***👓 INSTRUCTORS MANUAL: TUTORIAL REVIEW 3***

***Coulomb’s Law, Conductors, Linear Dielectrics, Ampere***

**Goals**:

To revisit the topics covered in the semester of tutorials

**Reflections on this tutorial:**

**Part 1:**

This was the most challenging section for most groups even though it was the third time they had seen this problem for many students. They could identify the correct coordinates and determine what curly-R was, but they had trouble applying it. Most groups at this point in the semester understood that their integral needed to just include the loop, but several still struggled for what to use for the radius of the tricorder (was it OK to have an x, y, and z in the integral without knowing what they were in terms of something else?)

Also, the idea of vector integration was still difficult. The idea of what r’-r meant also seemed to have become fuzzy for several students. Several thought they needed to subtract magnitudes rather than vecors.

**iii)** Lots of groups got stuck here and needed help to get unstuck. One group really struggled and spent about 50 minutes on this part alone.

**Part 2:**

**ii)** One group I spoke to was concerned that if the outside distribution on the outer shell was even (which they thought it would be) and the inside distribution on that shell was unevenly distributed that there would be and E-field inside the conductor. If I recall from the tutorial where the students first saw this, this was a common concern.

**Part 3:**

This part was new written for the review tutorial and seemed to be good practice but not too challenging (which was probably good given the amount of time other parts took).

**ii)** Some students were not sure how to get E fromm D and need to look it up.

**iv)** This is another area of common student confusion. One group asked for the equation and after a little discussion we decided it was P dot n-hat. One student then said “so sigma\_b is just P?” without thinking about particular surfaces, which is the kind of imprecise thinking that I think is quite common for students.

**Part 4:**

 **i)** I overheard debate in a lot of groups about whether B was zero outside the two wires or not. All of these arguments seemed to based on logical thinking, but did not make use of the tool of Ampere’s law to clarify their ideas.Some students didn’t quite remember what Ampere’s law was (“Is it the integral of B dot dl?”).

**ii)** When I asked one group if the 3rd region fell off faster or slower than the 2nd region they weren’t immediately sure, so seemed not to have a very physical grasp of what was going on.

**✯ TUTORIAL REVIEW 3 ✯**

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*Please start with whichever part you think would help you the most.*

**Part 1 –Coulomb’s Law**

In the year 2240, a bicyclist, named Thomas, gets lost east of Boulder, and he gets a flat tire. Thomas pulls off the tire and then consults his Tricorder to find out what life forms are nearby. However, the flat tire has somehow been charged with uniform charge density . The Tricorder complains that the electric field from the tire is very annoying.

Tricorder

Your goal is to calculate the electric field produced by the electrically-charged tire (ring of line-charge density).

1. The origin is at the center of the tire. Label the diagram with points (x,y,z) and (x’,y’,z’) (that is, define your coordinate system!)
2. Now label the three vectors: , ,and (where  is Griffiths’ “script r”).
3. Find the explicit integral expression for at the position of the tricorder; you do not need to evaluate the integral, but it should be in a form that it could be solved with a computer. This means using the variables defined in this particular problem and explicit limits on the integrals.

iv) Find the explicit integral expression for V at the position of the tricorder; you do not need to evaluate the integral.

**Part 2 - Conductors**

A coax cable is essentially one long conducting cylinder surrounded by a conducting cylindrical shell (the shell has some thickness). The two conductors are separated by a small distance. (Neglect all fringing fields near the cable’s ends)

1. Draw the charge distribution (little + and – signs) if the inner conductor has a total charge +Q on it, and the outer conductor is electrically neutral. Be precise about exactly where the charge will be on these conductors, and how you know. Also draw a rough sketch of the E field lines.

+Q

ii) Consider how the charge distribution would change if the inner conductor is shifted off-center, but still has +Q on it, and the outer conductor remains electrically neutral. Draw the new charge distribution (little + and – signs) and E field lines and be precise about how you know.

+Q

**Part 3– Linear Dielectrics**

A metal sphere (conducting) has a positive chare charge +Q on it. It is surrounded by a dielectric shell with electric susceptibility  as shown.

III

II

I

i) Can you use Gauss’s Law to find  or ? Why or why not?

ii) Find  and  in regions I, II and III.

iii) What is  in regions I, II and III?

iv) What is the bound charge,, on the inner and outer dielectric surfaces?

v) What is the sum of the bound charge on the inner and outer conductor? Does this make sense for the total charge in the dielectric?

v) Can you smuggle charge using this dielectric?**Part 4– Applications of Ampere’s Law**

While studying intensely for your physics final, you decide to take a break and listen to your stereo. As you unwind to a little 3OH!3, your thoughts drift to newspaper stories about the dangers of household magnetic fields on the body. You examine your stereo wires and find that most of them are coaxial cable: essentially one conducting cylinder surrounded by a thin conducting cylindrical shell (the shell has some thickness). At some moment in time current is traveling up the inside conductor and back down the conducting shell. As a way to practice for your physics final you decide to calculate the magnetic field at different radii.



i). Before you do any calculations, think about what answers you expect in the following questions.

 a) Is there a magnetic field inside either of the two conductors?

b) Which direction will the magnetic field point inside the conductors, between the conductors, and outside the cable?

ii). Now, assuming a uniform current densityin both conductors (also assume that they are made of a material with no magnetic susceptibility, = 0), calculate **B** in the four regions (you may assume I1 and I2 have the same magnitude *I*):

a) s < a

b) a < s < b

c) b < s < c

d) s > c

|B|

Sketch your result:

s