☐ VELOCITY, ACCELERATION - AGAIN

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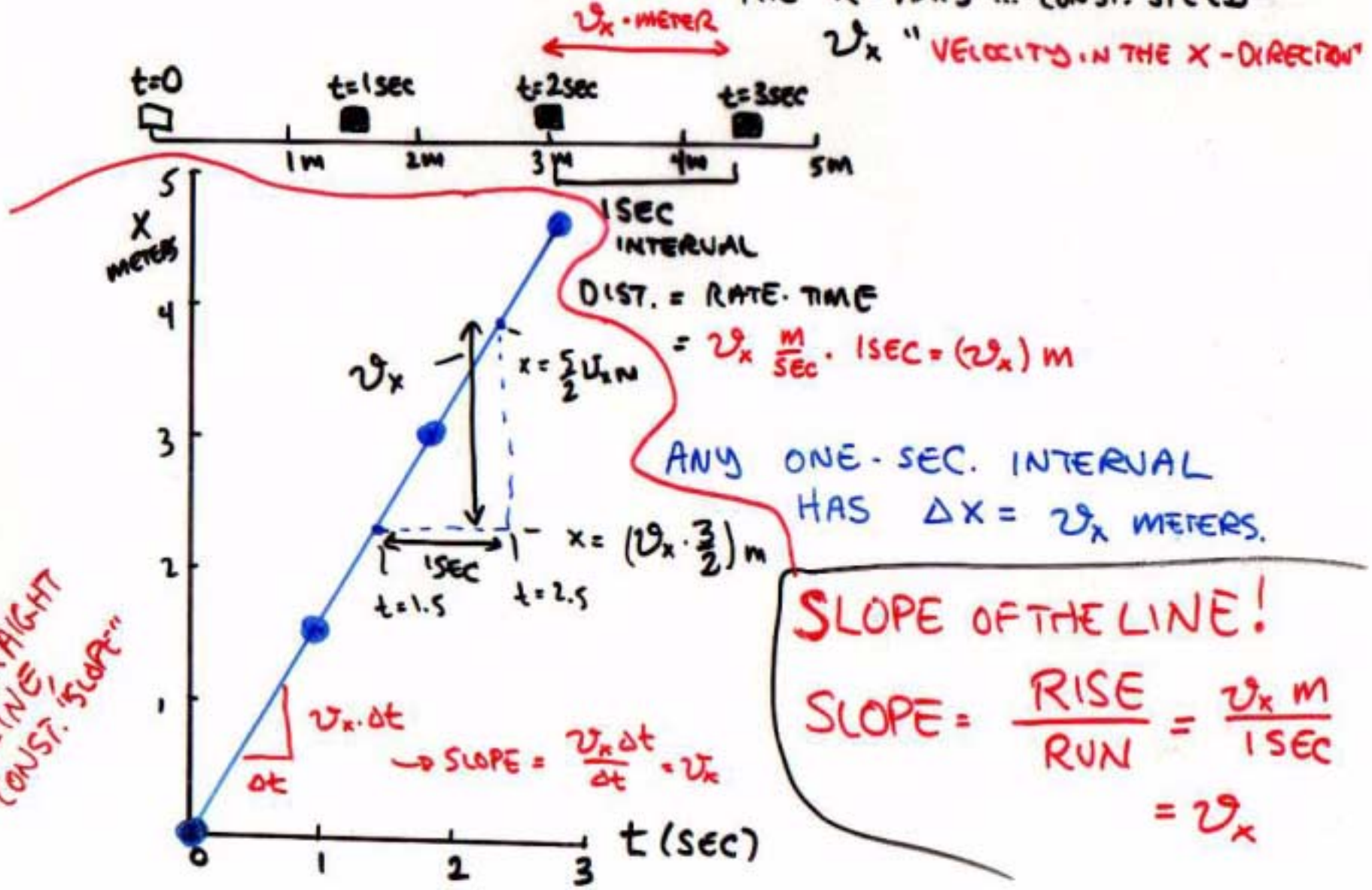
☐ ① (CONT. $\vec{a}=0$); $\vec{v}$ DOESN'T CHANGE

SUPPOSE $\vec{v} = (v_x, 0)\ \frac{m}{sec}$ ... CAR IS MOVING ON THE X-AXIS ... CONST. SPEED

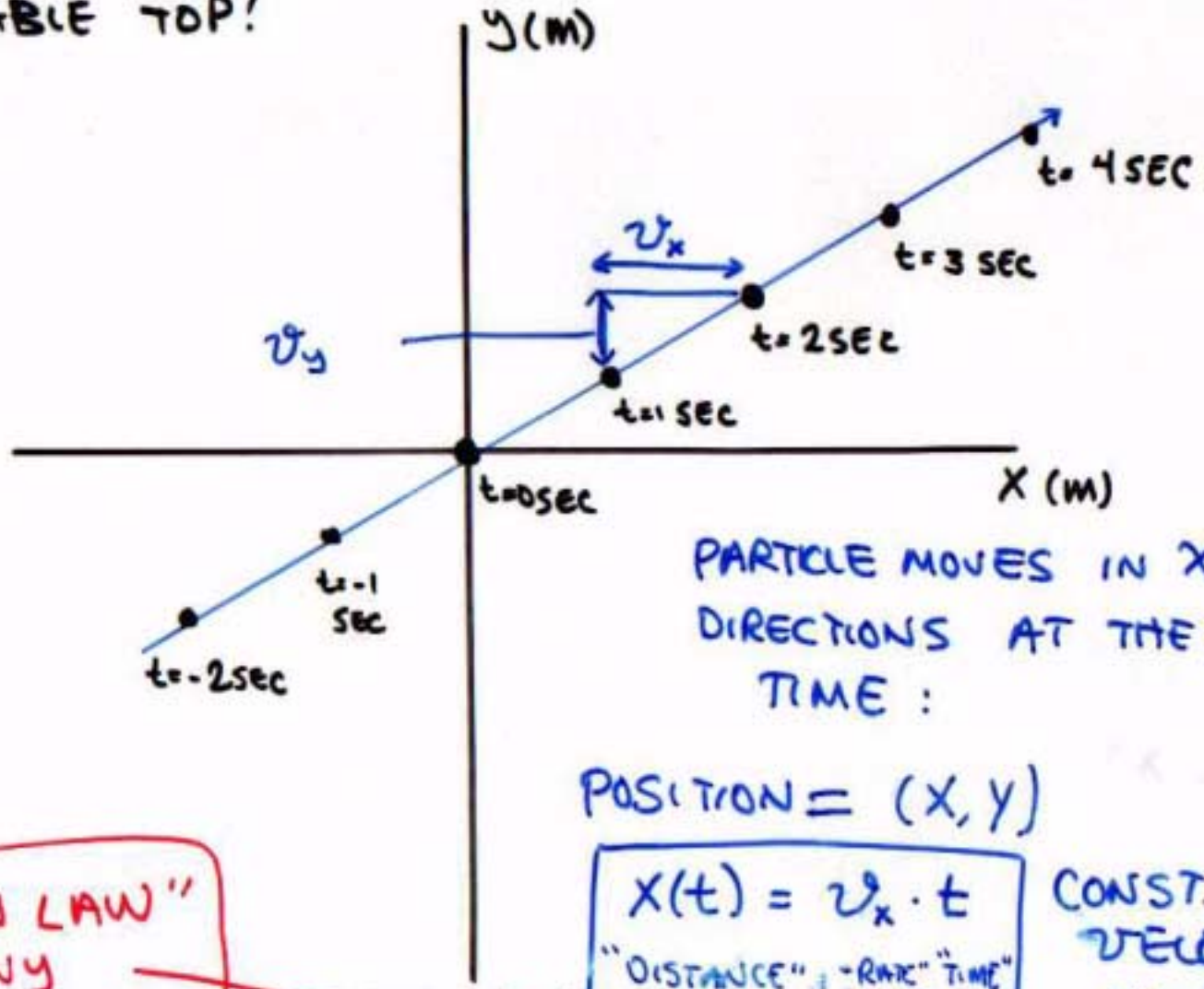
v_x "VELOCITY IN THE X-DIRECTION"



☐ No accel. at all $\vec{a}=0$ ① cont.

$\vec{v}$ can point in <u>any</u> direction. $\vec{v}=(v_x, v_y)$

TABLE TOP!



PARTICLE MOVES IN X AND Y DIRECTIONS AT THE SAME TIME:

POSITION = (X, Y)

"MOTION LAW" FOR ANY OBJECT WITH $\vec{a}=0$

$$X(t) = v_x \cdot t$$

"DISTANCE" "RATE" "TIME"

$$Y(t) = v_y \cdot t$$

CONST. VELOCITY IN 2 DIMENSIONS

☐ WHAT IS "NATURAL" MOTION OF A "HANDS-OFF" OBJECT?

ONE IDEA: STATIONARY DOESN'T MOVE AT ALL.

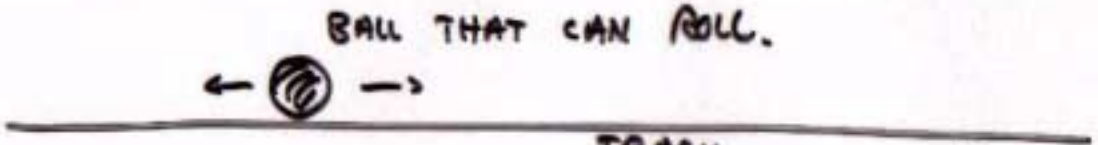
↖ BUT, FRICTION PUSHES THE BLOCK — IT ISN'T "HANDS OFF" THE EARTH IS RUBBING IT.

THINK ABOUT ELIMINATING FRICTION...

- ESSENTIALLY AN EXPERIMENTAL QUESTION
  - REDUCE FRICTION // OIL, BED OF AIR, MAGNETIC LEVITATION
  + FIND OUT WHAT HAPPENS.
- THINKING ABOUT IT (GALILEO) GUIDES EXP?. - STILL HAVE TO DO IT.

☐ THINKING... GALILEO.

- LITTLE FRICTION
- DON'T WANT GRAVITY TO INTRUDE



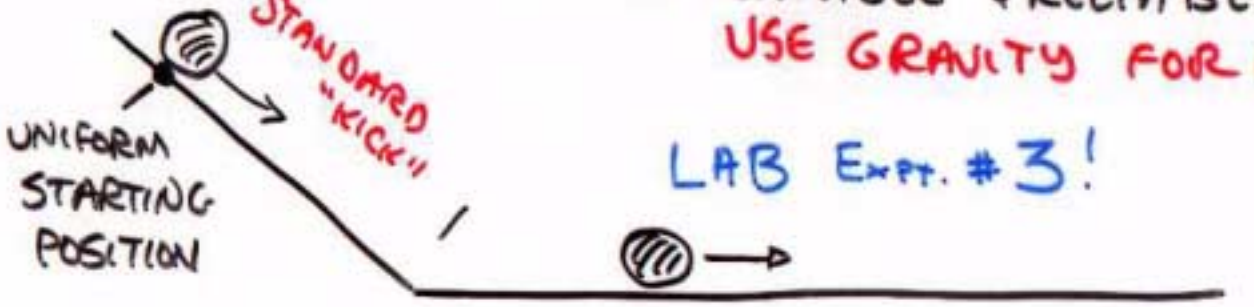
LEVEL... GRAVITY WON'T MOVE THE BALL.

FRICTIONLESS... THE TRACK WON'T "RUB" THE BALL.

LONG, LEVEL, FRICTIONLESS
- APPROXIMATE THIS IN THE LAB -

STANDARD WAY TO GET BALL MOVING
- REPEATABLE + RELIABLE.

USE GRAVITY FOR PART OF THE TRACK.

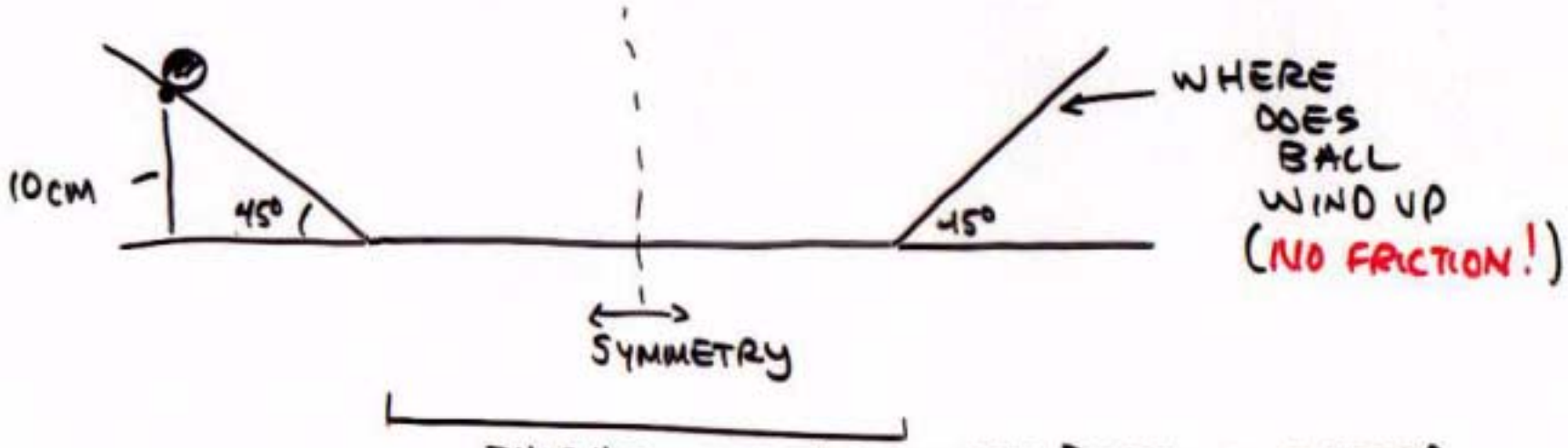


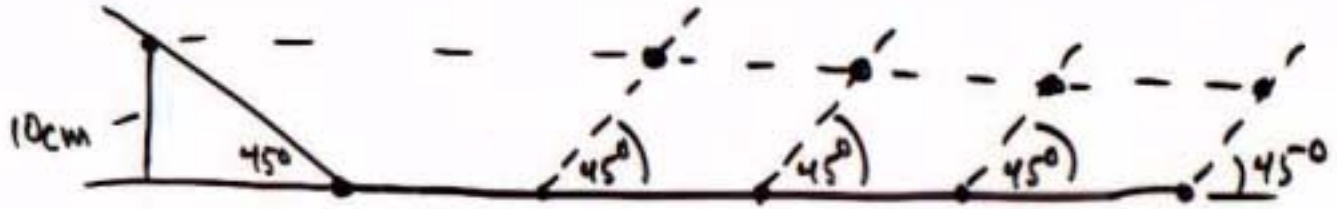
LAB EXPT. #3!

POSSIBLE WAY TO GET AT "NATURAL" MOTION.

☐ THINK A BIT MORE... BEFORE TRY IT.

CAN'T MAKE AN INFINITE TRACK... HAVE TO STOP IT SOMEHOW. ... ANOTHER RAMP.



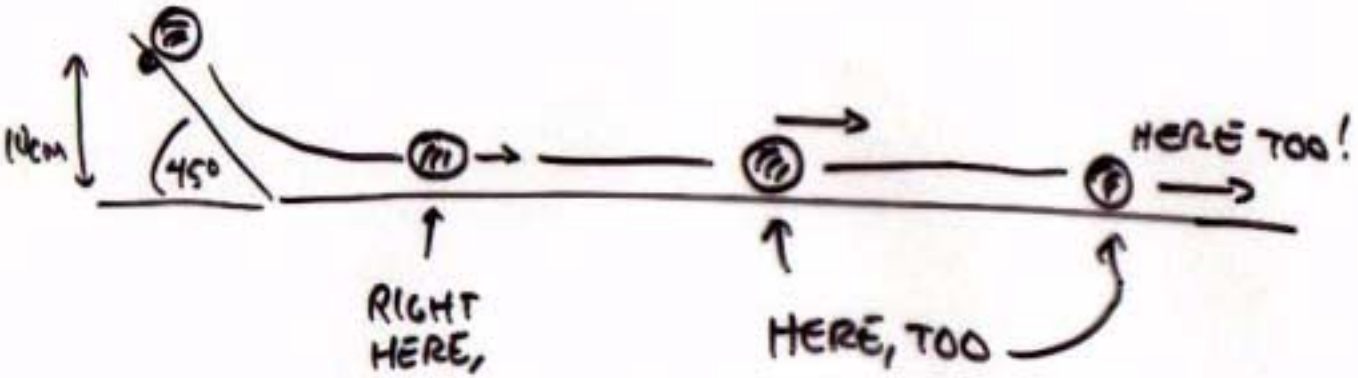


GOING UP A 45° RAMP IS EXACTLY THE REVERSE OF GOING DOWN!

THE MOTION-IN BETWEEN- IS DETERMINED BY THE INITIAL RAMP — NOT THE FLAT PART!

☐ CAN'T REALLY DO THIS ... BUT WHAT IF —

THERE WERE NO SECOND RAMP?

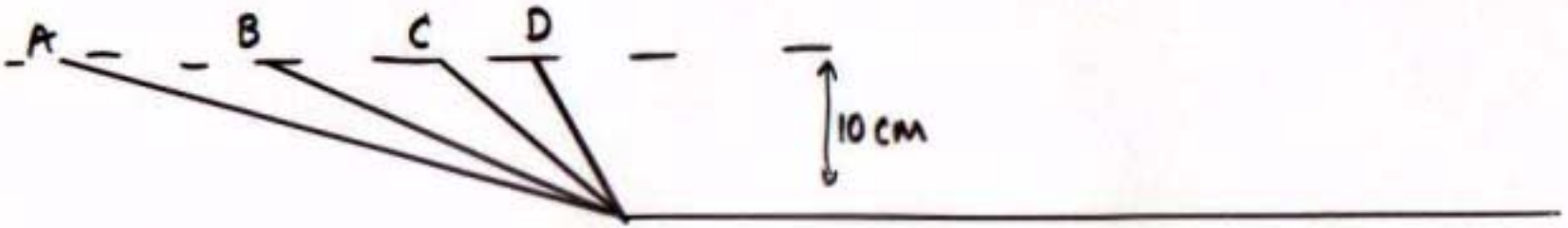


BALL HAS EXACTLY ENOUGH -UMPH- TO GET UP THE 45° SLOPE TO 10 cm.

STILL HAS TO BE CHECKED!

A GUESS FOR NATURAL MOTION: MOTION ON A STRAIGHT LINE, WITH CONSTANT SPEED ... $\overrightarrow{\text{VELOCITY}}$.

ONE OTHER THING... 45° ISN'T SPECIAL!



YOU CAN ROLL A BALL DOWN ANY OF THE TRACKS

A B C D – AND GET EXACTLY SAME SPEED

A: SHALLOW

D: STEEP

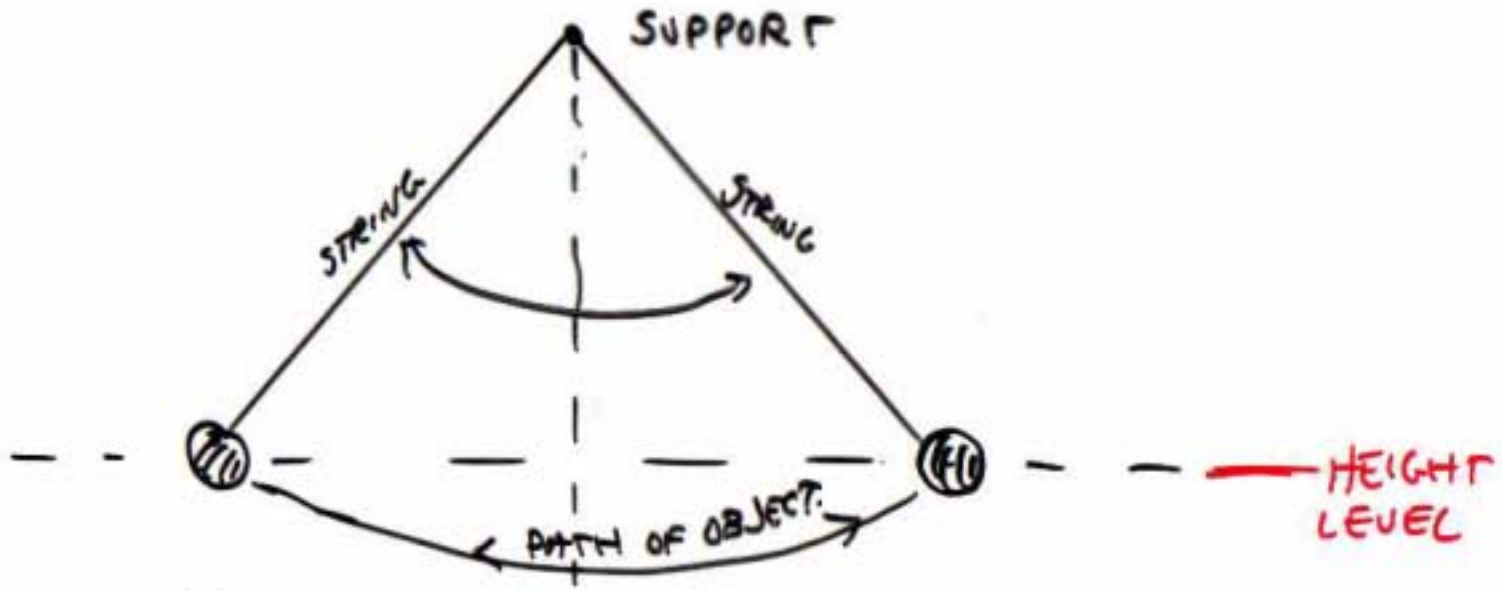
IMPORTANT CLUE THAT NEWTON WILL USE (+THOSE AFTER HIM)

YOU CAN GO UP AS HIGH AS YOU WENT DOWN.

GOING UP ... + DOWN HAD A NICE

REAL-LIVE EXPERIMENT TO BACK IT UP.

WEIGHTS ON STRINGS:



SHOULD SWING FROM SIDE TO SIDE,

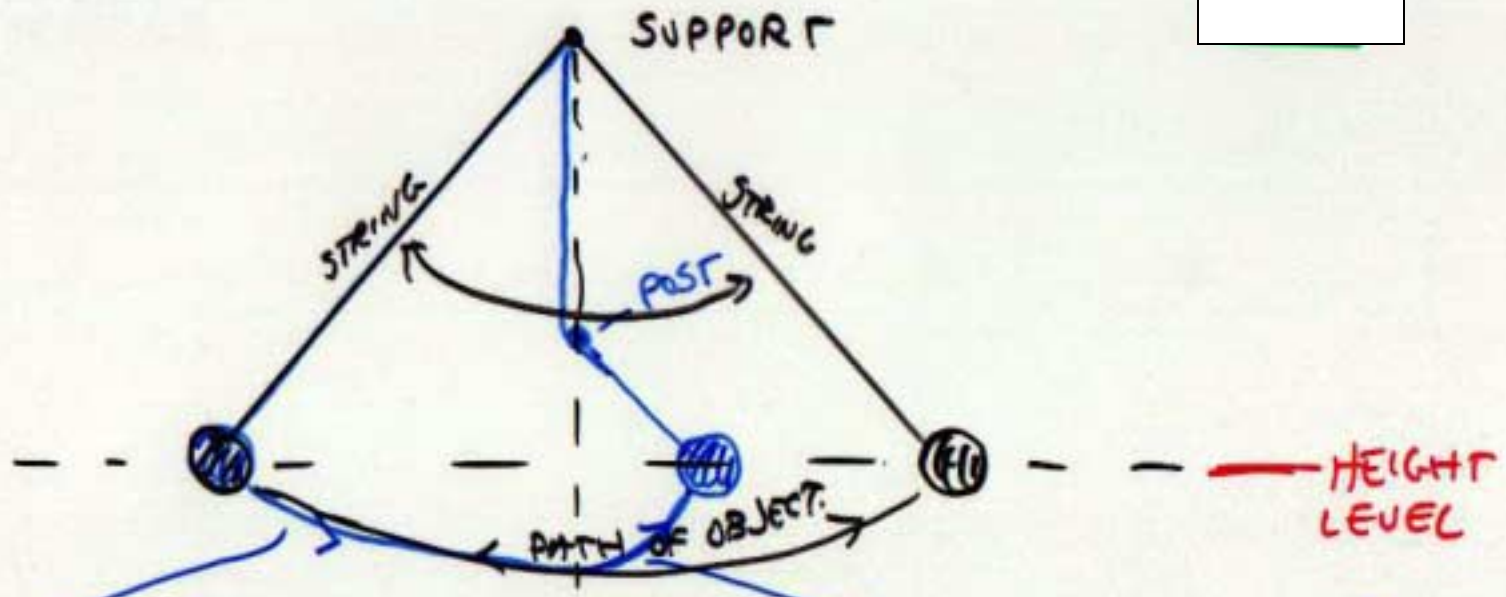
COME BACK TO SAME HEIGHT LEVEL

PUT AN OBSTRUCTION IN ...

GOING UP ... + DOWN HAD A NICE
REAL-LIVE EXPERIMENT TO BACK IT UP.

WEIGHTS ON STRINGS:

9-6



SHOULD SWING FROM SIDE TO SIDE,
COME BACK TO SAME HEIGHT LEVEL

SHALLOW PART OF PATH

STEEP.

BUT SAME HEIGHT.

PUT AN OBSTRUCTION IN ...

— VERY LOW FRICTION ... LETS TRY IT

☐ THINGS TO CHECK

- DOES THE UNRESTRICTED PENDULUM COME BACK TO SAME HEIGHT?
- PUT IN A CROSS-BAR: STILL WORK?
- DOES THE POSITION OF THE CROSSBAR MATTER?

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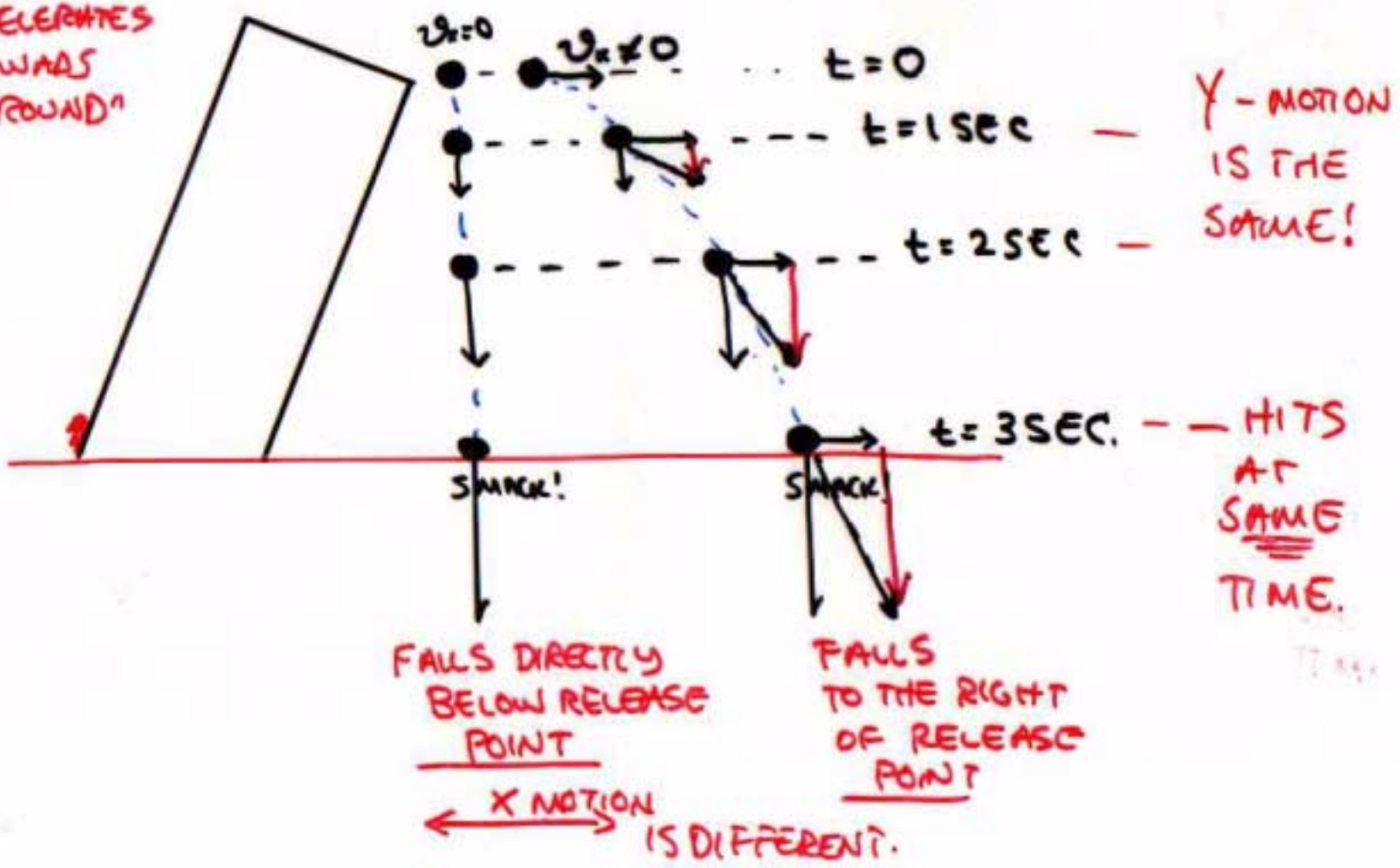
☐ ACCEL CONST. ② ... CONT.

WHAT HAPPENS TO v_x?

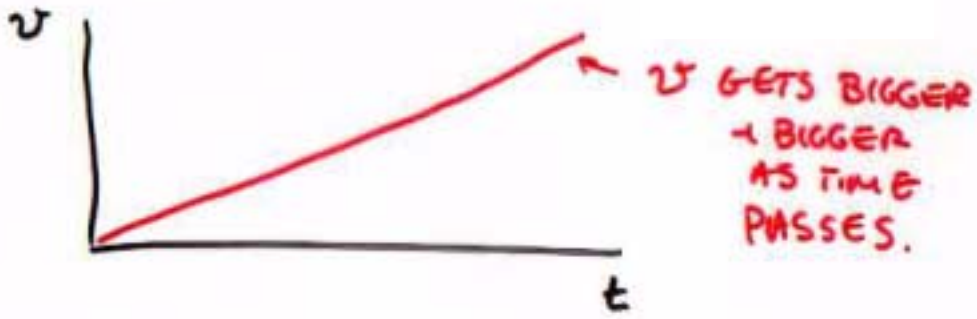
DOESN'T ACCELERATE ALONG GROUND!

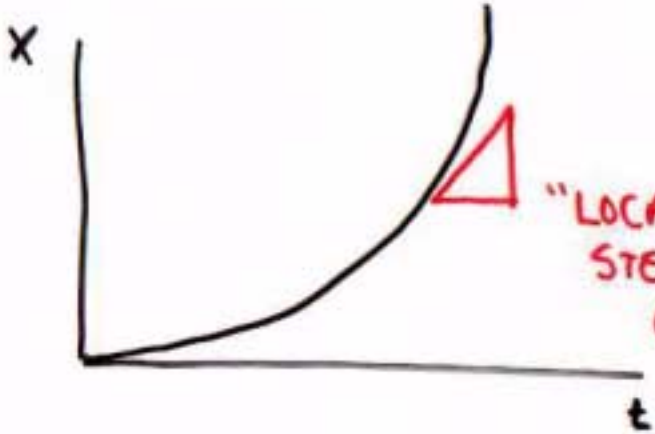
$$v_y = a_y \cdot t \qquad v_x = \text{CONST.}$$

"ACCELERATES TOWARDS GROUND"



☐ CONSTANT ACCELERATION:





X-VS-T IS NOT A STRAIGHT LINE; CURVES UP.

CONSTANT ACCELERATION - DOWNWARDS

CONSTANT RATE OF CHANGE IN $\vec{v}$.

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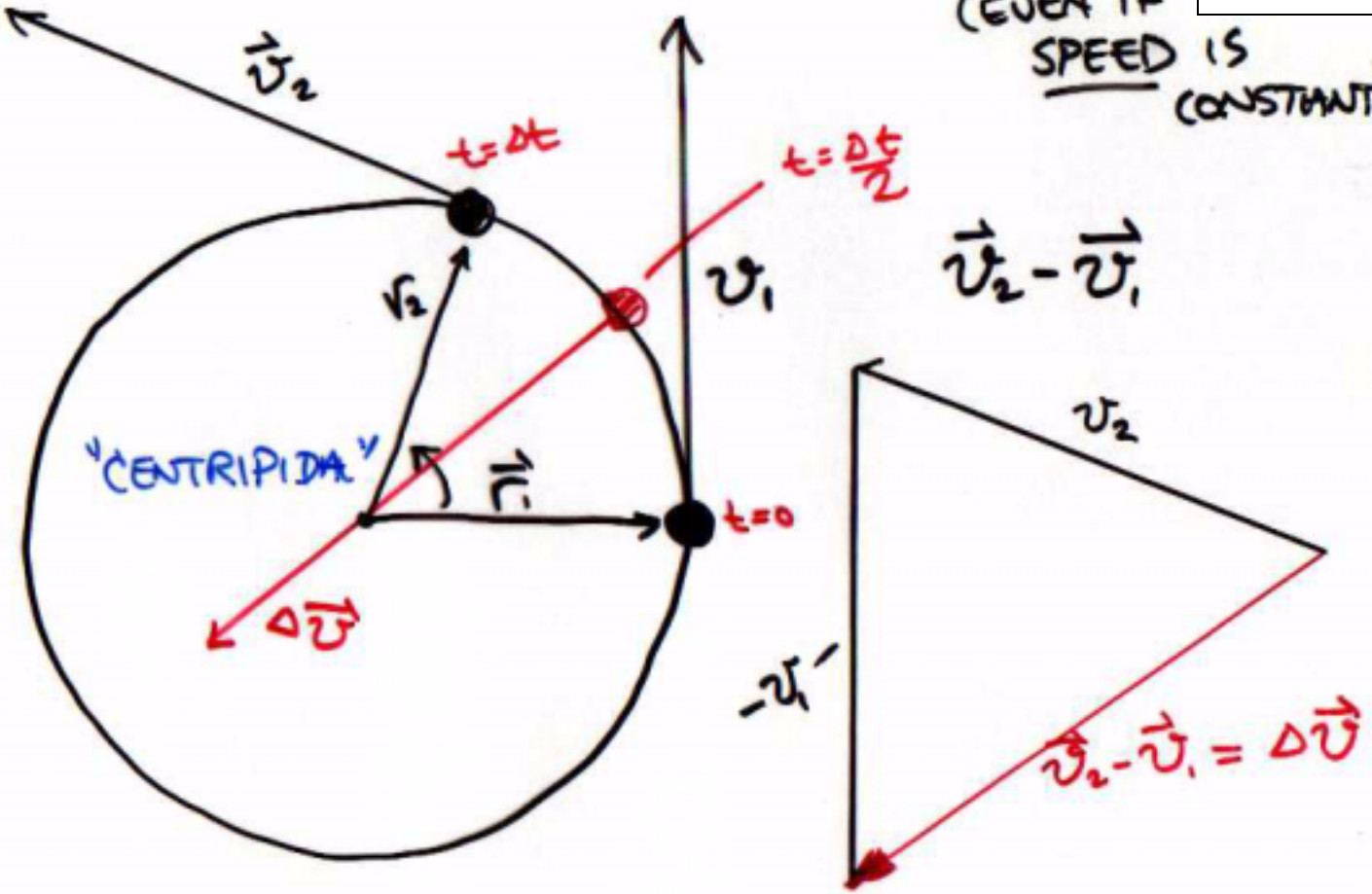
☐ CIRCULAR MOTION (3) MOTION ACCELERATES. (EVEN IF SPEED IS CONSTANT).



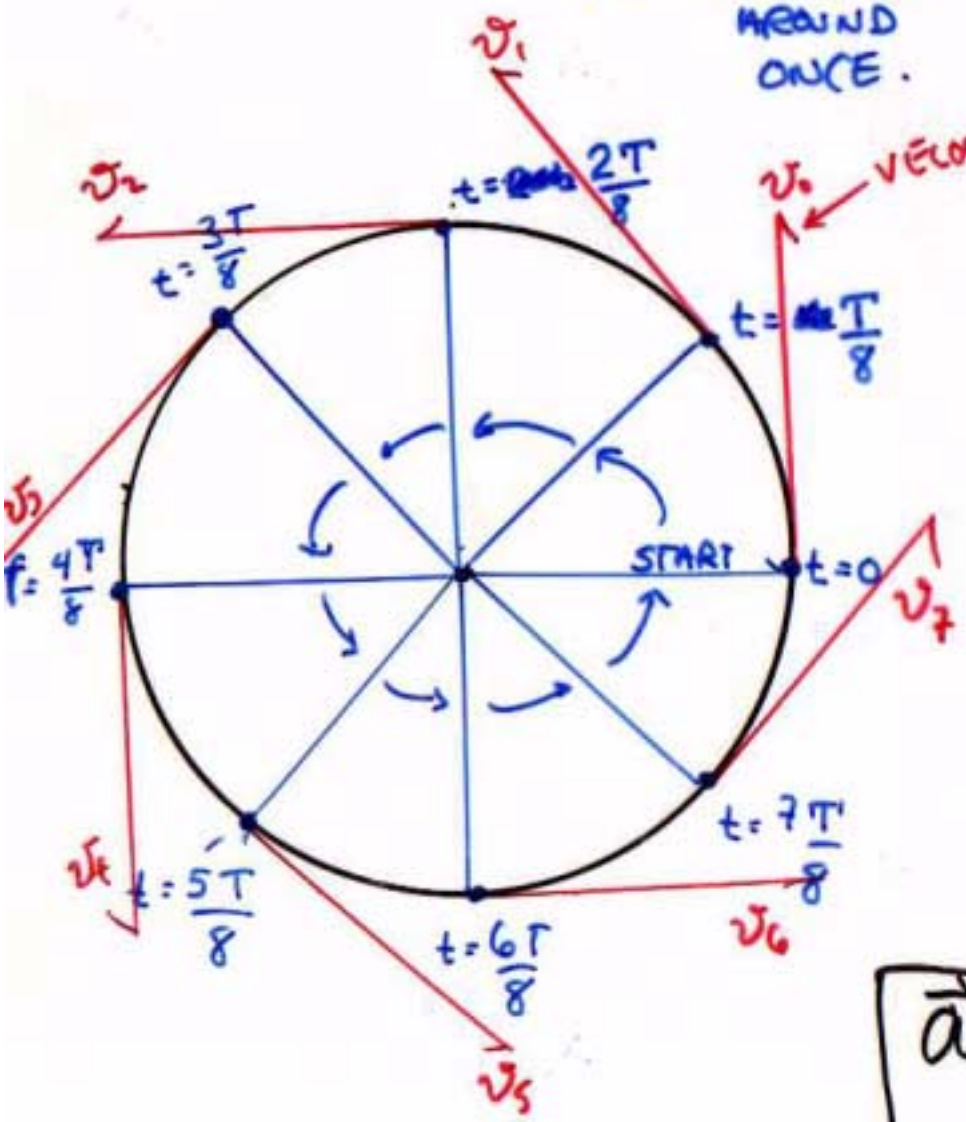
"CHANGE IN VELOCITY"

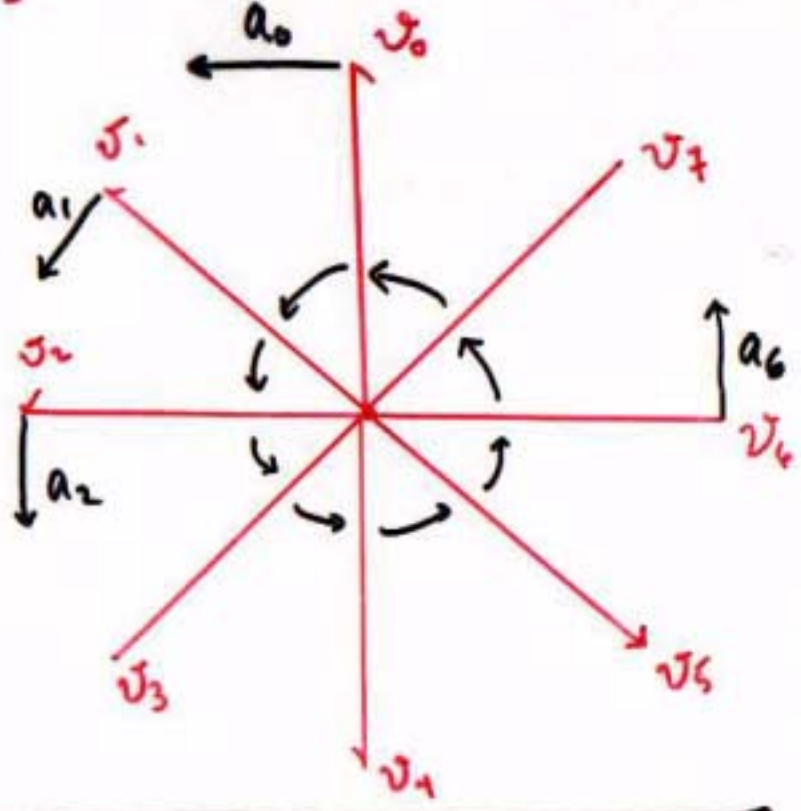
= ACCEL. VECTOR IS TOWARDS CENTER OF CIRCLE

☐ CIRCULAR ACCEL.

T = TIME TO GO AROUND ONCE.

$\vec{v}$ IS TANGENT TO CIRCLE





$\vec{a}$ POINTS TOWARD CENTER OF CIRCLE

MAGNITUDE OF CENTRAL ACCEL:

$$|\vec{a}| = \frac{v^2}{R}$$

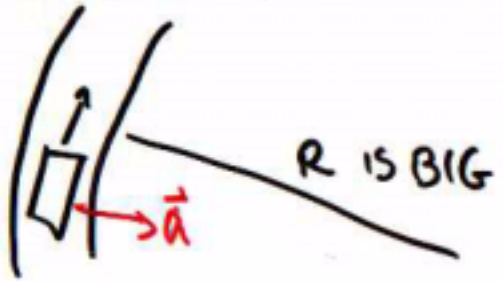
- v – SPEED AROUND CIRCLE
- R – RADIUS OF CIRCLE...

VERY IMPORTANT FOR NEWTON'S EXPLANATION OF KEPLER'S LAWS!

THINK OF A TIGHT TURN

$a = \frac{v^2}{R}$ ... v GOES DOWN, SO DOES a – AND YOU DON'T SKID!

WIDE TURN (ON FREEWAY)



$a = \frac{v^2}{R}$

MAKE R BIG, AND YOU DON'T HAVE TO SLOW DOWN.