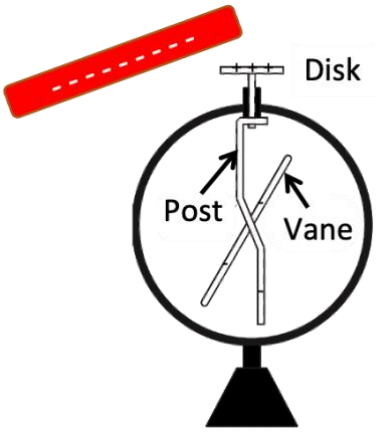
Name _____ **UW Net ID** _____
last *first* *(part before @uw.edu)*

I. [60 pts] Multiple Choice: Mark your answer on BOTH the bubble sheet and this page.

1. [5 pts] The vane on an electroscope is deflected from the vertical direction when a negatively charged insulating rod is brought close to the electroscope (without touching). The following describes different sequences of events.

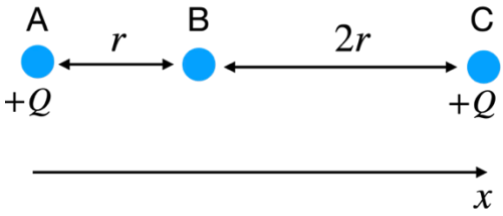


Case 1: You keep your hand on the disk while the rod is brought close to the electroscope and then move the rod away. You do not move your hand. You can consider yourself as a **conductor.**
Case 2: You keep your hand on the disk while the rod is brought close to the electroscope. You first remove your hand away from the disk, and afterwards you remove the rod.

After the sequences are completed, in which case does the vane remain deflected?

A. Case 1 only
B. Case 2 only
C. Both Case 1 and Case 2
D. Neither Case 1 nor Case 2
E. Not enough information

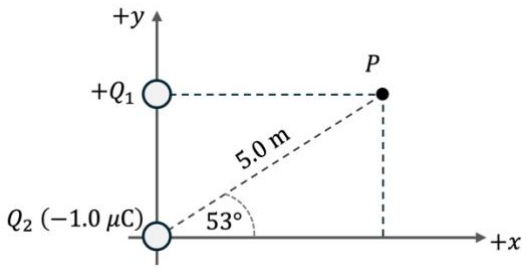
2. [5 pts] Three charged particles are separated as shown in the figure. Particles A and C have equal charge of $+Q$, and the charge of particle B is unknown. Assume that the positive x direction is to the right. The **magnitude** of the force exerted by particle C on particle A is F_0, and the **net force exerted** on particle A is $+2F_0$. What is the charge of particle B?



A. +1/3Q
B. -1/3Q
C. +3Q
D. –3Q
E. -Q

Name _____ **UW Net ID** _____
last *first* *(part before @uw.edu)*

3. [5 pts] Two charges, Q_1 and Q_2 are positioned as shown at right. Q_1 is positively charged, and the magnitude of the electric field at point *P* due to Q_1 is 560 N/C. What is the magnitude of the **net** electric field at point *P*?



   A. 200 N/C

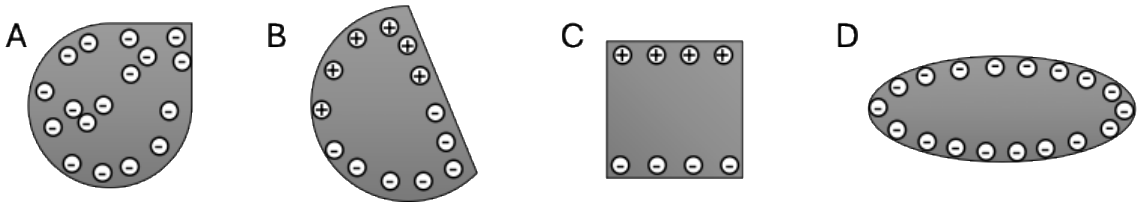
   B. 290 N/C

   C. 360 N/C

   D. 450 N/C

   E. 530 N/C

4. [5 pts] Which of the figures below correctly illustrates the charge distribution in an ideal conductor of various shapes? There is no external electric field and the conductors are isolated.



   A. Figure A

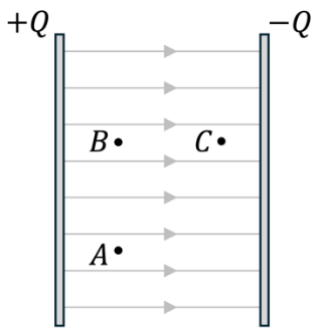
   B. Figure B

   C. Figure C

   D. Figure D

   E. None of these figures.

5. [5 pts] A point charge $+q$ is between the plates of a parallel plate capacitor. Consider moving the point charge first from point *A* to point *B* and then from point *B* to point *C*. The point charge moves at a constant speed throughout this process. What is true for the external work required to move the $+q$ point charge from *A* to *B* ($W_{A\to B}$) and from *B* to *C* ($W_{B\to C}$)? Ignore gravitational forces.



A. $W_{A\to B} > 0$ and $W_{B\to C} = 0$

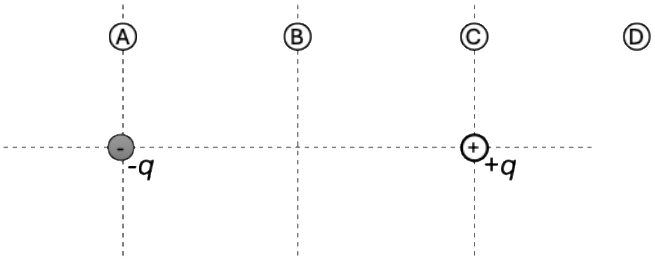
B. $W_{A\to B} < 0$ and $W_{B\to C} < 0$

C. $W_{A\to B} = 0$ and $W_{B\to C} > 0$

D. $W_{A\to B} = 0$ and $W_{B\to C} = 0$

E. $W_{A\to B} = 0$ and $W_{B\to C} < 0$

6. [5 pts] Two point particles of charge $-q$ and $+q$ are placed in space as shown. At which of the points (A, B, C, D) is the total electric potential zero (assuming the potential is zero at infinity)?



A. Point A

B. Point B

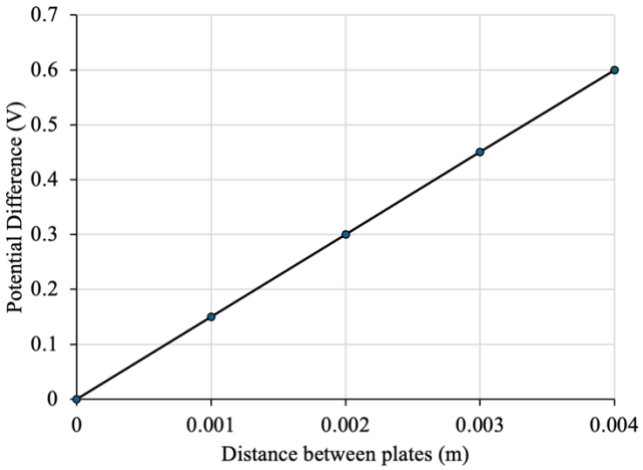
C. Point C

D. Point D

Name _____ **UW Net ID** _____

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

7. [5 pts] The graph at right shows how the electric potential difference in a parallel plate capacitor depends on the distance between the plates. What is the magnitude of the electric field between the plates?



A. 150 V/m

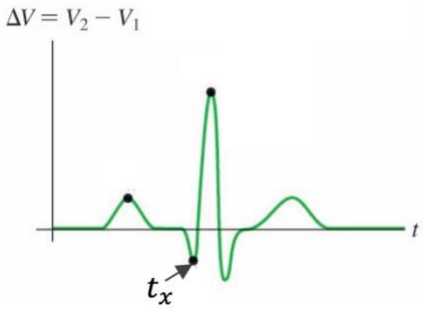
B. 250 V/m

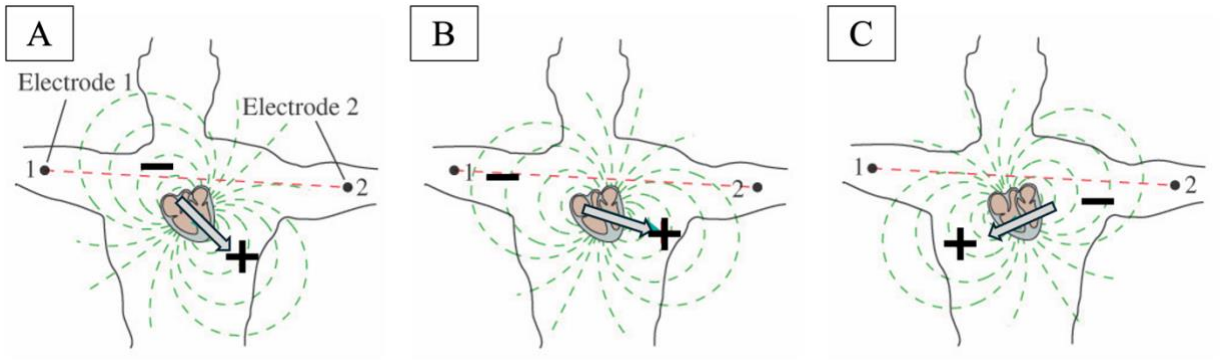
C. 300 V/m

D. 500 V/m

E. 1000 V/m

8. [5 pts] An electrocardiogram (ECG) produces the potential difference versus time graph shown at right. The ECG measurement is taken by placing two electrodes positioned at points 1 and 2 on the patient, as shown in the figure below. At the time instant, t_x, marked on the graph at right, which diagram (A, B, C) correctly shows the corresponding dipole orientation of the heart, as shown by the arrow in the diagrams below? Note that $\Delta V = V_2 - V_1$.





A. Diagram A

B. Diagram B

C. Diagram C

D. More information is needed.

9. [5 pts] A parallel plate capacitor consists of two round plates. They are separated by a distance of 0.02 mm and the space between them is filled with a dielectric that has a dielectric constant of $\kappa = 3.2$. What is the radius of the plates if the capacitance of the capacitor is 20×10^{-12} F? Note that the area of a circle is given as: $A_{circle} = \pi r^2$.

   A. 2.1 mm

   B. 7.7 mm

   C. 1.3 mm

   D. 0.7 mm

   E. 1.1 mm

10. [5 pts] Charge $Q = 2.4 \times 10^{-3}$C is stored in a capacitor with a capacitance $C = 1.2 \times 10^{-3}$ F. How much electrical energy is stored in the capacitor?

    A. 6.0×10^{-4} J

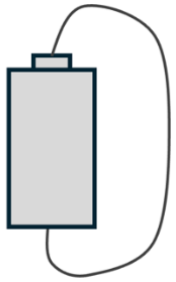
    B. 1.2×10^{-3} J

    C. 2.4×10^{-3} J

    D. 4.8×10^{-3} J

    E. 1.6×10^{-2} J

11. [5 pts] A piece of wire is connected to a battery as shown. For a battery with an emf of 4.0 V, the current in the wire is measured to be 0.15 A. If the wire is ohmic, what is the current in the wire when it is connected to a battery with an emf of 12.0 V?



A. 0.20 A

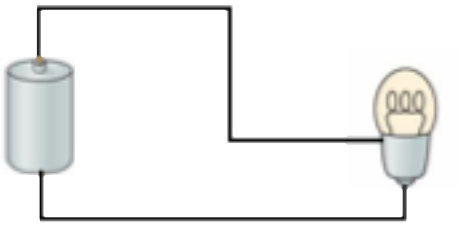
B. 0.30 A

C. 0.45 A

D. 0.68 A

E. 0.10 A

12. [5 pts] A light bulb is lit up by directly connecting to an AA battery of 1.5 V. Which of the following changes will increase the current through the bulb by a factor of 2?



A. Replacing the battery with a Li-Ion battery of 2 V.

B. Connect another identical light bulb in series with the current bulb.

C. Connect another identical light bulb in parallel with the current bulb.

D. Replacing the battery with two 1.5 V AA batteries connected in parallel.

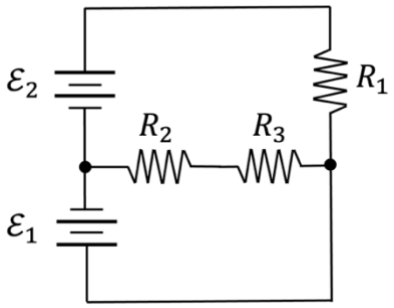
E. Replacing the battery with two 1.5 V AA batteries connected in series.

Name _____ **UW Net ID** _____

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

II. Lecture long-answer questions (20 points total)

Consider the following circuit with three resistors for questions 13-14. Assume that the resistors have the following resistances, $R_1 = 2.0\ \Omega$, $R_2 = 4.0\ \Omega$, and $R_3 = 3.0\ \Omega$, and that the EMF of the two batteries are $\mathcal{E}_1 = 20\ \text{V}$ and $\mathcal{E}_2 = 10\ \text{V}$. In the following questions please show your work to receive full credit.



13. [5 pts] Express the **voltage** across and the **current** through the resistor R_1, first symbolically in terms of the EMF of the two batteries and the resistance, and then numerically. Explain which of Kirchhoff laws you used to arrive at your solution.

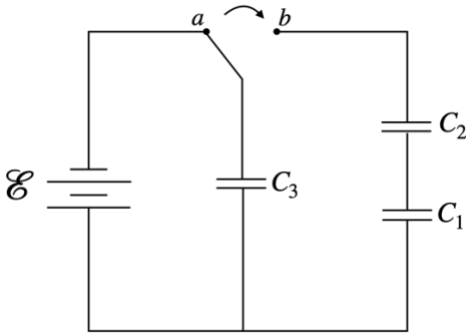
14. [5 pts] What is the magnitude of the currents through R_2 and R_3, respectively? Discuss which Kirchhoff laws you used to arrive at your solution.

Name _____ **UW Net ID** _____

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

Consider the following circuit with three capacitors for questions 15-16. Initially the switch is at position **a,** and we let the capacitor C_3 to fully charge. The capacitors C_1 and C_2 are uncharged. Then the switch is flipped to position **b.**

Assume that the capacitors have the following capacitances, $C_1 = 40$ μF, $C_2 = 40$ μF, and $C_3 = 20$ μF, and that the EMF of the battery is $\mathcal{E} = 500$ V. In the following questions please show your work to receive full credit.



15. [5 pts] What is the effective capacitance of the circuit after flipping the switch to position **b?** Show your work.

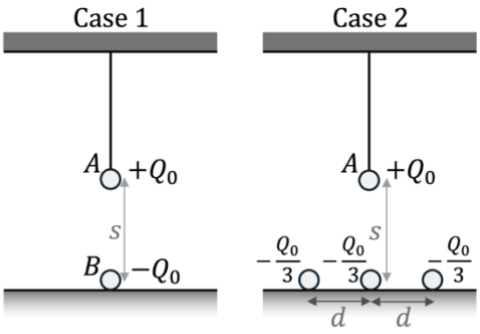
16. [5 pts] What are the charge and potential differences across each capacitor after flipping the switch to position **b** and waiting for the circuit to equilibrate? Show your work.

Name _____ **UW Net ID** _____
last *first* *(part before @uw.edu)*

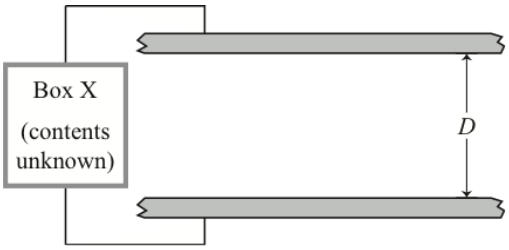
III. Tutorial and lab long answer questions (20 points total)

A small sphere, sphere A, with charge $+Q_0$is hung from a light inextensible string. In Case 1 a small sphere, sphere B, with charge $-Q_0$, is fixed on the ground directly below sphere A such that the distance between the centers of the spheres is s. The tension in the string is T_0.

17. [5 pts] In case 2, sphere B from case 1 is replaced with three small spheres, each with charge $-Q_0/3$, and they are fixed in place as shown. Is the magnitude of the tension in the string in case 2 *greater than, less than,* or *equal to* T_0? Explain your reasoning.



Two large conducting plates are placed parallel to one another a distance D apart. The plates are connected by wires to box X as shown. When the top plate is moved closer to the bottom plate, it is observed that the electric field between the plates increases.

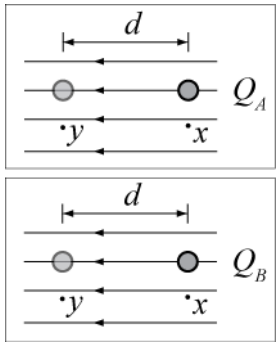


18. [5 pts] When the top plate is moved closer to the bottom plate, does the absolute value of the charge density on the top plate *increase, decrease,* or *remain the same?* Explain.

Name _____ **UW Net ID** _____
last *first* *(part before @uw.edu)*

Consider this context for questions 19 and 20.

Two particles with the ***same*** positive charge, Q_A and Q_B are released from rest at point *x* in separate uniform electric fields that point in the negative *x*-direction. There is no interaction between the two charges. Both charges move through a distance *d* to the left. (Ignore any gravitational forces.)



19. [5 pts] Is the value of $V_y - V_x$ *positive*, *negative*, or *zero?* Explain your reasoning.

It is known that the mass of Q_A is half as large as the mass of Q_B. When both charges have moved from point *x* to point *y*, the speed of Q_A is measured to be twice the speed of Q_B.

20. [5 pts] Is the magnitude of the electric field strength in which particle A is present *greater than*, *less than*, or *equal to* magnitude of the electric field strength in which particle B is present? Explain your reasoning.