Electromagnetics Spring

2020 Homework 3

Deadline: 4.2 23:59 pm

说明:
全用英文作答;
每道题要对所有小问作答，要给出全部必要的推导过程，计算题要算出最终的数值结果，比如开根号之类的;
所有计算出来的结果如果是有单位的物理量，一定要写明单位;
每题的分数在括号中给出;
可以互相讨论，也可以上网查，但是不能抄袭，也不能找别人代做;
可以在电脑敲字解答，也可以手写解答，最后统一转换为 PDF 格式，按分组信息邮件或 BB 上提交;
邮件主题&附件命名规范:姓名_章节，不按规范发送扣除一半分数;
请在作业 PDF 的第一行写上姓名和学号;
有问题请给老师或助教发邮件;

Textbook: Fundamentals of Applied Electromagnetics, 7th edition

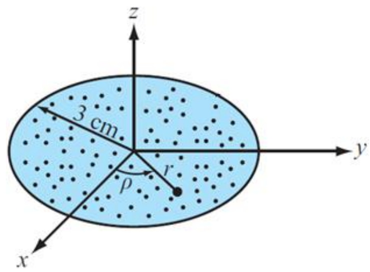
Part I. Problems in textbook.

4.16 (10 points)
4.18 (20 points)
4.24 (20 points)
4.28 (10 points)
4.40 (20 points)
4.49 (10 points)
4.51 (20 points)
4.53 (10 points)
4.56 (20 points)
4.60 (20 points)
4.61 (20 points)
4.62 (20 points)

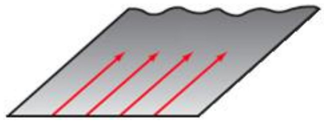
Part II.Problems in quiz.

1. (**8 points**)

(a) (**4 points**) In the case shown below, all the charges are located in the *xoy* plane. What kind of charge density does it represent? Write out the unit for this kind of charge density. How to calculate the total charge Q in an area S?



(b) (**4 points**) In the case shown below, all the currents are located in a plane. What kind of current density does it represent? Write out the unit for this kind of current density. How to calculate the total current I in this plane?



2. (**9 points**)

(a) (**1 point**) Write out the integral form of the Gauss's law for electrostatics.

(b) (**3 points**) In electrostatics, all electric field lines can only be in three possible forms. Draw the three forms.

(c) (**1 point**) Write out the integral form of the Gauss's law for magnetostatics.

(d) (**1 point**) All the magnetic fields lines can only exist in one form. What is it?

(e) (**3 points**) Write out the differential form of the Ampère's law for magnetostatics. Write out the integral form of the Ampère's law for magnetostatics. Is static magnetic field conservative or not?

3. (**11 points**)

(a) (**1 point**) Write out the Joule's law in electromagnetics.

(b) (**1 point**) Write out the Ohm's law in electromagnetics.

(c) (**3 points**) Is there any electric field inside a perfect conductor? Is there any conduction current inside a perfect conductor? Can static magnetic fields exist in a perfect conductor?

(d) (**2 points**) Can electric fields exist in a perfect dielectric material? Can conduction currents exist in a perfect dielectric material?

(e) (**2 points**) Write out the general expression of resistance in terms of electric field.

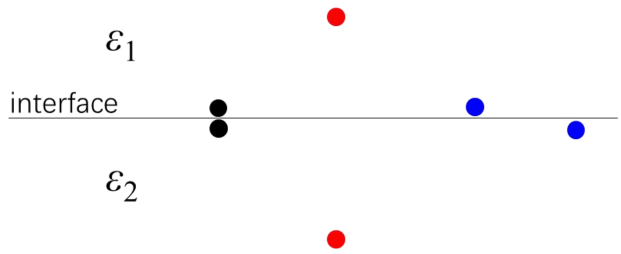
(f) (**2 points**) Write out the general expression of capacitance in terms of electric field.

4. (**4 points**)

(a) (**2 points**) Two points P_1 and P_2 in electric field $\boldsymbol{E}$ have electric potential V_1 and V_2, respectively. Write out the relationship between V_1, V_2 and $\int_{P_1}^{P_2} \boldsymbol{E} \cdot d\boldsymbol{l}$.

(b) (**2 points**) Express $\boldsymbol{E}$ by V.

5. (**12 points**) In the figure shown below, the two black points and two blue points are infinitely close to the interface. But the two red points are away from the interface. The two materials have different permittivity.



(a) (**2 points**) If some charges exist at the interface, the tangential components of the electric fields (E_t) at the two black points are the same or not?

(b) (**2 points**) If some charges exist in a volume across the interface, the normal components of the electric flux density (D_n) at the two black points are the same or not?

(c) (**2 points**) If no charge exists at the interface, the normal components of the electric flux density (D_n) at the two black points are the same or not?

(d) (**2 points**) If no charge exists at the interface, the normal components of the electric fields (E_n) at the two black points are the same or not?

(e) (**2 points**) If some charges exist at the interface, the tangential components of the electric fields (E_t) at the two red points are the same, different or unknown?

(f) (**2 points**) If no charge exists at the interface, the normal components of the electric flux density (D_n) at the two blue points are the same, different or unknown?

6. (**6 points**) Use the boundary conditions to derive electric fields due to an infinitely large surface source with uniform charge density ρ_s that resides in the *xoy* plane in free space.

7. (**8 points**)

(a) (**4 points**) Write out the values and units of permittivity and permeability in free space(vacuum).

(b) (**2 points**) What is the unit of $\frac{1}{2}\varepsilon E^2$? What does it represent?

(c) (**2 points**) What is the unit of $\frac{1}{2}\int_V \mu H^2 dv$? What does it represent?

8. (**5 points**)

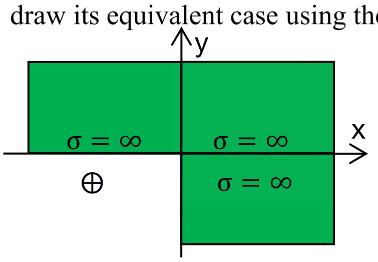
(a) (**2 points**) Demonstrate the units of the two terms of the equations $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ are equal.

(b) (**3 points**) Demonstrate the units of the three terms of the equations $\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$ are equal.

9. (**2 points**)Write out the general expression of inductance in terms of magnetic field.

10. (**7 points**)

(a) (**3 point**) For a positive charge +q locating near an infinitely large conductor shown below, draw its equivalent case using the image method.

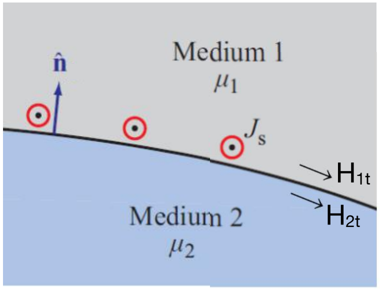


(b) (**2 points**) Which part of the region in the equivalent case has the same electric field as the original case?

(c) (**2 point**) Try your best to draw the electric fields in the region you obtained in (b).

11. (19 points)

(a) (**5 point**) For the figure shown below, write out the relationship between H_{1n} and H_{2n} across the boundary. Also write out the relationship between H_{1t} and H_{2t} across the boundary using J_s.



(b) (**2 point**) If no surface current exists at the interface of two different materials, is the tangential component of the magnetic field(H_t) continuous or discontinuous?

(c) (**3 points**) If some currents exist in a volume across the interface of two different materials, is the tangential component of magnetic field(H_t) continuous or discontinuous?

(d) (4 **points**) If the interface is on the *xoy* plane and the surface currents exist is in the *x* direction, is the magnetic field in *x* direction (H_x) continuous or discontinuous? Is the magnetic field in *y* direction(H_y) continuous or discontinuous?

(e) (6 **points**) Use the boundary conditions to derive magnetic fields due to an infinitely large surface current source with uniform current density J_s that resides in the *xoy* plane in free space.