscosity and viscosity index
- The Reynolds number, the mass balance equation and the Navier-Stokes equations
- The Gauss theorem for a vector field  $u$
- The divergence of a vector field  $u$  with the index notation

#### Friction and Wear

- The basic wear mechanisms and the classification of wear phenomena
- Hertz formulae
- Wear prediction models

#### Lubrication

- One-dimensional Reynolds Theory of hydrodynamic lubrication
- Raileigh step and linearly variable height profiles: Kingsbury-Michell axial bearings

#### Mechanical Vibrations

- Damped and not damped free oscillator
- Forced vibrations with damping
- Torsional and flexure vibrations
- Vibrations of systems with more than 1 DOF

#### A Short Introduction to some devices for automotive applications

- Gears, Bearings, Cam-follower systems, Joints, Brakes and clutches

#### Computer Lab and Exercises

- Numerical integration via Bezout and Cavalieri Simpson method
- Newton-Raphson method for solving systems of equations