## Answers for Tutorial 2

The marks to be awarded for each question are indicated in square brackets.

Problem 1 [5]

The E field must be directed upwards so that the electrostatic force counteracts the proton’s weight. [2]

The magnitude of the E field is given by:  [3]

Problem 2 [5]

Using Gauss’ law:  [3]

Electric flux is same for cube. [1]

Flux through each of six faces is same, i.e.  [1]

Results not affected by size of cube.

Problem 3 [10]

 [2]

200 m

300 m

 [2]

 [2]

Hence, the net outward flux is  [2]

Enclosed charge q from:  [2]

Problem 4 [20]

 [3]

1 nC

2 nC

3 nC

4 nC

10 cm

5√2 cm

Similar situation to that discussed in Tutorial 1, problem 2. Directions of fields due to charges of 1 nC and 3 nC and charges of 2 nC and 4 nC as illustrated above,

 [3]

Adding these gives the resultant field with direction as shown in the diagram. The magnitude of this field is  [1]

The potential is given by

 [3]

If the ordering changes as shown below, then, as illustrated, the direction of the E field changes, but the magnitude of the field and the value of the potential at the centre of the square remain the same.

1 nC

4 nC

3 nC

2 nC

10 cm

Place 1 nC charge first, no work must be done so no potential energy. This charge generates potential  [1]
(The value of V1 at the position of the second charge is 89.9 V)

Then bring in 2 nC charge. Potential energy due to its position in potential of 1st charge is  [2]

Choosing r1 and r2 appropriately, these two charges generate a potential  [1]
(The value of V12 at the position of the third charge is 243 V.)

Now bring up the third charge, potential energy is:  [2]

These three charges generate a potential  [1]
(The value of V123 at the position of charge 4 is 487 V.)

Bringing in the final charge results in a potential energy given by:  [2]

Adding up these contributions to the potential energy gives  [1]

The maximum total mark for this Tutorial is 40.