**Theory of Plasticity and its Applications**

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# Overview

Theory of plasticity is the basis for calculating the stresses, strains and hence forces needed to perform a forming operation. Plastic deformation begins with the process of yielding and the yield surfaces change shape during forming on account of mixed hardening. Hence, yield criteria exert significant influence on yielding, stable deformation and occurrence of instability. The corresponding associated flow rules therefore influence significantly the strains and stress calculations.

Friction plays a significant role in forming of metals. This is because of significant contact pressure between the tools and the workpiece resulting in a small layer of material deformed by shear close to the surface. The frictional effects, which influence a narrow region between the tool and the body of the deforming workpiece, contribute to forming loads and local strains developed at the tool - workpiece interface. The theory of plasticity provides means to analyse these effects. It also provides methods for design of tools of simple geometries, and provides the basis for calculation of forming loads and strains for complex geometries using the FEM. The present course however does NOT include FEM.

The course will impart mathematical tools and techniques to design different forming processes using the concept of ideal flows. The practical application of the methodology will be illustrated through examples. A Tutorial will be held daily to enable participants to solve some simple problems using the concepts developed over the day. Needless to say, solutions of these problems will be provided to the participants.

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| .Modules | **Theory of Plasticity and its Applications : November 25 – November 29, 2019** |
| You Should Attend If… | • You work on metal forming, fatigue and fracture or similar non-linear problems involving plasticity (Industrial R & Ds, academic institutions, Govt institutions)<br>• You teach in an educational institution<br>• You are a researcher in plasticity related field<br>• You perform numerical simulations / studies involving plasticity<br>• You are a student wanting to learn the theory of plasticity |
| Fees | The participation fees for taking the course is as follows:<br><br>**Participants from abroad : Rs. 25000**<br>**Industry : Rs. 20000**<br>**Academic Institutions / Government organisations : Rs. 10000**<br>**Full time Students : Rs. 5000**<br><br>The above fee includes all instructional materials, refreshments during breaks in the programme, and 24 hours free internet facility. Lodging and Boarding are NOT included in the fees. The participants are requested to bring their own laptops. *On-Campus accommodation will not be available for outstation participants.* **A certificate of participation will be issued to those participants who register as above.** |

# The Faculty

**Prof. Sergei Alexandrov**

**Dr. Sergei Alexandrov works at the Ishlinskii Institute for Problems in Mechanics of the Russian Academy of Sciences, in Moscow, Russia, is a visiting faculty at Beihang University, China and Chung Cheng University, Taiwan, and an adjunct faculty member at Ton Duc Thang University, Vietnam**

Dr. Sergei Alexandrov works on the mathematical theory of plasticity. He has proposed the theory of singular solutions and made a significant contribution to the theory of ideal flow. Both are applied for metal forming analysis and/or design and the former for structural analysis and design.

**Prof. Prashant P. Date**

Department of Mechanical Engineering IIT Bombay

Prof. Date's research interests lie in manufacturing processes, especially bulk metal forming and sheet metal working processes; sustainable manufacturing, Light weighting and manufacturing process design.

## Contents

Plasticity preliminaries : Stress and strain analysis, Plastic work rate, Equilibrium equations. Strain and strain rate compatibility equations.

Basic constitutive equations .

Viscoplasticity. Orthotropic plasticity. Plasticity of granular, porous and powder materials.

Mathematical Fundamentals : Gauge functions. Order symbols. Asymptotic expansions. Binomial theorem. Hyperbolic equations. Characteristics. Envelope of characteristics. Riemann's method.

Maximum friction law in plasticity

Definition of maximum friction law with simple analytic examples

Asymptotic singular representation of rigid perfectly plastic solutions near maximum friction surfaces.

Experiment on generating a layer with drastically modified microstructure near friction surface

Extrusion of round rods through conical dies. Distribution of grain size and hardness near friction surface.

Numerical method for calculating the strain rate intensity factor for rigid perfectly plastic material.

Finite difference method for calculating the strain rate intensity factor. viscoplastic solutions near maximum friction surfaces

Ideal flow condition : Definition of ideal flows Simple examples of ideal flows. Technological value of ideal flows.

Practical applications of ideal flows.

Ductile fracture in ideal flows. Prediction of ductile fracture in extrusion through optimal dies.

General theory of stationary and nonstationary planar ideal flow for the double shearing model.

Method of characteristics for calculating ideal flows. Method of Riemann for calculating ideal flows.