

Lect. 23; Apr. 23, 2010

①

# Electromagnetic Waves; EM waves (CH 23)  
Described by Maxwell's equations

A set of four equations (in differential form)

①  $\nabla \cdot \vec{D} = \rho$  ----- (1)

$D$ : electric displacement

$\rho$ : density of free electric charges

②  $\nabla \cdot \vec{B} = 0$  ----- (2)

$B$ : magnetic induction

③  $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$  ----- (3)

$E$ : electric field;  $V = E \cdot d$  (voltage)

④  $\nabla \times \vec{H} = \frac{\partial \vec{D}}{\partial t} + \vec{J}$  ----- (4)

$J$ : electric current  $\vec{J} = nq\vec{U}_q$   
 $H$ : magnetic field

# Where do these equations originate? (CH 23.9)

Eq. ① + ② from "Gauss" Law

Eq. ③ from "Faraday's Law"

Eq. ④ from "Ampere's Law"

# Eq. ①: Gauss's Law (1835):

"The electric flux through any closed surface is proportional to the enclosed electric charge."

$$\oint_S \vec{E} \cdot d\vec{s} = \frac{Q}{\epsilon_0}; \quad E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$$

Therefore,  $\oint_S \vec{E} \cdot d\vec{s} = \frac{1}{\epsilon_0} \int_V \rho dV$

using the Divergence Theorem,  $\oint_S \vec{E} \cdot d\vec{s} = \int_V (\nabla \cdot \vec{E}) dV$

$\Rightarrow \nabla \cdot \vec{E} = \frac{\rho}{\epsilon_0}$ , since  $\vec{D} = \epsilon_0 \vec{E}$  in free space

$\Rightarrow \nabla \cdot \vec{D} = \rho$

