Phys106, II-Semester 2018/19, Tutorial 3, Fri 25.1.

Work in teams of three. Do "Stages" in the order below. When all teams finished a stage, make sure all students at your table understand the solution and agree on one by using the board (in Studio-Air), or paper sheets (in L1).

For this tutorial, you may find the following list of physical constants convenient:

- $h = 6.62607004 \times 10^{-34}$ J s
- $\hbar = 1.054571800 \times 10^{-34}$ J s
- $e = 1.60217662 \times 10^{-19}$ C
- $k_B = 1.38064852 \times 10^{-23}$ J/K
- $c = 2.99792458 \times 10^{8}$ m/s

For unit prefixes, use internet.

Stage 1 (i) For the following photon frequencies, determine the name of their part of spectrum (radio, visible....), their energy in Joule and their energy in electron Volts (eV).

- $\nu = 10^2$ THz
- $\nu = 10^3$ THz
- $\nu = 10^{21}$ Hz
- $\nu = 10$ kHz
- $\nu = 1$ THz

(ii) Compare the energies you found in (i) with the following table of energy *scales* associated with physical processes/objects. For which combinations does the *order of magnitude* match (best)?

- Energy of rotational excitation of water molecules $E_{rot} \approx 2 \times 10^{-22}$ J.
- Energy scale of excitation of an atomic nucleus $E_{nuc} \approx 1$ MeV.
- Barely ionising an electron from an atom $E_{ion} \approx 13.6$ eV.
- Energy of vibrations of molecular bonds, $E_{vib} \approx 2 \times 10^{-20}$ J.
- Resonance energy of a large linear antenna, $E \approx 1 \times 10^{-30}$ J.

(iii) For the matching pairs, find the wave length of the photon and the sizescale associated with the physical process/object. Discuss.

Stage 2 **Wien's displacement law** says that the peak of the black body spectrum is at at $h\nu_{max} = 2.8214 k_B T$ (you can derive this later using mathematica). Now only find the temperature ranges for which the peak of the BB spectrum is within a certain part of the elm spectrum (radio, visible....), for all those parts.

Stage 3 Discuss on your table how Planck's calculation trick [that energy must have discrete quanta Eq. (23)], can be understood once we know about photons.

Stage 4 (i) Answer the following questions on the photo-effect:

- The work function for Litihum is 2.5 eV. What is the maximum kinetic energy of electrons you can get when shining blue light on it?
- Using UV light ($\lambda = 100$ nm) on platinum, you have to apply a counter voltage of at least 6 V to stop any electrons from arriving. Infer the work function of platinum.
- Copper has a workfunction of 4.7 eV, if you shine light with intensity $1W/cm^2$ and frequency $\nu = 6.6 \times 10^{14}$ Hz do you see photo electrons? What happens if you increase the intensity?
- What if instead you shine light with intensity $1W/cm^2$ and frequency $\nu = 1.2 \times 10^{15}$ Hz, do you see photo electrons? What happens now if you increase the intensity?

(ii) Use the online simulator at: http://vlab.amrita.edu/. For simulator use the login and password provided by TAs. Perform the virtual measurements described there and interpret them in the context of the lecture.