ORDER-OF-MAGNITUDE PHYSICS

Astro 250 / Fall 2014

Class times: Tuesdays and Thursdays 11:00–12:30 pm in 110 Barrows
Bi-weekly "Tuesday Labs" (no lecture) 11:00–12:30 pm in **127 Dwinelle**

Instructor: Eugene Chiang / Hearst Field Annex D29B / 701-5996 / echiang@astro.berkeley.edu

GSI: Alwin Mao (alwin.mao@berkeley.edu)

Office hours: Anytime I am not talking to somebody else.
For guaranteed meeting times, call or e-mail.

Website: http://astro.berkeley.edu/~echiang/oom/oom.html

Things we hope you will learn:

- How to make estimates.
- How to decide what physical effects are important in a given situation.
- How to decide what terms in complicated equations can be dropped.
- How to sketch the solutions of equations without actually solving them.
- How to develop a physical feeling for a subject.
- How to use physics to quantitatively understand the world around you.
- How to stop and think before saying, "I don't know."

"It is better to have estimated and erred
than never to have estimated at all."

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Rough Syllabus:

1. Everyday estimation (Fermi problems, global warming, energy requirements, natural resources)
2. Material properties (elastic moduli, surface tension, conductivity, magnetism)
3. Fluid mechanics (boundary layers, drag, flying) (Astro 202)
4. Biomechanics (human physical performance, top spin in racquet sports, diffusion)
5. Waves and sound (turbulent sound generation, tidal bores, tsunamis)
6. Interaction of electromagnetic radiation with matter (Astro 201)
7. Measurement of time (mechanical clocks, rotation period of Earth, electronic clocks, atomic clocks, GPS)

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REQUIRED TEXT:

Astro 250 Course Reader: purchase one at "Copy Central" on Bancroft. We will refer to the reader throughout lecture — please bring it to class. Its contents will be useful for solving homework problems.

RECOMMENDED TEXTS:

If you don't want to purchase your own copy, you can borrow one of mine (24-hour lending period).

1. *Order of Magnitude Physics* (in progress), S. Mahajan (http://www.inference.phy.cam.ac.uk/sanjoy/oom). A truly outstanding book.
2. *Consider a Spherical Cow: A Course in Environmental Problem Solving,* John Harte. A physicist by training, Harte has taught environmental science and OOM estimation at Berkeley to high acclaim for many years.
3. *Consider a Cylindrical Cow: More Adventures in Environmental Problem Solving,* John Harte. An even better set of problems.
4. *Back-of-the-Envelope Physics,* Clifford Swartz (concise, readable, quantitative questions and answers, written by an Oersted Medalist, as awarded by the American Association of Physics Teachers)
5. *Physics to a Degree,* E.G. Thomas (lots of advanced undergraduate physics problems with real-world applications, with quantitative answers at the back)
6. *Flying Circus of Physics with Answers,* J. Walker (a smorgasbord of physical puzzles, with qualitative answers at the back)
7. *Gases, Liquids, and Solids*, D. Tabor (perhaps the most clear text I have ever read)
8. *Physical Fluid Dynamics*, D. F. Tritton (concise and clear, with pictures)
9. *On Size and Life*, McMahon & Bonnor (examples of scaling in biology for Scientific American)
10. *Fluid Mechanics*, White (popular engineering text; clear and elementary)
11. *Fundamentals of Fluid Mechanics*, Munson, Young, & Okiishi (popular engineering text; clear and elementary)

12. *Modern Developments in Fluid Dynamics: An Account of Theory and Experiment Relating to Boundary Layers, Turbulent Motion, and Wakes*, edited by S. Goldstein (covers similar topics to Tritton, but denser and with beautiful pictures and graphs)

13. *The Simple Science of Flight*, Henk Tennekes (an easy read with giant fonts)

14. *Random Walks in Biology*, Howard C. Berg ("to understand diffusion, this is the book."—Mahajan)

15. *The Quantum Beat*, F. G. Major (breezy and rambling discussion of the physics underlying atomic clocks, with a sprinkling of equations)

16. *Splitting the Second*, Tony Jones (qualitative and readable discussion of the physics of precision timekeeping)

17. *Waves*, F. Crawford, Jr. ("a very intuitive book with excellent home experiments"—Mahajan)

18. *The Physics of Musical Instruments*, Fletcher & Rossing (systematically treats a universe of instruments, with derivations)

19. *Music, Physics, and Engineering*, Harry F. Olson (concise handbook on musical engineering, with formulas but few derivations)

20. *The Science of Musical Sound*, John R. Pierce (another readable, semi-quantitative Scientific American text, with fun records you can play on turntables in Berkeley's Music Library)

21. *Applications of Classical Physics*, Blandford & Thorne (unpublished) (http://www.pma.caltech.edu/Courses/ph136/yr2004) (a book to read for insight, after one has learned the material)

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Homework and Tuesday Labs:

- Weekly problem sets, available on course website. Due Thursday at the beginning of class.
- Late homework will not be accepted, except in unusual circumstances and by prior arrangement with the instructor.
- You are encouraged to rely as much as possible on your own brain, personal experience (including common sense), personal experiments, and the lecture material.
- You are free to use books and the internet, but you must cite any resource that you use (book title, page number, website, etc.) when you use it (just as one does for published papers).
- You may discuss problems with other students and with the instructor, but your final solution must be written by you alone.
- A natural — and professional — method of information exchange is word of mouth. For the Tuesday Labs, talk and sketch on the whiteboards together — check each other's thoughts and calculations in real time.
- As far as I can tell, the only way to learn how to estimate is to do problems.
- Please register for the class.