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Write your UCID in the space above

University of Calgary

Faculty of Science

Midterm Test

PHYSICS 259 ALL LECTURE SECTIONS

## Part II: Written Answer Questions (Total: 16 marks)

**IMPORTANT:** Write your answers to the problems in Part II in boxes. Work must be shown for full marks. Rough work can be done on the back of this question paper, but only the work in the boxes be marked.

### Question 22 (5 marks)

Six point charges are located in the x-y plane in a hexagon centered on the origin. The distance between adjacent charges is  $d$ . The charges all have the same magnitude  $q$ , but with signs as shown in Figure 22.

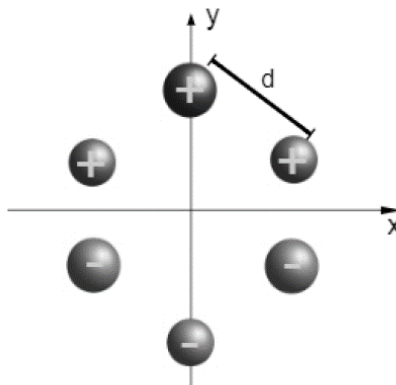


Figure 22: Charge hexagon

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Write your last name and initials in the space above

22.1. What is the electric field  $\vec{E}$  at the origin? Include diagram. (2 marks)

22.2. Calculate the electric field  $\vec{E}$  on the z-axis at  $(x=0, y=0, z=h)$ . (4 marks)

22.2a Diagram (1 mark)

22.2b Calculation of x component (1 mark)

22.2c Calculation of y component (1 mark)

22.2d Calculation of z component (1 mark)

## Question 23 (6 marks)

A total charge  $Q$  is uniformly distributed along a rod of length  $L$ . The rod is located on the  $x$ -axis with the midpoint at  $x = 0$ .

23.1 Draw a sketch of the problem including axes and labels. (1 mark)



23.2. Consider a small segment of the rod  $dx$  at the origin. Write down an expression for the electric field  $d\vec{E}$  due to the small segment at an arbitrary location outside the rod.  $\vec{r} = x\hat{i} + y\hat{j}$ . (1 mark)



23.3. Derive an integral expression for the electric field  $\vec{E}$  ( $x = L$ ,  $y = 0$ ) produced by the entire rod the location on the x-axis where  $x = L$ . Show your work, but you do not need to evaluate the final integral. (3 marks)

Diagram showing the set up for integration (1 mark):

Calculations (2 marks):

23.4. What is the linear charge density  $\lambda$  if  $Q = -3.00$  Coulombs and  $L = 2.00$  metres? (1 mark)

## Question 24 (4 marks)

A very long line of charge density  $\lambda$  is located on the x-axis.

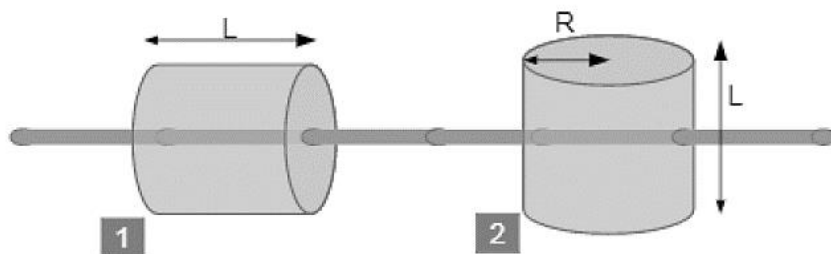


Figure. 24. Two Gaussian cylinders

24.1. Use Gauss's law to derive a general expression for the electric field (use cylinder 1), assuming that the rod is very long ( $L \rightarrow \infty$ ). Show all steps and clearly (2 marks) state any assumptions. (1 mark)

24.2. Two identical cylinders are placed as shown in Figure 24. If the total flux through both cylinders is identical, then what can we say about the cylinder dimensions? Explain. (1 mark)