Intermediate Dynamics: Homework 11

Due: day month year

1 King, *Vibrations and Waves*, 2.2, page 47.

2 King, *Vibrations and Waves*, 2.5a), page 48.

3 King, *Vibrations and Waves*, 2.8, page 48. This issue is famous! It describes the lifetime of an atom according to classical physics. To solve this, break the problem into these parts:

a) First show that the instantaneous power is $P = \dfrac{Ke^2\omega^4 A^2}{c^3}\ \sin^2(\omega t)$.

b) Determine the total energy radiated over one cycle and show that this is $\dfrac{Ke^2\pi\omega^3 A^2}{c^3}$.

c) Show that, for a lightly damped oscillator

$$\frac{\text{Energy lost per cycle}}{\text{Energy at start of cycle}} = 1 - e^{-2\pi/Q} \approx \frac{2\pi}{Q}.$$

d) Given that the energy of an oscillator is $\frac{1}{2}m\omega^2 A^2$, show that

$$Q = \frac{mc^3}{Ke^2\omega}$$

and use this to determine an expression for γ.

e) A measure of the lifetime of an oscillation is $\tau = 1/\gamma$. Determine the lifetime for the oscillating electron.

This ranks amongst the greatest conundrums in physics; the lifespan of atoms cannot be this short. This issue was only resolved after the development of quantum theory.