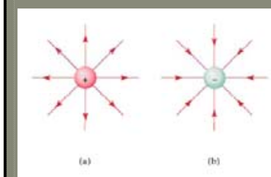
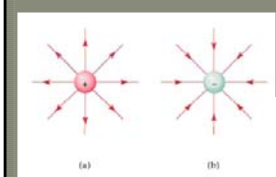
Electrostatics - 5

Field Lines



- Since **E** is a vector, electric fields are vector fields.
- We draw a series of lines to indicate the direction of an electric field at various points in space.

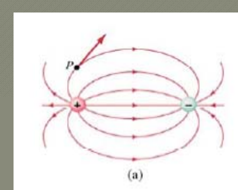
Field Lines



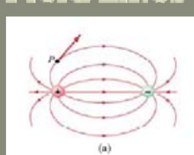
- Each line corresponds to the *lines of force* and is drawn so that they indicate the direction of the force due to the given field on a positive test charge (a).
- The lines point radially outward from a (+) charge and radially inward toward a (–) charge.

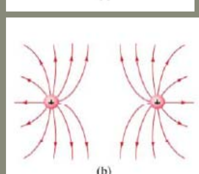
Field Lines – Da Rules

- *1. The number of lines starting on a positive charge or ending on a negative charge is proportional to the magnitude of the charge.*
- *2. The closer the lines are together, the stronger the electric field in that region.*



Field Lines – Stick to the Code

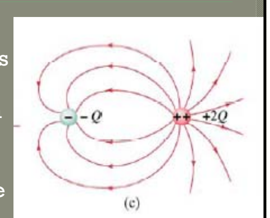




- (a) The electric field lines curve when 2 charges are present. The direction of the field **E** at any point is tangential to the field lines as shown by the arrow at point *P.*
- (b) Like charges repel, so their field lines curve away from one another.

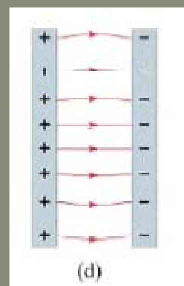
Field Lines – More Like Guidelines

- (c) Opposite charges attract, so their field lines originate on the (+) charge and terminate on the (–) charge.
- Also notice that there are twice as many lines radiating from the $+2Q$ charge as there are entering $-1Q$.



Field Lines – You Cheated!

- (d) The field lines between 2 oppositely charged parallel plates start out perpendicular to the plate and go directly from one plate to another, but fringe a bit at the edges.

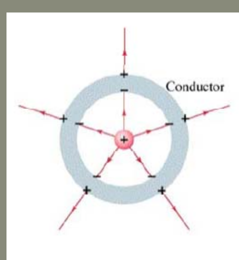


(d)

Electric Fields and Conductors

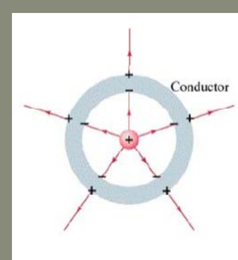
- *The electric field inside a good conductor is zero in the static situation (the charges are at rest).*
- If this were *not true, then the electrons would experience a force since* $\boldsymbol{F} = q\boldsymbol{E}$.
- *An interesting* consequence is that any net charge on a good conductor distributes itself on the *surface* of the conductor.

Electric Fields and Conductors



- Consider a positive charge placed within a metal hollow sphere (the cross-section is shown at left).
- The positive charge placed within attracts the mobile electrons within the metal.
- Since there is no electric field *within the metal itself*, the field lines leaving the (+) charge must *end* on negative charges on the inner surface of the metal sphere.

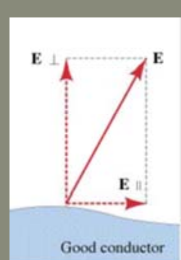
Electric Fields and Conductors



- Now a quantity of charge $-Q$ has been induced on the inner surface, thus an equal quantity of (+) charge $+Q$ *must exist on the outer surface* since the sphere is neutral.
- So, now an electric field exists *outside of the metal* conductor as if the conductor weren't even there!

Electric Fields and Conductors

- The electric field is *always* perpendicular to the surface outside of a conductor.
- *IF* there were a component of ***E*** parallel to the surface, electrons would move along the surface in response to this force until they reached positions where no force was exerted on them
- Which would be until the **E** was parallel to the surface.



Electric Fields and Conductors

- These properties pertain only to *conductors*.
- Inside a *nonconductor* an electric field can exist.
- Nonconductors have no mobile electrons.
- So, the electric field outside a nonconductor does not necessarily make an angle of 90° to the surface