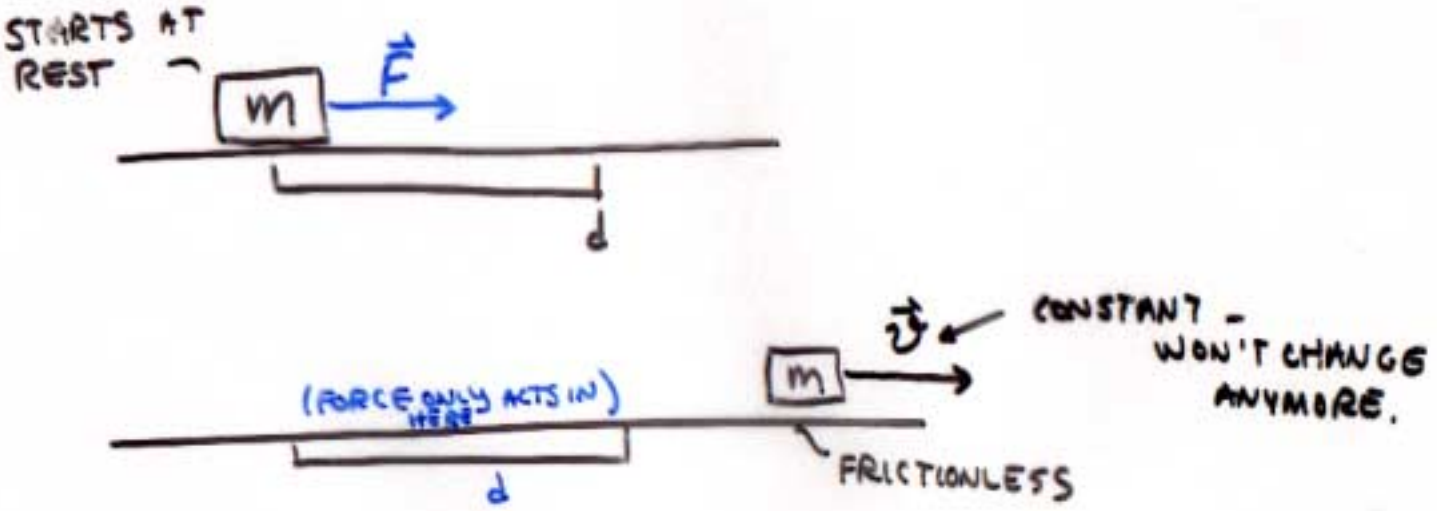
Kinetic Energy

Any object in motion has Kinetic energy.
"moving"

Let a Force: $\vec{F}$ act along a distance d for a body of mass m



Kinetic Energy = $\frac{1}{2} m v^2$

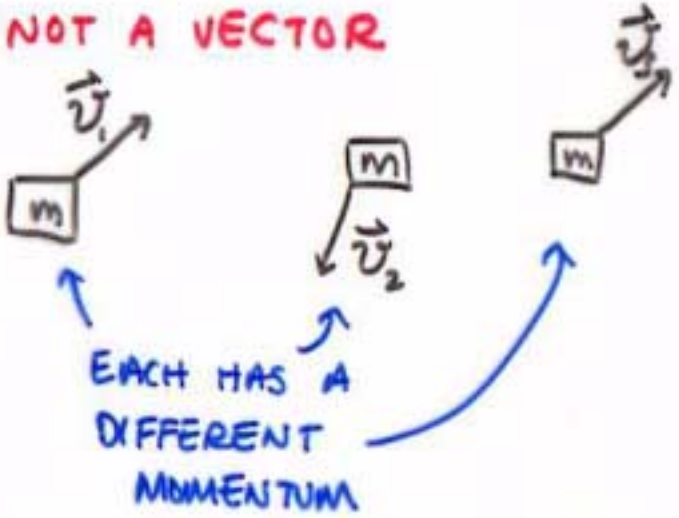
Work Done By Force = $F \cdot d$

Force "does work" on the mass - + gives it kinetic energy

$F \cdot d = \frac{1}{2} m v^2$

☐ WHAT'S SO GOOD ABOUT KINETIC ENERGY?

- IT IS **NOT A VECTOR**



IF LENGTH OF
$v_1 = v_2 = v_3$
(ALL SAME SPEED)
THEN EACH HAS
THE SAME K.E.

- DEPENDS ON v^2 SQUARE OF THE VELOCITY

- DEFINED THIS WAY, IT IS A **TYPE OF ENERGY**
  AND GOES INTO A **CONSERVATION LAW.**

$$KE = \frac{1}{2}mv^2$$

"VISIBLE" ENERGY

- EASY TO MEASURE + KEEP TRACK OF.

☐ Types of Energy

All energy is measured with the units of: Joule "J"

$$\frac{1}{2} m v^2 = Kg \frac{METER}{SEC} \cdot \frac{METER}{SEC} = \left(Kg \frac{METER}{SEC \cdot SEC}\right) \cdot METER$$

$$= NEWTON \cdot METER$$

"Force through a distance"

Kinetic Energy

$\frac{1}{2} m v^2$

- Visible in motion of objects

Potential Energy

"Hidden" "Stored"

Can spring out

*Cause a motion

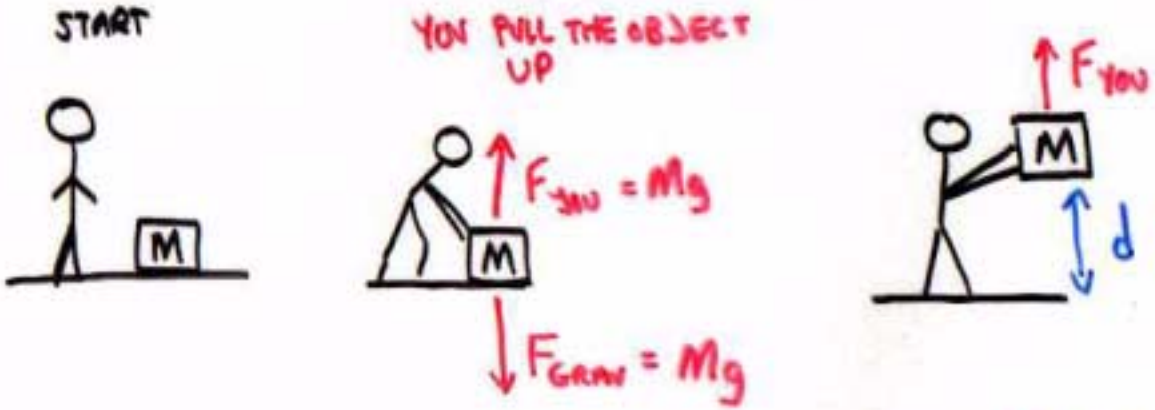
- Gravity
- Electricity

] Just 2 types of these (we know of!)

"WORK" IS A FORCE ACTING THROUGH A DISTANCE

"MOMENTUM IS A FORCE ACTING THROUGH A TIME" IS DIFFERENT.

THE "FORCE" IS SUPPLIED BY THE STORE OF ENERGY ... POTENTIAL.



YOU DID WORK: $F_{YOU} \cdot d = Mgd$.

$M = 1\,kg \quad d = 1m \quad g = 10 \frac{M}{S^2}$

WORK = $1kg \cdot 10\frac{M}{S^2} \cdot 1m = 10$ JOULE

(COMPARE ... CHEMICAL FOOD ENERGY CALORIE = 4,000 JOULE)

☐ IN LIFTING THE OBJECT

I DID WORK + GAVE THE OBJECT POTENTIAL ENERGY?

- HOW MUCH ENERGY IS INVOLVED?

ALL THE WORK I DID GOES INTO POTENTIAL ENERGY:

$$\text{WORK} = (Mg)d = \text{POTENTIAL ENERGY}.$$

IF YOU RAISE AN OBJECT OF MASS M A DISTANCE d UPWARDS!

YOU HAVE GIVEN IT

GRAVITATIONAL POTENTIAL ENERGY

$$P.E. = Mgd$$

NOW DROP THE OBJECT! P.E. TURNS BACK INTO KINETIC ENERGY

☐ Conservation of Mechanical Energy

Specialize to a system without friction. – No "external" influences

E_{TOTAL} = K.E. + P.E. Never changes.

Galileo's inclined planes:

Drop "from rest"

At point A:

$$E_{TOTAL} = \underbrace{\tfrac{1}{2}mv^2}_{v=0} + m \cdot g \cdot (30cm) = m \cdot 10 \frac{meter}{sec^2} \cdot \frac{1}{3} meter \cdot 3.3\, m \cdot \frac{meter^2}{sec^2}$$

At point B: $E_{TOTAL} = \tfrac{1}{2} m V_B^2 + m \cdot g \cdot 0 = \tfrac{1}{2} m V_B^2 = 3.3\, m \frac{meter^2}{sec^2} \rightarrow V_B =$

$E_{TOT\ AT\ B}$ $E_{TOT\ AT\ A}$

☐ Galileo's Inclined Planes (cont.)

Conservation of Energy means

E_{TOT} at start = E_{TOT} at bottom of ramp.

$3.3 \, M \, \frac{\text{meter}^2}{\text{sec}^2} = \frac{1}{2} M \, V_B^2$

(M cancels)

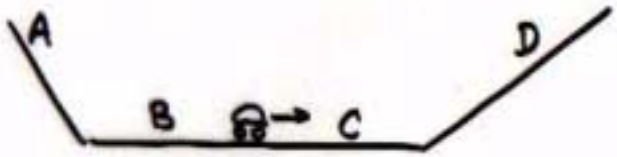
or $6.6 \, \frac{\text{meter}^2}{\text{sec}^2} = V_B^2$ or $V_B = \boxed{2.6 \, \frac{\text{meter}}{\text{sec}}}$

How does this compare to your experiment?!?

Without friction,

Conservation of Energy means

$E_{TOT\,A} = E_{TOT\,B} = E_{TOT\,C}$



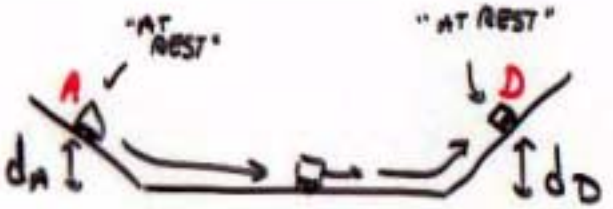
$E_{TOT\ AT\ B} = \frac{1}{2} M V_B^2 + mg \cdot 0 = \frac{1}{2} M V_C^2 + mg \cdot 0 = E_{TOT\ AT\ C}$

or $\boxed{V_B = V_C}$ — straight-line motion, constant speed — Galileo.

☐ GALILEO'S INCLINED PLANES (END)

CONSERVATION:

$E_{TOT\ AT\ A} = E_{TOT\ AT\ D}$



KINETIC AT A + POTENTIAL AT A = KINETIC AT D + POTENTIAL AT D

$\frac{1}{2}m\cancel{v_A^2} + mgd_A = \frac{1}{2}m\cancel{v_0^2} + mgd_D$

$v_A = 0!$ $\quad$ $v_0 = 0!$

$$mgd_A = mgd_D$$

$$\boxed{d_A = d_D}$$

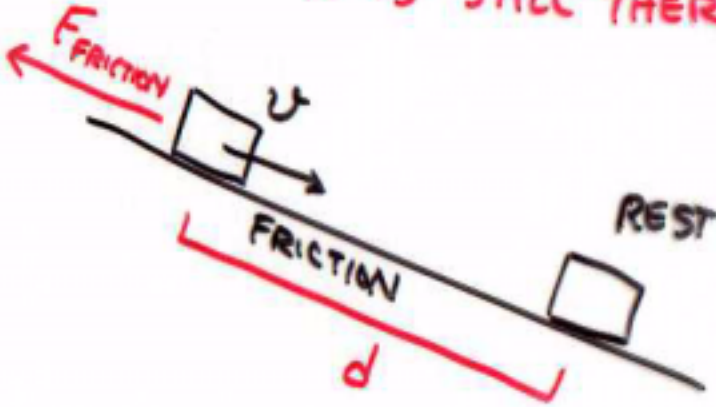
ENERGY CONSERVATION CAUSES THE CART TO GO UP EQUAL HEIGHTS ON EACH SIDE OF THE TRACK!

JUST AS GALILEO SAID. – WORKS THE SAME FOR PENDULUM EXPERIMENT.

☐ WORK DONE BY FRICTION GOES AWAY (NOT INTO KINETIC OR POTENTIAL)

IT IS NOT STORED, CAN'T BE RECALLED, BUT

IT IS STILL THERE



WORK = $F_{FRICTION} \cdot d$

"TAKES KINETIC ENERGY AND PUTS IT INTO HEAT"

↑

NOT RECOVERABLE

(BUT IT IS MEASUREABLE).

"MECHANICAL" ENERGY NOT CONSERVED W/ FRICTION PRESENT.

E_{TOTAL} = "HEAT" + KINETIC + POTENTIAL

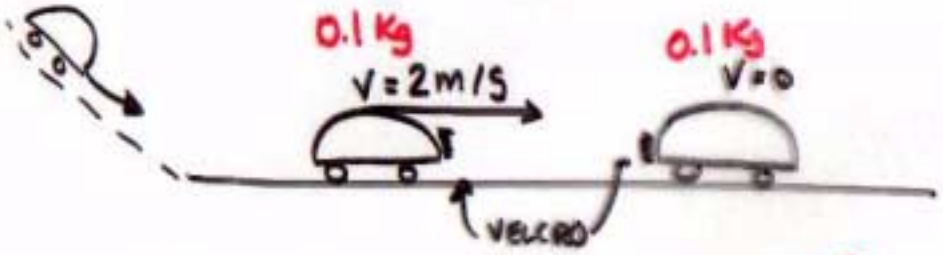
IS CONSERVED

12-19

COLLISION ON A HOT WHEELS TRACK

EXPERIMENT LAST WEEK:

WAS **MOMENTUM** CONSERVED IN THE COLLISION?



COLLIDE AND STICK.

$$\vec{P}_{INITIAL} = M_1 \cdot V_1 + M_2 \cdot V_2 \;(=0) = +0.1\,Kg \cdot 2\,\frac{m}{s} = 0.2\,\frac{Kg\,m}{s}$$

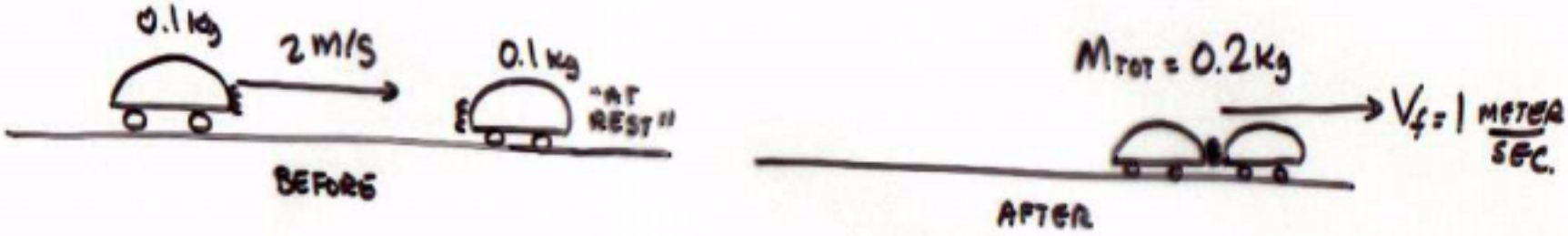
$$\vec{P}_{FINAL} = (M_1 + M_2) \cdot V_F$$

CONSERVATION OF MOMENTUM →

$$P_{INITIAL} = P_{FINAL} \rightarrow 0.2\,\frac{Kg\,m}{s} = (0.1\,Kg + 0.1\,Kg) \cdot V_F = 0.2\,Kg\,V_F$$

OR, $V_F = 0.2\,\frac{Kg\,m}{s}\,\frac{1}{0.2\,Kg} = 1\,\frac{m}{s}$ – DID IT HAPPEN?

What about Energy?



Only kinetic energy (since track is flat!)

$$E_{TOT}^{INITIAL} = \frac{1}{2} m_1 V_1^2 + \frac{1}{2} m_2 V_2^2 = \frac{1}{2}(0.1\,kg)\cdot\left(2\,\frac{m}{s}\right)^2 + \frac{1}{2}(0.1\,kg)\cdot\left(0.0\,\frac{m}{s}\right)^2$$

$$E_{TOT}^{INITIAL} = \frac{1}{2}\cdot 0.1\,kg\cdot 4\,\frac{meter^2}{sec^2} + 0 = 0.1\times\frac{4}{2}\,\frac{kg\,m^2}{s^2}$$

$$= \boxed{0.2\ Joule}$$

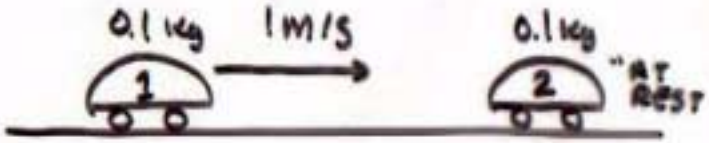
$$E_{TOT}^{FINAL} = \frac{1}{2}(0.1\,kg + 0.1\,kg)\cdot\left(1\,\frac{meter}{sec}\right)^2 = \frac{1}{2}\cdot 0.2\,kg\cdot\frac{1\,meter^2}{sec^2}$$

$$= \frac{1}{2}\cdot 0.2\,\frac{kg\,m^2}{s^2} = 0.1\,\frac{kg\,m^2}{s^2} = \boxed{0.1\ Joule}$$

Half of the energy is Gone. – It went into internal motion of molecules inside car... can be measured!

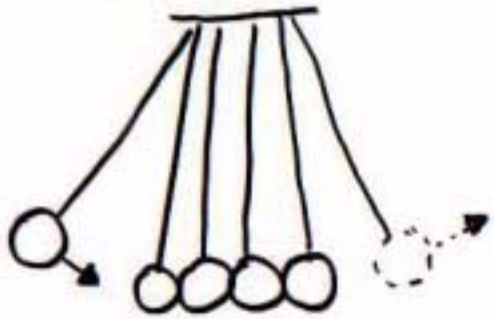
☐ "ELASTIC" COLLISIONS MEAN BOTH ENERGY AND MOMENTUM ARE CONSERVED.

EXAMPLE:



BEFORE

DURING



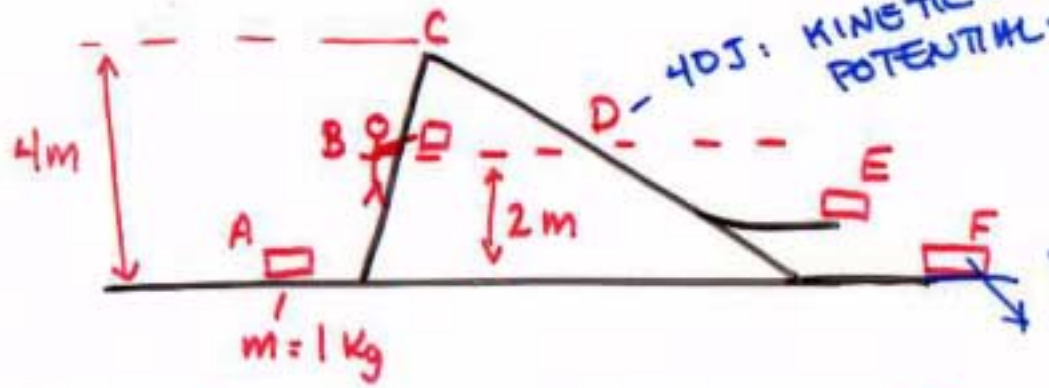
WHEN 2 BODIES - OF SAME MASS - COLLIDE IN A LINE...

TRADE THE ENERGY + MOMENTUM.

CONSERVES BOTH $(M_1V_1 + M_2V_2)$

AND $(\frac{1}{2}M_1V_1^2 + \frac{1}{2}M_2V_2^2)$

☐ EXAMPLE PROBLEM # 14 - CHAPTER 12



40J: KINETIC = ? = 20J
POTENTIAL = ?

$mgh = 1\,kg \cdot 10\frac{M}{S} \cdot 2M = 20J$

$E_{TOT} = 40J$ KINETIC = ? 40J
POTENTIAL = ? 0J

a) 1. HOW MUCH WORK TO LIFT BRICK TO C?

UPWARD FORCE = Mg = 10 NEWTON. DISTANCE = 4 METER

WORK = FORCE · DISTANCE(UP!) = 10N · 4m = 40 JOULE - THIS WORK IS STORED.

2. FORCE APPLIED ONLY COUNTS WHEN DISTANCE COVERED IS ALONG FORCE.

b) 1) $E_{TOT}^{C} = \frac{1}{2} m V_C^2 + mg \cdot d_C$ - BRICK IS AT REST, SO $V_C = 0$

$= \frac{1}{2} m \cdot 0^2 + mg \cdot 4\,METER = 1kg \cdot 10\frac{M}{S^2} \cdot 4m =$ **40 JOULE**

2) E_{TOT}^{D} = 40 JOULES, SAME AS C). - ENERGY CHANGES HANDS BETWEEN KINETIC + POTENTIAL, BUT SUM IS SAME

3) AT E, STILL E_{TOT}^{E} = 40 JOULES.

c) WHAT IS ORIGINAL SOURCE OF K.E. AT F - JUST BEFORE HIT GROUND?
- THE LITTLE GIRL WHO DID THE WORK!

d) IS KINETIC ENERGY CONSERVED? $K.E.^{C} = \frac{1}{2} m V_C^2 = 0$ $K.E.^{F}$ = 40 JOULES

K.E. NOT CONSERVED — POTENTIAL + KINETIC ARE —