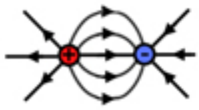
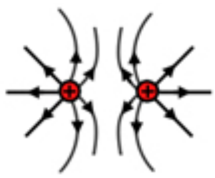
Problem Set 9: Electric Charges and Fields

9.1 [a]

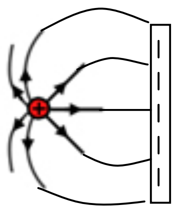
[b]



[c]



[d]

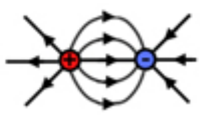


9.2 On dry days there is less water in the air to attract delocalised electrons created through the rubbing of materials. This allows electrons to build up to the point where there is enough charge to create a static discharge.

9.3 [a] electrons = 1000
$q = 1000 \times 1.60 \times 10^{-19}$
$= 1.60 \times 10^{-16}$ C has been transferred
$Q_{\text{Particle 1}} = -1.60 \times 10^{-16}$
$Q_{\text{Particle 2}} = +1.60 \times 10^{-16}$

[b] $r = 1 \times 10^{-5}$ m
$q = 1.60 \times 10^{-16}$ C
$k = 9.00 \times 10^{9}$ N
$F = (kq_1q_2)/(r^2)$
$= (9.00 \times 10^{9} \times 1.60 \times 10^{-16} \times -1.60 \times 10^{-16})/(1 \times 10^{-5})^2$
$= -2.30 \times 10^{-12}$ N
$= 2.30 \times 10^{-12}$ N Attraction

[c]



9.4 Threshold = 0.7×10^{-12} C
Electrons = 7.00×10^{6}
$q = 7.00 \times 10^{6} \times 1.60 \times 10^{-19}$
$= 1.12 \times 10^{-12}$ C
$1.12 \times 10^{-12} > 0.7 \times 10^{-12}$
Yes it will cause an error as the energy in the cosmic ray is enough to cause a bit in the 0 state to change into a 1.

9.5 [a] The rubbing action removes electrons from the wool, transferring them to the plate. This in turn induces a negative charge on the plate

[b] The plate will stick to the window as the plate's new charge is more negative than the glass's nucleus. Because of the difference in charges, there is an attractive force between the two objects. $F = (kq_1q_2)/(r^2)$

[c] The L plate won't stick to anything that has a negative charge because there will be a repulsive force between the two surfaces instead of an attractive force. For example, two L plates will not stick together.

[d] Assuming the whole plate is attracted to the glass and not just a corner then the charge is evenly spread on the plate.

9.6 $q = 2.00 \times 10^{-9}$ C
$t = 1.00 \times 10^{-6}$ s
$I = q/t$
$= 2.00 \times 10^{-9}/1.00 \times 10^{-6}$
$= 2.00 \times 10^{-3}$ A

9.7 [a] $t= 1.44 \times 10^4$ s
$I = 2A$
$q = It$
$= 2 \times 1.44 \times 10^4$
$= 2.88 \times 10^4$ C

[b] electrons $= q/(q_{electron})$
$= 2.88 \times 10^4/1.60 \times 10^{-19}$
$= 1.80 \times 10^{23}$ electrons

9.8 [a] $t = 90s$
$I = 4A$
$V = 240v$
$q = It$
$= 4 \times 90$
$= 360$ C

[b] $P = IC$
$= 4 \times 240$
$= 960$ w
$W = Pt$
$= 960 \times 90$
$= 8.64 \times 10^4$ j

9.9 As he pulls the cups apart, the Styrofoam cups rub against each other resulting in a build up of charge. Since each cup is light and placed in close proximity, the electrostatic forces between the cups are strong enough to move the cups according to coulombs law. $F = (kq_1q_2)/(r)^2$

9.10 [a] $q_1 = q_2$
$r = 8.00 \times 10^{-4}$ m
$F = 0.5$
$F = (kq_1q_2)/(r)^2$
$0.5 = (9.00 \times 10^9 \times q^2)/(8.00 \times 10^{-4})^2$
$3.2 \times 10^{-7} = 9.00 \times 10^9 \times q^2$
$q^2 = 3.56 \times 10^{-17}$
$q = 5.96 \times 10^{-19}$ C

[b] The calculated value is an assumption for two reasons: the distance between the cloths can't be measured and the charge of the cloths is being assumed to be the same.

9.11 [a] There must be a force up to counteract the force of gravity. Therefore the oil drop must be positively charged so that a force of attraction between the oil drop and the negative rail equals that of the gravitational force.

[b] $a_{net} = 0 ms^{-2}$
$F_g = F_E$
$F_E = 2.00 \times 10^{-3}$ N

[c] If the charge was doubled, the electric force exerted on the particle would increase above the force applied by gravity and the oil drop would accelerate upwards towards the negative plate.

[d] $q = 6.40 \times 10^{-18}$ C
$e = (6.40 \times 10^{-18})/(1.60 \times 10^{-19})$
$= 40$ electrons

[e] $r = (3 \times 0.02)/2$ *(estimating the distance between the two oil drops as the oil drop at point b enters the system)*
$= 0.03$m
$q_1 = 6.40 \times 10^{-18}$ C
$q_2 = 6.40 \times 10^{-18}$ C
$k = 9.00 \times 10^9$ N
$F = (kq_1q_2)/(r^2)$
$= (9.00 \times 10^9 \times 6.40 \times 10^{-18} \times 6.40 \times 10^{-18})/(0.03)^2$
$= 4.10 \times 10^{-22}$ N
$= 4.10 \times 10^{-22}$ N Repulsion the moment oil drop b enters the system

[f] The oil drop could be ionized with a cathode ray tube or with friction from a dripper bottle.

9.12 [a] $E = 1.00 \times 10^6$ Vm^{-1}
$S = 1.00 \times 10^3$ m
$E = V/s$
$V = 1.00 \times 10^6 \times 1.00 \times 10^3$
$= 1.00 \times 10^9$ v

[b] The charge is induced through water molecules rubbing against and colliding into each other causing a transfer of electrons.

[c] $P = 100$w
$t = 7.78 \times 10^6$ s
$W = Pt$
$= 100 \times 7.78 \times 10^6$
$= 7.78 \times 10^8$ j

[d] $W = 7.78 \times 10^8$ j
$V = 1.00 \times 10^9$ v
$W = qV$
$q = (7.78 \times 10^8)/(1.00 \times 10^9)$
$= 0.78$ C

[e] $t = 5.0 \times 10^{-6}$ s
$I = q/t$
$= 0.78/5.0 \times 10^{-6}$
$= 1.56 \times 10^4$ A