Physics 214 / Spring 2007 **Name: ______Answer Key______________________**
Dr. Zimmerman
Quiz 1, Ch. 21/22

I expect you to show *all* your work (if you want credit, that is).

A diffraction grating is illuminated simultaneously with red light of wavelength $645nm$ and light of an unknown wavelength. The sixth-order maximum of the unknown wavelength exactly overlaps the fourth-order maximum of the red light. What is the unknown wavelength?

$$d\sin\theta = m\lambda$$

So, $d\sin\theta_{red} = 4(645nm)$
Also, $d\sin\theta_{?} = 6\lambda_{?}$

However, if they overlap, then $d\sin\theta_{red} = d\sin\theta_{?}$ so,

$$4(645nm) = 6\lambda_{?}$$
$$\lambda_{?} = \boxed{430nm}$$

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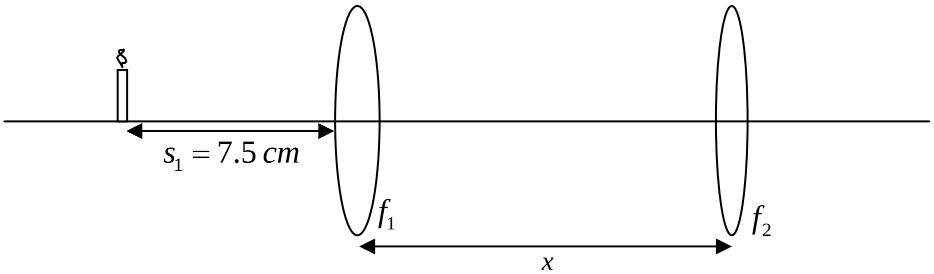
Quiz 2, Ch. 23

I expect you to show *all* your work (if you want credit, that is).

A candle is placed upright, $7.5\,cm$ in front of a converging lens of focal length, $f_1 = 5.0\,cm$. Find the distance x ($x > 15\,cm$) that a second lens of focal length $f_2 = 15\,cm$ should be placed so that the final image is upright and three times as tall as the object. Let *x* be the distance between the lenses as shown. Hint: Determine the location and magnification of the image formed by the first lens, then worry about the second lens and solve for the unknown using the requirement for the magnification.



$$\frac{1}{7.5} + \frac{1}{s_1'} = \frac{1}{5} \quad \rightarrow \quad \frac{1}{s_1'} = \frac{1}{15} \quad \rightarrow \quad s_1' = 15\,cm$$

$$M_1 = -\frac{15}{7.5} = -2$$

$$s_2 = x - 15$$

$$\frac{1}{x-15} + \frac{1}{s_2'} = \frac{1}{15} \quad \rightarrow \quad \frac{1}{s_2'} = \frac{1}{15} - \frac{1}{x-15}$$

$$\frac{1}{s_2'} = \frac{x-30}{15(x-15)}$$

We need $M_2 = -1.5$ to make the overall magnification equal to $+3$. Thus,

$$M_2 = -\frac{s_2'}{s_2} = -1.5 \quad \rightarrow \quad s_2' = 1.5 s_2 = 1.5x - 22.5$$

$$\frac{1}{1.5x - 22.5} = \frac{x-30}{15(x-15)}$$

$$15x - 225 = 1.5x^2 - 45x - 22.5x + 675$$

$$1.5x^2 - 82.5x + 900 = 0$$

$$x = 15\,cm,\ \boxed{40\,cm}$$

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Dr. Zimmerman
Quiz 3, Ch. 24

I expect you to show *all* your work (if you want credit, that is).

Electrons in atoms have energies that are typically on the order of a few electron volts (eV). In the hydrogen atom, an electron in its lowest, "ground" state has an energy of $13.6\, eV$. (a) Based on this information and using the particle in a box model, what is the size of a hydrogen atom? (b) If an electron in this hydrogen atom drops from the excited $n = 3$ level to the $n = 2$ level, what is the wavelength of the emitted photon? (c) By comparison to the actual wavelength of this transition in the hydrogen atom (about $656\, nm$) is this model very accurate in this case?

Equations: $E = hf = hc/\lambda$ $hc = 1240\, eV \cdot nm$ $h = 6.63\times10^{-34}\, J\cdot s$ $E_n = \dfrac{h^2 n^2}{8mL^2}$

$c = 3.0\times10^{8}\, m/s$ $c = \lambda f$ $\lambda = \dfrac{h}{p}$ $1eV = 1.6\times10^{-19}\, J$ $m_e = 9.11\times10^{-31} kg$ $1\, eV = 1.6\times10^{-19}\, J$

(a) $E_1 = \dfrac{h^2}{8mL^2}$

$$13.6\, eV = \frac{(6.63\times10^{-34}\ J\cdot s)^2}{8(9.11\times10^{-31}\ kg)L^2}$$

$$L^2 = 2.77\times10^{-20}\ m^2$$

$$L = \boxed{0.17\ nm}$$

(b) $E_3 = 9E_1 = 9(13.6\, eV) = 122.4\, eV$

$$E_2 = 4E_1 = 4(13.6\, eV) = 54.4\, eV$$

$$E = hc/\lambda$$

$$68\, eV = \frac{1240\, eV\cdot nm}{\lambda}$$

$$\lambda = \boxed{18.2\ nm}$$

(c) *This answer differs quite a bit from the actual wavelength and is not very accurate in this case.*

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Quiz 4, Ch. 36

I expect you to show *all* your work (if you want credit, that is).

Luke has a spaceship of length of $50\ m$. His friend Han has a spaceship that is twice as long at $100\ m$. One day as Luke and Han are racing they pass over head and you measure their ships to have the same length. (a) If Luke is traveling at $0.45c$, how fast is Han traveling? (b) If their clocks were synchronized before the start of the race, by how many seconds will Luke and Han differ for the elapsed time of the race if it took $60.0\ s$ according to your "stationary" clock?

(a) $L_{Luke} = 50\ m / \gamma_{Luke}$

$L_{Han} = 100\ m / \gamma_{Han}$

$L_{Luke} = L_{Han}$

$$\frac{50\ m}{\gamma_{Luke}} = \frac{100\ m}{\gamma_{Han}}$$

$$\gamma_{Han} = 2\gamma_{Luke} = \frac{2}{\sqrt{1-\beta_{Luke}^2}} = 2.24$$

$$\frac{1}{\sqrt{1-\beta_{Han}^2}} = 2.24$$

$\beta_{Han} = 0.895$

$v_{Han} = \boxed{0.895c}$

(b) $$\Delta\tau_{Luke} = \frac{60.0\ s}{\gamma_{Luke}} = 53.6\ s$$

$$\Delta\tau_{Han} = \frac{60.0\ s}{\gamma_{Han}} = 26.8\ s$$

Thus, the difference is: $\Delta\tau = \boxed{26.8\ s}$

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Dr. Zimmerman
Quiz 5, Ch. 38

I expect you to show *all* your work (if you want credit, that is).

As we have discussed, a crude model of an electron bound to a nucleus is the 1-dimensional particle in a box model. Consider an electron to be in its *1st excited state* with energy $536.8\,eV$. **(a)** What is the size of the box? **(b)** What is the ground state energy? **(c)** What wavelength photon will take this electron from the 1st excited state to the 2nd excited state? **(d)** How does your answer to part (c) change if you squeeze on the box making it one tenth the original size?

Equations: $E = hf = hc/\lambda$ $hc = 1240\ eV \cdot nm$ $h = 6.63\times10^{-34}\ J\cdot s$ $E_n = \dfrac{h^2 n^2}{8mL^2}$

$c = 3.0\times10^{8}\ m/s$ $c = \lambda f$ $\lambda = \dfrac{h}{p}$ $1eV = 1.6\times10^{-19}\ J$ $m_e = 9.11\times10^{-31} kg$

(a) $8.589\times10^{-17}\ J = \dfrac{(4)4.396\times10^{-67}\ J^2\cdot s^2}{(8)(9.11\times10^{-31}\ kg)L^2}$

$L^2 = 2.809\times10^{-21}\ m^2$

$L = \boxed{5.3\times10^{-11}\ m}$

(b) $E_1 = E_2/2^2 = \boxed{134.2\ eV}$

(c) $\left[(3^2)134.2 - (2^2)134.2\right] eV = \dfrac{1240\ eV\cdot nm}{\lambda}$

$\lambda = \dfrac{1240\ eV\cdot nm}{671\,eV} = \boxed{1.85\ nm}$

(d) $L \to L/10$ increases the energy by 100 ($E_n \to 100E_n$). This, in turn, reduces the wavelength by the same factor: $\lambda \to \lambda/100$. That is, $\lambda = \boxed{0.0185\ nm}$