Fall 2017 – MSE 8803A: HIGH-STRAIN-RATE DEFORMATION OF SOLIDS

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Scope/objective: To introduce a broad range of aspects of high-strain-rate deformation relevant to applications in materials fabrication, crash-worthiness, space-debris impact, and geological effects, with **emphasis on shock-wave propagation and mechanical behavior of materials during dynamic deformation**.

Text: "Dynamic Behavior of Materials," M.A. Meyers, John Wiley, 1994.

Outline:

1. DYNAMIC DEFORMATION AND SHOCK WAVES [Chaps 1-6]
   - (a) Elastic, plastic, and shock-waves
   - (b) Equations of State
2. SHOCK WAVE ATTENUATION, INTERACTION, REFLECTION, TRANSFORMATIONS & CHEMICAL CHANGES [Chap 7-8]
3. EXPLOSIVE MATERIAL INTERACTIONS AND DETONATION [Chap 9 & 10]
4. EXPERIMENTAL METHODS & DIAGNOSTICS [Chap 11 and 12]
   - (a) Dynamic deformation and shock wave generation techniques
   - (b) Measurements and diagnostics
5. HSR PROPERTIES & CONSTITUTIVE EQUATIONS [Chap 13]
   - (a) Empirical and constitutive stress/strain relations and validation
   - (b) Dislocation dynamics (thermal-activation, drag mechanisms)
6. MICROSTRUCTURE EVOLUTION IN SHOCK WAVES [Chap 14]
   - (a) Strengthening due to shock-wave propagation
   - (b) Generation of dislocations, point defects, deformation twins
7. SHEAR INSTABILITIES [Chap 15]
   - (a) Shear band formation criteria
   - (b) Constitutive models and Metallurgical aspects
8. DYNAMIC FRACTURE [Chap 16]
   - (a) Spalling of metals
   - (b) Fragmentation of brittle materials

Grading:

Homework Problems (Section 1 & 2):	25%
Presentation & Report (Sections 3-8):	75%

Each student will pick one (or part) of the concepts covered in Sections 3-8, prepare a report and make oral presentation (open to group) during Finals week.

Homework problems will need to be submitted along with the report at the end of the term. Homework solution will not be provided.

LECTURES: There will be no formal lecture presentations. Pre-recorded tapes of lectures on these topics are available for viewing. We will try to meet once every two weeks and have a group discussion on topics that may be unclear.

Classical Papers and Books:

1. M.H. Rice, R.G. McQueen , and J.M. Walsh, in Solid State Physics, 6 (1958) 1.

2. L. Davison and R.A. Graham, Phys. Rep., 55 (1979) 257.

3. G.E. Duvall and R.A. Graham, Rev. Modern Physics, 49 (1977) 523.

4. J.S. Rinehart, STRESS TRANSIENTS IN SOLIDS, Hyperdynamics, Santa Fe, NM 1975

5. H. Kolsky, STRESS WAVES IN SOLIDS, Dover, NY, 1963

6. A. Zukas, T. Nicholas, H.F. Swift, L.B. Greszczuk, and D.R. Curran, IMPACT DYNAMICS, J. Wiley, NY, 1982

7. R. Kinslow (editor), HIGH-VELOCITY IMPACT PHENOMENA, Academic, NY 1966.

8. R.A. Graham, SOLIDS UNDER HIGH-PRESSURE SHOCK COMPRESSION, Springer-Verlag, NY, 1993.

9. A. B. Sawaoka, SHOCK WAVES IN MATERIALS SCIENCE, Springer-Verlag, , Tokyo,1993

10. S.S. Batsanov, EFFECTS OF EXPLOSIONS ON MATERIALS, Springer, NY 1994

11. J.R. Asay and M. Shahinpoor, editors, HIGH-PRESSURE SHOCK COMPRESSION OF SOLIDS, Springer-Verlag, NY 1993

12. L. Davison, Y. Horie, and M. Shahinpoor, editors, HIGH-PRESSURE SHOCK COMPRESSION OF SOLIDS IV: Response of Highly Porous Solids to Shock Loading, Springer-Verlag, NY, 1997.

13. R.F. Trunin, SHOCK COMPRESSION OF CONDENSED MATERIALS, Cambridge University Press, Cambridge, 1997.

14. L. Davison, D. Grady, and M. Shahinpoor, (editors), DYNAMIC FRACTURE AND FRAGMENTATION, NY, 1994.

15. R.A. Graham and A.B. Sawaoka, (editors), HIGH PRESSURE EXPLOSIVE PROCESSING OF CERAMICS, Trans Tech Publications, Switzerland, 1987.

16. T.Z. Blazynski, (editor), EXPLOSIVE WELDING, FORMING, AND COMPACTION, Applied Science Publishers, 1983.

17. L.E. Murr, SHOCK WAVES FOR INDUSTRIAL APPLICATIONS, Noyes, Park Ridge, NJ, 1990.

18. Proceedings of APS Topical Conferences on SHOCK WAVES IN CONDENSED MATTER: Menlo Park - 1981, Santa Fe-1983, Spokane-1985, Monterey-1987, Albuquerque-1989, Williamsburg-1991, Colorado Springs -1993, Seattle - 1995, Amherst - 1997.

19. Proceedings of EXPLOMET Conferences: Albuquerque-1980, Portland-1985, La Jolla-1990, El Paso - 1995.