# Physics 142 - Sept. 16, 2008

- Class will NOT meet Thursday (Sept. 18, 2008)
- Turn P.S. in Following Tuesday
- I will post Thursday's lecture slides and an accompanying mp3 audio file on the class website
- Download the slides and page thru them as you listen to the audio.

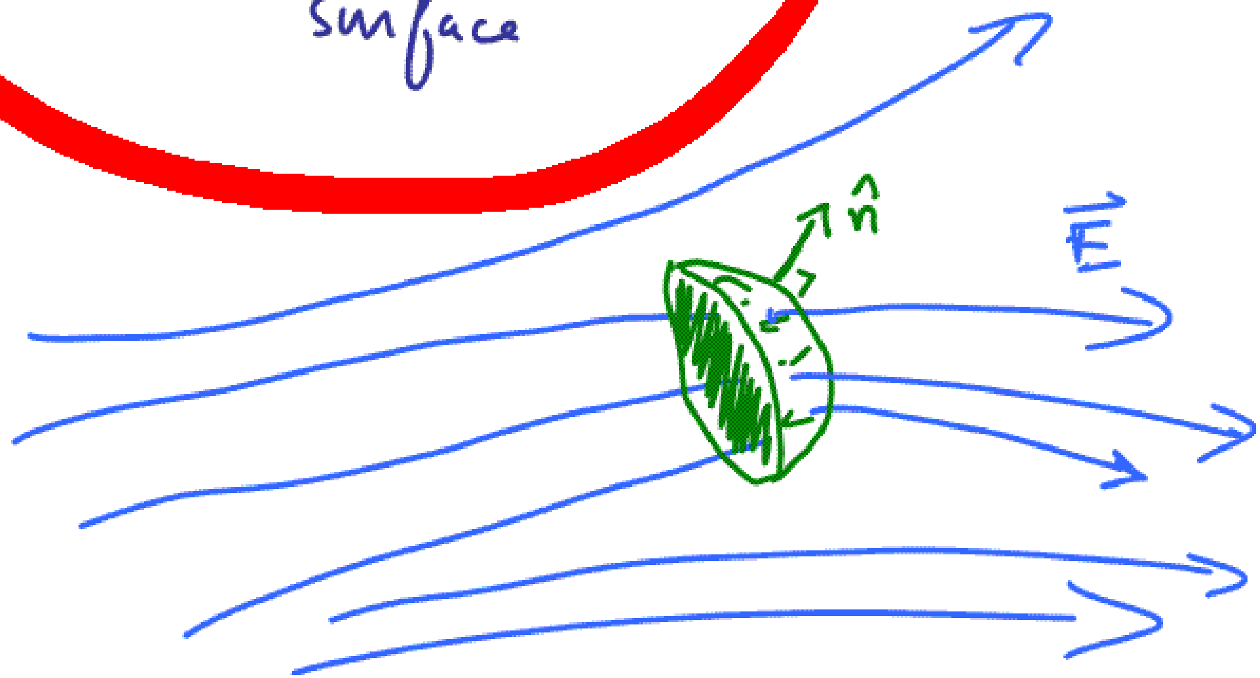
  Email me w/ questions
- I will assume that you did this just as I assume you are present for a normal lecture.

# Last Time

## Electric Flux

$$\Phi_{surf} = \int_{surface} \vec{E} \cdot d\vec{A}$$

($d\vec{A} = \hat{n}\, dA$)



# Gauss' Law

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{encl}}{\epsilon_0}$$

True in general

integral over volume inside gaussian surface (NOT necessarily all charge)

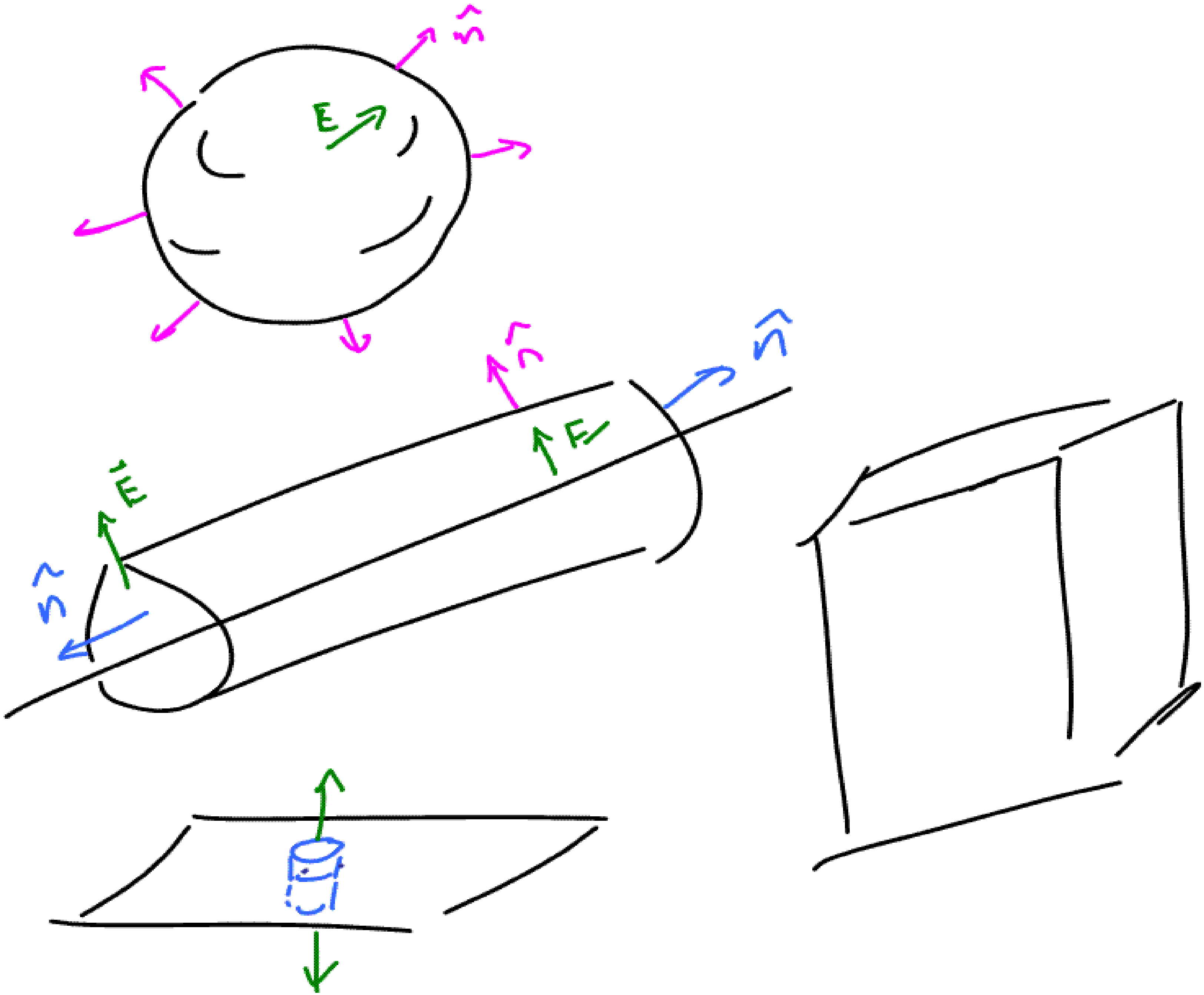
$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$$

$\int_V \rho \, dv$

integral over Gaussian surface

Easy if $\vec{E} \perp d\vec{A}$ or $\vec{E} \parallel d\vec{A}$

Easy if $|\vec{E}|$ is constant on surface – can pull out of integral


n̂
E
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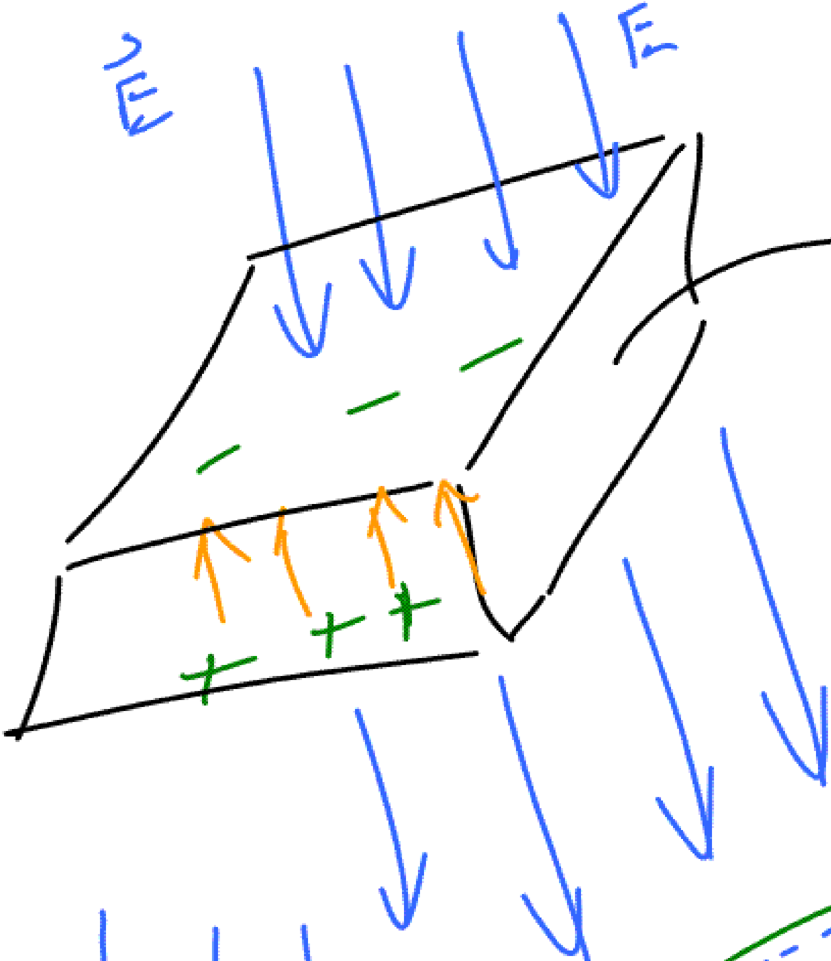
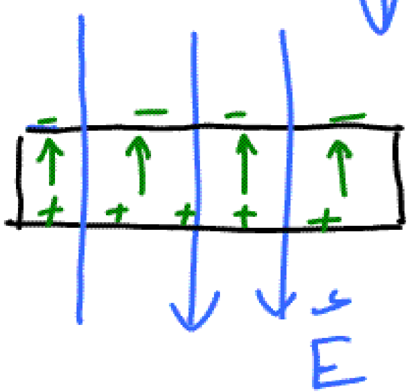
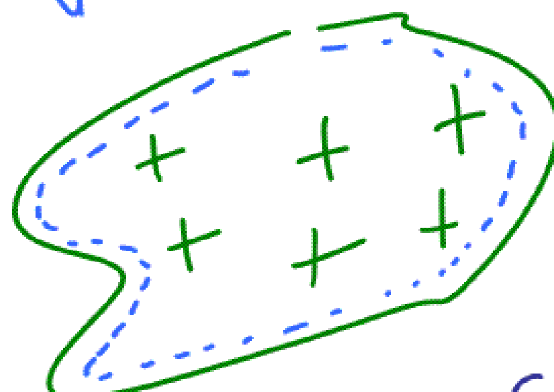



$\vec{E}_{\text{inside conductor}} = 0$

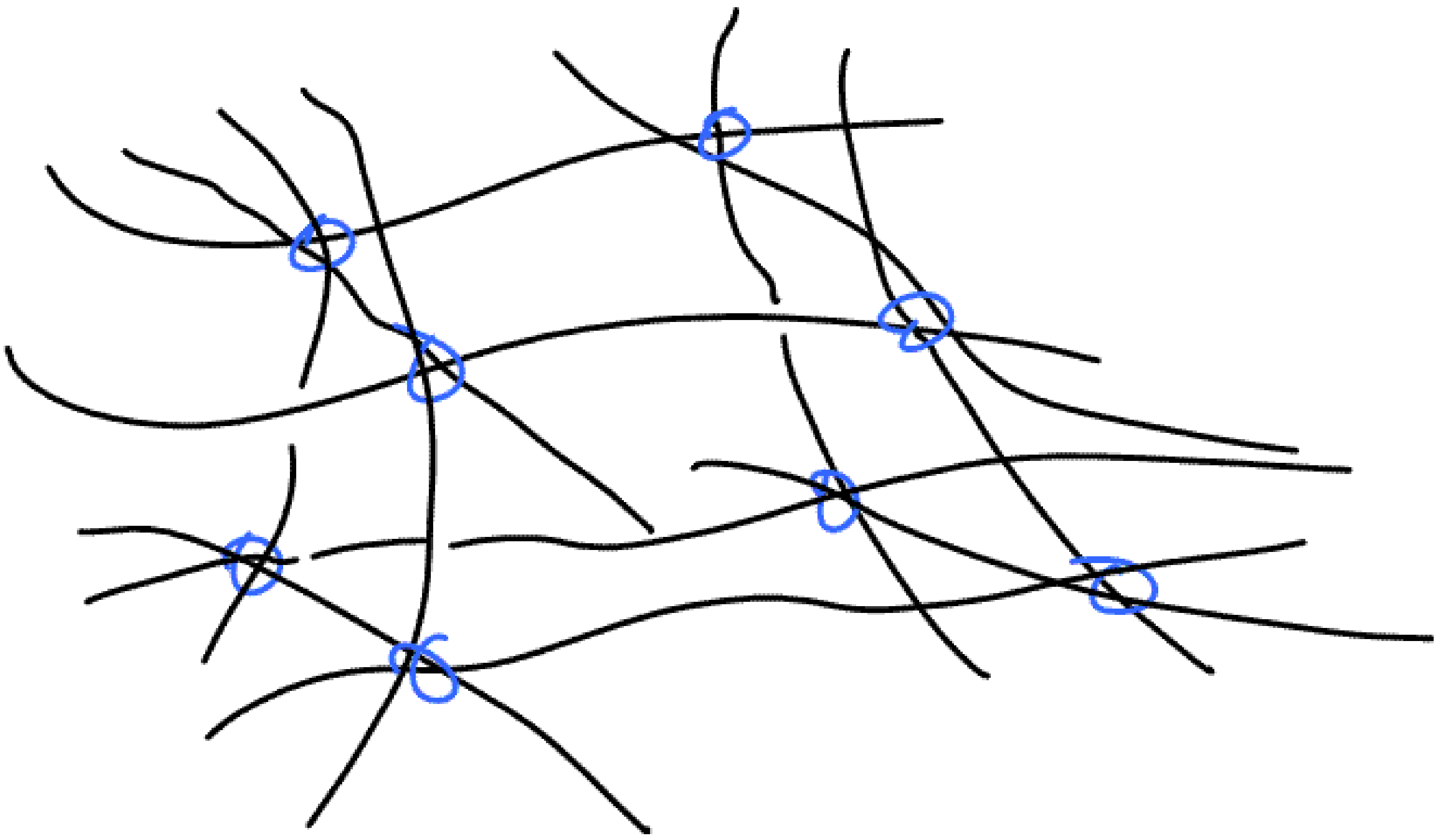
$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0} = 0$$

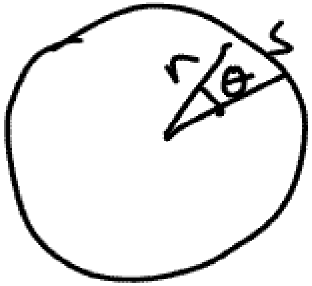


charge resides on surface of conductor

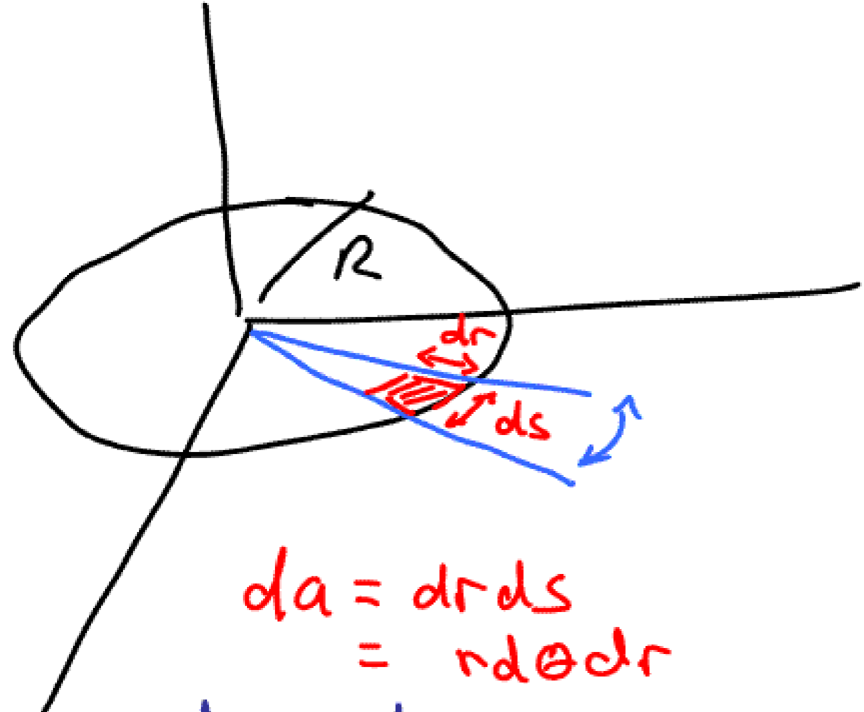
# Curvilinear Coordinate System






$S = r\theta$

Find Area of Circular disk




$da = dr\,ds$
$= r\,d\theta\,dr$

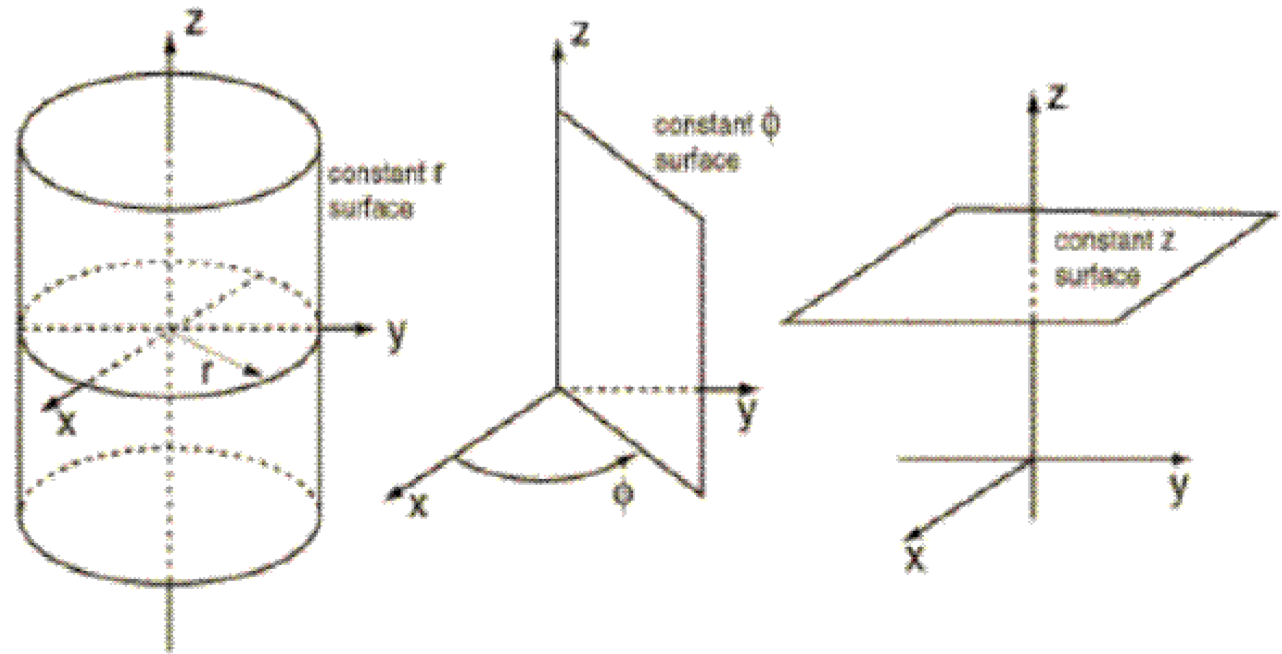
$ds = r\,d\theta$

$$\text{Area} = \int da = \int_0^R \int_0^{2\pi} r\,d\theta\,dr$$

$$= \int_0^R r\,dr \int_0^{2\pi} d\theta = \int_0^R r\,dr\,(2\pi)$$

$$\frac{R^2}{2} 2\pi = \pi R^2$$

# cylindrical coordinates

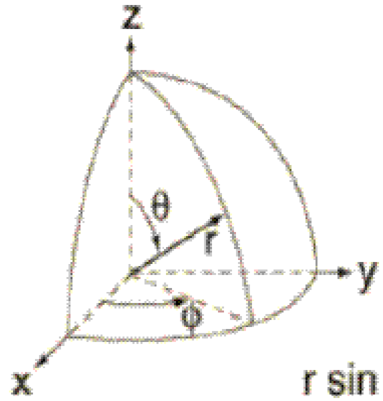



Some figures in this section from:

http://hyperphysics.phy-astr.gsu.edu/hbase/sphc.html

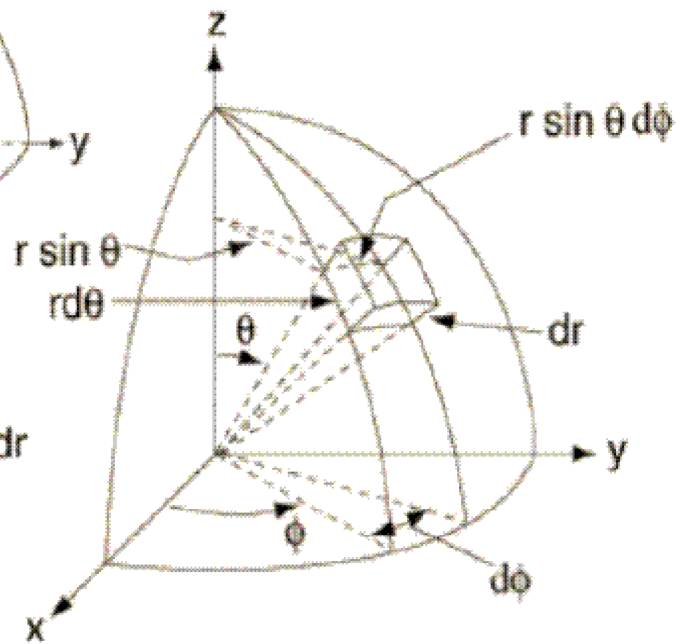
Also Griffiths, Intro to Electromagnetism

# Spherical polar coordinates

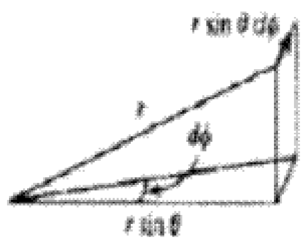



Volume element

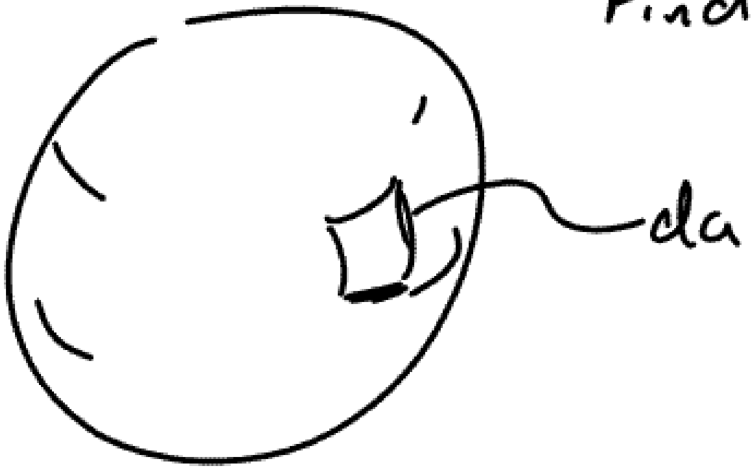
$dV = r^2 \sin\theta \, d\theta \, d\phi \, dr$




$$dl_\phi = r \sin\theta \, d\phi.$$



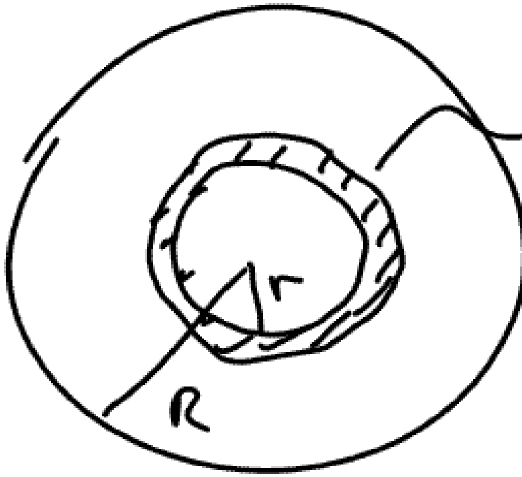
# Find Area of Sphere




$$\text{Area} = \int da = \int_0^{\pi}\int_0^{2\pi} r^2 \sin\theta \, d\theta \, d\phi$$

$$= r^2 \, 2\pi \underbrace{\int_0^{\pi} \sin\theta \, d\theta}_{2} = 4\pi r^2$$

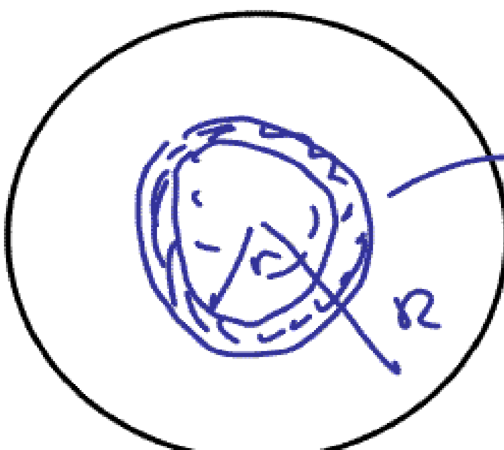
Area of circle as 1-d integral




$da = 2\pi r\,dr$

$$\int_0^R 2\pi r\,dr = \pi r^2$$

Vol of sphere




Shell

$dv = 4\pi r^2 dr$

$$\text{Vol sph} = \int_0^R dv = \int_0^R 4\pi r^2 dr = \frac{4}{3}\pi R^3$$


$\rho = k r^3 \quad r < R$

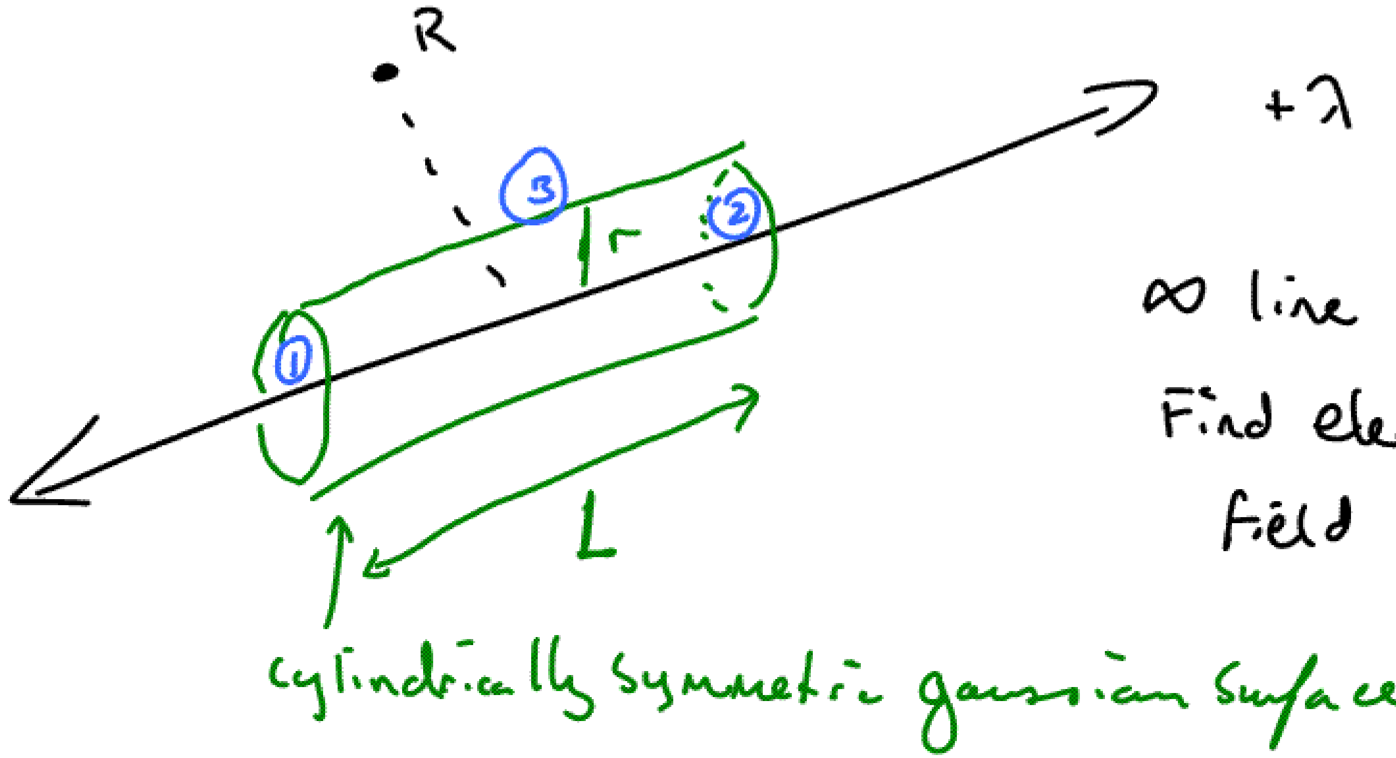
$= 0 \quad r \geq R$

Find total charge

$$Q_{TOT} = \int \rho \, dv = \int_0^R \rho \underbrace{4\pi r^2 dr}_{dv}$$

$$Q_{TOT} = \int_0^R k r^3 4\pi r^2 dr = k 4\pi \int_0^R r^5 dr$$

$$= k 4\pi \frac{R^6}{6}$$




$+\lambda$ chg/length

$\infty$ line charge

Find electric field at R

$\vec{E}$ radially out (symmetry)

$$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$$

$\vec{E}\cdot d\vec{A} = 0$ for ① + ②

$\vec{E} \cdot \vec{dA} = |\vec{E}|_r \, dA$ for surf ③

$$\oint \vec{E} \cdot \vec{dA} = |\vec{E}| \underbrace{\int_{\text{surf ③}} dA}_{2\pi r L} = \frac{Q_{encl}}{\epsilon_0} = \frac{\lambda L}{\epsilon_0}$$

$$|\vec{E}| \, 2\pi r L = \frac{\lambda L}{\epsilon_0}$$

$$\boxed{|\vec{E}| = \frac{\lambda}{2\pi r \epsilon_0}}$$