Notes on Homework Problems

A number of new homework problems were written by the instructors for the FA11 and SP12 transformed E&M II course at CU, but many were also borrowed and adapted from previous instructors, in some cases modified to greater emphasize sense making and/or connections to real-world situations. Homework problems are sorted by topic, and are given in both PDF and Word format. If you would like to see the original, complete homework sets, these can be found in the Past Courses at CU archive folder – individual questions in the accompanying documents indicate which instructors at CU have used them. Solutions to the original homework sets are available as a resource (contact us for access), though we always encourage instructors to work out the solutions for themselves. We provide below brief notes on the "Pre-Instruction Diagnostics", and the problem-solving sessions used in both semesters of the transformed courses. There is also a "Table of Contents" for the homework problems, with cursory descriptions of the questions by topic.

We ask for your cooperation in not making solutions to these homework questions available on the open web, or to at least sufficiently "disguise" or modify the questions. We ask this out of fairness to instructors and students at other institutions, and for maintaining the integrity of our research.

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II. Pre-Instruction Diagnostics

These were given at the very beginning (as in, the first day) of the FA11 and SP12 E&M II courses at CU (the two diagnostics are similar, but not exactly alike). In FA11, students were given two versions of the diagnostic – one they completed on their own, without help from others or reference to outside materials, to be handed in on the next day – the second was to be completed afterward with any help they desired, to be turned in at the beginning of the second class period. The SP12 version was completed by students only once, and turned in on the second day of class. In the end, both ways of doing it provided a great deal of information about what students were capable of after a long break between semesters, and helped us decide how to approach the first week of the semester, which was devoted to review topics from electrostatics. Giving two versions allowed us to separately gauge what students could first do entirely on their own, and then what they were capable of when they had their textbook and notes in front of them. Results from our own implementations of these diagnostics will be summarized as part of future publications.

III. Homework Problem-Solving Sessions

In lieu of "office hours", both FA11 and SP12 E&M II courses held twice-weekly homework help sessions outside of class (two hours each, on Monday and Tuesday afternoons, with assignments due on Wednesdays). The FA11 sessions were staffed by instructors and undergraduate learning assistants; in SP12, the two instructors alternated staffing them individually. The sessions were held in a large room with sufficient table space for students to work together on the homework problems, with occasional guidance from an instructor. This was particularly enlightening to us as instructors and researchers, since we could observe students as they were engaged in the process of "figuring it out". They were also extremely popular with students - 84% of FA11 students rated these sessions as *useful* or *very useful* for their learning. 80% of SP12 students who attended the sessions gave them similar ratings, though in this case 30% of students reported they could not attend the sessions because of scheduling conflicts (many of them were concurrently enrolled in a conflicting astrophysics course).

IV. List of Homework Problems by Topic

The following pages are just reproductions of the summary lists that appear at the beginning of each of the individual files in this folder. We list them here simply for easy reference. We anticipate being able to soon offer greater descriptions of the individual questions, in terms of their level of difficulty, and specific issues students had in answering them.

00 – Review

1. Conducting shell
2. Conducting shell (off-center charge)
3. Field of a charged rod
4. Field of a charged ring
5. "Curly" E-field
6. Magnetic fields of household currents
7. Force between two moving line-charges
8. Magnetic resonance imager
9. Helmholtz coils
10. Force between charged hemispheres
11. General electric potential in cylindrical geometry
12. Potential inside/outside cylindrical shell
13. Potential in a dielectric cylinder
14. Electric dipole in a dielectric sphere
15. Magnetic field inside/outside wire
16. Vector potential of coaxial conductors
17. Dipole approximation of a current loop
18. Magnetic field from a magnetized sphere
19. Permeable sphere in a magnetic field

01 – Current & Resistance

1. A, B & J-fields
2. Current density/drift velocity
3. Spherical resistor
4. Coaxial cable
5. Resistance of a rectangular slab
6. General formula for resistance

02 – EMF & Inductance

1. Moving bar in a uniform magnetic field
2. Falling loop in a uniform magnetic field
3. Horse-powered generator
4. Moving loop in magnetic field of a wire
5. Homopolar generator
6. Eddy current brake
7. Moving loop in a time-varying field
8. Conducting disk in a time-varying field
9. Magnetohydrodynamic generator
10. AC generator
11. Rotor generator
12. Voltage measurements near a solenoid
13. Conducting 'tethers' in space
14. B-field and self-inductance of a toroid
15. Loop around a solenoid
16. Jumping ring
17. Mutual inductance of concentric loops
18. Iron-core transformer
19. Self-inductance of a coax cable
20. Force on a permeable rod in a solenoid
21. Force for a compressible solenoid
22. Kinetic energy versus magnetic energy
23. EMF devices, energy storage and conversion

03 – *AC* Circuits

1. Self-inductance of a solenoid
2. Inductors and RL circuits
3. LC circuits
4. Phasor notation
5. Resistor and inductor in parallel
6. LR filter
7. Parallel RLC circuit
8. Series RLC circuit
9. Simple LC circuit
10. Underdamped RLC circuit

04 – Displacement Current, etc…

1. Displacement current in a coaxial cable
2. Loop antenna
3. Rod antenna
4. Dimensional analysis
5. Electromagnetic mass

05 – Conservation Laws

1. Charging Capacitor
2. Poynting vector of a solenoid
3. Energy flow in a coax – Part I
4. Energy flow in a coax – Part II
5. Feynman Rotator
6. Stress tensor for a solenoid
7. Force between two point charges
8. Stress in a charged plate capacitor

06 – EM Waves

1. Energy in a wave on a string
2. Traveling wave on a string
3. Standing wave
4. Spherical traveling wave
5. Traveling EM wave
6. 3-D electromagnetic plane wave
7. Wave equation in vacuum
8. Radiation pressure of a plane wave
9. EM plane wave surfing
10. Traveling wave packet
11. Quantum wave velocities
12. Complex wave notation
13. Polarization of waves

07 – R&T, Dispersion, Conductors

1. Wave equation in matter
2. Boundary conditions from Maxwell's equations
3. R & T – perpendicular polarization
4. Anti-reflection lens coating
5. Driven damped harmonic oscillator
6. Spring constant of an atom
7. Dispersion in hydrogen gas
8. Skin depth for various conductors
9. Good/poor conductors
10. Birefringence of dextrose solution
11. Waves in plasmas
12. Power flow in a rectangular waveguide
13. TM modes in a rectangular waveguide
14. Cylindrical waveguide

08 – Potentials and Fields

1. Maxwell's equations in general potential form
2. Temporal gauge
3. Vector potential for EM plane waves
4. Vector potential for an infinite wire
5. Time-dependent fields from an infinite wire
6. Infinite current sheet
7. Poynting vector of a point charge
8. Scalar and vector potential of a rotating point charge
9. Electric and magnetic fields of a moving point charge

09 – Radiation

1. Classical instability of the H-atom
2. Radiation from a falling point charge
3. EM waves from an oscillating electric dipole
4. Small antenna array
5. Radio signals, revisited
6. Dipole radiation from Larmor formula

10 – Special Relativity

1. Magnetic field of a wire
2. Star Wars with relativity
3. Spacetime diagrams
4. Faster-than-light neutrinos(?)
5. Lorentz transformation for general velocity vector
6. Transformation of acceleration
7. Rapidity

8. Lorentz transformation of the wave equation
9. Invariance of the spacetime interval
10. Conserved vs. invariant quantities
11. Muon calculations
12. Relativistic inelastic collision
13. E & B transformations