MODERN PHYSICS (Summer 2020)

Review Questions

(week of 22 June 2020)

$$\int_a^b |\psi(x)|^2\,dx = \int_a^b \rho\,dx = \int_a^b dN = N$$

1. How do we normalize wave functions in 1D scattering problems?

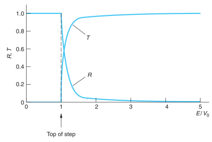
2. Sketch a generic 1D scattering problem. List the steps we need to follow to calculate the reflection and transmission coefficients.

$$R = \frac{|B|^2}{|A|^2} = \left(\frac{k_1 - k_2}{k_1 + k_2}\right)^2$$

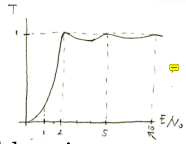
$$T = \frac{k_2}{k_1}\frac{|C|^2}{|A|^2} = \frac{4k_1k_2}{(k_1 + k_2)^2}$$

3. For all 1D scattering problems $R + T =$ . . . .

4. Consider scattering on a rectangular potential step with height V_0. Sketch the dependence of the transmission coefficient as a function of particle's energy E.



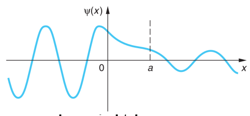
5. Consider scattering on a rectangular potential barrier with height V_0. Sketch the dependence of the transmission coefficient as a function of particle's energy E.



6. Is it possible that a quantum particle with energy E is transmitted through a rectangular potential barrier with height $V_0 > E$?

7. *True of false?* A quantum particle with energy $E > V_0$ incident on a rectangular potential barrier with height V_0 is transmitted through the barrier with probability 1 for any value of energy E.

8. Sketch the wave function of a particle with energy $E < V_0$ inside a barrier of height V_0.



9. Mark the correct answer: For 1D tunnelling through a rectangular barrier with height V_0 and width a, the transmission coefficient for a particle with energy $E < V_0$ *increases/decreases* with the height of the barrier.

10. Mark the correct answer: For 1D tunnelling through a rectangular barrier with height V_0 and width a, the transmission coefficient for a particle with energy $E < V_0$ *increases/decreases* with the width of the barrier.

11. Consider 1D tunnelling through a rectangular barrier with height V_0 and width a. Are energy levels in the infinite potential well of width a in any way related to this problem?

12. What is quantum tunnelling?

13. Give one example of a phenomenon or device where the effect of quantum tunneling plays a fundamental role.

14. What is the Ramsauer (also known as Ramsauer–Townsend) effect and how can it be modelled?

In the event that $E/V_0 > 1$, there is no reflected wave for $\alpha a = \pi, 2\pi, \ldots$ as a result of destructive interference. For electrons incident on noble gas atoms the resulting 100 percent transmission is called Ramsauer-Townsend effect and is a way of measuring atomic diameters for those elements.