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 1^{st} and 4^{th} order maximum, 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). (Electric potential energy is equal to voltage times charge).
(a) 1.1 $\times 10^{-17}$ (b) 7.8 $\times 10^{-11}$ (c) 8.5 $\times 10^{-24}$ (d) 4.0 $\times 10^{-19}$ (e) none of the above

(3) Which best describes the band structure of a doped semiconductor with effectively **positive** charge carriers?
(a) Has half-filled upper energy band
(b) Has a filled energy band with a large gap ($\approx$ 10 eV) to the next band
(c) Has a filled energy band with a small gap ($\approx$ 1 eV) to the next band
(d) Has a donor level close to ($\approx$ 0.025 eV) an unfilled energy band
(e) Has an acceptor level close to ($\approx$ 0.025 eV) a filled energy band

(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 $\times 10^{-27}$ kg. If the lighter fragment has a speed of 0.793c 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) 2.1×10^{-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

(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

(10) If the radiant energy from the sun comes in as a plane EM wave of intensity 1340 W/m^2, calculate the peak values 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) An electron in hydrogen is excited into the n=3 level.

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

(ii) For the largest l value and the largest m_l value from (i) what is the angle that the quantized angular momentum vector, $\vec{L}$, makes with the z-axis.

(iii) Assume that the electron makes a transition to the n=1 ground state. From which l and m_l values of the n=3 state is this transition allowed.

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

(i) Find values for $\mathbf{B}_0$, k, and ω. The magnetic field needs both magnitude and direction.

(ii) What is 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?