

□ ELECTRIC CHARGES

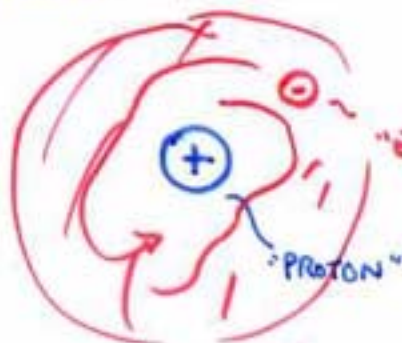
THEY COME IN TWO KINDS:

POSITIVE AND NEGATIVE

BASIC POINT OF THE EXP. #6 IS TO SHOW THAT THERE ARE
"TWO KINDS" OF ELECTRICITY.

(BY CONTRAST... ONLY ONE KIND OF MASS).

HYDROGEN ATOM



NEUTRAL

TOTAL CHARGE = 0
(ONE POSITIVE + ONE
NEG. = 0)

"ELECTRON"
WIZZING
AROUND

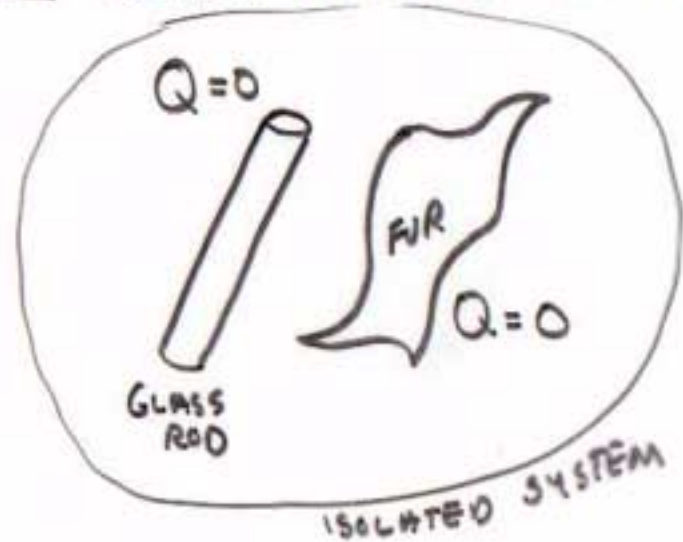
SEPARATE
THEM
"BREAK"
THE ATOM

POSITIVE
CHARGE



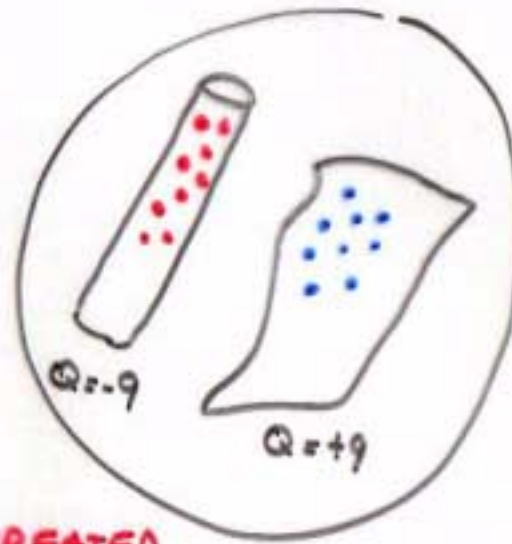
NEGATIVE
CHARGE

□ CONSERVATION OF CHARGE + STATIC ELECTRICITY:



Q STANDS FOR "CHARGE"

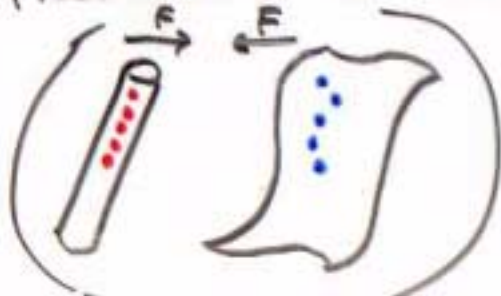
RUB
THEM
TOGETHER



THE CHARGE IS **NEITHER CREATED**
NOR DESTROYED, BUT IT CAN

- ① BE SEPARATED
- ② CANCEL OUT ANOTHER CHARGE.

PRESENCE OF AN EXCESS CHARGE CAUSES A FORCE



AND CAN CAUSE A
SPARK. - PHENOMENA.

□ TAKE-HOME EXPT. #6 ... YOU PROVE THIS!

2 KINDS OF "TAPE" - X AND Y



2 X-TAPES
REPEL

POSITIVE
CHARGES

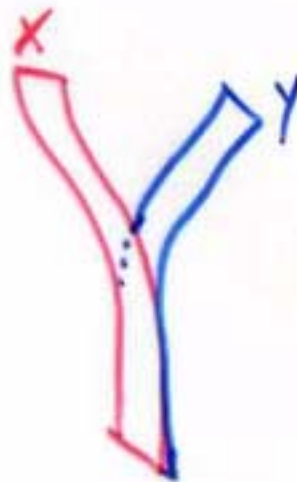
REPEL



2 Y-
TAPES
REPEL

NEGATIVE
CHARGES

REPEL



X AND Y

ATTRACT

OPPOSITE
CHARGES

ATTRACT

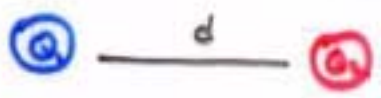
□ THE ELECTRIC FORCE LAW:

MEASURE CHARGE IN COULOMBS

$$Q = 1\text{ C}, Q = -1\text{ C}, Q = 0\text{ C}$$

POSITIVE - NEGATIVE - ZERO -

1 COULOMB = THE CHARGE OF 6×10^{18} PROTONS


$$F = k \cdot \frac{Q_1 \cdot Q_2}{d^2}$$

"K" IS A UNIVERSAL "ELECTRICITY CONSTANT"

CHECK: IF $Q_1 > 0, Q_2 > 0$

$F > 0$... REPULSION.

IF $Q_1 < 0, Q_2 < 0$

$$Q_1 \cdot Q_2 > 0$$

$F > 0$... REPULSION

IF $Q_1 > 0$ AND $Q_2 < 0$

$F < 0$... ATTRACTION

GRAVITY

$$F = G \frac{M_1 M_2}{d^2}$$

SAME FORM

FOR GRAVITY - ALWAYS GET AN ATTRACTION

ONLY ONE "SIGN" FOR MASS

YOU CAN NEUTRALIZE CHARGE - BUT NOT MASS

□ FORCE BETWEEN CHARGES:

OBJECT 1: EXCESS CHARGE Q_1



OBJECT 2: EXCESS CHARGE Q_2

CASES TO CONSIDER:

"LIKE CHARGES REPEL"

1. Q_1 AND Q_2 ARE BOTH POSITIVE:



ELECTRIC FORCE PUSHES THEM APART.

2. Q_1 AND Q_2 ARE BOTH NEGATIVE:



ELECTRIC FORCE PUSHES THEM APART.

"UNLIKE CHARGES ATTRACT"

3. Q_1 IS POSITIVE, Q_2 IS NEGATIVE:

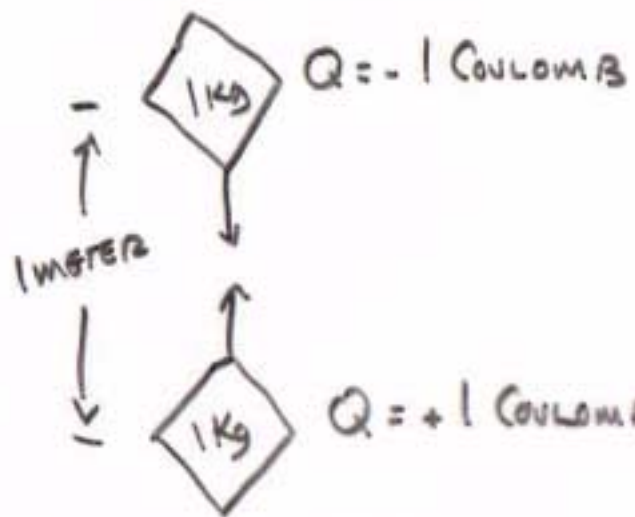


ELECTRIC FORCE BRINGS THEM TOGETHER
(ACTS TO MAKE TOTAL CHARGE GO TO ZERO!)

4. Q_1 IS NEGATIVE, Q_2 IS POSITIVE:



ELECTRIC FORCE IS BIG ... AND LONG-RANGED



FORCE $\approx 10^{10}$ NEWTON - FROM ELECTRIC FORCE

$\approx 10^{-11}$ NEWTON - FROM GRAVITY

MOST ORDINARY MATTER HAS JUST AS MANY

+ CHARGES AS - CHARGES

BECAUSE THIS FORCE IS SO BIG.



-10 ELECTRONS WHIZZING ABOUT

OVERALL CHARGE = 0
OVERALL ELECTRIC FORCE = 0.

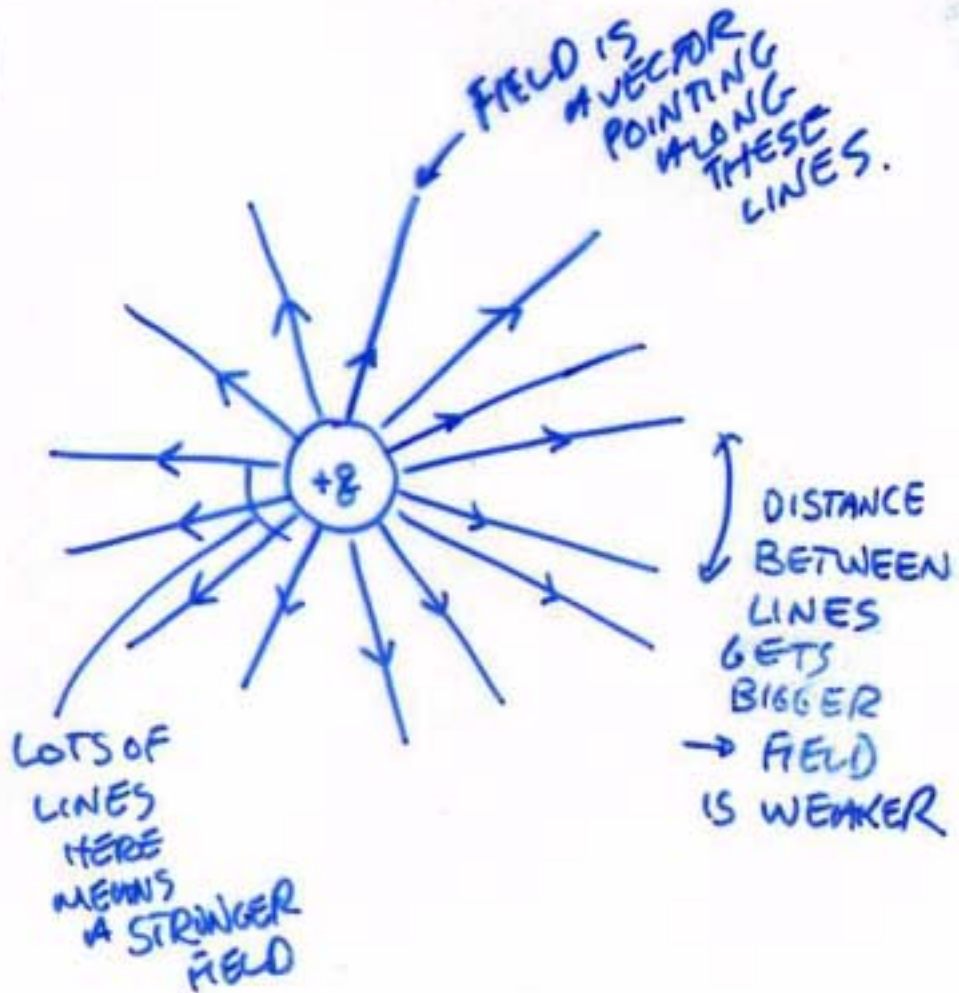
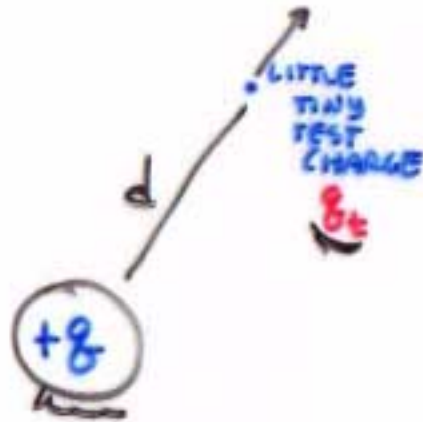
THE ELECTRIC FIELD

$$F = \frac{q_1 q_2}{d^2} K$$

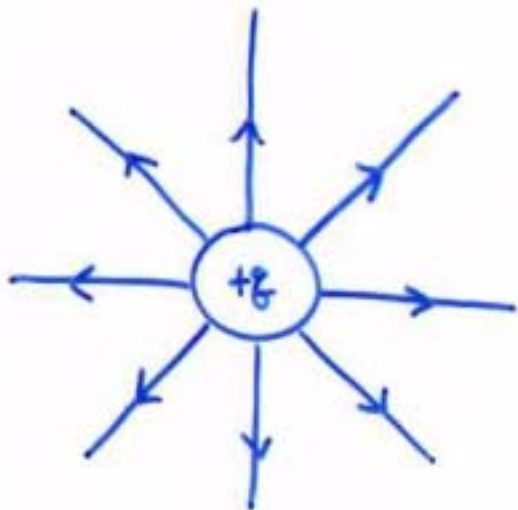
$$E = \frac{F}{q_t} = \text{"FORCE PER CHARGE"}$$

$E \cdot q_t =$ FORCE THAT TEST CHARGE FEELS -

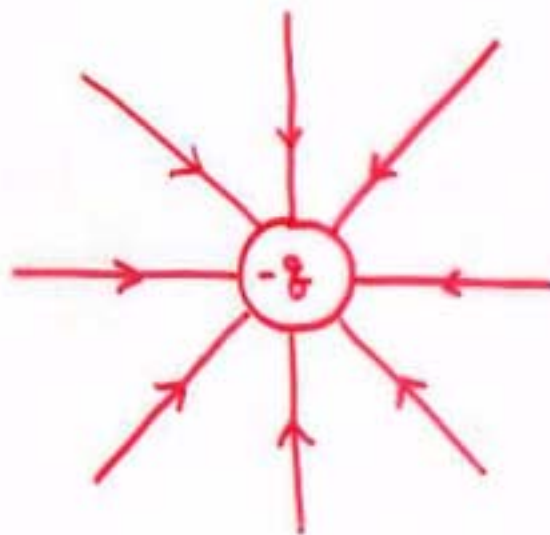
LOOK AT THE FIELD AS CREATING THE FORCE.



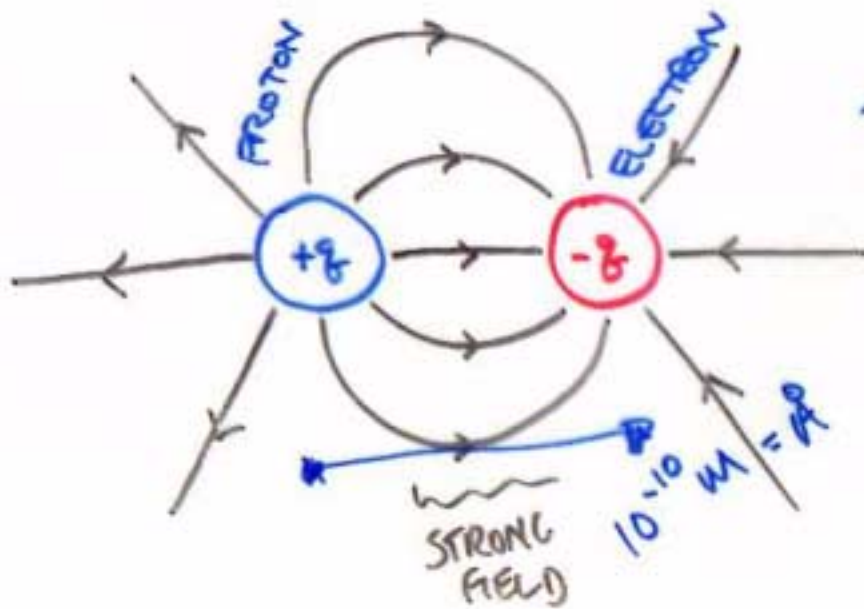
□ FIELD FROM OPPOSITE CHARGES, LIKE CHARGES:



POSITIVE

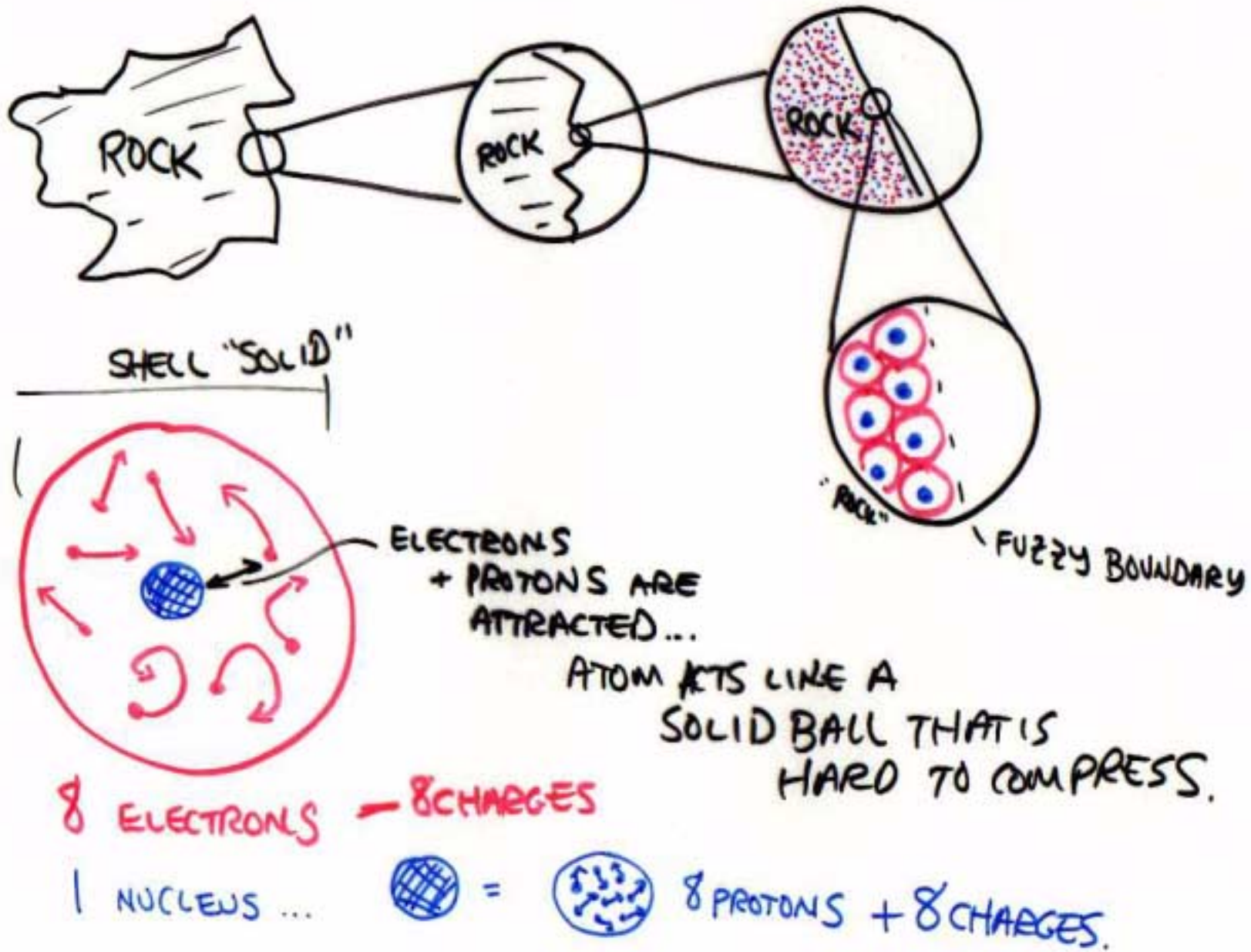


NEGATIVE



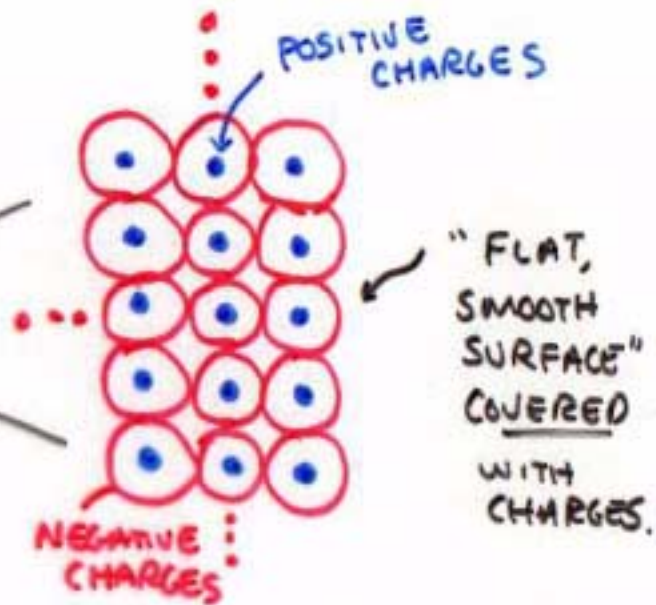
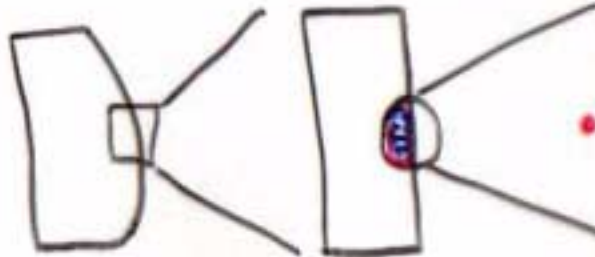
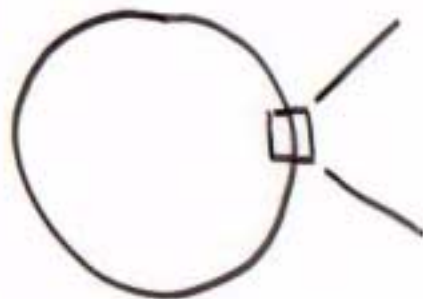
No
FIELD
FAR
AWAY
(TOTAL CHARGE=0)

□ MICROSCOPIC STRUCTURE OF MATTER

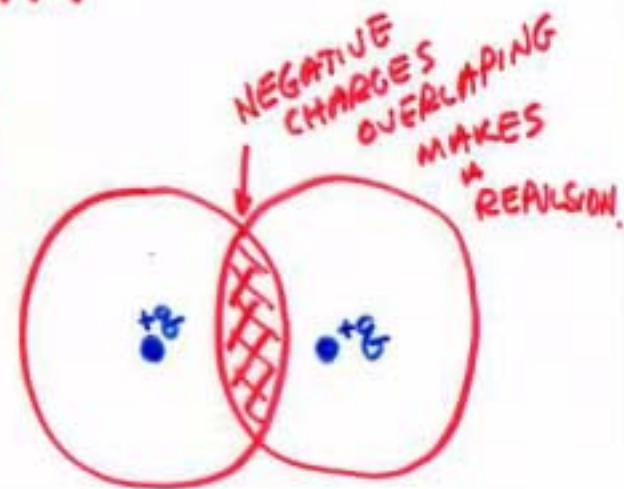
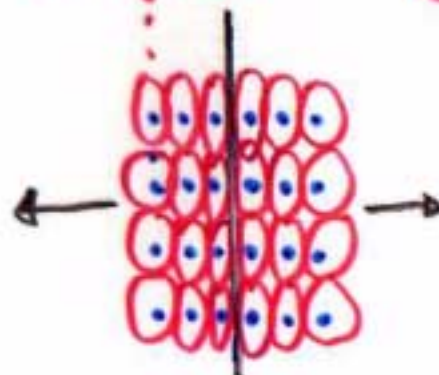
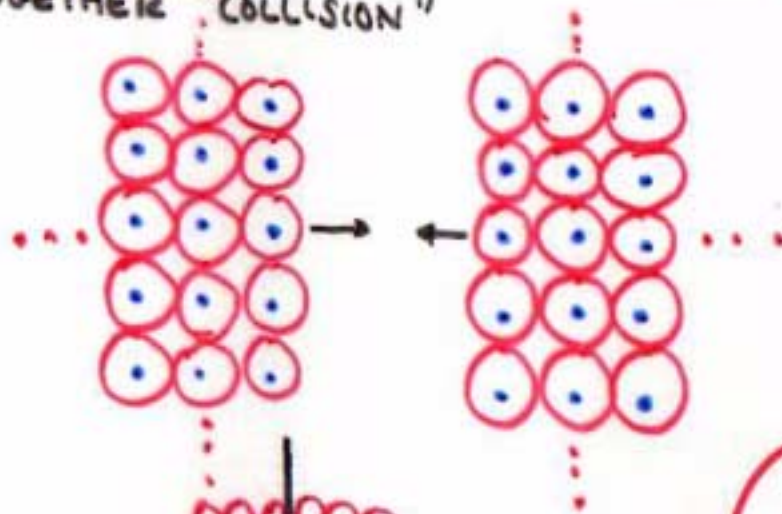
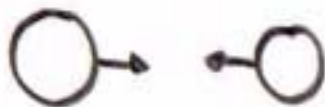


□ CONTACT: SHORT-RANGED FORCES

BALL



SMACK 2 BALLS TOGETHER "COLLISION"



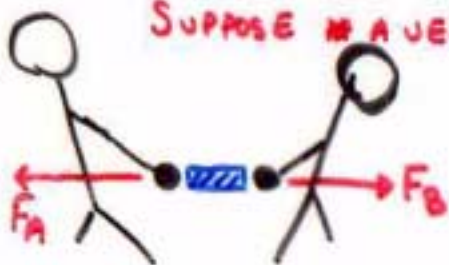
□ TENSION ON A TAUT ROPE



"TUG OF WAR"
 $F_A = F_B$ FOR AN EVENLY
 MATCHED
 TUG OF WAR
 - NO ACCELERATION.

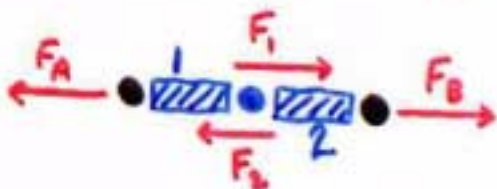
HOW DOES THE ROPE TRANSMIT A FORCE?

SUPPOSE A VERY SHORT ROPE:



FORCES ON THE ROPE MUST BALANCE:
 $F_A = F_B$ - NO ACCELERATION.

SUPPOSE 2 VERY SHORT ROPES TIED TOGETHER:



F_1 IS THE FORCE ON
 PIECE 1 FROM PIECE 2

$F_A = F_1$ - PIECE 1
 DOESN'T
 ACCELERATE



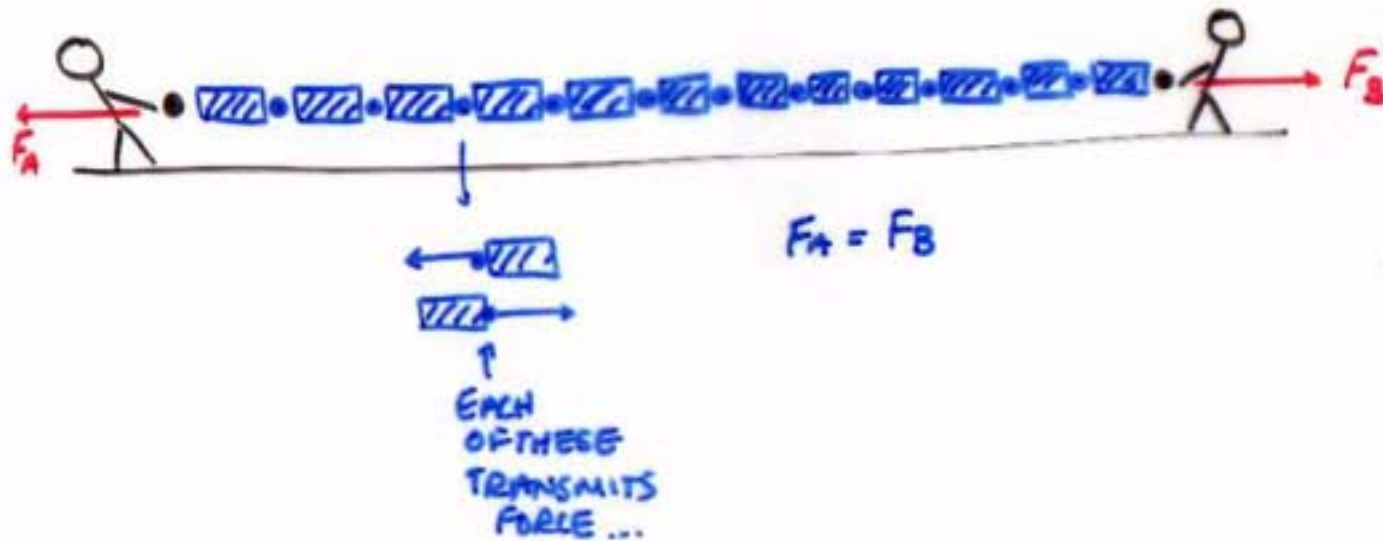
F_2 IS FORCE ON
 PIECE 2 FROM PIECE 1.

$F_B = F_2$ PIECE 2
 DOESN'T
 ACCELERATE

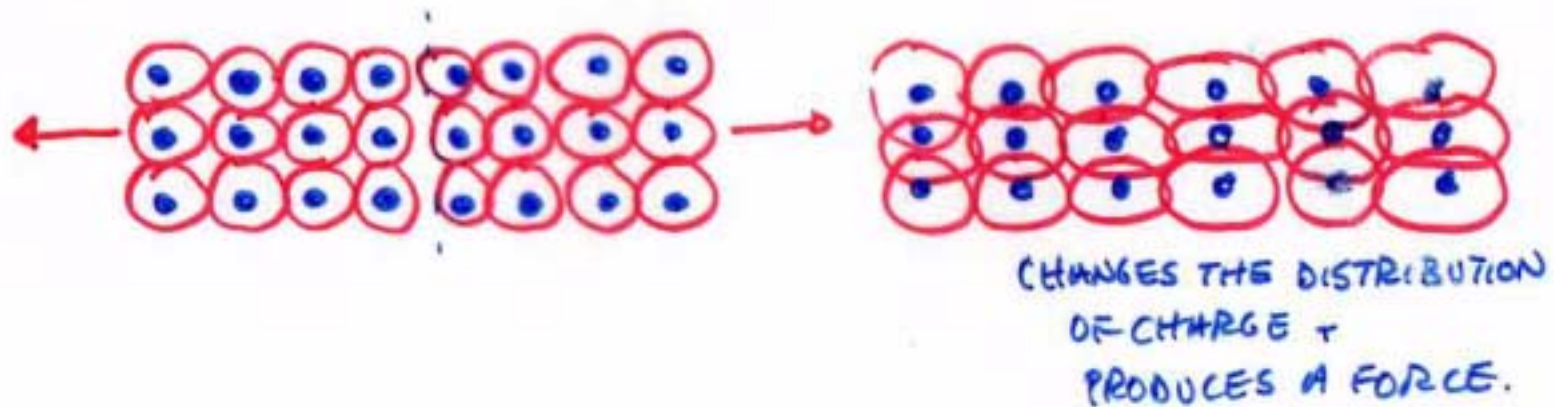
AND $F_1 = F_2$
 NEWTON'S
 3RD LAW

□ TENSION ON A TIGHT ROPE:

CAN BREAK THE ROPE UP INTO HUNDREDS OF PIECES:



SOURCE OF THE INTERNAL FORCES IS CHARGES, AGAIN.



□ FRICTION

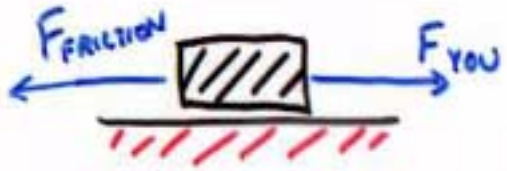
CONTACT BETWEEN MACROSCOPICALLY SMOOTH, MICROSCOPICALLY ROUGH SURFACES



THESE JAGGED "TEETH" CATCH EACH OTHER + CAUSE A FORCE.

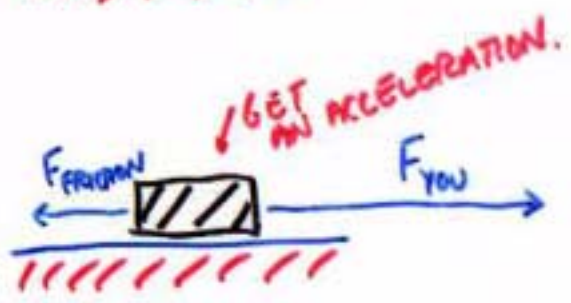
- UNTIL, THE FORCE GETS SO LARGE THE TEETH GET KNOCKED OFF + SURFACE STARTS TO SLIDE...

BREAKING TEETH COSTS ENERGY -

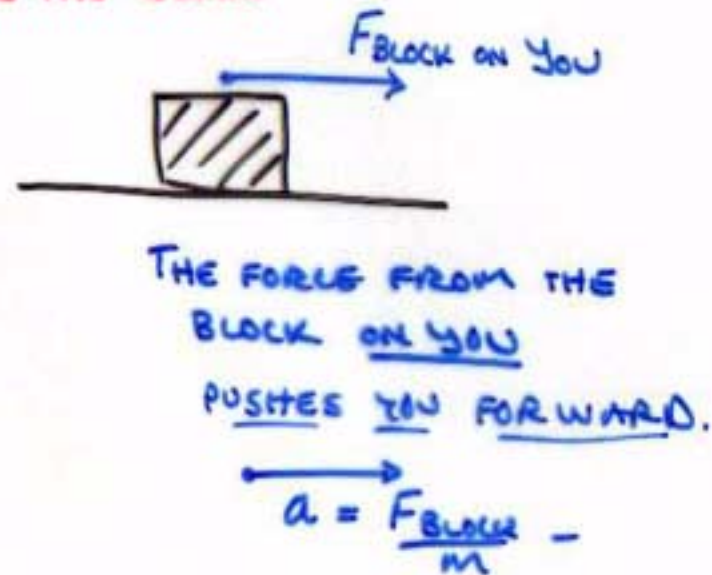
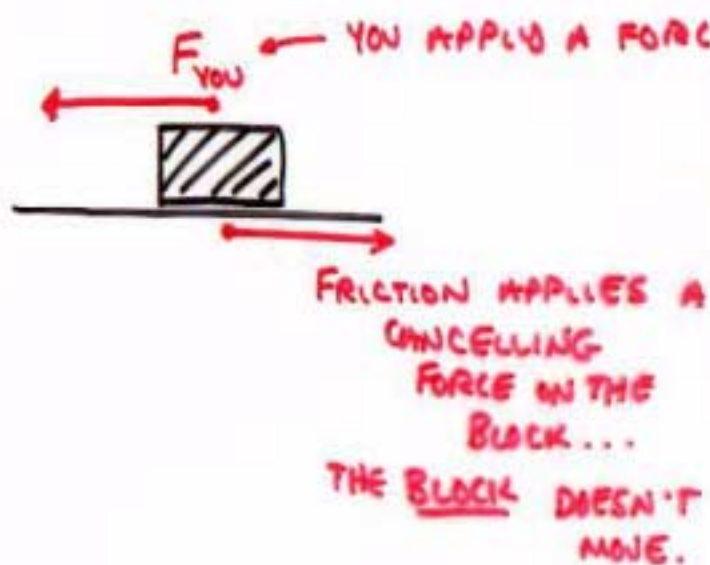


"SMALL FORCE" FRICTION CANCELS OUT APPLIED FORCE.

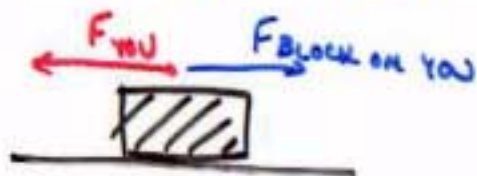
UNTIL APPLIED FORCE GETS ABOVE A THRESHOLD



□ FRICTION - WALKING



SUPPOSE NO FRICTION



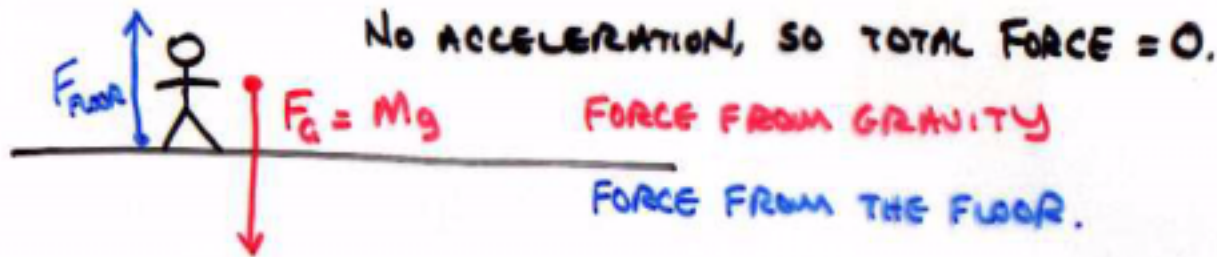
TOTAL FORCE VANISHES.

IF THE BLOCK IS A PART OF YOUR SHOE
YOU DON'T GO ANYWHERE.



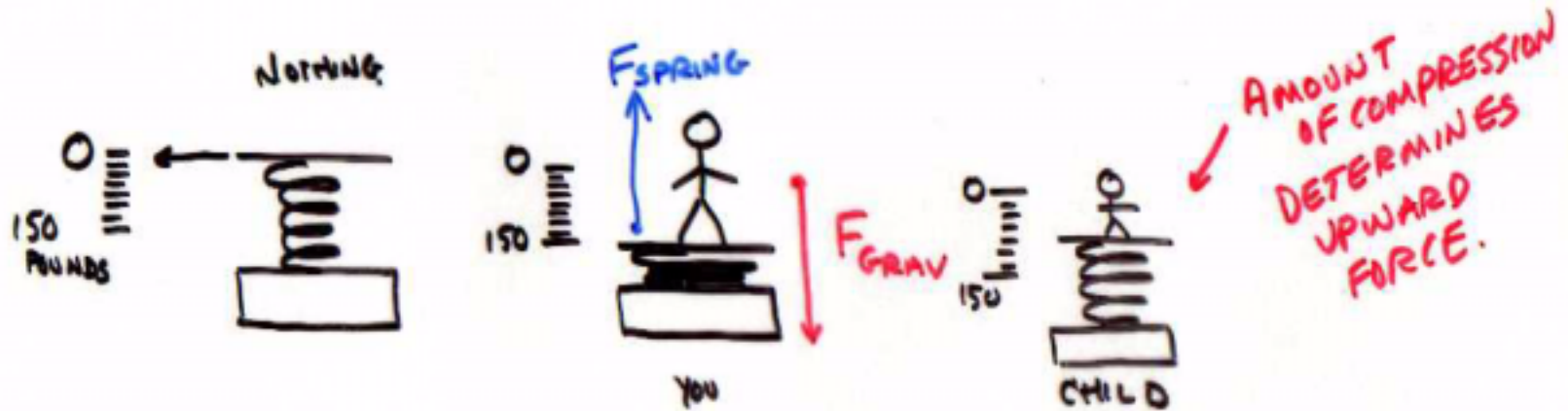
FRICTION MEANS TRACTION.

□ How DOES THE FLOOR KNOW YOUR WEIGHT?



$F_G = F_{\text{FLOOR}} \rightarrow F_{\text{FLOOR}} = Mg$ - THE FLOOR "MATCHES" YOUR WEIGHT? How so?

SPRING SCALE:

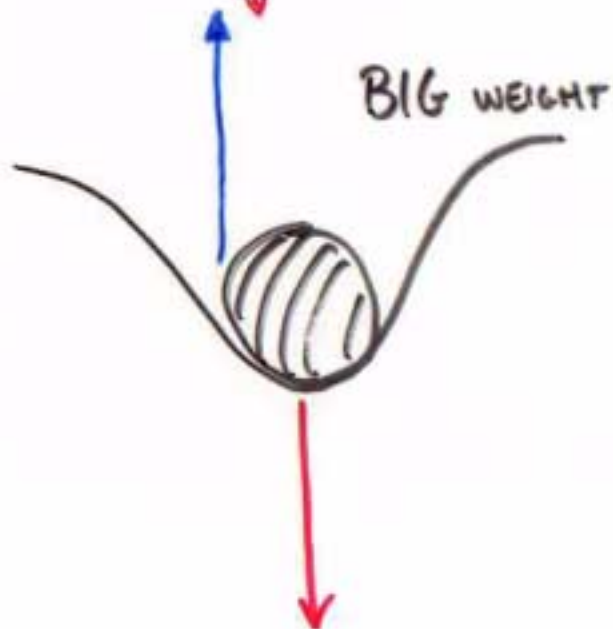


SPRING COMPRESSES UNTIL IT MATCHES YOUR WEIGHT.

□ THE FLOOR:



SURFACE DEFORMS
DUE TO WEIGHT APPLIED -
JUST LIKE
FRICTION / COLLISION / SCALE
SPRING.



JUST LIKE THE SPRING SCALE,
SURFACE DEFORMS - UNTIL JUST
THE RIGHT CANCELING FORCE
COMES ABOUT.

SOURCE IS STILL ELECTROMAGNETISM

