Physics 132-1 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.

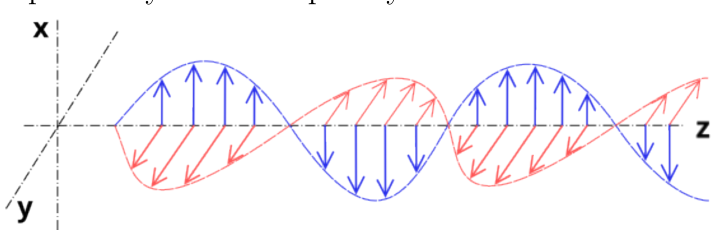
1. In the nuclear decay shown below what is the missing particle? Explain your reasoning.

   $^{225}\text{Ac} \rightarrow {}^{4}\text{He} + ?$

2. Consider the table below which shows the results from four different ^{14}C laboratories for the age of a medieval document. The typical uncertainty in these measurements is $\pm 20\ years$. Are the results of the four labs consistent? Explain.

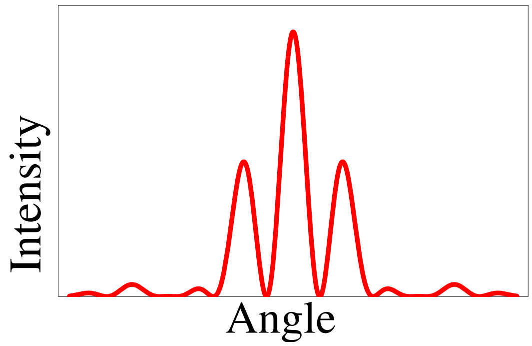
Lab	Age (years)
1	617
2	631
3	599
4	692

3. Consider the figure below of an electromagnetic wave like light. The red arrows represent the electric field and the blue arrows represent the magnetic field. What is the direction of the energy flow of the wave? Clearly state your reasoning and any equations you use. Express your answer in terms of $\hat{\imath}$, $\hat{\jmath}$, or $\hat{k}$.



DO NOT WRITE ON THIS PAGE BELOW THE LINE.

4. In our study of double-slit interference we used a red laser to create an interference pattern like the one shown below. How would that pattern change if we used white light instead? Explain. Recall that white light is a mixture of different colors. See the electromagnetic spectrum on page 5.



5. Induction furnaces are commonly used in industry to take advantage of electromagnetic induction to heat metals. How would such a device work and what things would you need to build one?

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

1. 15 pts. A radioactive isotope of mercury, ^{197}Hg, decays into gold, ^{197}Au, with a disintegration constant of 0.0108 h^{-1}. (a) What is its half-life? (b) What fraction of the original amount will remain after three half-lives?

DO NOT WRITE ON THIS PAGE BELOW THE LINE.

2. 20 pts. The Impressionist painter Georges Seurat created paintings like the one shown below with an enormous number of dots of pure pigment, each of which was approximately $d = 1.0 \times 10^{-3}$ m in diameter. The idea was to locate colors such as red and green next to each other to form a scintillating canvas. Outside what distance $\mathcal{L}$ would one be unable to discern dots on the canvas? Assume that $\lambda = 6.0 \times 10^{-7}$ m and the human pupil diameter is $a = 3.0 \times 10^{-3} m$.

You may have read about a factor needed to account for circular openings versus rectangular ones like we studied. If you don't remember that factor, don't worry about it - just use the equations for rectangular openings that are written on the equation sheet.

3. 25 pts. Helium atoms emit light at several wavelengths. Light from a helium lamp illuminates a double-slit and is observed on a screen $\mathcal{L} = 0.50$ m behind the slits. The emission at wavelength $\lambda_1 = 501.5 \times 10^{-9}$ m creates a first-order ($m = 1$) bright fringe at a distance $y_1 = 0.219$ m from the central maximum. What is the wavelength λ_2 of the bright fringe that is $y_2 = 0.316$ m from the central maximum?

DO NOT WRITE ON THIS PAGE BELOW THIS LINE.

Physics 132-1 Test 3 Equations

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

$$E = E_m \sin(kx - \omega t + \phi) \quad B = B_m \sin(kx - \omega t + \phi) \quad \sin\theta = \frac{y}{\sqrt{L^2 + y^2}} \approx \frac{y}{L} \quad \sin\theta \approx \theta$$

$$\vec{S} = \frac{1}{\mu_0}\vec{E} \times \vec{B} \quad E = cB \quad |\vec{S}| = Intensity = \frac{E^2}{2\mu_0 c} \quad v_{wave} = \frac{\lambda}{T} = \lambda f$$

$$\delta = m\lambda = d\sin\theta \approx \frac{dy_m}{L}\,(m = 0, \pm1, \pm2, ...) \quad \delta = m\lambda = a\sin\theta \approx \frac{ay_m}{L}\,(m = \pm1, \pm2, ...) \quad \phi = k\delta$$

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

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

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

$$\vec{F}_C = k_e \frac{q_1 q_2}{r^2}\hat{r} \quad \vec{F}_B = q\vec{v} \times \vec{B} \quad |\vec{F}_B| = |qvB\sin\alpha| \quad |\vec{F}_c| = m\frac{v^2}{r}$$

$$x = \frac{a}{2}t^2 + v_0 t + x_0 \quad v = at + v_0 \quad \sin A + \sin B = 2\sin\left(\frac{A+B}{2}\right)\cos\left(\frac{A-B}{2}\right)$$

$$\vec{A}\times\vec{B} = (A_y B_z - A_z B_y)\hat{i} - (A_x B_z - A_z B_x)\hat{j} + (A_x B_y - A_y B_x)\hat{k} = |\vec{A}||\vec{B}|\sin\alpha \text{ (right-hand-rule direction)}$$

$$\vec{A}\cdot\vec{B} = A_x B_x + A_y B_y + A_z B_z = |\vec{A}||\vec{B}|\cos\alpha \quad \ln(ab) = \ln a + \ln b \quad \ln(a^b) = b\ln a \quad e^{ab} = e^a e^b$$

$$\frac{df(x)}{dx} = \lim_{\Delta x \to 0}\frac{f(x + \Delta x) - f(x)}{\Delta x} \quad \frac{d}{dx}(f(u)) = \frac{df}{du}\frac{du}{dx}$$

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

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

$$\int_a^b f(x)dx = \lim_{\Delta x\to 0}\sum_{n=1}^{N} f(x)\Delta x \quad \int \frac{1}{x}dx = \ln x \quad \int x^n dx = \frac{x^{n+1}}{n+1} \quad \int e^{ax}dx = \frac{e^{ax}}{a}$$

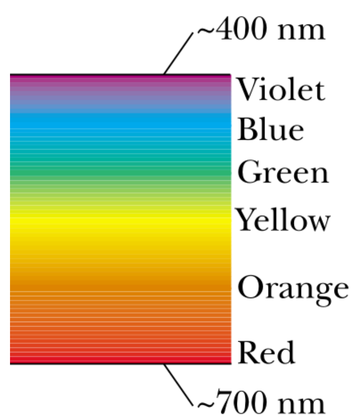
$$\int \frac{x}{\sqrt{x^2+a^2}}dx = \sqrt{x^2+a^2} \quad \int \frac{x^2}{\sqrt{x^2+a^2}}dx = \frac{1}{2}x\sqrt{x^2+a^2} - \frac{1}{2}a^2\ln\left[x+\sqrt{x^2+a^2}\right]$$

$$\int \frac{x^3}{\sqrt{x^2+a^2}}dx = \frac{1}{3}(-2a^2+x^2)\sqrt{x^2+a^2} \int \frac{1}{\sqrt{x^2+a^2}}dx = \ln\left[x+\sqrt{x^2+a^2}\right]$$

Physics 132-1 Test 3 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)	$1.097 \times 10^7\ m^{-1}$
Becquerel (Bq)	$1\ decay/s$	Curie (Ci)	$3.7 \times 10^{10}\ Bq$

Electromagnetic Spectrum



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.