

Condensed Matter Physics II  
Spring 1401(2022)

homework 2

Due Monday, 15.1.1401

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1-Problem 8, chapter 17 of “Condensed Matter Physics” (M. Marder, Wiley 2010).

2-Problem 9, chapter 17 of “Condensed Matter Physics” (M. Marder, Wiley 2010).

3-Problem 10, chapter 17 of “Condensed Matter Physics” (M. Marder, Wiley 2010).

4- Consider a free electron moving on a one-dimensional loop (circle), see the Fig.

- (a) Obtain the eigenvalues and eigenstates for this particle in the absence of magnetic field.
- (b) How are eigenvalues modified when a magnetic flux  $\Phi$  penetrate the ring.
- (c) Show that if the applied flux  $\Phi$  is an integer multiple of the flux quantum ( $\Phi_0 = h/e$ ), the spectrum has not changed at all. It is only the fractional fluxes that effect the spectrum and other observable quantities.
- (d) Show that at half-integer fluxes  $\Phi = \pm \frac{\Phi_0}{2}, \pm \frac{3\Phi_0}{2}, \dots$  the spectrum has a twofold degeneracy.

