Intuitive ontologies for energy in physics

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Energy Project

Professional development program
for K-12 teachers
on the learning of **energy** and
practices of **formative assessment**

Research program on:

- teaching and learning of energy
- embodied cognition
- proximal formative assessment
- Rogerian relational discourse

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Not conceptualizing energy

In physics, we are usually encouraged to think of energy a mathematical abstraction. The important property is that it is conserved.

"Conservation of energy... is not a description of mechanism, or anything concrete; it is just a strange fact that we can calculate some number and when we finish watching nature go through her tricks and calculate the number again, it is the same."

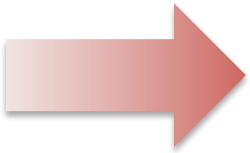
Research questions

Nonetheless, physics discourse includes many indicators of what kind of thing the speaker thinks of energy as being (ontology).

- **What are some intuitive ontologies for energy in physics?**
- **What is the significance for instruction?**

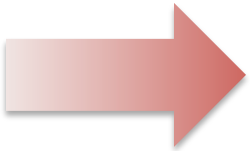
Theory and practices

Learning and knowledge show in what people say and do to learn together. *(Jordan & Henderson)*



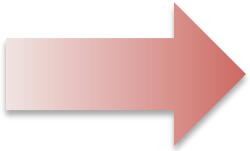
We mostly analyze classroom discourse.

Ontologies are based in sensorimotor experiences. *(Lakoff & Johnson)*



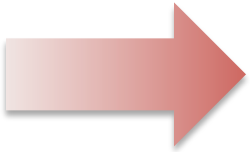
We examine physics discourse for embodied metaphors. *(Chi & Slotta, Brookes & Etkina)*

People have good reason to think of things the way they do.



We identify the advantages and limitations of specific metaphors.

People have easy cognitive access to a variety of ontologies. *(Gupta et al)*



We promote disciplined, flexible use of metaphorical language in instruction.

Talking about energy in physics class

Leaves blowing in the street:
How is energy involved?

Eighth grade, public school, Pacific Northwest; recorded as part of Energy Project professional development program

Talking about energy in physics class

Energy as a substance

Energy is a kind of stuff;
objects are containers that
can have such stuff in them.
(Brewe 2011; Amin 2009; Duit 1987; Close et al. 2010)

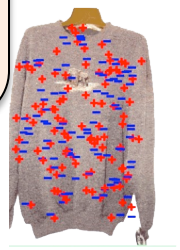
SUPPORTS
- conservation
- localization
- transfer
- flow

Leaves in the street *have* energy.
They're *getting* wind energy.

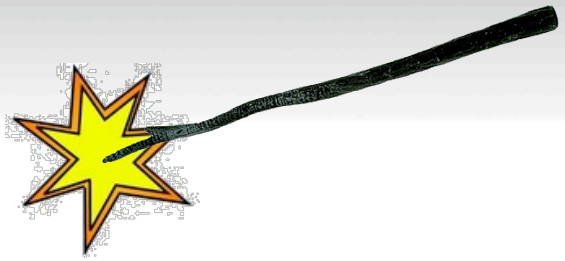
Ontologically similar to ***electric charge.***

permeates material objects and changes their quality without adding significant mass or volume

"Gravitational potential energy [is] the energy which an object *has* because of its relationship in space, relative to the earth



Energy as a stimulus



Energy is a thing that
has an effect on objects:
it stimulates action.

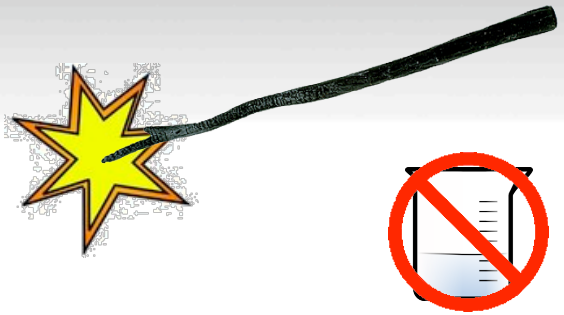
Leaves in the street *are pushed by* energy.
Wind *is* energy.
Wind is like your foot on a pedal.
Leaves wouldn't move without *wind* as a bicycle wouldn't move without a *pedaler.*

SUPPORTS

- sociopolitical discourse
- association of energy with forces

("ability to do work")

Energy as a stimulus



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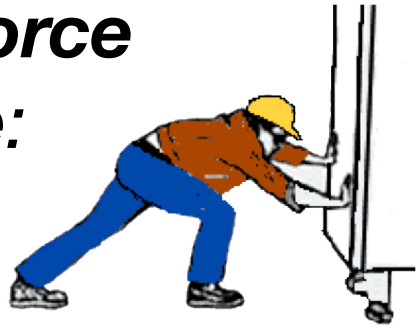
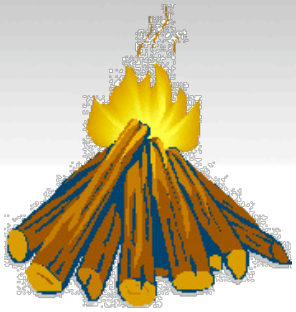
Ontologically similar to ***force***
or *agent that exerts force:*



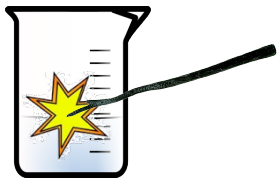
Energy/wind as fuel?



Wind can be a *source* of energy.
You can *use* wind to *power* stuff.
Leaves wouldn't move without wind as a bus wouldn't move without *gasoline.*

Fuel is:

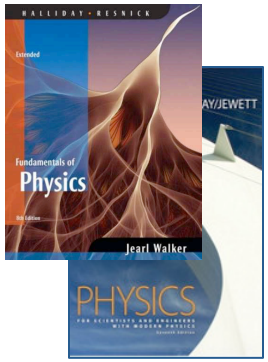
- a literal material substance
- not just any substance
- stores "useful" energy
- required for activity
- used up



Can be productive if learners can think of fuel as *having* energy rather than *being* energy

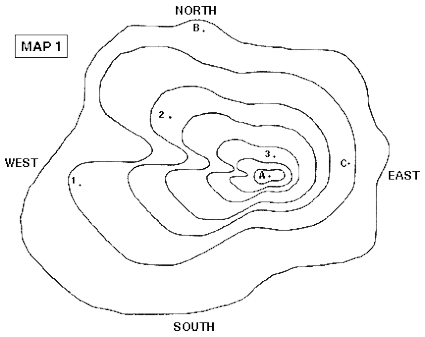
Energy as vertical location

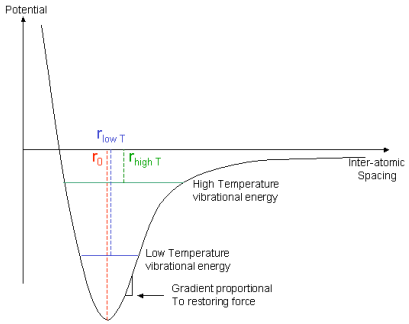
Energy is levels.

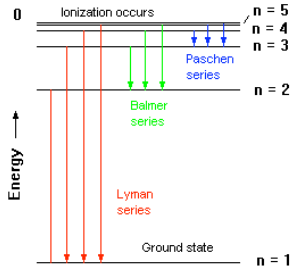


The kinetic energy of the cart gets *higher* as the cart speeds up.
The electron makes a transition *from* the n=2 energy level *to* the ground level (n=1).

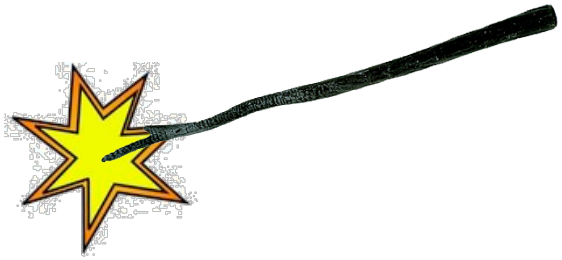
SUPPORTS
First law of thermo (increasing energy takes effort)







Summary



- **Each contributes to a valid understanding** of energy in physics.
- Instructors who appreciate each metaphor's **advantages and limitations** are better prepared to use them as a resource for instruction.