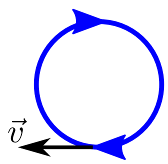
Physics 132-03 Test 3

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 figure below a uniform magnetic field $\vec{B}$ causes an electron to follow the trajectory shown. What is the direction of $\vec{B}$. Explain.

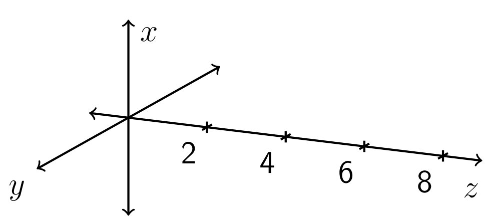


2. The decay of atomic nuclei is often characterized by a quantity known as the half-life τ. The half-life is the period of time for one-half of the original sample to disappear via radioactive decay. This statement can be expressed mathematically as $N_{nuc}(t = \tau) = \frac{N_0}{2}$. Starting with this expression show the decay constant λ and the half-life are related by the following equation.
$$\tau = \frac{\ln 2}{\lambda}$$

3. An electromagnetic plane wave is described by

$$\vec{E} = E_{MAX} \sin(kz - \omega t)\,\hat{x} \tag{1}$$
$$\vec{B} = B_{MAX} \sin(kz - \omega t)\,\hat{y}, \tag{2}$$

and has a wavelength of $\lambda = 8$ meters. All (x, y, z) points in this activity are in meters. Draw a sketch of the wave on the axes below, at time $t = 0$. Explain your reasoning.



4. Consider a laser beam shining on a circular hole. If a beam of light consisted of small, unseen particles that behaved as tiny billiard balls called corpuscles what would you see on a screen that is downstream from the circular hole? Now consider the same laser beam shining on a pair of narrow slits. What would you see on a screen downstream from the slits if light were made of corpuscles? Explain.

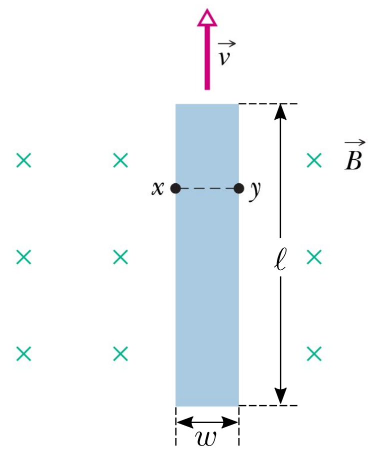
5. Does the spacing between bright spots in a double-slit interference pattern increase, decrease, or stay the same if the color of the light is switched from red ($\lambda \approx 650\ nm$) to blue ($\lambda \approx 450\ nm$)? Explain.

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

1. 15 pts. In a region of free space, the electric and magnetic fields from an electromagnetic wave at an instant of time are $\vec{E} = (80\,\hat{i} + 32\,\hat{j} - 64\,\hat{k})\ N/C$ and $\vec{B} = (0.20\,\hat{i}, + 0.08\,\hat{j} + 0.29\,\hat{k}) \times 10^{-6}\ T$. What is the magnitude of the Poynting vector for these fields?

2. 20 pts. The waves from a radio station can reach a home receiver by two paths. One is a straight-line path from transmitter to home, a distance of $L = 40\ km$. The second path is by reflection from the ionosphere (a layer of ionized air molecules high in the atmosphere). Assume this reflection takes place at a point midway between receiver and transmitter and that the wavelength broadcast by the radio station is $\lambda = 1000\ m$. The radio waves also undergo a change in phase equivalent to a shift of $\lambda/2$ upon reflection. What is the minimum, nonzero height of the ionospheric layer that produces destructive interference between the direct and reflected beams. Ignore the curvature of the Earth.

3. 25 pts. A metal strip $\ell = 6.50\ cm$ long, $w = 0.850\ cm$ wide, and $t = 0.076\ cm$ thick moves with constant velocity $\vec{v}$ through a uniform magnetic field $B = 1.20 \times 10^{-3}\ T$ directed perpendicular to the strip, as shown in below. This motion creates a uniform field $\vec{E}$ in the metal which exerts a force on the electrons in the metal. A potential difference $V = 3.90 \times 10^{-6}\ V$ is measured between points x and y across the strip. What is the speed v? Where would the electrons in the metal tend to end up?



DO NOT WRITE BELOW THIS LINE.

Physics 132-3 Equations

$$\vec{F} = m\vec{a} = \frac{d\vec{p}}{dt} \quad a_c = \frac{v^2}{r} \quad W = \int \vec{F}\cdot d\vec{s} \quad KE = \frac{1}{2}mv^2 \quad KE_0 + PE_0 = KE_1 + PE_1 \quad \vec{F}_C = k_e\frac{q_1 q_2}{r^2}\hat{r}$$

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

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

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

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

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

$$\delta = d\sin\theta = m\lambda \approx \frac{dy_m}{L}\ (m = 0, \pm 1, \pm 2, ...) \quad \delta = a\sin\theta = m\lambda \approx \frac{ay_m}{L}\ (m = \pm 1, \pm 2, ...) \quad \phi = k\delta$$

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

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

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

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

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

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

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

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

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

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

Physics 132-3 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.