Physics 132-03 Test 2

I pledge that I have neither given nor received unauthorized assistance during the completion of this work.

Name ______________________________ Signature ______________________________

Questions (6 for 7 pts. apiece) Answer in complete, well-written sentences WITHIN the spaces provided.

1. Starting with the expression for the entropy $S = k_B \log \Omega$ and the chain rule calculate $dS/dE = f(T)$ where T is the temperature in terms of the multiplicity Ω. Clearly show your reasoning.

2. Consider the following procedure using an electroscope.

   (a) Charge up the rubber rod by rubbing it with wool.

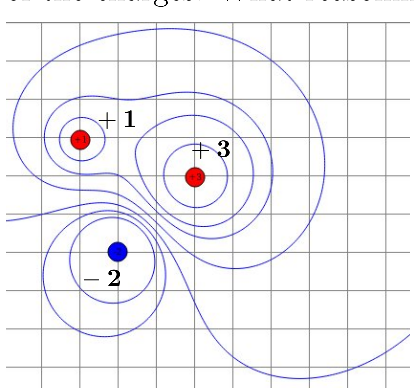
   (b) Touch it to the ball of the electroscope.

   (c) Charge up the rubber rod some more, by rubbing it again with wool.

   (d) Bring it close to the ball of the electroscope, without touching it.

   What do you think will happen when you do the last step? (Will the foil move up, down, or neither?) Explain.

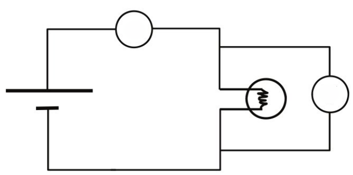
3. Consider the figure below of three charges (red is positive, blue is negative) and their equipotential lines. Draw a representative set of field lines including directions for each of the charges. What reasoning did you apply to draw the field lines?



Questions continued. Answer in complete, well-written sentences WITHIN the spaces provided.

4. You found in the simulation lab on the dipole charge distribution that the electric field of the dipole obeyed a power law $|\vec{E}| = Ar^n$ where $n < -2$. Compare and explain this observation with the field of a point charge where $n = -2$.

5. Consider the circuit shown in the figure. The two open circles represent instruments to measure the properties of the circuit. What instruments will measure electric current or electric potential? Where should they be placed in the circuit to work properly? Explain your reasoning.



6. Recall the lab where you used an oscilloscope to study the impact of a magnetic field on a beam of electrons. With no magnets or anything else turned on you now notice the beam spot which should be at the center of the scope is deflected to the right. Maybe it's broken, but there may be unknown external magnetic or electrical fields causing the deflection. You have nothing to create an additional electric or magnetic field. What could you do with the scope to determine if it is broken, in an electric field, or in a magnetic field? Explain. You cannot remove the oscilloscope from the room. Hint: A drawing might help.

Problems (3). Clearly show all reasoning for full credit. Use a separate sheet for your work.

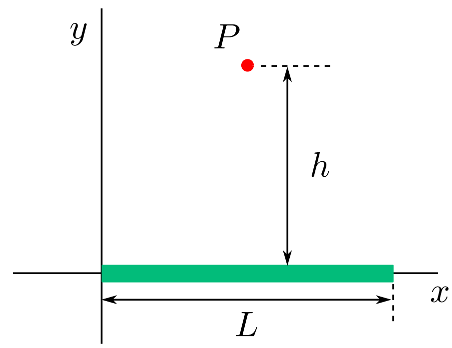
1. 15 pts. A cosmic-ray proton in interstellar space has an energy $E = 8.0\ MeV$ and executes a circular orbit having a radius r equal to that of Mercury's orbit around the Sun ($5.80 \times 10^{10}\ m$). Starting from Newton's Law describing the proton's orbit and the magnetic force law, what is the magnetic field in that region of space?

2. 18 pts. A newly-created material has a multiplicity

$$\Omega = \beta N E^4$$

where N is the number of atoms in the solid, E is the total internal energy in the solid, and β is a constant. How is the energy E of the material related to the temperature T? What is the molar specific heat? Does this result make sense? Explain.

3. 25 pts. A thin rod of length L sits along the x-axis as shown in the figure. Its left end is at the origin. The rod has a uniform charge density λ. Starting from the electric potential of a point particle, what is the electric potential at P located a distance h above the midpoint of the rod in terms of λ, h, L, and any other necessary constants?



Physics 132-03 Equations Test 2

$$E_{atom} = (n_x + n_y + n_z + \frac{3}{2})\hbar\omega_0 \qquad E = \sum_{i=1}^{3N} n_i \epsilon = q\hbar\omega_0 \qquad \Omega(N,q) = \frac{(q+3N-1)!}{q!(3N-1)!}$$

$$S = k_B \ln \Omega \qquad \frac{1}{T} = \frac{dS}{dE} \qquad q = \frac{E}{\hbar\omega_0} \qquad C = \frac{1}{n}\frac{dE}{dT} \qquad E = 3Nk_BT$$

$$\vec{F}_G = -G\frac{m_1 m_2}{r_{12}^2}\hat{r} \qquad \vec{F}_C = k_e \frac{q_1 q_2}{r_{12}^2}\hat{r} \qquad \vec{E} \equiv \frac{\vec{F}}{q_0} \qquad \vec{E} = k_e \sum_i \frac{q_i}{r_i^2}\hat{r}_i \qquad \vec{E} = k_e \int \frac{dq}{r^2}\hat{r} \quad k_e = \frac{1}{4\pi\epsilon_0}$$

$$\vec{E}_{dipole} = k_e \frac{q(2a)}{(x^2+a^2)^{3/2}}\hat{j} \quad \vec{E}_{ring} = k_e \frac{qx}{(x^2+R^2)^{3/2}}\hat{i} \quad \vec{E}_{plane} = 2\pi k_e \eta \hat{k} = \frac{\eta}{2\epsilon_0}\hat{k}$$

$$\vec{E}_{disk} = 2\pi k_e \eta \left[1 - \frac{z}{\sqrt{z^2+R^2}}\right]\hat{k} = \frac{\eta}{2\epsilon_0}\left[1 - \frac{z}{\sqrt{z^2+R^2}}\right]\hat{k}$$

$$W \equiv \int \vec{F}\cdot d\vec{s} \quad \Delta V \equiv \frac{\Delta PE}{q_0} = -\int_A^B \vec{E}\cdot d\vec{s} \quad V = k_e \frac{q}{r} \quad V = k_e \sum_i \frac{q_i}{r_i}$$

$$V = k_e \int \frac{dq}{r} \quad V = Ed \quad I = \frac{dQ}{dt} \quad Q = \int I dt \quad V = IR \quad P = IV \quad R_{equiv} = \sum R_i$$

The algebraic sum of the potential changes across all the elements of a closed loop is zero.

$$I = nev_dA$$

$$\vec{F}_B = q\vec{v}\times\vec{B} \quad |\vec{F}_B| = |qvB\sin\alpha| \quad \vec{B} = k_m \int \frac{Id\vec{s}\times\hat{r}}{r^2} \quad k_m = \frac{\mu_0}{4\pi} \quad \vec{B}_{ring} = \frac{\mu_o I R^2}{2}\frac{1}{(x^2+R^2)^{3/2}}\,\hat{i}$$

$$KE_0 + PE_0 = KE_1 + PE_1 \quad KE = \frac{1}{2}mv^2 \quad PE = qV$$

$$\vec{F} = m\vec{a} \qquad |\vec{F}_{cent}| = m\frac{v^2}{r} \qquad x = \frac{a}{2}t^2 + v_0 t + x_0 \qquad v = at + v_0$$

$$\frac{dx^n}{dx} = nx^{n-1} \qquad \frac{df(u)}{dx} = \frac{df}{du}\frac{du}{dx} \qquad \frac{d}{dx}f(x)\cdot g(x) = f\frac{dg}{dx} + g\frac{df}{dx}$$

$$\langle x\rangle = \frac{1}{N}\sum_i x_i \quad \sigma = \sqrt{\frac{\sum_i (x_i - \langle x\rangle)^2}{N-1}} \quad A = 4\pi r^2 \quad V = Ah \quad V = \frac{4}{3}\pi r^3$$

$$\frac{df(x)}{dx} = \lim_{\Delta x\to 0}\frac{f(x+\Delta x) - f(x)}{\Delta x} \qquad \int_a^b f(x)dx = \lim_{\Delta x\to 0}\sum_{n=1}^{N} f(x)\Delta x \qquad \frac{d\ln x}{dx} = \frac{1}{x}$$

$$\int \frac{1}{x}dx = \ln x \qquad \int x^n dx = \frac{x^{n+1}}{n+1} \qquad \int e^{ax}dx = \frac{e^{ax}}{a} \qquad \int \frac{1}{\sqrt{x^2+a^2}}dx = \ln\left[x + \sqrt{x^2+a^2}\right]$$

$$\int \frac{x}{\sqrt{x^2+a^2}}dx = \sqrt{x^2+a^2} \qquad \int \frac{x^2}{\sqrt{x^2+a^2}}dx = \frac{1}{2}x\sqrt{x^2+a^2} - \frac{1}{2}a^2\ln\left[x + \sqrt{x^2+a^2}\right]$$

$$\int \frac{x^3}{\sqrt{x^2+a^2}}dx = \frac{1}{3}(-2a^2 + x^2)\sqrt{x^2+a^2}$$

Physics 132-3 Constants

k_B	$1.38\times10^{-23}\ J/K$	proton/neutron mass	$1.67\times10^{-27}\ kg$
$1\ u$	$1.67\times10^{-27}\ kg$	g	$9.8\ m/s^2$
Gravitation constant	$6.67\times10^{-11}\ N-m^2/kg^2$	Earth's radius	$6.37\times10^{6}\ m$
Coulomb constant (k_e)	$8.99\times10^{9}\frac{N-m^2}{C^2}$	Earth's mass	$5.97\times10^{24}\ kg$
Magnet constant (k_m)	$10^{-7}\ Tm/A$	Earth-Sun distance	$1.5\times10^{11}\ m$
Elementary charge (e)	$1.60\times10^{-19}\ C$	Electron mass	$9.11\times10^{-31}\ kg$
Permittivity constant (ϵ_0)	$8.85\times10^{-12}\frac{kg^2}{N-m^2}$	1.0 eV	$1.6\times10^{-19}\ J$
Permeability constant (μ_0)	$4\pi\times10^{-7}\ Tm/A$	1 MeV	$10^{6}\ eV$

hydrogen 1 **H** 1.0079																		helium 2 **He** 4.0026
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.0122												boron 5 **B** 10.811	carbon 6 **C** 12.011	nitrogen 7 **N** 14.007	oxygen 8 **O** 15.999	fluorine 9 **F** 18.998	neon 10 **Ne** 20.180
sodium 11 **Na** 22.990	magnesium 12 **Mg** 24.305												aluminium 13 **Al** 26.982	silicon 14 **Si** 28.086	phosphorus 15 **P** 30.974	sulfur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.948
potassium 19 **K** 39.098	calcium 20 **Ca** 40.078		scandium 21 **Sc** 44.956	titanium 22 **Ti** 47.867	vanadium 23 **V** 50.942	chromium 24 **Cr** 51.996	manganese 25 **Mn** 54.938	iron 26 **Fe** 55.845	cobalt 27 **Co** 58.933	nickel 28 **Ni** 58.693	copper 29 **Cu** 63.546	zinc 30 **Zn** 65.39	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.61	arsenic 33 **As** 74.922	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.80
rubidium 37 **Rb** 85.468	strontium 38 **Sr** 87.62		yttrium 39 **Y** 88.906	zirconium 40 **Zr** 91.224	niobium 41 **Nb** 92.906	molybdenum 42 **Mo** 95.94	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.91	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.87	cadmium 48 **Cd** 112.41	indium 49 **In** 114.82	tin 50 **Sn** 118.71	antimony 51 **Sb** 121.76	tellurium 52 **Te** 127.60	iodine 53 **I** 126.90	xenon 54 **Xe** 131.29
caesium 55 **Cs** 132.91	barium 56 **Ba** 137.33	57-70 *	lutetium 71 **Lu** 174.97	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.95	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.21	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.22	platinum 78 **Pt** 195.08	gold 79 **Au** 196.97	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.38	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.98	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]	89-102 **	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [261]	dubnium 105 **Db** [262]	seaborgium 106 **Sg** [266]	bohrium 107 **Bh** [264]	hassium 108 **Hs** [269]	meitnerium 109 **Mt** [268]	ununnilium 110 **Uun** [271]	unununium 111 **Uuu** [272]	ununbium 112 **Uub** [277]		ununquadium 114 **Uuq** [289]				

*Lanthanide series	lanthanum 57 **La** 138.91	cerium 58 **Ce** 140.12	praseodymium 59 **Pr** 140.91	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.96	gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.93	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.93	erbium 68 **Er** 167.26	thulium 69 **Tm** 168.93	ytterbium 70 **Yb** 173.04
**Actinide series	actinium 89 **Ac** [227]	thorium 90 **Th** 232.04	protactinium 91 **Pa** 231.04	uranium 92 **U** 238.03	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]

The Periodic Chart.