Physics 1010 Homework 7 (23+ points)
Due Mon 10/29 midnight

Electromagnetic radiation

1.) (2pts) HW / Exam Correction: Each week you should review both your answers and the answer key for the previous week's homework or Exam. Often (including this week) you will get to submit one homework correction. Select one problem for which you had the wrong answer. In the text box below, 1) identify the question number you are correcting, 2) state (copy) your original wrong answer, 3) explain where your original reasoning was incorrect, the correct reasoning for the problem, and how it leads to the right answer. If you got all the answers correct!!! bling bling... state which was your favorite / most useful homework problem, and why.

2.) (1pt) Which of the following are types of electromagnetic radiation? **(Check ALL that apply)**

a) Sound
b) Radio waves
c) Gamma rays
d) Infrared
e) X-Rays
f) Visible light
g) Pressure waves

3.) (0.5pt) The color of a light wave is determined by

a) The speed of the light wave
b) The density of air that it is traveling through
c) Its wavelength and frequency
d) The size of the source
e) The intensity of the light beam

4.) (0.5pt) What is the wavelength of blue light?

a) 3 m
b) 5 mm
c) 450 nm
d) 550 nm
e) 500 fm

5.) (0.5pt) How big is a nanometer (nm)?

a) 1×10^{-3}m
b) 1×10^{-5}m
c) 1×10^{-6}m
d) 1×10^{-8}m
e) 1×10^{-9}m

6.) (0.5pt) What is the frequency of blue light?

a) 1 Hz
b) 6 x 10^{-12} Hz
c) 5.5 x 10^{14} Hz
d) 6.5 x 10^{14} Hz
e) 7.5 x 10^{-14} Hz

7.) (1pt) What is the frequency of white light? – Explain your answer.

Blackbody Spectrum

For the rest of this homework, you will use the Blackbody Spectrum Simulation to investigate how the spectrum of electromagnetic radiation emitted by objects is affected by the object's temperature. There is a link to the simulation on the Phys 1010 website under 'simulations'. In this simulation, you can input the temperature and observe the spectrum of the radiation emitted. Note you can either raise and lower the temperature using the bar, or enter a temperature directly in the temperature box. The ruler (activated by a box near bottom right) is very useful.

The temperature of stars in the universe varies with the type of star and the age of the star, among other things. By looking at the shape of the spectrum of light emitted by a star, we can tell something about its average surface temperature.

8.) (1.5pt) What is the wavelength and color at which most power is emitted from the sun? Does this surprise you?

9.) (0.5pt) If we observe a star's spectrum and find that the peak power occurs at yellow light, what is the approximate surface temperature of the star in K?

a) 3225 K
b) 3900 K
c) 4710 K
d) 5745 K
e) 6125 K

10.) (0.5pt) What is the answer to Question 9 in degrees Celsius?
a) 5852 °C
b) 5472 °C
c) 4437 °C
d) 3627°C
e) 2952°C

11.) (0.5pt) If we observe a star's spectrum and find that the peak power occurs at the border between blue and violet light, what is the surface temperature of the star in K?

a) 4225 K
b) 5670 K
c) 6145 K
d) 6780 K
e) 7640 K

12.) (1pt) What is the wavelength at which the most power is emitted for a lightbulb operating at 2500 °C? (Use the simulation, and be careful which temperature units you use!)

a) 1150nm
b) 1050nm
c) 950nm
d) 850nm
e) 750nm

13.) (2pts) Explain why regular incandescent bulbs waste a lot of energy. Be sure to include your reasoning.

You would like to make an incandescent light bulb that is more efficient, so a greater percentage of the electrical power going in gets turned into visible light. Consider the effect of the following changes in Questions 14-18:

14.) (0.5pt) You increase the temperature of the filament. This will reduce the amount of (unwanted) radiation at 1100nm (T/**F**)

15.) (0.5pt) Increasing the temperature will increase the efficiency of the bulb (**T**/F)

16.) (0.5pt) You could improve the efficiency by increasing the surface area of the filament but keeping the temperature constant (T/F)

17.) (0.5pt) If you increase the temperature of the bulb, the light will look… (select **ALL** that apply!)

a) Redder
b) Whiter
c) Dimmer
d) Brighter

18.) (0.5pt) If you increase the temperature of the bulb, the lifetime of the bulb will be:

a) Shorter
b) Longer
c) Unchanged

At a temperature of 2500K a certain lightbulb produces 75W of radiation. Consider this bulb in Questions 19-22.

19.) (1pt) If it has an emissivity of 0.8, what is the surface area of the filament?

a) 4×10^{-2} m^2
b) 4×10^{-5} m^2
c) 8×10^{-5} m^2
d) 5×10^{-8} m^2
e) 6×10^{-9} m^2

20.) (1pt) How much radiated power would be produced if the temperature of the bulb filament were increased to 2900K?

a) 40 W
b) 87 W
c) 100 W
d) 136 W
e) 175 W

21.) (0.5pt) What electrical input power would be required to maintain the bulb at 2900K?

a) 40W
b) 87 W
c) 100 W
d) 136 W
e) 175 W
f) Something else

22.) (1pt) Consider the power radiated at 500nm (green/blue light) by a bulb at 2500K or at 2900K. Use the spectrum simulator to estimate the factor by which the power at 500nm increases when you increase the bulb temperature from 2500 to 2900K? (The ruler in the simulation is helpful for doing this.)

a) 1
b) 3
c) 5
d) 10
e) 100

23.) (1pt) In everyday life we know that something described as 'white hot' is hotter than something described as 'red hot'. What is the physics behind these everyday sayings?

a) The BB spectrum: Peak emission wavelength gets shorter as object gets hotter: Wavelength of white photons is shorter than red photons.
b) The BB spectrum: Peak emission wavelength gets longer as object gets hotter: Wavelength of white photons is longer than red photons.
c) The BB spectrum: Peak emission wavelength gets shorter as object gets hotter: White hot object is emitting all visible photons with roughly equal intensity. Red hot object is just emitting the long wavelength red photons.
d) The BB spectrum: Peak emission wavelength gets longer as object gets hotter: White hot object is emitting all visible photons with roughly equal intensity. Red hot object is just emitting the long wavelength red photons.
e) There is no physics behind these sayings.

I'm designing an oil-filled electric space heater. An electric element inside the heater heats oil to temperature T, which in turn heats the metal casing to the same temperature. I want to maximize the radiated power from the metal casing to the room.

24.) (0.5pt) Why should the metal casing be made as a series of connected vertical oil chambers, rather than just a single rectangular tank?

a) Looks more attractive in the room
b) Cheaper to fabricate
c) Increases percentage of radiated power in the IR range
d) Increases surface area of casing and hence radiated power for a given temperature
e) Increases the emissivity of the casing and hence radiated power for a given temperature

25.) (0.5pt) By changing the material from which the casing is fabricated, I can increase the emissivity by a factor of 2. By what factor does the radiated power change (assume temperature remains constant)?

a) stays same
b) decreases by factor of 0.5
c) increases by factor of 2
d) increases by factor of 4
e) increases by factor of 8

26.) (0.5pt) If I decrease the surface area of the casing by a factor of 2 and increase the temperature by a factor of 1.5, by what factor does the total radiated power change?

a) Increases by a factor of 2.5
b) Stays the same
c) Decreases by a factor of 0.75
d) Decreases by a factor of 0.375
e) Can't determine from data given

27.) (1.5pt) The maximum temperature of the casing is limited to 120°F (49°C). What is this temperature in Kelvin? Do you expect any visible radiation to be emitted, i.e. do you expect the heater to visibly glow? – Explain your answer.

28.) (1pt) Use the BB simulation (change scales), experiments that we did in class, and/or everyday life to estimate the lowest temperature (approximately) at which an object produces a faintly visible red glow (remember that in a darkened room your eye is very sensitive). Give your answer in <u>both</u> K and degrees C. Explain your reasoning.

BOUNUS: Design an experiment to verify #28 above BE CAREFUL. For instance, you might consider using an oven with a class to see in… How did you run the experiment? What evidence did you collect? Can you share a photo? I wholly anticipate this will not work on most ovens.. but even negative result is a result (and worthy of credit). Explain WHY you think you didn't see any changes…note there are lots of things to think about – temperature, surface area, cooling from air, oxidation, ...