1. Solve the following Problem in spherical coordinates, by separation of variables and choose the appropriate values of the constants to obtain a physical solution. Show that the equation for θ can reproduces the Lagender equation and the associated Legender equation.

$$\nabla^2 \phi(r, \theta, \phi) = 0$$

2. Using the generating function of the Legender polynomial obtain a general expression for $P_n(0)$

3. Prove all parts of equation 5.8 page 570 of the book

4. Find a general expression for the following integrals:

$$\int_{-1}^{1} x P_l(x) P_n(x) dx$$

$$\int_{-1}^{1} x^2 P_l(x) P_n(x) dx$$

5. Dirac delta function is defined as:

$$\delta(x - a) = \begin{cases} 0 & \text{if } x \neq a \\ \infty & \text{if } x = a \end{cases}$$

$$\int_{x_1}^{x_2} f(x) \delta(x - a) dx = f(a) \quad \text{if } a \epsilon (x_1, x_2)$$

write $\delta(x - a)$ as a fourier series.