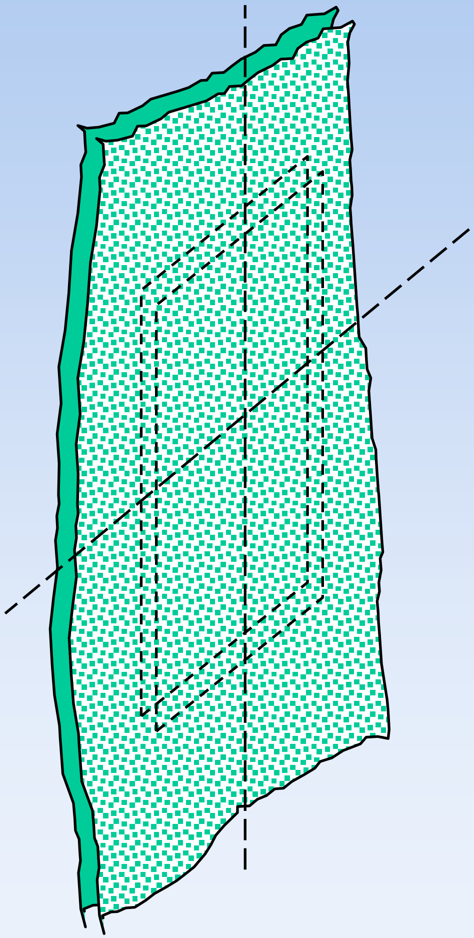
Gauss' Law for Planar Symmetry

Presentations:

- Electromagnetism: History
- Electromagnetism: Electr. topics
- Electromagnetism: Magn. topics
- Electromagnetism: Waves topics
- Capacitor filling (complete)
- Capacitor filling (partial)
- Divergence Theorem
- E-field of a thin long charged wire
- E-field of a charged disk
- E-field of a dipole
- E-field of a line of dipoles
- E-field of a charged sphere
- E-field of a polarized object
- E-field: field energy
- Electromagnetism: integrations
- Electromagnetism: integration elements
- Gauss' Law for a cylindrical charge
- Gauss' Law for a charged plane
- Laplace's and Poisson's Law
- B-field of a thin long wire carrying a current
- B-field of a conducting charged sphere
- B-field of a homogeneously charged sphere

Gauss' Law for Planar Symmetry



Available:

Thin flat plane, infinitely large, covered with homogenous surface charge density σ [C/m^2]

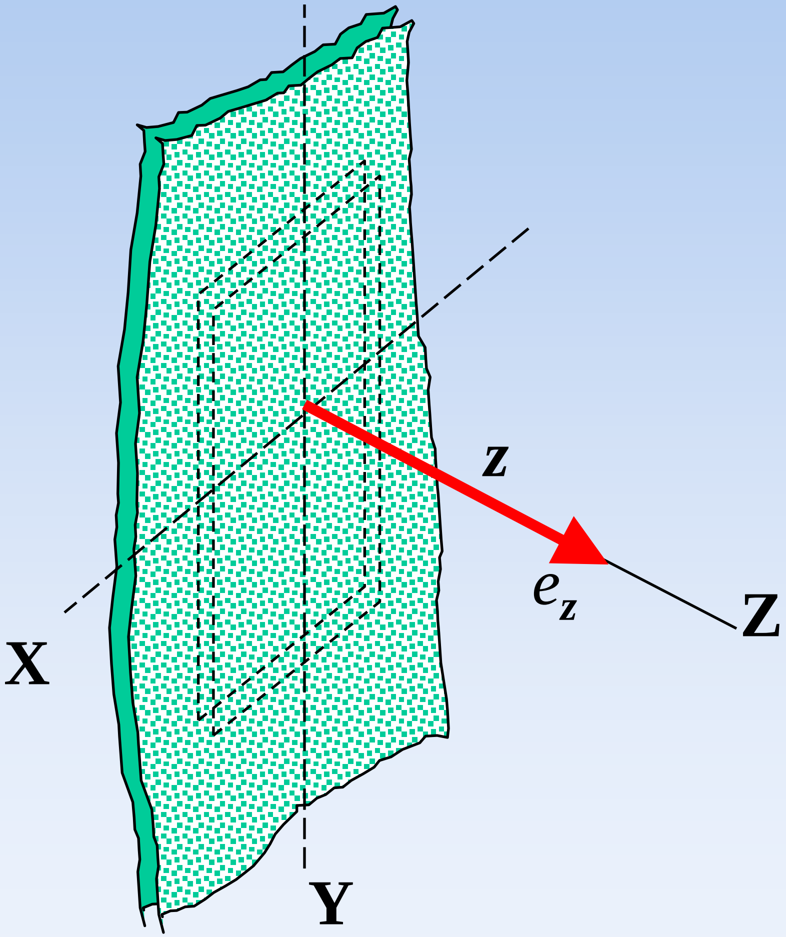
Question:

Calculate ***E***-field at arbitrary points at both sides of the plane

Gauss' Law for Planar Symmetry

- Analysis and symmetry
- Approach to solution
- Calculations
- Conclusions

Analysis and Symmetry (1)



1. Charge distribution:

   σ [C/m^2] ; homogeneous.

2. Symmetry:

   Z-axis = symm. axis,

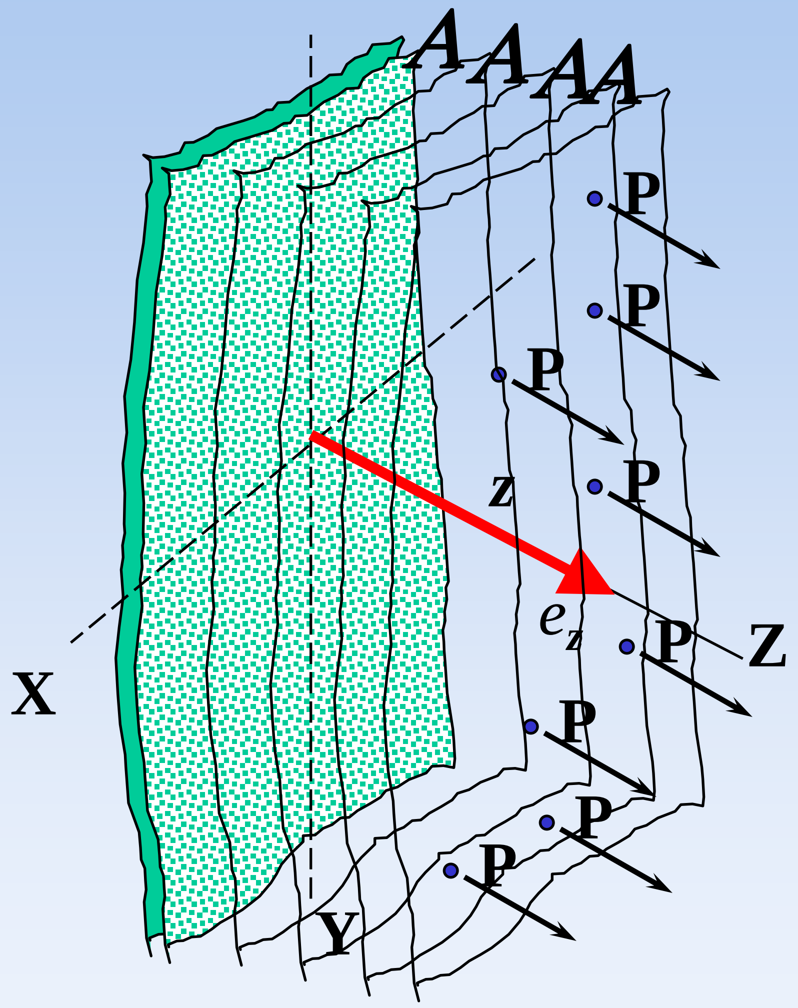
   perpendicular to plane.

3. Plane: infinitely large.

4. Front & backside are

   equivalent.

Analysis and Symmetry (2)



5. Charge distribution:

   σ [C/m^2] ; homogeneous.

6. Plane *A* // charged plane:

7. All points *P* equivalent

8. Point charge in *A*:

   will not move // *A*

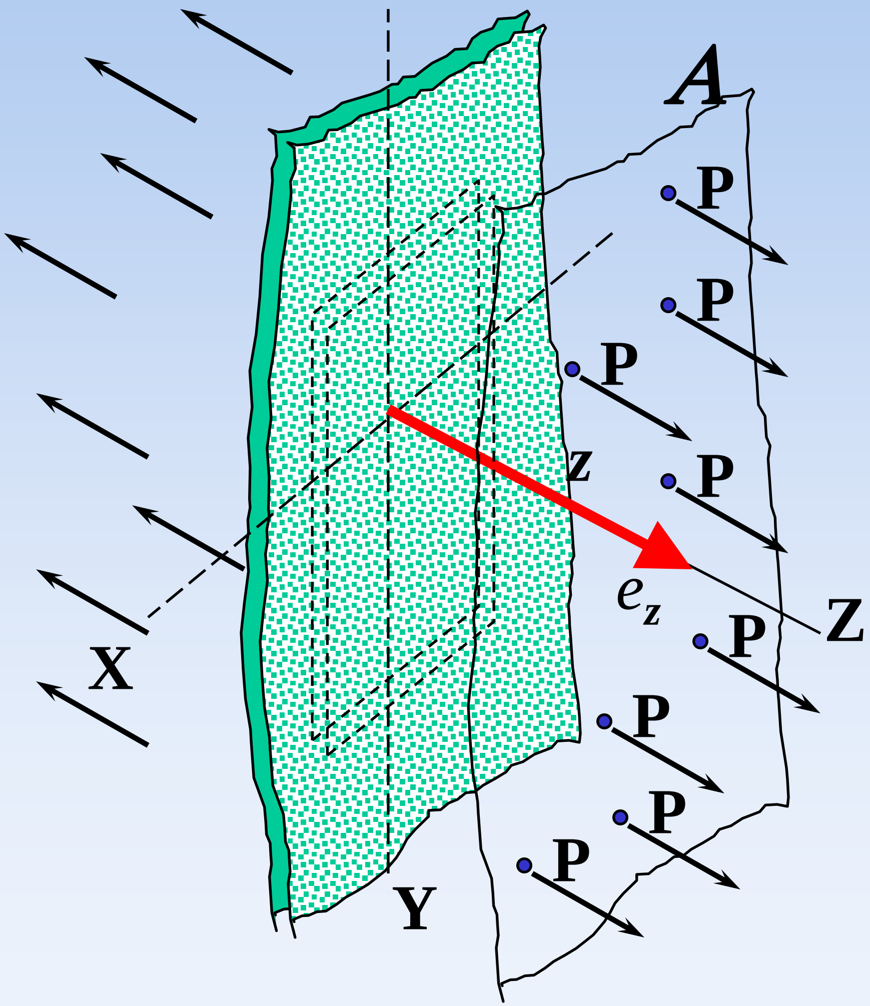
   due to symmetry

9. ***E*** : Z-component only !!

10. ***E*** : uniform field

11. All *A*-planes equivalent

Analysis and Symmetry (3)



12. Backside:

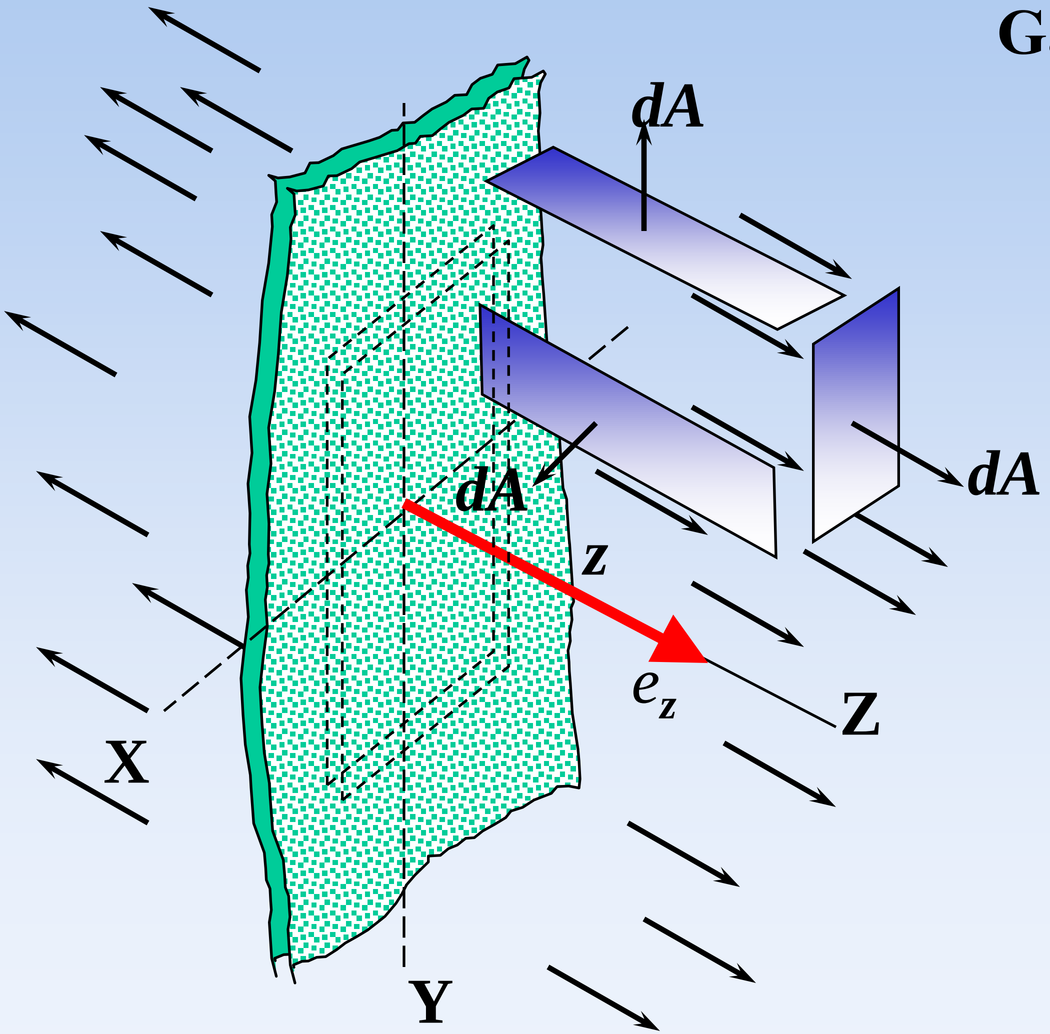
    similar situation

13. <u>Conclusion from symmetry:</u>

    uniform fields;

    opposite directions

Gauss' Box (1)



Gauss' Law: $$\iint_A \mathbf{E} \bullet d\mathbf{A} = \frac{Q}{\varepsilon_0}$$

Choose Gauss-box A.

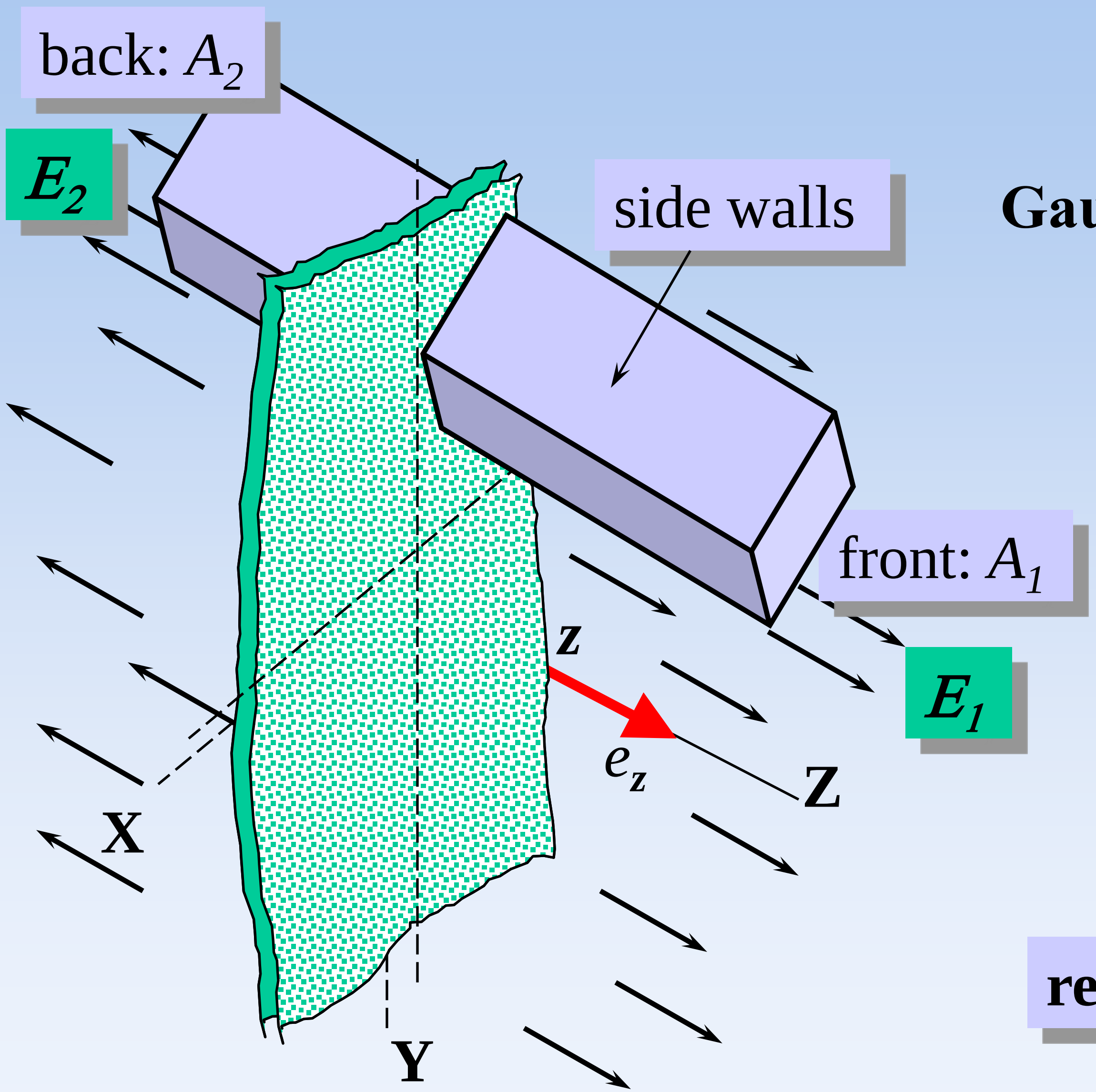
How to make optimum use of symmetry ??

- where $\mathbf{E} \,//\, d\mathbf{A}$
- where $\mathbf{E} \perp d\mathbf{A}$
- where $E = 0$??

closed box needed !!

closure at backside necessary !!

Gauss' Box (2)



Gauss' Law: $\iint_A \mathbf{E} \bullet d\mathbf{A} = \dfrac{Q}{\varepsilon_0}$

choose Gauss-box:

sides do not contribute.

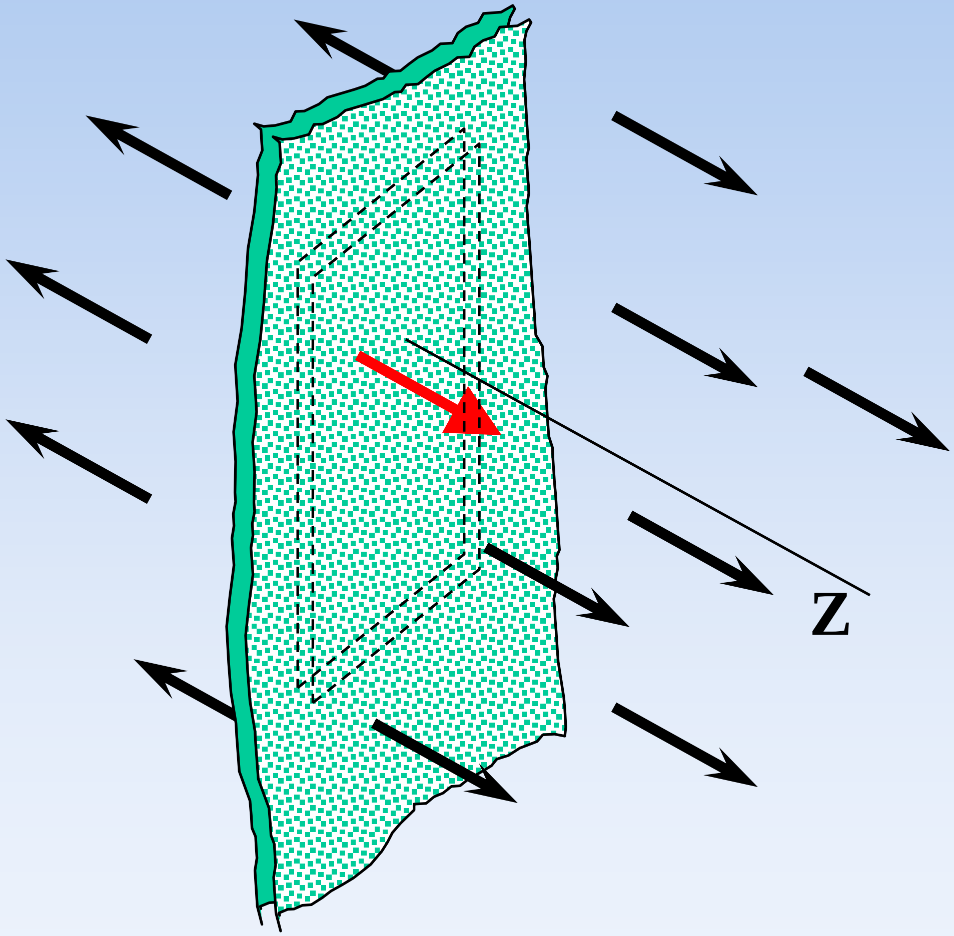
only front and back lids contribute :

$E_1 A_1 + E_2 A_2 \quad (A_1 = A_2)$

charge enclosed: σA_1

result: $E_1 = E_2 = \sigma / (2\varepsilon_0)$

Conclusions



for infinite plane:

$$\boldsymbol{E}_P = \frac{\sigma}{2\varepsilon_0}\boldsymbol{e_z}$$

field strength independent of distance to plane =>

homogeneous field

the end