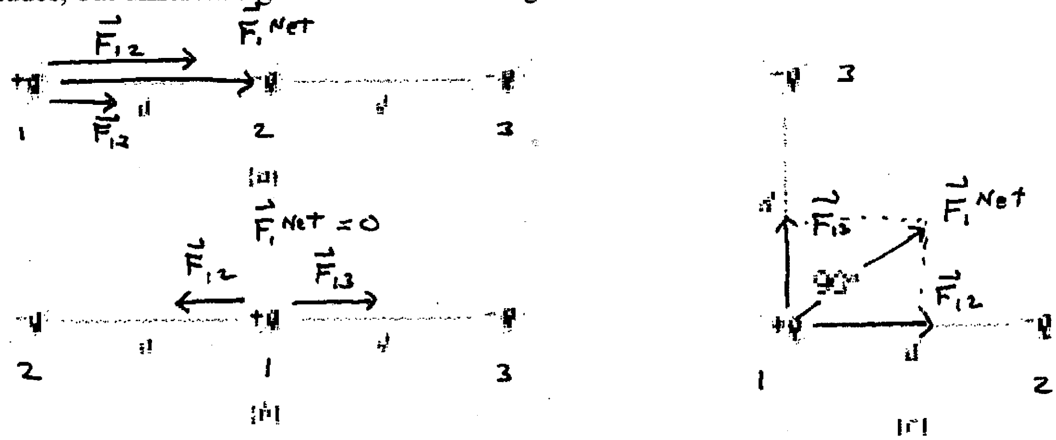
Physics 2102 **Section 004** **Dowling**

January 16, 2007 Quiz 1 Name (print): SOLUTION

The figure shows three point charges arranged in different ways. The charges all have the same magnitudes, but different signs as shown in the figure.



Rank the arrangements according to the magnitude of the total electrostatic force on the **positive charge**, greatest first. Three points to get all right, one point if one ranking is correct.

USE COULOMB'S LAW

(a) $_a\vec{F}_1^{NET} = \vec{F}_{12} + \vec{F}_{13} = -\frac{kq^2}{d^2}\hat{i} - \frac{kq^2}{(2d)^2}\hat{i} = -\frac{5kq^2}{4d^2}$

$_aF_1^{Net} = |_a\vec{F}_1^{Net}| = \boxed{\frac{5}{4}\frac{kq^2}{d^2}}$ MAG $= \boxed{1.25\ \frac{kq^2}{d^2}}$

(b) By symmetry $_b\vec{F}_1^{NeT} = 0 \Rightarrow |_b\vec{F}_1^{NeT}| = {_bF_1^{NeT}} = \boxed{0}$

(c) $|_c\vec{F}_{12}| = |_c\vec{F}_{13}| = \frac{kq^2}{d^2}$ by symmetry.

Magnitude is Hypotneus — use Pythagoras!

$|\vec{F}_1^{NET}| = \sqrt{|\vec{F}_{12}|^2 + |F_{13}|^2} = \sqrt{2}\,\frac{kq^2}{d^2} = \boxed{1.41\ \frac{kq^2}{d^2}}$

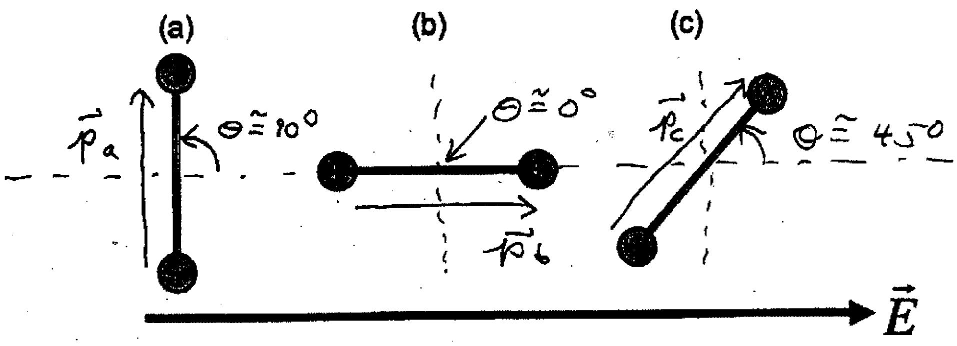
$|_c\vec{F}_1^{NET}| > |_a\vec{F}_1^{NET}| > |_b\vec{F}_1^{NeT}|$

$\boxed{(c) > (a) > (b)}$

Physics 2102 Section 004 **Dowling**

January 18, 2007 Quiz 2 Name (print): SOLUTION

The figure shows three dipoles arranged in different ways. The charges and dipole moments all have the same magnitudes, and a constant, homogeneous electric field is applied as shown.



Rank the three dipoles according to the magnitude of the total electrostatic **torque** on the **dipole**, greatest first. Three points to get all right, one point if one ranking is correct.

$$|\vec{\tau}| \equiv \tau = |\vec{p} \times \vec{E}| \equiv |\vec{p}||\vec{E}||\sin\theta| \equiv pE\sin\theta$$

$$|\vec{\tau}_a| \cong pE\underbrace{\sin(90^\circ)}_{1} = pE = 1.0\,pE$$

$$|\vec{\tau}_b| \cong pE\underbrace{\sin(0^\circ)}_{0} = 0$$

$$|\vec{\tau}_c| \cong pE\underbrace{\sin(45^\circ)}_{\sqrt{2}/2} = \frac{\sqrt{2}}{2}pE \cong 0.7\,pE$$

$$1.0 > 0.7 > 0.0$$

$$\boxed{(a) > (c) > (b)}$$

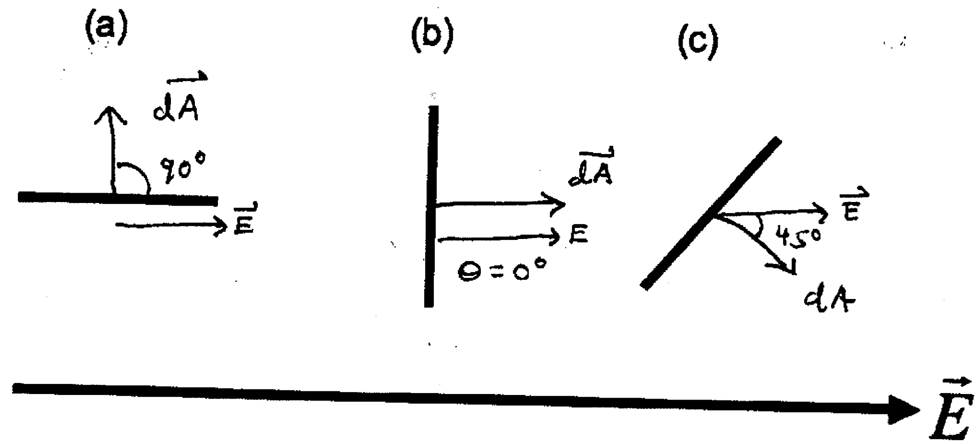
TORQUE $\propto \sin\theta$!

$$\underbrace{\sin 90^\circ}_{1} > \underbrace{\sin 45^\circ}_{0.7} > \underbrace{\sin 0^\circ}_{0}$$

Physics 2102 **Section 004** **Dowling**

January 23, 2007 Quiz 3 Name (print): SOLUTION

The figure shows a side view of three, square, Gaussian surfaces, each of area A, arranged in different ways. A constant, homogeneous electric field of magnitude E is applied as shown.



Rank the three Gaussian surfaces according to the magnitude of the total electrostatic **flux** through each **surface**, greatest first. Three points to get all right, one point if one ranking is correct.

(a) $\Phi = \oint \vec{E}\cdot\vec{dA} = EA \underbrace{\cos 90^\circ}_{0} = 0$

(b) $\Phi = \oint \vec{E}\cdot\vec{dA} = EA \underbrace{\cos 0^\circ}_{1} = EA$

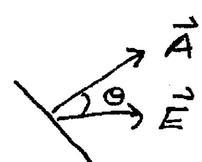
(c) $\Phi = \oint \vec{E}\cdot\vec{dA} = EA \cos 45^\circ \cong 0.7 EA$

$$\boxed{(b) > (c) > (a)}$$

DEFINITION FLUX $= \Phi = \oint \vec{E}\cdot\vec{dA}$

FOR FLAT SURFACE & CONSTANT FIELD

$\Phi = \vec{E}\cdot\vec{A} = EA \cos\theta$

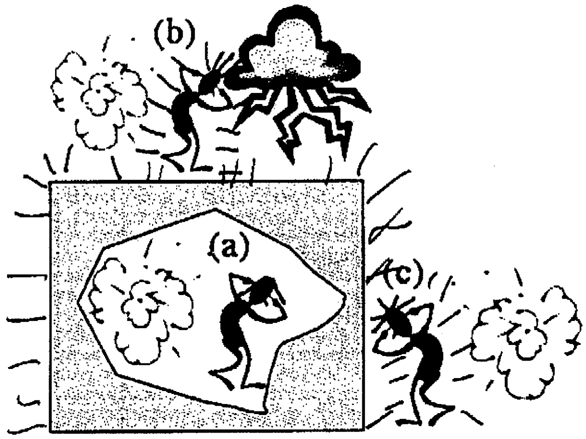


$\vec{A}$ IS NORMAL TO SURFACE.

Physics 2102 **Section 004** **Dowling**

January 25, 2007 Quiz 4 Name (print): SOLUTION

Alice, Bob, and Charlie are painting their tool shed. The shed is all aluminum and completely enclosed. They are positioned as shown, when lightning from a passing thundercloud strikes the shed.



Rank the three people; based on the likelihood they will require medical assistance, greatest first. Three points to get all right, one point if one ranking is correct.

(b) > (c) > (a)

ALICE (a) IS SAFE BECAUSE $\vec{E}$-FIELD INSIDE A CONDUCTING, ENCLOSED, SURFACE IS ALWAYS ZERO, SO CURRENT, VOLTAGE, ETC. IS ZERO. BOB AND CHARLIE ARE GOOD CONDUCTORS — LIKE THE SHED — AND SO BECOME CHARGED — FIELD LINES RADIATE OUTWARDS BUT BECOME BUNCHED AT THE HEADS WHERE $\vec{E}$ IS STRONGEST. BOB IS CLOSEST, NARROWEST, OBJECT TO CLOUD — HE'S IN MOST DANGER.

Physics 2102 **Section 004** **Dowling**

January 30, 2007 Quiz 5 Name (print): SOLUTION

Charlie is hiking over a mountaintop near trail-ridge road Colorado — 11,000ft above sea level — when the suddenly weather turns bad. He then encounters Alice and Bob coming the other way on the trail (see photo). Alice and Bob say "Hi" to Charlie.

Rank Charlie's possible responses, below, from *most appropriate first* to *least appropriate last.* Three points to get all right; one point if one ranking is correct.

(a.) Nice hair.

(b.) If you stand still, I will use Gauss' Law to calculate the charge on your heads.

(c.) ***RUN FOR YOU LIVES OR WE'RE ALL GONNA DIE!!!***

ALICE & BOB'S HAIR IS STANDING ON END BECAUSE DIELECTRIC BREAKDOWN OF THE AIR HAS BEGUN AND A LIGHTNING STRIKE IS IMMINENT! THEY ALL ARE HUMAN LIGHTNING RODS! (SEE SAMPLE PROBLEM 23-5, pg 615)

(a) THIS REPONSE SHOWS CHARLIE IS AS CLUELESS AS ALICE OR BOB. HOWEVER IT IS SORT OF NEUTRAL.

(b) IF CHARLIE IS SMART ENOUGH TO DO THIS HE IS SMART ENOUGH TO KNOW (c) IS THE RIGHT ANSWER! MAKING EVERYBODY STAND STILL IS THE WORST CHOICE.

(c) THIS IS THE SAFEST BET — GET AWAY FROM THE FORMING "UPWARD STREAMER".

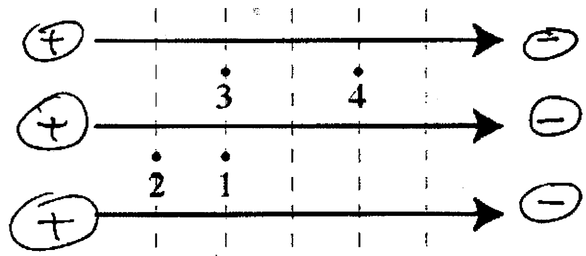
$$\boxed{(c) > (a) > (b)}$$

Physics 2102 **Section 004** **Dowling**

February 1, 2007 **Quiz 6** **Name (print):** SOLUTION

The figure shows a uniform electric field, pointing to the right. The equipotential surfaces are indicated with dashed lines.

HIGH V



LOW V

There are four points indicated on the figure (1, 2, 3, and 4). We define V = 0 at point 1 ($V_1 = 0$). What is the electric potential at the three other points? (Circle the right answer).

(a) $V_2 < 0$ $V_2 = 0$ $V_2 > 0$

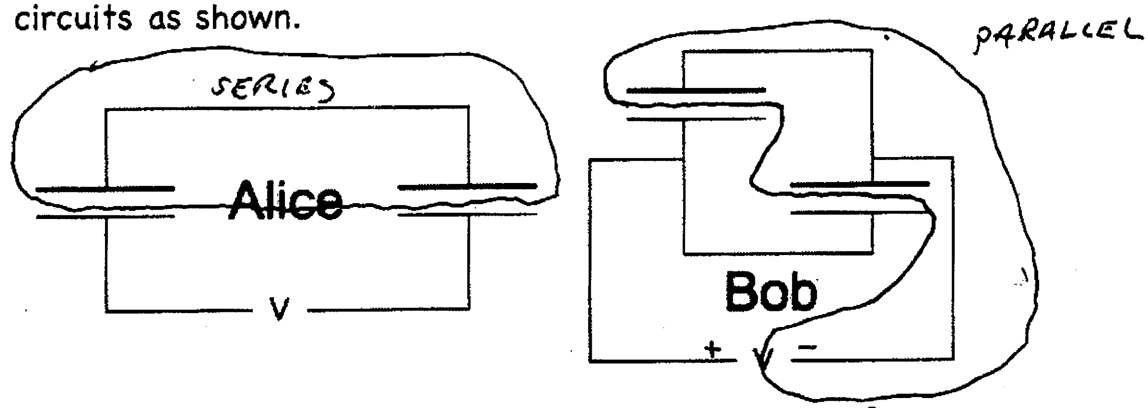
(b) $V_3 < 0$ $V_3 = 0$ $V_3 > 0$

(c) $V_4 < 0$ $V_4 = 0$ $V_4 > 0$

Physics 2102 Section 004 Dowling

February 8, 2007 Quiz 7 Name (print): SOLUTION

Alice and Bob are lab partners. They are given two identical batteries and four identical capacitors. They then construct the two circuits as shown.



Alice gloats to Bob, "The total equivalent capacitance of my circuit is bigger than yours." Bob retorts to Alice, "No, the total equivalent capacitance of *my* circuit is bigger than *yours!*" Charlie looks over their shoulders and exclaims, "You're *both* wrong — the total equivalent capacitance of these two circuits is the *same!*"

Who is right? (Circle one.)

(a) Alice: $C_A \cancel{>} C_B$

(b) Bob: $C_A < C_B$

(c) Charlie: $C_A \cancel{=} C_B$

A - SERIES B - PARALLEL $\Rightarrow$ $C_A \neq C_B$ (CHARLIE WRONG)

SERIES: $\frac{1}{C_A} = \frac{1}{C} + \frac{1}{C} = \frac{2}{C} \Rightarrow C_A = \frac{1}{2} C$

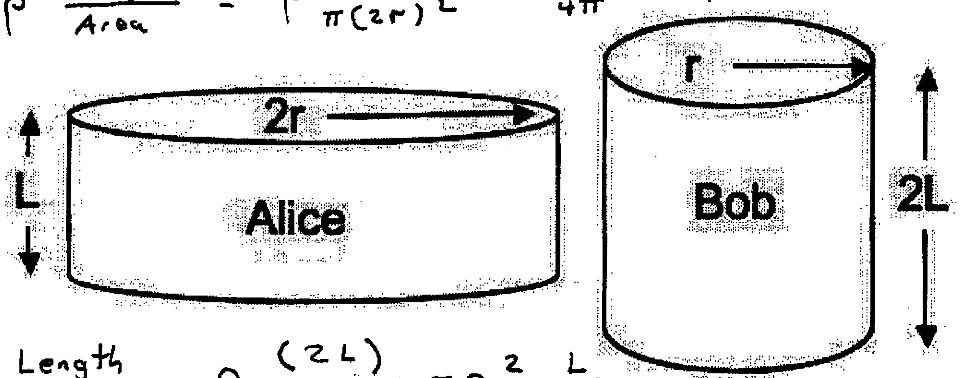
PAR: $C_B = C + C = 2C \Rightarrow C_A < C_B$ BOB RIGHT

Physics 2102 Section 004 Dowling

January 23, 2007 Quiz 8 Name (print): SOLUTION

Alice and Bob are NASA engineers, designing a shunt for the Mars-Lander battery. (A shunt is a metal bar used to short circuit the battery, just before landing, in order to heat up and burn the oxidation off the battery terminals.) It is important for the shunt to have as high a total resistance *R* as possible. Alice and Bob are both using identical metal, nichrome, for their designs, shown below, are both cylinders with the indicated radii and lengths:

$$R_A = \rho \frac{\text{Length}}{\text{Area}} = \rho \frac{(L)}{\pi(2r)^2} = \frac{1}{4\pi} \rho \frac{L}{r^2}$$



$$R_B = \rho \frac{\text{Length}}{\text{Area}} = \rho \frac{(2L)}{\pi(r)^2} = \rho \frac{2}{\pi} \frac{L}{r^2}$$

Alice once again gloats, "Hey Bob, the total resistance for my design is the largest." Bob once again retorts, "No Alice, the total resistance for my design is the largest." Charlie, the typically clueless NASA manager (responsible for the last Mars-mission disaster involving a unit conversion error), leans over their shoulders again and exclaims, "You're both wrong – as usual – the total resistance of these two designs is identical!"

Who is right? (Circle One.)

(a.) Alice: $R_A \cancel{>} R_B$

(b.) Bob: $R_A < R_B$ $\qquad \rho \frac{2}{\pi} \frac{L}{r^2} > \rho \frac{1}{4\pi} \frac{L}{r^2}$

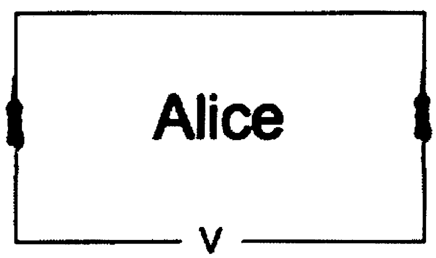
(c.) Charlie: $R_A \cancel{=} R_B$

Physics 2102 Section 004 **Dowling**

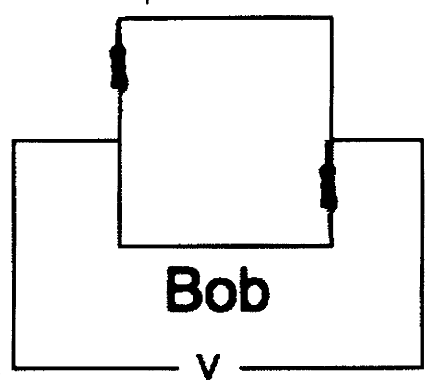
February 15, 2007 Quiz 9 Name (print): SOLUTION

Alice and Bob, the NASA engineers, are redesigning the battery shunt after nearly losing two Mars Landers. They are given two identical batteries and four identical resistors. They then construct the two circuits as shown. (For the shunt the resistance should still be as high as possible.)

SERIES



PARALLEL



$R_A = R + R = 2R$

Alice brags to Bob, "The total equivalent resistance of my circuit is bigger than yours." Bob responds to Alice, "No, the total equivalent resistance of *my* circuit is bigger than *yours!*" Charlie, the clueless NASA manager, looks over their shoulders and yells, "You idiots! They're the same!"

Who is right? (Circle one.)

(a) Alice: $R_A > R_B$

(b) Bob: $R_A < R_B$

(c) Charlie: $R_A = R_B$

$$\frac{1}{R_B} = \frac{1}{R} + \frac{1}{R} = \frac{2}{R}$$

$$\boxed{R_B = \frac{1}{2}R < 2R = R_A}$$

Physics 2102 Section 004 Dowling

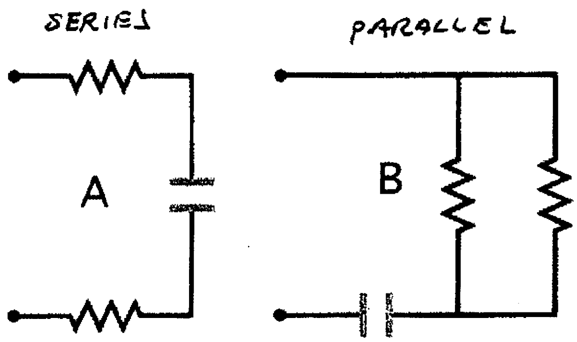
February 22, 2007 Quiz 10 Name (print): SOLUTION

Alice and Bob are nuclear engineers, designing an RC circuit for a fusion reactor. It is important for the circuit to dump as much energy as quickly as possible to ignite the reactor. Alice and Bob are each using an identical, two-story-tall capacitor C and two resistors R, for their designs, shown below.

$\frac{1}{R_B} = \frac{1}{R} + \frac{1}{R} = \frac{2}{R}$

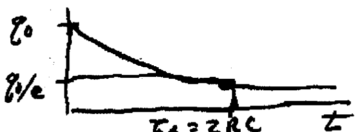
$R_A = R + R = 2R$

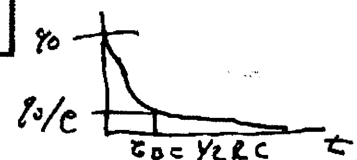
$\tau_A = R_A C = 2RC$



$R_B = R/2$

$\tau_B = R_B C = \frac{1}{2}RC$





Alice brags, "Hey Bob, the total discharge time for my circuit is the shortest."
Bob scoffs, "No Alice, the total discharge time for my design is the shortest."
Charlie, the typically clueless Department of Energy manager (responsible for the 50-year delay in getting fusion energy to market), leans over their shoulders on his walking cane again croaks hoarsely, "You're both wrong – the total discharge time of these two designs is identical!"

Who is right? (Circle One.)

(a.) Alice: $\tau_A < \tau_B$

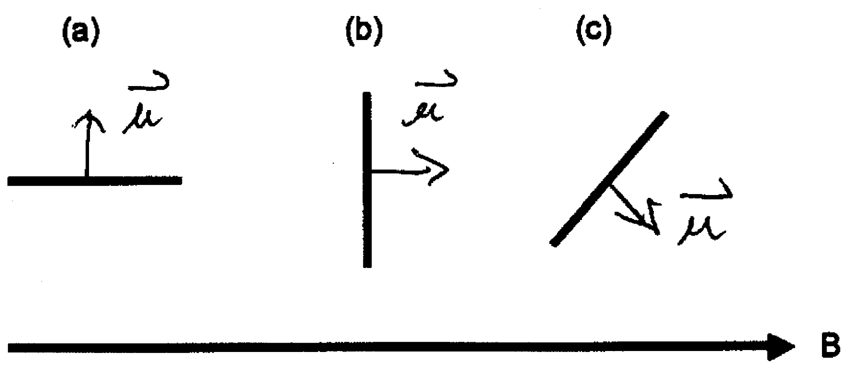
(b.) Bob: $\tau_A > \tau_B$

(c.) Charlie: $\tau_A = \tau_B$

Physics 2102 Section 004 Dowling

March 01, 2007 Quiz 11 Name (print): SOLUTION

Alice, Bob, and Charlie have built three magnetic dipoles arranged in three different ways. The dipoles are identical square loops of wire with current running through them, shown on edge. The currents all have the same magnitudes and directions around the loop, and a constant, homogeneous magnetic field is applied as shown.



Rank the three magnetic dipoles according to the magnitude of the total magneto-static **torque** on the magnetic **dipole**, greatest first. Three points to get all right, one point if one ranking is correct.

$$|\vec{\tau}| = |\vec{\mu} \times \vec{B}| = \mu B \sin\theta$$

(a) $\sin 90^\circ = 1$

(b) $\sin 0^\circ = 0$

(c) $\sin 45^\circ = \sqrt{2}/2 = 1/\sqrt{2} < 1$

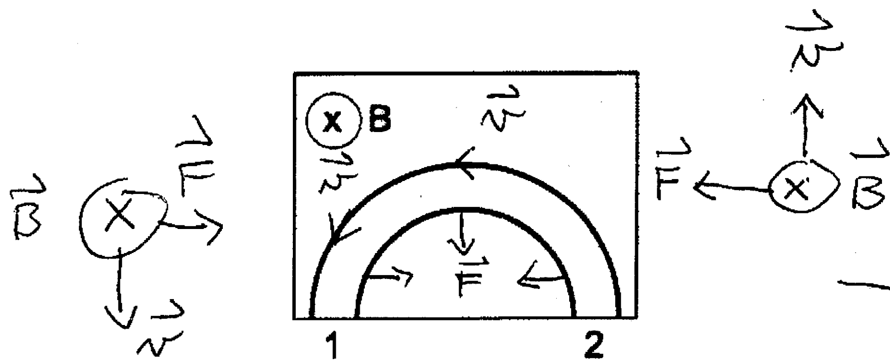
$$0 < 1/\sqrt{2} < 1$$

$$\boxed{(b) < (c) < (a)}$$

Physics 2102 Section 004 Dowling

March 06, 2007 Quiz 12 Name (print): SOLUTION

Alice and Bob are nuclear engineers, building an A-Bomb. They design a mass spectrometer uranium isotope separator to separate heavy single positively charged U_{238} ions from light single positively charged U_{235} ions, as shown in the figure. The magnetic field B is into the page and the ions enter the bottom of the box with equal velocities.



Alice states, "The outer circular path is the desired U_{235} moving clockwise from 1 to 2." Bob replies, "No, the inner circular path is the desired U_{235} moving counterclockwise from 2 to 1." Charlie says, "I don't care — it's good enough for government work."

Who is right? (Circle One.)

(a.) Alice: (Outer/Clockwise)

(b.) Bob: (Inner/Counterclockwise)

(c.) Charlie: (Doesn't matter which.)

$$F_B = qvB = ma = m\frac{v^2}{R} \Rightarrow R = \frac{mv^2}{qvB} = \frac{mv}{qB}$$

$$m_{U238} > m_{U235} \Rightarrow \boxed{R_{238} > R_{235}}$$

SMALL CIRCLE