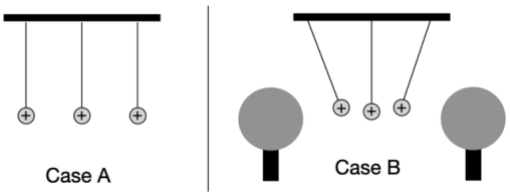
Name: _____ UW NET ID: _____

last *first* *(part before @uw.edu)*

I. Lecture multiple choice [45 points]

Choose only one answer for each question and fill it out on your scantron.

1. (5 points) Three small positively charged conducting spheres hang from strings far enough apart from each other that they do not exert strong forces on each other, as shown in Case A. In Case B, two much larger spherical shells, with much more net charge, are brought near the suspended spheres. Which one of the following statements is completely TRUE for Case B? For this question, assume all electrostatic forces are horizontal.



   A. The electric field is zero at the midpoint between the shells, and both shells are positively charged.

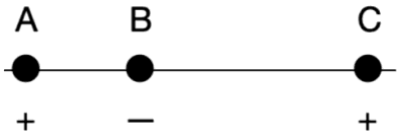
   B. The electric field is zero at the midpoint between the shells, and both shells are negatively charged.

   C. The electric field is zero at the midpoint between the shells, and the shells are oppositely charged.

   D. The electric field points to the right at the midpoint between the shells, and the shells are oppositely charged

   E. The electric field points to the left at the midpoint between the shells, and both shells are positively charged.

2. (5 points) Two small conducting spheres, A and C, are fixed in place along a line and charge B is free to move. Charge C is a distance d_o from charge B, and charge A is $d_o/2$ from B. Both A and C are positively charged and B is negatively charged. The net force on B is zero. Which one of the following statements is completely TRUE?



   A. $q_A > |q_B|$ and $q_C > q_A$

   B. $q_C > |q_B|$ and $q_C > q_A$

   C. $q_A > |q_B|$ and $q_A > q_C$

   D. $|q_B|$ could have any value and $q_C > q_A$

   E. $|q_B|$ could have any value and $q_A > q_C$

Name: _____ UW NET ID: _____

last *first* *(part before @uw.edu)*

3. (5 points) A positive charge is in a uniform electric field, and the charge experiences a net force to the right. Assuming there are no other forces acting, which one of the following statements could be TRUE?

   A. The electric field is to the right and the charge is moving at a constant velocity.

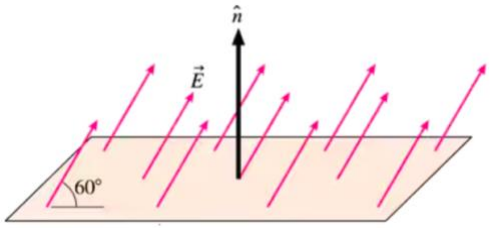
   B. The electric field is to the left and the charge is slowing down.

   C. The electric field is to the right and the charge is speeding up.

   D. The electric field is to the left and the charge is speeding up.

   E. The electric field is uniform, so the charge is moving at a constant velocity.

4. (5 points) The electric flux through the surface shown is $25\ \mathrm{N \cdot m^2/C}$, and the surface area of the rectangle is $0.40\ \mathrm{m^2}$. Which of the following is closest to the magnitude of the electric field, $\vec{E}$?



   A. 540 N/C

   B. 72 N/C

   C. 130 N/C

   D. 630 N/C

   E. 36 N/C

Name: _____ UW NET ID: _____

last *first* *(part before @uw.edu)*

5. (5 points) A rectangular surface area, represented by the perpendicular vector $A\hat{n}$, is positioned in a constant electric field, $\vec{E}_o$. Which one of the following choices represents a possible combination of the quantities associated with the flux through the surface, Φ?

A. $\vec{E}_o = -10\ \mathrm{N/C}\ \hat{\imath}$, $A\hat{n} = +5\ \mathrm{m}^2\ \hat{\jmath}$, $\Phi = -50\ \mathrm{m^2N/C}$

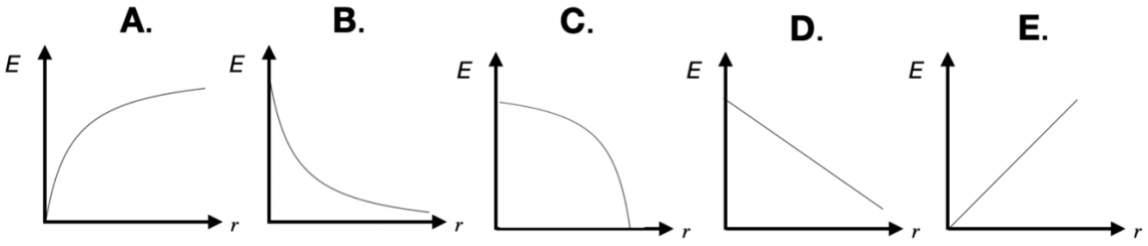
B. $\vec{E}_o = (-10\hat{\imath} + -5\hat{\jmath})\ \mathrm{N/C}$, $A\hat{n} = -2\ \mathrm{m}^2\ \hat{\imath}$, $\Phi = -20\ \mathrm{m^2N/C}$

C. $\vec{E}_o = (-10\hat{\imath} + -5\hat{\jmath})\ \mathrm{N/C}$, $A\hat{n} = +4\ \mathrm{m}^2\ \hat{\jmath}$, $\Phi = -20\ \mathrm{m^2N/C}$

D. $\vec{E}_o = (-10\hat{\imath} + -5\hat{\jmath})\ \mathrm{N/C}$, $A\hat{n} = +5\ \mathrm{m}^2\ \hat{\imath}$, $\Phi = -25\ \mathrm{m^2N/C}$

E. $\vec{E}_o = (-10\hat{\imath} + -5\hat{\jmath})\ \mathrm{N/C}$, $A\hat{n} = +5\ \mathrm{m}^2\ \hat{\imath}$, $\Phi = +50\ \mathrm{m^2N/C}$

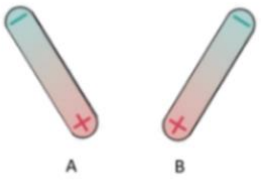
6. (5 points) Which of the following graphs best represents the magnitude of the electric field as a function of r, measured radially outward from the surface of a very long wire of length L of charge density λ? Assume r much less than L.



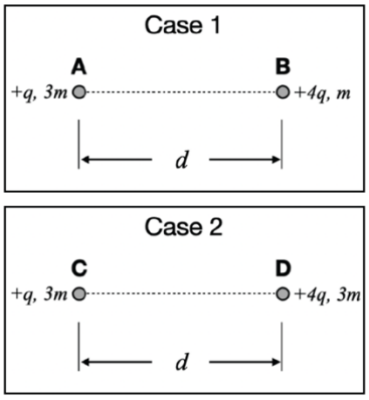
Name: _____ UW NET ID: _____

last *first* *(part before @uw.edu)*

7. (5 points) Two identical polar molecules are placed in a region that has a uniform electric field. At one instant they have the orientations shown. Molecule A is experiencing no torque and molecule B is experiencing a counterclockwise torque. Which vector best represents the direction of the external electric field at this instant? You may assume the molecules are far away enough from one another that they do not affect each other's motion.



8. (5 points) In each case shown at right, a particle of charge $+q$ is placed a distance d from a particle of charge $+4q$. The masses of the particles, A, C, and D are all $3m$, the mass of particle B is m as labeled in the diagram. The particles are then released simultaneously. For which particle, if any, will the magnitude of the acceleration be the greatest after the particles are released?



A. A

B. B

C. C

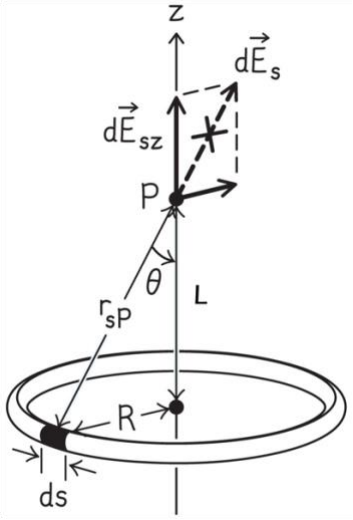
D. D

E. The magnitude of the acceleration for all particles will be the same.

Name: _____ UW NET ID: _____

last *first* *(part before @uw.edu)*

9. (5 pts) A thin ring of radius R carries a uniformly distributed charge q. The ring lays on the xy-plane with its center at the origin. What is the magnitude of the electric field at point P on the z-axis, a distance L away from the origin?



A. $\int_0^{2\pi R} k \frac{Lq}{2\pi R(L^2+R^2)} ds$

B. $\int_0^{2\pi R} k \frac{q}{2\pi R(L^2+R^2)} ds$

C. $\int_0^{2\pi R} k \frac{q}{2\pi R(L^2+R^2)^{3/2}} ds$

D. $\int_0^{2\pi R} k \frac{q}{2\pi (L^2+R^2)^{3/2}} ds$

E. $\int_0^{2\pi R} k \frac{Lq}{2\pi R(L^2+R^2)^{3/2}} ds$

II. Lab multiple choice [15 points]

Choose only one answer for each question, and fill it out on your scantron.

10. (5 pts) In Lab A2, a group places two charges 0.50 m apart and measures the force on one of the charges. They repeat the experiment three times and tabulate their data as shown. Which of the values below correctly reports the best estimate and the associated uncertainty according to the rules introduced in these labs?

Trial	Force (N)
1	4.51
2	4.64
3	4.73

A. (4.63 ± 0.1) N

B. (4.63 ± 0.11) N

C. (4.6 ± 0.1) N

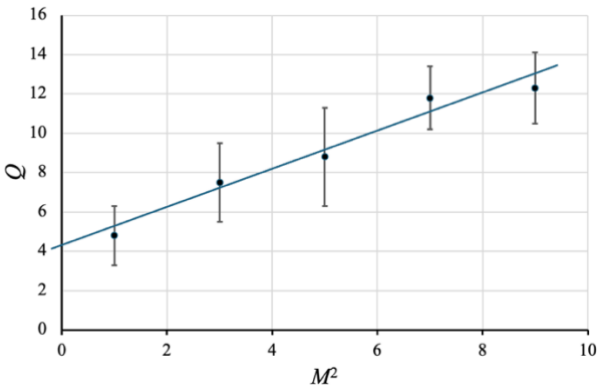
D. (4.6 ± 0.2) N

E. More than one of these choices correctly reports the best estimate and its uncertainty.

Name: _____ UW NET ID: _____

last *first* *(part before @uw.edu)*

11. (5 pts) A student has formed the graph of quantity Q versus the square of quantity M (M^2). They have also drawn the best-fit line on the graph. Which of the following is true?



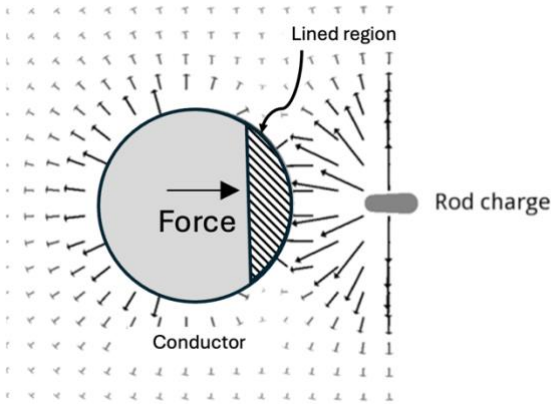
A. Quantity Q is proportional to quantity M.

B. Quantity Q is proportional to quantity M^2.

C. Quantity Q is linearly related to quantity M.

D. Quantity Q is linearly related to quantity M^2.

12. (5 pts) The diagram at right is a screenshot from the Lab A1 simulation. Both the rod and the conductor have excess charge. Based on the information given in the image, which of the following statements do you agree with?



I. The lined region on the conductor has the same sign charge as the rod.

II. The lined region on the conductor has the opposite sign charge as the rod.

III. The charge on the rod and conductor must have opposite signs since the conductor experiences an attractive force to the rod.

IV. The charge on the rod and conductor could be the same sign and the conductor is attracted to the rod due to polarization.

A. Statements I and III

B. Statements I and IV

C. Statements II and III

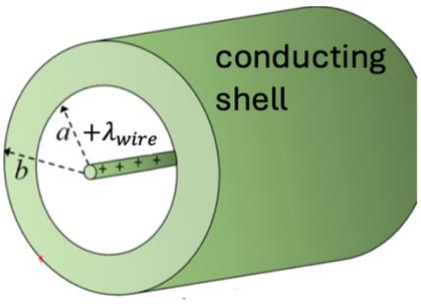
D. Statements II and IV

Name: _____ UW NET ID: _____

last *first* *(part before @uw.edu)*

III. Lecture Free Response [25 points]

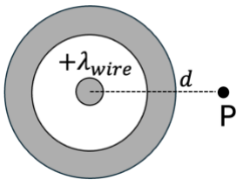
$Q13$ – $Q17$ refer to this context: An infinite wire with charge density $+\lambda_{wire}$ is surrounded by an infinitely long cylindrical conducting shell that has zero excess charge. The shell and wire share the same axis.



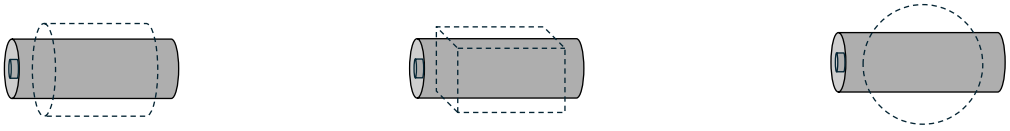
13. [6 pts] What is the surface charge density, λ_{inner}, on the **inner surface** of the conducting shell (at $r = a$ from the axis)? Answer in terms of the given variables. Be sure to include the sign and explicitly state if λ_{inner} is zero. Explain your reasoning.

14. [5 pts] What is the surface charge density, λ_{outer}, on the **outer surface** of the large conducting shell? Answer in terms of the given variables. Be sure to include the sign and explicitly state if λ_{outer} is zero. Explain your reasoning.

15. [3 pts] A cross section of the setup is shown at right. On the diagram, sketch the direction of the electric field at point P. If the electric field is zero, state so explicitly. No explanation required.



16. [5 pts] Which of the following Gaussian surfaces would allow you to determine the electric field strength at point P? Explain your reasoning for your choice.



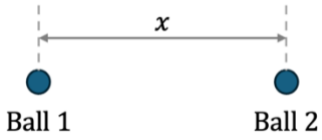
17. [6 pts] Use the Gaussian surface you chose in the previous question to write an expression for the electric field at point P in terms of the variables given and any constants. If you choose to use any additional variables, be sure to define them. Show your work.

Name: _____ UW NET ID: _____

last *first* *(part before @uw.edu)*

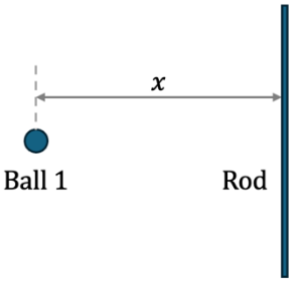
IV. Tutorial Free Response [15 points]

18. (5 pts) Two positively charged balls are placed a distance x apart as shown. The magnitude of the charge on ball 1 is larger than the magnitude of the charge on ball 2. The balls are observed to repel.



Is the magnitude of the electric force on ball 1 *greater than, less than,* or *equal to* the magnitude of the electric force on ball 2? Explain.

19. (5 pts) Ball 2 is replaced by a rod. The rod has the same positive charge that ball 2 had (in the previous section) and is placed the same distance x from ball 1 as shown. The charge on the rod is uniformly distributed along its length.

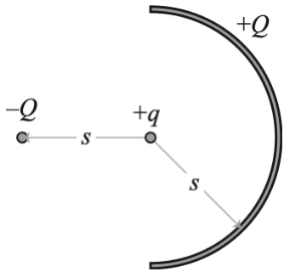


Is the magnitude of the electric force on ball 1 by the rod (F_{1R}) *greater than, less than,* or the same as the magnitude of the electric force on ball 1 by ball 2 (F_{12}) in the previous section? Explain.

Name: _____ UW NET ID: _____

last *first* *(part before @uw.edu)*

20. (5 pts) A thin, semicircular rod has a total charge $+Q$ uniformly distributed along it. A positive point charge $+q$ and a negative point charge $-Q$ are placed as shown. (The $+q$ charge is equidistant from $-Q$ and from all points on the rod.)



Let F_P and F_R represent the magnitudes of the forces on the $+q$ charge due to the $-Q$ point charge and due to the rod, respectively.

Is F_P *greater than, less than,* or *equal to* F_R? Explain.