

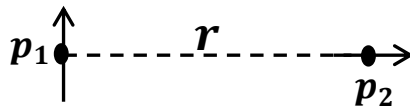
**Department of Physics, Shiv Nadar Institution of Eminence**  
**Spring 2025**  
**PHY102: Introduction to Physics-II**  
**Tutorial – 8**

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1. The statement that “the induced dipole moment of an atom is proportional to the external field” is a “rule of thumb,” and not a fundamental law --- it is easy to concoct exceptions in theory. Suppose, for example, the charge density of the electron cloud were proportional to the distance from the center, out to a radius  $R$ . To what power of  $E = |\mathbf{E}|$  would  $p = |\mathbf{p}|$  be proportional in that case? Here,  $\mathbf{E}$  is the external electric field and  $\mathbf{p}$  is the induced dipole moment.

2. An ideal electric dipole is situated at the origin, and points in the  $z$  direction. An electric charge is released from rest at a point in the  $xy$  plane. Show that it swings back and forth in a semi-circular arc, as though it were a pendulum supported at the origin.

3.  $\mathbf{p}_1$  and  $\mathbf{p}_2$  are (perfect) dipoles a distance  $r$  apart. What is the torque on  $\mathbf{p}_1$  due to  $\mathbf{p}_2$ ? What is the torque on  $\mathbf{p}_2$  due to  $\mathbf{p}_1$ ? In each case, torque refers to the torque on each dipole at its center.



4. A “pure” dipole  $p$  is situated at the origin, pointing in the  $z$ -direction.

(i) What is the force on a point charge  $q$  at  $(a, 0, 0)$  (Cartesian coordinates)

(ii) What is the force on  $q$  at  $(0, 0, a)$ ?

(iii) How much work does it take to move  $q$  from  $(a, 0, 0)$  to  $(0, 0, a)$ ?