PYL101
(Electromagnetic Waves and **Quantum Mechanics**)
Tutorial Sheet 1 (L1-L2)

Note: The following are a mixed set of short and descriptive type questions.

1. Whether wave- or the particle-nature was used by Niels Bohr to describe the hydrogen atom spectrum? Explain.

2. Which experiment showed particle nature of X-rays? Draw clear schematic.

3. What is the de Broglie wavelength of an electron at rest, moving with speed $c/10$, and $c/2$? c is speed of light in free space.

4. Which experiment showed wave nature of electrons? Draw clear schematic.

5. In the pair production process, one γ-photon disappears. Explain.

6. Like pair production process, can there exist pair annihilation process? What would be the conditions and the outcomes?

7. Name any two experiments that can give an estimate of the Planck's constant. Explain.

8. Two black bodies of masses M_1 = 10 kg and M_2 = 1000 kg are maintained at constant temperature of 1000 K. Which one would give brighter (more intense) radiation out and why?

9. How did Planck correct Rayleigh-Jean's model to give correct description of black body radiation?

10. Hertz prepared an experiment on two metal surfaces exposed to the same type of light. In one case the photocurrent in the external circuit was double than the other. What is the reason?

11. In the Compton's experiment with an electron and a proton both initially at rest, what would be the wavelength shift in the two cases found using a photodetector placed at an arbitrary angle θ from the initial direction of the photons?

12. Compare Compton scattered wavelength shifts for X-rays (1 nm) and visible radiation (500 nm) from an electron (mass m_e) at rest and a nucleus ($M = 10^4 m_e$) at rest.

13. Double slit experiment with a single electron source, i.e., one electron at a time, is conducted. Draw the expected intensity pattern on the screen kept away from the slits at distance D. Where does the maximum lie?

14. Consider the formula for energy density from Planck's distribution law for black body as given below where all symbols have usual meaning,

$$u(\nu, T) = \frac{8\pi\nu^2}{c^3}\frac{h\nu}{e^{h\nu/kT} - 1}$$

Proceed to take the low frequency limit of this. How does it compare with the Rayleigh-Jean's law of black body radiation?

15. In the above problem, proceed to take the high-frequency limit of this. How does it compare with the Wein's displacement law of black body radiation?

16. In Hertz's experiment, two metal surfaces were exposed to same type of light. The stopping potential for one case was found to be double of the other. At a certain voltage V on the anode, what would be the ratio between the photocurrents in the two cases?

17. Consider the above Compton's experiment again and derive the famous equation given below,

$$\Delta\lambda = \lambda_f - \lambda_i = \frac{h}{m_e c}(1 - cos\,\theta)$$

18. In Electron diffraction from a nickel single crystal target, the angle corresponding to intensity maximum on a detector got reduced by 5 degrees when the electron source was changed to a new one. What is the ratio of energies of the electrons in the two cases?

19. In Davisson Germer experiment on electron diffraction from a single crystal nickel target, maximum intensity was found on the detector at angle theta = 50 degrees from the incident direction. Given that the interplanar distance in nickel is 0.091 nm, what would be the energy of the electrons in the incident beam?

20. In Compton's experiment with X-rays and a free electron initially at rest, wavelength shift of 1 nm is detected on the detector placed at an angle θ. Calculate the direction in which the recoiling electron flies off.