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  Newton's Laws can be derived from Conservation of Momentum (and vice versa).
- Coloumb's Law and Gauss' Law can be derived from each other too. Use whichever is easiest/best for a certain situation.
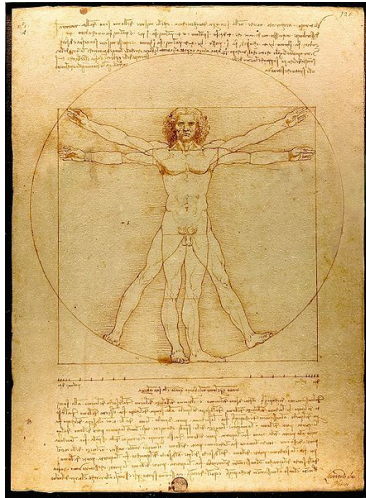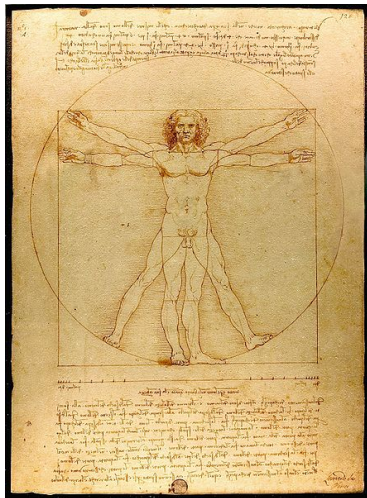
- SYMMETRY — YRTEMMYS
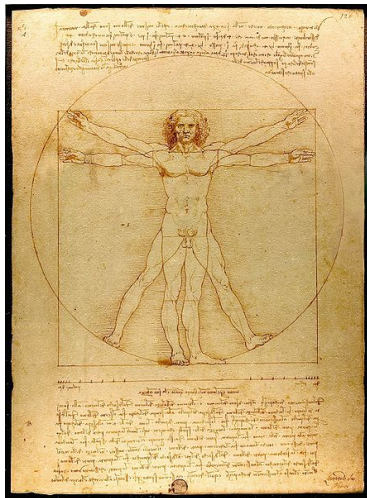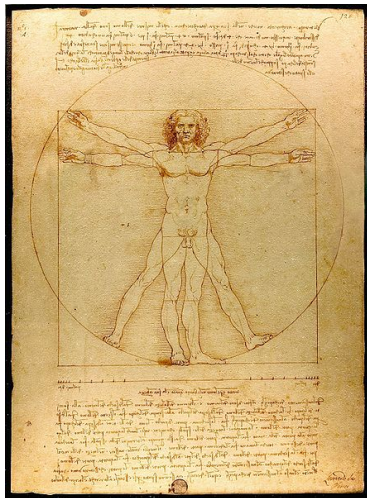
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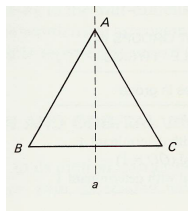- What is a symmetry??

What is Symmetry

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A symmetry is an operation you can perform on a system which leaves the system unchanged. In other words, you cannot tell that you did anything!

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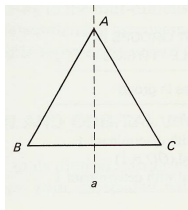Consider an equilateral triangle as an example

You can rotate this by 120 degrees and not know that you did it.

What is Symmetry

Symmetry

A symmetry is an operation you can perform on a system which leaves the system unchanged. In other words, you cannot tell that you did anything!

Consider an equilateral triangle as an example

You can rotate this by 120 degrees and not know that you did it. You can flip it about axis Aa (or similar axes) and not know that you did it. These are symmetry operations.
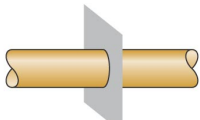
Symmetry
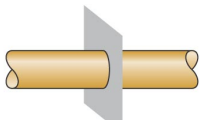

Original cylinder

Translation parallel to the axis

Rotation about the axis

Reflection in plane containing the axis

Reflection perpendicular to the axis

- Imagine an infinitely long cylinder full of charges. What geometric operations could you perform on that cylinder and not know that you did it??

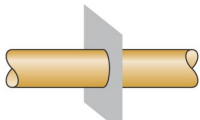# Symmetry

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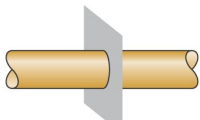
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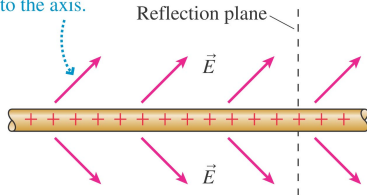
Reflection in plane containing the axis

Reflection perpendicular to the axis

- Imagine an infinitely long cylinder full of charges. What geometric operations could you perform on that cylinder and not know that you did it??
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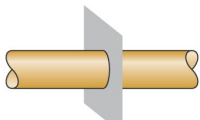
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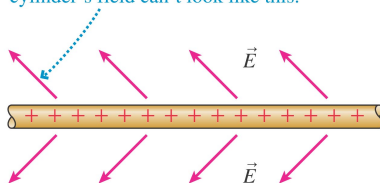   - Reflect the charge in a mirror

  (See the figures to the left)

Symmetry

(a) Is this a possible electric field of an infinitely long charged cylinder? Suppose the charge and the field are reflected in a plane perpendicular to the axis.

(b) The charge distribution is not changed by the reflection, but the field is. This field doesn't match the symmetry of the cylinder, so the cylinder's field can't look like this.
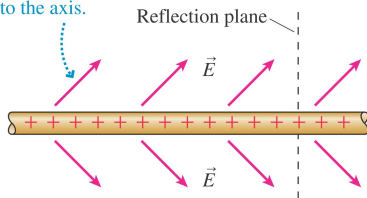
- The field on the left does not remain the same under a reflection!
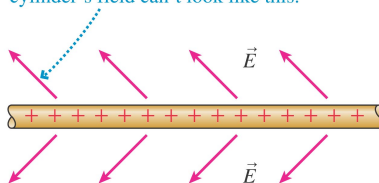
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Reflection plane

$\vec{E}$

$\vec{E}$

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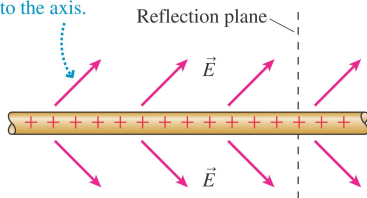
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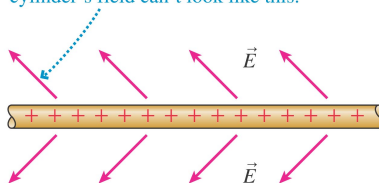
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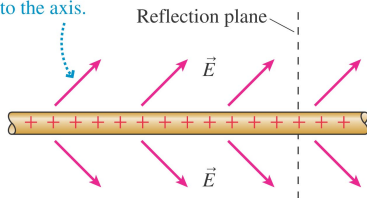

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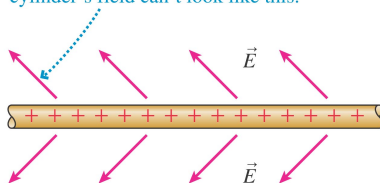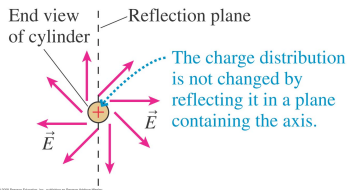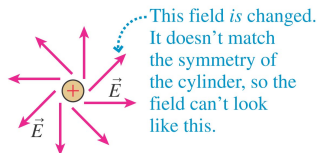
The symmetry of the electric field must match the symmetry of the charge distribution.

(a)

End view of cylinder — Reflection plane

The charge distribution is not changed by reflecting it in a plane containing the axis.

$\vec{E}$

$\vec{E}$

(b)

This field *is* changed. It doesn't match the symmetry of the cylinder, so the field can't look like this.

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- The previous page showed us that an electric field component parallel to the cylindrical axis will not work.

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End view of cylinder | Reflection plane

The charge distribution is not changed by reflecting it in a plane containing the axis.

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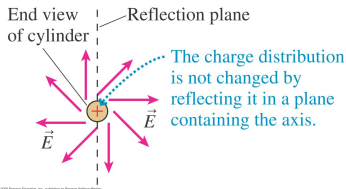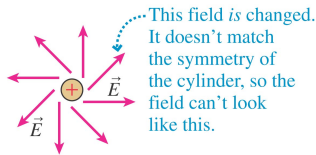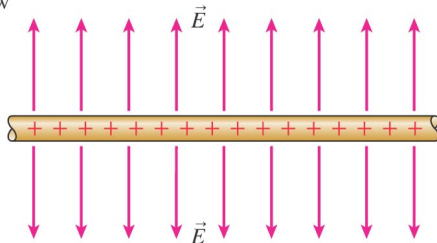Copyright © 2008 Pearson Education, Inc., publishing as Pearson Addison-Wesley.
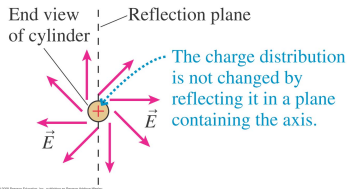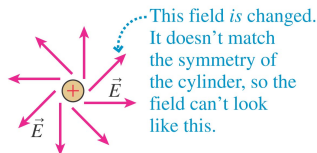
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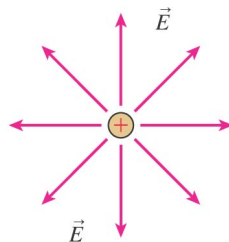- Nope. Also bad. If we reflect it through a plane containing the axis I can tell it changed!

Symmetry

Side view

$\vec{E}$

$\vec{E}$

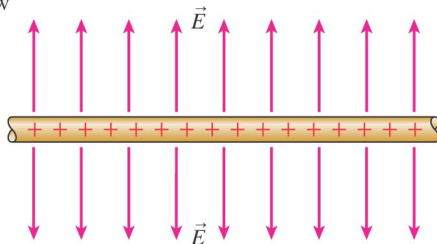Copyright © 2008 Pearson Education, Inc., publishing as Pearson Addison-Wesley.

End view

$\vec{E}$

$\vec{E}$

+ + + + + + + + + + + + + + + + +

- Well, there is only one shape left!

Symmetry

Side view $\vec{E}$

End view $\vec{E}$

$\vec{E}$

$\vec{E}$

$\vec{E}$
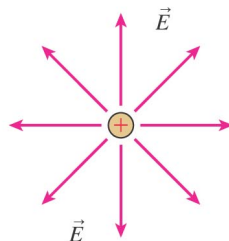
Copyright © 2008 Pearson Education, Inc., publishing as Pearson Addison-Wesley.
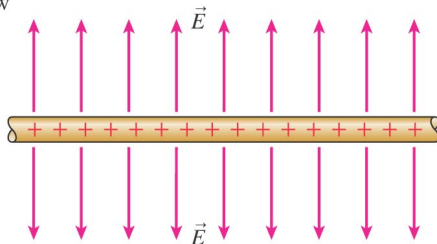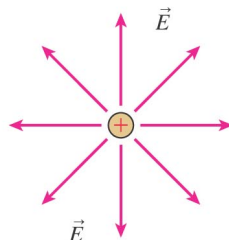
- Well, there is only one shape left!
- The electric field must be radial, pointing straight out from the center of the cylinder.

Side view

$\vec{E}$

$\vec{E}$

End view

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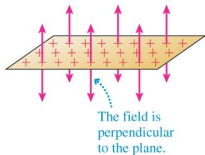
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+ + + + + + + + + + + + + + + +

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- Well, there is only one shape left!
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- You can see already how we exploit symmetries. We have used them to rule out possible field shapes.
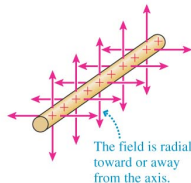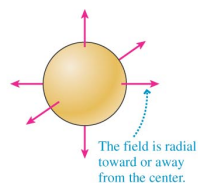
Some Fundamental Symmetries

Planar symmetry

Basic symmetry:

The field is perpendicular to the plane.

More complex example:

Infinite parallel-plate capacitor

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Cylindrical symmetry

The field is radial toward or away from the axis.

Coaxial cylinders

Spherical symmetry

The field is radial toward or away from the center.

Concentric spheres