## GS543 (Tutorial 7)

**Assignment**-Write a Fortran program to compute apparent resistivity for schlumberger array for Nlayer resistivity model using subroutine program.

Note: Name of the subroutine program will be: DCyourfirstname

**Theory**- First, for a particular value of electrode separation ' $s_i$ , i=1,ns (s is half of current electrode separation), determine Resistivity transform  $T_1(\lambda_i)$ , j=1, M using the relation (M number of filter coefficients)  $\lambda_j = 10^{(a_j - \log_{10} s_i)}$  where  $a_j$  are the base 10 abscissa values of filter coefficients in given table below.

The resistivity transform for a N layer case for a particular value of  $\lambda_i$  is given by the recurrence relation

$$T_{k-1}(\lambda_j) = \frac{T_k + \rho_{k-1} \tanh(\lambda_j h_{k-1})}{1 + \frac{T_k \tanh(\lambda_j h_{k-1})}{\rho_{k-1}}}$$

 $T_{k-1}(\lambda_j) = \frac{T_k + \rho_{k-1} \tanh(\lambda_j h_{k-1})}{1 + \frac{T_k \tanh(\lambda_j h_{k-1})}{\rho_{k-1}}}$   $k=N,N-1,\dots 2. \quad \rho_k \text{ and } h_k \text{ are resistivity and thickness of } k^{th} \text{ layers. Resistivity transform}$  $T_N = \rho_N$ 

The Schlumberger apparent resistivity is then given by

$$\rho_a(s_i) = \sum_{j=1}^M f_j T_1(\lambda_j)$$

 $f_j$ , j=1, M are filter coefficients.

Table: Nineteen point filter

| $\begin{array}{c ccccccccccccccccccccccccccccccccccc$   | 1 00 10 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |                      |                     |
|---|---|----------------------|---------------------|
| 1     -0.980685     0.00097112       2     -0.771995     -0.00102152       3     -0.563305     0.00906965       4     -0.354615     0.01404316       5     -0.145925     0.09012       6     0.062765     0.30171582       7     0.271455     0.99627084       8     0.480145     1.3690832       9     0.688835     -2.99681171       10     0.897525     1.65463068       11     1.106215     -0.59399277       12     1.314905     0.22329813       13     1.523595     -0.10119309       14     1.732285     0.05186135       15     1.940975     -0.02748647       16     2.149665     0.01384932       17     2.358355     -0.00599074       18     2.567045     0.00190463 |   | Abscissa of filter   | Filter coefficients |
| 2   -0.771995   -0.00102152     3   -0.563305   0.00906965     4   -0.354615   0.01404316     5   -0.145925   0.09012     6   0.062765   0.30171582     7   0.271455   0.99627084     8   0.480145   1.3690832     9   0.688835   -2.99681171     10   0.897525   1.65463068     11   1.106215   -0.59399277     12   1.314905   0.22329813     13   1.523595   -0.10119309     14   1.732285   0.05186135     15   1.940975   -0.02748647     16   2.149665   0.01384932     17   2.358355   -0.00599074     18   2.567045   0.00190463  |   | coefficients $(a_j)$ | $(f_j)$             |
| 3   -0.563305   0.00906965     4   -0.354615   0.01404316     5   -0.145925   0.09012     6   0.062765   0.30171582     7   0.271455   0.99627084     8   0.480145   1.3690832     9   0.688835   -2.99681171     10   0.897525   1.65463068     11   1.106215   -0.59399277     12   1.314905   0.22329813     13   1.523595   -0.10119309     14   1.732285   0.05186135     15   1.940975   -0.02748647     16   2.149665   0.01384932     17   2.358355   -0.00599074     18   2.567045   0.00190463  | 1                                       | -0.980685            | 0.00097112          |
| 4   -0.354615   0.01404316     5   -0.145925   0.09012     6   0.062765   0.30171582     7   0.271455   0.99627084     8   0.480145   1.3690832     9   0.688835   -2.99681171     10   0.897525   1.65463068     11   1.106215   -0.59399277     12   1.314905   0.22329813     13   1.523595   -0.10119309     14   1.732285   0.05186135     15   1.940975   -0.02748647     16   2.149665   0.01384932     17   2.358355   -0.00599074     18   2.567045   0.00190463   | 2                                       | -0.771995            | -0.00102152         |
| 5     -0.145925     0.09012       6     0.062765     0.30171582       7     0.271455     0.99627084       8     0.480145     1.3690832       9     0.688835     -2.99681171       10     0.897525     1.65463068       11     1.106215     -0.59399277       12     1.314905     0.22329813       13     1.523595     -0.10119309       14     1.732285     0.05186135       15     1.940975     -0.02748647       16     2.149665     0.01384932       17     2.358355     -0.00599074       18     2.567045     0.00190463  | 3                                       | -0.563305            | 0.00906965          |
| 6   0.062765   0.30171582     7   0.271455   0.99627084     8   0.480145   1.3690832     9   0.688835   -2.99681171     10   0.897525   1.65463068     11   1.106215   -0.59399277     12   1.314905   0.22329813     13   1.523595   -0.10119309     14   1.732285   0.05186135     15   1.940975   -0.02748647     16   2.149665   0.01384932     17   2.358355   -0.00599074     18   2.567045   0.00190463  | 4                                       | -0.354615            | 0.01404316          |
| 7   0.271455   0.99627084     8   0.480145   1.3690832     9   0.688835   -2.99681171     10   0.897525   1.65463068     11   1.106215   -0.59399277     12   1.314905   0.22329813     13   1.523595   -0.10119309     14   1.732285   0.05186135     15   1.940975   -0.02748647     16   2.149665   0.01384932     17   2.358355   -0.00599074     18   2.567045   0.00190463  | 5                                       | -0.145925            | 0.09012             |
| 8   0.480145   1.3690832     9   0.688835   -2.99681171     10   0.897525   1.65463068     11   1.106215   -0.59399277     12   1.314905   0.22329813     13   1.523595   -0.10119309     14   1.732285   0.05186135     15   1.940975   -0.02748647     16   2.149665   0.01384932     17   2.358355   -0.00599074     18   2.567045   0.00190463  | 6                                       | 0.062765             | 0.30171582          |
| 9   0.688835   -2.99681171     10   0.897525   1.65463068     11   1.106215   -0.59399277     12   1.314905   0.22329813     13   1.523595   -0.10119309     14   1.732285   0.05186135     15   1.940975   -0.02748647     16   2.149665   0.01384932     17   2.358355   -0.00599074     18   2.567045   0.00190463   | 7                                       | 0.271455             | 0.99627084          |
| 10 0.897525 1.65463068   11 1.106215 -0.59399277   12 1.314905 0.22329813   13 1.523595 -0.10119309   14 1.732285 0.05186135   15 1.940975 -0.02748647   16 2.149665 0.01384932   17 2.358355 -0.00599074   18 2.567045 0.00190463  | 8                                       | 0.480145             | 1.3690832           |
| 11   1.106215   -0.59399277     12   1.314905   0.22329813     13   1.523595   -0.10119309     14   1.732285   0.05186135     15   1.940975   -0.02748647     16   2.149665   0.01384932     17   2.358355   -0.00599074     18   2.567045   0.00190463   | 9                                       | 0.688835             | -2.99681171         |
| 12   1.314905   0.22329813     13   1.523595   -0.10119309     14   1.732285   0.05186135     15   1.940975   -0.02748647     16   2.149665   0.01384932     17   2.358355   -0.00599074     18   2.567045   0.00190463   | 10                                      | 0.897525             | 1.65463068          |
| 13   1.523595   -0.10119309     14   1.732285   0.05186135     15   1.940975   -0.02748647     16   2.149665   0.01384932     17   2.358355   -0.00599074     18   2.567045   0.00190463  | 11                                      | 1.106215             | -0.59399277         |
| 14   1.732285   0.05186135     15   1.940975   -0.02748647     16   2.149665   0.01384932     17   2.358355   -0.00599074     18   2.567045   0.00190463  | 12                                      | 1.314905             | 0.22329813          |
| 15   1.940975   -0.02748647     16   2.149665   0.01384932     17   2.358355   -0.00599074     18   2.567045   0.00190463   | 13                                      | 1.523595             | -0.10119309         |
| 16   2.149665   0.01384932     17   2.358355   -0.00599074     18   2.567045   0.00190463   | 14                                      | 1.732285             | 0.05186135          |
| 17   2.358355   -0.00599074     18   2.567045   0.00190463  | 15                                      | 1.940975             | -0.02748647         |
| 18 2.567045 0.00190463  | 16                                      | 2.149665             | 0.01384932          |
|   | 17                                      | 2.358355             | -0.00599074         |
| 19 2.775735 -0.0003216  | 18                                      | 2.567045             | 0.00190463          |
|   | 19                                      | 2.775735             | -0.0003216          |

## Flowchart-

Start

Read ns (ns is number of spacing or AB/2 values)

Read  $s_i$ , i=1, ns (s-half of current electrode separation)

Read, number of layers (N), their resistivity (N values) and thickness (N-1 values)

Read  $a_j, f_j$ , j=1, M (M is number of number of filter coefficients)

Loop over  $s_i$ , i=1,ns

Loop over  $a_i$ , j=1 to 19

Compute  $\lambda_j = 10^{(a_j - \log_{10} s_i)}$ 

For each  $\lambda_i$  compute resistivity transform  $T_1(\lambda_i)$  and keep in memory

(Start from  $T_N = \rho_N$  and evaluate till  $T_1$ , N is number of layers)

End Loop over  $a_j$ 

Compute  $\rho_a(s_i) = \sum_{j=1}^M f_j T_1(\lambda_j)$ 

Save  $s_i$  verses  $\rho_a(s_i)$ 

End loop over si

stop

Use

s=1.5, 2, 3, 4, 6, 8, 10, 15, 20, 25, 30, 40, 50, 60, 80, 100, 120, 140, 160, 180, 200, 250, 300, 350, 400, 500, 600, 800, 1000. m

Plot s verses  $\rho_a$  on log-log scale.