Physics 132-01 Test 3

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

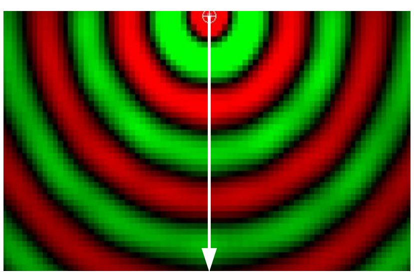
Name ______________________ Signature ______________________

Questions (5 for 8 pts. apiece) Answer in complete, well-written sentences WITHIN the spaces provided.

1. The three laboratories measuring the age of the Shroud of Turin obtained the following results. Are the results of the three laboratories consistent? Be quantitative in your answer.

Laboratory	Age (years)
Arizona	$662 \pm 40\ yrs$
Oxford	$800 \pm 40\ yrs$
Zurich	$731 \pm 40\ yrs$

2. Consider the simulation of outward-moving, spherical, electromagnetic waves shown in the figure. The green and red colors indicate the electric field - green areas are positive ($\vec{E}$ toward you) and red areas are negative ($\vec{E}$ away from you). The electric field is always perpendicular to the plane of the paper. Note the arrow defining a point on one of the waves moving down the center of the figure. In what direction does the magnetic field point in the red regions along the arrow? Explain your reasoning.



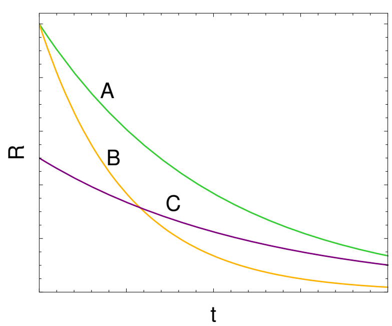
3. In the lab where you measured the hydrogen Balmer lines you measured the angular position of the direct beam θ_0 which passed straight through the diffraction grating. Why?

4. The intensity I_{diff} for the diffraction of a single slit can actually be written in closed form as

$$I_{\text{diff}} = I_{\max} \left(\frac{\sin\left(\frac{\pi a}{\lambda} \sin\theta\right)}{\frac{\pi a}{\lambda} \sin\theta} \right)^2$$

where a is the width of the single slit, θ is the angular position of the phototransistor relative to the incident beam, and $I_{\max}$ is the maximum intensity at the center of the diffraction pattern. What is the value of the argument of the sine function at the maxima of the diffraction pattern? Explain.

5. The figure shows the activities of three radioactive samples versus time. Rank the samples according to the size of their decay constants (biggest first). Explain your reasoning?



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

1. 18 pts. The allowed energies of a simple atom are 0.00 eV, 2.00 eV, and 5.00 eV.

   1. Draw the atoms energy-level diagram at least roughly to scale. Label each level with the energy and the quantum number.

   2. Draw arrows to show all the transitions in absorption and emission spectra.

   3. What is the wavelength λ of the lowest energy emission transition?

DO NOT WRITE BELOW THIS LINE.

2. 18 pts. A sample contains radioactive atoms of two types, A and B. Initially at $t_0 = 0$ there are four times as many A atoms as there are B atoms so $N_{A0} = 4N_{B0}$. At a time $t_1 = 2\ hrs$ later, the numbers of the two atoms are equal $N_A = N_B$. The decay constant of A is $\lambda = 1.4\ hr^{-1}$. What is the decay constant of atom B?

3. 24 pts. A spy satellite, commercial or otherwise, like the IKONOS satellite consists of a large-diameter concave mirror forming an image on a digital sensor. It was an astronomical telescope looking down instead of up. The IKONOS telescope had an aperture of size $a = 0.70\ m$ and orbited the Earth at an altitude of $L = 681\ km$. Could the camera be used to read a license plate on Earth? The range of visible light is $\lambda = 400 - 700 \times 10^{-9}\ m$. Show your reasoning.

Physics 132-1 Constants and Conversions

Avogadro's number (N_A)	6.022×10^{23}	Speed of light (c)	$3 \times 10^8\ m/s$
k_B	$1.38 \times 10^{-23}\ J/K$	proton/neutron mass	$1.67 \times 10^{-27}\ kg$
1 u	$1.67 \times 10^{-27}\ kg$	g	$9.8\ m/s^2$
Gravitation constant	$6.67 \times 10^{-11}\ N - m^2/kg^2$	Earth's radius	$6.37 \times 10^6\ m$
Coulomb constant (k_e)	$8.99 \times 10^9 \frac{N-m^2}{C^2}$	Electron mass	$9.11 \times 10^{-31}\ kg$
Elementary charge (e)	$1.60 \times 10^{-19}\ C$	Proton/Neutron mass	$1.67 \times 10^{-27}\ kg$
Permittivity constant (ϵ_0)	$8.85 \times 10^{-12} \frac{kg^2}{N-m^2}$	1.0 eV	$1.6 \times 10^{-19}\ J$
1 MeV	$10^6\ eV$	atomic mass unit (u)	$1.66 \times 10^{-27}\ kg$
Planck's constant (h)	$6.63 \times 10^{-34}\ Js$	Planck's constant (h)	$4.14 \times 10^{-15}\ eVs$
Permeability constant (μ_0)	$1.26 \times 10^{-6}\ Tm/A$	Rydberg constant (R_H)	$1.097 \times 10^7\ m^{-1}$

Physics 132-1 Equations

$$\vec{F} = m\vec{a} = \frac{d\vec{p}}{dt} \quad a_c = \frac{v^2}{r} \quad W = \int \vec{F} \cdot d\vec{s} \quad KE = \frac{1}{2}mv^2 \quad KE_0 + PE_0 = KE_1 + PE_1$$

$$\vec{F}_C = k_e \frac{q_1 q_2}{r^2}\hat{r} \quad \vec{E} \equiv \frac{\vec{F}}{q_0} \quad \vec{E} = k_e \sum_i \frac{q_i}{r_i^2}\hat{r}_i \quad \vec{E} = \int \frac{k_e dq}{r^2}\hat{r} \quad V = k_e \sum_n \frac{q_n}{r_n} \quad V = k_e \int \frac{dq}{r} \quad PE = qV$$

$$\frac{dN}{dt} = -\lambda N \quad N = N_0 e^{-\lambda t} \quad t_{1/2} = \frac{\ln 2}{\lambda} \qquad y = A\sin(kx - \omega t) \quad k\lambda = 2\pi \quad \omega T = 2\pi$$

$$E = E_m \sin(kx - \omega t + \phi) \quad B = B_m \sin(kx - \omega t + \phi) \quad \vec{S} = \frac{1}{\mu_0}\vec{E} \times \vec{B} \quad E = cB \quad |\vec{S}| = I = \frac{E^2}{2\mu_0 c}$$

$$I = 4I_0 \cos^2\left(\frac{\pi d}{\lambda}\sin\theta\right) \quad I = I_m \left[\frac{\sin\left(\frac{\pi a}{\lambda}\sin\theta\right)}{\frac{\pi a}{\lambda}\sin\theta}\right]^2 \quad I = I_m \cos^2\left(\frac{\pi d}{\lambda}\sin\theta\right)\left[\frac{\sin\left(\frac{\pi a}{\lambda}\sin\theta\right)}{\frac{\pi a}{\lambda}\sin\theta}\right]^2$$

$$\delta = d\sin\theta = m\lambda \ (m = 0, \pm 1, \pm 2, ...) \quad \delta = a\sin\theta = m\lambda \ (m = \pm 1, \pm 2, ...) \quad \phi = k\delta$$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right) \quad E_n = -\frac{13.6\ eV}{n^2} \quad E = hf = \frac{hc}{\lambda} \quad p = \frac{h}{\lambda} \quad \vec{p} = m\vec{v} \quad \vec{p}_0 = \vec{p}_1$$

$$\theta = \frac{s}{r} \quad \omega = \frac{v_\perp}{r} = \frac{d\theta}{dt} \quad L = I\omega = mv_T r \quad I = \sum_i m_i r_i^2 \quad I_i\omega_0 = I_f\omega_1 \quad KE_{rot} = \frac{1}{2}I\omega^2$$

$$\vec{F} = m\vec{a} \quad x = \frac{a}{2}t^2 + v_0 t + x_0 \quad v = at + v_0$$

$$\frac{d}{dx}(x^n) = nx^{n-1} \quad \frac{d}{dx}(f(u)) = \frac{df}{du}\frac{du}{dx} \quad \int x^n dx = \frac{x^{n+1}}{n+1} \quad \int \frac{1}{x}dx = \ln x$$

$$\frac{de^x}{dx} = e^x \quad \frac{d}{dx}(\ln x) = \frac{1}{x} \quad \frac{d}{dx}(\cos ax) = -a\sin ax \quad \frac{d}{dx}(\sin ax) = a\cos ax$$

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

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.