

## Assignment-5

**Problem-1:** Write a program to determine the complete eigenvalue spectrum of the following perturbed harmonic oscillator Hamiltonian for different values of perturbation parameter using the Jacobi method .

$H = H_0 + \lambda x^5$ , where  $H_0 = a^\dagger a + \frac{1}{2}$  and  $\lambda$  is the perturbation parameter. Starting your calculation with a basis size of  $n = 5$

- Print  $x$ ,  $H_0$  and  $H$  matrices separately.
- Generate a data file with first column as  $\lambda$  (take  $\lambda$  between 0 and 1 in steps of 0.1) and subsequent columns as  $E_0, E_1, \dots$  up to  $E_n$ . Here  $n$  represents the number of basis considered known as the basis size.  $|n >$  represents the eigenstates of the number operator.
- Plot the energy spectrum as a function of  $\lambda$ . i.e. plot  $\lambda$  and  $E_n$  in the  $x$  and  $y$  axes respectively using gnuplot.

### Commands for gnuplot.

Open a terminal and type gnuplot. You will see the gnuplot command prompt. Then type the command

plot "outputfile" using col1:col2 with linepoint

In short you can write

p "outputfile" u 1:2 w lp

To plot more than one file, e.g. 3 output files then you have to type

p "output1" u 1:2 w lp, "output2" u 1:2 w lp, "output3" u 1:3 w lp

If you don't want line and points together then type

p "output" u 1:2 w l

To plot different columns with respect to the first column of the output file then type,

p "outputfile" u 1:2 w lp, "outputfile" u 1:3 w lp, "outputfile" u 1:4 w lp, "outputfile" u 1:5 w lp