1) **Problem 3.2** in Rybicki and Lightman. (Emission from a charged particle moving in a circle)

2) **Problem 3.3** in Rybicki and Lightman. (Emission from a pair of coherent, aligned dipoles)

3) In this problem you will derive the relation for the oscillator strength of a singly charged \((q = e)\) quantum oscillator between states \(n\) and \(n-1\); namely, \(f_{n,n-1} \approx n/3\).

   a) Show if a nonrelativistic electron oscillates along one direction at frequency, \(\omega\), and amplitude, \(x\), the radiated power averaged over an oscillation is \((1/3)(e^2/c^3)\omega^4 x^2\). At approximately what frequency is the power emitted? (Assume in this problem that the emission is monochromatic. Then, since the energy in the oscillating motions is \(E(t) = (1/2) \omega^2 x^2 m\), where \(m\) is the electron mass, show in the absence of any external driving that radiative damping leads to the relation \(x(t)^2 = x_0^2 \exp(-\Gamma_{\text{classic}} t)\), where \(\Gamma_{\text{classic}} = (2/3) e^2 \omega^2/(c^3 m)\), and \(x(t=0) = x_0\).

   b) Assume, according to the correspondence principle, that the classical radiated power matches the quantum mechanical result for large quantum number, \(n\). Then, recalling that the energy of a quantum oscillator is \((n+1/2)\hbar \nu\), where \(n\) is the quantum number and \(\nu = \omega/(2\pi)\), show that the Einstein coefficient \(A_{n,n-1} \rightarrow (2n m \omega^2 e^2)/(3mc^3)\) as \(n \gg 1\).

   c) Then using the oscillator strength definition for radiative transitions from some upper state, \(u\), to some lower state, \(l\); namely, \(f_{u,l} = A_{u,l} / (3 \Gamma_{\text{classic}})\), obtain the result, \(f_{n,n-1} \approx (n/3)\). (We will show subsequently that the only “allowed” downward radiative transition from level \(n\) is to level \(n-1\). Given that the classical emission is only at frequency \(\omega\), this should be obviously true for large quantum numbers.)