Monday Jan 20

Office hours MW 12-2 with a few exceptions during 12-1 and Tu12-3

Problem on the hole in spherical shell of charge:

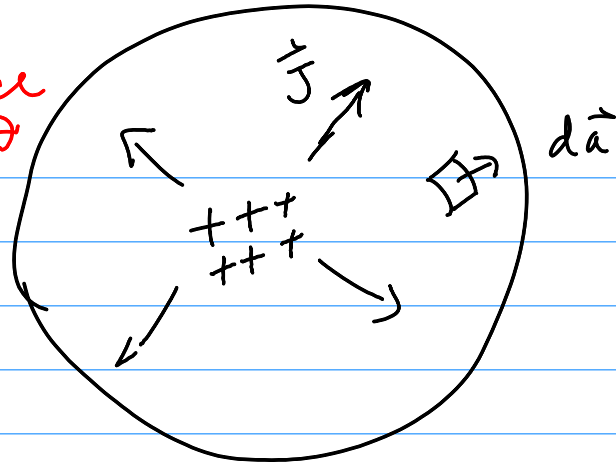
- very close to a surface of a tile it looks like an infinite plane
- the tile in this case is a uniformly charged circle

Questions:

Conservation of charge continued.

by this surface

$$\oint \vec{J} \cdot d\vec{a} = -\frac{dQ_{enclosed}}{dt}$$



$$Q_{enclosed} = \int \rho \, d\,volume$$

$$d\,volume = dx\,dy\,dz \text{ or } r^2 \sin\theta \, d\theta \, d\phi \, dr$$

$$-\frac{dQ_{enclosed}}{dt} = \int -\frac{\partial \rho}{\partial t} dx\,dy\,dz$$

$$//$$

$$\oint \vec{J} \cdot d\vec{a} = \int \vec{\nabla} \cdot \vec{J} \, dx\,dy\,dz \quad \text{Divergence theorem}$$

Differential form of conservation of charge is

$$\boxed{\vec{\nabla} \cdot \vec{J} = -\frac{\partial \rho}{\partial t}}$$

Also called the CONTINUITY EQUATION

http://en.wikipedia.org/wiki/Continuity_equation

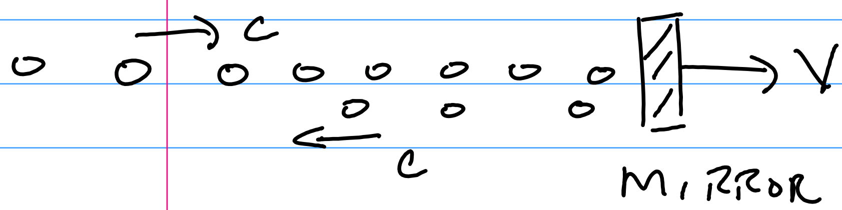
this link gives examples for 4-current in special relativity, fluid dynamics, thermodynamics, quantum mechanics, general relativity, quantum chromodynamics

traffic flow continuity equation

SEE THE REFERENCE ON THE WIKI ABOUT CONSERVATION LAWS IN TRAFFIC FLOW

Example: conservation of photons in a laser beam reflecting from a moving mirror

Photons reflecting as a stream of particles 1-D



$$\vec{J}_{in} = \rho_{in} \vec{v}_{in} \rightarrow \lambda_{in} c$$

$$J_{reflected} = \rho_{ref} \vec{v}_{ref} \rightarrow \lambda_{ref} c$$

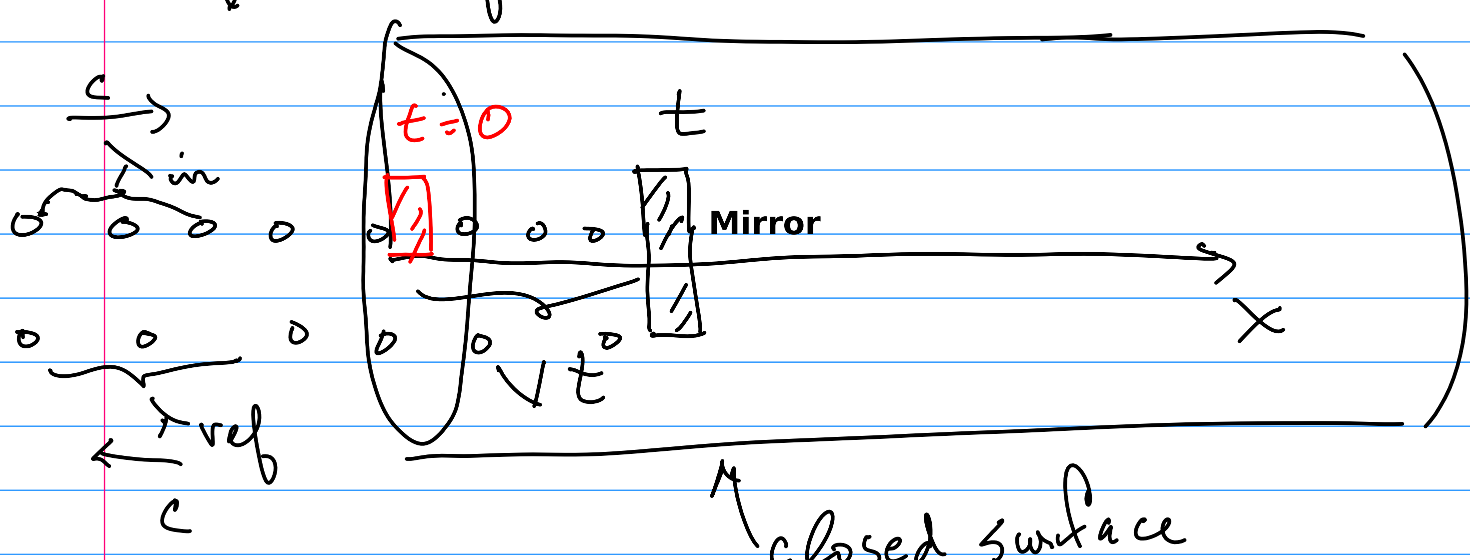
Model

$$\vec{J}_{in} = \lambda_{in} c \hat{x}$$

$$\vec{J}_{ref} = -\lambda_{ref} c \hat{x}$$

Reality

$$10^{14} \frac{\text{photons}}{\text{sec}} \pm \sqrt{10^{14}}$$



Conservation eqn ?

$$\boxed{\vec{\nabla} \cdot \vec{J} = -\frac{\partial \rho}{\partial t}}$$

$$\oint \vec{J} \cdot d\vec{a} = -\frac{dQ_{enclosed}}{dt}$$

$\vec{J} = \lambda v \hat{x}$

not charge but photons

What is $Q_{enclosed}$?