

## Practice problems for the final exam (solutions omitted)

Here are 29 questions. There will be at least a couple of problems on the final which will be identical to, or at least very similar to, problems listed here. Not all the questions here are multiple choice. Some are multi-part and are rather long (20-7 and 22-7 in particular). If you want to time yourself, this is probably about 2.5 to 3 hours' worth of questions (very rough estimate).

Useful coefficients:  $g = 9.8 \text{ m s}^{-2}$ ; Unit of elementary charge  $e = 1.6 \times 10^{-19} \text{ C}$   
Mass of proton,  $m_p =$  Mass of neutron,  $m_n = 1.67 \times 10^{-27} \text{ kg}$   
Mass of electron,  $m_e = 9.11 \times 10^{-31} \text{ kg}$   
Coulomb's constant,  $k_e = 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$   
Permittivity of free space  $\epsilon_0 = \frac{1}{4\pi k_e} = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$   
 $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$        $1 \text{ T} = 10^4 \text{ G}$   
Permeability of free space  $\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$ .  
Prefixes: milli (m) =  $10^{-3}$ ; micro ( $\mu$ ) =  $10^{-6}$ ; nano (n) =  $10^{-9}$ ; pico (p) =  $10^{-12}$ ; fempto (f) =  $10^{-15}$

19-1: Excess charge on any conductor

- a. is always evenly distributed.
- b. is in the center.
- c. is on the surface.
- d. is fixed in space.
- e. cannot be detected.

19-2: Electric field lines start

- a. at positive charges or at infinity.
- b. at negative charges or infinity.
- c. at infinity and end at positive charges.
- d. midway between positive charges and negative charges.
- e. midway between positive charges and infinity.

19-3: The electric flux through a surface of fixed area is maximum when the surface is

- a. parallel to the electric field.
- b. antiparallel to the electric field.
- c. perpendicular to the electric field.
- d. at an angle of  $45^\circ$  to the electric field.
- e. closed, but does not contain the charge.

19-4: When a conductor is in electrostatic equilibrium, the electric field inside the conductor is \_\_\_\_\_.

(Choices: 0,  $\sigma/\epsilon_0$ ,  $2\sigma/\epsilon_0$ ,  $\sigma/(2\epsilon_0)$  ).

19-5: When a conductor is in electrostatic equilibrium, the electric field a point just outside the conductor is \_\_\_\_\_.

(Choices: 0,  $\sigma/\epsilon_0$ ,  $2\sigma/\epsilon_0$ ,  $\sigma/(2\epsilon_0)$  ).

19-6: The  $xy$  plane is "painted" with a uniform surface charge density of  $40 \text{ nC/m}^2$ . Consider a spherical surface with a  $0.04\text{m}$  radius that has a point in the  $xy$  plane as its center. What is the total electric flux  $\Phi_E$  in  $\text{Nm}^2/\text{C}$ ?

20-1. The electrical potential energy of a pair of like charges is  
a. positive. b. negative. c. zero. d. proportional to the square of the distance. e. inversely proportional to the square of the distance.

20-2. Equipotential surfaces are  
a. perpendicular to electric field lines. b. parallel to electric field lines.

20-3: When the potential difference between the plates of a parallel-plate capacitor is doubled (while keeping the area and plate separation distance constant), the magnitude of the charge stored on one of the plates  
a. is doubled. b. is increased by a factor of 4. c. is tripled. d. remains the same. e. is halved.

20-4: Four positive point charges, each with identical amounts of charge  $Q$ , are placed  $(+1,0)$ ,  $(-1,0)$ ,  $(0,+1)$ , and  $(0,-1)$ . Which is not zero at the origin?

- a.  $V$
- b.  $\vec{F}_e$  on a positively-charged particle placed at the origin
- c.  $\vec{F}_e$  on a negatively-charged particle placed at the origin
- d.  $\vec{E}$

20-5. When the electric field is zero at all points in any region of space

- a. the potential must be zero at all points in that region.
- b. the potential must have a constant value at all points in that region.
- c. the potential cannot be found unless we know its value at a minimum of two points in the region.
- d. charged bodies cannot be present on the boundaries of the region.
- e. the region might be found between the plates of a charged capacitor.

20-6. When a cavity is present inside a conductor in equilibrium

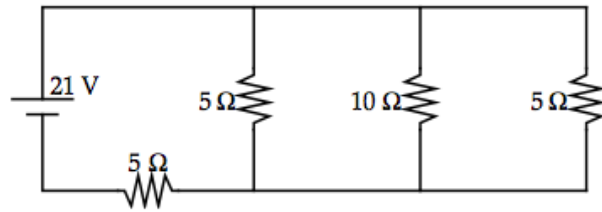
- a. the potential in the cavity must be zero.
- b. the electric field in the cavity must be zero.
- c. the electric field in the cavity must have a constant non-zero value.
- d. the electric field in the cavity must decrease inversely as the square of the distance from the walls.
- e. no two points on the surface of the cavity can be at the same potential.

20-7. Three point charges are positioned on the x-axis:  $Q_1 = +3\mu\text{C}$ , located at  $x=+0\text{cm}$ ,  $Q_2 = -2\mu\text{C}$ , located at  $x=+10\text{cm}$ , and  $Q_3 = +8\mu\text{C}$ , located at  $x=+25\text{cm}$ . What is the magnitude and direction of the net electrostatic force acting on each particle? How much work is required by us to assemble this system by simultaneously bringing in all three points from infinity?

21.1. A 9.0-volt battery moves 100 milliCoulombs of charge through a circuit connecting the battery's terminals. How much energy was delivered to the circuit?

- a. 90.0 J
- b. 9.0 J
- c. 0.9 J
- d. 3.0 J
- e. 0.3 J

21.2: Find  $R_{eq}$  and the magnitude of the currents through each resistor.



22-1. The magnetism of ferromagnetic materials, such as iron, has its origin in the intrinsic magnetic moment of electrons that is associated with their  
a. orbital angular momentum. b. spin angular momentum. c. electric charge. d. being magnetically soft. e. being magnetically hard.

22-2. When two parallel current-carrying wires have currents in the same direction, the wires  
a. attract one another.  
b. repel one another.  
c. exert no forces on one another.  
d. exert equal and opposite repulsive forces on one another perpendicular to the plane of the wires.  
e. exert equal and opposite attractive forces on one another perpendicular to the plane of the wires.

22-3 The head end of a nail is attracted to the north pole of a magnet and also to its south pole.  
a. The nail is magnetized.  
b. The nail is initially not magnetized.  
c. The nail is aluminum.  
d. The nail is copper.  
e. The magnet is aluminum.

22-4. The head of a nail is attracted to the north pole of a magnet and repelled by the magnet's south pole.  
a. The nail is magnetized.  
b. The nail is initially not magnetized.  
c. The nail is aluminum.  
d. The nail is copper.  
e. The magnet is aluminum.

22-5. If an electron moves from right to left across this page and suddenly is subjected to a magnetic field directed into the page, what is the direction of the magnetic force on the electron?  
a. Into the page b. Out of the page c. From the bottom to the top of the page d. From the top to the bottom of the page e. From the left to the right of the page

22-6: An electron is located on the Earth's magnetic equator at an altitude of several km. In which direction can the velocity vector be pointing such that the deflection due to magnetic force is zero?

Choices are: magnetic north, upward, downward, magnetic south, magnetic east, magnetic west. Note that 2 answers are acceptable.

22-7: Suppose you have in your possession a gigantic single copper loop that has a radius  $r$  of 1.1 km. You want to run a current through the loop to generate a magnetic field whose strength at the center of the loop is ten times the strength of the Earth's magnetic field at the surface (roughly 0.3 to 0.5 G, depending on location. Let's choose 0.3 G). The total resistance of the loop is  $0.12\Omega$ .

22-7A: What EMF do you need to supply?

22-7B: If the loop is horizontal, in which direction should the current flow if you want the B-field generated by the current loop to be directed downward?

22-7, cont'd: The loop is made from pure copper, which, as per Table 21.1, has a resistivity  $\rho$  of  $1.7 \times 10^{-8} \Omega\text{m}$  at an operating temperature  $T_0 = 20^\circ\text{C}$ .

22-7C: The loop has a square cross section. What is the cross-sectional area of the loop and the size of the square?

22-7D: How much power is dissipated in the resistor?

22-7, cont'd: Suppose a friend of yours (who has not taken Physics 1B yet) thinks that making the loop hotter will “somehow” make the magnetic field strength larger. He/she heats up the loop uniformly (I dunno, a giant blowtorch?), so that its temperature is  $80^\circ\text{C}$ . Assume the EMF supplied does not change.

22.7E: What effect will this really have on the B-field at the center of the loop? Explain to your friend what effect increasing the temperature will have on the current (at the microscopic level) and thus the final magnetic field strength at the loop's center.

BTW, Copper has a temperature coefficient  $\alpha$  of  $3.9 \times 10^{-3} [(\text{C})^{-1}]$ , as per Table 21.1. Ignore any thermal expansion in the copper. On an exam, you would be given  $\alpha$  &  $\rho$ .



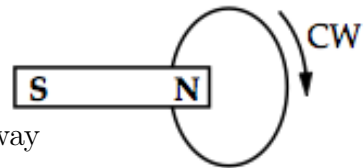
22-8: What does a commutator do?

23-1: The magnetic flux  $\Phi_B$  through a 100-turn coil increases from 0.04 Wb to 0.09 Wb in a time  $\Delta t$  of 0.5 sec. Calculate the average  $\epsilon_{\text{ind}}$ . Then, assuming that the total resistance in the entire coil is  $2\Omega$ , calculate the magnitude of the average induced current.

23-2: The magnetic field in a certain region of space is uniform, but is decreasing exponentially at a rate quantified as  $B(t) = e^{-ct}$  where  $c$  is a constant. Derive an expression for the induced EMF as a function of time through a single conducting loop with area  $A$ .

23-3: A 100-turn coil with cross-section  $0.1 \text{ m}^2$  is immersed in a magnetic field of  $0.01 \text{ T}$ . Initially, the plane of the loops is perpendicular to the magnetic field lines. Then, in a time  $\Delta t$ , the coil is turned  $90^\circ$  such that the magnetic flux is zero. You would like to obtain an induced EMF in the coil whose magnitude is  $2 \text{ V}$ . Calculate the  $\Delta t$  necessary to accomplish this.

23-4: A bar magnet approaches, and passes through, a conducting loop from the left with its north pole directed towards the right. It moves with a constant velocity; the loop, which has radius  $r$ , is held stationary. The current in the loop has its greatest magnitude AND a clockwise direction



- as the north pole is approaching the loop, a distance  $3r$  away
- just as the north pole of the magnet is entering the loop
- When the magnet is exactly halfway through the loop
- as the south pole is leaving the loop
- after the south pole has left the loop and is a distance  $3r$  away

23-5. An ideal transformer is one that:

- has a turn ratio,  $N_2/N_1$ , equal to 1.
- works with direct current.
- experiences no power loss.
- has an output frequency of  $60 \text{ Hz}$ .

23-6. An AC power source produces a peak voltage of 7200 V and a peak current of 100 A in a circuit. This circuit is attached to an ideal transformer whose job is to step-up the voltage to 200,000 V (peak) for energy transmission in a long-distance power line. What is the peak current in the long-distance line?

- a. 1.0 A
- b. 2.8 A
- c. 24 A
- d. 2800 A
- e. 3.6 A