Dawson College

Physics 203-NYB-05 Electricity & Magnetism

Sample Final Examination

This exam is divided into two parts:

Part I: Problems (*10 marks each*) Solve all six problems. Show all of your work, clearly and in order, to receive full marks. If you use a formula not given on the formula sheet, a derivation must be shown.

Part II: Multiple Choice Questions (*2 marks each*) Answer all twenty questions. Circle the best response from the choices given. If your nal selection is unclear you will not be given the marks. No marks will be awarded for diagrams, calculations, or reasoning.

Part I: Problems (*10 marks each*)

Solve all six problems. Show all of your work, clearly and in order, to receive full marks. If you use a formula not given on the formula sheet, a derivation must be shown.

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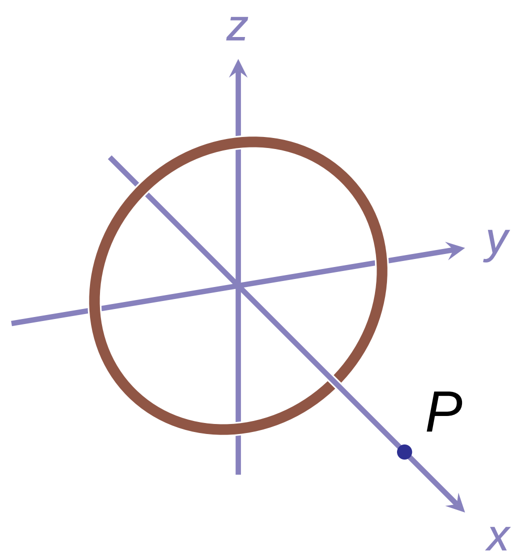
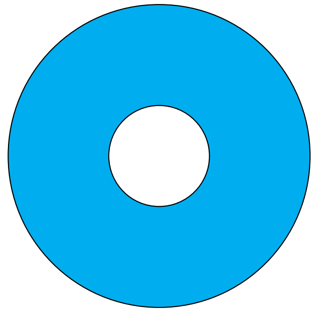
1. Pictured below is uniformly charged ring in the yz-plane, centered at the origin. The ring has radius R and linear charge density .



   (a) (7pt) Integrate contributions from the ring to determine the expression for the electrical potential at a position P on the x-axis. (Use $V = 0\,\mathrm{V}$ in nitely far away from the ring.)

   (b) (3pt) What is the electric eld vector at that position? State all three of its components. (Hint: you do not need to integrate, again. Use the result of part (a).)

2. A hollow sphere made from a non-conducting material is shown below in cross-section. The inner radius is R_1, and the outer radius is R_2. The material is charged uniformly ρ.



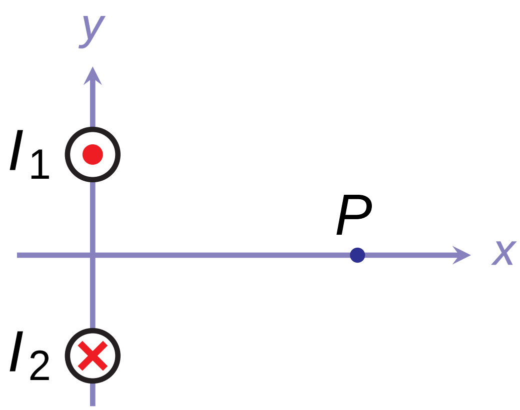
   (a) (7pt) What is the magnitude (measured in N/C) and the direction (away from or towards the center) of the electric field at a distance r from the center of the sphere, for values $R_1 < r < R_2$? (For full marks you are required to use Gauss' Law only to solve this first part of the problem. Do all this work symbolically – don't use the values of part (b) for this part.)

   (b) (3pt) The inner radius is $R_1 = 1.00\,\text{cm}$, and the outer radius is $R_2 = 3.00\,\text{cm}$. The material is charged uniformly $\rho = 1.07\,\text{nC/m}^3$. If the electric potential is 0 V infinitely far away, what is the electric potential at the outer surface of the sphere?

3. Below is a circuit with four branches. The currents I_1 and I_2, and the emf

4.

5. Two long, straight, parallel current-carrying wires are shown below. The wires are parallel to the z-axis (the $+z$-axis points out of the page). The current in the wire above the origin is flowing in the $+z$-direction ($I_1 = 3.2$ A, out of the page), while the current in the wire below the origin is flowing in the $-z$-direction ($I_2 = 3.2$ A, into the page). The wire above the origin passes through $y = +13.3$ cm, the wire below the origin passes through $y = -13.3$ cm, and the point P is at $x = +35.0$ cm.



(a) (5pt) Find all three components of the magnetic field vector at the point P on the x-axis.

(b) (2pt) If an electron were traveling in the $+z$-direction at 5200 m/s what would be the magnitude and direction of the magnetic force acting on it as it passed through P?

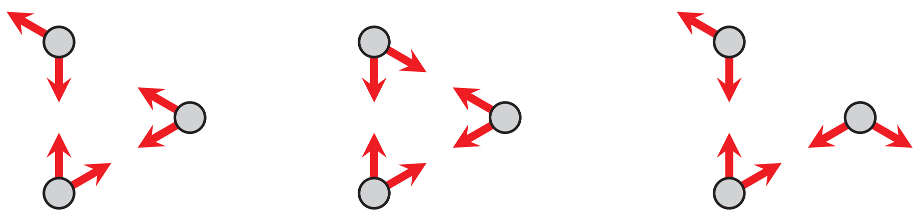
(c) (3pt) What electric field (state all three components) would we need to apply to the electron in part (b) so that the net force acting on it were zero?

6. There is a rectangular conducting coil, measuring $40.0\,\text{cm}$ by $20.0\,\text{cm}$, with resistance $50.0\,\text{ohm}$ has 10 turns, as shown below. The coil moves at a constant speed of $50.0\,\text{cm/s}$ from a region where the magnetic field is zero and into a region where the field is $2.00\,\text{T}$ pointed along the $+z$-axis.

Part II: Multiple Choice Questions (*2 marks each*)

Answer all twenty questions. Circle the best response from the choices given. If your final selection is unclear you will not be given the marks. No marks will be awarded for diagrams, calculations, or reasoning.

1. Which of the following diagrams represent the forces that three charged objects might exert on each other?



(Fig.1) (Fig.2) (Fig.3)

   (a) Fig.1.
   (b) Fig.2.
   (c) Fig.3.
   (d) Fig.1 and Fig.3, but not Fig.2.
   (e) All three.

2. The force acting on an electron is 4.337×10^{-16} N along the $+y$-axis. What is the magnitude and direction of the electric field vector at the electron's position?:

   (a) 6.95×10^{-35} N/C along the $-y$-axis.
   (b) $4.76 \times 10^{+14}$ N/C along the $-y$-axis.
   (c) $2.71 \times 10^{+3}$ N/C along the $-y$-axis.
   (d) $2.71 \times 10^{+3}$ N/C along the $+y$-axis.
   (e) Defined only for a positive charge.

3. Two positively charged objects are on the x-axis, as shown below. The object on the left has a larger charge than the object on the right.

On the x-axis there is a position where $\vec{E} = \vec{0}$ N/C. This position is

(a) to the left of the larger charge.

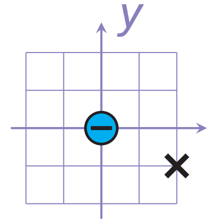
(b) between the two charges, but closer to the larger charge.

(c) between the two charges, exactly in the middle.

(d) between the two charges, but closer to the smaller charge.

(e) to the right of the smaller charge.

4. A 3 nC charge is at the origin, as shown below.



What are the components $(E_x; E_y)$ of the electric eld at the position "X", measured in N/C?

(a) $(+241; \ 482)$.

(b) $(\ 241; +482)$.

(c) $(+482; +241)$.

(d) $(\ 482; \ 241)$.

(e) $(\ 482; +241)$.

5. A positively charged particle is in a uniform magnetic eld. As it moves along the x-axis ($\vec{v} = \ v\hat{\imath}$) the magnetic force it experiences points along the z-axis ($\vec{F}_m = \ F\hat{k}$). The magnetic eld vector points along

(a) the $+x$-axis ($+\hat{\imath}$).

(b) the $+y$-axis ($+\hat{\jmath}$).

(c) the $+z$-axis ($+\hat{k}$).

(d) the y-axis ($\hat{\jmath}$).

(e) some other direction, not listed.

6. A proton has velocity $\vec{v} = (-300\ \text{m/s})\hat{\imath} + (+400\ \text{m/s})\hat{\jmath}$. It is moving through a uniform magnetic field $\vec{B} = (0.5\ \text{T})\hat{\imath} + (+0.5\ \text{T})\hat{\jmath}$. The magnetic force acting on the proton is:

(a) $+8.01 \times 10^{-18}\ \text{N}\ \hat{k}$.
(b) $-8.01 \times 10^{-18}\ \text{N}\ \hat{k}$.
(c) $+5.61 \times 10^{-17}\ \text{N}\ \hat{k}$.
(d) $-5.61 \times 10^{-17}\ \text{N}\ \hat{k}$.
(e) zero.

7. A conducting loop and a long straight wire are shown.

There is a current along the wire and a current around the loop. If the magnetic field is zero at the center of the loop then direction of current flow in the wire and in the loop must be:

(a) right; clockwise.0 cm 2.26802 0i0 cm /Fm7 Do Q Q Q Q the loop .0 cm 0pkw-1(.0 cm 2.268f

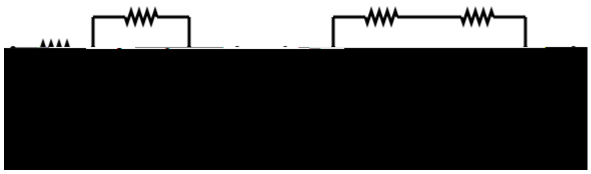
9. In a uniform electric eld $\vec{E} = (+32\ \text{N/C})\hat{\imath} + (\ \ 45\ \text{N/C})\hat{\jmath}$ what is the di erence in electric potential $V_B \quad V_A$ if A is at $x = \quad 0.050$ m, $y = \quad 0.200$ m and B is at $x = \quad 0.050$ m, $y = +0.200$ m?

   (a) 22 V
   (b) 18 V
   (c) 0 V
   (d) +18 V
   (e) +22 V

10. An electron, between the oppositely charged plates of a capacitor is launched towards the negative plate. As it moves closer to the negative plate

   (a) $V > 0$ V and $U_e > 0$ J.
   (b) $V >$

13. Compare the equivalent resistance of these two groups of resistors:

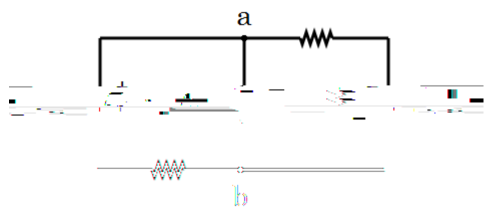


(a) $R_1 > R_2$.

(b) $R_1 = R_2$.

(c) $R_1 < R_2$.

14. In the circuit shown below each resistor is 100 . The current owing through the 25 V battery is 200 mA, and the current owing through the 10 V battery is 150 mA.



The current through the resistor in the center is:

(a) 150 mA from a towards b.

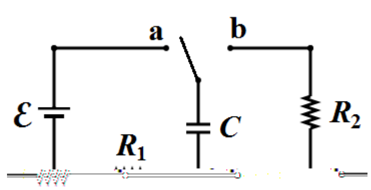
(b) 150 mA from b towards a.

(c) 50 mA from a towards b.

(d) 50 mA from b towards a.

(e) 0 mA.

15. Shown below is a charging/discharging circuit.



If $R_1 > R_2$, then which would take longer: charging, or discharging?

(a) Charging.

(b) They would be the same because the capacitor is the same for both.

(c) Discharging.

(d) This can't be determined without knowing the value of the capacitance C.

(e) This can't be determined without knowing the value of the emf E.

16. If an LC circuit oscillates with angular frequency ω, by what factor must you change the inductance to make the new frequency $\omega/2$?

(a) 4.

(b) 2.

(c) $\sqrt{2}$.

(d) $1/2$.

(e) $1/4$.

17. A singly-ionized Helium atom has one electron, two protons, and two neutrons. The electric flux (measured in $\text{N m}^2/\text{C}$) through a Gaussian surface that encloses this ion is:

(a) -5.43×10^{-8}

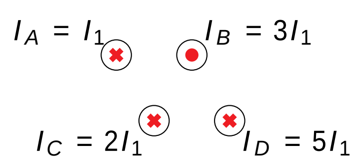
(b) -1.81×10^{-8}

(c) $+1.81 \times 10^{-8}$

(d) $+5.43 \times 10^{-8}$

(e) $+9.05 \times 10^{-8}$

18. Shown in cross-section are four long straight current-carrying wires that pass perpendicular to the page.



If a clockwise Amperian loop that encloses wire A only gives $\oint \vec{B} \cdot d\vec{s} = +\mu_0 I_1$, what Amperian loop would give $\oint \vec{B} \cdot d\vec{s} = -4\mu_0 I_1$?

(a) a clockwise loop that encloses wires A, B and C only.

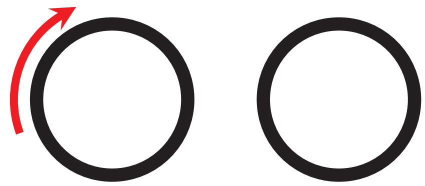
(b) a counter-clockwise loop that encloses wires A and D only.

(c) a clockwise loop that encloses wires B and C only.

(d) a clockwise loop that encloses wires A and B only.

(e) a counter-clockwise loop that encloses wires B, C and D only.

19. Two conducting loops are in the plane of the page, as shown.



The current around the loop on the left is initially zero, increases up to a large clockwise current, then decreases back down to zero. The current induced in the loop on the right is:

(a) initially clockwise, then counter-clockwise.

(b) initially clockwise, then clockwise again.

(c) initially counter-clockwise, then clockwise.

(d) initially counter-clockwise, then counter-clockwise again.

20. Current owing through a 80 mH inductor increases from 400 mA to 1:2 A over 128 s. If we cross the inductor in the direction of current ow, the di erence in electric potential is

(a) +750 V

(b) +500 V

(c) 78 V

(d) 500 V

(e) 750 V

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SPOILERS!

ANSWERS begin on the next page...

Answers

Problems

1. (a) $V = \int dV = \int_0^{2} \frac{1}{4 \ _0} \frac{R\,d}{\sqrt{x^2+R^2}} = \frac{2 \ R}{4 \ _0 \sqrt{x^2+R^2}} = \frac{k_e Q}{\sqrt{x^2+R^2}}$.

   (b) By symmetry $E_y = E_z = 0$ N/C. $E_x = \ \frac{d}{dx} V(x) = \qquad = \frac{k_e Q\, x}{(x^2+R^2)^{3/2}}$.

2. (a) With a concentric sphere as the Gaussian surface between R_1 and R_2 the charge inside is $Q_{in} = \ (\frac{4}{3} r^3 \quad \frac{4}{3} R_1^3)$ (where we subtract the volume of the empty space to get the

5. (a) The distance from wire 1 to the point P is $r = 0.374\,\mathrm{m}$. The magnetic field due to wire 1 by itself is $\mu_0 I/2\pi r = 1.709\ \mu\mathrm{T}$. Draw a line from wire 1 to the point P. This magnetic field contribution is perpendicular to that, pointed up (the $+y$-direction) and slightly to the right (the $+x$-direction). Consequently the x-component of this is $+0.607\ \mu\mathrm{T}$. (Draw the diagram to see the correct triangles!) The contribution due to wire 2 will have the same magnitude and same x-component, by will have the opposite y-component (which will cancel!). Neither wire contributes to the z-component. The net magnetic field is thus $B_x = +1.214\ \mu\mathrm{T}$, $B_y = 0\,\mathrm{T}$ and $B_y = 0\,\mathrm{T}$ (alternatively $\vec{B} = (+1.214\ \mu\mathrm{T})\hat{\imath}$).

(b) Since $q = -1.602 \times 10^{-19}\,\mathrm{C}$ and $\vec{v} = (+5200\,\mathrm{m/s})\hat{k}$, the magnetic force is $\vec{F}_m = q\vec{v} \times \vec{B} = (-1.012 \times 10^{-21}\,\mathrm{N})\hat{\jmath}$ (pointing in the $-y$-direction).

(c) Requiring $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B}) = q\vec{E} + \vec{F}_m = \vec{0}\,\mathrm{N}$ gives $\vec{E} = -\vec{F}_m/q = (-6.314$