

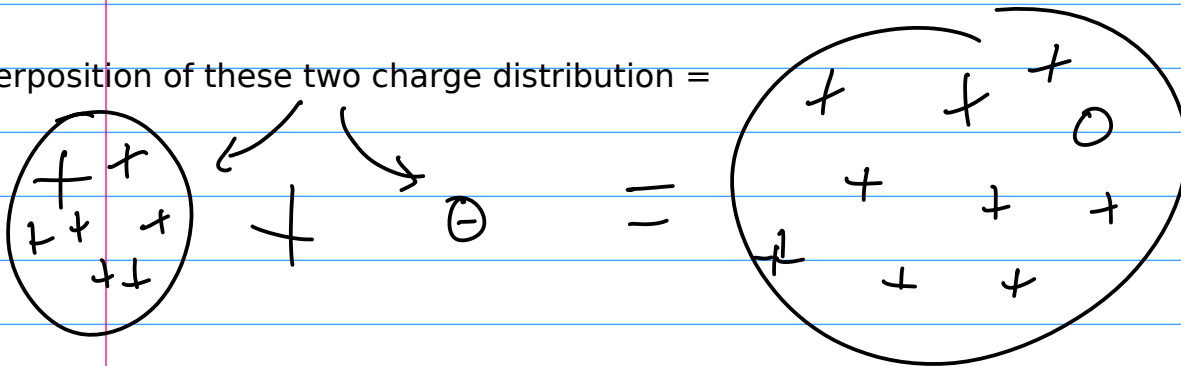
Monday Jan 20

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

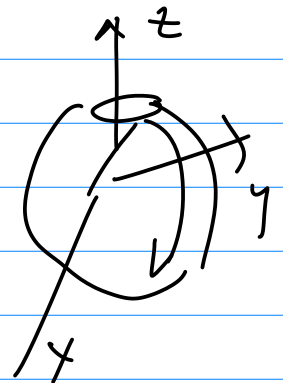
superposition of these two charge distribution =



Solve the problem by integration or using Gauss's law

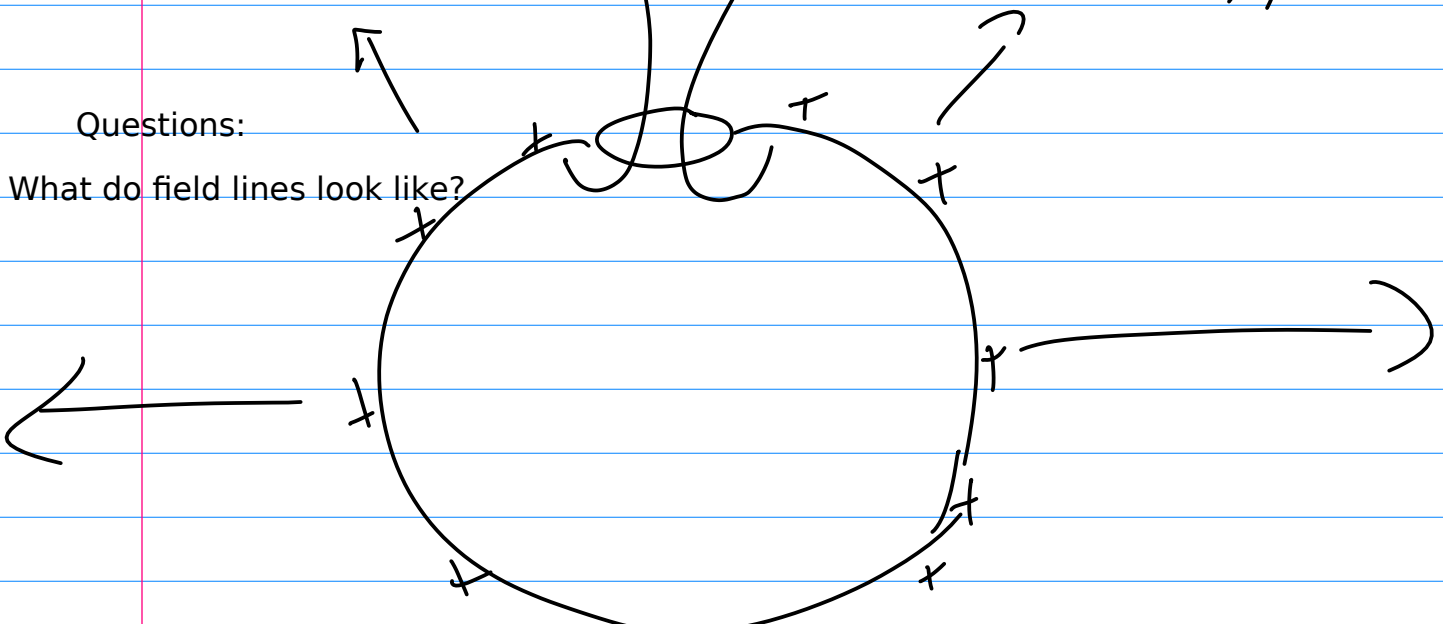
$$\vec{E} = \int d\vec{E} = \int k \frac{dQ}{r^2} \hat{r}$$

limit $\theta = \theta_{in} \rightarrow \pi$



Questions:

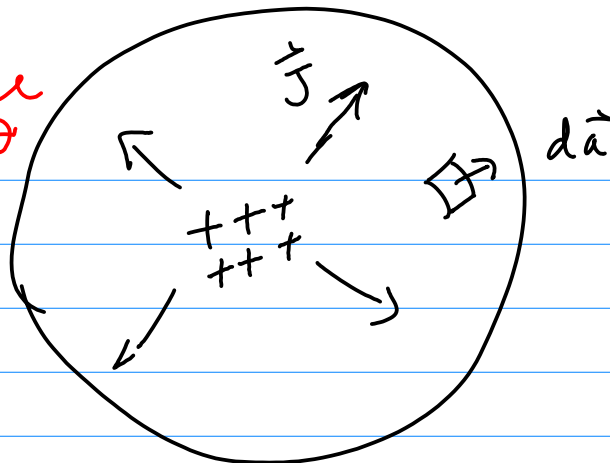
What do field lines look like?



Conservation of charge continued.

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

by this surface



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

" $dx dy dz$ or $r^2 \sin \theta \, d\theta \, d\phi \, dr$

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

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

Differential form of conservation of charge is

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

Also called the CONTINUITY EQUATION

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

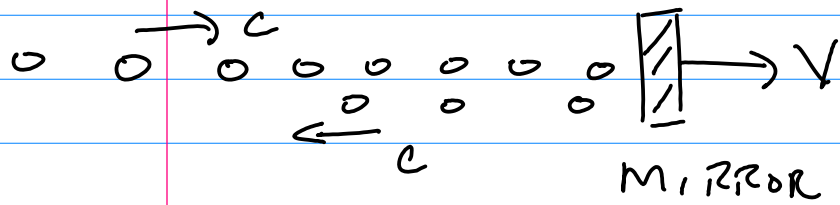
this link gives examples for 4-current in special relativity, fluid dynamics, thermodynamics, quantum mechanics, general relativity, quantum chromodynamics

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



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

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

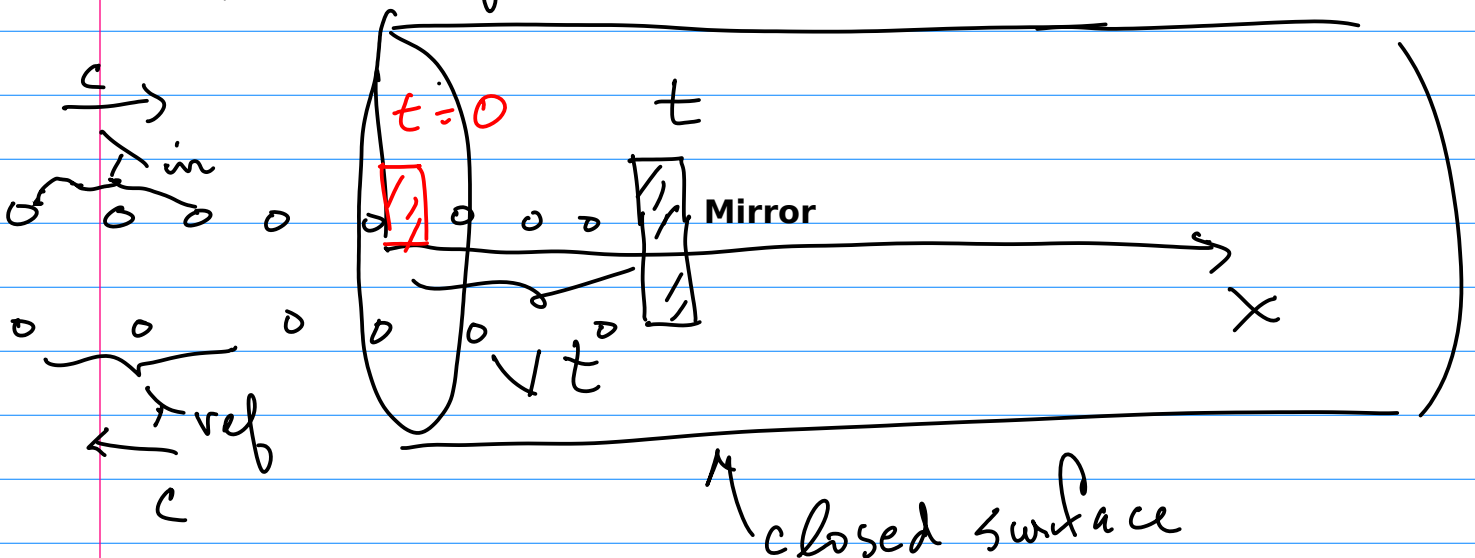
Model

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

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

Reality

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



Conservation eqn?

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

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

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

What is Q_{enclosed} ? ← not charge but photons

$$\lambda_{\text{in}} c - \lambda_{\text{ref}} c = \frac{d}{dt} (\text{Particle \#})$$

? $\lambda_{\text{in}} vt + \lambda_{\text{ref}} vt$