**HEMI/MSEE Impact Research Workshop Detailed Schedule**

**July 17 – 19, 2023**

**Johns Hopkins University, Baltimore, MD**

***Day 1 – July 17, 2023***

***Focus***: Why we do impact experiments. Governing equations and fundamentals.

**Note: Specific topics and timing subject to change. Specific locations will be provided in a future schedule.**

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| **Time** | **Instructor or Speaker** | **Topic** | **Location** |
| 8:00 – 9:00 am | Hot breakfast | Levering Hall, Great Hall |
| 9:00 – 9:15 am | HEMI/MSEE Organizers | Transition and Introduction | Hackerman Hall, B17 |
| 9:15 – 10:15 am | Naresh Thadhani (Georgia Tech) | Keynote: A Journey with Gas/Powder Gun Impact Experiments: Applications and Opportunities | Hackerman Hall, B17 |
| 10:15 – 10:30 am | Coffee break | Hackerman Hall, B17 |
| 10:30 – 11:30 am | David Lambert (AFRL) | Air Force Munitions S&T Overview for Extreme Environments | Hackerman Hall, B17 |
| 11:30 am – 12:30 pm | Lunch | Levering Hall, Great Hall |
| 12:30 – 2:00 pm | KT Ramesh (JHU) | Impact; stress waves; mathematical foundations. | Hackerman Hall, B17 |
| 2:00 – 2:15 pm | Coffee break | Hackerman Hall, B17 |
| 2:15 – 3:30 pm | KT Ramesh (JHU) | Shock waves, Hugoniot relations, release waves, elastic-plastic shocks. | Hackerman Hall, B17 |
| 3:30 – 3:45 pm | Coffee break | Hackerman Hall, B17 |
| 3:45 – 5:00 pm | KT Ramesh (JHU) | Equations of state. Design of planar shock experiments. | Hackerman Hall, B17 |
| 5:00 – 6:00 pm | Poster session, reception, networking, HyFIRE tours | Malone Hall Lobby |
| 6:00 pm | Adjourn, dinner on own |

***Day 2 – July 18, 2023***

***Focus:*** State-of-the-art in material response to impact and shock.

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| **Time** | **Instructor or Speaker** | **Topic** | **Location** |
| 8:00 – 9:00 am | Hot breakfast | Levering Hall, Great Hall |
| 9:00 – 9:15 am | HEMI/MSEE Organizers | Transition and Introduction. Possible review of previous day. | Hackerman Hall, B17 |
| 9:15 – 10:15 am | Saryu Fensin (LANL) | Keynote: The role of microstructure on dynamic material properties | Hackerman Hall, B17 |
| 10:15 – 10:30 am | Coffee break | Hackerman Hall, B17 |
| 10:30 – 11:30 am | Scott Schoenfeld (ARL) | DoD research needs, interests, opportunities. | Hackerman Hall, B17 |
| 11:30 am – 12:30 pm | Lunch | Levering Hall, Great Hall |
| 12:30 – 1:15 pm | Ghatu Subhash (UF) | Lecture\*: Introduction, examples of dynamic behavior, basics of wave propagation. | Hackerman Hall, B17 |
| 1:15 – 1:30 pm | Coffee break | Hackerman Hall, B17 |
| 1:30 – 2:45 pm | Ghatu Subhash (UF) | Lecture\*: Impact and shock response of brittle materials. Rankine-Hugoniot relations and equations of state. | Hackerman Hall, B17 |
| 2:45 – 3:00 pm | Coffee break | Hackerman Hall, B17 |
| 3:00 – 4:00 pm | Ghatu Subhash (UF) | Lecture\*: Impact and shock response of transparent solids, visualization of wave propagation and damage in glasses. | Hackerman Hall, B17 |
| 4:00 – 4:15 pm | Coffee break | Hackerman Hall, B17 |
| 4:15 – 5:15 pm | Ghatu Subhash (UF) | Lecture\*: Dynamic response of metals, strain rate and temperature dependence, thermally activated dislocation motion. | Hackerman Hall, B17 |
| 5:15 – 6:15 pm | Poster session, reception, networking, HyFIRE tours | Malone Hall Lobby |
| 6:15 pm | Adjourn, dinner on own |

\*Detailed lecture syllabus on page 4.

***Day 3 – July 19, 2023***

***Focus:*** State-of-the-art in constitutive modeling.

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| **Time** | **Instructor or Speaker** | **Topic** | **Location** |
| 8:30 – 9:00 am | Continental breakfast | Malone Hall Lobby |
| 9:00 – 9:15 am | HEMI/MSEE Organizers | Transition and Introduction. Possible review of previous day. | Hackerman Hall, B17 |
| 9:15 – 10:15 am | Nathan Barton (LLNL) | Keynote: High-rate strength and constitutive modeling for impact-loading scenarios | Hackerman Hall, B17 |
| 10:15 – 10:45 am | Coffee break | Hackerman Hall, B17 |
| 10:45 – 11:30 am | Eric Herbold (LLNL) | Lecture: Math and numerical methods for mechanics. | Hackerman Hall, B17 |
| 11:30 am – 12:30 pm | Lunch | Malone Hall Lobby |
| 12:30 – 1:30 pm |  | Lecture: Continuum mechanics. | Hackerman Hall, B17 |
| 1:30 – 1:45 pm | Coffee break | Hackerman Hall, B17 |
| 1:45 – 2:30 pm | Eric Herbold (LLNL) | Lecture: Constitutive model development. Explicit updates. | Hackerman Hall, B17 |
| 2:30 – 2:45 pm | Coffee break |  |
| 2:45 – 3:30 pm | Eric Herbold (LLNL) | Application 1: Constitutive model development. | Hackerman Hall, B17 |
| 3:30 – 3:45 pm | Coffee break |  |
| 3:45 – 4:15 pm | Eric Herbold (LLNL) | Lecture: Hydrocode overview and applications. Lagrangian, Eulerian, and ALE codes. | Hackerman Hall, B17 |
| 4:15 – 4:30 pm | Coffee break |  |
| 4:30 – 5:15 pm  | Eric Herbold (LLNL) | Application 2: 1D shock problem. | Hackerman Hall, B17 |
| 5:15 pm | End of Workshop, adjourn |

Detailed Lecture syllabus for Workshop Day 2 (July 18, 2023).

**Lecture 1 (45 min): Introduction**

Real life examples of dynamic behavior of materials and how they relate to concepts being covered in the next three lectures; Basics of wave propagation, energy dissipation, dynamic response; Differences between static and dynamic responses.

**Lecture 2 (75 min): Impact and Shock response of brittle materials**

Plastic waves to Shock waves- Conservation laws; Hydrodynamic treatment; EOS, Rankine-Hugoniot Relations; Shockwave profiles in ceramics; Propagation characteristics of shock waves; Spall; Influence of pressure (confinement) and strain rate; Impact response of intact vs damaged ceramic.

**Lecture 3 (60 min): Impact and shock response of transparent materials**

Visualization of shock wave propagation and damage evolution (failure waves) in glasses; Impact response of glasses, sapphire, and spinels; Damage progression in laminates; Failure kinetics of glasses and ceramics.

**Lecture 4 (60 min): Dynamic Response of Metals**

Strain rate and temperature dependence of material behavior; Thermally activated dislocation motion; Physics based constitutive modeling; Substructure evolution during dynamic deformation in FCC, BCC and HCP metals (Taylor Impact); Adiabatic Shear bands.