Flavour 5

Physics 207 – Comprehensive

Fall 2024 (all UP sections) November 25, 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 Comprehensive.

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 **13 numbered pages** (7 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 15*] (6 points) A conducting wire of $L = 1.00$ m in length and $R = 1.00$ mm radius is uniformly charged with a total positive charge $Q = 100$ nC is placed in a concentric conducting tube of the same length. The tube is $t = 1.00$ mm thick, has the external radius of 3.00 mm, and it was initially uniformly charged with the same $Q = 100$ nC. What is the electric flux passing through an external concentric cylindrical surface T with radius 4.00 mm and a height of 1.00 mm? (Note that the answer is the same if the cylindrical surface T is a closed surface or an open surface that is just the curved part of a cylinder.)

   (A) 622 Nm^2/C

   (B) 11.3 Nm^2/C

   (C) 4.52×10^{-2} Nm^2/C

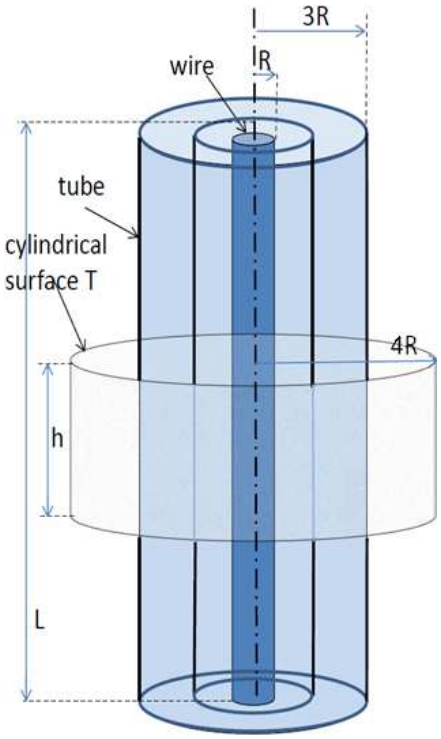
   (D) 2830 Nm^2/C

   (E) 185 Nm^2/C

   (F) 2.26×10^{-2} Nm^2/C

   (G) 22.6 Nm^2/C

   (H) 1990 Nm^2/C



2. [*Qid 18*] (4 points) A block of copper is set aside to make wire. The copper originally has cross-section A and length ℓ. If the copper block is of uniform resistivity and uniform density, but is stretched to double its original length, what happens to the resistance of the block? Assume the volume stays constant.

   (A) Resistance is decreased by a factor of 8

   (B) Resistance is decreased by a factor of 4

   (C) Resistance is decreased by a factor of 2

   (D) Resistance stays constant

   (E) Resistance is increased by a factor of 2

   (F) Resistance is increased by a factor of 4

   (G) Resistance is increased by a factor of 8

3. [*Qid 17*] (4 points) An EM wave has wave number k and angular frequency ω. At some instant in time, t and at position x, the electric field points along the $+y$-direction. If the wave travels in the $-z$-direction and the amplitude of the magnetic field is B_0, what is the vector equation for the magnetic field?

(A) $\vec{B} = -B_0 \sin(kz + \omega t)\,\hat{x}$

(B) $\vec{B} = -B_0 \sin(kz - \omega t)\,\hat{x}$

(C) $\vec{B} = B_0 \sin(kz + \omega t)\,\hat{x}$

(D) $\vec{B} = B_0 \sin(kx - \omega t)\,\hat{z}$

(E) $\vec{B} = B_0 \sin(kx + \omega t)\,\hat{z}$

(F) $\vec{B} = -B_0 \sin(kx + \omega t)\,\hat{z}$

(G) $\vec{B} = B_0 \sin(kz - \omega t)\,\hat{x}$

(H) $\vec{B} = -B_0 \sin(kx - \omega t)\,\hat{z}$

4. [*Qid 7*] (6 points) A conducting rod of length L is free to slide on two parallel conducting bars, as shown in the figure below. Two resistors R_1 and R_2 are connected across the ends of the bars to form a loop. A constant magnetic field B is directed perpendicular into the page. An external agent pulls the rod to the left with a constant speed of v. Find the current through R_1.

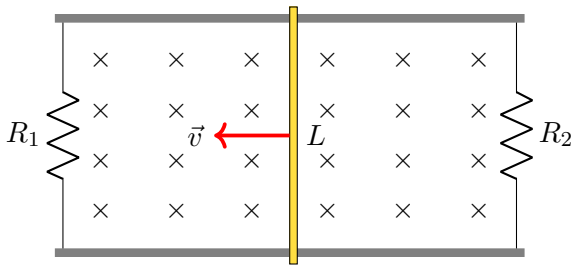
(A) $\dfrac{BLv}{R_1}$

(B) $BLvR_1$

(C) $\dfrac{BLv(R_1 + R_2)}{R_1 R_2}$

(D) BLv

(E) $\dfrac{BLv}{R_1 + R_2}$



5. [*Qid 10*] (6 points) The sun emits an average power of 3.86×10^{26} W and the distance from the sun to mars is 2.28×10^{6} km. Assuming the light is monochromatic, what is the amplitude of the magnetic field at the location of Mars?

   (A) 1.57×10^{-4} T

   (B) 2.22×10^{-4} T

   (C) 4.45×10^{-4} T

   (D) 1.11×10^{-4} T

   (E) 3.15×10^{-4} T

6. [*Qid 11*] (6 points) A circuit contains a battery and an inductor that is long enough to have an appreciable resistance. There are no other components to the circuit. When the circuit is connected it takes 0.750 seconds for the circuit to reach 40% of the maximum current. If the inductor has 5.00 H of inductance, what is the resistance of the inductor?

   (A) 3.41 Ω

   (B) 1.11 Ω

   (C) 0.819 Ω

   (D) 9.24 Ω

   (E) 6.11 Ω

   (F) 4.61 Ω

   (G) 1.47 Ω

   (H) 2.03 Ω

7. [*Qid 12*] (6 points) A thin ring of radius $a = 2.00$ cm is uniformly charged with a positive charge $Q = 25.0$ μC. A point charge of $q = -12.0$ μC is held at rest at a distance of $x = 4.00$ cm from the center of the ring along the axis. If q is released, what is the work done by the electric field to bring the point charge to the center of the ring?

   (A) 135 J

   (B) 7.13 J

   (C) 13.9 J

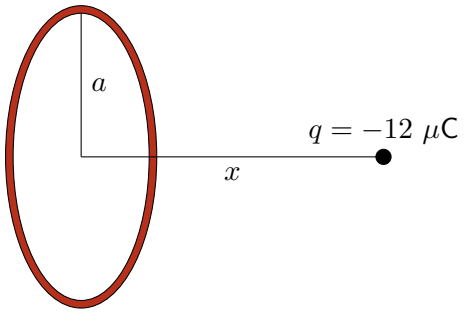
   (D) 93.3 J

   (E) 156 J

   (F) 67.5 J

   (G) 74.6 J

   (H) 60.4 J



8. [*Qid 9*] (6 points) In an ideal LC-circuit the charge on the capacitor can be defined by the function $q(t) = q_0 \sin(\omega t)$ where $q_0 = 320.0$ mC. The capacitor has a capacitance of 47.00 μF and the inductor has an inductance of 140.0 mH. What is the magnitude of the potential that would be measured across the inductor at the time $t = 3.000$ s?

   (A) 4891 V

   (B) 6796 V

   (C) 2764 V

   (D) 5112 V

   (E) 3348 V

9. [*Qid 1*] (6 points) In the circuit below, assume the switch has been closed for a very long time. What is the current delivered by the capacitor just after the switch is opened? $\mathcal{E} = 12.0$ V, $R_1 = 3.00\ \Omega$, $R_2 = 2.00\ \Omega$, $R_3 = 6.00\ \Omega$, $C = 9.00\ \mu$F.

(A) 2.67 A

(B) 2.40 A

(C) 1.33 A

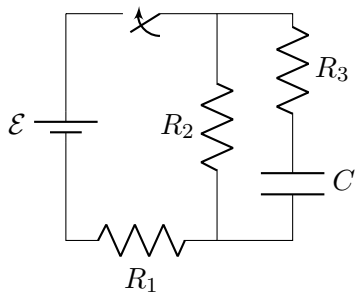
(D) 0.500 A

(E) 2.00 A

(F) 1.50 A

(G) 0.600 A

(H) 0.667 A



10. [*Qid 2*] (6 points) What is the potential energy stored in the capacitor just before the switch is opened?

(A) 233 μJ

(B) 104 μJ

(C) 824 μJ

(D) 352 μJ

(E) 648 μJ

(F) 442 μJ

11. [*Qid 19*] (6 points) At one instant, a 3.00 C charge has a velocity vector $\vec{v} = 900\hat{\imath}$ in a region of space with an electric field $\vec{E} = 600\hat{\jmath} + 700\hat{k}$ and a magnetic field $\vec{B} = 2.5\hat{k}$. All vectors are given in SI units. What is the magnitude of the force acting on this charge?

    (A) 2770 N

    (B) 2930 N

    (C) 6750 N

    (D) 4880 N

    (E) 7610 N

    (F) 1790 N

    (G) 5380 N

    (H) 8800 N

12. [*Qid 8*] (6 points) A current path shaped as shown in the figure below produces a magnetic field at P, the center of the arc. If the arc subtends an angle of 30.0°and the radius of the arc is 4.00 m, what are the magnitude and direction of the field produced at P if the current is 24.0 A?

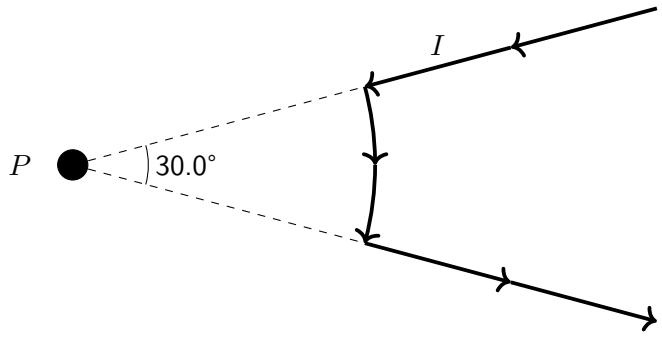
    (A) 4.83×10^{-7} T

    (B) 4.66×10^{-6} T

    (C) 3.77×10^{-6} T

    (D) 3.14×10^{-7} T

    (E) 0



13. [*Qid 3*] (4 points) A parallel plate capacitor is fully charged and then disconnected from the battery. If the separation between the plates is decreased, what happens to the electric field between the plates?

    (A) The magnitude of the electric field stays constant.

    (B) The electric field increases in magnitude.

    (C) The electric field decreases in magnitude.

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

14. [*Qid 13*] (6 points) Four identical charges Q and a fifth charge $-q$ are arranged as shown in the figure below. In this configuration, what is the magnitude of the electric force acting on $-q$?

    (A) $\frac{kqQ}{a^2}$

    (B) $\frac{3kqQ}{a^2}$

    (C) $\frac{kqQ}{\sqrt{2}a^2}$

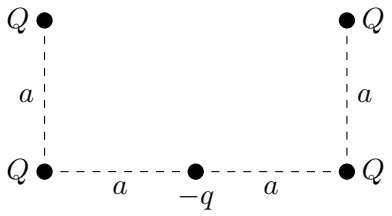
    (D) $\frac{kqQ}{2a^2}$

    (E) $\frac{2kqQ}{a^2}$

    (F) $\frac{\sqrt{2}kqQ}{a^2}$

    (G) $\frac{3kqQ}{2a^2}$

    (H) $\frac{4kqQ}{a^2}$

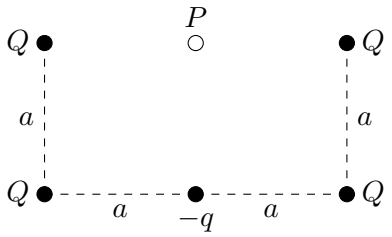


15. [*Qid 14*] (2 points) What is the sign of the work done by the electric field to move the charge $-q$ in the previous problem from its original position to point P shown in the figure below? Note that P is in line with the top two charges.

(A) $W > 0$

(B) $W = 0$

(C) $W < 0$



16. [*Qid 5*] (6 points) In the circuit below all resistors have a resistance of 6.0 Ω and the battery emfs are labeled. The three currents have also been labeled along with their directions. What is the current labeled I_3 based on its predicted direction?

(A) +0.33 A

(B) +1.0 A

(C) +0.63 A

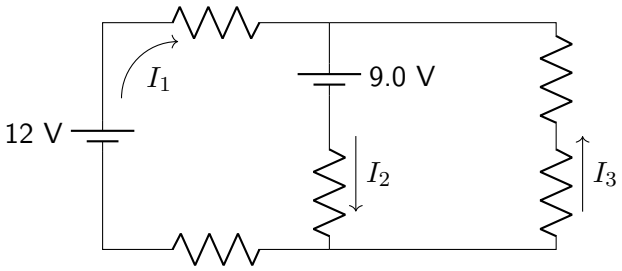
(D) -1.0 A

(E) -0.33 A

(F) +0.50 A

(G) -0.50 A

(H) -0.63 A



17. [*Qid 6*] (4 points) Which unit vector below represents the initial direction of the deflection of the positively charged particle as it enters the magnetic field? Pay attention to the direction of the magnetic field and the coordinate axes as drawn in the figure.

(A) $+\frac{1}{\sqrt{2}}\hat{\imath}+\frac{1}{\sqrt{2}}\hat{\jmath}$

(B) $+\frac{1}{\sqrt{2}}\hat{\imath}-\frac{1}{\sqrt{2}}\hat{\jmath}$

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

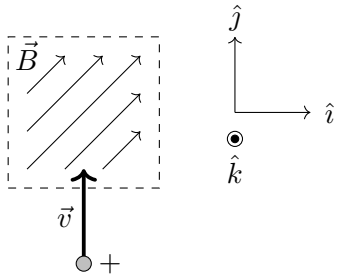
(D) $-\hat{k}$

(E) $-\frac{1}{\sqrt{2}}\hat{\imath}-\frac{1}{\sqrt{2}}\hat{\jmath}$

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

(G) $-\frac{1}{\sqrt{2}}\hat{\imath}+\frac{1}{\sqrt{2}}\hat{\jmath}$

(H) $+\hat{k}$



18. [*Qid 16*] (4 points) Which of the following surfaces has the greatest flux through it?

(A) S1

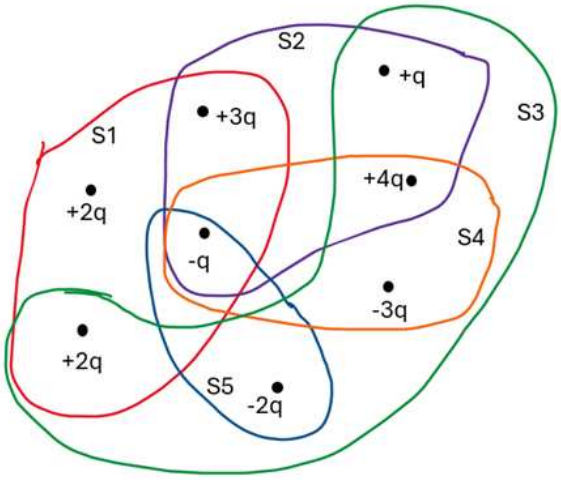
(B) S2

(C) S3

(D) S4

(E) S5

(F) It is impossible to tell



19. [*Qid 4*] (6 points) In the following circuit, all the resistors have identical resistors R. What is the equivalent resistance of the circuit?

(A) $6R$

(B) $\frac{8}{3}R$

(C) R

(D) $\frac{5}{12}R$

(E) $\frac{9}{4}R$

(F) $\frac{4}{9}R$

(G) $\frac{12}{5}R$

(H) $\frac{3}{8}R$