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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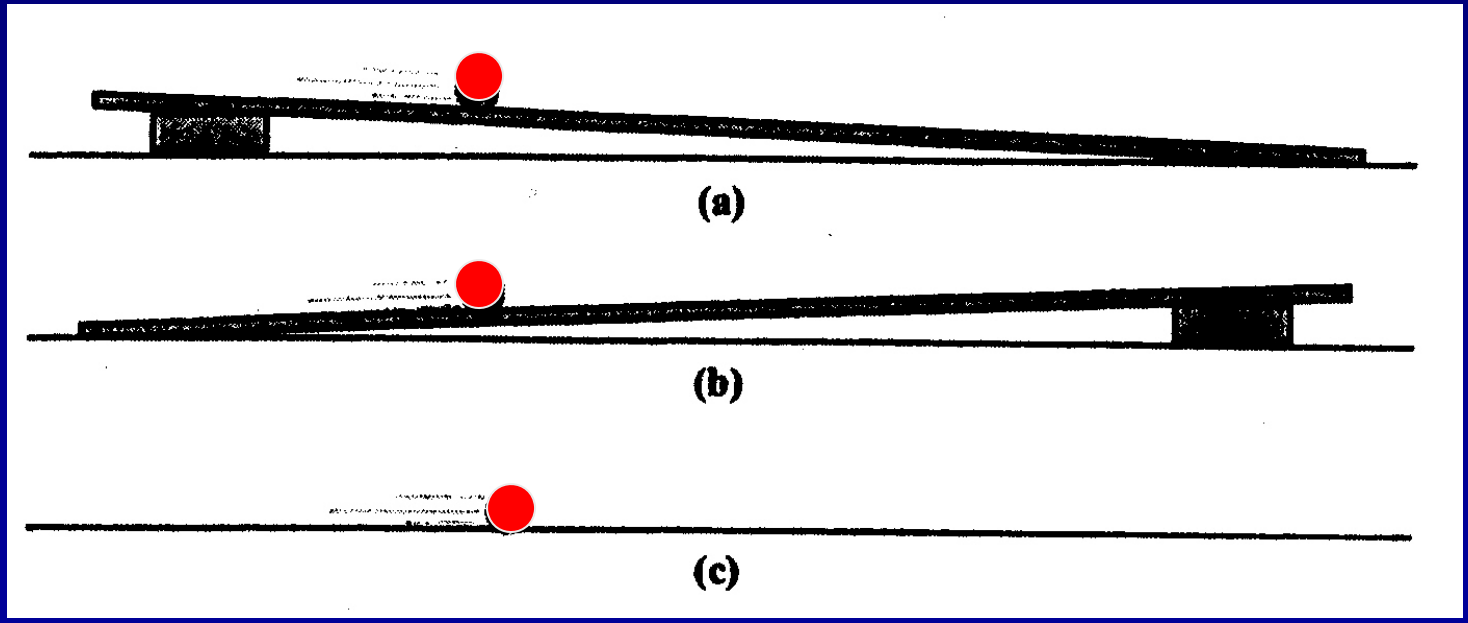
SCIENCE IS A CUMULATIVE ENTERPRISE

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.

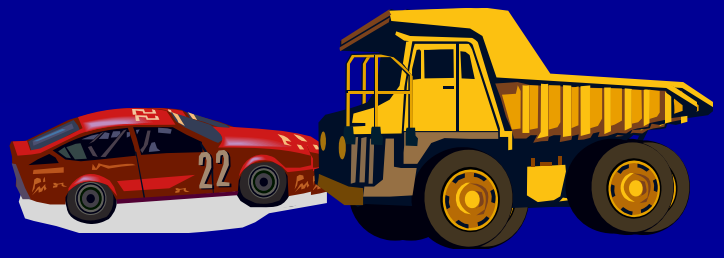
If acting in the in the SAME direction = the (vector) sum of the two forces

→ + → = →

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

→ + ← = →

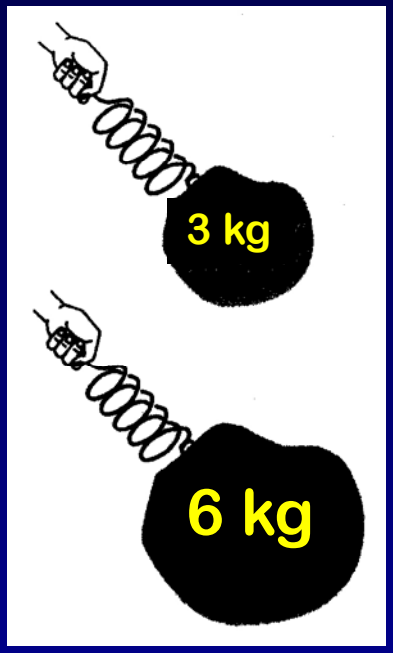
Net force acts in the direction of the stronger force:



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:

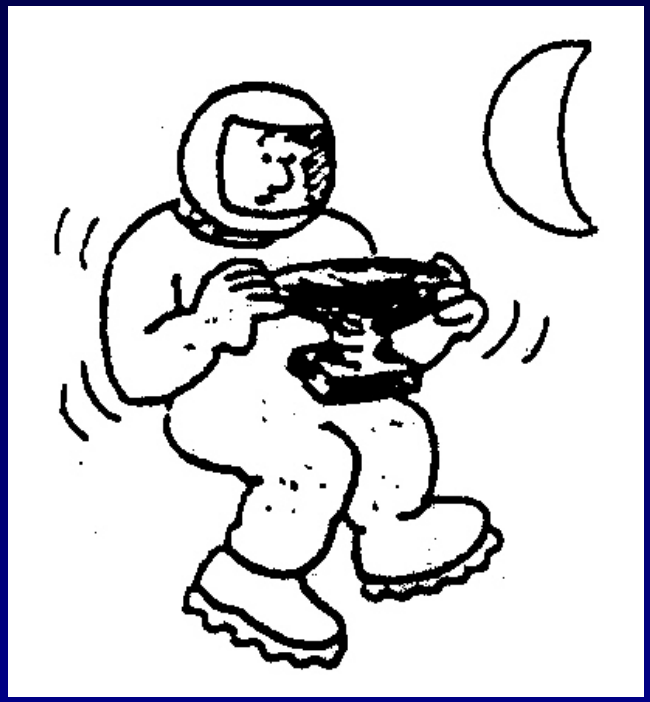
Mass vs. weight

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:

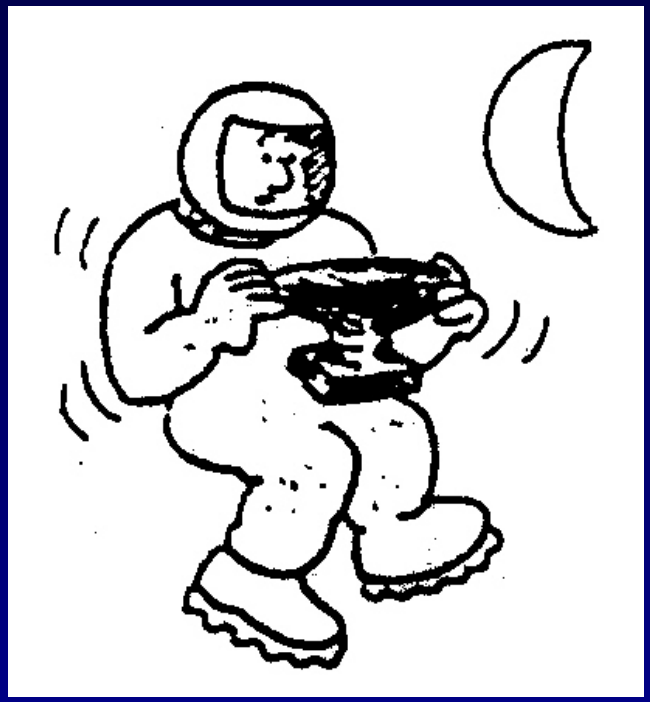
1 = the anvil

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.

p 48 – box at top

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!

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 or F = ma

2nd Law: F= ma

Acceleration ∝ net force / mass

∝ = "is proportional to"

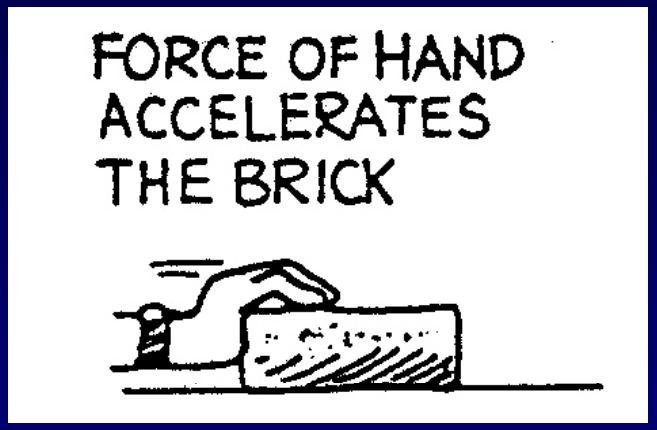
or

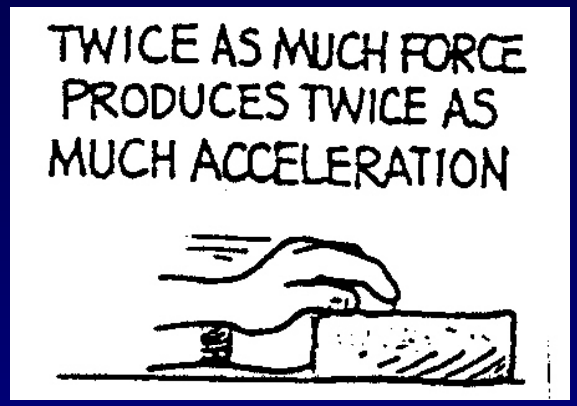
a ∝ F / m

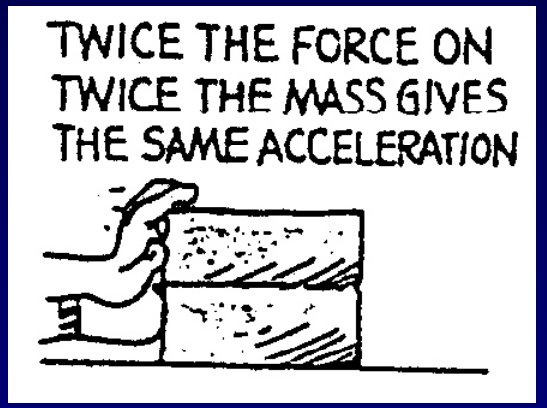
a = F / m

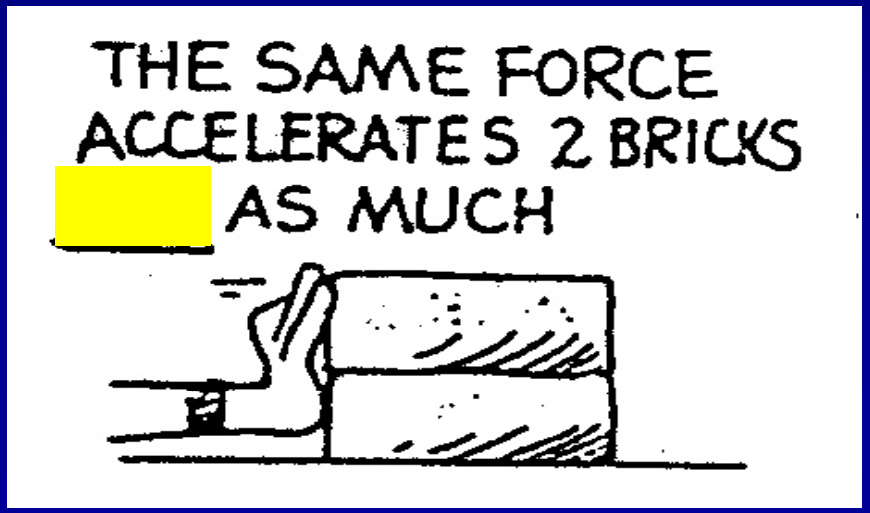
(with appropriate units of m/s² for a, newtons for F, kilograms for m)

F = ma


FORCE OF HAND ACCELERATES THE BRICK

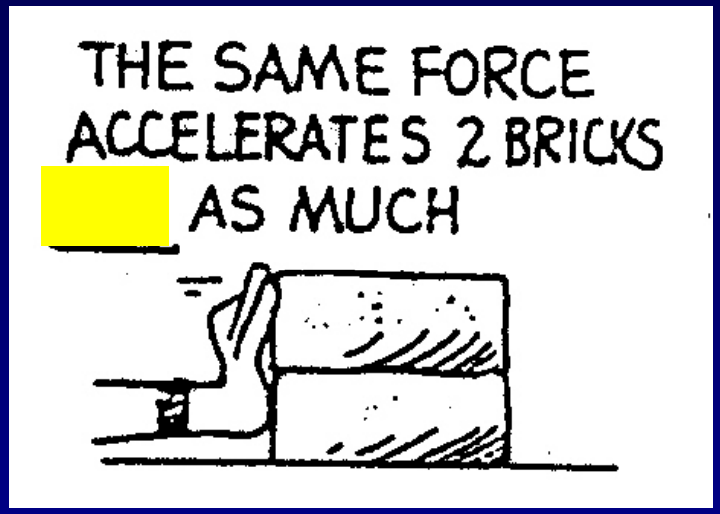

TWICE AS MUCH FORCE PRODUCES TWICE AS MUCH ACCELERATION

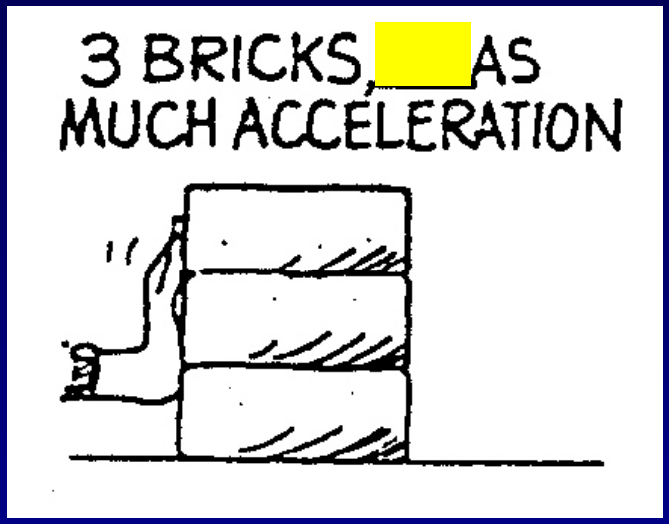

TWICE THE FORCE ON TWICE THE MASS GIVES THE SAME ACCELERATION


THE SAME FORCE ACCELERATES 2 BRICKS AS MUCH

F = ma

Q2: Fill in both blanks





CHOICES FOR ABOVE:

A = 1/2 ←

B = twice

C = 1/3

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.

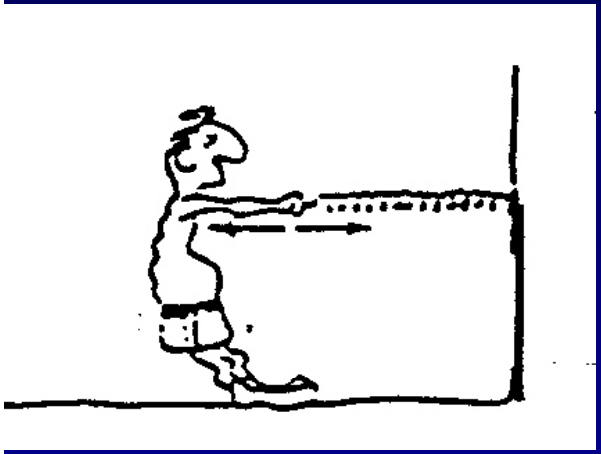
3rd Law = "Law of Force Pairs"

- **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

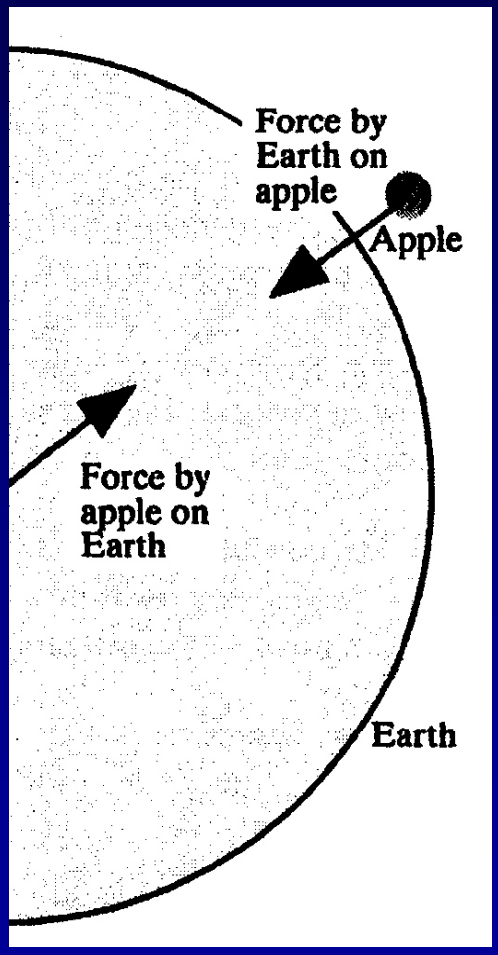
NEWTON'S INSPIRATION = apple & moon!

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 CO_2 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 $P = mv$

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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 = (change in) mv

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

MASS x VELOCITY = TIME x **FORCE**

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

MASS x VELOCITY = **TIME** x 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 jacknifed 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???

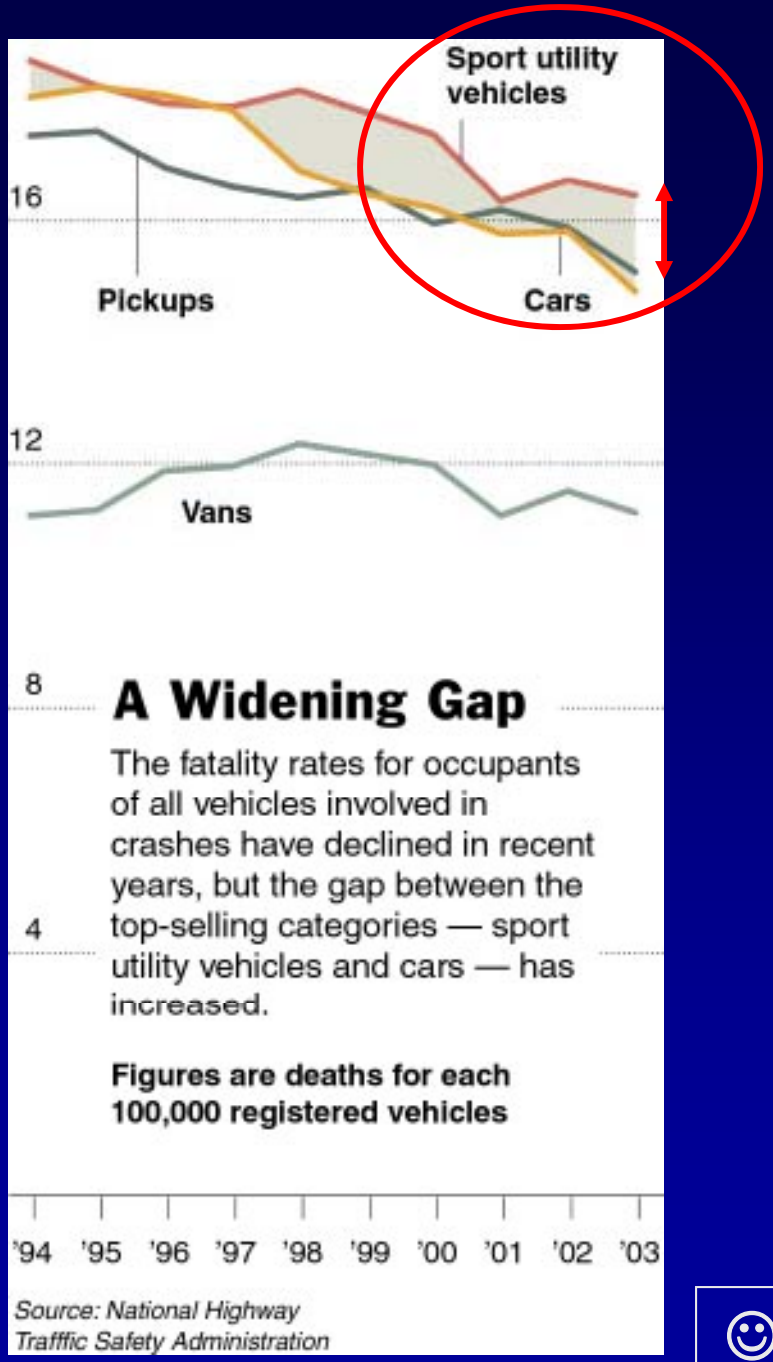
Dr H and her hummer

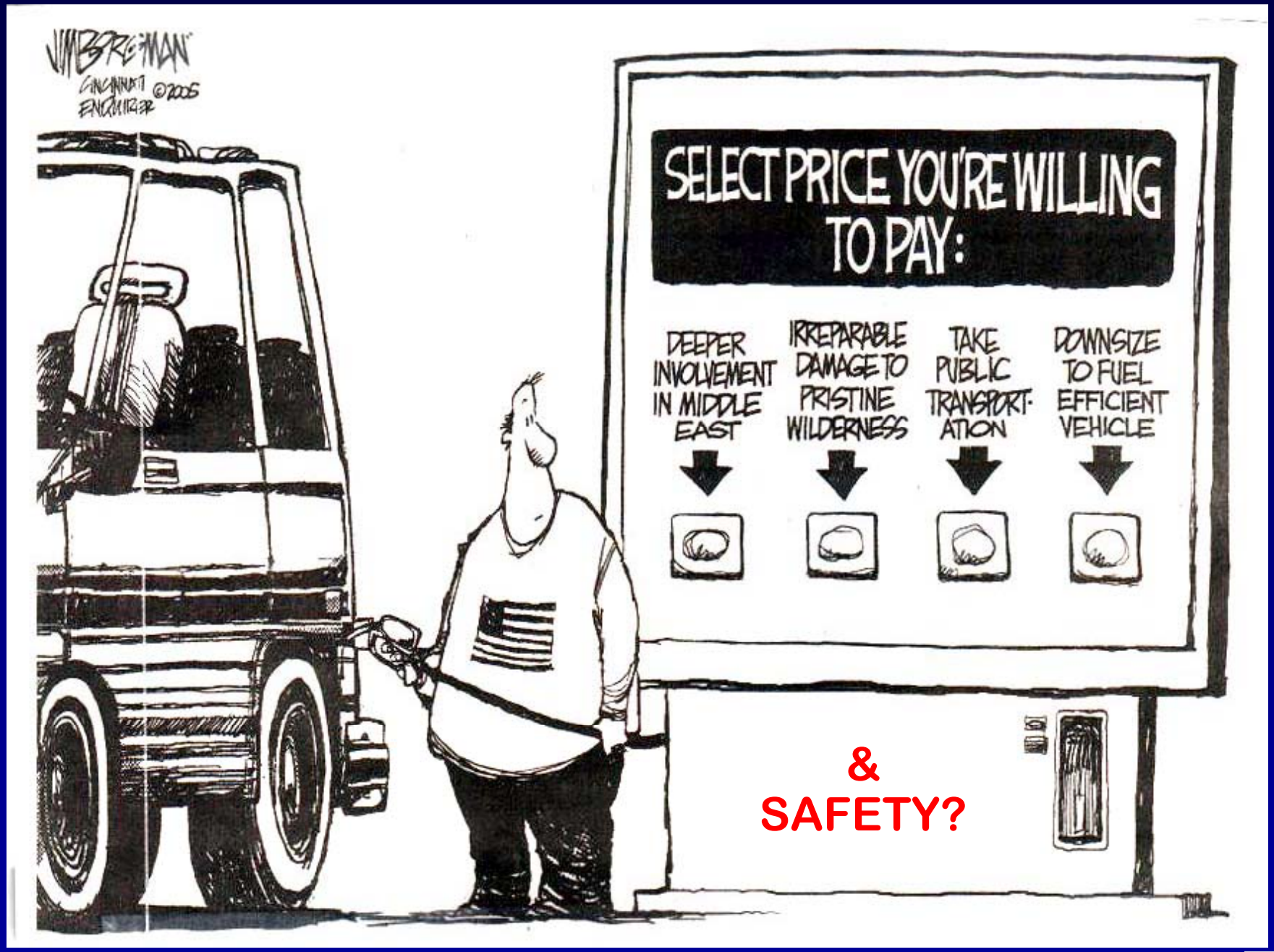
???????????

Your CAR & GLOBAL CHANGE

Fatality Rates for occupants of all vehicles involved in crashes

(deaths per 100,000 vehicles)




JIM BORGMAN
CINCINNATI ENQUIRER ©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 CO_2 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!