PHY313/CEI544

Homework 1 Solution

Q1: Describe briefly the 3 important discoveries that Einstein published in 1905.

A1:
1) Einstein explained photo-electron effect. According to Einstein’s viewpoint, light is an energy quantum that can be treated like a particle. This theory forms a large part of the basis of quantum mechanics.
2) Einstein studied the Brownian motion and showed that it is the result of small particles’ collisions, and proposed a simple method for experimentalists to measure atomic properties.
3) Einstein proposed the theory of relativity, which assumes that the speed of light in vacuum is the same in all inertial reference frame.

Q2: What insight made it possible for Maxwell to incorporate Optics into Electrodynamics?

A2:
Maxwell predicted the electro-magnetic wave and found that its speed is exactly the same as the speed of light. So he said that light is an E-M wave, which incorporates optics into EM theory.

Q3: Give the approximate dimensions of the Earth, an ant, an atom and a nucleus, with their appropriate dimensional prefixes.

A3:
1) The diameter of earth is about 12700 km, which is about 10 megameter (Mm).
2) The size of an ant is about 2 millimetre (mm).
3) The size of an atom is about $10^{-10}$m, which is about several nanometer (nm).
4) The size of a nucleus is about $10^{-14}$–$10^{-15}$m, which is about 1 femtometer (fm).

Q4: Name the four forces that we encounter in Nature and describe briefly what action they perform.

A4:
1) Strong force: it is a short range force which binds the nuclei together.
2) Electromagnetic force: a long range force which binds the atoms and condensed states.

3) Weak force: a short range force which produces the $\beta$ decay.

4) Gravity: a long range force which binds stellar systems such as the Solar system.

Q5: If you (weight 50 kg) run down a ski slope on a snowboard at a velocity of 10 m/s your energy of motion is $\sim 2500$ Joules. Explain why you don’t have to worry about the theory of relativity to describe your motion.

A5: Because my speed is far less than the speed of light, the special relativity will give a result which has almost no difference from Newton’s theory. (when $v=10\text{m/s}$, $\frac{1}{\sqrt{1-v^2/c^2}} \approx 1$)

Q6: If the same snow boarder collides with another person during 1 second, explain why quantum effects are not important.

A6: We know that quantum effects become important when energy $\times$ size is about $\hbar c$. In our situation, $E=2500\text{J}$, size $\sim 1\text{m}$, which yields a product $2500\text{J}\cdot\text{m}$, much bigger than $\hbar c$, which is about $2\times10^{-25}\text{J}\cdot\text{m}$. So in this case, the quantum effect is not important.