Q1- An electric dipole with a dipole moment of 2 x 10^{-29} C.m is positioned in an electric field of 5 x 10^{5} N/C. If the dipole is perpendicular to the field direction calculate the torque experienced by the dipole.

The torque experienced by an electric dipole is given by

$$\vec{\tau} = \vec{p} \times \vec{E}$$

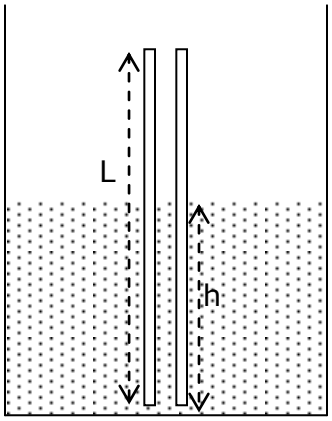
Its magnitude is given by τ = p*E*sin θ where θ is the angle between the field and the dipole moment and the direction is given by the right hand rule of cross product.

Here the dipole is perpendicular to the field hence the angle is 90^0 and the torque is then

$$\tau = p*E*\sin\theta = 2 \times 10^{-29} * 5 \times 10^{5} * \sin 90^0 = \mathbf{1*10^{-23}\ Nm}$$

Q2- Two vertical parallel plate electrodes are placed in a container as a liquid-level detector. The air and liquid in the container form the dielectric between the electrodes. Explain in detail how the measurement of the capacitance of detector can be used to determine the height of liquid in the container. Include a diagram in your answer.

Let the length of the plates (vertical) is L and their width (into the page) is b. The separation between them is d and they form a parallel plate capacitor. The lower ends of the plates are very near to the bottom of the tank.



When the liquid fills to a height h it divides the capacitor in two parts one is air filled and the other is liquid filled. As the potential difference applied between the plates is the same for both parts, they are considered as in parallel combination.

The area of the liquid filled part will be h*b and hence its capacitance is given by

$$\left[C = \frac{\epsilon * A}{d}\right]$$

$$C_{liquid} = \frac{\epsilon_0 \epsilon_r\, h\, b}{d}$$

Here ϵ_r is the relative permittivity of the liquid (dielectric constant) and the capacitance of the air filled part will be

$$C_{air} = \frac{\epsilon_0 * (L-h) b}{d}$$

Hence the total capacitance of the combination will be

$$C = C_{liquid} + C_{air} = \frac{\epsilon_0 \epsilon_r * h b}{d} + \frac{\epsilon_0 * (L-h) b}{d} = \frac{\epsilon_0 * b}{d}[\epsilon_r * h + L - h]$$

Or $$C = \frac{\epsilon_0 * b}{d}[(\epsilon_r - 1)h + L]$$

Determining the capacitance and knowing the values of other quantities we can calculate the height of the liquid in the tank using above equation.

****