☐ WHERE HAVE WE GONE WITH THE COURSE?

1. OBSERVED MOTION IN THE SKY -

FIXED STARS - CHANGE SLOWLY SUMMER/WINTER CONSTELLATIONS

MOON - PHASES

SUN - YEAR

5 "PLANETS" WHOSE MOTION ISN'T "CONNECTED" TO THE ☆'S

- TYCHO BRAHE + KEPLER SHOWED LAWS FOR PLANET'S MOTION.

2. WHY DO PLANETS - ANY OBJECTS MOVE?

NEWTON'S LAWS: ANY OBJECT MOVES BECAUSE OF A FORCE ACTING ON IT. THE FORCE CHANGES MOMENTUM + GIVES ENERGY

WITH LAW OF GRAVITY, $F = \frac{GM_1M_2}{d^2}$ - EXPLAINS MOTION OF PLANETS

3. WHAT DOES NEWTON'S LAWS IMPLY ABOUT EVERYTHING ELSE?

NEWTON'S LAWS DON'T APPLY TO JUST PLANETS -

DO THEY APPLY FOR SMALL THINGS TOO?

EXPERIMENT + THINKING ARE ONLY WAY TO PROCEEDE.

☐ GASES

- STATE OF MATTER EXAMPLES: AIR, OXYGEN GAS, WATER "GAS" "VAPOR"

  NOT DENSE "RAREFIED" - OFFERS LITTLE RESISTANCE TO MOTION

WHAT CAN YOU DO TO A GAS?

YOU CAN CONFINE IT, TRAP IT INSIDE A VOLUME = V

PRESS IT WITH A PRESSURE = P

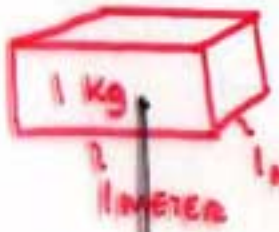
ADD SOME MORE, OR TAKE SOME OUT; NUMBER OF GAS PARTICLES = N

HEAT IT UP OR COOL IT DOWN, TEMPERATURE = T

BEFORE WE GET INTO NEWTON'S LAWS, WHAT IS THE EXPERIMENTAL SITUATION?

☐ Atmospheric Pressure

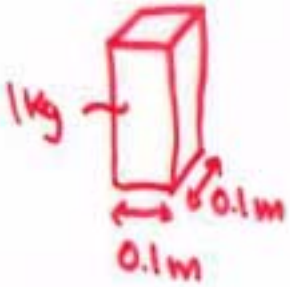
$$\text{PRESSURE, } P = \frac{\text{FORCE}}{\text{AREA}}$$



AREA = 1 METER × 1 METER

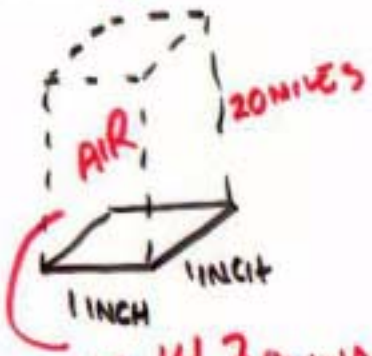
$F_G = 1\text{Kg} \cdot 10 \frac{M}{S^2} = 10 \text{ NEWTONS}$

PRESSURE FROM BLOCK ON GROUND IS $\frac{10 \text{ NEWTON}}{M^2} = 10$ "PASCAL"



$$\text{PRESSURE} = \frac{10\text{N}}{(0.1\text{m})(0.1\text{m})} = 10 \cdot 10 \cdot 10 \frac{\text{N}}{\text{M}^2} = 1000 \text{ PASCAL.}$$

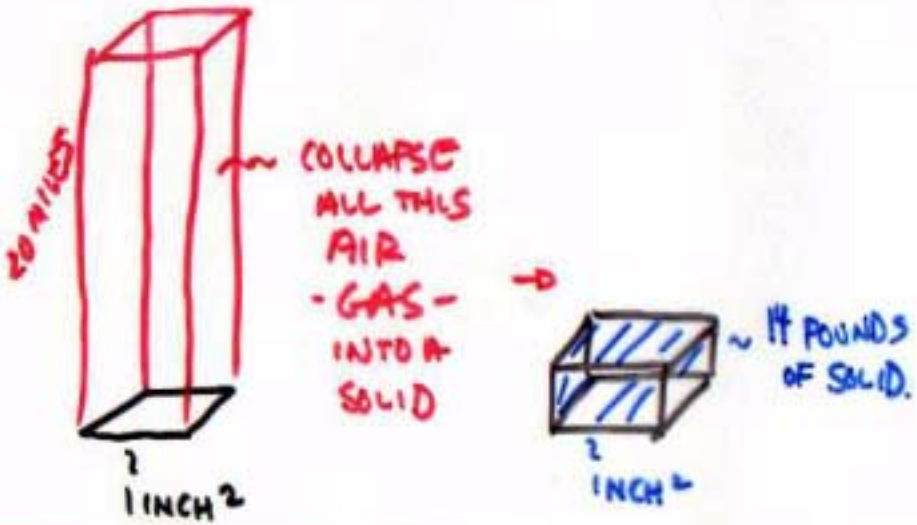
MADE OF MATTER, ATTRACTED BY GRAVITY,
IT HAS A WEIGHT!



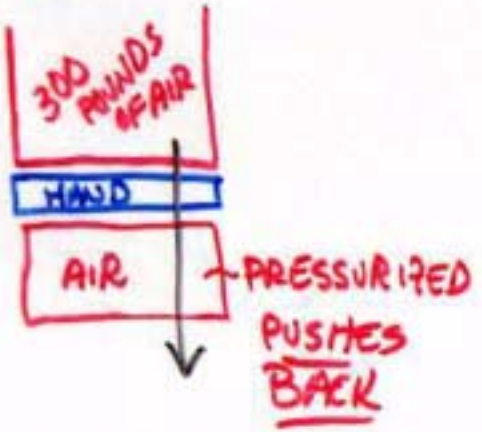
≈ 14.7 POUNDS

☐ ATMOSPHERE HAS A WEIGHT!

FOR EACH SQUARE INCH:



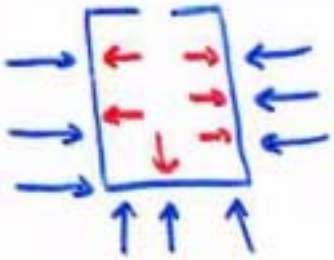
HOW CAN YOU HOLD UP THIS WEIGHT?



WHY AREN'T YOU CRUSHED?

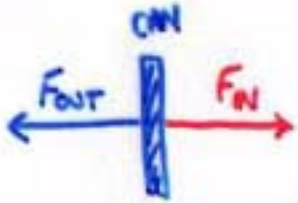
YOU WOULD BE, IF YOU WERE EMPTY.

SODA CAN —



AIR PRESSES ON CAN.

AIR IN CAN PRESSES BACK



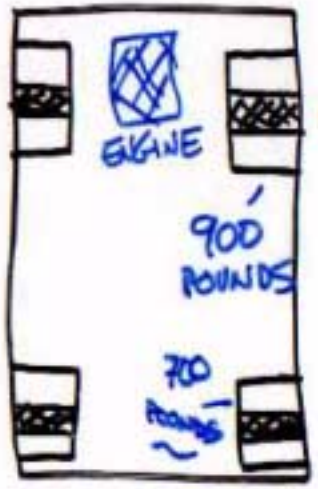
JUST CANCEL.

WHAT IF WE TAKE F_{IN} AWAY?

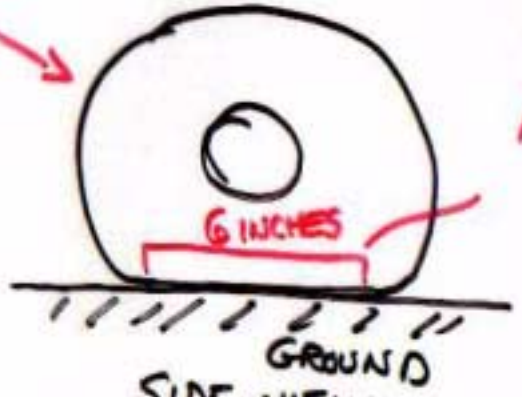
☐ PRESSURE - HOLDS YOUR CAR UP:

EXTRA-CREDIT
-TH EXP. # 58
WORTH
10 POINTS
ON FINAL EXAM
DUE: May 19

TOP VIEW



ONLY A PART OF EACH TIRE TOUCHES THE GROUND.

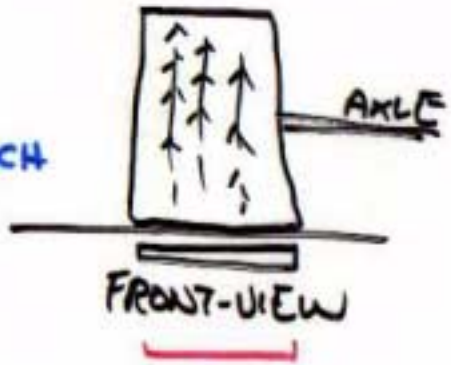


SIDE-VIEW
EXAGERATED.

A RECTANGULAR PATCH OF RUBBER TOUCHES THE GROUND.

TIRE PRESSURE GAUGE:

$P_{\text{IN TIRE}} \approx 30 \frac{\text{POUNDS}}{\text{SQUARE INCH}}$

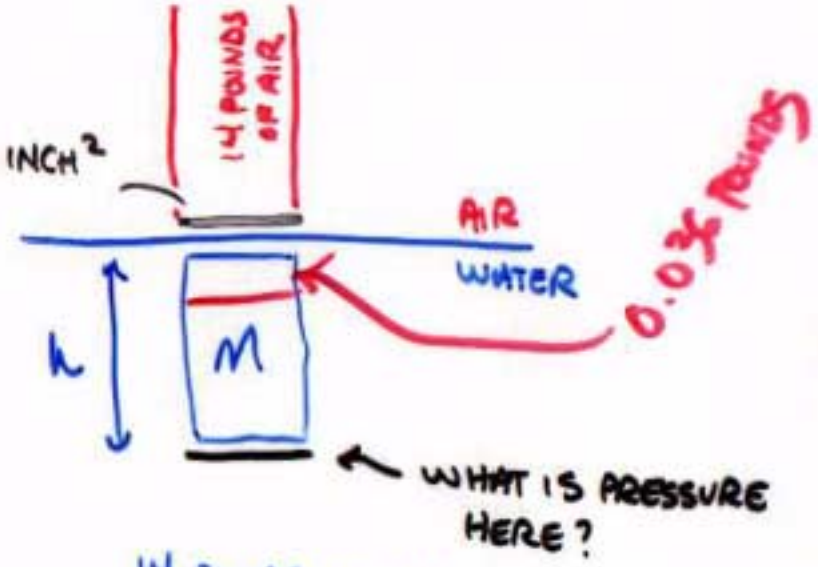


FRONT-VIEW

AREA IN CONTACT WITH GROUND =
5 INCH . 6 INCH
= 30 SQUARE INCHES

TOTAL FORCE ON TIRE = P . AREA = $30 \frac{\text{POUNDS}}{\text{INCH}^2} \cdot 30\ \text{INCH}^2 = 900$ POUNDS
— ONE TIRE!

☐ UNDER THE SURFACE OF A LIQUID...



14 POUNDS OF AIR + WEIGHT OF THE WATER ABOVE YOU!

$gM = 0.036$ POUNDS FOR EVERY INCH BELOW SURFACE

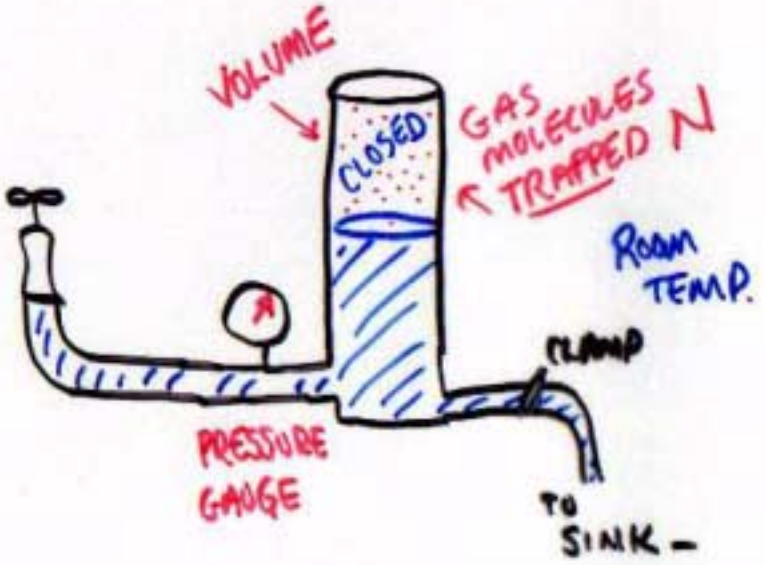
$$gM = 0.036 \frac{\text{POUNDS}}{\text{INCH}} \cdot h$$

PRESSURE = $P_{ATM} + P_{WATER}$ ADD TOGETHER

- BOTTOM OF A SWIMMING POOL — CAN FEEL THIS PRESSURE.

☐ LAB EXPERIMENT

WHAT DOES IT SAY ABOUT P, V, N, T?



ABSTRACT

PUSH PLUNGER ↓ VOLUME GOES DOWN
PRESSURE GOES UP

N = THE NUMBER OF GAS PARTICLES DID NOT CHANGE

T = TEMPERATURE OF THE GAS DID NOT CHANGE

PRESSURE AND VOLUME DID CHANGE

WHERE DOES "PUSH" COME FROM IN YOUR EXPERIMENT?

- FAUCET PUSHES AIR W/ WATER PRESSURE
  ≈ 60 LBS/INCH²
  ≈ 3 ATM.

☐ "SPRING" OF AIR AND PRESSURE.

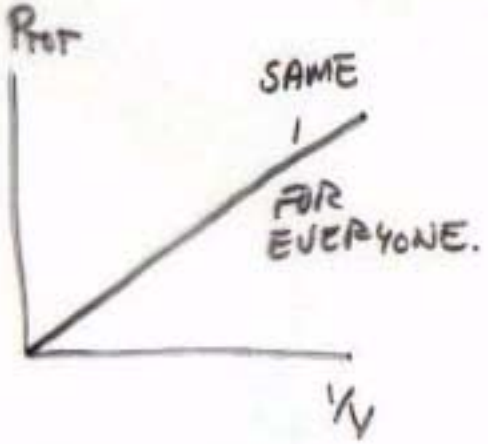
AIR "SPRINGS" BACK THROUGH A CONSTANT PROCESS OF COLLISION.

☐ BOYLE'S LAW THAT YOU FOUND OUT, TOO

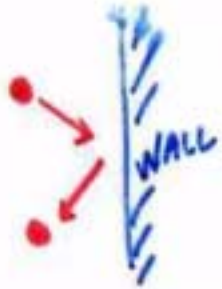
$PV = \text{CONST}$ - IF N DOESN'T CHANGE AND T DOESN'T CHANGE.

$P_{TOT} \cdot V =$ CONST.

HEIGHT	H·A = VOL	$\frac{1}{VOL}$	P_{GAUGE}	$P_{GAUGE} + P_{ATM}$
		DATA		DATA



NEWTON'S LAWS EXPLAIN THIS AT A MICROSCOPIC LEVEL.



WALL EXERTS A FORCE ON EACH AIR MOLECULE THAT BOUNCES OFF IT.

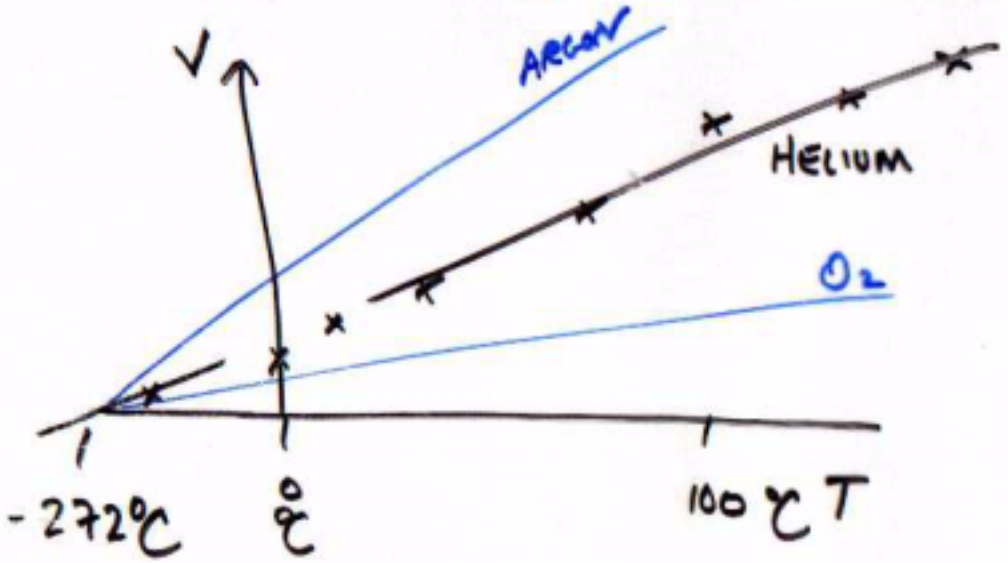
TWICE AS MANY AIR MOLECULES MEANS TWICE THE FORCE.

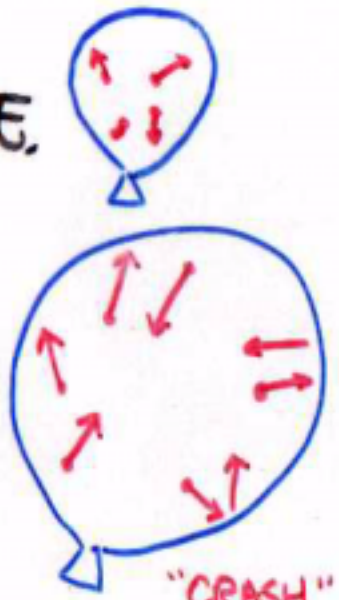
BY MAKING VOLUME SMALL, INCREASE # OF BOUNCES, ∴ PRESSURE.

☐ TEMPERATURE:

BALLOON UNDER ATMOSPHERIC PRESSURE.

INCREASE T, WHAT HAPPENS TO VOLUME?





"CRASH" INTO SIDE OF BALLOON + EXPAND IT

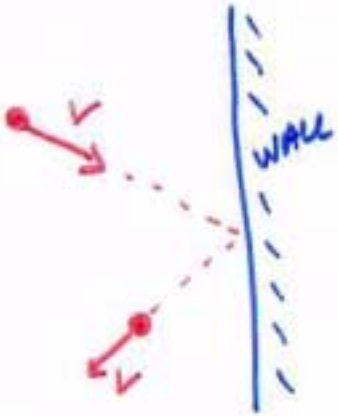
ALL EXTRAPOLATE TO $V=0$ AT $-272\,^{\circ}C$

"ABSOLUTE ZERO".

AT ABSOLUTE ZERO, MOLECULES DON'T MOVE, DON'T CRASH INTO THE WALL, BALLOON SHRINKS —

☐ TEMPERATURE

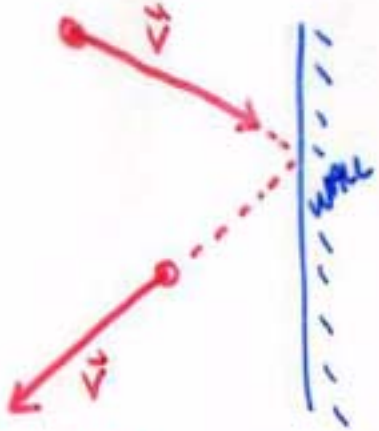
T CONTROLLS HOW FAST THE MOLECULES ZIP AROUND:



SMALL SPEED, LOW TEMPERATURE

LOW MOMENTUM / PARTICLE

→ LOW FORCE OR LOW PRESSURE



BIG SPEED, HIGH TEMPERATURE

BIG MOMENTUM, BIG FORCE, HIGH PRESSURE

MAKE THIS PRECISE WITH NEWTON'S LAWS

- "KINETIC" THEORY OF GASSES.

☐ WHAT DOES N = NUMBER OF PARTICLES DO?

INCREASE N, AND INCREASE COLLISIONS WITH THE WALL!

YOUR EXPERIMENT:

PV = CONST (WHEN N, T ARE CONSTANT)

DOUBLING N DOUBLES COLLISIONS, SO

$P = N \cdot$ CONST (WITH V, T CONSTANT)

DOUBLING T DOUBLES MOMENTUM / PARTICAL

$P = T \cdot$ CONST (WITH N, V CONST)

ALL TOGETHER $\boxed{PV = kNT}$ — LAW OF IDEAL GASSES