E&M Multiple Choice Assessed Solutions 1: Electric fields and Gauss's law

1. Four positive point charges of equal magnitude are at the corners of a square. Not including "at infinity" at how many points in space is the field strength exactly zero?

Five: the centre point and two each symmetrically located along the axis connecting two charges as if they are arranged in a diamond shape. Answer (d)

2. An electric dipole is placed in the vicinity of a static positive point charge. There are no other electromagnetic influences near the dipole.

The dipole will usually undergo some combination of rotational plus linear acceleration but not always. If it is perfectly aligned along a field line it will translate but not rotate. It will never remain stationary, nor will it just rotate but the proper answer is (e).

3. A point charge of value $+q$ is placed at the centre of a spherical conducting shell of finite thickness that has a net charge of $-Q$. Which of the following statements is true? **(3 marks)**

Without the point charge at the centre the shell has all of its net charge on the outer wall thus maintaining a net field of zero with its thickness. To maintain a field strength of zero inside the walls of the shell once the point charge is added, a charge of $-q$ accumulates on the inner wall and charge of $+q$ therefore joins the already-present charge of $-Q$ on the outer wall giving a total outer wall charge of $q - Q$. So the field inside the shell is that of a point charge $+q$ at the centre, the field within the thickness of the shell is zero and the field outside the shell is that of a point charge $q - Q$ at the centre. Answer (b).

4. A metal shell has a uniform surface charge density of $+\sigma$ on its outer surface of radius b and a uniform charge density of $-\sigma$ on its inner surface of radius a. What is the field strength at a distance $r > b$ from the centre of the shell?

The charge on the outer surface of the shell is $4\pi b^2\sigma$ and the charge on the inner surface of the shell is $-4\pi a^2\sigma$. For there to be zero field strength within the metal shell there must be a charge of $+4\pi a^2\sigma$ inside the shell averaged about the centre. This means the net charge for the arrangement is $4\pi b^2\sigma$ and thus the field strength recorded outside will be as if a charge of this value resided within. Answer (c).