PROPOSAL OF A NEW TERMINOLOGY FOR NEWTON'S 3RD LAW

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APRIL 28, 2018
SPRING MEETING OF THE CHESAPEAKE SECTION OF THE AAPT
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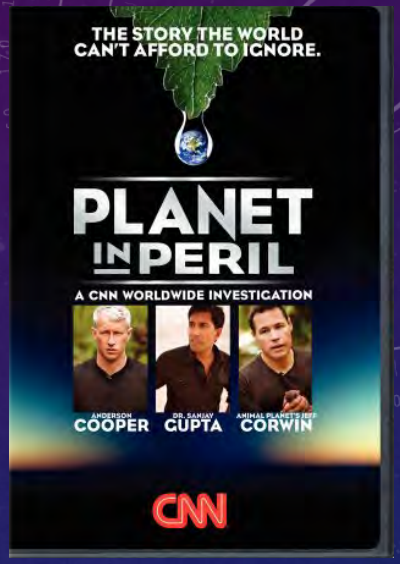
"FAKE" UNDERSTANDING OF NEWTON'S 3RD LAW

- The 2007 CNN documentary "Planet in Peril," which is about human actions destroying the environment, begins with Anderson Cooper narrating the following words:

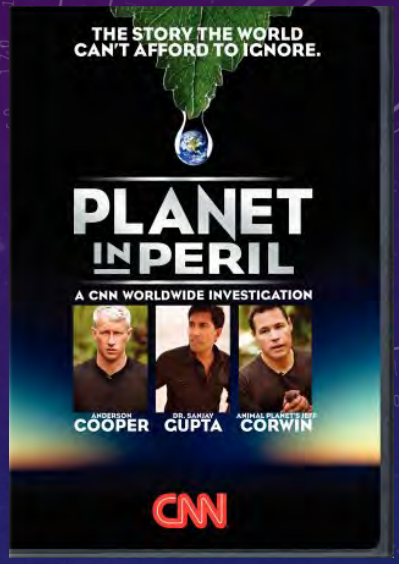
  "For every action there is an equal and opposite reaction. It's one of the fundamental laws of physics, of nature."



- The documentary then talks about how nature is reacting to human actions to our detriment.

THAT'S "FAKE" ~~NEWS~~ PHYSICS, ANDERSON!

- If hearing this did not make you cringe, your understanding of Newton's 3rd Law is suspect. If it made you nod approvingly, then your understanding is "fake." (I'll explain)



- Why has the "fake" understanding of Newton's 3rd Law become so widespread that even Anderson Cooper is promulgating it?

- It's because the terminology is super-confusing!
  It's so confusing that not only students, but instructors and even textbook authors get it wrong!

WHAT IS SO "FAKE" ABOUT WHAT ANDERSON SAID?

- "Reaction" (physics term) is NOT the reaction (everyday English term) to "action" (physics term)
- It has NOTHING to do with the recipient of the "action" (physics term) reacting (everyday English term) to it
- If "reaction" (physics term) is not reaction (everyday English term) at all, why do we keep on calling it that, especially given that it is the source of so much confusion?

→ the terms were used by Newton himself in the Principia!

"Lex. III: Actioni contrariam semper & æqualem esse reactionem: sive corporum duorum actiones in se mutuo semper esse æquales & in partes contrarias dirigi."

WHAT NEWTON IS ACTUALLY SAYING

- English translation by I. Bernard Cohen and Anne Whitman: "Law 3: To any action there is always an opposite and equal reaction: in other words, the actions of two bodies upon each other are always equal and always opposite in direction."

- Newton qualifies the Law in the following paragraph:

  "If some body in contact with another body changes the momentum of that body in any way, then it also will in turn undergo the same change in its own momentum in the opposite direction. The changes in the velocities that occur in opposite directions are inversely proportional to the masses because the momenta are changed equally."

  * Newton is clearly talking about momentum conservation!

NEWTON'S 3RD LAW IN MOMENTUM LANGUAGE

- When momentum is exchanged between objects A and B, the momentum lost by A is exactly the same as the momentum gained by B. No momentum is lost in the transaction.
- Let's say that A "pushes" B and momentum $\Delta\vec{p}$ is transferred from A to B:

$$\Delta\vec{p}_A = -\Delta\vec{p}, \qquad \Delta\vec{p}_B = \Delta\vec{p}$$

  Note that A lost momentum $\Delta\vec{p}$ because it gave $\Delta\vec{p}$ to B by "pushing" it. NOT because B "reacted" to the push and "pushed back." It is a single transaction.

- The rates of momentum transfer are:

$$\vec{F}_{B\to A} = \frac{\Delta\vec{p}_A}{\Delta t} = -\frac{\Delta\vec{p}}{\Delta t} = -\frac{\Delta\vec{p}_B}{\Delta t} = -\vec{F}_{A\to B}$$

- The "reaction force" is NOT the reaction to the "action force"!

MANY TEXTBOOK AUTHORS STRUGGLE WITH NEWTON'S 3RD LAW

- Question 1: How can reaction be the same as action?

  Common strategy: Argue that though it may not seem plausible, experiments confirm it so we have to accept it (indoctrination)

- Question 2: How can an inanimate object like a wall react to an exerted force?

  Common strategy: Try to talk your way out of it by giving a plausible (but hand waving) argument

  But ANY argument which explains reaction as a reaction is incorrect!

EXAMPLE (ONE OF MANY) :

"Physics for scientists and engineers" by Randall D. Knight, p.119-120

- Tension Force: "If you were to use a very powerful microscope to look inside a rope, you would "see" that it is made of atoms joined together by molecular bonds. Molecular bonds are not rigid connections between atoms. They are more accurately thought of as tiny springs holding the atoms together. Pulling on the ends of the spring or rope stretches the molecular springs ever so slightly. The tension within a rope and the tension force experienced by an object at the and of the rope are really the net spring force being exerted by billions and billions of microscopic springs"
- Normal Force: "If you sit on a bed, the springs in the mattress compress and, as a consequence of the compression, exert an upward force on you. ….. Figure 5.7 shows an object resting on top of a sturdy table. The table may not visibly flex or sag, but - just as you do to the bed - the object compresses the molecular springs in the table. ….. As a consequence, the compressed molecular springs push upward on the object ….. Suppose you place your hand on a wall and lean against it. Does the wall exert a force on your hand? As you lean, you compress the molecular springs in the wall and, as a consequence, they push outward against your hand."

CONSEQUENCE OF THE "FAKE" EXPLANATION :

Assertions:

- Tension, which is the reaction force of the rope/string being pulled on the object/person that is pulling it, is due to the elasticity of the molecular springs.
  It is the result of the molecular springs reacting to being pulled.
- The normal force, which is the reaction force of the table surface or wall on the object/person that is pushing it, is due to the elasticity of the molecular springs.
  It is the result of the molecular springs reacting to being pushed.

Logical conclusion:

- There is no reaction force when you pull/push a rigid body which is not elastic at all !!?

DO WE HAVE TO USE NEWTON'S TERMINOLOGY?

- No! We should come up with better terminology so that less people (students/instructors/textbook authors/Anderson Cooper) are confused.

- Newton himself uses the term "reaction" only four times in the Principia (though he uses the term "action" profusively)

- Traditional terms we have done away with already:

  Quantity of Matter (quantitas materiæ) → mass
  Quantity of Motion (quantitas motus) → momentum
  Electromotive Force (used by Faraday?) → emf

WHAT WOULD BE A GOOD ALTERNATIVE?

- Newton's Laws of motion is all about keeping track of (accounting for) the momentum that is being exchanged between bodies
- Why not use the terminology we use to keep track of money?

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https://www.neuronsnotincluded.com/

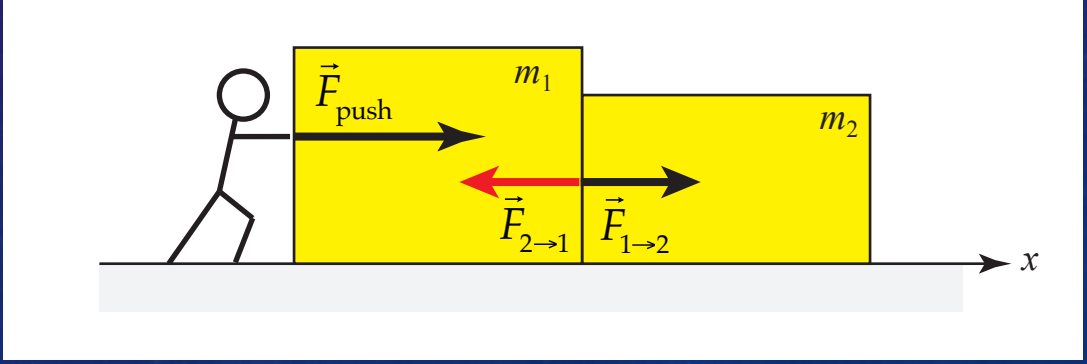
ACTION-REACTION → CREDIT-DEBIT

- Proposal: rename the "action-reaction law" as the "credit-debit law"

$$\Delta\vec{p}_A = -\Delta\vec{p}, \qquad \Delta\vec{p}_B = \Delta\vec{p}$$

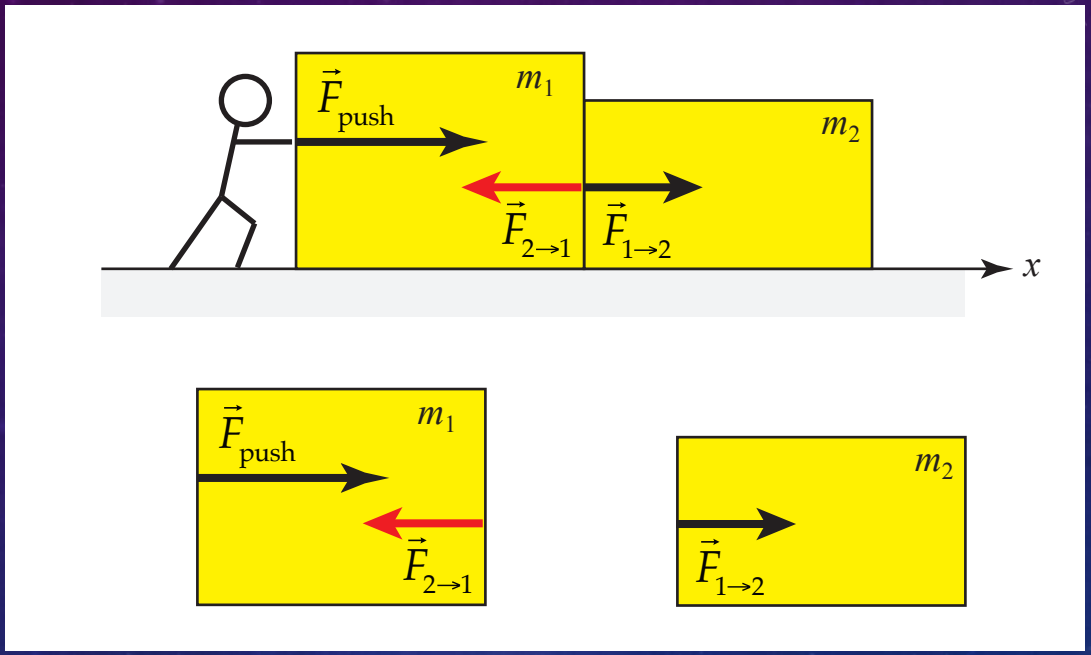
$\Delta\vec{p}$ appears as a credit on B's momentum account
$\Delta\vec{p}$ appears as a debit on A's momentum account

- A's debit must be the same as B's credit
- Use black and red arrows to indicate credit and debit forces:



“FREE BODY DIAGRAM” IS ALSO A WEIRD TERM

- Proposal: rename the “free body diagram” the “momentum accounting diagram”



DON'T SAY THAT THE WALL "PUSHES BACK"

- Many textbooks state that Newton's 3rd Law tells us that when we push a wall, the wall pushes back with an equal and opposite force
- It makes it sound like the wall reacting to our push
- It is almost like saying that the numbers that appear in parentheses on our bank statements (debits) are the result of the bank reacting to our payments and paying us back!
- Force should not be taught as "a push or a pull" (it isn't).
  It is the rate of momentum transfer.