

Electrical Power

(Assigned: 20 November 2007 • Due: Tuesday 4 December 2007)

I. It is the Year 2007, and while we do not have Moon colonies, personal hovercraft, or robotic maids and valets, we do have a lot of electrical gadgets. During the course of a typical school day (Monday-Friday), make a list of all the electrical devices you use during that day (up to a maximum of 12 items – if you have more than 12 items, we prefer the ones that use more power or more time). *On the back of this sheet is a handy fill-in-the-blanks table to make this easy to calculate.* Then separately count up “large”, “medium” and “small” lamps that you are likely to use around the house. Specify your criteria. Example: Large might be a halogen floor lamp or big fixture of 300 W to 500 W. Medium might be a 3-way light bulb or a fixture with multiple bulbs totally 100 W to 200W. Small might be 25 W to 60 W single light bulbs. Ignore little 7W nightlights. Estimate a single number to indicate how long you keep the lights on during this season – say an average of 5 hours? Then multiply the total lamp counts by say 400 W, 150 W and 50 W (L, M and S) to add to your totals for Watts.

II. Estimate how many Joules of energy that your use of the items in (I) entailed.

III. We seem to be moving into a period of more and more unstable weather. Despite our dependence on electrical devices, our electrical power system is aging and getting more chaotic. So lots of people are buying emergency generators. One rule for figuring out how big a generator you need to get is to add up the wattages of all the critical devices (refrigerator, furnace, water pump if you have a well), plus the wattages of those devices you *have* to use all the time, then multiply by 150 % ($\times 1.5$). How big a generator do you need?

Worksheet 1 Worksheet

| | Item | Watts | Minutes | Seconds | Joules |
|-----|------|-------|---------|---------|--------|
| 1. | | | | | |
| 2. | | | | | |
| 3. | | | | | |
| 4. | | | | | |
| 5. | | | | | |
| 6. | | | | | |
| 7. | | | | | |
| 8. | | | | | |
| 9. | | | | | |
| 10. | | | | | |
| 11. | | | | | |
| 12. | | | | | |

Total Watts: _____

Total Joules: _____

Lamps:

| |
|--------|
| Small |
| Medium |
| Large |

Frequency and Wavelength

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I. For your hometown, what channel is your local PBS station? (If your hometown is not in the United States, use the channel for Kalamazoo/Grand Rapids.) We need the broadcast channel number, not the channel number that it might be located on your cable TV. For example, in Allendale, PBS is on cable channel 12, but that is not the answer we want here. Next, find out what frequency, f , the visual and audio signals for that channel number are broadcast at. Finally, turn those frequencies into wavelengths, λ in meters, and tell us what kind of EM waves these are. How can you know what frequencies go with what channel numbers? I dunno – they're standardized for the U.S. Try *Ask.com*, *Google* or use some other search engine on the Web, for one.

II. Visible light falls between about 400 nm and 750 nm. A pure bright yellow or red-orange color might be $\lambda = 670\text{nm}$ or $\lambda = 555\text{ nm}$. Which is which? And what is the frequency of these two pure colors?

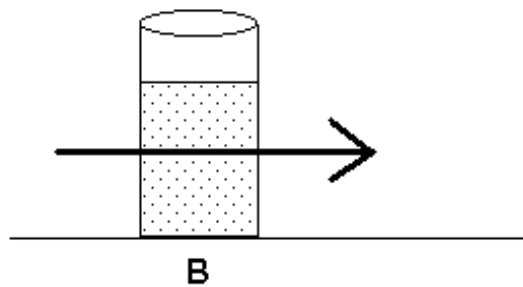
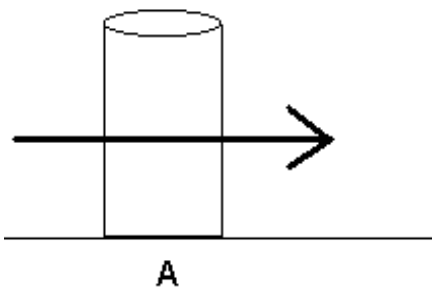
III. In the thrilling bound volume, *An Ab Initio Study of the K- α Spectra of Lithium Ions in Lithium Halides (LiX)*, *A Thesis for the Degree of Masters of Science in Physics, Michigan Technological University, Philip Edward Kaldon, 1988*, the not-yet-Dr. Phil writes about photons which have an energy of 60.9 eV. Given that $1\text{ eV} = 1.602 \times 10^{-19}\text{ J}$ and for photons, $E = hf$, where h is Planck's constant (it's probably inside of the front or back book cover of your text) – find the frequency f and wavelength λ of a 60.9 eV photon, and show that it falls somewhere near the border between X-rays and UV.

Optics Observations

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I. Mirrors • Try as you might, you cannot see behind your head with a *single* plane mirror. Position yourself in front of a mirror at any angle θ other than $\theta = 0^\circ$, which would be normal to the surface. Now turn your head until you can see your eyes. If you want to stare at the space in between your eyes, while your eyes face straight ahead, what angle θ is this? Does this make sense? Is there any other angle you can do this with a single plane mirror?

II. Find a drinking glass that is (a) made of clear glass, (b) has relatively straight sides so that it is nearly a cylinder. Look through the glass under the conditions A=empty and B=filled with water. Describe the images that you see. Repeat with a spoon in the glass, resting at an angle. Raise your head so you are looking down at the top surface. Describe what you see.



III. The Blind Spot • The human eye is a remarkable instrument. But it does have flaws. For some people, these show up in being nearsighted or farsighted, or other vision problems up to and including no vision at all. There is speculation that some of the Impressionist painters had vision problems, which explains the blurry swirls of all the colors and no discernible detail. In this part we want you to locate your “blind spot”. This is where your optic nerve attaches to the retina and there are no rods or cones. You don’t normally notice this because your brain “fills in the blanks” by putting a similar adjacent pattern over the “hole”. You will need someone to help you. Close your left eye and center the dot “•” below directly ahead of your right eye. Move the paper slowly forward and back, all the time staring at the dot. At some distance, the cross “×” will seem to disappear. Have your assistant measure the distance roughly from the tip of your nose to the page. Turn this sheet around 180° and repeat for the left eye. Are the distances the same?



Radium - The Only Thing Missing is "U"

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I. "Half-ing" A Good Time (25,000 points)

9.) A radioactive substance will decay at a rate according to its *half-life*. For example, if you have a *billion* atoms of the same isotope, then after the time of one half-life, we typically expect half of the billion will decay, leaving half a billion atoms of the original isotope. Fill in this table for the 2nd through the 75th half-lives. *PTPBIP - Round off any fractions of an atom. Stop if number < 1. We want whole atoms only.*

| | | | | | |
|----|---------------|----|--|----|--|
| 0 | 1,000,000,000 | | | | |
| 1 | 500,000,000 | 26 | | 51 | |
| 2 | | 27 | | 52 | |
| 3 | | 28 | | 53 | |
| 4 | | 29 | | 54 | |
| 5 | | 30 | | 55 | |
| 6 | | 31 | | 56 | |
| 7 | | 32 | | 57 | |
| 8 | | 33 | | 58 | |
| 9 | | 34 | | 59 | |
| 10 | | 35 | | 60 | |
| 11 | | 36 | | 61 | |
| 12 | | 37 | | 62 | |
| 13 | | 38 | | 63 | |
| 14 | | 39 | | 64 | |
| 15 | | 40 | | 65 | |
| 16 | | 41 | | 66 | |
| 17 | | 42 | | 67 | |
| 18 | | 43 | | 68 | |
| 19 | | 44 | | 69 | |
| 20 | | 45 | | 70 | |
| 21 | | 46 | | 71 | |
| 22 | | 47 | | 72 | |
| 23 | | 48 | | 73 | |
| 24 | | 49 | | 74 | |
| 25 | | 50 | | 75 | |