

# RAJAT ARORA

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## EDUCATION

### Carnegie Mellon University (CMU)

Ph.D. Candidate, Computational Mechanics  
M.S., Computational Mechanics  
GPA: Ph.D.- 4.0/4.0, M.S.- 4.0/4.0

Pittsburgh, PA  
Jul'15 - Feb'19  
Jul'15 - Dec'17

### Indian Institute of Technology Kanpur (IITK)

Bachelor and Master of Technology in Mechanical Engineering  
GPA: B. Tech.- 8.2/10, M. Tech.- 9.7/10

Kanpur, India  
Jul'09 - Oct'14

## SKILLS

In-depth Knowledge: Finite Element Method (Continuous/Discontinuous), Isogeometric Analysis, Numerical Methods, Continuum Mechanics, Solid Mechanics, Modeling defects across atomic, mesoscopic, and continuum scales  
Programming: C/C++, Python, MATLAB,  $\text{\LaTeX}$   
Computational: Git, PETSc, Deal.II, P4est, VTK, High Performance Computing (OpenMP, MPI)

## RELEVANT COURSEWORK

\*Audit

- Finite Element Method
- Advanced Finite Element Method
- Theory of Plasticity
- Advanced Mechanics of Solids
- Computational Modeling of Materials\*
- Dislocation Mechanics
- Ordinary and Partial Differential Equations
- Differential Geometry for Mechanics
- Mathematics of Finite Element Method\*
- Numerical Methods in Engineering
- Thermodynamics of Continuous Media
- Fracture & Fatigue\*
- Molecular Simulation of Materials
- Principles of Real Analysis I
- Principles of Real Analysis II\*

## RESEARCH EXPERIENCE

### Computational Approximation of Mesoscale Field Dislocation Mechanics (MFDM) at Finite Deformation

Ph.D. Thesis, *Advisor - Dr. Amit Acharya*, CMU

Jul'15 - Feb'19

- Developed a massively parallel finite element based theoretical-computational framework for finite deformation MFDM theory to study plastic deformation in materials; Used: MPI, Deal.ii, PetSc, and P4est
- Developed and implemented an efficient numerical scheme, along with an intricate cut-back algorithm to ensure robust, stable, and accurate evolution of plastic response
- Applied the framework to
  - Simulate size effect in metals with  $J_2$  & crystal plasticity under simple shear up to large strains
  - Predict stressed and unstressed patterned micro-structures in the presence/absence of any external loads
  - Simulate longitudinal propagation of shear band (quasi-static) within fully stress coupled material response
  - Study the dynamics of moving dislocations with inertia
  - Calculate the finite deformation stress fields of dislocation walls
  - Quantify the change in volume on the introduction of dislocations
  - Modeling strain localization in crystals undergoing symmetric double slip in tension

### Shape Evolution of Precipitates using Extended Finite Element Method Coupled with Level Set Method

Master's Thesis, *Advisor - Dr. Anurag Gupta*, IITK

May'13 - July'14

- Analyzed morphological evolution of arbitrarily shaped precipitates embedded coherently in a matrix
- Implemented Extended Finite Element Method (XFEM) coupled with PDE based narrow band Level Set Method (LSM) to capture motion of the interface as the precipitate evolves
- Developed C++ code which implements shared memory parallelism using OpenMP to achieve 3X boost in performance over serial execution

For more details of projects please [visit homepage](#)

## ACADEMIC PROJECTS

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### Modeling Elastic-Plastic Deformation

Aug'15 - Dec'15

Supervisor - Dr. Jessica Zhang, CMU

- Developed a C++ code employing finite element method (FEM) to analyze elasto-plastic deformation of a 2D plate under plane strain conditions using  $J_2$  plasticity theory along-with non-linear isotropic hardening
- Used Backward Euler integration algorithm (elastic predictor/plastic corrector approach) to integrate the rate elastoplastic evolution equations

### Modeling Crack using Extended Finite Element Method

Mar'14 - Apr'14

Supervisor - Dr. P. Venkitanarayanan, IITK

- Modeled opening of a crack in a finite 2D plate under uniaxial tension using Extended Finite Element Method (XFEM) and Linear Elastic Fracture Mechanics (LEFM)

### Elastically Induced Shape Bifurcation of Inclusions

Jan'13 - Apr'13

Supervisor - Dr. Anurag Gupta, IITK

- Examined transitions in equilibrium shape of a precipitate, embedded coherently in a matrix, for isotropic systems under plane-strain conditions, as a function of various parameters: size of particle, mismatch, external stress, elastic and interfacial energies
- Developed MATLAB code to numerically determine the equilibrium shape by minimizing Taylor series expansion of total system energy

### Nonlinear Modeling of Beam Bending at Large Deformation

Mar'13 - Apr'13

Supervisor - Dr. Chandra Shekhar Upadhyay, IITK

- Developed an FEM code to simulate beam bending using Total Lagrangian formulation with von Kármán strains
- Compared various mathematical iterative schemes (Picard's method, Newton-Raphson method, Arc Length method) to obtain solution to nonlinear equations

## INDEPENDENT PROJECTS

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- Learned and implemented Discontinuous Galerkin Finite element method to solve advection equation
- Implemented Local Discontinuous Galerkin (LDG) Method to solve an unsteady convection-diffusion equation
- Learned and Implemented Isogeometric Analysis to solve Laplace equation in a  $2d$  domain
- Employed Automatic Differentiation (Sacado) to solve a non-linear minimal surface equation
- Implemented Adaptive Mesh Refinement (AMR) on unstructured meshes in the MFDM framework
- Contributed to open source FEM package Deal.ii

## TEACHING EXPERIENCE

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- Teaching Assistant for junior level undergraduate courses at CMU
  - Introduction to Civil Engineering Jan'18 - May'18
  - Introduction to Civil Engineering Jan'17 - May'17
  - Engineering Mechanics Jan'16 - May'16
- Teaching Assistant for senior level undergraduate courses at IIT Kanpur
  - Design of Machine Elements Jan'14 - Apr'14
  - Experiments in Solid Mechanics Jul'13 - Nov'13

## EMPLOYMENT EXPERIENCE

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### Engineer, Vehicle Group, Eaton Technologies Pvt. Ltd.

Aug'14 - Jan'15

Eaton India Engineering Center, Pune, India

- Coordinated bearing selection project for Eaton's next generation heavy duty transmission which involved optimizing bearing life and contact stresses for various parameters: lubrication, clearance, misalignment
- Performed bearing analysis using ROMAX software to perform bearing selection & address bearing field failure

## PUBLICATIONS

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- **Rajat Arora**, Xiaohan Zhang, Amit Acharya. *Finite element approximation of Mesoscale field dislocation mechanics at finite deformation* (in preparation)
- **Rajat Arora**, Amit Acharya. *The mechanics of longitudinally propagating shear bands* (in preparation)
- **Rajat Arora**, Amit Acharya. *Dislocation pattern formation in finite strain crystal plasticity* (in preparation)

## PRESENTATIONS

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† Presented by Prof. Amit Acharya

- Poster presentation at *Nonconvexity, Nonlocality and Incompatibility: From Materials to Biology*: “Towards modeling longitudinally propagating shear bands”. University of Pittsburgh, May 5-7, 2017.
- *Society of Industrial and Applied Mathematics*: “Computational Approximation of Mesoscale Field Dislocation Mechanics (MFDM) at Finite Deformation”. Portland, Jul’8-13, 2018.
- *World Congress of Computational Mechanics (WCCM)*: “Computational Approximation of Mesoscale Field Dislocation Mechanics (MFDM) at Finite Deformation”. New York, Jul’22-27, 2018.
- *Micromechanics of Defects in Crystalline Solids and Metals*: “Finite Deformation Mesoscale Field Dislocation Mechanics”. Sevilla, Jun’11-15, 2018.†
- *Physics and Mechanics of Random Structures: from Morphology to Material properties*: “Finite Deformation Mesoscale Field Dislocation Mechanics”. Peninsula of Olèron, Jun’17-22, 2018.†
- *Mechanics of Time Dependent Materials*: “Finite Deformation Mesoscale Field Dislocation Mechanics”. Italy, Sept’4-7, 2018.†

## WORKSHOPS

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- Completed an advanced C++ programming course from Udemy Aug’15 - Jan’16
- Attended one day workshop on OpenMP conducted by *XSEDE HPC* Oct’16
- Attended two day training session on Scientific Visualization organized by *XSEDE HPC* Oct’16
- Attended two day workshop on MPI conducted by *XSEDE HPC* Sept’15

## AWARDS AND HONORS

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- Fennes Travel Grant, Civil Engineering Department, CMU 2018
- Dean’s Fellowship, Civil Engineering Department, CMU 2015
- Awarded two Excellence Stars and a certificate of appreciation, Inclusion & Diversity Council, Eaton 2014
- Awarded Boeing - IITK Research Scholarship 2012
- 3<sup>rd</sup> prize in Robotics competition, IIT Kanpur 2010
- 3<sup>rd</sup> prize in Electronics competition, IIT Kanpur 2010
- 99.42 percentile in All India Engineering Entrance Exam (AIEEE) amongst 1 million applicants 2009
- All India Rank 761 (99.84 percentile) in IIT Joint Entrance Exam amongst 0.4 million applicants 2009

## EXTRA-CURRICULAR ACTIVITIES

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- Member of Inclusion & Diversity Council, Eaton Corporation Pvt. Ltd. Aug’14 - Jan’15
- Technical Head, Science & Technology Council, IIT Kanpur Apr’12 - Mar’13
- Overall Coordinator of Takneek, Intra IIT Kanpur Science & Technology Championship Aug’12 - Sept’12
- Coordinator, Electronics Club, Science & Technology Council, IIT Kanpur Apr’11 - Mar’12