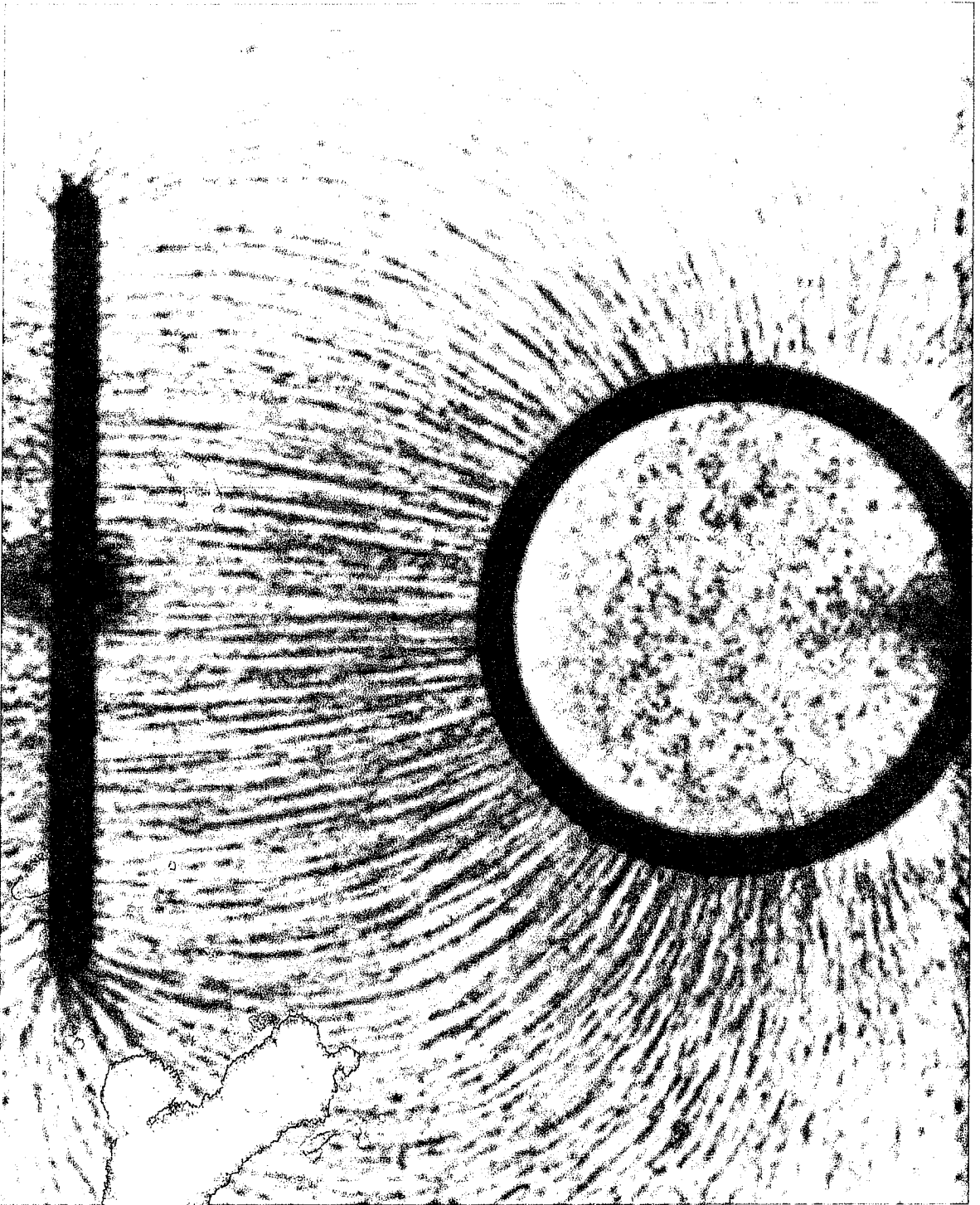


Phys 303 L

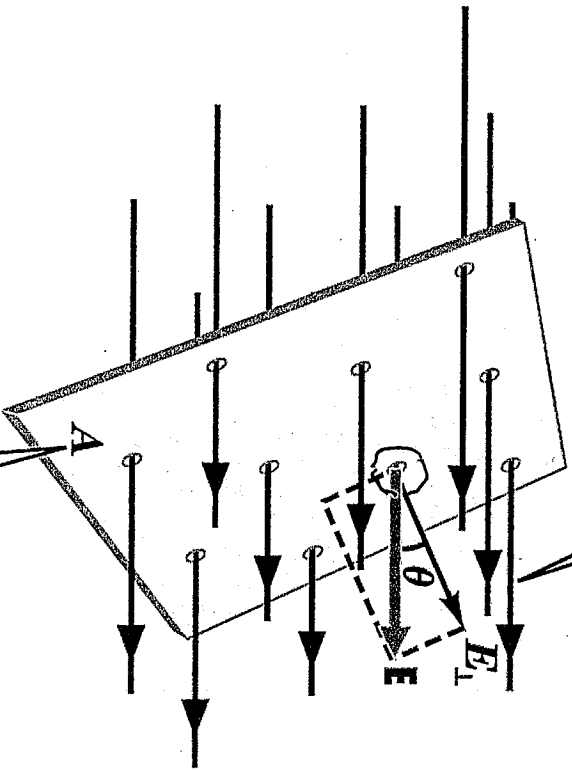
Lecture # 4



Chapter 24 Opener Physics for Engineers and Scientists 3/e
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(a)

Electric flux Φ_E is the product of E_{\perp} , the component of E normal to the surface,...

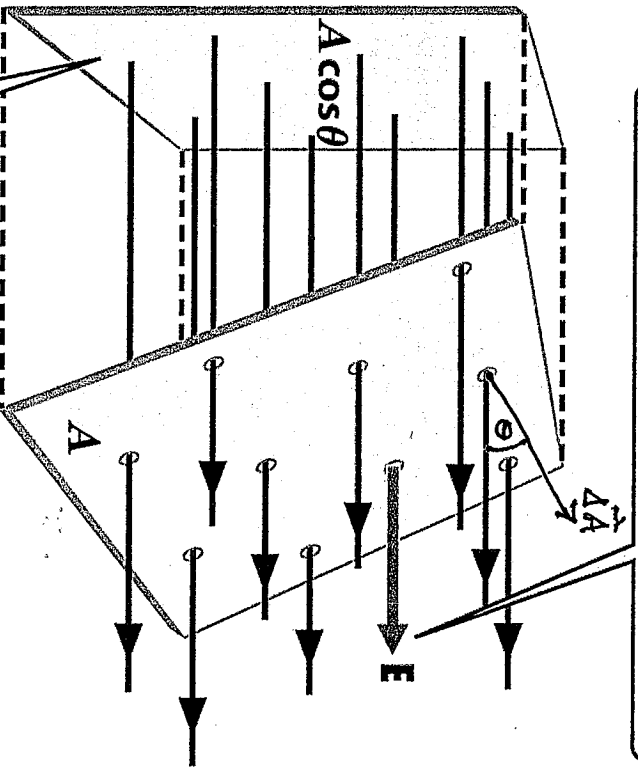


...and the surface area A .

ΔA

(b)

Φ_E is the product of the magnitude of the electric field...



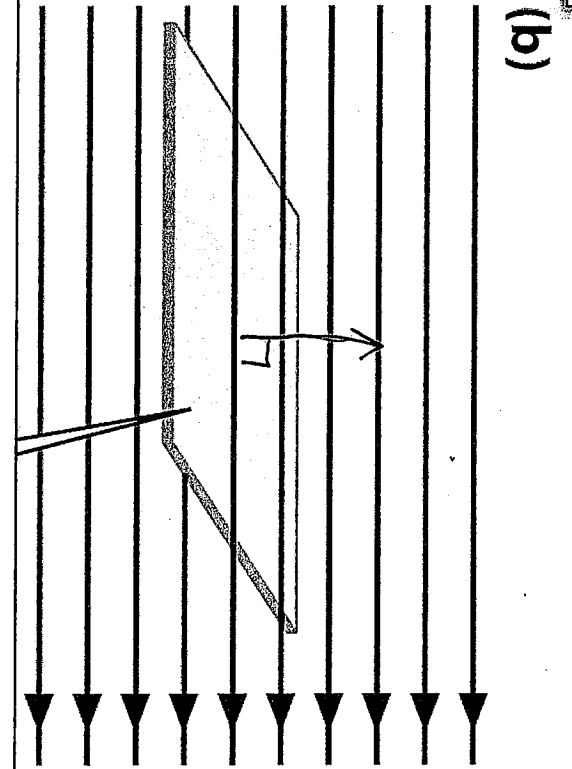
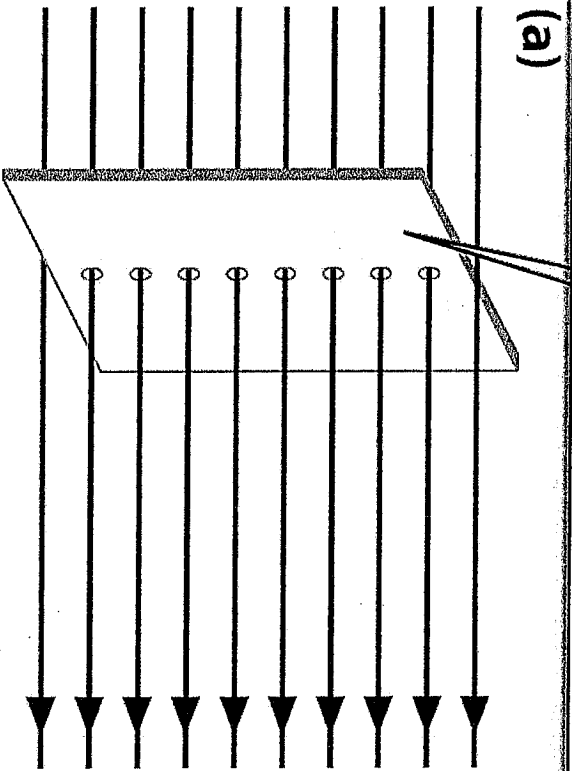
...and the area $A \cos \theta$ facing perpendicular to the field.

Area is a vector directed normal to the surface

Figure 24-1 Physics for Engineers and Scientists 3/e
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$$\Delta \Phi_E = \vec{E} \cdot \Delta \vec{A} = E \Delta A \cos \theta$$

The plate area is A and the electric field is E . What is the electric flux through areas in fig. (a) and fig. (b)?

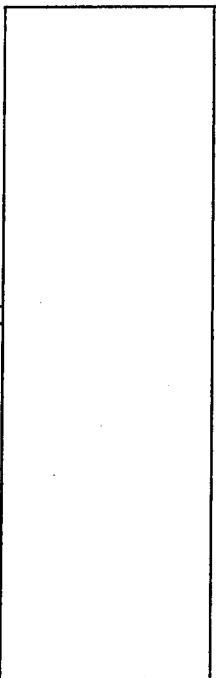


1. EA and 0 in (a) and (b) respectively.
3. EA and EA in (a) and (b) respectively.

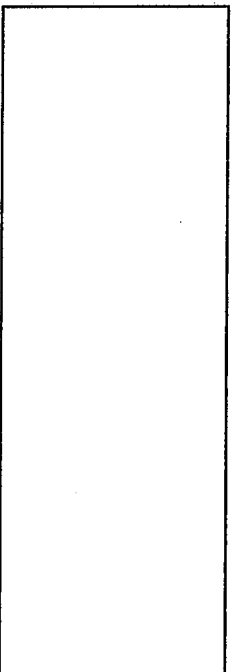
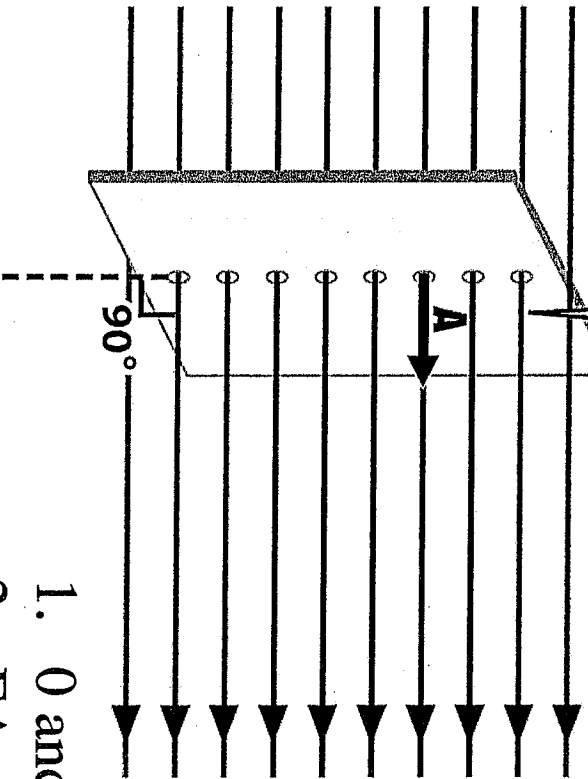
2. 0 and EA in (a) and (b) respectively.
4. 0 and 0 in (a) and (b) respectively.

Figure 24-2 Physics for Engineers and Scientists 3/e
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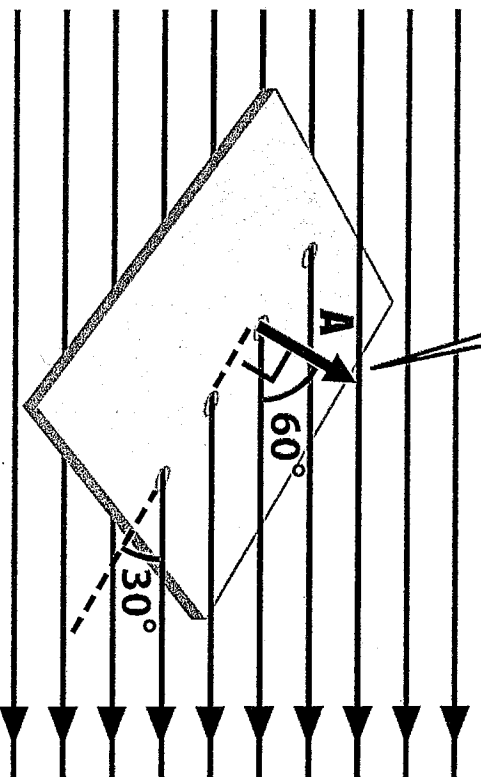
What is the electric flux through (a) and (b) in and electric field E ?



(a)



(b)

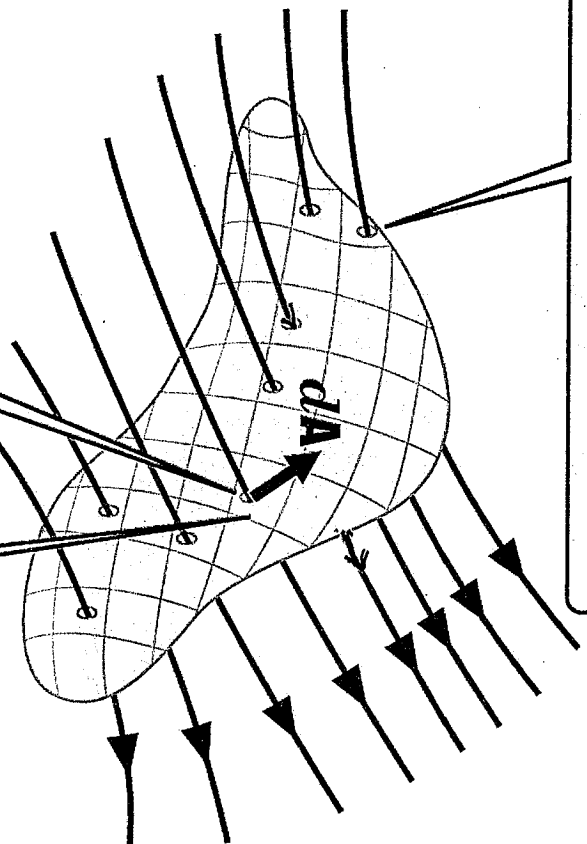


1. 0 and EA respectively
2. EA and $EA/2$
3. EA and $\sqrt{3}EA/2$
4. 0 and $EA/2$
5. 0 and $\sqrt{3}EA/2$

Figure 24-5 Physics for Engineers and Scientists 3/e
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Electric Flux through a closed surface

When the electric field has different magnitudes and directions at different points on a surface...



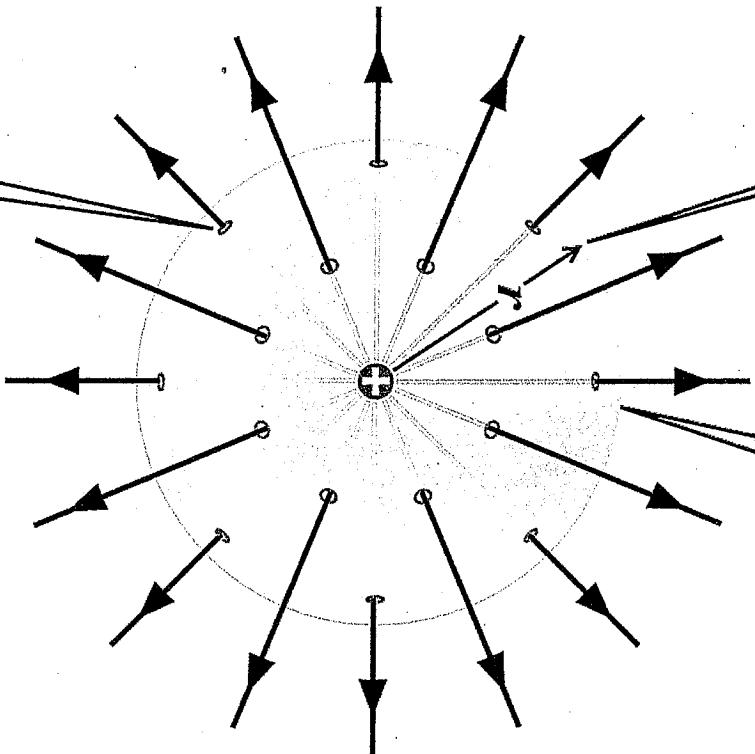
...we may regard the surface as consisting of many small flat pieces.

Vector area dA has magnitude dA and direction perpendicular to surface.

Figure 24-3 Physics for Engineers and Scientists 3/e
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Consider an imaginary spherical surface with radius r .

Electric field is everywhere perpendicular to surface.



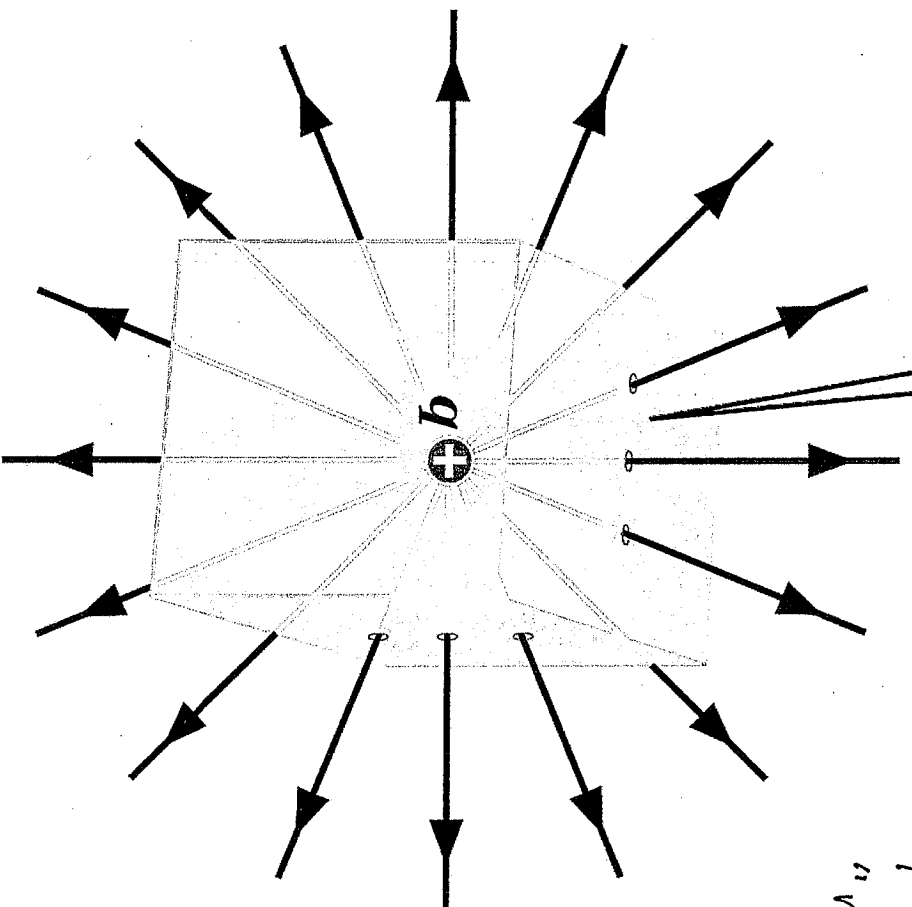
Magnitude of electric field is constant over area $4\pi r^2$.

Figure 24-6 Physics for Engineers and Scientists 3/e
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9

5)

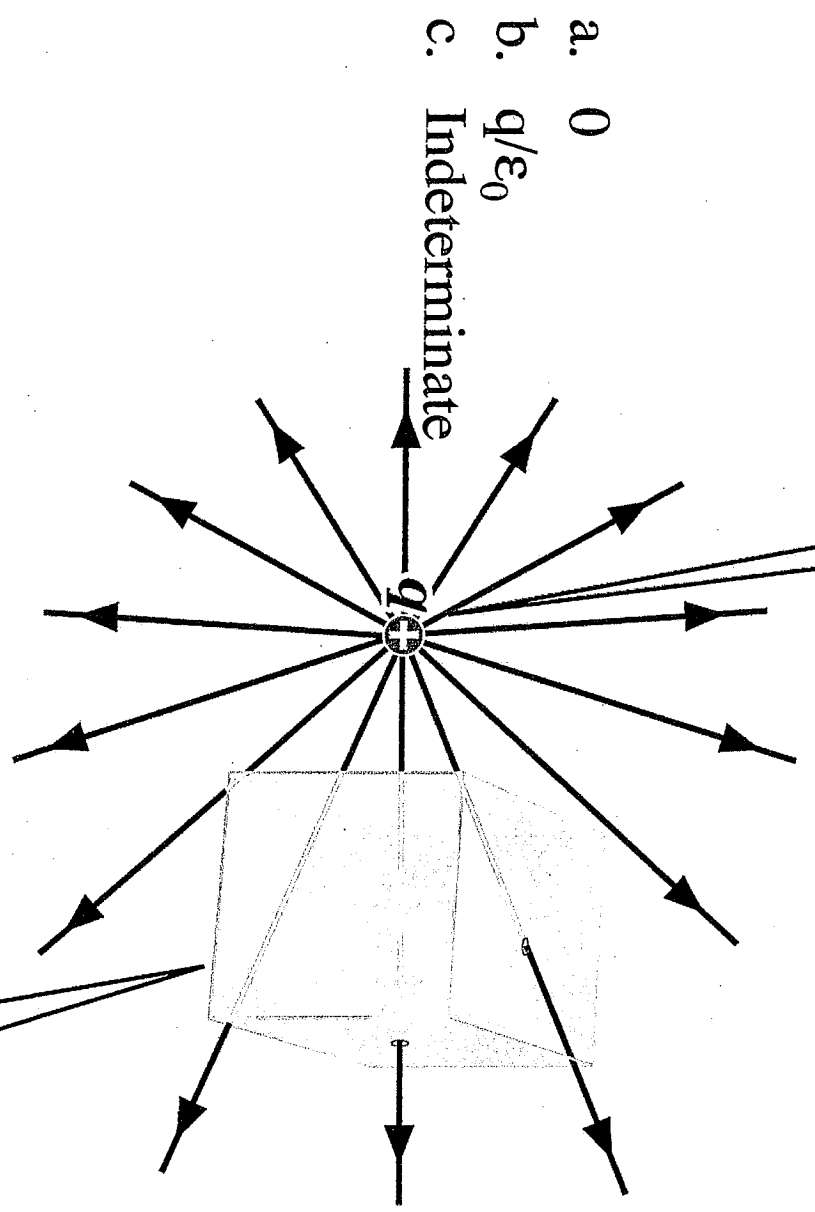
The sphere of Example 2 has been replaced by a cube. Does the flux change?



The same "number" of lines go through the rectangular prism as through the concentric sphere.

Figure 24-8 Physics for Engineers and Scientists 3/e © 2007 W.W. Norton & Company, Inc.

With a point charge outside a cube...

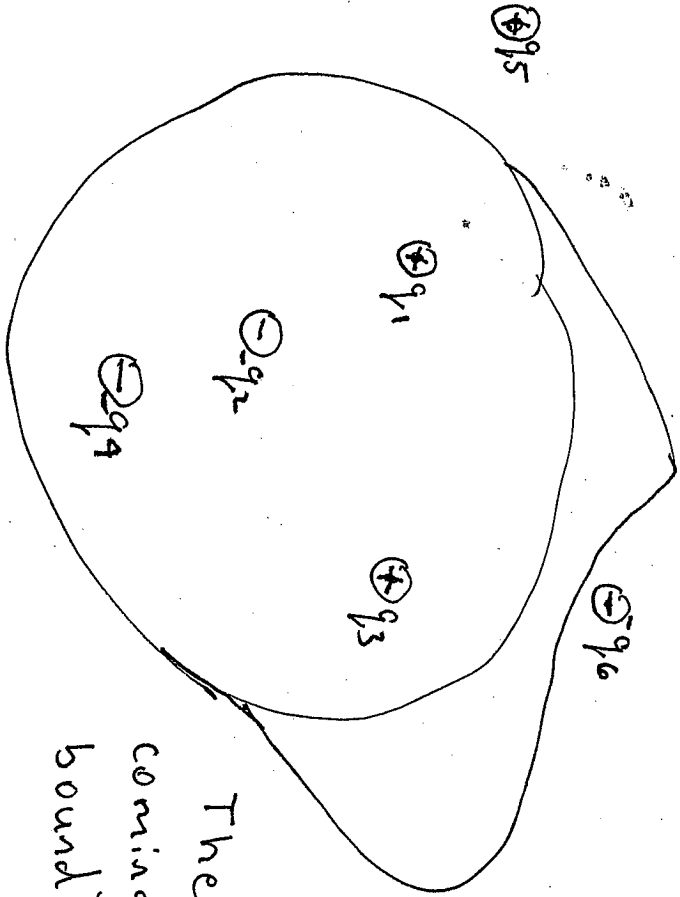


- a. 0
- b. q/ϵ_0
- c. Indeterminate

...what is the net flux through the cube?

Figure 24-9 Physics for Engineers and Scientists 3/e
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Gauss's Law



$q_1 - q_4$ inside volume

q_5 and q_6 outside the volume

The total electric flux, Φ_E , coming out of a surface bounding an enclosed volume

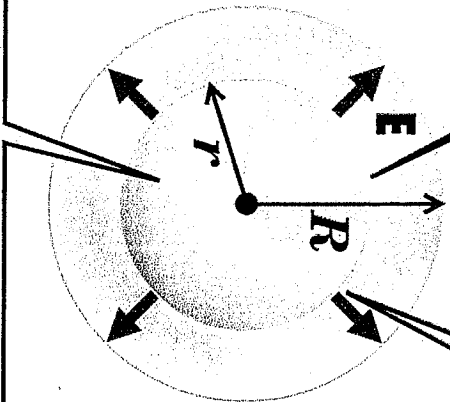
is $\sum \frac{q_i}{\epsilon_0}$ (inside charges)

For our example

$$\Phi_E = \frac{q_1}{\epsilon_0} - \frac{q_2}{\epsilon_0} + \frac{q_3}{\epsilon_0} - \frac{q_4}{\epsilon_0}$$

To apply Gauss' Law, imagine a spherical surface with radius $r < R$, where you want to know the value of E .

Electric field is radial and perpendicular to surface of area $4\pi r^2$.



We then determine the amount of charge inside our imaginary surface, $Q_{\text{inside}} = \rho V_{\text{inside}}$.

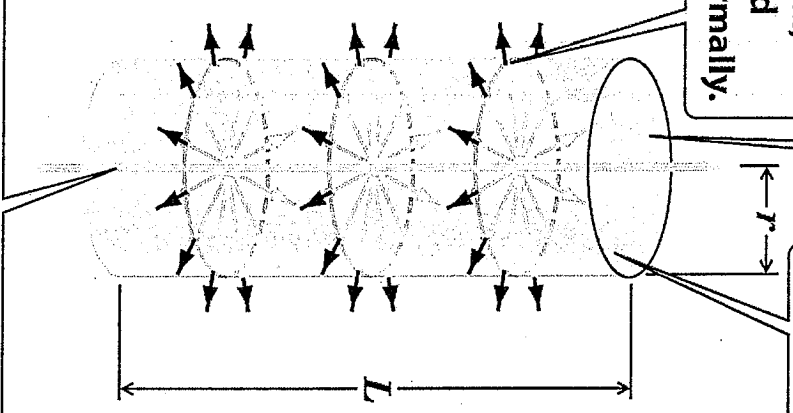
We have uniform charge of radius R
Find electrical field at radius r

Figure 24-12a Physics for Engineers and Scientists 3/e
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To apply Gauss' Law, we imagine a cylindrical surface with radius r and some length L .

Electric field is radial, intercepting curved area $A = 2\pi rL$ normally.

No electric flux intercepts top or bottom.



Inside our Gaussian surface, charge on rod is $Q_{\text{inside}} = \lambda L$.

$$\Phi_E = E(r) A$$

$$= E(r) 2\pi r L$$

$$= \frac{\lambda L}{\epsilon_0}$$

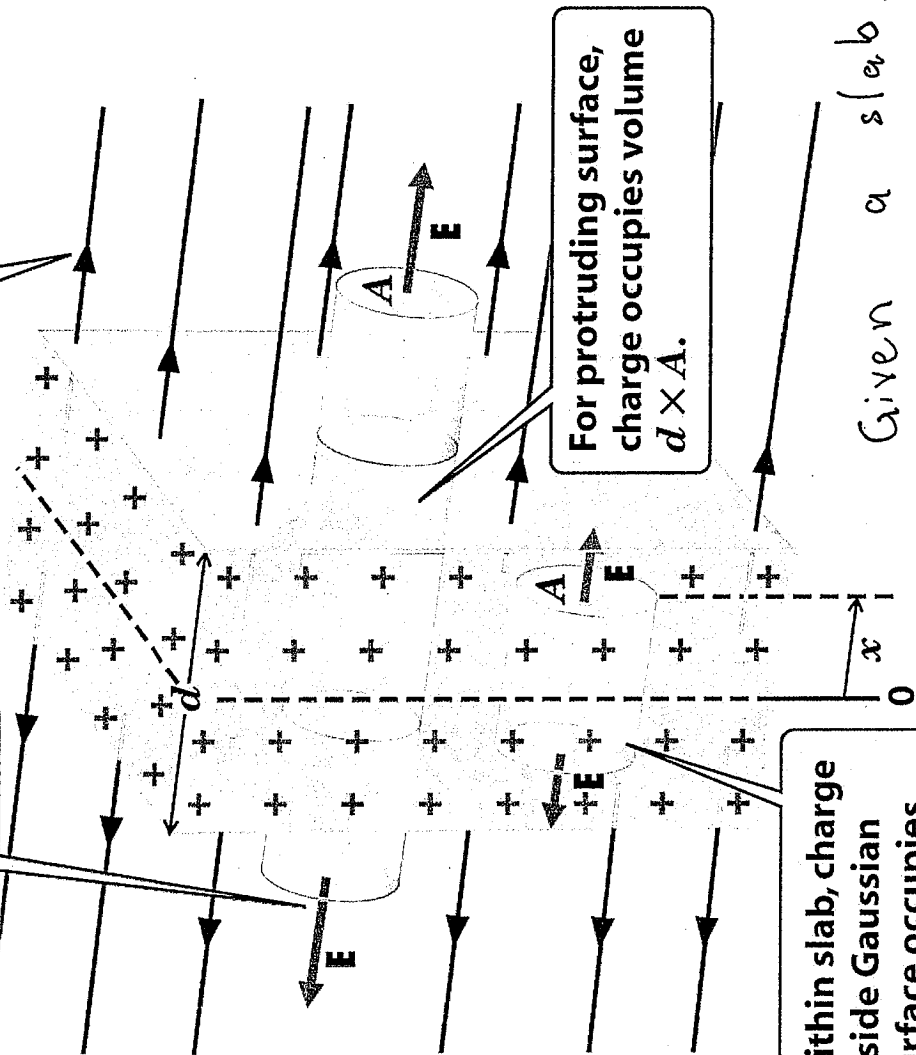
$$E(r) = \frac{\lambda}{2\pi \epsilon_0 r}$$

We are given long axial rod of λ c/m. Find electrical field outside

Figure 24-14 Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

E is perpendicular to circular ends of Gaussian surface.

Electric field is perpendicular to slab, pointing outward on both sides of center.



For protruding surface, charge occupies volume $d \times A$.

Within slab, charge inside Gaussian surface occupies volume $2x \times A$.

Given a slab, with charge density ρ . Find electric field inside and outside slab.

Figure 24-17 Physics for Engineers and Scientists 3/e © 2007 W.W. Norton & Company, Inc.

large
 Given a uniformly
 charged plates of
 surface charge
 density σ .
 What is electric
 field outside
 plate?

Top and bottom ends of
 Gaussian surface intercept
 electric field normally...

$$\begin{aligned} \Phi_E &= EA \\ &= E(\pi r^2 + \pi r^2) \\ &= \sigma A \\ &= \sigma \pi r^2 \end{aligned}$$

...but curved side
 does not intercept
 electric field.

$$\begin{aligned} 2\pi r^2 E &= \frac{\sigma}{\epsilon_0} \pi r^2 \\ E &= \frac{\sigma}{2\epsilon_0} \end{aligned}$$

Charge inside Gaussian surface
 is on area A of sheet.

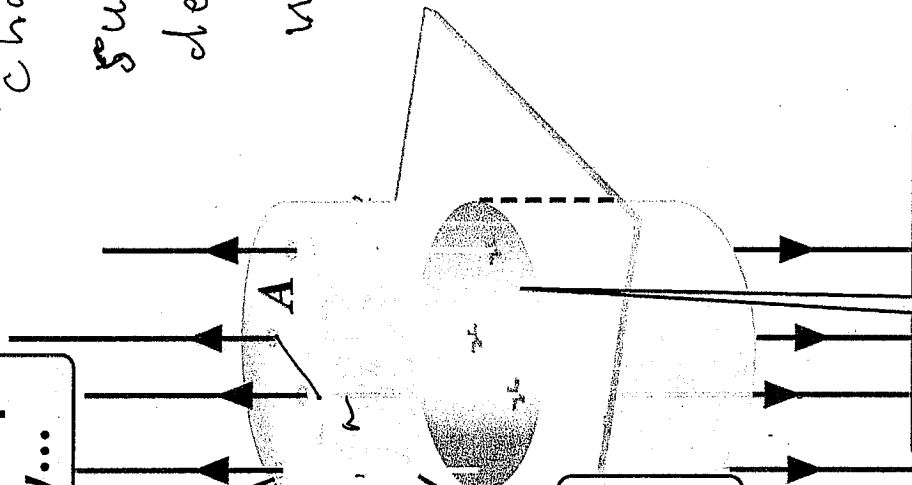


Figure 24-16b Physics for Engineers and Scientists 3/e
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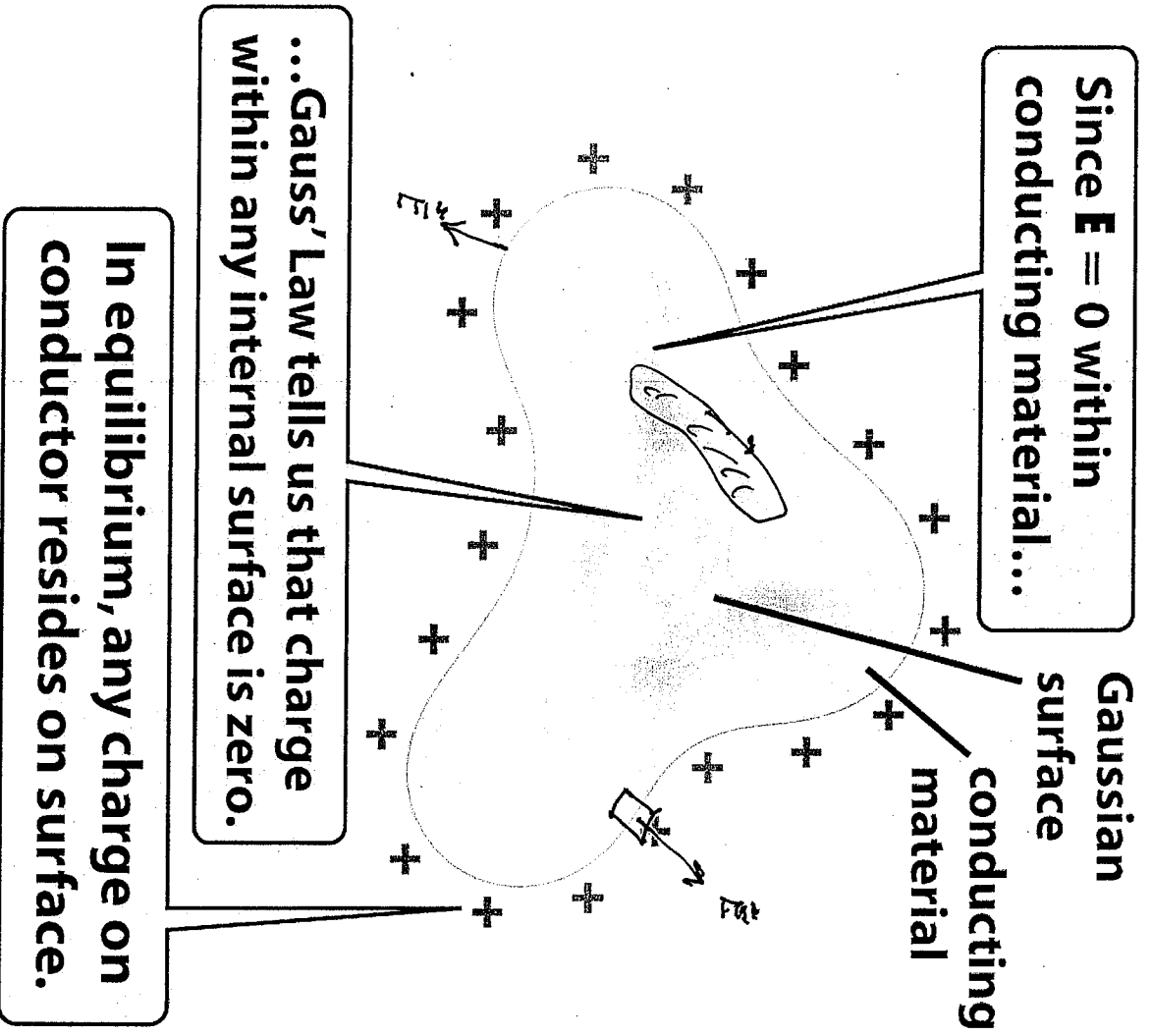


Figure 24-21 Physics for Engineers and Scientists 3/e © 2007 W.W. Norton & Company, Inc.

electric field at surface is perpendicular to surface (in direction of normal)

In equilibrium, any charge on conductor resides on surface.

...Gauss' Law tells us that charge within any internal surface is zero.

Since $E = 0$ within conducting material...

Gaussian surface

conducting material

What is the electric at conducting surface in terms of surface charge σ at surface?

- (a) 0
- (b) $\sigma / 2\epsilon_0$
- (c) σ / ϵ_0
- (d) indeterminate
- (13)