1. For the equation
\[ \ddot{x} + x + \epsilon x^3 = 0, \quad |\epsilon| \ll 1 \tag{1} \]
with \( x(0) = a, \dot{x}(0) = 0 \), assume an expansion of the form
\[ x(t) = x_0(t) + \epsilon x_1(t) + \ldots \tag{2} \]
and carry out the perturbation process without assuming periodicity of the solution. Show that
\[ x(t) = a \cos t + \epsilon a^3 \left\{ -\frac{3}{8} t \sin t + \frac{1}{32} (\cos 3t - \cos t) \right\} + O(\epsilon^2) \tag{3} \]
Is this expansion valid, so far as it goes? Why is it not so suitable for finding the solution of (1) as opposed to other methods, such as Lindstedt-Poincaré method?

2. Determine the solution of the Van der Pol Equation through the method of multiple scales.

3. Determine the solution of the Rayleigh damping equation through the KBM method.