PHYS 301: Electricity and Magnetism

Midterm 1

February 14th 2025

Duration: 50 mins

NAME: _____

Student Number: | | **Signature_____**

Please print your Student Number legibly in this box – we need it for proper scanning and uploading your exam!

- This exam consists of 3 questions, which add up to 25 pts.
- Part marks will be awarded for partially correct solutions. Make sure your work is clear and easy to read; don't skip steps. Include diagrams or brief explanations, if useful.

Please turn off and remove from the desk all cell phones, tablets and other communications devices!

Please note: you are not required to write this exam in series. Consider reading the entire exam first and beginning with what you feel most comfortable

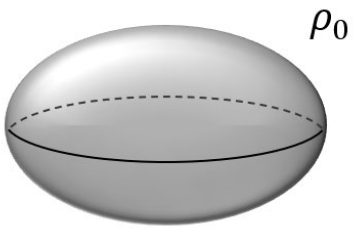
1. Each candidate must be prepared to produce, upon request, a UBC card for identification.
2. Candidates are not permitted to ask questions of the invigilators, except in cases of supposed errors or ambiguities in examination questions.
3. Candidates suspected of any of the following, or similar, dishonest practices shall be immediately dismissed from the examination and shall be liable to disciplinary action:

- having at the place of writing any books, papers or memoranda, calculators, computers, sound or image players/recorders/transmitters (including cell phones), or other memory aid devices, other than those authorized by the examiners;
- speaking or communicating with other candidates; and
- purposely exposing written papers to the view of other candidates or imaging devices. The plea of accident or forgetfulness shall not be received.

5. Candidates must not destroy or mutilate any examination material; must hand in all examination papers; and must not take any examination material from the examination room without permission of the invigilator.
6. Candidates must follow any additional examination rules or directions communicated by the instructor or invigilator.

You can use extra pages at the end of the exam booklet. If you want them to be marked, write "see extra page" in the exam booklet, next to the question that you want us to mark on these extra pages.

Problem 1 [2 pts]. Consider a 3D ellipsoid (see figure) charged with a uniform volume charge density ρ_0.



Can you use Gauss's law to find its electric field? If yes, sketch "useful" Gaussian surfaces, and clearly explain why they are useful. If not, clearly explain why this would not work. One short sentence is not enough.

Note: You don't need to actually compute the field.

Problem 2 [13 pts]. A sphere of radius R carries a constant uniform surface charge density $-\sigma_0$ and volume charge density $\rho(r) = 8\sigma_0 r/R^2$.

a) [2 pts] Find net charge on the sphere.

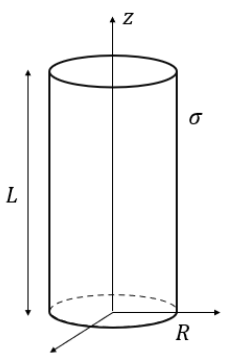
b) [4 pts] Determine electric field $\mathbf{E}(\mathbf{r})$ for all $\mathbf{r}$. Draw its graph as a function of coordinate(s). In the graph, clearly explain what happens to the field at $r = R$, and write in the functional dependences for $r < R$ and $r > R$.

c) [3 pts] Find potential at $r = 0$, assuming the reference point at $r = \infty$. Show all your steps.

d) [3 pts] Find electric potential energy of the sphere.

e) [1 pt] Someone says that this sphere is made of a metal. Can this be true? Explain your answer.

Problem 3 [10 pts]. A cylindrical **shell** (radius R, height L) carries a uniform surface charge density σ.



a) [1 pt] Find total charge Q on the shell.

b) [3 pts] Set up the expression for potential at the z axis, at a point $z > L$. Take the reference point of the potential at an infinite distance from the cylinder. Don't compute the integral.

c) [2 pts] Consider the limit $z \gg R, L$. Approximate the expression in the integral by the leading term, and compute the integral. Express your answer through the total charge Q which you have found in part a).

d) [2 pts] Now consider the limit $R \gg z$. Approximate the expression in the integral by the leading term, and compute the integral. Express your answer through the total charge Q which you have found in part a).

e) [2 pts] Do your answers from parts c) and d) remind you of something? If yes, name what it is. Is it what you expected?

Extra page. If you want your work on it to be marked, indicate this clearly next to the question you are solving.

Extra page. If you want your work on it to be marked, indicate this clearly next to the question you are solving.