PHYS 272 (Spring 2019): Introductory Physics: Fields

Homeworks

Note: the 1st homework is simply signing the honor pledge (but still it is *compulsory*); the actual homework starts with #2.

And, please sign the honor pledge on a *separate* sheet of paper from HW 2.

1 Homework 1 (due Friday, February 8 in folder outside Room 3118 of PSC by 5 pm.)

Print your name and sign (with date) the Honor Pledge (which covers *all* assignments, including exams):

"I pledge on my honor that I will not give or receive any unauthorized assistance (including from other persons and online sources) on all examinations and homework assignments in this course."

General guidelines for homework

(1). Please read the problem *and* chapter *number* (when it is from the textbook by Giancoli, henceforth simply referred to as "Giancoli") correctly.

(2). Many of the following homework problems have *multiple* parts. So, it is your responsibility to read the *full* statement of the problem carefully.

(3). Most (if not all) of the problems here are *not* purely mathematical ones, i.e., are instead (mostly) *physics*-based. So, *unless it is (explicitly) stated otherwise*, feel *free* to use any computer programs (such as mathematica) for solving the mathematical parts (for example, doing complicated integrals) or to look up mathematical formulae in reference tables (including online). However, if you take such a step, please indicate what exactly you did here (this will help us grade appropriately).

(4). You are welcome to ask for help (for example, hints) on homework from the instructor or TA. Also, "limited" discussion with other students *is* allowed (and encouraged): for example, just in order to get started, but the actual problem-solving part should be your own work. And, you should try *not* to get any *other* outside help.

(5). In order to get full credit for homework (*and* exam) problems, you should show as many steps as you can.

2 Homework 2 (due Friday, February 8 outside Room 3118 of PSC by 5 pm.)

All problems in this homework are from Giancoli.

2.1 Coulomb's law

Problem 13 from chapter 21.

2.2 Electric field due to discrete charges (I)

Problem 33 from chapter 21.

2.3 Electric field due to discrete charges (II)

Problem 36 from chapter 21.

2.4 Electric field due to continuous charge distribution (I): *no* integration required

Problem 40 from chapter 21.

You can simply use (i.e., with*out* any need to re-derive it) the result from Example 21-9 of Giancoli, although you are advised to go through that example carefully (just for your own learning).

2.5 Electric field due to continuous charge distribution (II): *no* integration required

Problem 47 from chapter 21.

Note that problem #46, whose result is to be used here for computing the electric field due to each side of the square loop, was actually done during lecture. Also, remember to add the electric fields due to the four sides *vectorially*: you might wish to make use of the symmetry of the configuration. Finally, check your answer in the limiting case of $z \gg l$.

2.6 Electric field and acceleration due to continuous charge distribution (III): integration required

This problem is for *Honors* section *only*.

Problem 50 from chapter 21.

3 Homework 3 (due Monday, February 18 in folder outside Room 3118 of PSC by 5 pm.)

All problems in this homework are from Giancoli: first one from chapter 21, rest from chapter 22.

3.1 Electric field due to charged arc of circle: integration required

Problem 49 from chapter 21.

Note: Recall a general "strategy" for computing $\mathbf{E}$ due to a *continuous* charge distribution (of course each problem might have its own special features/subtleties):

(1). Draw a picture displaying division of the charge distribution into small (infinitesimal) elements, labelled by a suitable coordinate (for example, y going along line of charge that we worked out in lecture/example 21-11 of Giancoli). Also, show the *direction* of electric field ($d\mathbf{E}$) due to this small piece (as usual, directed away/toward the positive/negative charge): note that this *could* depend on location of the elemental charge.

(2). Compute the magnitude of $d\mathbf{E}$ using the usual formula (i.e., for a point charge): again, this *might* vary with the element in consideration.

(3). Sum (integrate) – vectorially (i.e., keeping track of direction) – the various $d\mathbf{E}$'s: try to use "symmetry" to spot cancellation between $d\mathbf{E}$'s from some elements.

(4). Try to check that in a suitable *limit* (for example, field point is very far away), your exact answer above (using a possibly long calculation!) agrees with the (approximate) expectation based on a (much) *simpler* argument which is valid in this case.

3.2 Computing electric flux given field

Problem 3 from chapter 22.

3.3 Flux using Gauss's law

Problem 7 from chapter 22.

3.4 Gauss's law for (thin) spherical shells

Problem 27 from chapter 22.

(You can study examples 22-3 through 22-5 from Giancoli for how to apply Gauss's law to a spherical distribution of charge: we will also do an example during Wednesday session.)

Note: Recall a general "strategy" for computing $\mathbf{E}$ using Gauss's law:

(1). choose the Gaussian surface appropriately, i.e., (a). needless to say, it should pass through the point P where we want $\mathbf{E}$ so that Left-hand side (LHS) of Gauss's law (electric flux) will contain the desired E and (b). conform to the "symmetry/geometry" of the charge configuration (hence the direction of the electric field itself); for example, for a long (straight) line of charge or a charged cylinder (whether solid or shell), where we expect the electric field to be directed radially outward/inward from the axis, the Gaussian surface should be a cylinder.

(2). LHS of Gauss's law then typically (but one should nonetheless check it!) reduces to simply $\sim$ (desired) E (which is due to *all* changes, whether inside or outside) $\times$ (appropriate) area *if* the electric field is along the direction of the normal to the some part the closed surface. On the other hand, on other parts of the closed surface, the electric field might be perpendicular to the normal (or tangential to the surface), in which case the relevant contribution to the flux vanishes.

(3). RHS, i.e., charge enclosed, can more subtle: again, only charge *in*side the above Gaussian surface counts, whether it is a discrete/point charge or (part of) a continuous charge distribution; in latter case, it might schematically looks like $\sim$ (appropriate) length/area/volume $\times$ right type of charge density (and if charge density is *not* a constant, then one has to start with infinitesimal version of length/area/volume, then integrate as usual).

3.5 Gauss's law for (thin) cylindrical shells

Problem 35 from chapter 22.

Hint: for part (d), you will have to recall the "ingredients" of uniform circular motion from your previous classes!

3.6 Flux via Gauss's law, requiring integration

This problem is for *Honors* section *only*.

Problem 50 from chapter 22.

Note: after some careful thought, you might wish to take the area element on the end cap of the cylinder to be an (infinitesimally) thin ring so that we are left with a *one*-dimensional integral, just like in example 21-12 of Giancoli (or in computing area of a circle by integration that we did in class).

4 Homework 4 (due Thursday, February 28 during lecture or in folder outside Room 3118 of PSC by 5 pm.)

The first problem in this homework is from chapter 22 of Giancoli and the second from chapter 23.

4.1 Gauss's law for sphere with cavity or a *thick* spherical shell

Problem 29 from chapter 22.

Note: while computing electric field for points *in*side the *thick* spherical shell, be especially careful with the amount of change enclosed by the corresponding Gaussian surface. (For a *cylindrical* version of this problem, see #9 from Wednesday session.)

4.2 Basics of work and energy (electric potential and kinetic)

Problem 4 from chapter 23.

4.3 Potential from electric field

Consider a straight thin rod of length l carrying a uniformly distributed total charge of Q. We already computed the electric field directly from this charge distribution at a point along the perpendicular to the midpoint of the rod: see notes from lecture or problem 46 of chapter 21 (referring to Fig. 21-29). *Using* this electric field, compute the potential at the same point. Assume that the potential vanishes infinitely far away from this rod.

4.4 Potential (directly) from charge distribution

For the same situation as above, compute the potential *directly* from the charge distribution, i.e., with*out* "going through" the electric field (cf. above). Compare your result with what you obtained above.

4.5 Electric field from potential

Finally, continuing with the same situation, given the potential that you computed in HW 4.4 just above (i.e., *directly* from charge distribution), determine the component of the electric field along the direction perpendicular to the rod (at the same point): here, you are supposed to "forget" HW 4.3 above. Compare this to the result of problem 46 of chapter 21 (which was also derived in lecture).

Note: was this "two-step" approach (HW 4.4 and 4.5, i.e., "do *not* consider" HW 4.3 here) for calculating electric field (i.e., via potential) easier than the direct method for getting electric field that was used in problem 46 of chapter 21 (again, also in lecture)?

Note: in lecture, we followed a procedure similar to the above three "steps" for the case of the field point being along the axis of the rod.

4.6 Potential from a *non*-uniform charge distribution

This problem is for *Honors* section *only*.

Problem 41 from chapter 23.

5 Homework 5 (due Tuesday, March 12 during lecture or outside Room 3118 of PSC by 5 pm.)

All problems in this homework are from Giancoli: first one from chapter 23, rest from chapter 24.

5.1 Electrostatic potential energy of a charge distribution (requires integration)

Problem 62 of chapter 23.

Hint: The idea here is to generalize (as follows) the procedure discussed in section 23-8 for *point* changes (also done in lecture) to the present case of *continuous* charge distribution (and a similar approach is used in section 24-4 and lecture for computing the energy stored in a capacitor). Namely, one can build-up the total charge Q on the spherical surface bit-by-bit, i.e., suppose the charge on the spherical surface is q $(< Q)$ – uniformly distributed – at some "intermediate" stage of such a process. What is the (small) work done in bringing in a (small) additional charge dq (again to be uniformly spread on the spherical surface)? In case you need it, the potential for a spherical surface charge distribution is given in example 23-4 of Ginacoli. As usual, integrate to get the total charge Q, thus the final work done.

5.2 Basics of capacitance (including energy stored)

Problem 48 of chapter 24.

Hints: First determine the initial charge on the 2.20-μF capacitor; then use the fact that while charge can be re-distributed, the *total* charge is conserved (and that the potential difference between two points is *in*dependent of path along which we evaluate it, with connecting/conducting wires being equipotentials, i.e., there is no potential "drop" across them).

Note: This problem is similar to # 14 from Wednesday problem solving session, example 24-7 of Giancoli and problem 24-6 of Ginacoli, which was done in lecture.

5.3 Calculation of Capacitance

Problem 18 of chapter 24.

Hint: Recall the general strategy for computing capacitance for a configuration of two oppositely charged objects ("plates"), i.e., determine the electric field for *this* charge distribution; then the resulting potential difference between the two plates and use the definition of capacitance.

Hint: If needed, see examples 24-1 through 24-4 of Giancoli (the first two were done also in lecture).

Note: As discussed during lecture, charges in the (net) neutral piece of metal (here, the sheet) will re-arrange themselves (i.e., get separated) so that the induced field due to these (surface-only) charges (exactly) cancels that due to the external charges (here, on the capacitor plates) *in*side the metal: in this specific case, i.e., (infinite) parallel plates, (if needed) you should be able to figure out what this induced charge distribution on the surfaces of metal sheet looks like.

5.4 Capacitors in Series and Parallel

Problem 29 of chapter 24.

Note: part (a) of such problems (see also # 16 of Wednesday problem-solving session or the one done in lecture, which was based on example 24-5 of Giancoli) ask for equivalent capacitance of a large network, which is to be obtained by multiple uses of the series and parallel formulae for a pair of capacitors.

Part (b) then is about charge/voltage for each capacitor of the original network; for obtaining this, one typically has to "work backward" through the analysis done for part (a): see lecture/Wednesday session notes or example 24-6 from Giancoli.

5.5 Electric Energy Stored: various approaches, some requiring integration

Problem 51 of chapter 24.

Note: part (c) here is essentially same as HW 5.1 above.

Hint: Since it is a *conducting* sphere, where exactly does the charge Q redside?

5.6 Electric field inside a cylindrical capacitor

This problem is for *Honors* section *only*.

Problem 20 of chapter 24.

6 Homework 6 (due Thursday March 28 during lecture or in folder outside Room 3118 of PSC by 5 pm.)

All problems in this homework are from Giancoli: first one (and extra one for Honors section only) is from chapter 24, rest are from chapter 25.

6.1 Capacitance with dielectric

Problem 61 of chapter 24.

Hint: Can you consider this capacitor as two capacitors in series or in parallel?

6.2 Microscopic view of electric current

Problem 58 of chapter 25.

6.3 Computing resistance

Problem 22 of chapter 25.

6.4 Basics of electric current, resistance and voltage: Ohm's law

Problem 8 of chapter 25.

6.5 Power changing with voltage

Problem 38 of chapter 25.

6.6 Using energy/work considerations to compute force

This problem is for *Honors* section *only*.

Problem 63 of chapter 24.

Note: the force being referred to in part (c) is that of attraction between the induced change on the dielectric and the charges on the plates: see Fig. 24-17 (c) and (d) from Giancoli. In order to compute this force, you can imagine trying to pull out the dielectric slab (*against* the above force), then use the ideas of conservation of energy/work done in this process etc.: you might find examples 24-11 and 24-12 and problem 50 of chapter 24 (solved during lecture) relevant here.

7 Homework 7 (due Thursday, April 4 during lecture or in folder outside Room 3118 of PSC by 5 pm.)

All problems in this homework are from Giancoli: first one is from chapter 25, rest are from chapter 26.

7.1 Computing resistance by integrating

Problem 30 of chapter 25.

Hint [for part (a)]: as suggested in the problem, you can divide the resistor into concentric (infinitesimally) *thin* cylindrical shells; compute the (small) resistance of each such shell: can the current density/electric field be assumed to be (approximately) constant over its *small* "length" along the direction of current *and* (using the symmetry of the configuration) over its cylindrical surface so that you can use the usual resistance formula for a wire? Then, "add-up/integrate" these (small) resistances suitably.

Hint [for part (a)]: Alternately, (and equivalently), think about whether the current *density*/electric field (the two quantities being related by Eq. 25-17) inside this resistor will be uniform along the direction of the current (i.e., *in*dependent of the radial distance r from axis of the cylinder). Given the symmetry of the configuration, will the *magnitude* of current density/electric field have any "angular" dependence? And, based on charge not accumulating/leaking anywhere, does the *total* current crossing a cylindrical surface of radius r (as given by Eq. 25-12) depend on r? Use all these points in order to figure out how the current density (thus *electric field*) will depend on r; then compute the potential difference using this electric field.

7.2 Battery with internal resistance

Problem 4 of chapter 26

7.3 Series and parallel combinations of resistances

Problem 18 of chapter 26

Note: 1st part of such problems (see also # 25, 26, of Wednesday problem-solving session or the one done in lecture, which was based on examples 26-4, 26-5 of Giancoli) ask for equivalent resistance of a large network, which is to be obtained by multiple uses of the series and parallel formulae for a pair of resistors.

2nd part then is about current through/voltage across for each resistor of the original network; for obtaining this, one typically has to "work backward" through the analysis done for 1st part: see lecture/above Wednesday session problems or examples from Giancoli.

7.4 Kirchhoff's rules: single battery

Problem 30 of chapter 26

Recall a general "recipe/strategy" for solving for currents etc. in a circuit using Kirchhoff's rules:

(1). Label the *current* in each separate branch of the circuit [i.e., in-between two junctions (where connecting wires meet)], choosing a *direction* for it: typically, these are the unknowns in the problem.

(2). Apply Kirchhoff's *junction/current* rule at one or more junctions of the circuit, i.e., sum of currents entering is equal to sum leaving.

(3). Apply Kirchhoff's *voltage/loop* rule to one or more loops of the circuit (again, choose a *direction* for going around each loop): sum of voltages (with appropriate signs) across each component around the loop is zero. In particular,

(a). For a resistor with resistance R and current I flowing through it, the voltage is taken to be $-RI$ if the chosen direction of loop [from step (2) above] is *same* as that (assumed) of the current [from step (1) above] (and $+RI$ if the two directions are opposite).

(b). For a battery, the (usually given) voltage is taken with a positive sign if the chosen direction of the loop is from negative to positive terminal, whereas it is negative if the direction of the loop is the opposite.

(4). Check that there are as many equations as unknowns: again, voltages across resistances can be written in terms of currents, so do not count as further unknowns. If you are "short" of equations, then you need to apply Kirchhoff's rules to additional junctions or loops.

(5). Solve algebraically (the linear, *in*homogeneous system of equations) for the unknown (currents): if value of a current turns out to be negative, then it just implies that the actual direction is opposite to what was assumed to start with. You can check the answers by using any "extra" loop or junction rule equations.

7.5 Kirchhoff's rules: two batteries with internal resistances

Problem 42 of chapter 26

7.6 Combinations of resistors, but not quite series or parallel!

This problem is for *Honors* section *only*.

Problem 41 of chapter 26

8 Homework 8 (due Thursday, April 11 during lecture or in folder outside Room 3118 of PSC by 5 pm.)

All problems in this homework are from Giancoli: first one is from chapter 25, next two are from chapter 26 and last two are from chapter 27.

8.1 Alternating current: average vs. maximum power

Problem 55 of chapter 25.

8.2 RC circuit

Problem 49 of chapter 26.

8.3 Ammeter and voltmeter reading

Problem 61 of chapter 26.

8.4 Hall effect

Problem 48 of chapter 27.

Hint: you can study Example 27-13 from Giancoli. And, for the last part, you might have to re-visit what you learnt in previous chapter(s).

8.5 Force on charge moving in Magnetic field

Problem 28 of chapter 27.

8.6 Magnetic moment of current distribution

This problem is for *Honors* section *only*.

Problem 40 of chapter 27.

9 Homework 9 (due Thursday, April 18 during lecture or in folder outside Room 3118 of PSC by 5 pm.)

All problems in this homework are from Giancoli: first two are from chapter 27, while rest are from chapter 28.

9.1 Force on electric current in Magnetic field

Problem 9 of chapter 27.

Hints: as usual, use symmetry of the configuration in order to spot possible cancellations. Also, you might find Example 27-3 from Giancoli (also done in lecture) useful here.

Note: In fact, you can use the following general "strategy" for computing the magnetic force on a current-carrying wire of *arbitrary* shape (of course each problem might have its own special features/subtleties):

(1). Draw a picture displaying division of the current-carrying wire into small (infinitesimal) elements, labelled by a suitable coordinate (for example, angle ϕ going along the semi-circular wire that we worked out in lecture/example 27-3 of Giancoli). Also, show the *direction* of magnetic force ($\mathbf{F}_{\text{mag}}$) on this *small* piece, i.e., along $\mathbf{dl} \times \mathbf{B}$: note that this *could* depend on location of the elemental current.

(2). Compute the *magnitude* of $d\mathbf{F}_{\text{mag}}$ using $|I\mathbf{dl} \times \mathbf{B}|$: again, this *might* vary with the element in consideration.

(3). Try to use "symmetry" of the current in order to spot cancellation between $d\mathbf{F}_{\text{mag}}$'s from some elements.

(4). Sum (integrate) – vectorially (i.e., keeping track of direction) – the various $d\mathbf{F}_{\text{mag}}$'s, keeping in mind the symmetry considerations of the step just above.

(5). Try to check that in a suitable *limit* (for example, $\theta_0 \to 0$ in HW 9.1, i.e., problem 9 of chapter 27 of Giancoli), your exact answer above (using a possibly long calculation!) agrees with the (approximate) expectation based on a (much) *simpler* argument which is valid in this case.

9.2 Torque on a current loop

Problem 37 of chapter 27.

9.3 Biot-Savart Law

Problem 37 of chapter 28

Hint: you might find it useful to study the generalized version of Example 28-11 from Giancoli (which was done in class: see note posted at https://www.physics.umd.edu/courses/Phys272/agashe-spring19/notes/B_straight_wire.pdf) and Example 28-13.

Note: In fact, you can use the following general "strategy" for computing magnetic field due to a current-carrying wire of *arbitrary* shape (of course each problem might have its own special features/subtleties):

(1). Draw a picture displaying division of the wire into small (infinitesimal) elements, labelled by a suitable coordinate, for example, y going along the *finite* straight wire that we worked out in lecture (see note posted also). Also, show the *direction* of magnetic field ($d\mathbf{B}$) due to this small piece, using Biot-Savart law, i.e., along $\mathbf{dl} \times \mathbf{r}$: note that this *could* depend on location of the elemental current.

(2). Compute the *magnitude* of $d\mathbf{B}$ using the Biot-Savart law, i.e., $\mu_0/(4\pi)|\mathbf{dl} \times \mathbf{r}|/r^3$: again, this *might* vary with the element in consideration.

(3). Try to use "symmetry" of the current in order to spot cancellation between $d\mathbf{B}$'s from some elements.

(4). Sum (integrate) – vectorially (i.e., keeping track of direction) – the various $d\mathbf{B}$'s, taking into account symmetry considerations in step just above.

(5). Try to check that in a suitable *limit* (for example, the length of the straight wire being "infinite"), your exact answer above (using a possibly long calculation!) agrees with the (approximate) expectation based on a (much) *simpler* formula/argument (for example, using Ampere's law) which is valid in this case.

9.4 Biot-Savart law, but requiring integration

Problem 39 of chapter

Hint: As usual, you can divide-up the disc into infinitesimal rings of charge, each of which is rotating and so constitutes a current, and then simply use result of Example 28-12 (also done in lecture), adding-up the small contributions to the magnetic field *and* the magnetic dipole moment from the various rings.

Note: in part (c), you will have to do an appropriate Taylor series expansion for $R/x \ll 1$.

9.5 Force between straight wires due to their magnetic fields, *not* requiring integration (once "symmetry" is used)

Problem 18 of chapter 28.

Hint: first get the magnetic field due to the long wire at the location of rectangular current loop. Then, use *this* field for computing the force on each part of the loop.

Hint: as usual, be careful with *directions* of forces on various parts of the rectangular loop of current, watching out for possible cancellations.

9.6 Magnetic field due to current-carrying *strip*, requiring integration

This problem is for *Honors* section *only*.

Problem 23 of chapter 28.

10 Homework 10 (due Thursday, May 2 during lecture or in folder outside Room 3118 of PSC by 5 pm.)

All problems in this homework are from Giancoli: first two (and last one for Honors section) are from chapter 28, rest are from chapter 29.

10.1 Ampere's law: cylindrical geometry

Problem 31 of chapter 28.

Hint: you might find it useful to study Example 28-6 (also done in lecture) and Example 28-7 (also done in lecture) or its variation: problem # 35 from Wednesday session.

Note: Recall a general "strategy" for computing the magnetic field (**B**) using Ampere's law (also given at bottom of page 740 of Giancoli):

(1). Based on the symmetry of the current configuration, make an "educated guess" for the direction of **B**; for example, for an "axial" current (whether along a long, straight wire or a long, thin cylindrical shell), we expect **B** to be "circumferential", i.e., **B** lines form concentric circles, with *magnitude* of **B** being the same on each such circle.

You can simply assume one "sign" of **B**, for example, say, clockwise in above situation: if (in the end) the (magnitude of) B that you compute turns out to be *negative*, then **B** is actually *counter*-clockwise.

(2). Choose the Amperian loop [i.e., *closed* path, along which (line) integral of **B** on the Left-hand side (LHS) of Ampere's law is computed] appropriately, i.e., (a). needless to say, it should pass through the point P where we want **B** so that the LHS of Ampere's law will contain the desired B and (b). conform to the "symmetry/geometry" of the charge configuration etc.; for example, for an axial current mentioned above, the Amperian loop should be a concentric circle.

Also, (c). it is "convenient" to choose the *direction* of going around the Amperian loop to be the "same" as that of the assumed **B**. Just to be clear, it is also Ok to make the opposite choice of going around the loop: in this way, there might be an "extra" negative sign in the step below (computing LHS of Ampere's law), of course giving the same final answer (once you are careful in step 4 below about sign of the enclosed current).

(3). LHS of Ampere's law then typically (but one should nonetheless check it!) reduces to simply $\sim$ (desired) B (which is due to *all* currents, whether inside or outside) $\times$ length of appropriate part of the Amperian loop, i.e., there could be other pieces of the Amperian loop which do not give any contribution due to either B vanishing or $\mathbf{B} \perp$ tangent to the path.

(4). RHS, i.e., current enclosed, can be more subtle: again, only current *piercing/threading through* the surface whose boundary is the Amperian loop on LHS counts, whether it is a discrete/line current or (part of) a continuous current distribution; in the latter case, the enclosed current schematically looks like $\sim$ area$\times$ current density (i.e., current per unit area) and if current density is *not* a constant, then one has to start with infinitesimal version of area, then integrate as usual.

Be careful with the *sign* of each part of the (enclosed) current, i.e., follow the *right-hand rule*: if the fingers of your right hand indicate the direction of integration around the closed path, then your thumb defines the direction of *positive* current.

10.2 Ampere's law: solenoid

Problem 29 of chapter 28.

10.3 Lenz's law

Problem 8 of chapter 29.

Hint: you can use the general *strategy* given below for using Lenz's law in order to figure out the *direction* of the induced current, which is also outlined at the top of page 763 of Giancoli (and it was also done in lecture): Example 29-4 from Giancoli or problem # 37 from Wednesday session will also be useful here.

(1). Figure out whether the magnetic flux (due to *another* current or a permanent magnet) inside the loop is decreasing, or increasing, or unchanged.

(2). The *magnetic field* due to the induced current: (a). points in the *same* direction as the external field if the inducing flux is *decreasing*; (b). points in the opposite direction from the external field if the flux is increasing; or (c). is zero if the flux is not changing.

(3). Knowing the direction of the magnetic field due to the induced current, use the right-hand rule to determine the direction of the induced *current*.

10.4 Faraday's law

Problem 23 of chapter 29

10.5 Motional EMF

Problem 31 of chapter 29.

Hint: you might take a look at Examples 29-5 and 29-8 (versions of which were also done in lecture) and problem # 39 from Wednesday session; in particular, in *this* problem, what force "replaces" the one applied by "us" in the *other* cases?

10.6 Ampere's law: cylindrical geometry, but requiring integration

This problem is for *Honors* section *only*.

Problem 32 of chapter 28

Hint: as usual, divide each conductor into *infinitesimal* concentric cylindrical shells (over which current density *is* constant), get the (infinitesimal) current in each such shell and then integrate to compute the current enclosed by an Amperian loop.

11 Homework 11 (due Friday, May 10 in folder outside Room 3118 of PSC by 5 pm.)

All problems in this homework are from Giancoli: first two (and last one for Honors section) are from chapter 29, rest are from chapter 30.

11.1 Faraday's law, but requires integration, and Lenz's law

Problem 25 of chapter 29.

Hint [for part (a)]: is the magnetic field due to the current I uniform over the square loop? If not, then you will have to divide-up the square (as shown in the figure) into (appropriate) infinitesimal elements (such that magnetic field over each *is* a constant), compute the flux through each element and then integrate.

Hint [for part (b)]: the flux through the square loop that you computed in part (a) above should depend on the distance of the square loop (b) from the straight wire. If the loop is pulled away from the wire, is this distance (hence flux) changing?

Hint [for part (d)]: this computation is similar to the "motional EMF" problems: see Examples 29-5 and 29-8 (versions of which were also done in lecture), HW 10.5 (Problem 31 of chapter 29 of Giancoli) and problem # 39 from Wednesday session.

Note [for part (d)]: assume that the resistance of the square loop is R.

11.2 Changing magnetic field produces electric field

Problem 54 of chapter 29

Hint: you might find Example 29-14 from Giancoli (also done in lecture) and part (a) of problem 40 from Wednesday session useful here.

11.3 Mutual inductance

Problem 3 of chapter 30.

Hint: you might find problem 41 from Wednesday session (in turn, based on # 30-2 of Giancoli) useful here. Also, compare this result to that of Example 30-1 of Giancoli (also done in lecture).

11.4 Self-inductance

Problem 12 of chapter 30

Hint: you might find Example 30-3 from Giancoli (also done in lecture) useful here.

11.5 Energy stored in magnetic field (requires integration)

Problem 20 of chapter 30

Hint: first compute the magnetic field in the space between the two conductors. If this magnetic field is not uniform, then you will have to divide-up this region into *infinitesimal* cylindrical shells (such that magnetic field *is* (approximately) a constant over each such shell), compute the infinitesimal energy stored in the magnetic field in each shell and then integrate. (A similar approach is to be used for problem 42 of Wednesday session.) You can of course use the solution to Example 30-5 from Giancoli here.

A cross-check: does your result above (for the energy stored in the magnetic field) agree with that obtained by simply plugging-in the self-inductance computed in Example 30-5 into the formula $U = \frac{1}{2}LI^2$?

11.6 Motional EMF, but with also *another* source of EMF

This problem is for *Honors* section *only*.

Problem 34 of chapter 29

12 Homework 12 (due Friday, May 17 in folder outside Room 3118 of PSC by 5 pm.)

All problems in this homework are from Giancoli: first two are from chapter 30, rest are from chapter 31.

12.1 LR circuit

Problem 26 of chapter 30

Hint: this is a *generalization* of the simple LR circuit (i.e., with one resistance and one loop/current) discussed in section 30-4 of Giancoli (also done in lecture): we have *three* currents to solve for, but (as usual) we can use Kirchhoff's rules (junction and loop) to relate them.

Note: in the steady state, i.e., "after a long time", what is the *rate of change* of current? Is there any potential difference (induced/back-emf) in the inductor in this situation (even if current through it is *non*-zero)?

12.2 LC circuits and oscillations

Problem 35 of chapter 30.

The discussion in section 30-5 of Giancoli (also done in lecture) should be useful here.

12.3 Magnetic field produced by changing electric field (I)

Problem 4 of chapter 31.

Hint: you might find Example 31-1 of Giancoli (also done in lecture) useful here.

12.4 Plane EM waves

Problem 11 of chapter 31

Hint: compare above situation to Eq. 31-7 of Giancoli (which is a plane wave traveling in the x-direction).

12.5 EM wave energy/Poynting vector

Problem 23 of chapter 31.

(This problem is another version of problem 46, i.e., # 31-30 of Giancoli, from Wednesday session and Example 31-6 of Giancoli.)

12.6 Magnetic field produced by changing electric field (II)

This problem is for *Honors* section *only*.

Problem 7 of chapter 31.