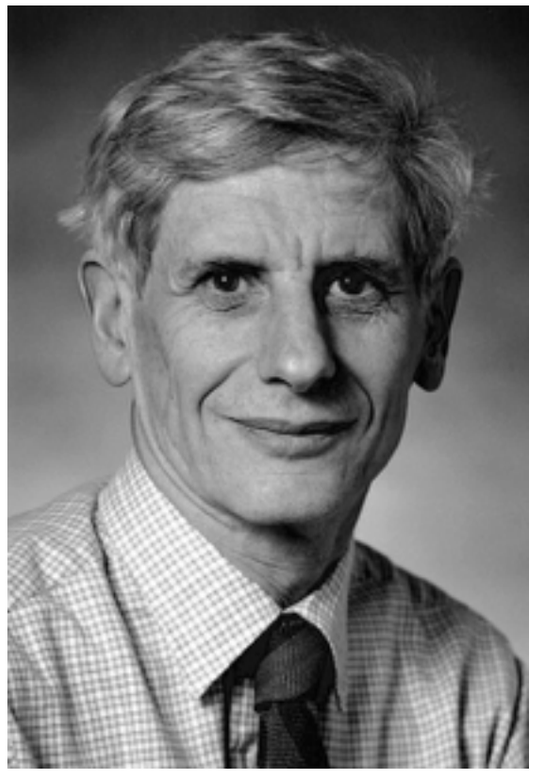
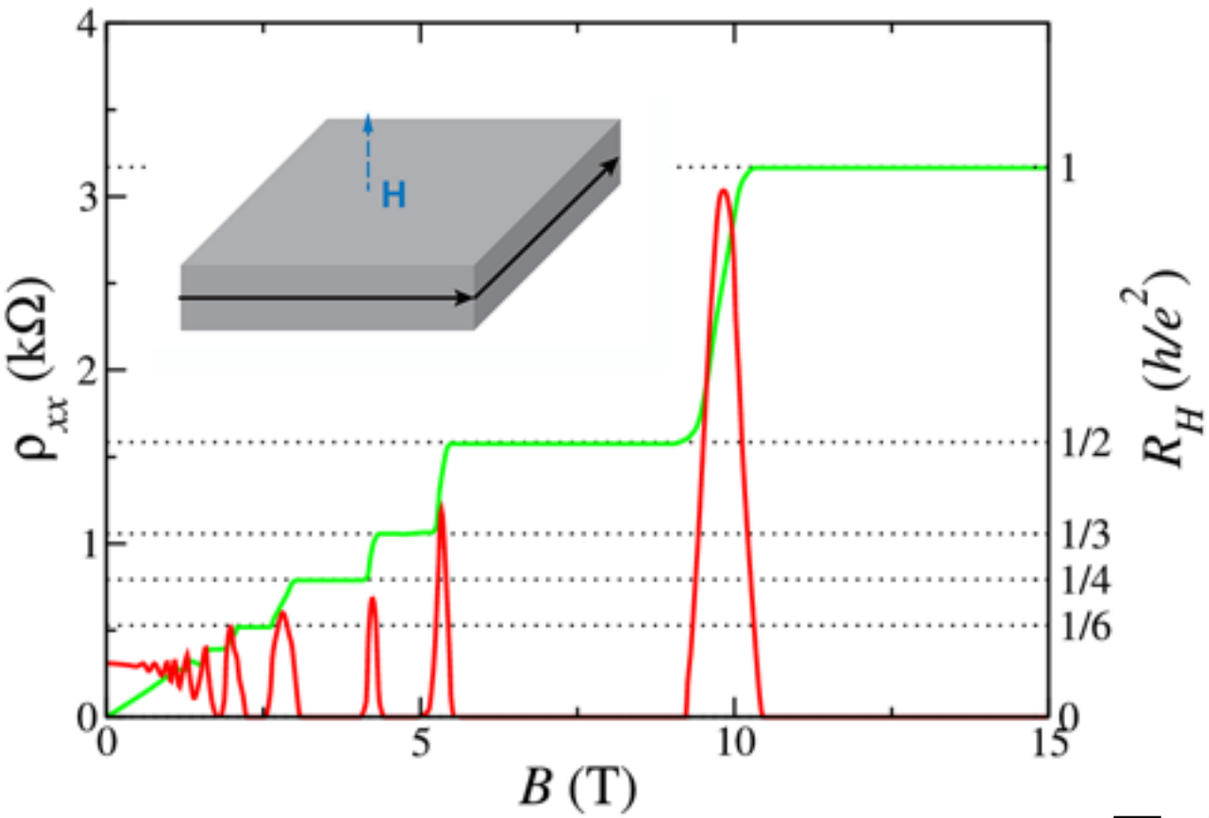
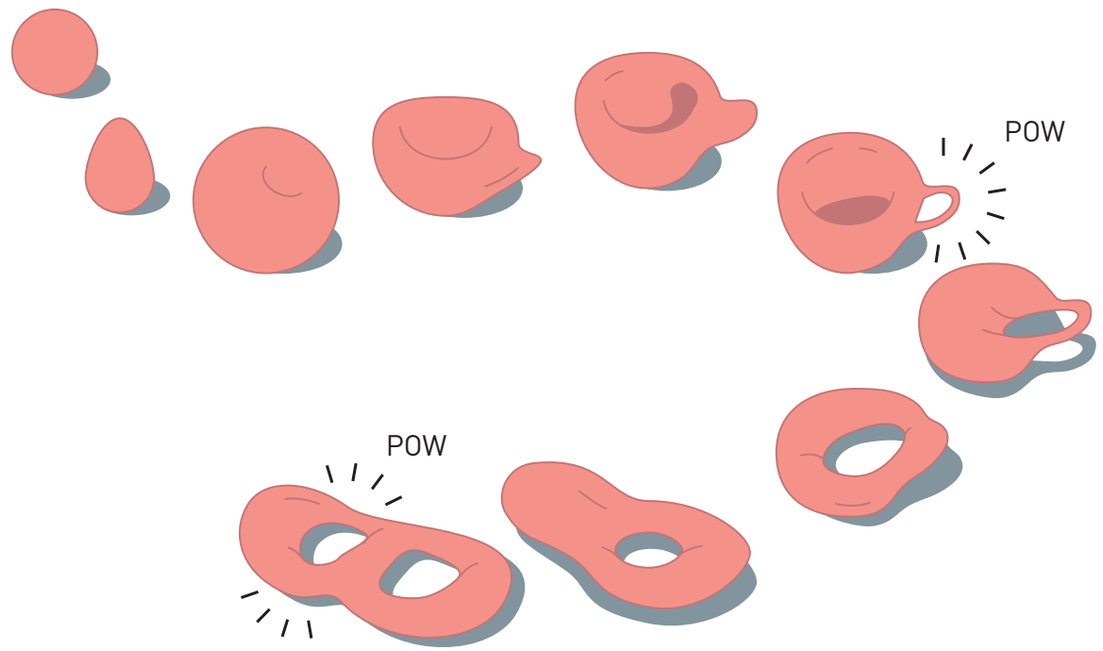
Nobel Prize to UW Physicist!

David J. Thouless



- Quantum Hall Effect: quantized conductivity
- DJT: Topological quantum numbers





Example: genus

Talk more about Hall Effect later…

E field from (more) continuous charge distributions…

Lecture 4.

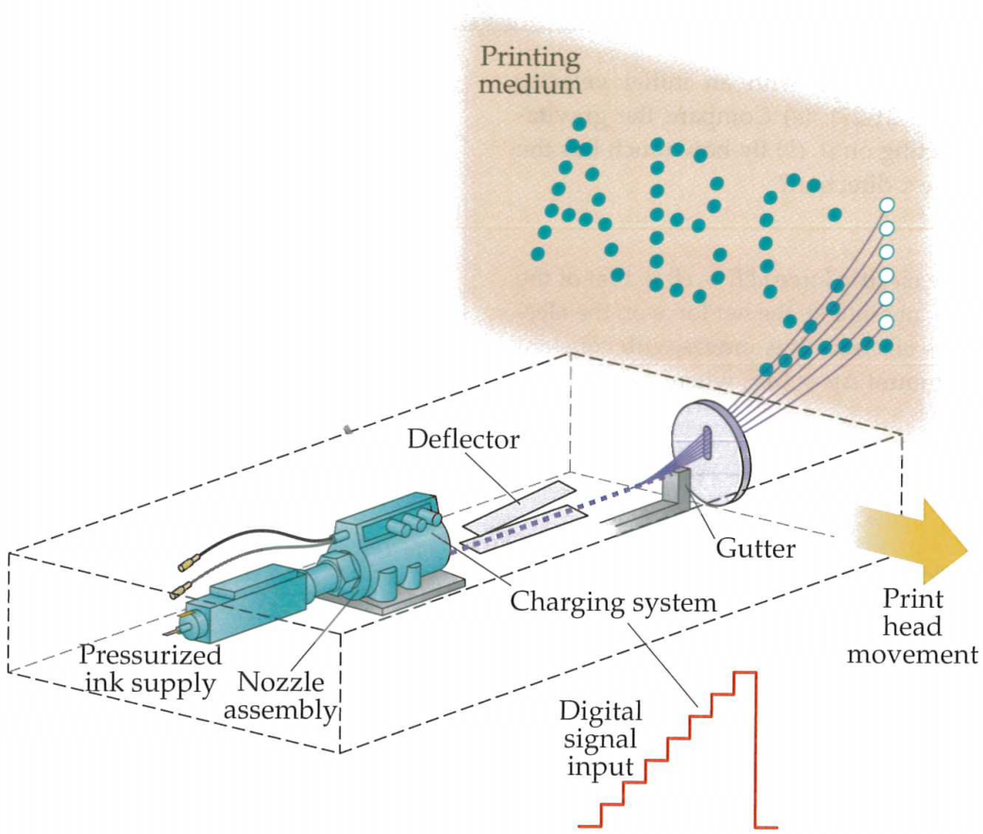
Reading for next time

- 22-2 to 22-3: Flux and Gauss Law

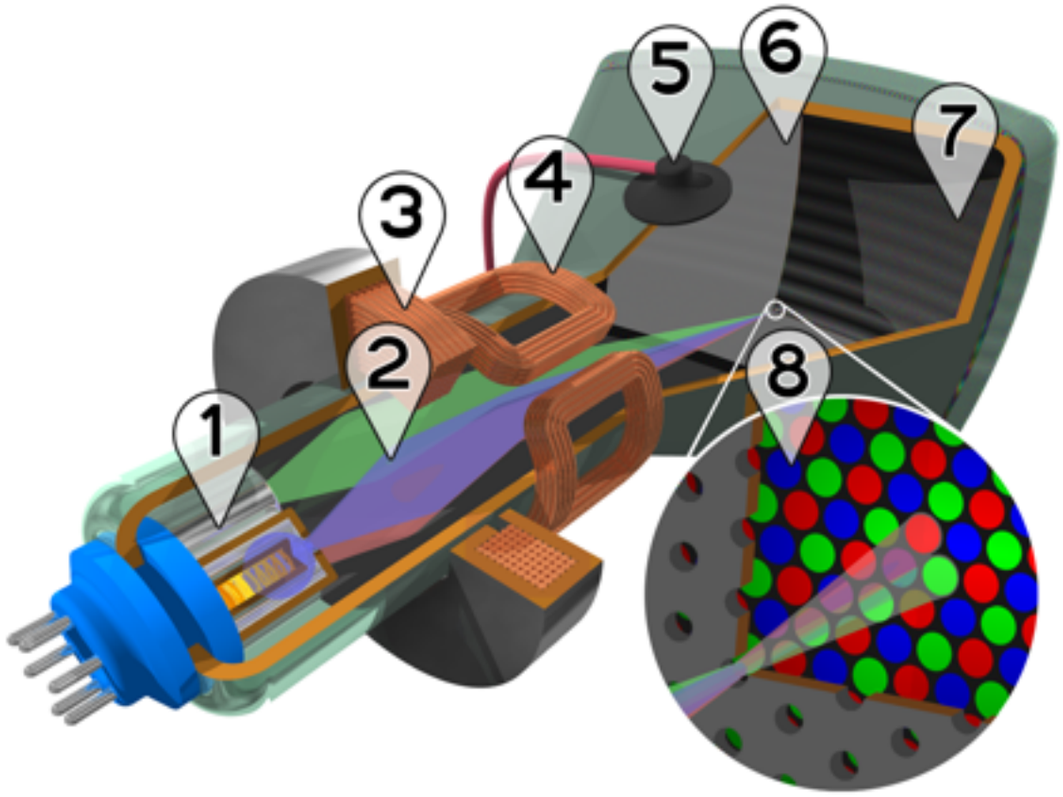
Clicker

Demo: Application of forces generate by the E field

- Use the definition of the Electric field: $\vec{F}_{\mathrm{Net},0} = q_0\vec{E}$



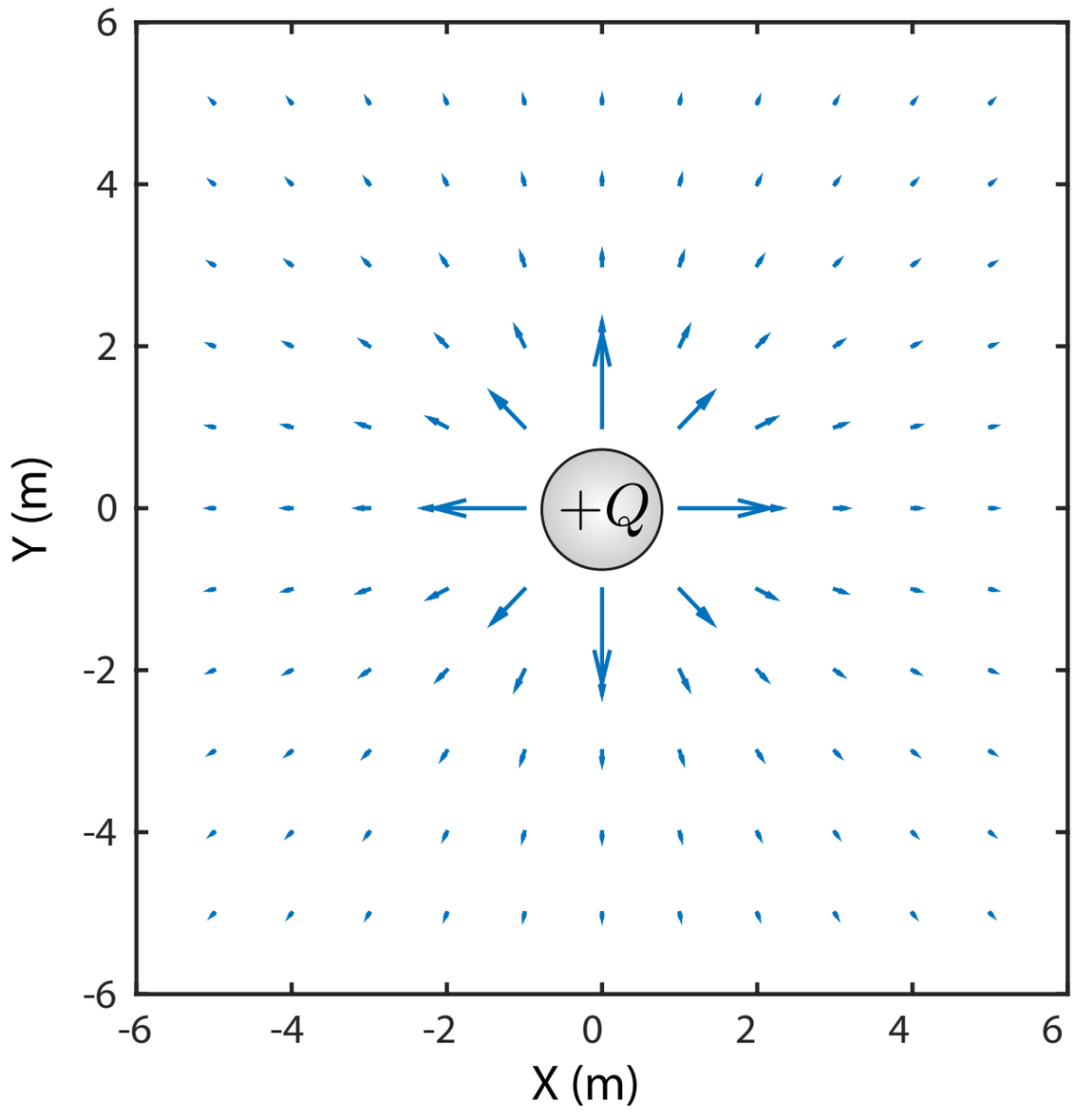
Ink jet printer



Cathode Ray Tube (CRT)

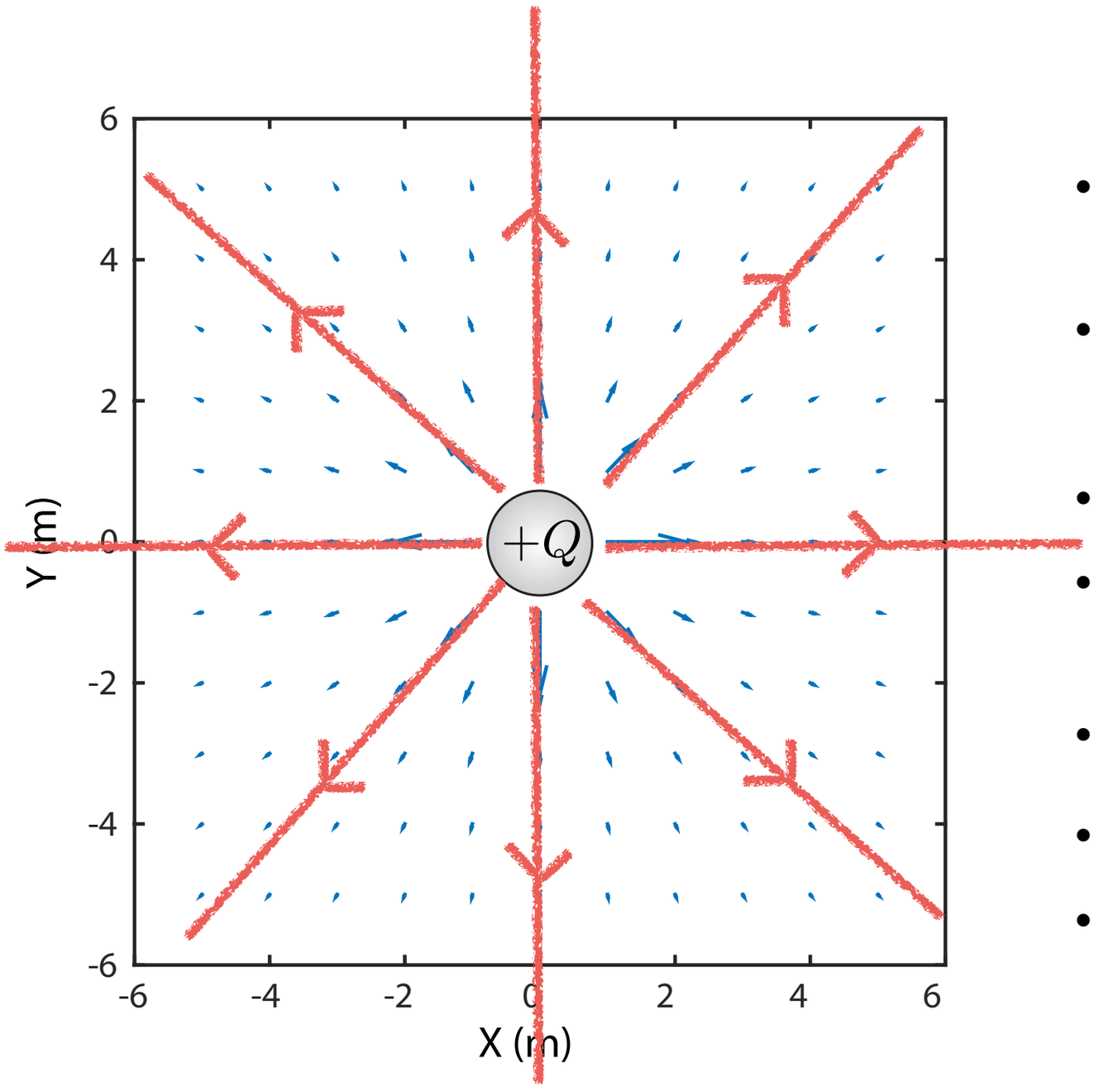
Demos for field lines

E field lines



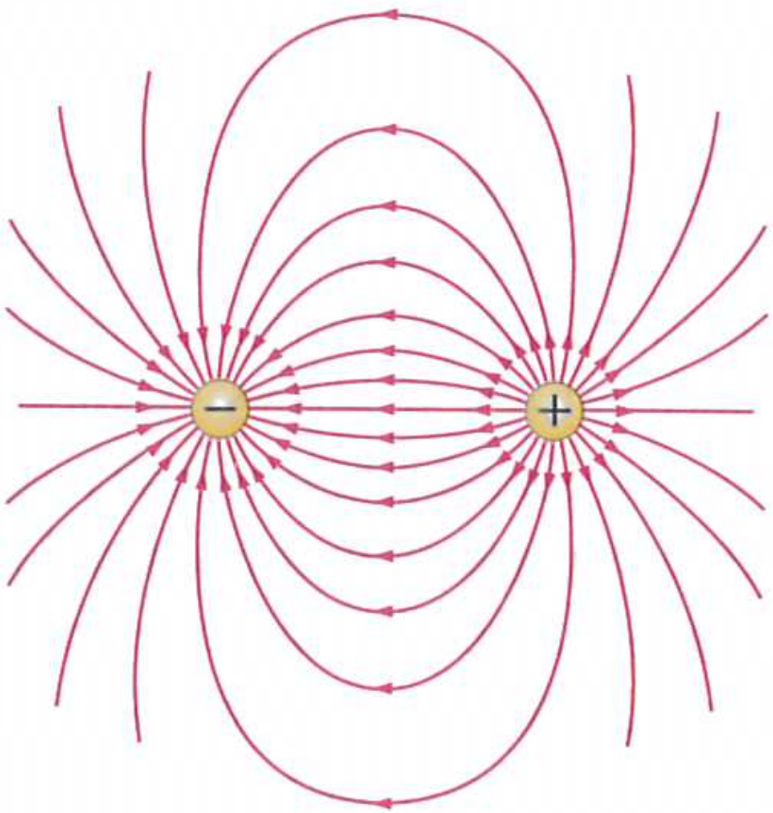
- Lines start/end at +/- charges (or ∞)
- Number of lines starting/ending is ∝ |charge|
- Lines emanating/terminating are uniformly spaced
- Density of lines is ∝ |E|
- Lines are tangent to E field
- Lines are radial and equally spaced →∞

E field lines

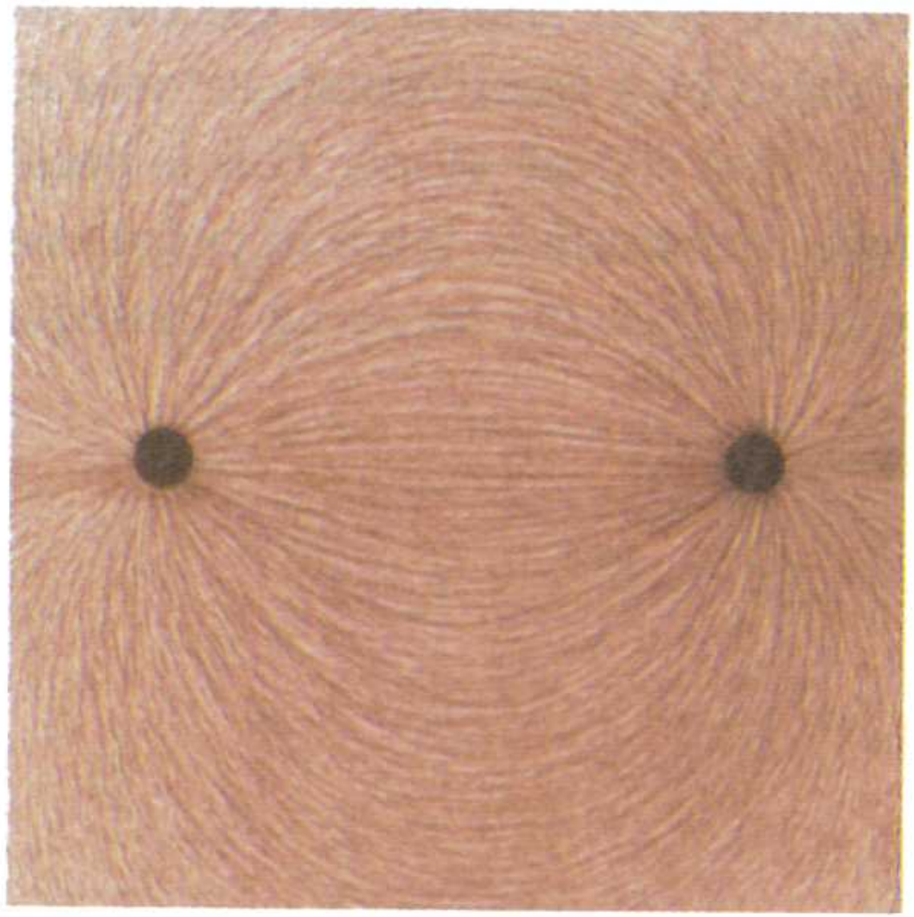


- Lines start/end at +/- charges (or ∞)
- Number of lines starting/ending is ∝ |charge|
- Arrow is the direction of the Field
- Lines emanating/terminating are uniformly spaced
- Density of lines is ∝ |E|
- Lines are tangent to E field
- Lines are radial and equally spaced →∞

Field lines: Opposite charges

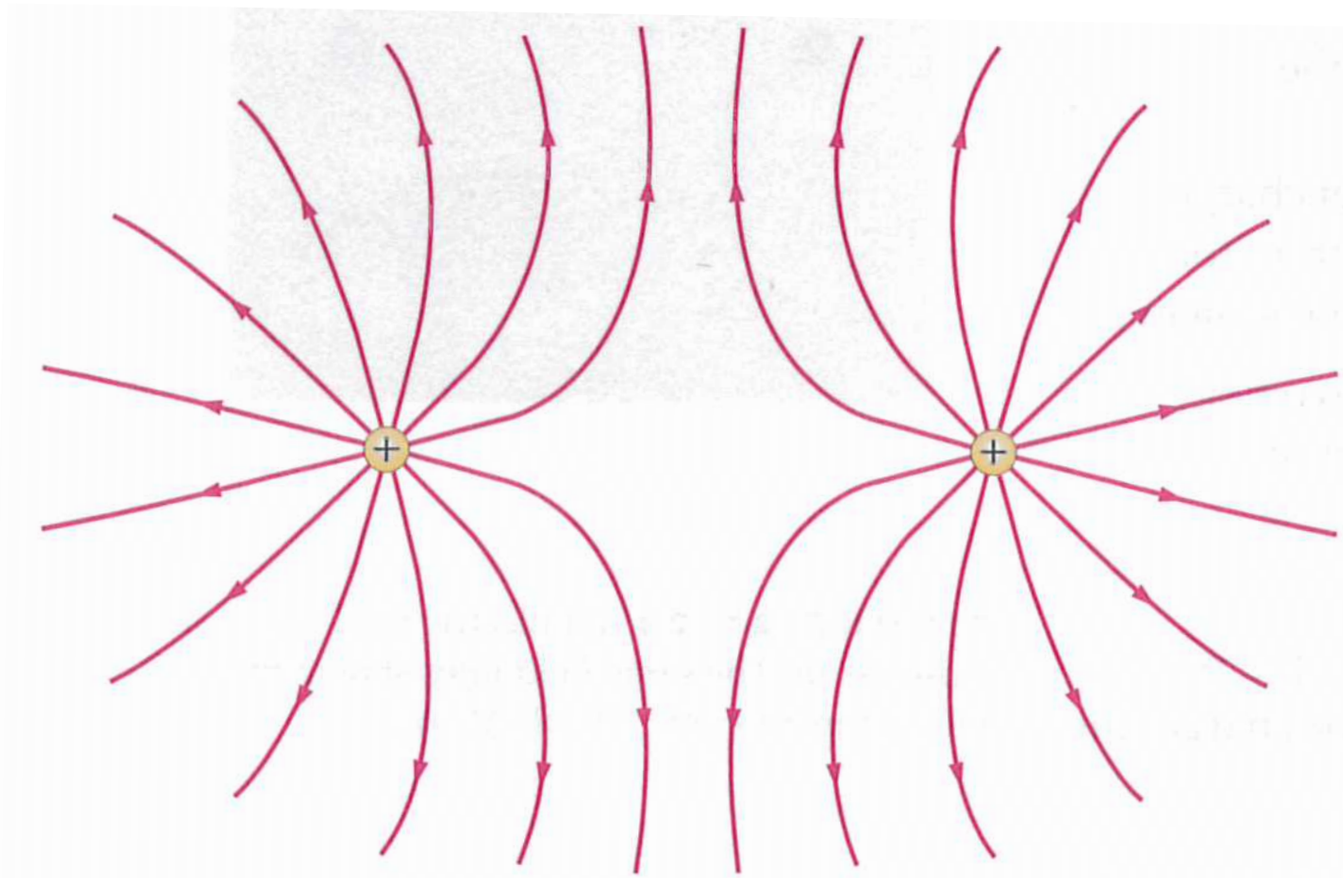


(*a*)

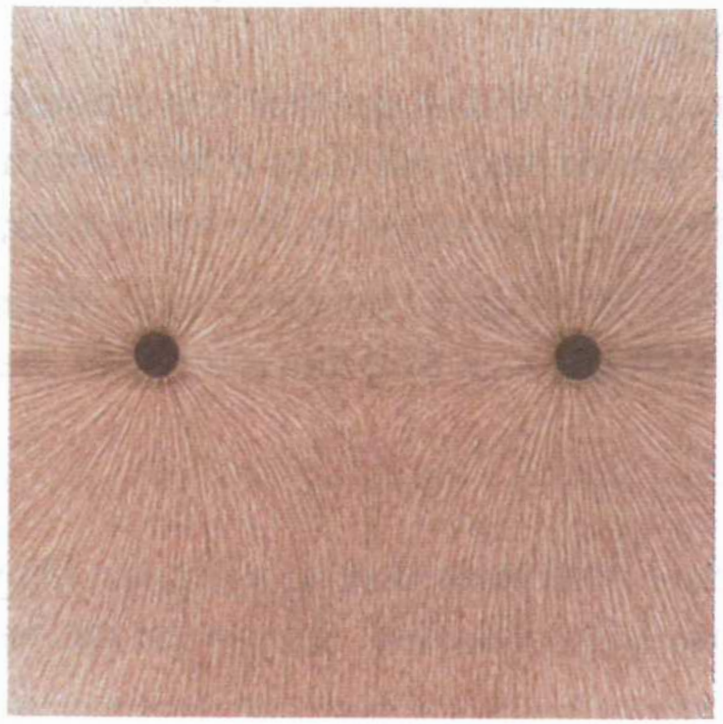


(*b*)

Field lines: Like charges

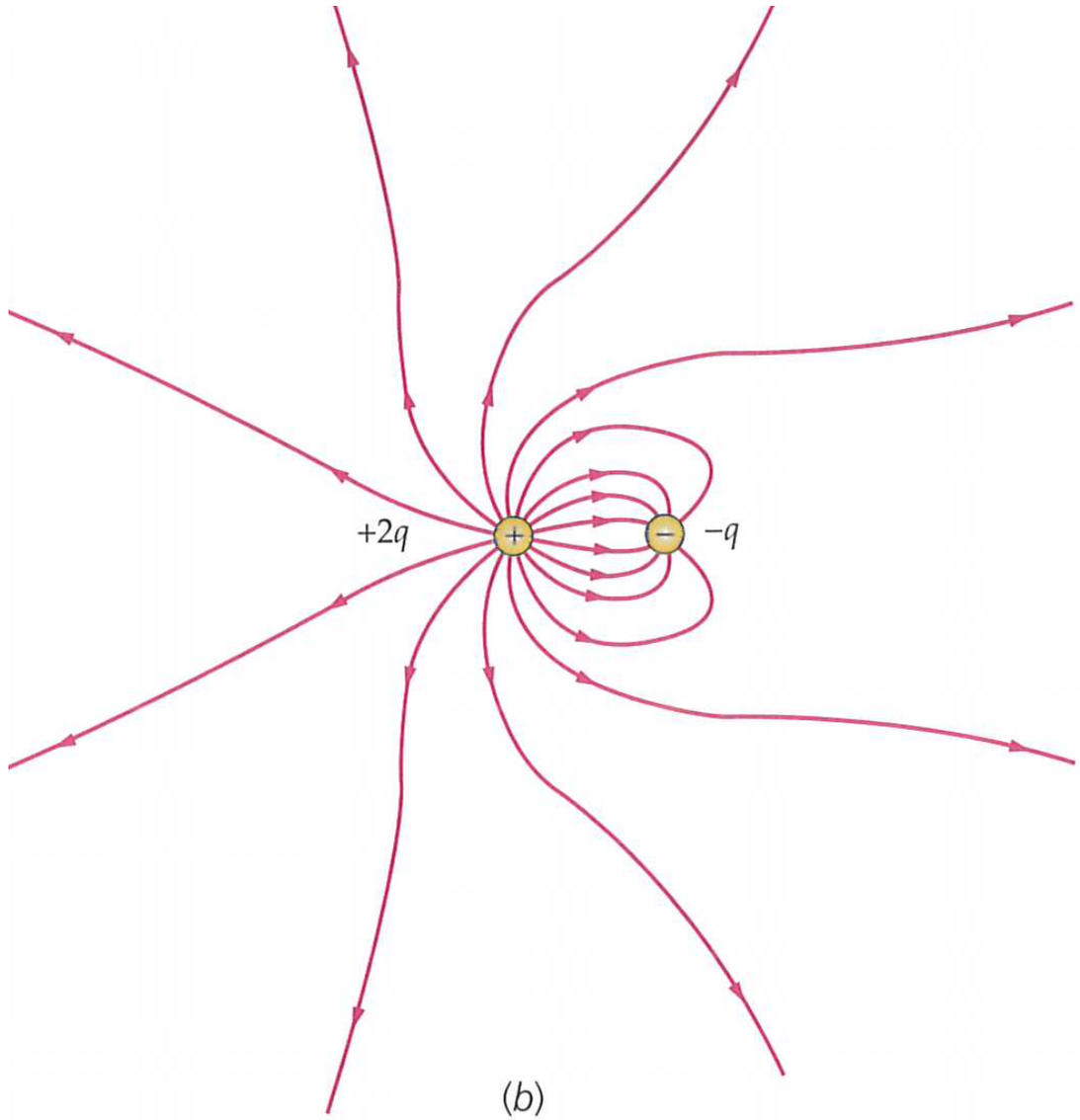


(*a*)



(*b*)

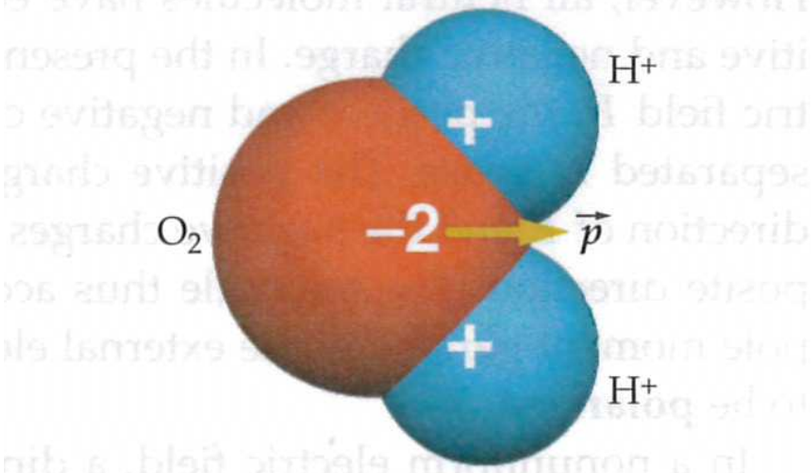
Field lines: Opposite but unequal charges



(*b*)

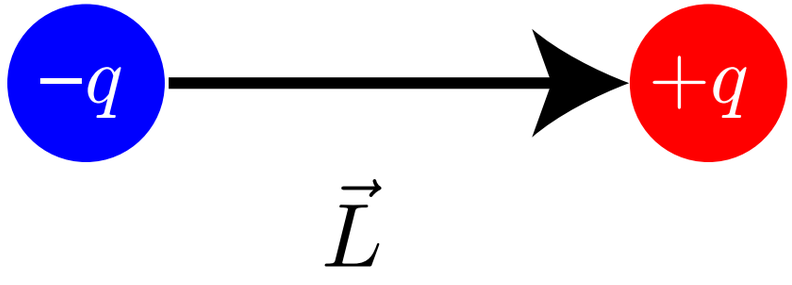
What is a dipole?

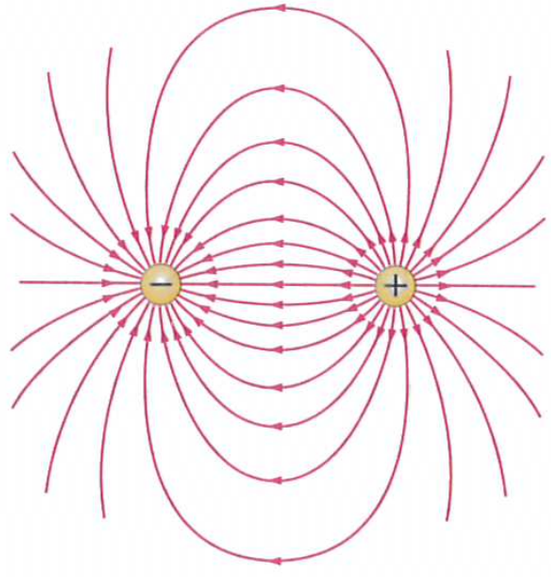
- What happens when a charge distribution has 0 net charge



- Introduce dipole moment:

$$\vec{p} = q\,\vec{L}$$





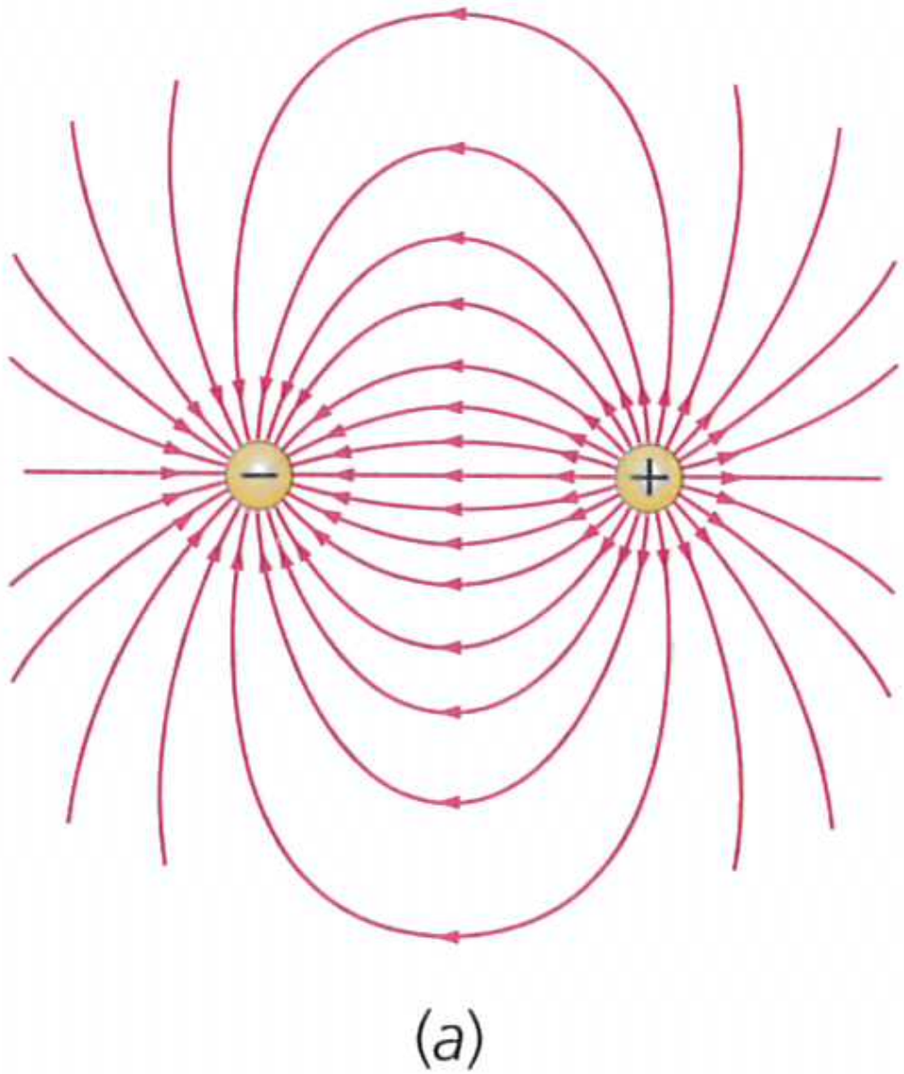
Field from a dipole

- E fields *almost* cancel

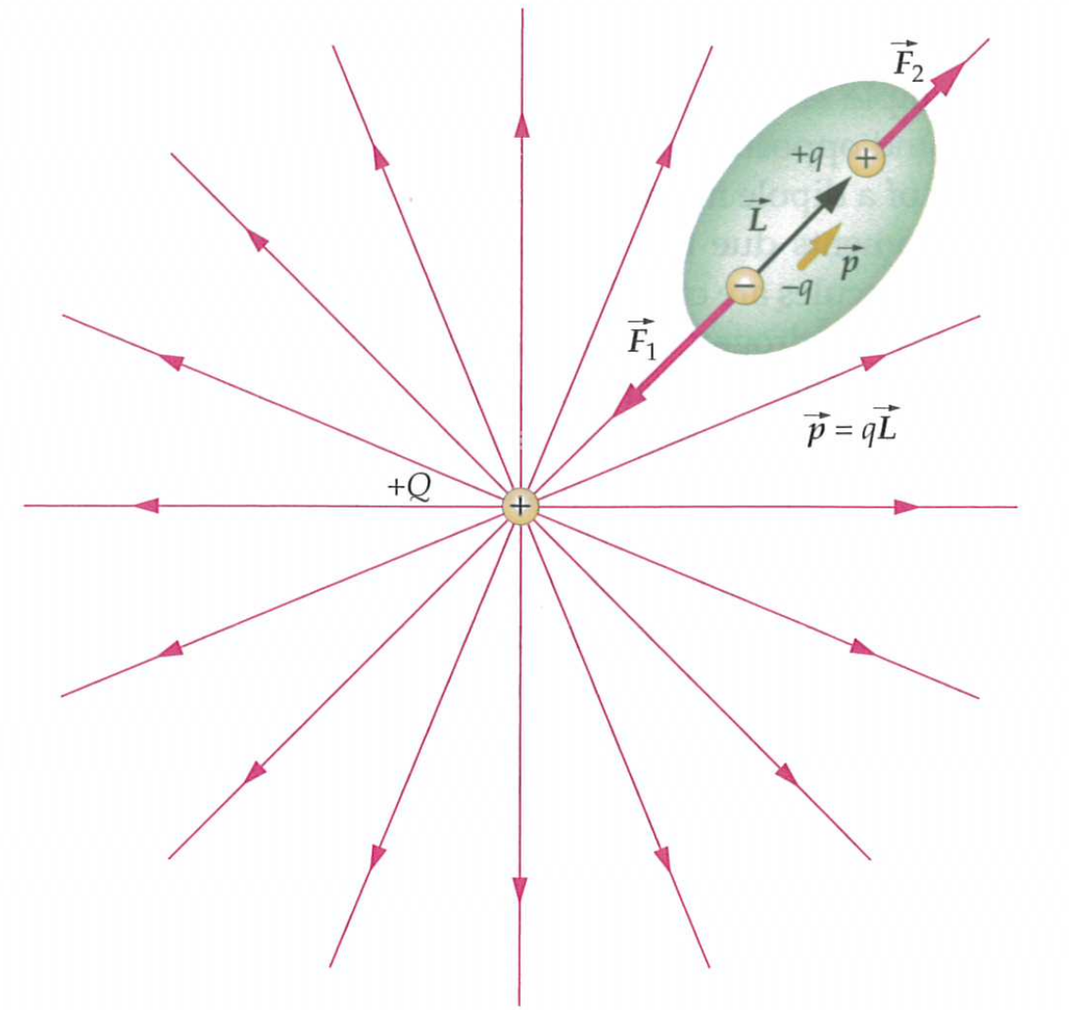
- Derive:

- Result:

$$\vec{E} = \frac{k}{r^3}\left[3\hat{r}(\hat{r}\cdot\vec{p}) - \vec{p}\right]$$

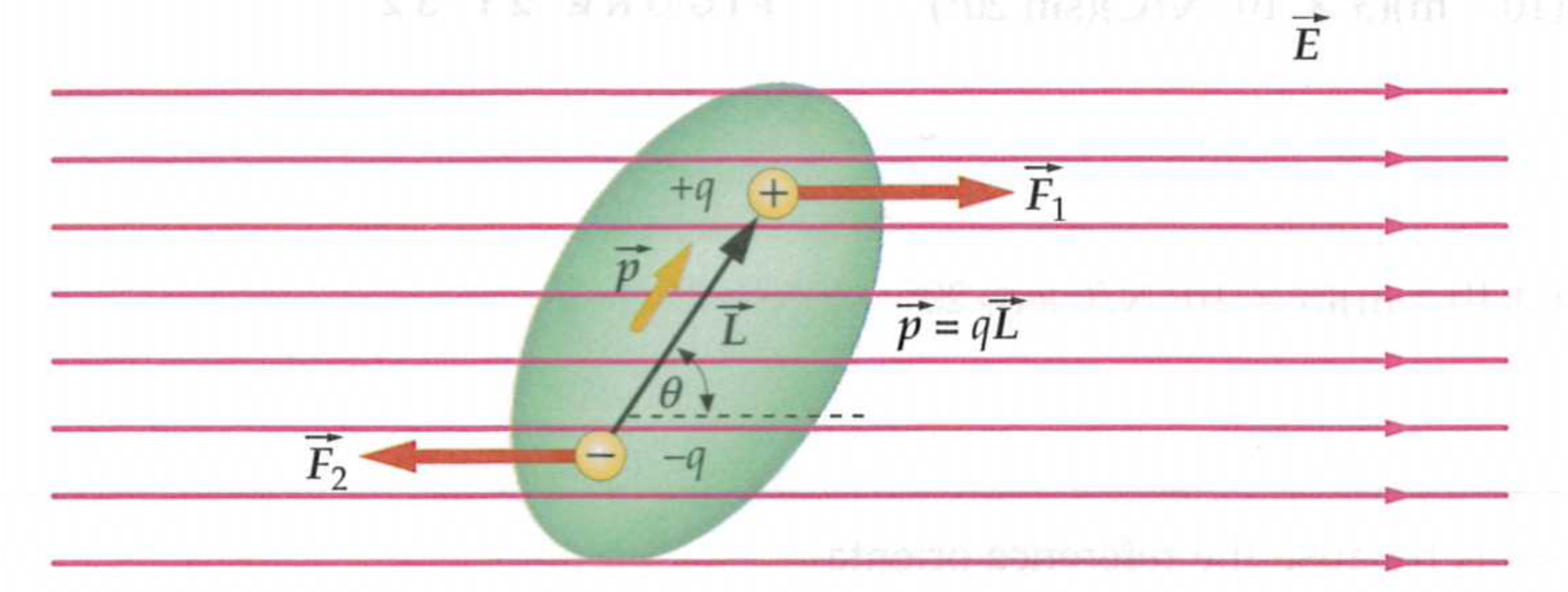


Dipoles feel force in non-uniform fields



- Dimensional analysis

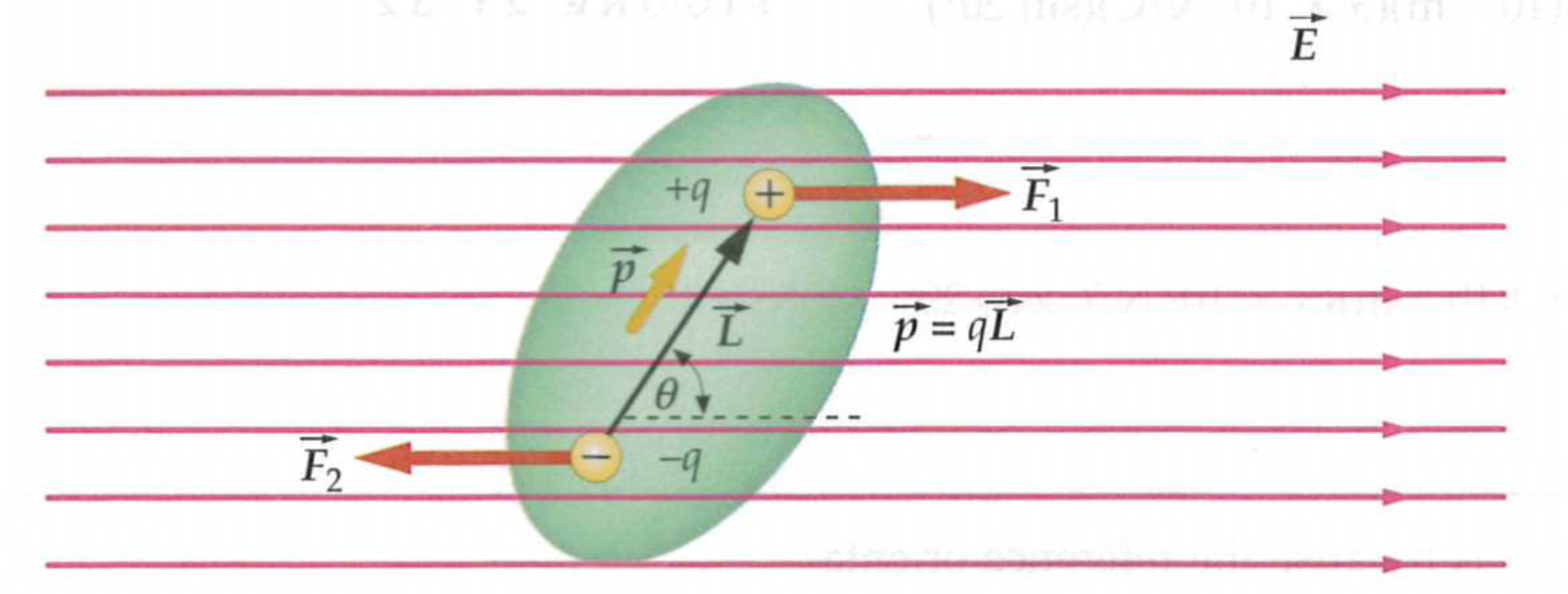
Torque and energy for a dipole in an E field



- Torque: $\vec{\tau} = \vec{r} \times \vec{F}$

- Energy: $dW = -\tau \, d\theta$

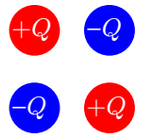
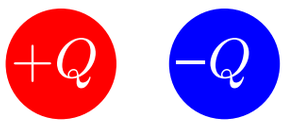
Torque and energy for a dipole in an E field



- Torque: $\vec{\tau} = \vec{p} \times \vec{E}$

- Energy: $W = -\vec{p} \cdot \vec{E}$

Summary of field scaling

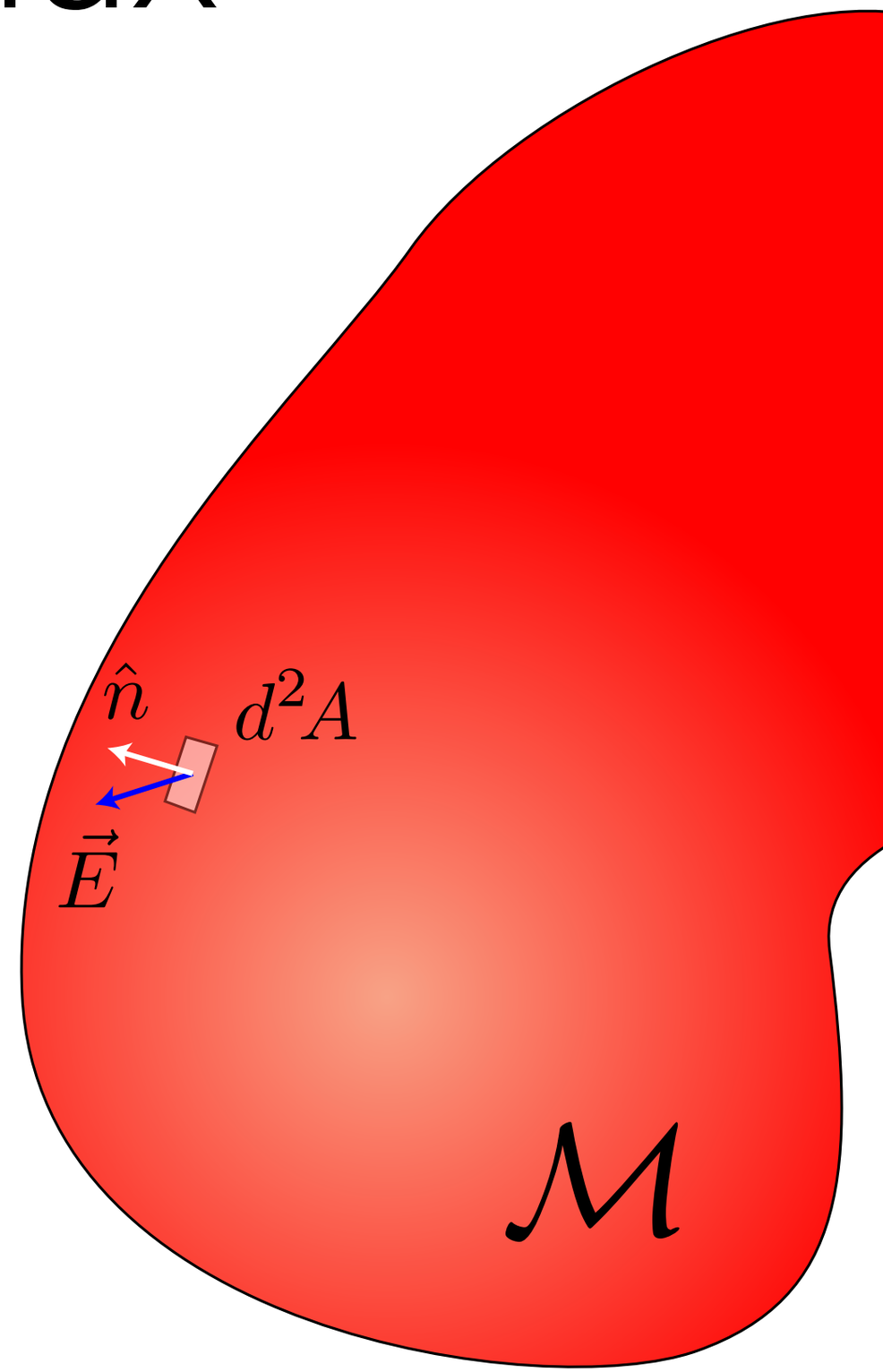
Charge configuration	**Symbol**	**Illustration**	**Asymptotic field**
quadrupole	Q_{ij}		$\propto r^{-4}$
dipole	p_i		$\propto r^{-3}$
point charge	q		$\propto r^{-2}$
line charge	λ		$\propto r^{-1}$
plane charge	σ		$\propto r^{0}$
…			

Electric Flux

- Definition of Electric Flux:

$$\Phi_{\mathcal{M}} = \oint_{\mathcal{M}} d^2A \; \hat{n} \cdot \vec{E}$$

- Meaning of **flux**:
  ~ Number of field lines passing through a surface



How much water is flowing down the Amazon?

Flux: water analogy