

TOPIC # 9 (cont.)
ENERGY TRANSFORMATIONS &
KINETIC ENERGY
The Law of Motion & Momentum



(and some links to GLOBAL CHANGE!)

CLASS NOTES: pp 47-50

QUOTE :

*Mathematical and
mechanical principles are
the alphabet in which
God wrote the world.*

~Robert Boyle



ANOTHER QUOTE FOR TODAY:

*“If I have seen farther
than other men,
it is by standing on the
shoulders of giants”*

Sir Isaac Newton (1642-1727)



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Stand on the shoulders of giants

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SCIENCE IS A CUMULATIVE ENTERPRISE



"IT'S OUR NEW ASSEMBLY LINE. WHEN THE PERSON AT THE END OF THE LINE HAS AN IDEA, HE PUTS IT ON THE CONVEYOR BELT, AND AS IT PASSES EACH OF US, WE MULL IT OVER AND TRY TO ADD TO IT."



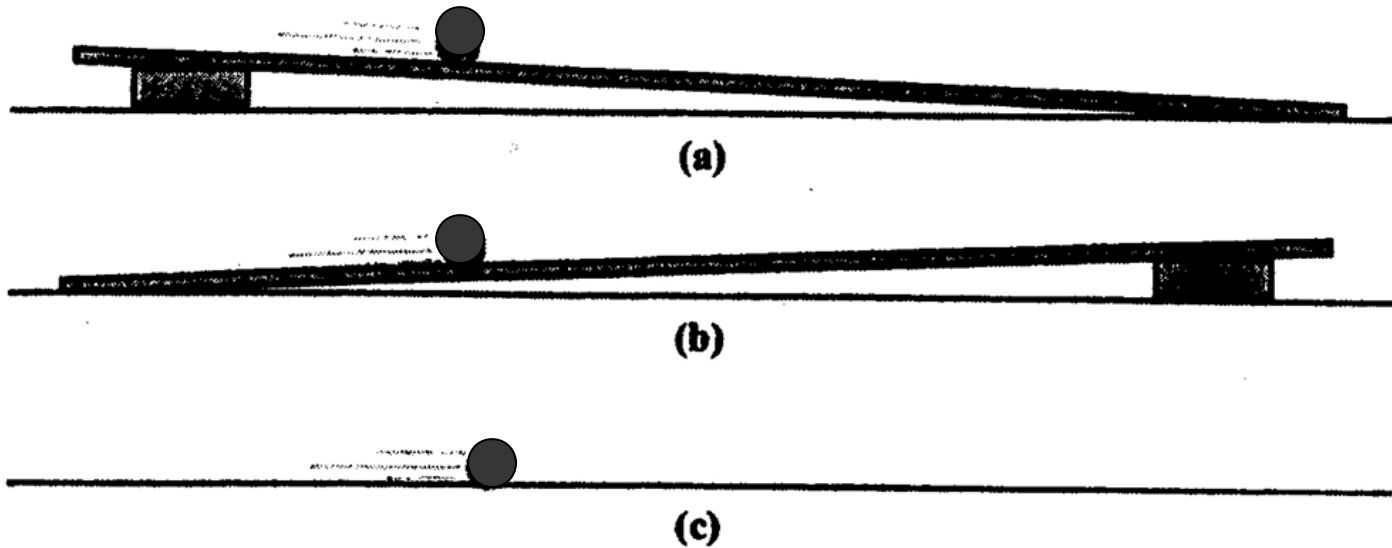
**EVER-CHANGING
NATURE OF SCIENTIFIC
KNOWLEDGE**



Galileo Galilei

(1564-1642)

- “Father of Experimental science”



Isaac Newton

(1642-1727)

Newton later expressed many of Galileo's ideas, observations and theories as formal "laws" which we know as "THE LAWS OF MOTION."



SOME DEFINITIONS WE NEED:

Force (F) = any influence that can cause a body to be accelerated.

(The common force unit is the *newton*. A force is an *action*, not a thing.)

Every force is similar to a push or a pull.

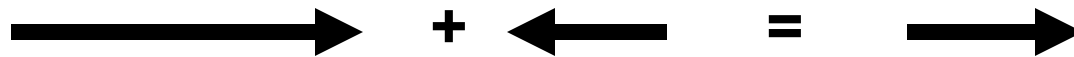
Acceleration (def) = The change that occurs in an object's speed or direction in a certain period of time.

Net force = the total, overall force on an object.

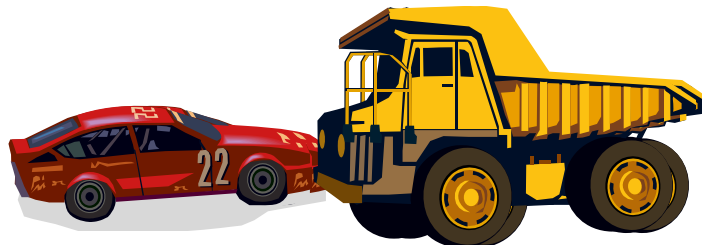
If acting in the in the SAME direction = the (vector) sum of the two forces



If acting in the OPPOSITE direction = the (vector) difference between the two forces:



Net force acts in the direction of the stronger force:



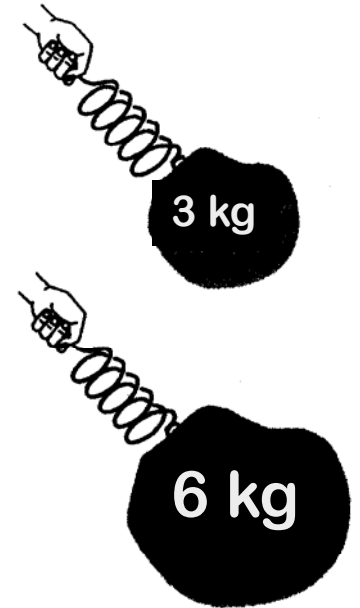
SOME DEFINITIONS WE NEED:

Inertia = The tendency of a body to resist a change in motion;

... or a body's ability to stay at rest or to maintain an unchanging velocity

(A body's INERTIA is its degree of resistance to acceleration, in other words: its MASS)

Mass = the quantity of matter in a body, a measurement of the inertia or sluggishness that a body exhibits (in absence of friction)



SOME DEFINITIONS WE NEED:

Mass vs. weight

Mass = the quantity of matter in a body, a measurement of the inertia or sluggishness that a body exhibits (in absence of friction)

Weight = The force *due to gravity* upon a body.

(More specifically: the net gravitational force exerted on it by all other bodies.)

The astronaut in space depicted at right finds it just as difficult to shake the “weightless” anvil as it would be on earth.

Q1: If the anvil is more massive than the astronaut, which shakes more:



1 = the anvil

2 = the astronaut

3 = neither shakes more than the other

ANSWER =
2 = the astronaut



WHY?

Both the anvil and astronaut are weightless, but the anvil has more MASS, hence the anvil has more inertia and shakes less.

1st Law of Motion

(Law of Inertia)

A moving object will continue moving in a straight line at a constant speed . . .

. . . and a stationary object will remain at rest . . . unless acted on by an unbalanced force.

Other ways of stating Law #1:

- Every body continues in its state of rest, or of uniform motion in a straight line, unless it is compelled to change that state by forces impressed upon it. (MH text)

or

- All bodies have inertia.

Newton's Laws in everyday life:

1st LAW =

The LAW
of
INERTIA!

REAL LIFE ADVENTURES/Gary Wise & Lance Aldrich



Every so often, Newton's Laws of Motion
rear their ugly heads.



EASY WAY of remembering the 1st Law:

The key word is "continue."

If a body is at rest, it continues to stay at rest; if moving, it continues to move in a straight line.

**It can't start or stop moving on its own without some external force, i.e.
"a body does not accelerate itself."**

2nd Law of Motion

(Newton's Law of Motion)

The acceleration (a) produced on a body by a force (F)

is proportional to:
the magnitude of the force (F)

and inversely proportional to:
the mass (m) of the object.

$$a = F / m \quad \text{or} \quad F = ma$$

2nd Law: $F = ma$

Acceleration \propto net force / mass

\propto = "is proportional to"

or

$$\mathbf{a \propto F / m}$$

$$\mathbf{a = F / m}$$

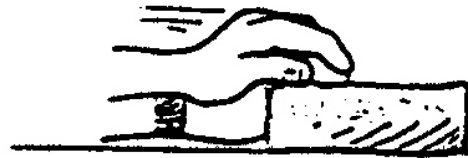
***(with appropriate units of m/s^2 for a ,
newtons for F , kilograms for m)***

$$F = ma$$

FORCE OF HAND
ACCELERATES
THE BRICK



TWICE AS MUCH FORCE
PRODUCES TWICE AS
MUCH ACCELERATION



TWICE THE FORCE ON
TWICE THE MASS GIVES
THE SAME ACCELERATION



THE SAME FORCE
ACCELERATES 2 BRICKS
AS MUCH



$$F = ma$$

Q2: Fill in both blanks

THE SAME FORCE
ACCELERATES 2 BRICKS
_____ AS MUCH



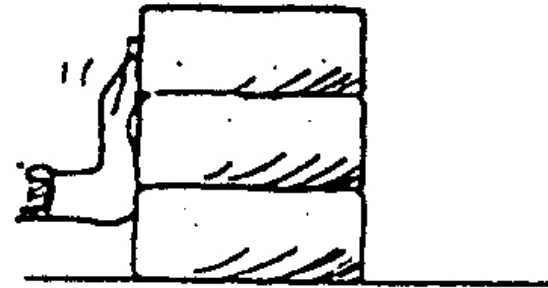
CHOICES FOR ABOVE:

A = $1/2$ ←

B = twice

C = $1/3$

3 BRICKS, _____ AS
MUCH ACCELERATION



CHOICES FOR ABOVE:

D = 3 times

E = 6 times

F = $1/3$ ←

3rd Law of Motion

(Law of Force Pairs)

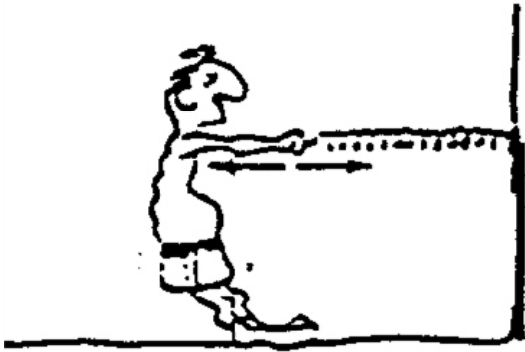
**For every action there is an equal
and opposite reaction.**

**3rd Law = “Law of
Force Pairs”**

- Forces always occur in pairs;
an action and a reaction.

To every action force there is an equal and opposite reaction force;

- whenever one body exerts a force on a second body, the second body exerts an equal and opposite force on the first body.
- The two forces are equal in strength but opposite in direction. There is never only a single force in any situation.



ACTION: Man pulls on spring

REACTION : _____ pulls on _____

String pulls on man

Remember this quote?

Newton's passage from a falling apple to a falling moon was an act of the prepared imagination.

~ John Tyndall (1820-1893)

→ Inspiration emerges
from a well-informed mind!



Isaac Newton's Apple Tree in
Lincolnshire, England

**NEWTON'S INSPIRATION =
apple & moon!**

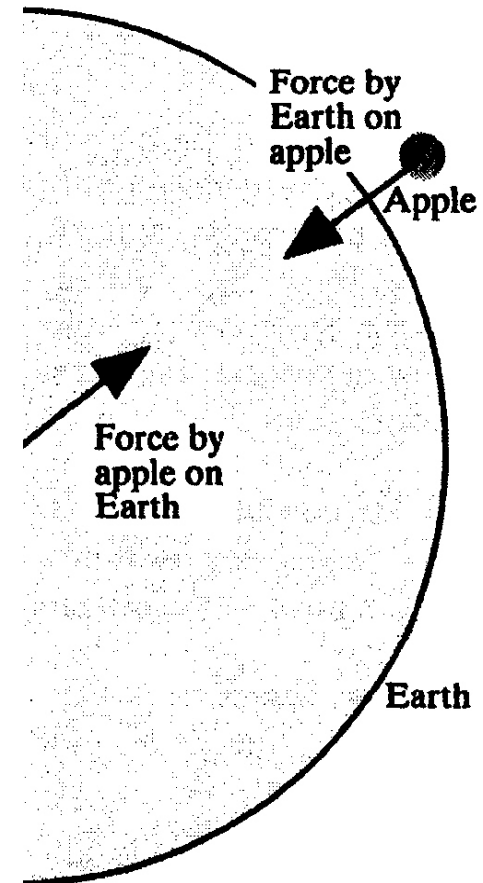
Earth pulls on apple (gravity)

but . . .

**THE APPLE ALSO PULLS ON
THE EARTH!**

**(so small it cannot be
measured -- but it is there)**

**→ He then likened the force
pairs between the apple &
earth to the apple & the moon!**



GLOBAL CHANGE LINK:

**For every gallon of gas you use, you add ~
22 pounds of CO₂ to the atmosphere.**

Recall Newton's 1st and 2nd Laws.

**Now consider the mass
(and acceleration capabilities) of a
large SUV (sport utility vehicle) vs. a
small sedan . . .**

2nd law reminds that MASS is involved!

LARGE Acceleration
(due to small MASS)

$$\frac{F}{m} = a$$

SMALL Acceleration
(due to larger MASS)

$$\frac{F}{m} = a$$

Econo-car vs. SUV!!



An SUV and a small sedan are both at rest at a stop light. Which vehicle has a greater inertia?

Choices:

1 = The SUV has a greater inertia because it has a greater mass and resistance to acceleration.

2 = The sedan has a greater inertia because it has a greater ability to accelerate.

3 = Since both are at rest, their inertia is the same.

An SUV and a small sedan are both at rest at a stop light. Which vehicle has a greater inertia?

1. The SUV has a greater inertia because it has a greater mass and resistance to acceleration.

2. The sedan has a greater inertia because it has a greater ability to accelerate.

3. Since both are at rest, their inertia is the same.

If the mass of the SUV is three times that of the sedan,

the same amount of force (via consumption of gasoline) will accelerate the SUV _____ as much as the sedan (all other things being equal in the two engine designs)?

Choices:

1 = 3 times

2 = 1/3



3 = nine times

One more concept

Momentum = inertia in motion; or more specifically, the product of mass of an object and its velocity.

Momentum = mass x velocity

or $P = m v$

Back to bottom of p 47

**To change the momentum of
something requires**

(an external) force and time

(and depends on how long the FORCE acts)

IMPULSE = Force x time interval

IMPULSE (Ft) changes momentum

Force x time interval = change in (mass X velocity)

$Ft = (\text{change in}) mv$

*Wall is opposite FORCE slowing
down the truck over short TIME interval*



$$\text{MASS} \times \text{VELOCITY} = \text{TIME} \times \text{FORCE}$$

*Haystack is opposite FORCE slowing down the truck over
long TIME interval*



$$\text{MASS} \times \text{VELOCITY} = \text{TIME} \times \text{FORCE}$$

MOMENTUM IS CONSERVED

“before and “after” In EACH CASE

(Principle of Conservation of Momentum)

Now imagine that the two vehicles are moving down the freeway side by side at equal velocities of 75 mph.

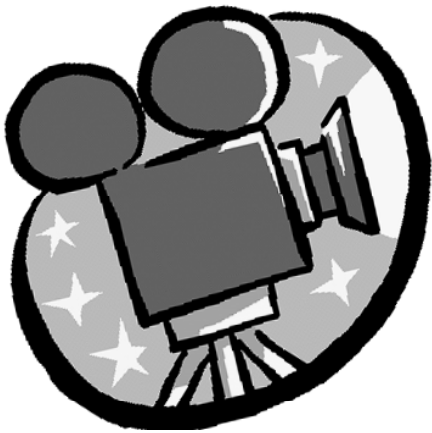
Suddenly, after rounding a curve, the drivers encounter a large semi-truck at a standstill that has jackknifed across both lanes.

If the two vehicles have comparable brakes, which one is most in danger of smashing into the truck ahead? _____

Explain why, using the term momentum.

“Understanding Car Crashes: It’s Basic Physics”

**As you watch the video,
fill in the blanks on pp 49-50
in CLASS NOTES.**



Epilogue: YOUR CAR & GLOBAL CHANGE

**(Being a GC Savvy
Consumer)**

SAFETY vs. ENVIRONMENT??

**What kind of car do you
drive???**





**Dr H and her
hummer**

????????????

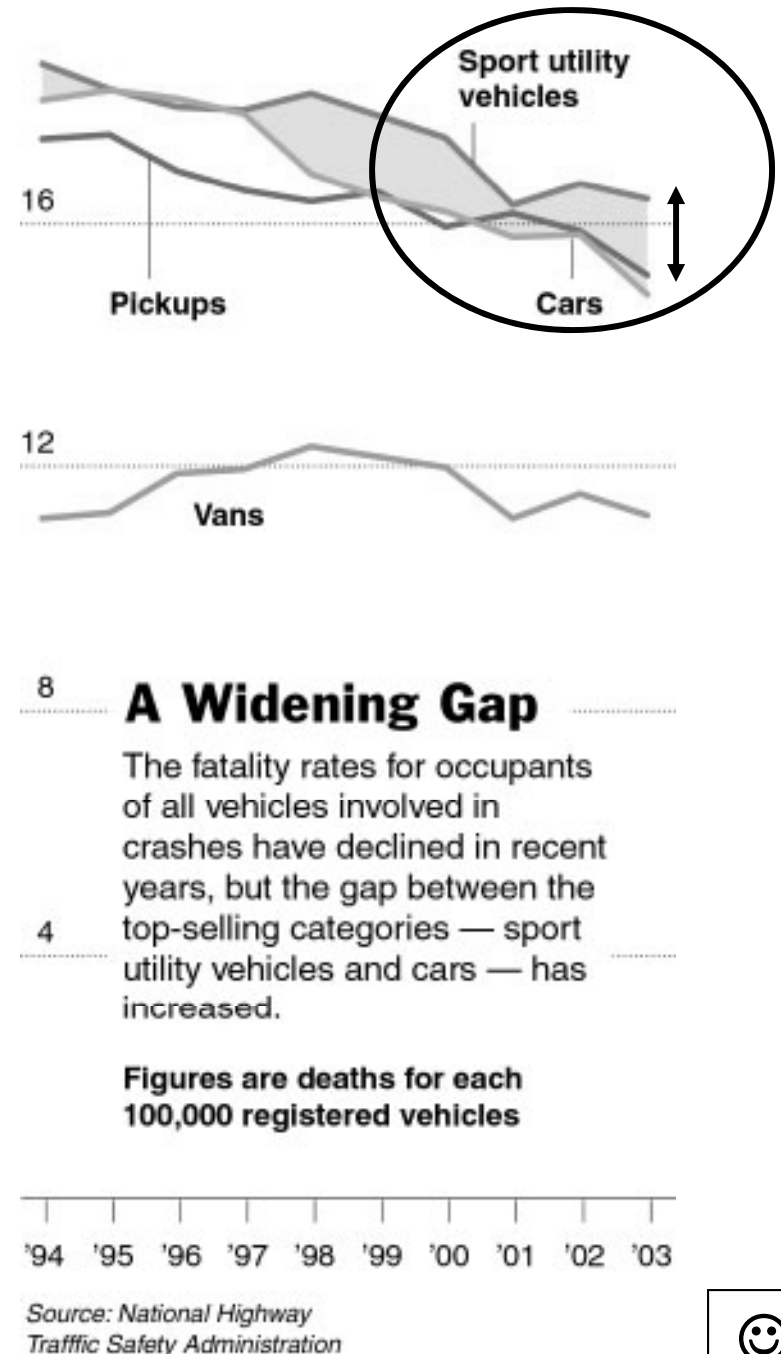


Your CAR & GLOBAL CHANGE



Fatality Rates
for occupants
of all vehicles
involved in
crashes

(deaths per 100,000
vehicles)



VINE BREMAN
CINCINNATI
ENCL 12/22 ©2005



SELECT PRICE YOU'RE WILLING
TO PAY:

DEEPER
INVOLVEMENT
IN MIDDLE
EAST



IRREPARABLE
DAMAGE TO
PRISTINE
WILDERNESS



TAKE
PUBLIC
TRANSPORT-
ATION



DOWNSIZE
TO FUEL
EFFICIENT
VEHICLE



&
SAFETY?



QUESTIONS TO CONSIDER!

- Are large SUVs & Pickups safer just because of their size and mass ?**
- Now that we have hybrid SUV's will that solve the problem of their notoriously low gas mileage and larger contribution of CO₂ to the atmosphere – compared to smaller cars?**

QUESTION #1:

Suppose the traffic accident mortality rate goes up because cars are made smaller to preserve fuel.

Is that a good trade- off ?

Or QUESTION #2:

Is it environmentally irresponsible or a good safety practice to own a large SUV or pickup truck that gets mileage of LESS than 20 mpg?

**HAVE A GREAT WEEKEND
& STUDY HARD
FOR TEST #2**

Go CATS!