

Gauss' Law: Choice of the Gaussian Surface and Form of the Electric-Field Vector

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Gauss' law is one of the fundamental laws of electromagnetism, which is, primarily, used to determine the electric-field vector, if the system possesses certain symmetries. This is possible, provided a proper gaussian surface is selected, according to the following criteria:

- a) Field point (where the electric-field vector needs to be determined) must lie on the gaussian surface.
- b) It should be a closed surface (well-defined interior and exterior).
- c) It could be a real (coinciding with a physical boundary) or an imaginary surface.
- d) It should be chosen considering symmetries of the system, as suggested by strong Noether's theorem.
- e) Direction of the electric-field vector should either be tangential or normal to any chosen section of surface.
- f) Magnitude of the electric-field vector should be constant throughout each section of surface, allowing one to take it outside the integral.

Examples were worked out for computing electric fields generated by (i) an infinite plane charge sheet, with constant surface-charge density and (ii) an infinite line charge, with constant line-charge density, with special emphasis to determine the form of electric-field vector.

Similarities and differences of electricity and magnetism as well as electricity and gravitation were highlighted. An expression of Gauss' law for gravitation was presented and illustrated with computation of gravitational field inside and outside earth.

In the context of Ampère circuital law, line integral of magnetic flux density is to be computed along a closed curve. Criteria for choosing this curve, to most efficiently determine the magnetic field, were, also, be mentioned.

Keywords: Gauss' law, gaussian surface, strong Noether's theorem, Ampère circuital law, space-time symmetries

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