Flavour 5

Physics 207 – Exam I

Fall 2024 (all UP sections) February 17, 2025

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 I.

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 12*] (8 points) There is an electric field in a region of space given by $\vec{E}(z) = 8.70z^2\hat{k}$. The potential is defined to be 3750 V at $z = -12.0$. How far away is the closest position where the potential is 7100 V?

    (A) 4.10

    (B) 3.69

    (C) 14.2

    (D) 2.23

    (E) 13.1

    (F) 21.0

    (G) 8.31

    (H) 11.8

2. [*Qid 5*] (8 points) Three particles all have a mass of 15.0 mg and are initially held at rest at the corners of an equilateral triangle that has sides of 4.00 mm. The particles have charges of $+3.00$, $+6.00$ and $+9.00$ μC. If all three particles are simultaneously released, what is the total kinetic energy of the system when the particles are infinitely far away?

    (A) 122 J

    (B) 28.4 J

    (C) 40.5 J

    (D) 223 J

    (E) 147 J

    (F) 60.8 J

    (G) 365 J

    (H) 12.0 J

3. [*Qid 6*] (4 points) In the previous problem, which charge will have the greatest speed when they are all infinitely far away from each other?

    (A) The 6.00 μC charge

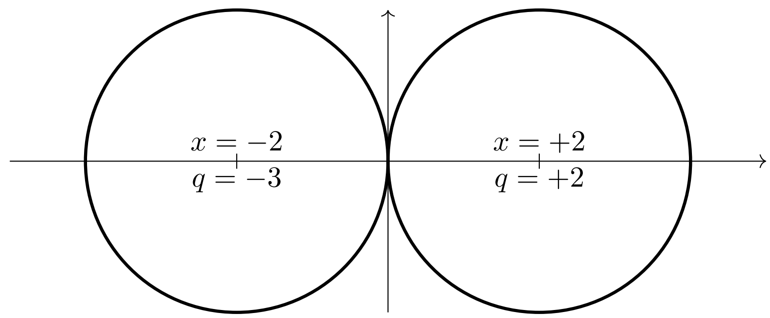
    (B) The 3.00 μC charge

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

    (D) Since they all have the same mass they will have the same speed.

    (E) The 9.00 μC charge

4. [*Qid 14*] (6 points) Two solid, insulating, uniform spheres exist with their centers at $x = -2$ and $x = +2$ and both have radii of $R = 2$. The sphere with center at $x = -2$ has a total charge -3 C and the sphere at $x = +2$ has total charge $+2$ C. There are two positions on the x-axis where the potential is equal to zero. Which of the following represents the two locations on the x-axis where the electric potential is equal to zero?



(A) $0 < x < 2$ and $-2 < x < 0$

(B) $2 < x < 4$ and $-4 < x < -2$

(C) $2 < x < 4$ and $0 < x < 2$

(D) $4 < x$ and $-2 < x < 0$

(E) $4 < x$ and $0 < x < 2$

(F) $2 < x < 4$ and $-2 < x < 0$

(G) $4 < x$ and $2 < x < 4$

(H) $4 < x$ and $-4 < x < -2$

5. [*Qid 11*] (8 points) A uniform arc of total charge $+Q$ is distributed along a quarter circle of radius R in quadrant 1 as shown below. What is the integral that you would use to evaluate the electric potential at the position (R, R)?

(A) $\frac{kQ}{2\pi R}\int_0^{2\pi}\frac{d\theta}{\sqrt{(1-\cos\theta)^2+(1-\sin\theta)^2}}$

(B) $\frac{kQ}{2\pi R}\int_0^{\pi/2}\frac{d\theta}{\sqrt{(1-\cos\theta)^2+(1-\sin\theta)^2}}$

(C) $\frac{2kQ}{\pi R}\int_0^{\pi/2}\frac{d\theta}{\sqrt{(1-\cos\theta)^2+(1-\sin\theta)^2}}$

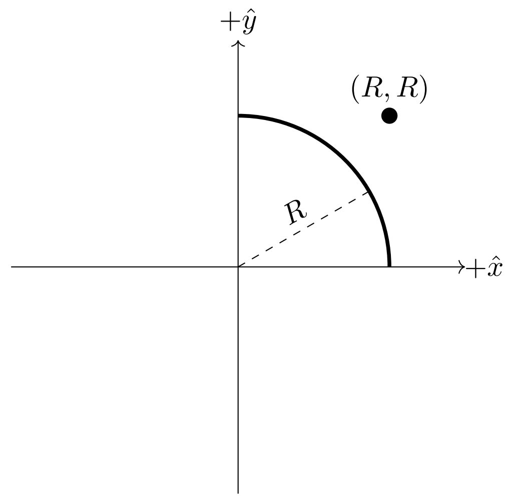
(D) $\frac{kQ}{2\pi R}\int_0^{\pi/2}\frac{d\theta}{\sqrt{(\cos\theta)^2+(\sin\theta)^2}}$

(E) $\frac{kQ}{2\pi R}\int_0^{2\pi}\frac{d\theta}{\sqrt{(\cos\theta)^2+(\sin\theta)^2}}$

(F) $\frac{2kQ}{\pi R}\int_0^{\pi/2}\frac{d\theta}{\sqrt{(\cos\theta)^2+(\sin\theta)^2}}$

(G) $\frac{2kQ}{\pi R}\int_0^{2\pi}\frac{d\theta}{\sqrt{(1-\cos\theta)^2+(1-\sin\theta)^2}}$

(H) $\frac{2kQ}{\pi R}\int_0^{2\pi}\frac{d\theta}{\sqrt{(\cos\theta)^2+(\sin\theta)^2}}$



6. [*Qid 2*] (6 points) In the diagram below there are two thick-walled conducting shells that are centered at the same point. The smaller shell has a net charge of $+2Q$ with inner radius R and outer radius $2R$. The larger shell has a net charge $-5Q$ with inner radius $3R$ and outer radius $4R$. The surfaces have been labeled A, B, C and D. Rank the surfaces from most positive surface charge density to most negative surface charge density.

   (A) D>C>B>A

   (B) A>C>B>D

   (C) C>D>A>B

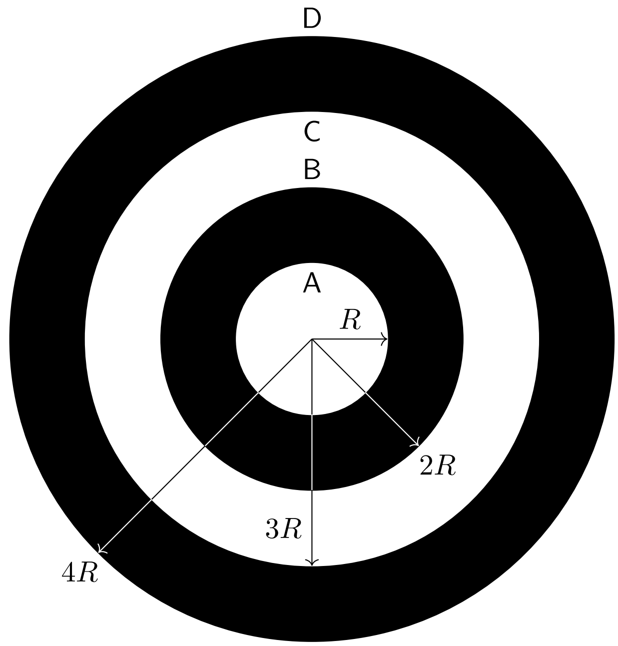
   (D) D>A>B>C

   (E) B>A>D>C

   (F) B>A>C>D

   (G) A>B>C>D

   (H) C>B>D>A



7. [*Qid 1*] (8 points) A 50.0 μC charge exists at the position $(2.00, 0.00)$ and a proton exists at the position $(0.00, 3.00)$ where the positions are given in units of meters. There is a uniform electric field in this region of space $\vec{E} = 23,000\hat{\imath}$. What is the magnitude of acceleration of the proton? For this problem, full credit was given to all answers because there was a typo in the magnitude of the electric field. It should have been 23,000 instead of 230,000. The points listed below are what it would have been had there not been a typo.

(A) 9.67×10^{12} m/s^2

(B) 3.32×10^{12} m/s^2

(C) 2.20×10^{12} m/s^2

(D) 5.21×10^{12} m/s^2

(E) 4.90×10^{12} m/s^2

(F) 6.44×10^{12} m/s^2

(G) 7.55×10^{12} m/s^2

(H) 2.78×10^{12} m/s^2

8. [*Qid 3*] (8 points) A box contains a number of electrons and a number of protons such that the flux through the box is 1.70×10^{-3} Nm^2/C. If the flux changes so that it is now 1.20×10^{-3} Nm^2/C, how many particles changed inside the box? (For this problem, assume that only one type of particle is added or removed, not both.)

   (A) 8.19×10^4 particles

   (B) 2.68×10^{15} particles

   (C) 6.64×10^4 particles

   (D) 3.13×10^{15} particles

   (E) 7.50×10^{15} particles

   (F) 4.17×10^{15} particles

   (G) 2.77×10^4 particles

   (H) 1.87×10^4 particles

9. [*Qid 4*] (4 points) In the previous problem, which of the following describes what happened to make the flux change. Remember that only one type of particle was added or removed.

   (A) Protons had to be added

   (B) Protons had to be removed

   (C) Protons could have been added or electrons could have been removed

   (D) Protons could have been removed or electrons could have been added

   (E) Protons could have been added or electrons could have been added

   (F) Electrons had to be removed

   (G) Protons could have been removed or electrons could have been removed

   (H) Electrons had to be added

10. [*Qid 16*] (4 points) In the diagram below, there are 3 point charges. Charge q_1 is on the left, q_2 is in the middle and q_3 is on the right. Rank the charges from most positive to most negative.

    (A) $q_1 > q_2 > q_3$

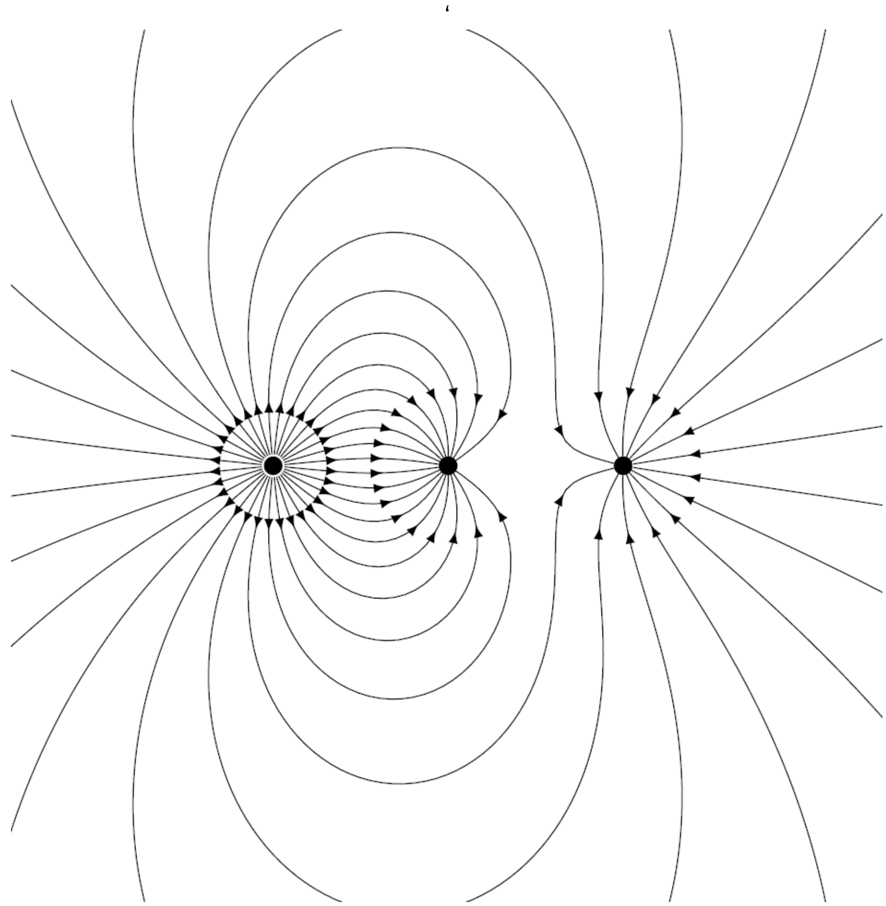
    (B) $q_3 > q_1 > q_2$

    (C) $q_1 > q_3 > q_2$

    (D) $q_2 > q_3 > q_1$

    (E) $q_2 > q_1 > q_3$

    (F) $q_3 > q_2 > q_1$



11. [*Qid 10*] (6 points) Three charges, each with $+q$, are all initially in a line as shown below on the left. What is the work done by an external force to change the configuration to the triangular configuration on the right?

(A) $-\frac{3kq^2}{2\ell}$

(B) $-\frac{kq^2}{2\ell}$

(C) $+\frac{3kq^2}{\ell}$

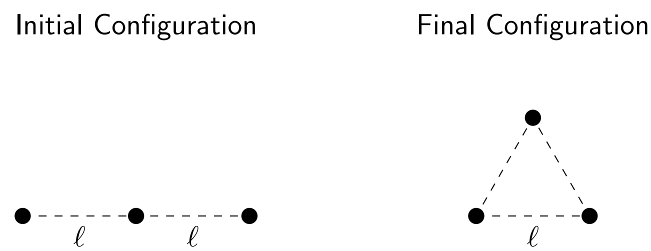
(D) $+\frac{5kq^2}{2\ell}$

(E) $+\frac{kq^2}{2\ell}$

(F) $-\frac{5kq^2}{2\ell}$

(G) $-\frac{3kq^2}{\ell}$

(H) $+\frac{3kq^2}{2\ell}$



12. [*Qid 7*] (6 points) There are three *infinite* sheets of charge each separated by 2.00 cm. Plate 1 has a charge density of $\sigma_1 = +2\sigma_0$, Plate 2 has a charge density of $\sigma_2 = -3\sigma_0$ and Plate 3 has an unknown charge density, σ_3. At the point A in the figure below you measure the electric field to be exactly 0. What is the charge density of Plate 3?

(A) $-1\sigma_0$

(B) $+1\sigma_0$

(C) $-5\sigma_0$

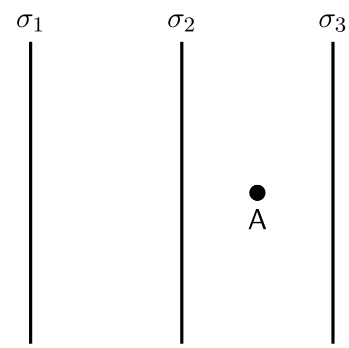
(D) $+5\sigma_0$

(E) $-2\sigma_0$

(F) $+2\sigma_0$

(G) $-3\sigma_0$

(H) $+3\sigma_0$



13. [*Qid 8*] (8 points) A positive point charge of magnitude $q = 6.00$ C is placed in the center of a large, spherical cavity inside a solid insulating material with uniform density $\rho = -3.00$ C/m^3. The cavity has radius $R = 0.600$ m. At what distance from the point charge is the electric field exactly zero?

   (A) 0.885 m

   (B) 0.901 m

   (C) 0.477 m

   (D) 0.973 m

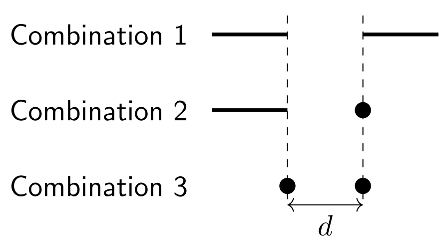
   (E) 0.528 m

   (F) 0.782 m

   (G) 0.730 m

   (H) 0.693 m

14. [*Qid 9*] (4 points) Below are three combinations of charges. The lines represent uniform rods with total charge Q and the points represent point charges with the same charge Q. Which combination will have the greatest force acting on the two objects?



   (A) Combination 1

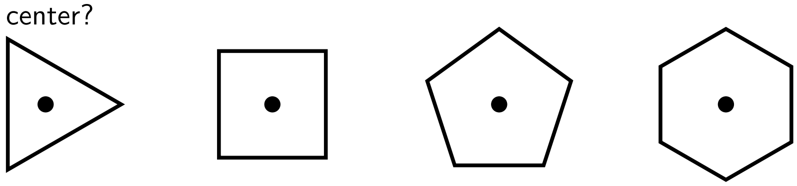
   (B) Combination 2

   (C) Combination 3

   (D) All three will be the same

   (E) It is impossible to determine

15. [*Qid 15*] (4 points) There are four uniform, linear distributions of charge. They do not necessarily have the same total charge or side lengths. Which pair of distributions will create an electric field that is **NOT** zero at the center?



(A) Triangle and Hexagon

(B) It is impossible to tell without knowing their charges or side lengths.

(C) Pentagon and Hexagon

(D) Square and Hexagon

(E) Triangle and Square

(F) Triangle and Pentagon

(G) Square and Pentagon

16. [*Qid 13*] (8 points) In a region of space, the potential energy function for an 8.00 C charge is $U(x, y) = x^2y + 3xy^2$. What is the magnitude of the force acting on this charge at the position $(3.00, 4.00)$?

(A) 61.3 N

(B) 13.5 N

(C) 36.1 N

(D) 248 N

(E) 108 N

(F) 180 N

(G) 22.7 N

(H) 153 N