Flavour 5

Physics 207 – Exam III

Fall 2024 (all UP sections)   November 11, 2024

Do **not** open the exam until told to do so.

Before you begin, make sure you filled out the bubbles on the grading sheet indicating this exam flavour (this is **flavour 5**) *and* your UIN! Without this information, your exam will not be able to be processed and may result in a zero.

Mark what answers you put on the bubble sheet on this copy of the exam and keep it for your records so that you can refer back to this later in the semester and know what you did; it will be your only record of Exam III.

There are several flavours of this exam. Do not read anything into the sequence of the questions nor the answers; they are randomized. The "*Qid*" label is the ordering of questions the answer key (and your professor, should you want to ask about a particular problem) will have.

⇒ When filling out the grading sheet, **use the problem number of your flavour**, *not* the "*Qid*" ⇐

Rules of the exam:

1) You have **120** minutes to complete the exam.
2) You will answer using the **Grading Sheet** provided. **Make sure you have one before the exam starts**. Be sure to fill out the bubbles of the Grading sheet **completely** with a dark (e.g. #2) pencil or dark (black, blue) pen so as not to lose marks. If necessary (e.g. you cannot adequately erase a mistake), the proctor has extra Grading Sheets.
3) Formulae are similarly provided to you for the exam. **Make sure you have one before the exam starts**. You may *not* use your own or any other formula sheet.
4) Cell phone use during the exam is **strictly prohibited**. Please turn off all ringers as calls during an exam can be quite distracting. If we see you using a cell phone we will assume you are cheating.
5) Check to see that there are **15 numbered pages** (8 double-sided sheets) in your exam.
6) You are **not** required to show any work, and you will only submit the Grading Sheet at the end of the exam. You may use the blank spaces on the exam to work out problems. If you run out of room, your proctor should have extra scratch paper you may use.
7) Calculators that cannot wirelessly connect to the internet are allowed during the exam.
8) There is only one correct answer of the options given, but incorrect answers may yield some reduced amount of points as partial credit.
   - **Multiple answers are not allowed**. If two or more bubbles are filled for a given question, you will receive a zero for that question – even if one is correct.
   - There is **no penalty** for incorrect answers. So there is no harm in guessing if you can't solve the problem and/or run out of time.
9) Have your **TAMU ID ready when submitting your Grading Sheet** to the proctor. You should keep the exam, any blank sheets you used to work out problems, and/or the formula sheet following submitting your grading sheet. Alternatively, your proctor can recycle any material you don't want to keep.

1. [*Qid 16*] (6 points) A single loop of wire with radius R is carrying a constant current I. At what point along the axis of the loop is the magnitude of the magnetic field half of the magnitude at the center of the loop? Assume this distance is measured from the center of the loop.

   (A) $1.30R$

   (B) $0.630R$

   (C) $1.59R$

   (D) $0.766R$

   (E) $0.500R$

   (F) $2.00R$

   (G) None of the above since the magnetic field at the center of a coil of wire is 0.

2. [*Qid 13*] (8 points) A student creates an inductor in the shape of a solenoid that has a circular cross section with radius $r = 5.00$ mm. The student uses 45.0 m of thin wire and the solenoid itself is 3.00 cm long. The student filled the core of the solenoid with an object that has a relative permeability of 4.00. What is the self inductance of this solenoid.

   (A) 27.0 mH

   (B) 19.8 mH

   (C) 10.6 mH

   (D) 17.1 mH

   (E) 23.3 mH

   (F) 8.33 mH

   (G) 6.75 mH

   (H) 12.5 mH

3. [*Qid 17*] (8 points) Which of the following correctly evaluates the magnetic field at the point (ℓ, ℓ) for a line segment carrying current from $x = \ell$ to $x = 0$?

(A) $\frac{\mu_0 I}{4\pi} \int_{\ell}^{0} \frac{(\ell - x) dx \hat{k}}{((\ell - x)^2 + \ell^2)^{3/2}}$

(B) $\frac{\mu_0 I}{4\pi} \int_{0}^{\ell} \frac{(\ell - x) dx \hat{k}}{((\ell - x)^2 + \ell^2)}$

(C) $\frac{\mu_0 I}{4\pi} \int_{\ell}^{0} \frac{\ell dx \hat{k}}{((\ell - x)^2 + \ell^2)}$

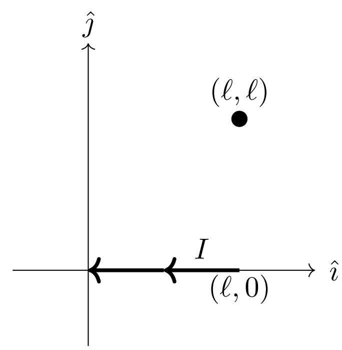
(D) $\frac{\mu_0 I}{4\pi} \int_{0}^{\ell} \frac{\ell dx \hat{k}}{((\ell - x)^2 + \ell^2)}$

(E) $\frac{\mu_0 I}{4\pi} \int_{0}^{\ell} \frac{\ell dx \hat{k}}{((\ell - x)^2 + \ell^2)^{3/2}}$

(F) $\frac{\mu_0 I}{4\pi} \int_{0}^{\ell} \frac{(\ell - x) dx \hat{k}}{((\ell - x)^2 + \ell^2)^{3/2}}$

(G) $\frac{\mu_0 I}{4\pi} \int_{\ell}^{0} \frac{\ell dx \hat{k}}{((\ell - x)^2 + \ell^2)^{3/2}}$

(H) $\frac{\mu_0 I}{4\pi} \int_{\ell}^{0} \frac{(\ell - x) dx \hat{k}}{((\ell - x)^2 + \ell^2)}$



4. [*Qid 14*] (10 points) A wire with a circular cross section is made in such a way that the current density has a function of $\vec{j} = j_0 \left(1 - \frac{r}{R}\right)$ where this is in SI units. What is the magnitude of the magnetic field at $r = R/2$?

   (A) $\frac{\mu_0 j_0 R}{2}$

   (B) $\frac{\mu_0 j_0 R}{4}$

   (C) $\frac{\mu_0 j_0 R}{5}$

   (D) $\frac{\mu_0 j_0 R}{6}$

   (E) $\frac{\mu_0 j_0 R}{3}$

   (F) $\mu_0 j_0 R$

5. [*Qid 15*] (2 points) Two single loops of wire are parallel to the xy-plane and centered on the z-axis. They both carry current in the same direction. Will the force between these wires be attractive or repulsive?

   (A) Repulsive

   (B) Attractive

   (C) It will depend on the radii of the loops.

6. [*Qid 4*] (6 points) An Airbus A380 has a wingspan of 79.8 m. At a particular point during a flight, while traveling at 250. m/s parallel to the Earth's surface, the potential difference between the wingtips is measured at 0.600 V. What angle does the Earth's magnetic field make with the vertical if the total magnetic field strength in that region of space is 4.00×10^{-5} T?

   (A) 67.9 degrees

   (B) 36.9 degrees

   (C) 21.2 degrees

   (D) 26.8 degrees

   (E) 80.9 degrees

   (F) 53.1 degrees

   (G) 41.2 degrees

   (H) 48.8 degrees

7. [*Qid 8*] (4 points) An electron enters a velocity selector where $\vec{E}$ and $\vec{B}$ are perpendicular to each other and the velocity as shown below. Find the direction of the magnetic force on the electron and the direction the electron will deflect in this device if $v < E/B$.

(A) The magnetic force is into the page and the deflection is out of the page

(B) The magnetic force is down and the deflection is down

(C) The magnetic force is up and the deflection is up

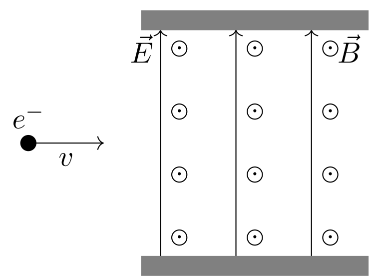
(D) The magnetic force is out of the page and the deflection is into the page

(E) The magnetic force is into the page and the deflection is into the page

(F) The magnetic force is up and the deflection is down

(G) The magnetic force is out of the page and the deflection is out of the page

(H) The magnetic force is down and the deflection is up



8. [*Qid 1*] (4 points) The figure shows three metal coils labeled A, B, and C heading towards a region where a uniform static magnetic field exists and is pointing out of the page. The coils move with the same constant velocity and all have the same resistance. Their relative sizes are indicated by the background grid. As they enter the magnetic field the coils will have an induced electric current in them. For which coil will the current be the greatest?

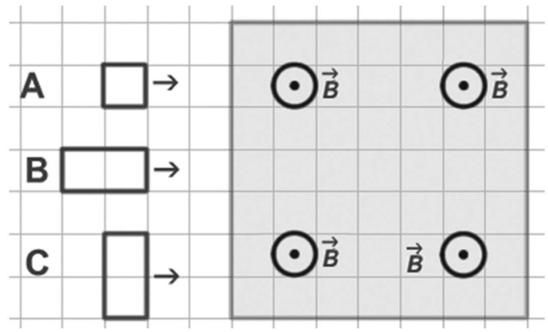
   (A) Coil C

   (B) The induced current is the same in all three since they move at the same constant velocity.

   (C) Coil B

   (D) There is no induced current in any of them since they move at the same constant velocity.

   (E) Coil A



9. [*Qid 6*] (6 points) A proton has a velocity in the positive z-direction. The magnetic force on the proton is in the positive y-direction. What can you conclude about the components of the magnetic field at the location of the proton?

   (A) $B_x > 0$, Nothing can be concluded about B_y, $B_z = 0$

   (B) $B_x > 0$, $B_y = 0$, Nothing can be concluded about B_z

   (C) Nothing can be concluded about B_x, $B_y = 0$, $B_z < 0$

   (D) $B_x = 0$, $B_y > 0$, $B_z < 0$

   (E) $B_x < 0$, $B_y = 0$, Nothing can be concluded about B_z

   (F) B_x, B_y, B_z

   (G) $B_x > 0$, $B_y = 0$, $B_z = 0$

10. [*Qid 11*] (8 points) You know that the current in Coil 1 follows a function $i(t) = 0.800 - 0.0500t^2$. Coil 1 has 400 turns while Coil 2 has 600 turns. At $t = 3.00$ s an emf of $\mathcal{E} = +75$ mV is induced in Coil 2. What is the average magnetic flux through a single turn of Coil 2 at this instant?

    (A) 1.46×10^{-4} Wb

    (B) 8.80×10^{-5} Wb

    (C) 9.56×10^{-5} Wb

    (D) 8.53×10^{-5} Wb

    (E) 1.88×10^{-4} Wb

    (F) 1.25×10^{-4} Wb

    (G) 9.12×10^{-5} Wb

    (H) 2.19×10^{-4} Wb

11. [*Qid 2*] (4 points) The long straight wire in the figure carries a current I that is decreasing with time at a constant rate. The circular loops A, B, and C all lie in a plane containing the wire. The induced emf in each of the loops A, B, and C is such that

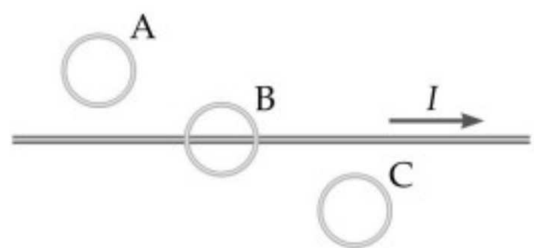
    (A) There is no emf induced in any loop

    (B) A clockwise emf is induced in all loops.

    (C) Loop A has a counterclockwise emf, Loop B has no emf and Loop C has a clockwise emf

    (D) Loop A has a clockwise emf, Loop B has no emf and Loop C has a counterclockwise emf

    (E) A counterclockwise emf is induced in all loops.



12. [*Qid 3*] (8 points) As shown in the figure, a wire and a 10-Ω resistor are used to form a circuit in the shape of a square, 20 cm by 20 cm. A uniform but nonsteady magnetic field is directed into the plane of the circuit. The magnitude of the magnetic field is decreased from 1.50 T to 0.50 T in a time interval of 63 ms. The average induced current and its direction through the resistor, in this time interval, are closest to

    (A) 38 mA from b to a

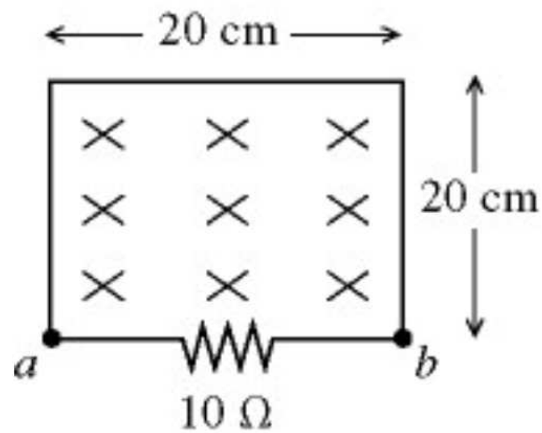
    (B) 95 mA from b to a

    (C) 63 mA from b to a

    (D) 38 mA from a to b

    (E) 95 mA from a to b

    (F) 63 mA from a to b



13. [*Qid 7*] (6 points) You need to build a cyclotron to accelerate protons from a kinetic energy of 1.0 MeV up to 29 MeV. The maximum magnetic field in the cyclotron is 2.0 T. What does the minimum radius of this cyclotron need to be? (Do not consider relativistic effects at all for this problem.)

    (A) 0.39 m

    (B) 1.3 m

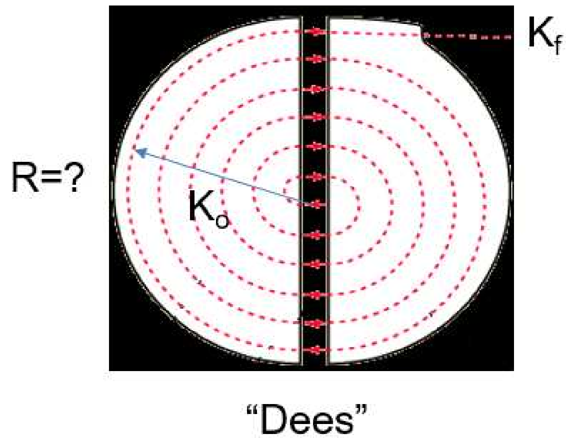
    (C) 0.072 m

    (D) 0.24 m

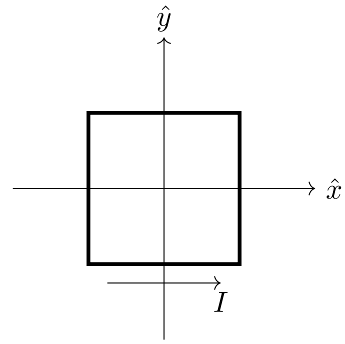
    (E) 0.56 m

    (F) 2.1 m

    (G) 3.4 m



14. [*Qid 9*] (6 points) A square loop with side lengths of 3.0 cm is in the xy-plane and carries a current of 200 mA counterclockwise from the point of view of the figure. There is a uniform magnetic field vector $\vec{B} = 4\sin(30)\hat{\jmath} + 4\cos(30)\hat{k}$ which is in SI units. What is the magnitude of the torque acting on the loop?



   (A) 6.2×10^{-4} Nm

   (B) 3.6×10^{-4} Nm

   (C) 5.1×10^{-4} Nm

   (D) 4.9×10^{-4} Nm

   (E) 7.3×10^{-4} Nm

15. [*Qid 10*] (2 points) What is the direction of the torque vector in the previous problem?

   (A) $-\hat{k}$

   (B) $+\hat{k}$

   (C) $+\hat{\jmath}$

   (D) $-\hat{\jmath}$

   (E) $+\hat{\imath}$

   (F) $-\hat{\imath}$

16. [*Qid 5*] (8 points) A horizontal wire is free to slide on the vertical rails of a conducting frame, as shown in the figure below. The wire has length $l = 2$ m, and the resistance of the circuit is $R = 5\,\Omega$. If a uniform magnetic field $B_{out} = 10$ T is directed perpendicular to the frame and the terminal speed of the wire as it falls under the force of gravity is measured to be $v = 3$ m/s, what is the mass m of the wire? (take $g = 10$ m/s^2)

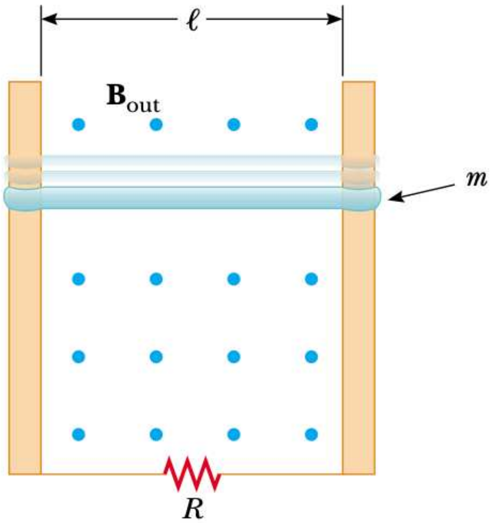
    (A) 3 kg

    (B) 12 kg

    (C) 24 kg

    (D) 1 kg

    (E) 6 kg



17. [*Qid 12*] (4 points) An empty region of space contains a uniform electric field with a magnitude of 24,000 N/C and a uniform magnetic field with a magnitude of 2.4 mT. Which field produces a greater energy density in this region?

    (A) Both fields produce the same energy density.

    (B) The electric field produces a greater energy density.

    (C) It is impossible to tell with the given information.

    (D) The magnetic field produces a greater energy density.