Physics 132-03 Test 3

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

Name ______________________ Signature ______________________

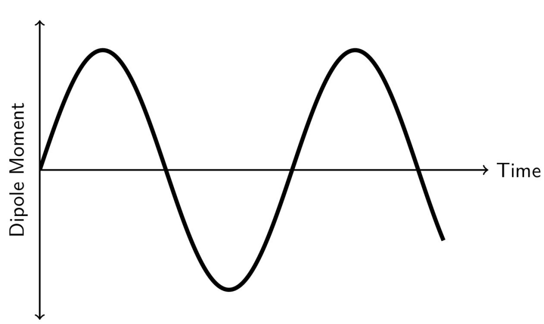
Questions (5 for 8 pts. apiece) Answer in complete, well-written sentences WITHIN the spaces provided.

1. In the table below a nuclear decay is shown in the first column. In most cases the original nucleus (often referred to as the parent) produces two smaller particles. Only one of the daughter nuclei is listed. In the adjacent column list the missing nucleus. Explain your reasoning.

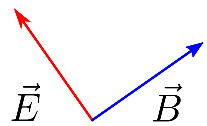
Decay	Unknown
$^{212}\text{Bi} \rightarrow {}^{4}\text{He} + ?$	
$^{204}\text{Pb} \rightarrow \gamma + ?$	

2. The expression for the electron mass from the lab entitled *Weighing an Electron* is $m_e = eB^2r^2/(2V)$. The radius measurement is $r = 3.45 \pm 0.21\ cm$ and the rest of the expression is $eB^2/(2V) = 7.40 \times 10^{-28}\ kg/m^2$. What is the uncertainty on the electron mass δm_e due to the uncertainty in the radius r? Show your reasoning.

3. Suppose the motion of two charges can be described as an oscillating dipole so the dipole moment as a function of time looks like the figure. Assume the dipole is aligned with the z-axis. What do you expect the electric field to look like as a function of time at some arbitrary distance r away from the source in the $x - y$ plane? What is the direction of the $\vec{E}$ field? Make a sketch on the plot and label your curve. Explain your reasoning.



4. The figure shows the electric and magnetic fields of an electromagnetic wave at a particular moment. In what direction is the wave traveling? Explain your reasoning.

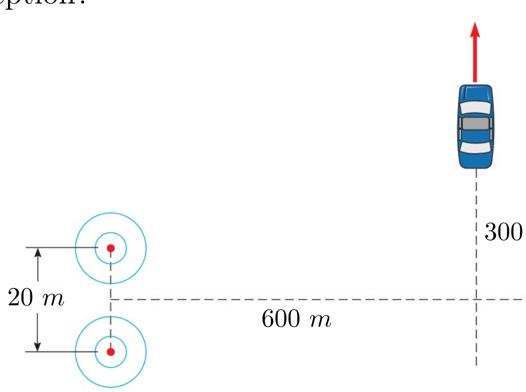


5. Sound has wavelengths in the range $\lambda = 17 - 17000\ mm$ audible to human ears. Light has wavelengths in the range $\lambda = 4000 - 7000\ nm$ that we can see. Why can you hear around corners, but you can't see around corners? Explain.

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

1. 18 pts. The radioactive decay of radon ${}^{222}\text{Rn} \rightarrow {}^{4}\text{He} + {}^{218}\text{Po}$ has a decay constant of $\lambda = 0.1812\ d^{-1}$. (a) What is its half-life ($t_{1/2}$)? (b) What fraction f will remain after 10 days?

2. 20 pts. Two radio antennas separated by a distance $d = 20\ m$ as shown in the figure simultaneously broadcast identical signals at the same wavelength $\lambda = 5\ m$. A radio in a car traveling due north a perpendicular distance $L = 600\ m$ away from the sources receives the signals. If the car is at the position $y_i = 300\ m$ of the second maximum, how much farther must the car travel to encounter the next minimum in reception?



DO NOT WRITE BELOW THIS LINE.

3. 22 pts. Two extremely narrow parallel slits separated by a distance $d = 0.850\ mm$ are illuminated by $\lambda = 600 - nm$ light The viewing screen is $L = 2.80\ m$ away from the slits. (a) What is the phase difference between the two interfering waves on a screen at a point $y = 2.50\ mm$ from the central bright fringe? (b) What is the ratio of the intensity at this point to the intensity at the center of a bright fringe? Assume diffraction effects are negligible so the intensity distribution is purely due to two-slit interference from point sources.

Physics 132-3 Equations

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

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

$$\vec{F}_B = q\vec{v} \times \vec{B} \qquad |\vec{F}_B| = |qvB\sin\theta| \qquad |\vec{F}_c| = m\frac{v^2}{r}$$

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

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

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

$$\delta = d\sin\theta = m\lambda\ (m = 0, \pm1, \pm2, ...) \quad \delta = a\sin\theta = m\lambda\ (m = \pm1, \pm2, ...) \quad \phi = k\delta$$

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

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

$$\frac{d}{dx}(f(u)) = \frac{df}{du}\frac{du}{dx} \quad \int x^n dx = \frac{x^{n+1}}{n+1} \quad \int \frac{1}{x}dx = \ln x \quad \vec{A}\cdot\vec{B} = AB\cos\theta \quad |\vec{A}\times\vec{B}| = |AB\sin\theta|$$

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

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

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

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

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

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

Physics 132-3 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)	$3.7 \times 10^{10}\ Bq$

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.