Electricity and Magnetism

- Physics 259 – L02
- Lecture 20

Midterm Review and Class Activity

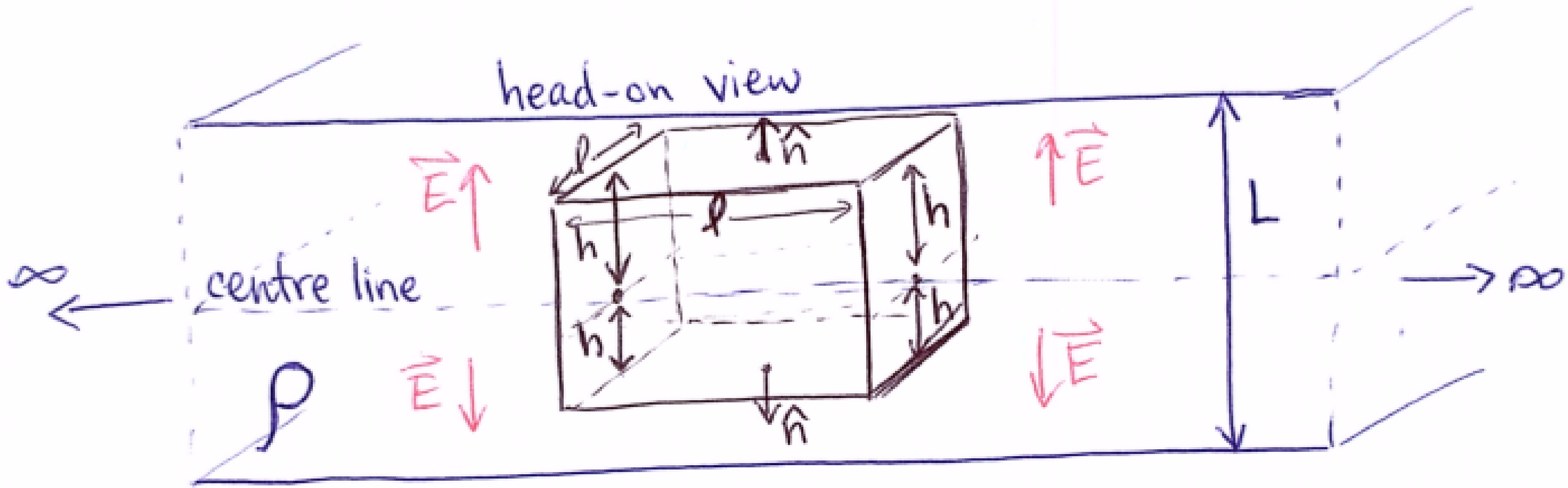
Last time

- Chapter 23 

This time

- Midterm Review and Class Activity 

What is the field inside the slab?



The slab has thickness L, we have to choose a Gaussian surface with the same symmetries as the slab: choose a box whose centre coincides with the centre of the slab.

What about cylinder?

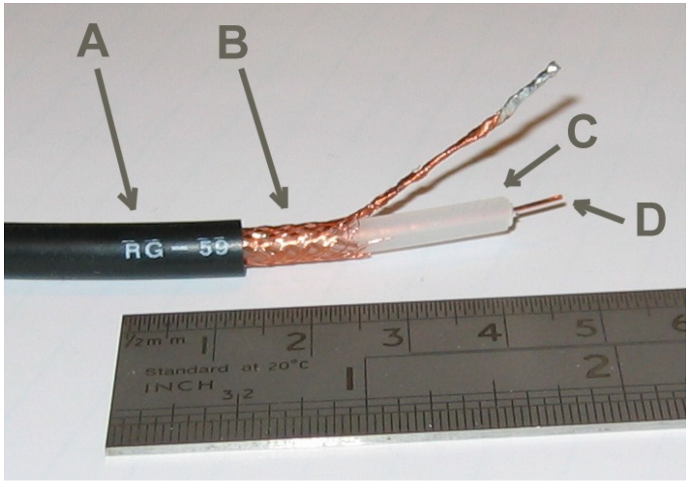
Study appendix 1-chapter 23 posted on D2l.

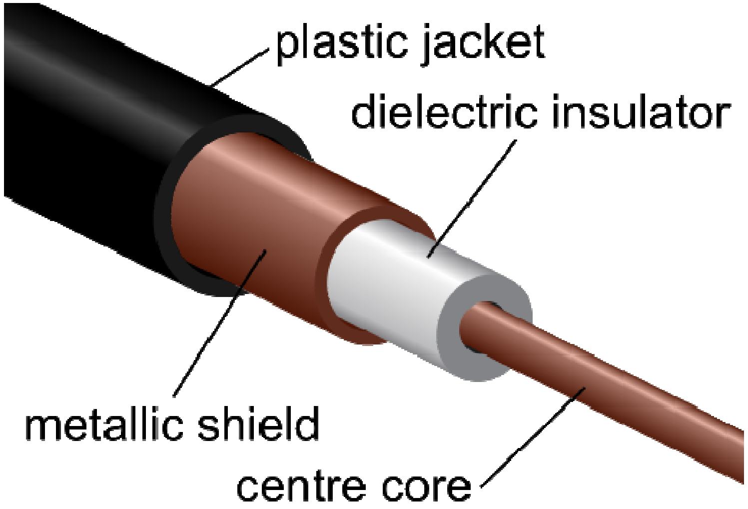
Exercise: Coaxial Cable

Study appendix 1-Chapter 23

Assume there is a charge **+Q** on the centre core and **-Q** on the metallic shield. (Ignore the dielectric insulator and plastic jacket.)

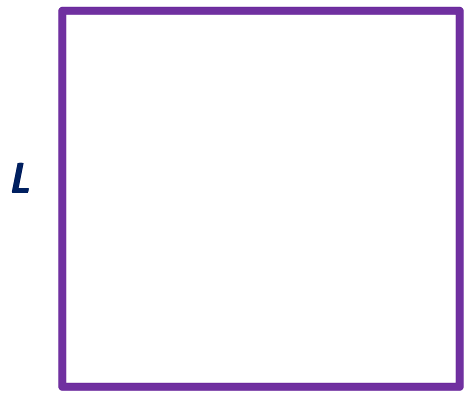
Find the electric field outside the metallic shield (**E_2**) and just outside the central core (**E_1**).





TopHat Question

What is the charge of the insulating wire (the wire is reshaped to form a rectangle) with charge density $-\lambda$?



A) $L^2\lambda$
B) $-L^2\lambda$
C) $4L\lambda$
D) $-4L\lambda$

– Calculate the electric field due to a positively charged line of linear charge density λ.

We note that the direction of E is radially away from the rod.

$$\Phi_{total} = \oint_{cylinder} E\,dA = \int_{tube} E\,dA + \int_{top} E\,dA + \int_{bottom} E\,dA$$

Angle between E and dA is always 0!

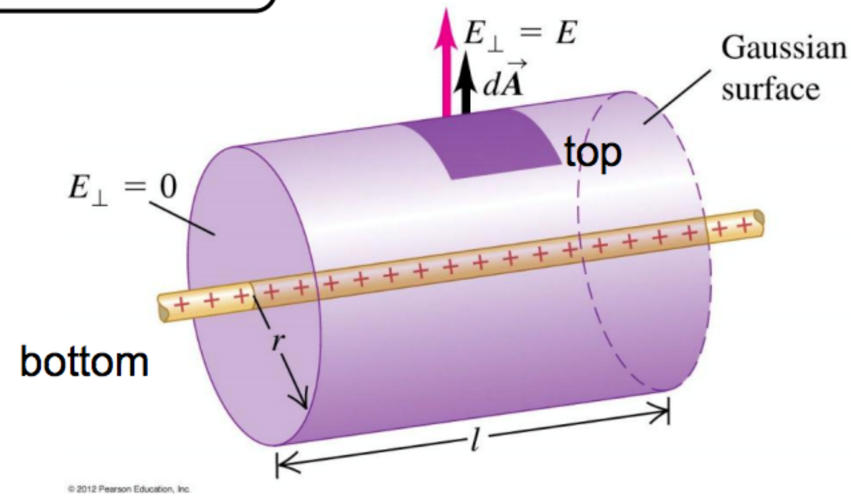
E and dA are always perpendicular!

$$= E \int_{tube} dA$$

$$= 2\pi r l E$$

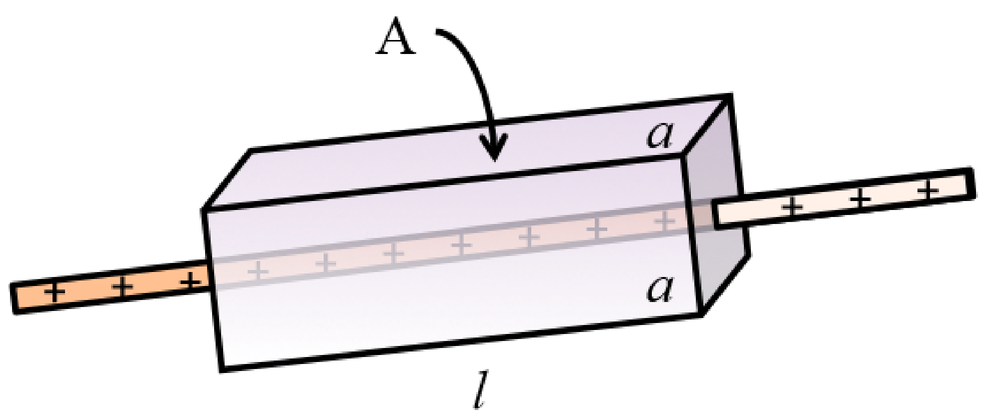
$$= \frac{\lambda l}{\varepsilon_0}$$

-> $$E = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}$$



Field of a line charge

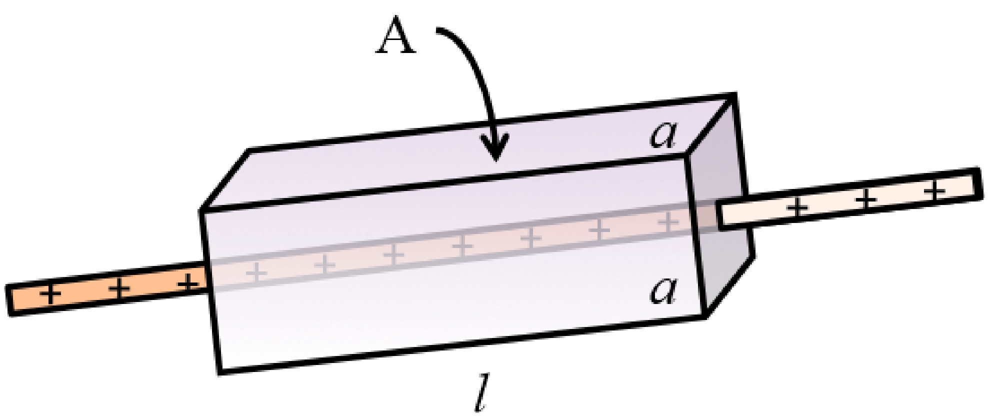
Consider an infinitely long, positively charged rod of linear charge density λ. How large is the flux through side A of the box? Suppose the values for l, a and λ are given.



Field of a line charge

- Consider an infinitely long, positively charged rod of linear charge density λ. How large is the flux through side A of the box? Suppose the values for l, a and λ are given.
- Gauss' law tells us that the total electric flux only depends on the enclosed charge – not the shape of the (closed) Gaussian surface:

  $\Phi_{tot} = Q_{encl}/\varepsilon_0 = \lambda l/\varepsilon_0$



Field of a line charge

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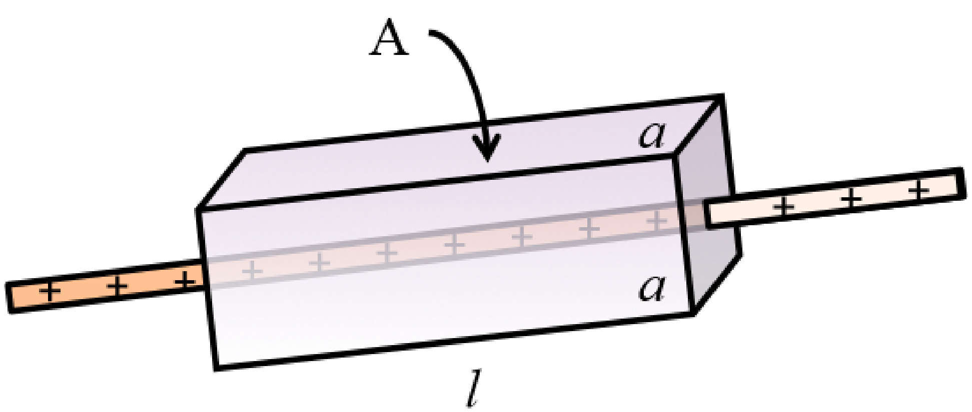
- Gauss' law tells us that the total electric flux only depends on the enclosed charge – not the shape of the (closed) Gaussian surface:

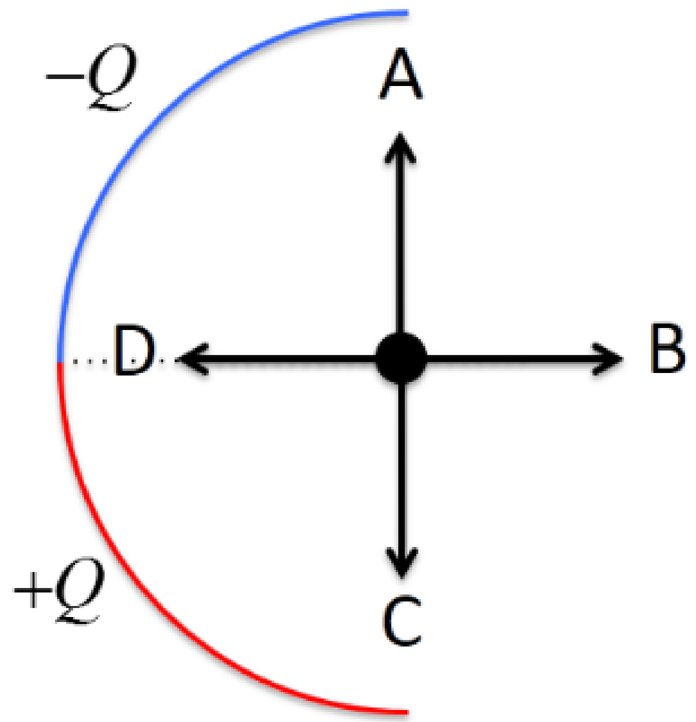
  $\Phi_{tot} = Q_{encl}/\varepsilon_0 = \lambda l/\varepsilon_0$
- The total flux must be equally partitioned into flux through the four surfaces whose area vectors are parallel to the electric field.

  Hence, $\Phi_A = \lambda l/4\varepsilon_0$

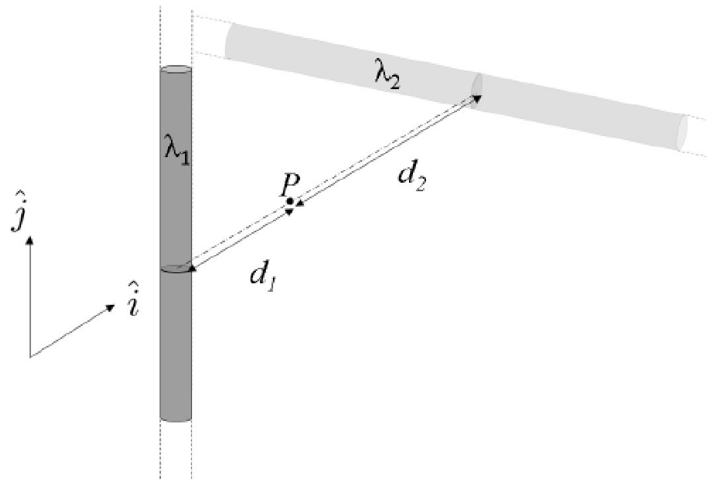


TopHat Question #1:

What is the direction of electric field at point indicated?



(10 marks) What is the electric field, $\overrightarrow{E}$, at point P due to two charged rods of infinite length, as presented in the figure below? Rod 1 has a positive, linear charge density λ_1 and is oriented vertically, a distance d_1 from P. Rod 2 has a positive, linear charge density λ_2 and is oriented horizontally, a distance d_2 from P.



1. **(1 mark)** What Gaussian surface (i.e., what 3D shape) makes it **easiest** to apply Gauss' law for a rod? Explain why.

2. **(2 marks)** For each rod, **draw** the cylindrical Gaussian surface needed to find its electric field contribution at point P. **Label** each Gaussian surface with length l and the appropriate radius.

3. **(1 mark)** Calculate the charge enclosed in **each** of your Gaussian surfaces, in terms of l, λ_1 and λ_2.

4. **(2.5 marks)** Use Gauss' law ($\oint \overrightarrow{E} \cdot \overrightarrow{dA} = \frac{Q}{\epsilon_0}$) to calculate $\overrightarrow{E_1}$, the electric field at point P due to Rod 1, in terms of λ_1 and d_1.

5. **(1.5 marks)** Use Gauss' law ($\oint \overrightarrow{E} \cdot \overrightarrow{dA} = \frac{Q}{\epsilon_0}$) to calculate $\overrightarrow{E_2}$, the electric field at point P due to Rod 2, in terms of λ_2 and d_2.

6. **(1 mark)** Write the total electric field ($\overrightarrow{E}$) at point P **in terms of** $\overrightarrow{E_1}$ **and** $\overrightarrow{E_2}$.

This section we talked about:

Midterm Review & Class Activity

See you on Monday