Make sure to fill out the grading sheet completely including your name, instructor, exam flavor and UIN. You are allowed to write and work on this exam copy, but your answers must be bubbled in on the grading sheet to receive credit. Your bubbled responses are the only responses that will be considered for the grade.

Physics 207 Exam 1 – Flavor 1

Problem 1 (6 points) A particle of mass m and charge q is under the influence of gravity g a distance L above an infinitely large plane with constant positive charge density σ as shown in the picture. Compute the value of q so that the particle stays fixed in place.

A) $-\dfrac{mgL^2 4\pi\epsilon_0}{\sigma}$

B) $+\dfrac{mgL^2 4\pi\epsilon_0}{\sigma}$

C) $-\dfrac{2mgL^2 4\pi\epsilon_0}{\sigma}$

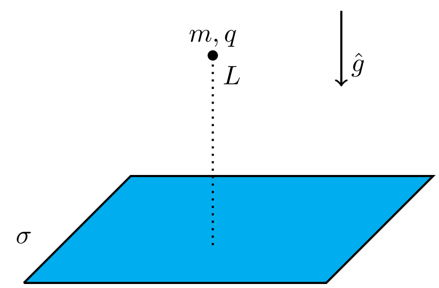
D) $+\dfrac{2mgL^2 4\pi\epsilon_0}{\sigma}$

E) $-\dfrac{mg\epsilon_0}{\sigma}$

F) $+\dfrac{mg\epsilon_0}{\sigma}$

G) $-\dfrac{2mg\epsilon_0}{\sigma}$

H) $+\dfrac{2mg\epsilon_0}{\sigma}$



Problem 2 (4 points) How does the electric potential change as a function of position due to the infinite plane in the previous problem?

A) The potential increases the further away from the plane.
B) The potential decreases the further away from the plane.
C) Above the plane the potential increases but below the plane it decreases the further away.
D) Above the plane the potential decreases but below the plane it increases the further away.
E) The potential stays constant everywhere.

Problem 3 (6 points) A thin, conductive spherical shell is initially neutral. There is also a solid conductive sphere with charge Q. The two spheres are concentric as shown in the picture below. If now a charge of q is taken from the inner solid sphere and placed on the outer shell, what is the electric field inside the shell ($r < R_1$)?

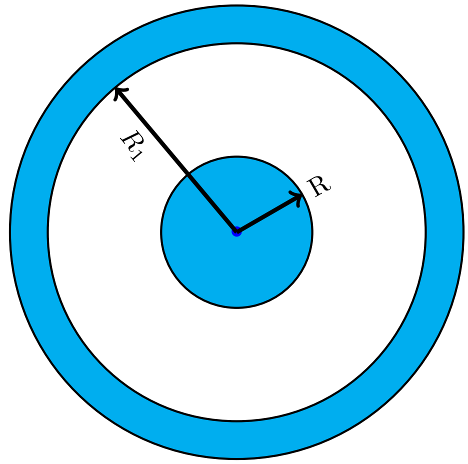
A) $\vec{E}(r) = \begin{cases} 0\hat{r} & r < R \\ \frac{-kq}{r^2}\hat{r} & R < r < R_1 \end{cases}$

B) $\vec{E}(r) = \begin{cases} 0\hat{r} & r < R \\ \frac{-kQ}{r^2}\hat{r} & R < r < R_1 \end{cases}$

C) $\vec{E}(r) = \begin{cases} 0\hat{r} & r < R \\ \frac{+k(Q-q)}{r^2}\hat{r} & R < r < R_1 \end{cases}$

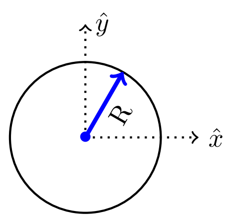
D) $\vec{E}(r) = \begin{cases} \frac{-k(Q-q)}{r^2}\hat{r} & r < R \\ \frac{+k(Q-q)}{r^2}\hat{r} & R < r < R_1 \end{cases}$

E) $\vec{E}(r) = \begin{cases} \frac{+k(Q-q)}{r^2}\hat{r} & r < R \\ \frac{-k(Q+q)}{r^2}\hat{r} & R < r < R_1 \end{cases}$



Problem 4 (8 points) A circular flat surface of radius $R = 3$ m lies in the xy-plane as shown in the picture below. The surface is embedded in an electric field $\vec{E} = 2r\hat{z}$ in N/C where r is the radial distance from the center of the circle. What is the electric flux through the surface? (Assume the area direction is $+\hat{z}$ and that all answers below are in units of Nm^2/C.)

A) 54π
B) 54
C) 36π
D) 36
E) 18π
F) 18
G) 9π
H) 9



Problem 5 (6 points) A quarter section of a cylindrical surface surrounds an infinitely long line of uniform charge density λ as shown in the picture. Compute the electrical flux assuming the area of the surface points outwards. (Hint: use Gauss' law)

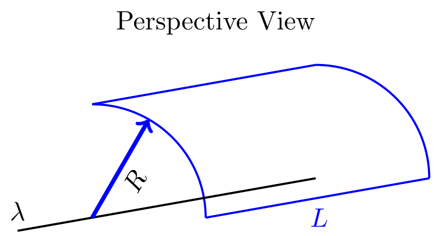
A) $\dfrac{\lambda L}{4R\epsilon_0}$

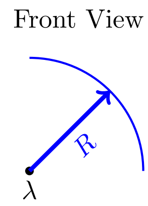
B) $\dfrac{\lambda L}{4\pi R\epsilon_0}$

C) $\dfrac{\lambda R}{4\epsilon_0}$

D) $\dfrac{\lambda L}{4\epsilon_0}$

E) $\dfrac{\lambda R}{4\pi L\epsilon_0}$





Problem 6 (8 points) A infinitely long line with uniform charge density λ produces an electric field in the radial direction. Compute the difference in potential $V(r = R) - V(r = 2R)$.

A) $\dfrac{\lambda}{2\pi\epsilon_0}\ln(2)$

B) $\dfrac{\lambda}{2\pi\epsilon_0}\ln\left(\dfrac{1}{2}\right)$

C) $\dfrac{\lambda}{2\pi\epsilon_0}\ln(3)$

D) $\dfrac{\lambda}{2\pi\epsilon_0}\ln\left(\dfrac{1}{3}\right)$

E) $\dfrac{\lambda R}{\pi\epsilon_0}$

F) $\dfrac{\lambda R}{4\pi\epsilon_0}$

Problem 7 (6 points) A region of space is defined by the potential function given below. What is the magnitude of the electric field at $(x, y) = (4, -7)$.

A) 0.806 N/C
B) 0.729 N/C
C) 0.571 N/C
D) 0.481 N/C
E) 0.263 N/C
F) 0.165 N/C

$$V(x, y) = \frac{x}{y}$$

Problem 8 (6 points) Which of the following situations produces the largest net force on a positive charge Q?

A) Charge Q is placed 1 m from a -2 C charge
B) Charge Q is placed 0.5 m from a -1 C charge
C) Charge Q is placed halfway between a -1 C charge and a +1 C charge that are separated by 2 m
D) Charge Q is placed halfway between two -2 C charges that are separated by 2 m
E) Charge Q is placed 2 m away from a charge of -4 C

Problem 9 (8 points) A charge Q is uniformly distributed along the x-axis with total length ℓ centered on the origin. Which integral below would correctly find the electric field at a point $x = +d$ where d is beyond the end of the distribution?

A) $\dfrac{kQ}{\ell}\displaystyle\int_0^{\ell} \frac{dx}{x^2}\hat{\imath}$

B) $\dfrac{kQ}{\ell}\displaystyle\int_0^{\ell} \frac{dx}{x^{3/2}}\hat{\imath}$

C) $\dfrac{kQ}{\ell}\displaystyle\int_0^{\ell} \frac{dx}{(d-x)^2}\hat{\imath}$

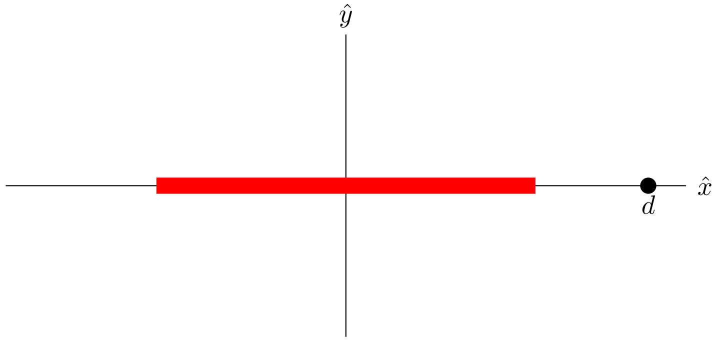
D) $\dfrac{kQ}{\ell}\displaystyle\int_0^{\ell} \frac{dx}{(d-x)^{3/2}}\hat{\imath}$

E) $\dfrac{kQ}{\ell}\displaystyle\int_{-\ell/2}^{\ell/2} \frac{dx}{x^2}\hat{\imath}$

F) $\dfrac{kQ}{\ell}\displaystyle\int_{-\ell/2}^{\ell/2} \frac{dx}{x^{3/2}}\hat{\imath}$

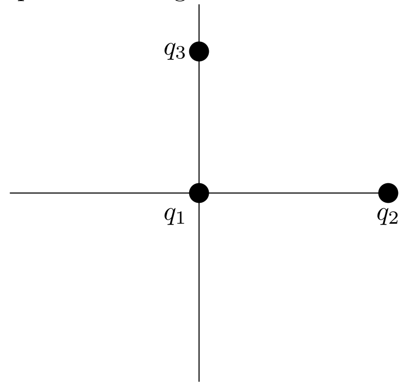
G) $\dfrac{kQ}{\ell}\displaystyle\int_{-\ell/2}^{\ell/2} \frac{dx}{(d-x)^2}\hat{\imath}$

H) $\dfrac{kQ}{\ell}\displaystyle\int_{-\ell/2}^{\ell/2} \frac{dx}{(d-x)^{3/2}}\hat{\imath}$



The following diagram and information is used on both problems 10 and 11. Three charges are fixed in place in the xy-plane as shown below. Make sure to note that the coordinates for all positions are given in meters.

$$q_1 = +2 \text{ C at } (0,0)$$
$$q_2 = -3 \text{ C at } (4,0)$$
$$q_3 = +1 \text{ C at } (0,3)$$



Problem 10 (8 points) What is the total electrical potential energy in this system?

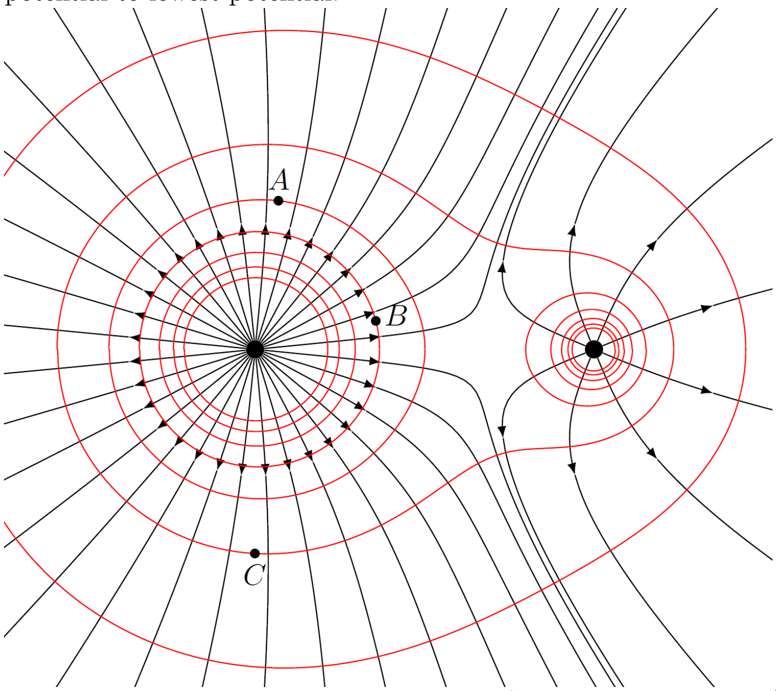
A) -8.56×10^9 J
B) -3.18×10^{10} J
C) $+2.49 \times 10^{10}$ J
D) $+1.71 \times 10^{11}$ J
E) -1.29×10^{10} J

Problem 11 (8 points) In the previous problem, what is the magnitude of the electric force acting on q_3?

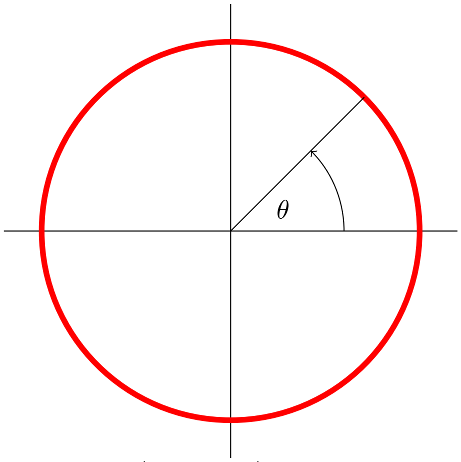
A) 6.64×10^8 N
B) 8.96×10^8 N
C) 1.60×10^9 N
D) 2.79×10^9 N
E) 3.08×10^9 N
F) 4.79×10^9 N

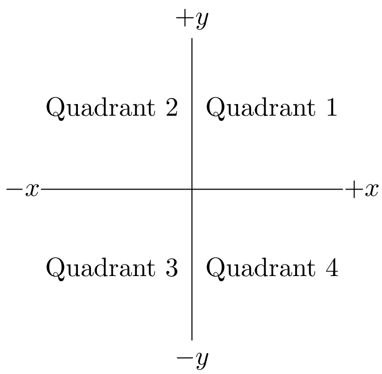
Problem 12 (4 points) Using the electric field diagram and the associated equipotential surfaces, rank the the electric potential at points A, B and C from highest potential to lowest potential.

A) A>B>C
B) A>C>B
C) B>A>C
D) B>C>A
E) C>A>B
F) C>B>A



Problem 13 (4 points) A ring of charge is centered on the origin. The charge density of this ring is given by $\lambda(\theta) = \lambda_0 \cos\theta$ where θ is measured counterclockwise from the $+x$-axis. Which of the options below represents the direction of the electric field at the origin due to this ring of charge? (e.g. Quadrant 1 would represent an electric field anywhere in that region, whereas $+x$ would represent an electric field ONLY pointing in $+x$ and has no y-component.)

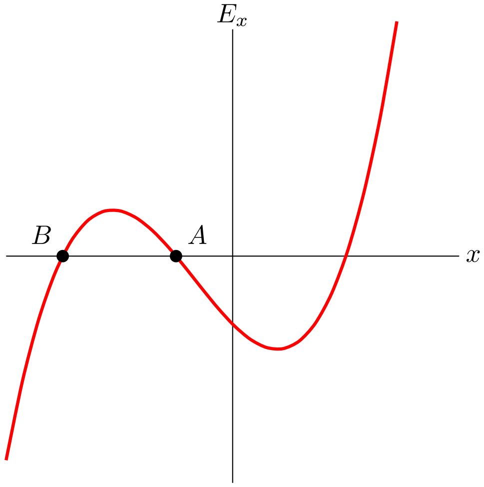




A) $+x$
B) Quadrant 1
C) $+y$
D) Quadrant 2
E) $-x$
F) Quadrant 3
G) $-y$
H) Quadrant 4

Problem 14 (4 points) The graph below shows an electric field as a function of position. What happens to the kinetic energy of an electron as it moves from position A to position B? The components of the electric field E_y and E_z are both zero and the electron is not under the influence of any other forces.

A) The kinetic energy increases
B) The kinetic energy decreases
C) The kinetic energy stays constant
D) It is impossible to tell



Problem 15 (6 points) An object has a total charge of $q = 9.70 \times 10^{-15}$ C. The object is made up of N_p protons and N_e electrons. You also know that $N_p + N_e = 100,000$. What is the number of protons N_p?

A) 39,400 protons
B) 50,000 protons
C) 60,600 protons
D) 73,600 protons
E) 80,300 protons

Problem 16 (8 points) A proton is fired with a speed of 7500 m/s from a very large distance away directly toward a carbon nucleus which has a charge $q = +6e$ and a mass $m = 12m_p$. How far apart are the charges, when the speed is 20% of its initial speed? For this problem assume that the carbon nucleus is fixed in place.

A) 2.55 nm
B) 5.11 nm
C) 12.6 nm
D) 30.7 nm
E) 73.5 nm
F) 87.5 nm
G) 184 nm
H) 736 nm