$\bar{x} = 82$
$s = 8$

PHYSICS 203 **EXAM #1** NAME KEY
10 October 2014

General Instructions: For each problem your solution must be readable and your logic followable. Put a box around any numerical answers.

Constants: $\mu_0 = 1.26 \times 10^{-6}$ H/m $e = 1.60 \times 10^{-19}$ C $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m
1 eV = 1.6×10^{-19} J   electron mass = 9.11×10^{-31} kg   proton mass = 1.67×10^{-27} kg
Prefixes: c = 10^{-2} m = 10^{-3} $\mu = 10^{-6}$ n = 10^{-9} p = 10^{-12}

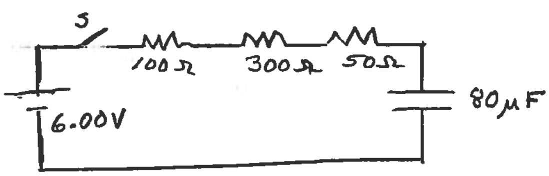
PART I - SHORT ANSWER QUESTIONS.

Do the 5 short questions/problems. Worth 8 points each.

1. The circuit below has its switch closed at t = 0.

5 a) How much time does it take for the current to drop to one half of its maximum value?

3 b) If each of the resistors is made of the same material and has the same length (the diameter is changed to get different resistances) rank them in terms of the electric field in the resistor just after the switch is closed. Put your ranking in order from greatest to least.



a) $i = i_0 e^{-t/RC}$ so $\frac{i}{i_0} = \frac{1}{2} = e^{-t/RC}$

$-t/RC = \ln\frac{1}{2} \Rightarrow t = RC\ln 2$

$R_{eq} = 450\,\Omega$ $t = (450\,\Omega)(80\times10^{-6}\,\text{s})\ln 2$

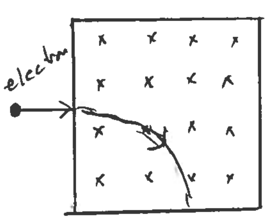
$\boxed{t = 0.025\ \text{s}} = 25\ \text{ms}$

b) $V = iR$ & $E = V/\text{length}$ Since i is the same for all, $E \propto R$ so $\boxed{300\,\Omega,\ 100\,\Omega,\ 50\,\Omega}$

2. In the rectangular region below, a uniform magnetic field of 0.085 T is directed into the page. An electron traveling at a speed of 2.0×10^5 m/s enters the region from the left, as shown.

3 a) Sketch the path the electron takes after entering the field.

5 b) What is the radius of curvature of the electron path?



a) Since $\vec{F} = q\vec{v}\times\vec{B}$ curves clockwise

b) $r = \frac{mv}{qB} = \frac{9.11\times10^{-31}\,\text{kg} \cdot 2.0\times10^{5}\,\text{m/s}}{1.6\times10^{-19}\,\text{C} \cdot 0.085\,\text{T}} = \boxed{13.4\ \mu\text{m}}$

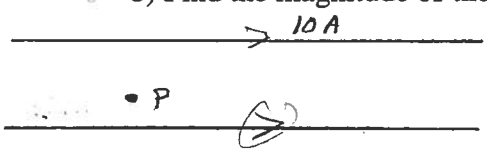
3. According to Fischer, "The statement that we are accepting the Bible as reliable and authoritative is by no means a simple one." What does he mean by this?

words of the Bible need interpretation . . .

4. Two long straight parallel wires are directed as shown. The top wire carries 10.0 A to the right and the lower wire carries a current that leads to there being zero magnetic field at point P.

2 a) Draw an arrow on the diagram that indicates the direction of the current flow in the lower wire.

6 b) Find the magnitude of the current in the lower wire. P is 3.0 cm from lower wire, 6.0 cm from upper wire.



a) need opp. dir via RHR so to right

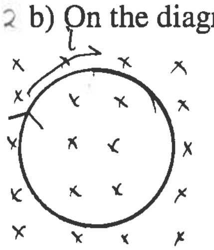
b) $B = \frac{\mu_0 i}{2\pi R}$ so $B_{10} = \frac{\mu_0 (10A)}{2\pi (6.0cm)} = \frac{\mu_0 I}{2\pi (3.0cm)} \rightarrow I = \frac{10A(3cm)}{6cm}$

$= 5.0A$

5. A 10 turn, 0.075 m radius flat coil sits in a region of spatially uniform but time dependent magnetic field which is directed into the paper. The field strength is given by $B = B_0 e^{-kt}$ where B_0 and k are constants.

6 a) If the coil has a resistance of R, what is the induced current as a function of time?

2 b) On the diagram, indicate the direction of current flow.



a) $\mathcal{E} = \left|N\frac{d\phi}{dt}\right| = \left|N\pi R^2 \frac{d}{dt}B\right| = \left|10(\pi)(0.075m)^2 B_0(-k)e^{-kt}\right|$

$= 0.177 B_0 k e^{-kt}$

$i = \frac{\mathcal{E}}{R} = \frac{0.177 B_0 k}{R} e^{-kt}$

Part III - Problems.
Do all three. Worth 20 points each. Show and explain your work.

6. A solenoid is circular in cross-section, has a length of 45.0 cm, and a diameter of 1.00 cm. It has a total number of turns of 600. 5A

8 a) What is the magnetic field inside the solenoid?
~~b) How much energy is stored in the field inside the solenoid?~~
12 c) If the current through the solenoid is now reduced at a rate of 0.030 A/s, what electric field is induced inside the solenoid at a distance of 0.25 cm from the central axis of the solenoid?

a) $B = \mu_0 n i = 1.26\times10^{-6}\frac{H}{m}\left(\frac{600}{0.45m}\right)5.00A = \boxed{0.0084T}$

c) $\oint \vec{E}\cdot d\vec{s} = -\frac{d\Phi}{dt}$

$E\cdot 2\pi r = -\pi r^2 \frac{d}{dt}\mu_0 n i =$

$E\, 2\pi r = -\pi r^2 \mu_0 n \frac{di}{dt}$

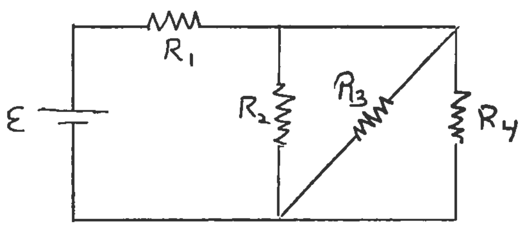
$E = \frac{r}{2}\mu_0 n \cdot \left|\frac{di}{dt}\right|$

$= \frac{0.0025m}{2}\left(1.26\times10^{-6}\frac{H}{m}\right)\left(\frac{600}{0.45m}\right)\left(\frac{.030A}{s}\right)$

$= \boxed{6.3\times10^{-8} V/m}$

7. In the circuit shown, the battery can be considered to be ideal. It has an emf of 6.00 V. The values of the resistors are: $R_1 = 100\ \Omega$, $R_2 = 50.0\ \Omega$, $R_3 = 50.0\ \Omega$, $R_4 = 75.0\ \Omega$.

6 a) What is the equivalent resistance of the combination of the four resistors?
6 b) How much current flows through R_1?
8 c) How much power is dissipated by R_2?



R_2, R_3, R_4 are in parallel

$$\frac{1}{R_{eq}} = \frac{1}{50.0\Omega} + \frac{1}{50.0\Omega} + \frac{1}{75.0\Omega}$$

$$R_{eq} = 18.75\Omega$$

this is in series with R_1 so $R_{eq} = 100\Omega + 18.75\Omega$

$$R_{eq} = 118.75\Omega$$

too many digits

b) i from batt $= \frac{\mathcal{E}}{R_{eq}} = \frac{6.00V}{118.75\Omega}$

$i = 0.0505A$ which all flows thru R_1

c) $P_2 = \frac{V_2^2}{R_2}$

Kirchoff loop: $\mathcal{E} - i_1R_1 - V_2 = 0$

$V_2 = 6.00V - (0.0505A)(100\Omega) =$

$= 0.95\ V$

$P_2 = \frac{(0.95V)^2}{50\Omega} = 18.05\ mW$

8. A circular loop of wire has a radius 12.0 cm and carries a current of 1.30 A. It is placed in a uniform external magnetic field of magnitude 4.20 T such that the normal to the plane of the loop is at 30.0^0 from the field direction.

a) What is the magnetic dipole moment of the loop?
b) What is the magnitude of the torque on the loop?
c) What is the potential energy of the dipole?
d) Suppose the loop is now rotated so that the torque on it has its maximum possible value. What is the angle between the normal to the coil plane and the field? What is the magnitude of this maximum torque? What is the dipole's potential energy at this angle?

a) $\mu = NiA = (1)(1.30A)\pi(0.12m)^2 = \boxed{0.0558\ A \cdot m^2}$

b) $|\vec{\tau}| = |\vec{\mu} \times \vec{B}| = (0.0558\ A \cdot m^2)(4.20T)\sin 30^0$

$= \boxed{0.124\ Nm}$

c) $U = -\vec{\mu} \cdot \vec{B} = -\mu B \cos\theta = 0.0558\ A \cdot m^2\ (4.20T)\cos 30^\circ$

$= -0.214\ J$

d) T_{max} is at $\sin\theta = 1$ so $\boxed{90^0}$

$\tau_{max} = \mu B = \boxed{0.248\ Nm}$

$U = -\mu \vec{B} = -\mu B \cos 90^0 = \boxed{0}$

PHYSICS 203 **EXAM #2** NAME (2 points) KEY

19 November 2014

General Instructions: For each problem your solution must be readable and your logic followable. Put a box around any numerical answers.

Constants: $\mu_0 = 1.26 \times 10^{-6}$ H/m $e = 1.60 \times 10^{-19}$ C $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

$c = 3.00 \times 10^8$ m/s $n_{water} = 1.33$ $n_{air} = 1.00$ $n_{diamond} = 2.42$

Prefixes: $c = 10^{-2}$ $m = 10^{-3}$ $\mu = 10^{-6}$ $n = 10^{-9}$

PART I - SHORT ANSWER QUESTIONS.

Do any 10 of the 12 short questions/problems. Worth 8 points each. Be clear which are to be omitted or the first 10 with any markings will be graded.

1. A series RLC circuit has a resistance of ~~1.20 kΩ~~ 8.00 and an inductance of 1.85 mH. If the current amplitude has its maximum possible value when the sinusoidal voltage varies at a linear frequency of 285 Hz, what is the value of the capacitance?

at $i = I_m$ $Z = R$ $\omega L = \frac{1}{\omega C}$ $\omega = 2\pi f = 1791\ s^{-1}$

$$C = \frac{1}{\omega^2 L} = \frac{1}{(2\pi \cdot 285\,Hz)^2 (1.85 \cdot 10^{-3} H)} = \boxed{169\ \mu F}$$

2. If the circuit described in the question above is now driven at 570 Hz with the same maximum voltage as before, what is the impedance of the circuit? If the average power provided by the voltage source in question 1 is P_o, what is the average power (given as some number times P_o) when driven at this frequency?

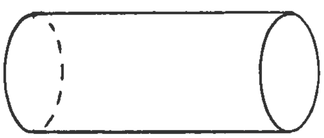
$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} \qquad \omega = 2\pi f = 2\pi(570\,Hz) = 3581\ s^{-1}$$

6.62 1.65

$$Z = \sqrt{(8\ \Omega)^2 + \left((3581 \cdot 1.85 \times 10^{-3}) - \frac{1}{3581 \cdot 169 \times 10^{-6}}\right)^2} = \boxed{9.42\ \Omega}$$

$$P_o = \frac{\mathcal{E}_m^2}{R} \qquad P = \left(\frac{\mathcal{E}_m}{Z}\right)^2 R = \frac{\mathcal{E}_m^2}{R} \cdot \frac{R^2}{Z^2} = P_o \left(\frac{8.00\,\Omega}{9.42\,\Omega}\right)^2 = \boxed{0.72 P_o}$$

3. The cylindrical region shown below has a flux through its sides of +0.150 mT·m^2 and a flux through its right end of -0.220 mT·m^2. What is the flux through its left end? Is the magnetic field going into the cylinder or coming out of it at the left end?



$\oint \vec{B} \cdot d\vec{A} = 0$ so

$0 = 0.150\ mT \cdot m^2 + (-0.220\ mT\,m^2) + \Phi_L$

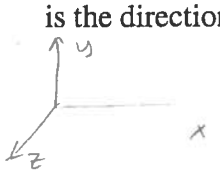
$\Phi_L = +0.07\ mT\,m^2$

since +, $\vec{B}$ comes out of left end.

4. Both paramagnetic and ferromagnetic materials will be attracted to an external magnet. Yet only ferromagnetic materials can be made into permanent magnets. How are these two types of materials different (at the atomic level)? How does this difference explain why one can be made into a permanent magnet and the other cannot?

Ferromagnets have an exchange interact that cause the atom dipoles to line up even without an external field. Paramagnet will line up with an external field but randomize when that field is removed. The alignment of dipoles in a ferromagnet means it can have a net magnetic field of its own.

5. An electromagnetic wave travels in the +x direction. The electric field component has an amplitude of 2.5 V/m and at a particular instant, points in the –y direction. At this instant, what is the direction of the magnetic component of the wave, and what is its amplitude?



$\vec{E} \times \vec{B}$ points in travel direction, so $\vec{B}$ points in the $-z$ dir

$\frac{E_m}{B_m} = c$ so $B_m = \frac{E_m}{c} = \frac{2.5\ V/m}{3.00 \times 10^8\ m/s} = 8.3 \times 10^{-9}\ T$

6. The wave described in the previous question strikes a surface where the wave is completely absorbed. What pressure does it exert on the surface?

$P = \frac{I}{c} = \frac{1}{c}\frac{E_{rms}^2}{c\mu_0} = \frac{E_m^2}{2c^2\mu_0} = \frac{(2.5\ V/m)^2}{2(3.0 \times 10^8\ m/s)^2(1.26 \times 10^{-6}\ H/m)}$

$= 2.76 \times 10^{-11}\ N/m^2$

7. An object is placed 0.25 m away from a lens that has a focal length of 0.35 m. How far from the lens is the image located? Is the image upright or inverted? Is it on the same side of the lens as the object or the opposite side?

$\frac{1}{p} + \frac{1}{i} = \frac{1}{f} \Rightarrow \frac{1}{i} = \frac{1}{0.35\,m} - \frac{1}{0.25\,m}$ $\quad$ $i = -0.875\,m$

$m = -\frac{i}{p} > 0$ so upright $\quad$ same side

8. Suppose the object in the question above is now placed 0.25 m from a mirror. Is it possible for a mirror to produce an image the same distance away and having the same orientation (upright or inverted) as in the previous question? If so, what would the focal length of the mirror be? Would the image be on the same side of the mirror as the object or be on the opposite side?

$\frac{1}{p} + \frac{1}{i} = \frac{1}{f}$ still holds so $f = 0.35\,m$

opposite side

9. If a step-down transformer is designed to take 120 V from the wall socket as its primary voltage and produces a secondary voltage of 3.0 V, what is the ratio of primary to secondary turns in its windings? If this transformer has its primary side connected to a 12.0 V battery, what would the output voltage be?

$V_s = V_p \frac{N_s}{N_p}$ so $\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{120V}{3.0V} = 40$

zero if connected to DC battery

10. When Maxwell looked at the four key equations that involve line and surface integrals of electric and magnetic fields, he noticed two asymmetries. One was due to there not being isolated magnetic poles (i.e. there are only N-S pairs). The other asymmetry was one that was overlooked and led to an additional term that was added to one of the equations. What was this additional term and to which equation was it added? Just writing down the equation and pointing out which is the new term is sufficient.

Maxwell's term

$\oint \vec{B} \cdot d\vec{s} = \mu_0 i + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$

11. Un-polarized light of intensity I_0 is sent through a polarizer that has its polarization axis oriented at 30^0 clockwise from the vertical (as viewed along the direction the light travels). The light then passes through a second polarizer that is oriented at 45^0 counter-clockwise from the vertical. What is the intensity of light (as some number times I_0) that emerges from this second polarizer?

$I_0 \rightarrow \frac{1}{2} I_0 \rightarrow \quad I = (\frac{1}{2} I_0) \cos^2(75°) = 0.0335 I_0$

12. A converging lens is made of a type of glass that has an index of refraction of 1.52 and has one flat side and the other has a radius of curvature of 15.0 cm. What is the focal length of this lens? If the lens is now immersed in water, would its focal length increase, decrease, or stay the same? Explain.

$\frac{1}{f} = (n-1)\left(\frac{1}{r} - \frac{1}{\infty}\right) = 0.52\left(\frac{1}{15.0\,cm}\right)$

$f = 28.[illegible]\,cm$ Increase

less diff. in indices n_{lens} & n_{medium} means less bending of light at surf.

Part II – Shorter Questions: Do any <u>six of the nine</u> questions based on presentations and your readings from Fischer's book. Be very clear which ones you are omitting or the first 6 with any markings at all will be graded. Worth 3 points each.

1) Fischer cites several physical phenomena that show that an old age for the Earth. What are three of them?

3 of: radioactive decay of elements
meas. on salt content of oceans
motion of Moon w.r.t Earth
energy emission from Sun
spectral dist. & light intensity of dist. stars & galaxies

2) Fischer cites several shortcomings of biological evolution. What are three of them?

3 of: claim that ev. is a fact rather than explanation
only small fraction of time span available for study, rest extrap.
imperfections in fossil record
evidence of abrupt changes
assumption that similarity in foss[illegible] means descent

3) What is Fischer's working definition of a miracle?

an extraordinary event accomplished by God as a sign of some purpose of his own

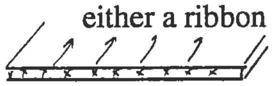
4) What is scientism?

the view that science sci. methods are the only valid source / method of knowledges

5) Why does Fischer warn against trying to make a distinction between the natural and supernatural?

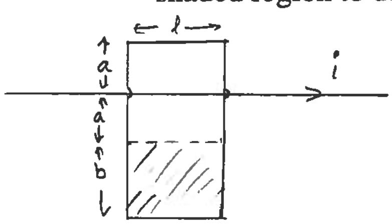
- difficult to make a clear def'n that distinguishes between them
- Bible doesn't do so
- often the distinction identifies God with supernatural, lets science do natural leading to "God of the gaps"

6) What technique (or 'trick') was used as a start to find the magnetic field produced by either a ribbon or conducting sheet carrying a current?



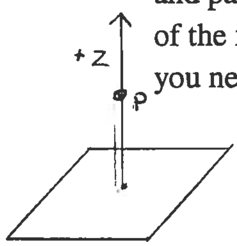
treat it as as a collection of parallel conducting wires & integrate the results

7) A current carried by a long straight wire produces a flux through the rectangular region indicated in the drawing. Explain why you only need to calculate the flux through the shaded region to determine the flux through the entire rectangle.



$\Phi = \int \vec{B} \cdot d\vec{A}$. Using the RHR, the part above & below have $\vec{B}$ in opp. dir so the unshaded regions total flux will be zero.

8) A square loop of wire carries a current. If you want to find the magnitude of the total field at point P which is on the +z axis which is perpendicular to the plane of the square and passing through its center, you do not need to find all of the x, y, and z components of the field for each side of the square. Why not? What component or components do you need to find?



Only need the z component – the x & y will cancel as you integrate around the loop.

9) To what extent did Michael Faraday speak out about the role his faith played in his science? Explain.

Very little – he felt faith was very personal.