Exam 1

Honors Physics

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February 12, 2004

RULES:

- This is an open-book, open-notes take-home exam.
- Show all your work *clearly* in the blue books.
- The exam is due Monday, February 16 at 1:25 pm.
- You may not consult with anyone about this exam starting noon on February 12 until you turn it in on February 16.

Problem 1

Final numerical answers are expected here – be sure to specify units.

Figure 1(a) shows a capacitor $C = 0.01\ \mu F$ and inductor $L = 700\ mH$ connected by a switch S that will be closed at $t = 0$. Before the switch is closed the capacitor carries charge of 6 μC.

(a) How soon, after the switch is closed, is the charge on the capacitor equal to zero? (b) What is the maximum current in the inductor?

Figure 1(b) is a modification of Figure 1(a) – a resistor, $R = 1200\ \Omega$, is added. Again, before the switch is closed the capacitor carries charge of 6 μC and the switch is closed at $t = 0$.

(c) What is the difference in the oscillation frequency of this circuit and the oscillation frequency of the circuit of Figure 1(a)? (d) If R is a variable resistor, for what range of R (if any) will there be *no* oscillations after the switch is closed – assuming L and C are fixed at their current values?

Problem 2

Consider a spherical non-conducting shell of inner radius a and outer radius b. Between $r = a$ and $r = b$ the density of charge is given by $\rho(r) = A \cdot r$ where r is measured from the center of the shell and A is a constant. On the inside surface of the shell is a thin uniform layer of charge with $-\sigma_o$ charge per area and on the outside surface there is another this layer of charge with $+\sigma_o$ charge per area. The total charge of the sphere is Q.
(a) In terms of Q and σ_o what is A?
What is the electric field:
(b) Just outside $r = b$ and just inside $r = b$? (c) Just outside $r = a$ and just inside $r = a$?

Problem 3

See Figure 2. Two electric dipoles, $\vec{p}_1$ and $\vec{p}_2$ are anti-parallel and separated by a distance d. At what point(s) along a line perpendicular to the dipoles and passing through their centers is the total electric field zero?

Problem 4

See Figure 3. Two charges, $+q_1$ and $+q_2$ are each held a distance a above an infinite conducting plane. The charges are also separated by distance a.
(a) Ignoring the forces holding the charges in place what is the total electrical force on each charge?
(b) What force, if any, do the two charges exert on the infinite conducting plane?

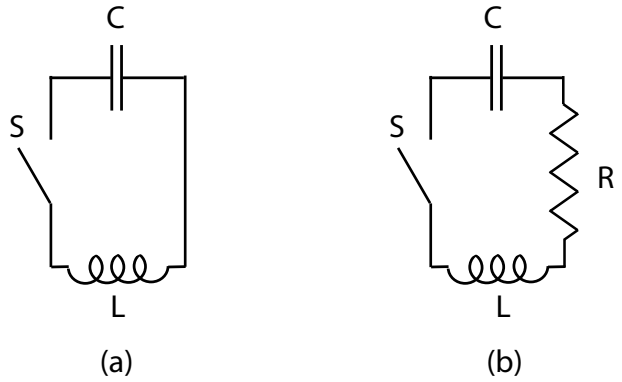

Figure 1: Problem 1

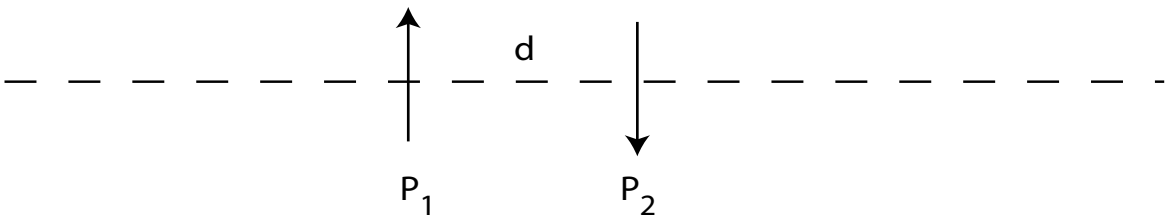

Figure 2: Problem 3

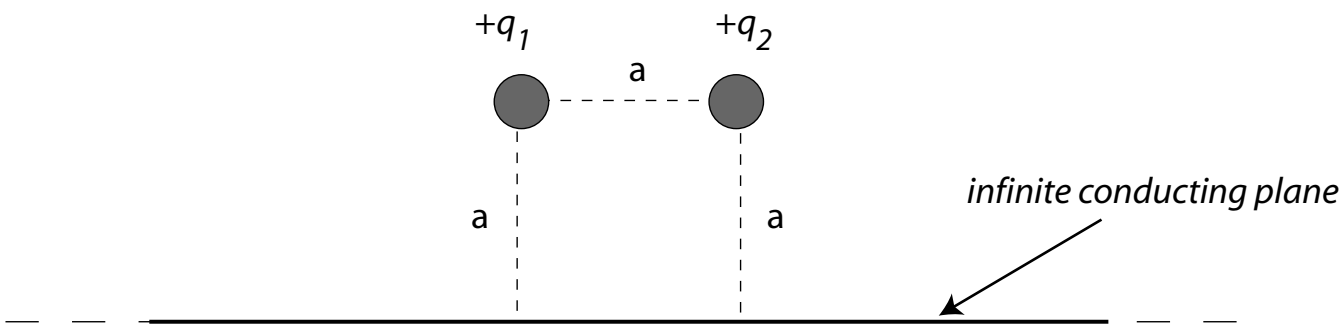

Figure 3: Problem 4