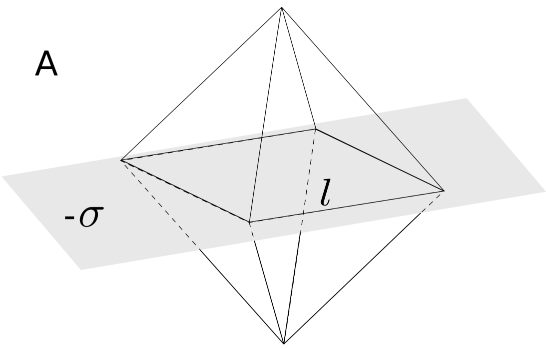
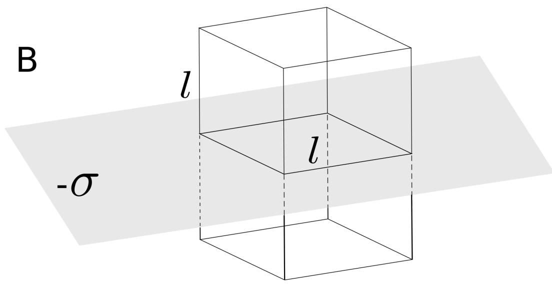
| Group # | Student | Last Name | First Name |
|---|---|---|---|
| | **1** | | |
| | **2** | | |
| | **3** | | |
| | **4** | | |

**(10 marks)** The figure below shows an octahedral Gaussian surface made up of equilateral triangles with a square base of length $l$ and a pill-box with a square base of length $l$. The horizontal plane represents a large thin sheet with uniform **negative** surface charge density $\sigma$. Find the electric flux through the octahedral Gaussian surface.




*The parts below walk you through related questions, and the steps with which to solve this problem. Please show all work in the boxes provided and then choose the correct answer at the bottom*

1. **(1 mark)** In one sentence, state the meaning of Gauss's relation $\oint \vec{E}\cdot d\vec{A} = \frac{Q}{\epsilon_0}$.

**The electric flux through a closed surface is proportional to the total charge contained within that surface divided by the permittivity constant**

2. **(3 marks)** Find the total electric flux through the Gaussian surface in figure B and draw the surface area vector(s) for a side of your choosing.

$\phi_{box} = \phi_{top} + \phi_{bottom} + \phi_{sides}$

$\phi_{box} = \oint \vec{E}\cdot d\vec{A} = \int\limits_{top} \vec{E}\cdot d\vec{A} + \int\limits_{bottom} \vec{E}\cdot d\vec{A} + \int\limits_{sides} \vec{E}\cdot d\vec{A}$—-1 Mark

$\int\limits_{top} \vec{E}\cdot d\vec{A} = \int\limits_{top} E\,dA\,\cos(\pi) = -E\int\limits_{top} dA = -El^2$—- 0.5 Marks

$\int\limits_{bottom} \vec{E}\cdot d\vec{A} = \int\limits_{bottom} E\,dA\,\cos(\pi) = -E\int\limits_{bottom} dA = -El^2$—- 0.5 Marks

$\int\limits_{sides} \vec{E}\cdot d\vec{A} = \int\limits_{sides} E\,dA\,\cos\left(-\frac{\pi}{2}\right) = 0$—- 1 Mark

$\phi_{box} = -2EA$

3. **(2 marks)** For the pill-box in figure B, using Gauss's relation; $\oint \vec{E}\cdot d\vec{A} = \frac{Q}{\epsilon_0}$, find an expression for the electric field in terms of the charge density $\sigma$.

$Q = -\sigma A$

using Gauss's relation we obtain:
$-2EA = \frac{-\sigma A}{\epsilon_0} \implies E = \frac{\sigma}{2\epsilon_0}$

4. **(1 mark)** What is the difference between the electric field flux through the pill-box and the octahedron? Explain.
**There is no difference. The electric flux through the square area formed the intersection of the octahedron and the horizontal plane is the same as the flux through the sides. Given that the square area has the same dimensions as the pill-box; the total field flux through the surfaces of the octahedron and the pill-box are the same.**

5. **(2 marks)** Find the total electric flux through the octahedral Gaussian surface?

$\phi_{top-oct} = -El^2$ (using answer from Q2 with argument from Q4)—- 0.5 Marks

$\phi_{bottom-oct} = -El^2$ (using answer from Q2 with argument from Q4)—- 0.5 Marks

$\phi_{oct} = \phi_{top-oct} + \phi_{bottom-oct} = -2El^2$—- 1 Mark

**(1 mark for the correct answer)** What is the electric flux through the octahedron? Express your answer in terms of $\sigma$ using the relation $E = \sigma/2\epsilon_0$.

A. $-\frac{\sigma}{2\epsilon_0}l^2$ B. $\boxed{-\frac{\sigma}{\epsilon_0}l^2}$ C. $\frac{\sigma}{2\epsilon_0}l^2$ D. $\frac{\sigma}{\epsilon_0}l^2$