Assignment 11
PHY114 (2023-24-I)
Week-8 (to be discussed on 19-10-2023)

Problems to be submitted by Students –1, 2, 3, 5, 7

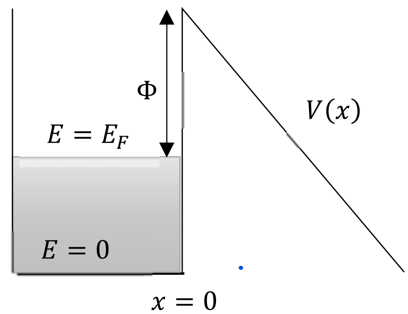
Problems to be solved in the tutorial – 4, 6 , 8

1. Estimate the size of the CdTe quantum dots in the four solutions that gave out different colours when ultraviolet light was passed through them, as demonstrated in lecture 27. For this, use the parameters given in the lecture slides.
2. Problem 3 (Eisberg and Resnick, 2^{nd} Edition Chapter 6).
3. Problem 8 (Eisberg and Resnick, 2^{nd} Edition Chapter 6).
4. Problem 10 (Eisberg and Resnick, 2^{nd} Edition Chapter 6).
5. Problem 15 (Eisberg and Resnick, 2^{nd} Edition Chapter 6).
6. Problem 17 (Eisberg and Resnick, 2^{nd} Edition Chapter 6).
7. **Geiger–Nuttall plot for thorium** The lifetimes (in various units) and observed α-particle energies (in MeV) for decays of various isotopes of thorium ($Z = 90$) are given below:

Mass number	τ	E_α (MeV)
232	1.4×10^{10} yr	4.01
230	7.7×10^{4} yr	4.69
229	7.34×10^{3} yr	4.85
228	1.91 yr	5.42
227	18.7 day	6.04
226	31 min	6.34
225	8 min	6.48
224	1.04 s	7.17
223	0.66 s	7.29
222	2.9 ms	7.98
221	1.68 ms	8.15
220	10 μs	8.79
219	1.05 μs	9.34
218	0.11 μs	9.67

Plot $\log(\tau)$ versus $1/\sqrt{E_\alpha}$ and try to "fit" a straight line through the data points (either by eye or via some fitting routine if you know how). Also plot the theoretical expression in Eqn. (11.63) on your graph and compare the "slopes" and "intercepts" of your lines; this exercise gives some feel for the reliability of this simplest estimate of tunneling effects.

8 In the phenomena of cold emission, electrons are drawn from a metal at room temperature by an externally applied electric field, as shown in the figure. Here shaded region shows the states filled by electrons and Φ represents the work function. Electrons coming out are mainly from the uppermost energy level at energy E_F.



(i) For applied electric field $\mathcal{E}$, write the functional form of the potential $V(x)$.

(ii) Using only the exponential factor in the expression for transmission through a rectangular barrier, find the transmission coefficient for electron for the applied electric field $\mathcal{E}$. The equation obtained is known as the Fowler-Nordheim equation and is used to calculate tunnelling current in the situation given.