exam 2.pdf

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Individual work

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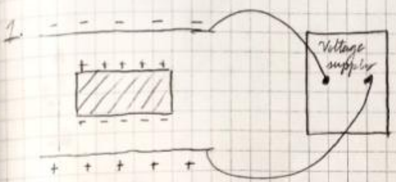
Exam 2

<u>Resources used</u>

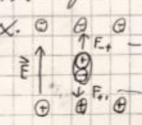
- Phet simulation
- Griffiths; pp. 172 - 197

1.



i) The electric field going from the bottom conducting plate to the top will result in the negatively charged part of the dipoles in the dielectric being pulled downward while the positively charged parts will be pulled upwards. This will result in a net-negative charge on the lower face of the dielectric and a net-positive charge on the upper face.

ex.



F_{-+} – force from negative on positive

F_{+-} – force from positive on negative

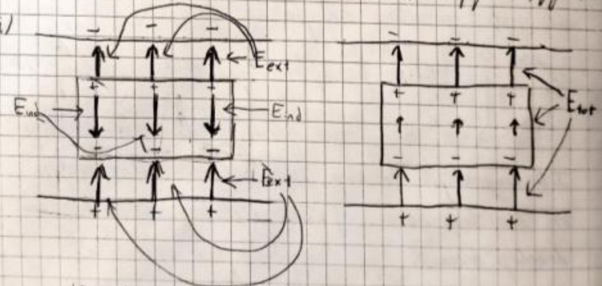
It's important to say that these net charges on the two faces of the dielectric do not develop because of moving, free charged particles like we see in a conductor. It is because the each dipole experiences a torque due to the external field that results in a configuration where each face gains a net-charge.

ii)

Term	Units
σ	C/m^2
$\vec{P}$	$C\cdot m/m^3 \equiv C/m^2$
$\hat{n}$	(unitless; is a unit vector)

This makes sense since the relationship $\sigma = \vec{P}\cdot\hat{n}$ tells us that the surface charge density will be equal to the polarization if the dielectric is lined up with the magnetic field; ie if the surface normal of the dielectric is 180° from the electric field lines, the dielectric will have a surface charge density equal to the dipole moments per unit volume. (Griffiths, pp. 172)

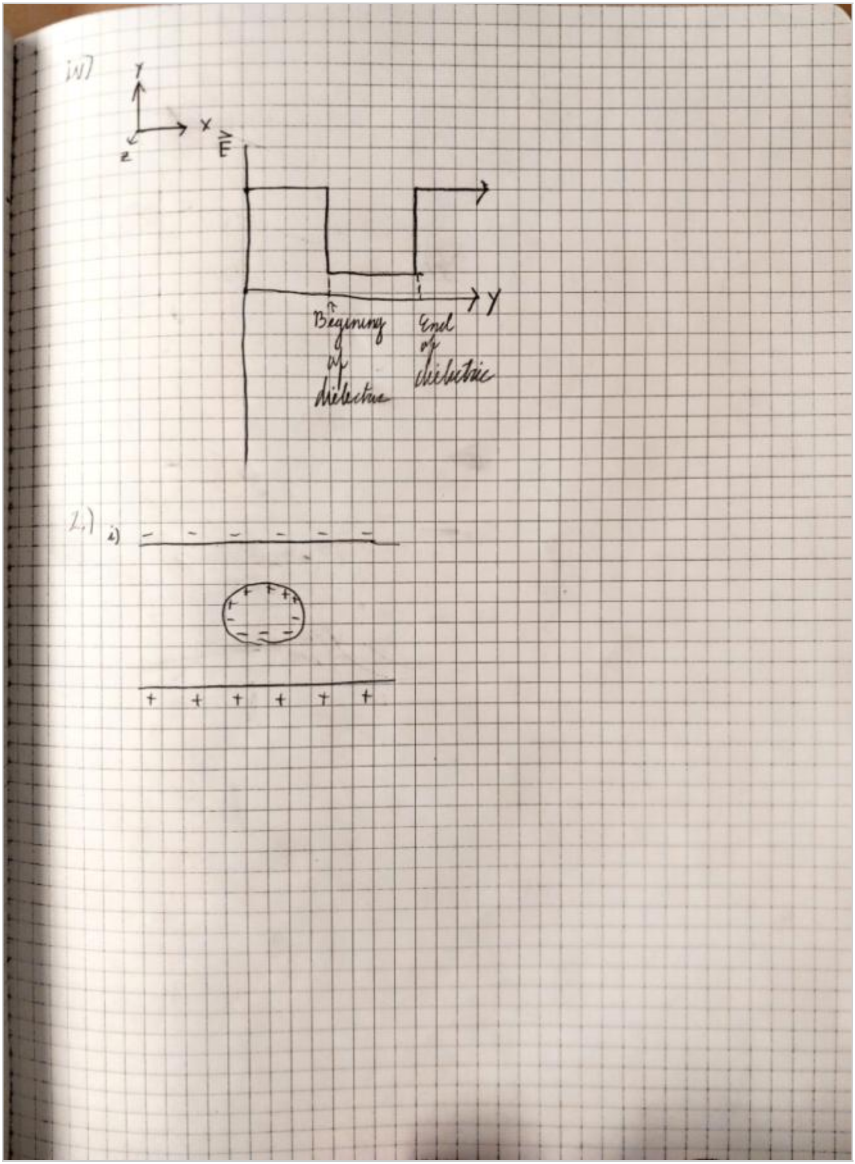
iii)



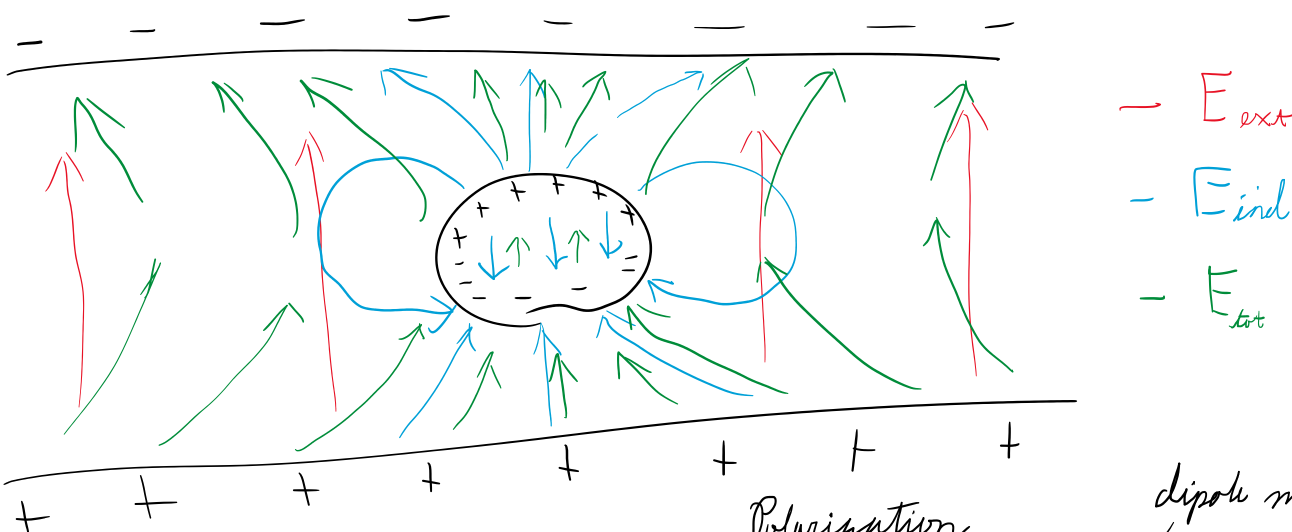
$$|\vec{E}_{ext}| = \frac{\sigma}{\epsilon_0} \quad \text{(two infinite plates)}$$

$$|\vec{E}_{ind}| = \left|\frac{\vec{P}}{\epsilon_0}\right| = \frac{\sigma_b}{\epsilon_0}$$

$$|\vec{E}_{tot}| = \frac{\sigma}{\epsilon_0} - \frac{\sigma_b}{\epsilon_0}$$



2.) Continued
Ii)



Polarization

dipole moment

$$E_{tot} = \frac{\sigma}{\varepsilon_0} - \frac{P}{\varepsilon_0} = \frac{\sigma}{\varepsilon}\hat{y} - \frac{p}{\left(\frac{4}{3}\pi r^3\right)\varepsilon}\hat{r}$$

$$E_{tot} = \frac{\sigma}{\varepsilon_0} - \frac{P}{\varepsilon_0} = \frac{\sigma}{\varepsilon_0}\hat{y} - \frac{p}{\left(\frac{4}{3}\pi r^3\right)\varepsilon_0}\hat{r}$$

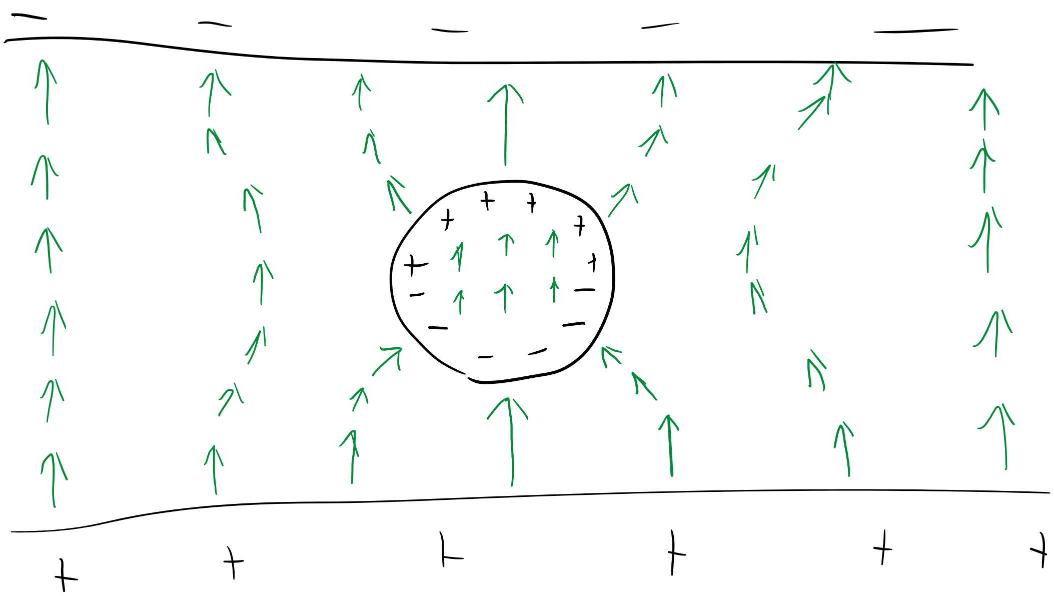
This is for the total E-field outside of the dielectric. Outside of the dielectric, the E-field will vary with the distance from the dielectric. Inside of the dielectric, the E-field will be constant.

E-field in sphere

$$E_{in} = -\frac{1}{3\varepsilon_0}\vec{P}$$

(from Griffiths pp 180)

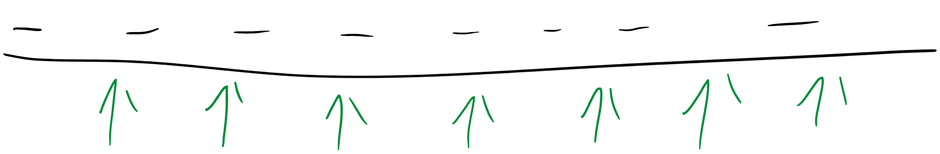
Iii) From my understanding, we're saying that if the electric external electric field is perpendicular to the normal, then it is just equal to the surface charge density of the conducting plates; meaning that the induced dielectric field does not effect it. However, if there is a parallel component, then the parallel components will be proportional to the polarization of the dielectric. I think this can be seen in my drawing by the way that the external field lines bend towards the dielectric (or bend away bending on which half of the drawing we look) until we reach the center where, if they are sufficiently far enough, they will go straight up. In a cleaned up drawing, we can see the total electrics doing this.

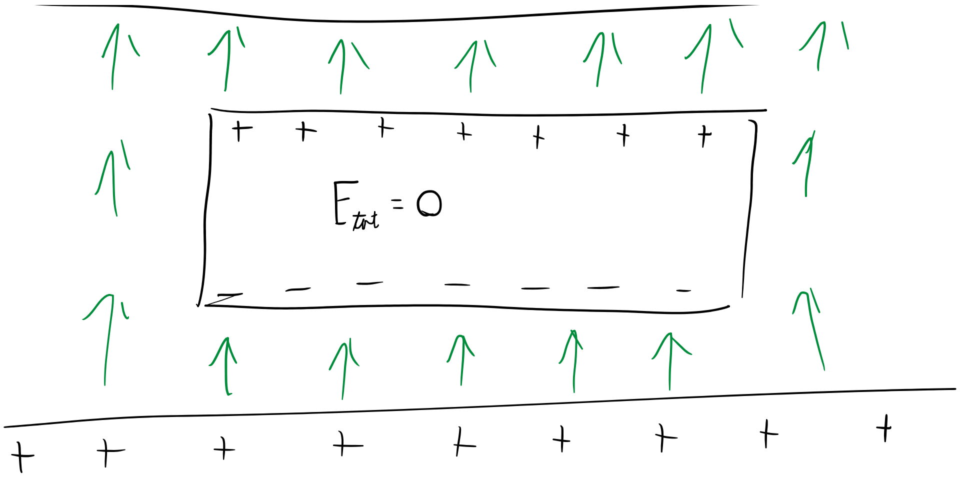


From my understanding, I needed to correct the lines coming off of the dielectric in my original drawing to start by going straight up and "fall in" to the point where they are going in orthogonally.

3.) If the dielectric was a conductor instead.

First system: If the rectangle from the first system is replaced with a conductor, the free charges will distribute themselves in such a way that that the inside has a constant voltage and no electric field. Given this, the configuration would seem relatively similar to that of a rectangular dielectric.





The free electrons in the metal will move downwards, towards the positively charged plate, leaving a net positive charge towards the top, nearest the negatively charged plate.

Second system: The main variation for this system would be in the surface charge density. The free electrons would still move to the bottom, close to the positively charged plate. However, since the strength of the external field will not hit every part of the conducting sphere's surface with the same strength, the charges will be more concentrated at the bottom and more dispersed on the sides, where the external field if perpendicular to the normal vector coming out of the sphere.