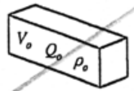
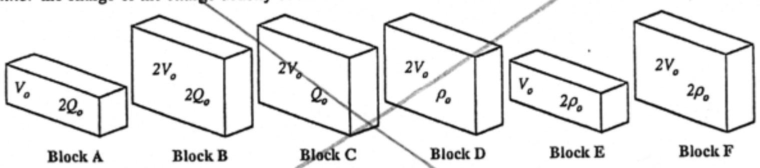
KEY

ET1-RT3: Charged Insulating Blocks—Charge

The block of insulating material shown at right has a volume V_o. An overall charge Q_o is spread uniformly throughout the volume of the block so that the block has a charge density ρ_o.



Six additional charged insulating blocks are shown below. For each block, the volume is given as well as *either* the charge or the charge density of the block.



Rank the overall charge of the six blocks.

Greatest 1 ______ 2 ______ 3 ______ 4 ______ 5 ______ 6 ______ Least

OR, the charge is the same for all six blocks. ____

OR, the ranking for the charge cannot be determined. ____

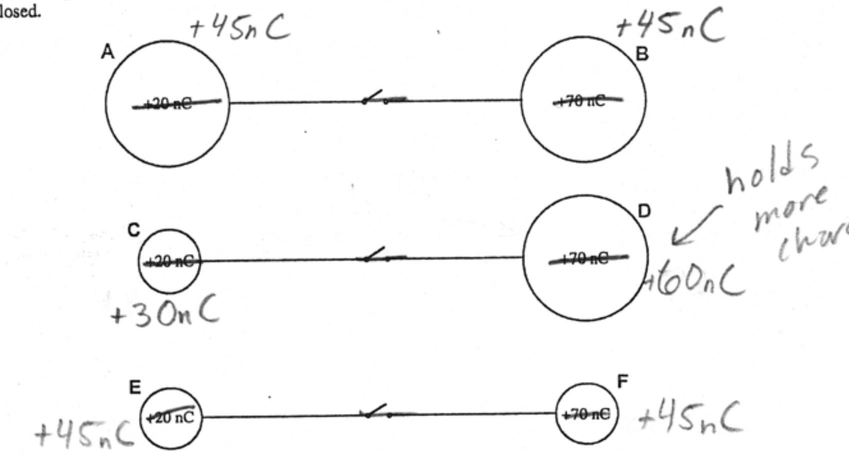
Carefully explain your reasoning.

How sure were you of your ranking? (circle one)

Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	10

ET1-RT4: Pairs of Connected Charged Conductors—Charge

Three pairs of charged, isolated, conducting spheres are connected with wires and switches. The spheres are very far apart. The large spheres have twice the radius of the small spheres. Each sphere on the left has a charge of +20 nC and each sphere on the right has a charge of +70 nC before the switches are closed.



Rank the electric charge of the spheres after all of the switches are closed.

Greatest 1 __D__ 2 __ABEF__ 3 __C__ 4 ______ 5 ______ 6 ______ Least

OR, the electric charge is the same for all six spheres. ____

OR, the ranking of the electric charge cannot be determined. ____

Carefully explain your reasoning.

The larger spheres will hold x2 the charge of the small when in equilibrium.

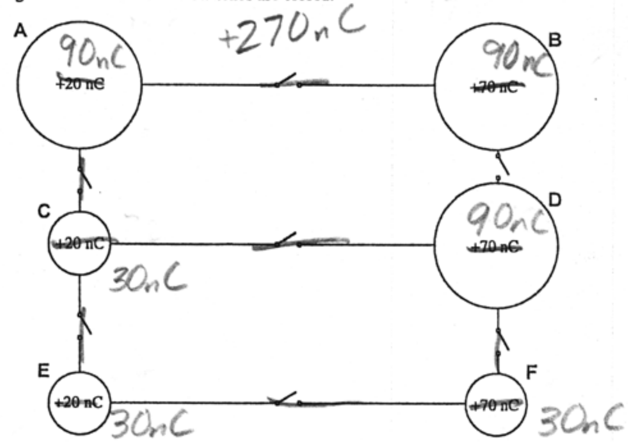
How sure were you of your ranking? (circle one)

Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	10

ET1-RT5: Collection of Six Charged Connected Conductors—Charge

Six charged conducting spheres are connected with wires and switches. The large spheres have twice the radius of the small spheres. Each sphere on the left has a charge of +20 nC and each sphere on the right has a charge of +70 nC before the switches are closed.

$V = \frac{kQ}{r}$ ↑ same ratios of $\frac{Q}{r}$



Rank the electric charge of the spheres after all of the switches are closed.

Greatest 1 ABD 2 CEF 3 ______ 4 ______ 5 ______ 6 ______ Least

OR, the electric charge is the same for all six spheres. ______

OR, the ranking of the electric charge cannot be determined. ______

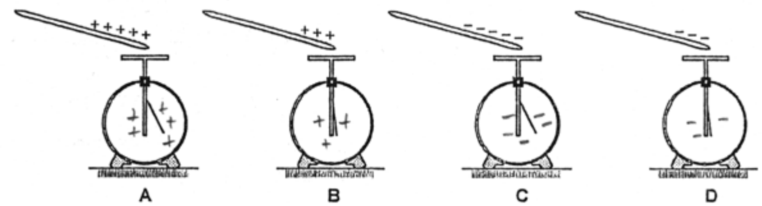
Carefully explain your reasoning.

How sure were you of your ranking? (circle one)

Basically Guessed				Sure				Very Sure
1	2	3	4	5	6	7	8	9	10

ET1-RT7: Charged Rod and Electroscope—Excess Charge

In each of the four cases below, a charged rod is brought close to an electroscope that is initially uncharged. In cases A and B, the rod is positively charged; in cases C and D, the rod is negatively charged. In cases A and C, the leaf of the electroscope is deflected the same amount, which is more than it is deflected in cases B and D.



Rank the net charge on the electroscope while the charged rod is near. (This will be a negative value if there is more negative than positive charge on the electroscope.)

Greatest positive 1 A 2 B 3 C 4 C Greatest negative

OR, the net charge is the same for all four situations but it is not zero. ______

OR, the net charge is zero for all of these situations. ______

OR, the ranking for the net charge cannot be determined from the information given. ______

Carefully explain your reasoning.

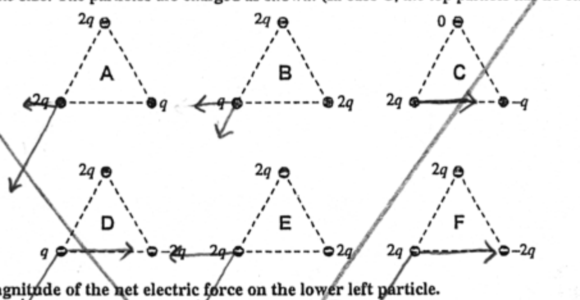
How sure were you of your ranking? (circle one)

Basically Guessed				Sure				Very Sure
1	2	3	4	5	6	7	8	9	10

Skip

ET3-RT2: Charges Arranged in a Triangle—Force

In each case below, three particles are fixed in place at the vertices of an equilateral triangle. The triangles are all the same size. The particles are charged as shown. (In case C, the top particle has no charge.)



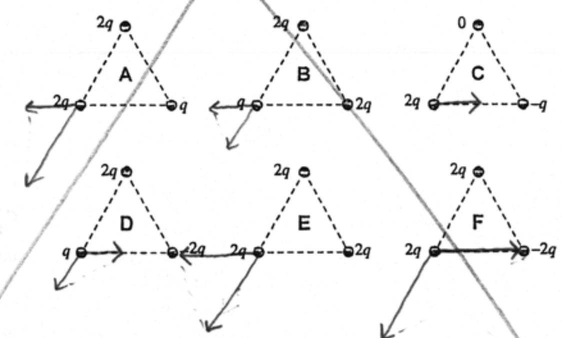
Rank the magnitude of the net electric force on the lower left particle.

Greatest 1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ Least

OR, the net electric force on the lower left particle is the same for all six cases. ____

OR, the ranking for the net electric force on the lower left particle cannot be determined. ____

Carefully explain your reasoning.



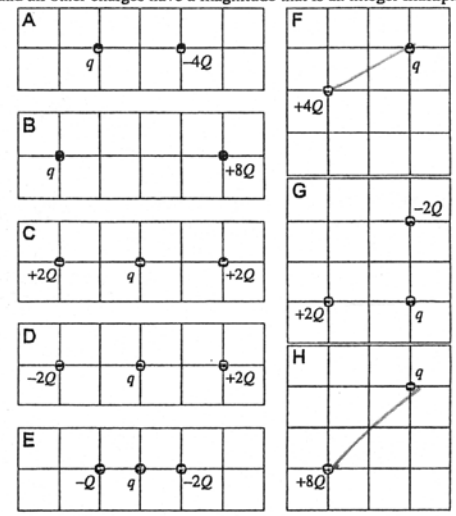
How sure were you of your ranking? (circle one)

Basically Guessed 1 2 3 4 5 Sure 6 7 8 9 Very Sure 10

Don't worry about this one!

ET3-RT3: Charges in a Plane—Force

In each case shown below, small charged particles are fixed on grids having the same spacing. Each charge q is identical, and all other charges have a magnitude that is an integer multiple of Q.



$F_A = \frac{kq4Q}{(2r)^2} \propto \frac{4}{4} \propto 1$

$F_B = \frac{kq8Q}{(4r)^2} \propto \frac{8}{16} \propto \frac{1}{2}$

$F_C = \emptyset$

$F_D = \frac{kq(4Q)}{(2r)^2} \propto 1$

$F_E = \frac{kq1Q}{r^2} \propto 1$

$F_F = \frac{kq4Q}{(\sqrt{5}r)^2} \propto \frac{4}{5}$

$F_G = \sqrt{2}\frac{kq2Q}{(2r)^2} \propto \sqrt{2}\frac{2}{4}$

$F_H = \frac{kq8Q}{(\sqrt{2}\,2r)^2} \propto 1$

Rank the magnitude of the electric force on the charge labeled q due to the other charges.

Greatest 1 ADEH 2 F 3 G 4 B 5 C 6 _____ 7 _____ 8 _____ Least

OR, the electric force on q is the same but not zero for all eight cases. ____

OR, the electric force on q is zero for all eight cases. ____

OR, the ranking for the electric force on q cannot be determined. ____

Carefully explain your reasoning.

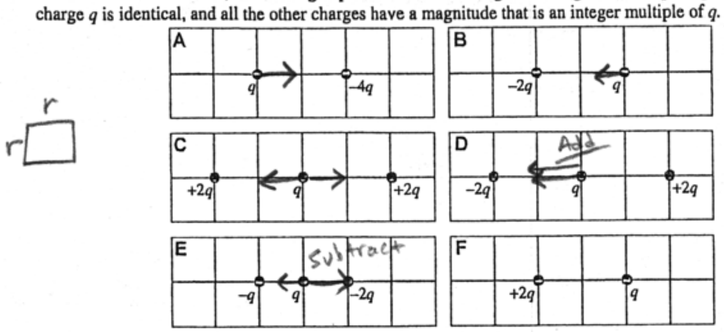
$F_e = \frac{kqQ}{r^2}$

How sure were you of your ranking? (circle one)

Basically Guessed 1 2 3 4 5 Sure 6 7 8 9 Very Sure 10

ET3-RT5: Two and Three Charges in a Line—Force

In each case shown below, small charged particles are fixed on grids having the same spacing. Each charge q is identical, and all the other charges have a magnitude that is an integer multiple of q.



Rank the magnitude of the electric force on the charge labeled q due to the other charges.

Greatest 1 ADE 2 BF 3 C 4 ____ 5 ____ 6 ____ Least

OR, the electric force on q is the same but not zero for all six cases. ____

OR, the electric force on q is zero for all six cases. ____

OR, the ranking for the electric force on q cannot be determined. ____

Carefully explain your reasoning.

$$F_A = \frac{kq(4q)}{(2r)^2} \propto \frac{4}{4} \propto 1$$

$$F_B = \frac{kq(2q)}{(2r)^2} \propto \frac{2}{4} \propto \frac{1}{2}$$

$$F_C = \emptyset$$

$$F_D = 2\left(\frac{kq(2q)}{(2r)^2}\right) \propto \frac{4}{4} \propto 1$$

$$F_E = \frac{kq(1q)}{r^2} \propto 1$$

$$F_F = \frac{kq(2q)}{(2r)^2} \propto \frac{2}{4} \propto \frac{1}{2}$$

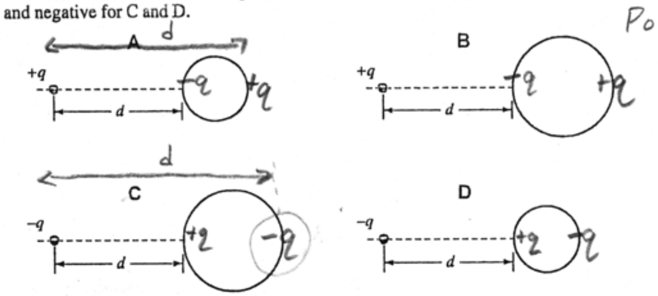
How sure were you of your ranking? (circle one)

Basically Guessed 1 2 3 4 5 Sure 6 7 8 9 10 Very Sure

ET3-RT9: Sphere and a Point Charge—Force

A point charge is placed a distance d away from a neutral metal sphere. The diameters of the spheres in A and D are the same and smaller than the equal diameters in B and C. The point charge is positive for cases A and B, and negative for C and D.

Polarizes



Rank the force exerted on the point charge by the sphere (let a force to the right be a positive force and a force to the left be a negative force).

Greatest positive 1 BC 2 AD 3 ____ 4 ____ Greatest negative

OR, the force is the same but not zero for all four situations. ____

OR, the force is zero for all these situations. ____

OR, the ranking for the forces cannot be determined. ____

Carefully explain your reasoning.

$$F_e = \frac{kq_1q_2}{r^2}$$

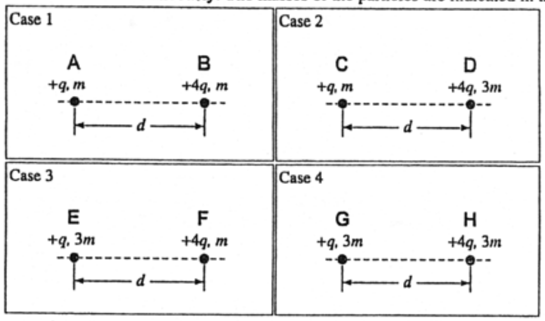
The larger spheres allow the same charge to repel further away. This allows the opposite charge to not be opposed as much.

How sure were you of your ranking? (circle one)

Basically Guessed 1 2 3 4 5 Sure 6 7 8 9 10 Very Sure

ET4-RT1: Two Charged Objects—Acceleration

In each case shown below, a particle of charge $+q$ is placed a distance d from a particle of charge $+4q$. The particles are then released simultaneously. The masses of the particles are indicated in the diagram.



Rank the magnitude of the acceleration of each particle just after it is released.

Greatest 1 ABCF 2 DEGH 3 ____ 4 ____ 5 ____ 6 ____ 7 ____ 8 ____ Least

OR, the magnitude of the initial acceleration is the same but not zero for all these particles. ____

OR, the magnitude of the initial acceleration is zero for all these particles. ____

OR, the ranking for the magnitude of the initial acceleration cannot be determined. ____

Carefully explain your reasoning.

F_e is the same for all the masses. $\frac{\Sigma F}{m} = a$ smallest mass will have the greatest acceleration.

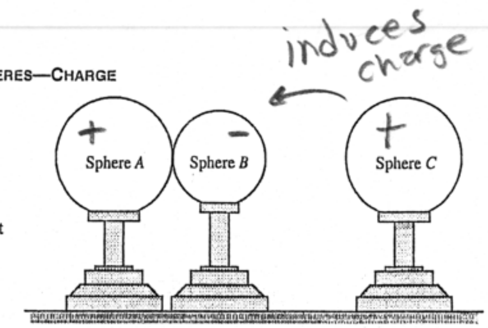
How sure were you of your ranking? (circle one)

Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	10

ET1-QRT5: Three Conducting Spheres—Charge

Two conducting spheres rest on insulating stands. Sphere B is smaller than sphere A. Both spheres are initially uncharged and they are touching.

A third conducting sphere, C, has a positive charge. It is brought close to (but not touching) sphere B as shown.



Is the net charge on Sphere A at this time *positive*, *negative*, or *zero*?

(+)

Is the net charge on Sphere B at this time *positive*, *negative*, or *zero*?

(−)

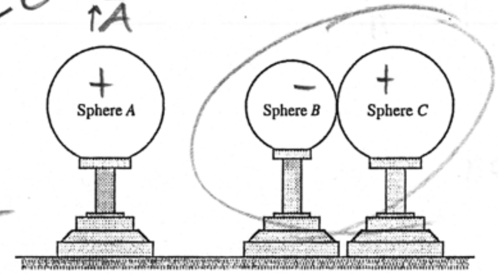
Is the magnitude of the net charge on Sphere A *greater than*, *less than*, or *equal to* the magnitude of the net charge on Sphere B?

same, they have been polarized

Is the magnitude of the surface charge density on Sphere A *greater than*, *less than*, or *equal to* the magnitude of the surface charge density on Sphere B?

less than $\downarrow \sigma = \frac{Q}{\uparrow A}$

Sphere B is now moved to the right so that it touches Sphere C. As a result of this move:



Does the magnitude of the net charge on Sphere A *increase*, *decrease*, or *remain the same*?

remains same

Does the magnitude of the net charge on Sphere C *increase*, *decrease*, or *remain the same*?

remains the same (still polarized)

ET3-QRT2: Three Charges in a Line—Force

Two charged particles, *A* and *B*, are fixed in place. A third charge, *C*, is fixed in place to the right of charge *B* at twice the distance between *A* and *B*. All charges are the same magnitude.

In the chart to the left below, use arrows to indicate the direction of the net force on charge *C* due to charges *A* and *B*. If the force is zero, state that explicitly.

In the chart on the right below, use arrows to indicate the direction of the net force on charge *B* due to charges *A* and *C*. If the force is zero, state that explicitly.

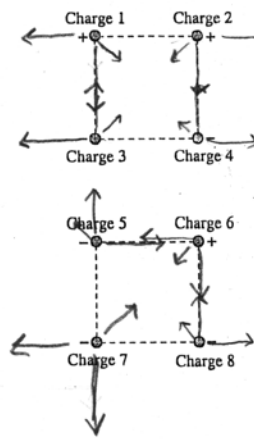
A	B	C	$\Sigma\vec{F}$ on charge *C* Direction:
+	+	+	→
+	+	−	←
+	−	+	←
+	−	−	→
−	+	+	→
−	+	−	←
−	−	+	←
−	−	−	→

A	B	C	$\Sigma\vec{F}$ on charge *B* Direction:
+	+	+	←
+	+	−	→
+	−	+	←
+	−	−	←
−	+	+	←
−	+	−	←
−	−	+	→
−	−	−	→

ET3-QRT9: Force Direction on Charges in a Square—Force

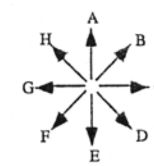
Four charges are fixed at the vertices of each square shown below. All charges have the same magnitude.

Determine the direction of the net electric force acting on each charge due to the other three charges in the same square. Answer by using letters A through H representing directions from the choices given below. If the angle is between two labeled directions, indicate those two directions (AB for a direction between A and B, for example).



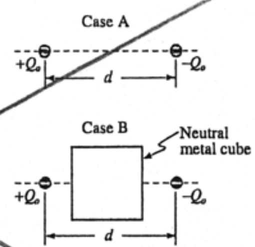
	Net Force Direction
Charge 1	FE
Charge 2	DE
Charge 3	HA
Charge 4	AB

	Net Force Direction
Charge 5	AB
Charge 6	F
Charge 7	F
Charge 8	AB



ET3-CCT6: Conducting Cube Between Point Charges—Force

In case A, two equal and opposite charges are separated by a distance d. Case B is identical to case A except that a neutral metal cube has been placed between the two charges. Four students are comparing the electric force on the positive charge in the two cases:



Alicia: *"Since the block is a conductor, it lets more charge travel between the point charges. The force will be stronger."*

Boris: *"The electric field inside of a conductor is zero. So the metal cube blocks the electric force on the positive charge by the negative charge. There might be some field lines that still attract the positive charge by going around the metal cube, but the force is much smaller in case B."*

Cody: *"If the cube is a perfect conductor, they will be equal, since then the cube would not interfere at all with the charge. Otherwise the force would be greater in case A."*

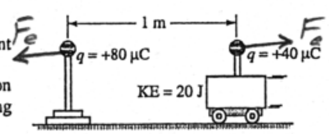
Delia: *"B is greater than A. The cube is a conductor! It is as if the distance in the cube 'wasn't there' because of the permittivity constant of the metal cube."*

Which of these students is correct?

Alicia_____ Boris_____ Cody_____ Delia_____ None of them_____ **Explain.**

ET4-CCT1: Cart Approaching Sphere—Distance

An electrically charged sphere mounted on a cart is approaching a fixed electrically charged sphere. At the instant shown, the spheres are one meter apart and the cart has a kinetic energy of 20 Joules. Ignore friction and the charges on the spheres are given in the figure. Three students considering this situation make the following contentions:



Alan: *"The cart will slow down as it approaches the fixed sphere, stop and reverse its motion. We cannot figure out how close the cart will get because we don't know the mass so we can't find the acceleration."*

Brad: *"While I agree that the cart will slow down and stop, I don't think you can figure out how close it will come to the fixed sphere because the force will be changing."*

Carlos: *"Well you guys do have the motion right, but you are both wrong about finding how close the cart gets to the sphere. I think you can use energy to find the final distance between spheres."*

Which of these students is correct?

Alan _______ Brad _______ Carlos ✓_______ None of these _______ **Explain.**

Don't worry about this!

ET10-CCT2: Charged Rod and Electroscope—Deflection

A positively charged rod is brought near an electroscope. Even though the rod does not touch the electroscope, the leaf of the electroscope deflects. Below, three students discuss this demonstration.

Alfredo: *"There are positive charges that jump from the rod to the plate of the electroscope. Since the electroscope is now charged, the leaf moves out."*

Brent: *"No charges move from the rod to the plate. When the rod comes close, electrons in the electroscope move toward the plate. This leaves the bottom of the electroscope positively charged, and the leaf lifts."*

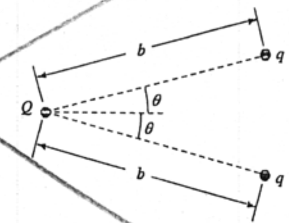
Carmen: *"Positive charges are fixed in place. When the rod is brought close to the electroscope plate, the electrons in the plate are attracted and jump to the rod. This leaves the electroscope positively charged, and the leaf lifts."*

Which of these students is correct?

Alfredo_____ Brent✓_____ Carmen_____ None of them_____ **Explain.**

ET3-WWT1: CHARGES ARRANGED IN A TRIANGLE—FORCE

Three charges are arranged in an isosceles triangle as shown at right. A student trying to find an expression for the net force on the charge Q due to two other charges, each of magnitude q, arrives at the following expression:



$$F = 2k\frac{Qq}{b^2}$$

What, if anything, is wrong with this expression? If something is wrong, explain the error and how to correct it. If the statement is valid, explain why.