Physics 4C PRACTICE FINAL EXAM

Instructions: There are 10 multiple choice questions (worth 5.5% each) and 3 longer questions (worth 15% each). Read the problems *carefully* and give the best answer based on the material presented during lecture and in the text.

(1) Blue light with a wavelength of 410 nm strikes a double-slit setup where the slit separation is 0.093 mm and the distance to the screen is 2.8 m. What is the separation between the first-order ($n = 1$) and the fourth-order ($n = 4$) maxima, if the small angle approximation is valid?
(a) 0.019 m (b) 0.15 m (c) 0.012 m (d) 0.037 m (e) none of the above

(2) An electron is accelerated through a potential difference of 1000 Volts. What is the de Broglie wavelength of the electron (in meters)?
(a) 1.1×10^{-17} (b) 7.8×10^{-11} (c) 8.5×10^{-24} (d) 4.0×10^{-19} (e) none of the above

(3) Unpolarized light passes through three polarizing filters. The first one is oriented with a horizontal transmission axis. The second filter has its transmission axis 25.7° from the horizontal. The third filter has a vertical transmission axis. What percent of the intensity of the light gets through this combination of filters? (a) 7.6% (b) 92.4% (c) 50.0% (d) 22.5% (e) 0.00%

(4) Light passes through a single slit and the diffraction pattern is projected onto a screen. If the slit width is doubled then the separation between the minima in the pattern on the screen will
(a) double (b) quadruple (c) stay the same (d) decrease by 1/2 (e) decrease by 1/4

(5) A concave mirror has a focal length of 35.0 cm. Determine the object position for which the resulting image is upright and five times the size of the object.
(a) −140 cm (b) 42.0 cm (c) 28.0 cm (d) 14.0 cm (e) 21.0 cm

(6) An unstable particle at rest breaks into two fragments of unequal mass. The mass of the lighter fragment is 3.00×10^{-28} kg and that of the heavier particle is 1.67×10^{-27} kg. If the lighter fragment has a speed of 0.793 c after the breakup, what is the speed of the heavier fragment?
(a) 0.228 c (b) 0.143 c (c) 0.336 c (d) 0.527 c (e) 0.744 c

(7) Assume we can localize a particle to an uncertainty of 0.5 nm. What will be the resulting uncertainty in the particle's momentum (in kg m/s)?
(a) 1.1×10^{-25} (b) 4.2×10^{-25} (c) 2.5×10^{-25} (d) 1.3×10^{-24} (e) 6.6×10^{-25}

(8) Forbidden transitions and selection rules suggest that:
(a) a photon has linear momentum (b) a photon has energy (c) a photon has angular momentum
(d) a photon has parity (e) a photon has mass

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(9) The half-life of ^{131}I is 8.04 days. Three days after it was prepared, its activity was 0.5 μCi. How many curies (in μCi) were initially prepared?
(a) 0.24 (b) 0.07 (c) 0.15 (d) 0.65 (e) 0.39

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(10) If the radiant energy from the Sun arrives at Earth as plane electromagnetic (e/m) waves of intensity 1340 W/m^2, calculate the peak value of the electric field.
(a) 300 V/m (b) 1000 V/m (c) 225 V/m (d) 111 V/m (e) 710 V/m

Problems. You must explicitly show all your work on this part. No work = no credit

(A) Consider two inertial reference frames S and S', where S' is moving to the right with a constant speed of 0.75 c as measured by an observer in S. A stick of proper length 1.0 m moves to the **left** toward the origins of both S and S'. The length of the stick as measured by the observer in S' is 0.6 m.

(i) What is the speed of the stick as measured by S' ?

(ii) What is the speed of the stick as measured by S ?

(iii) What is the length of the stick according to S ?

(B) For (i) and (ii), suppose the electron in a hydrogen atom is excited into the $n = 3$ level.

(i) What are *all* possible values of l and m_l that are permitted for this excited state?

(ii) Assume that the electron makes a transition to the $n = 1$ orbit, which is also called the ground state. From which l and m_l values of the $n = 3$ state is this transition allowed?

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(iii) A particle is confined to a one-dimensional box (also called an infinite square well) on the x-axis between $x = 0$ and $x = L$. The potential height of the walls of the box is infinite. The normalized wave function of the particle, which is in the ground state, is given by $\psi(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{\pi x}{L}\right)$, with $0 \leq x \leq L$. What is the probability of finding the particle between $x = 0$ and $x = L/3$? [Hint: A useful integral is $\int \sin^2(ax)dx = \frac{x}{2} - \frac{\sin(2ax)}{4a}$.]

(iv) Find the value of A to normalize the wave function $\psi(x)$, where:

$$\psi(x) = \begin{cases} A & \text{for } -L \leq x \leq L; \\ 0 & \text{for all other } x. \end{cases}$$

This is Chapter 40 material – Do this –

(C) A linearly polarized e/m wave of wavelength 3.50 cm is traveling in along the positive z-axis. The magnitude of the electric field is $\mathbf{E}_0 = 275$ V/m. The electric field oscillates along the x-axis direction. Assume that the **B** field can be written in the standard form $\mathbf{B} = \mathbf{B}_0 \sin(kx - \omega t)$.

(i) Calculate the values for k and ω, and both the magnitude and direction of $\mathbf{B}_0$.

(ii) What are the magnitude and direction of the Poynting vector of this wave?

(iii) What radiation pressure would this wave exert if it fell onto a perfectly reflecting surface?

(iv) What is the ground-state electronic configuration for the chemical element neon (Z = 10)?