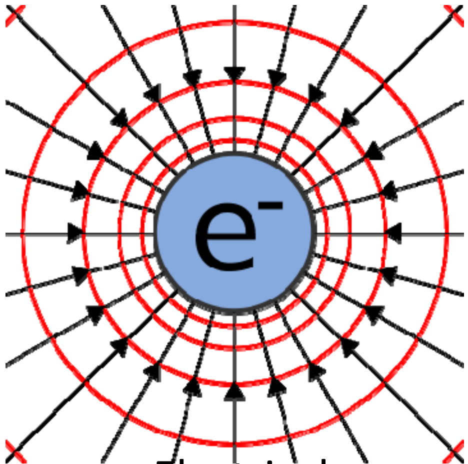
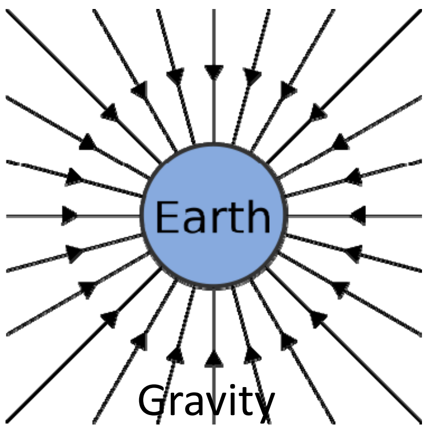
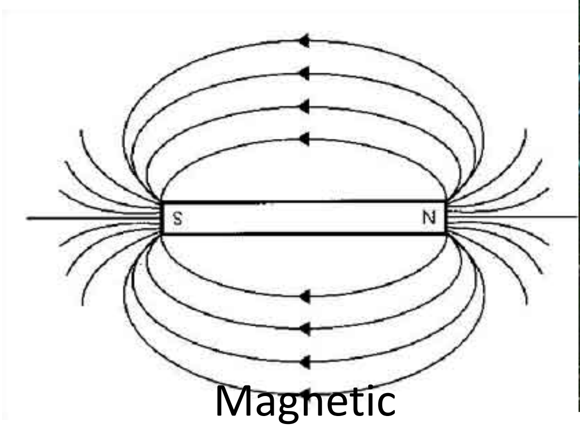
Energy and Fields



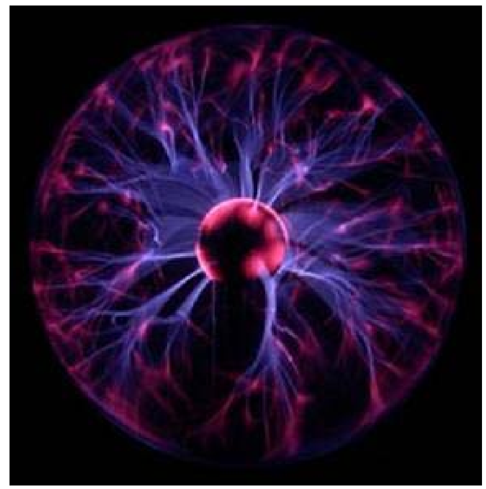
Electrical



Gravity



Magnetic



Common misconceptions

•Energy is NOT a force. A force applied over a distance has units of energy (work).

•Energy, Work, Force, and Momentum are all different things.

•A mass moving at a non-zero speed has energy of motion (kinetic) that can be transformed into heat or do work. Throw a ball into a spring and lock the spring when the ball stops…where does the energy go ?

•I do work by raising a mass upwards in the earth's gravity field. Where did the energy go? Release the ball, the gravitational energy causes acceleration of mass to make KE.

•It feels like I am doing work while pushing on a wall, but there is no displacement, so no work is being done. Wrong…your muscle cells are contracting/expanding hence doing work.

• Energy never disappears it just degrades into more dispered forms as measured by the entropy which always increase in a closed system.

•Fields cannot exist if I cannot see them. Not true. Try to push the North Pole of two magnetic together, do you feel the force field ?

Heat Energy: solids, fluids, gas and EM waves

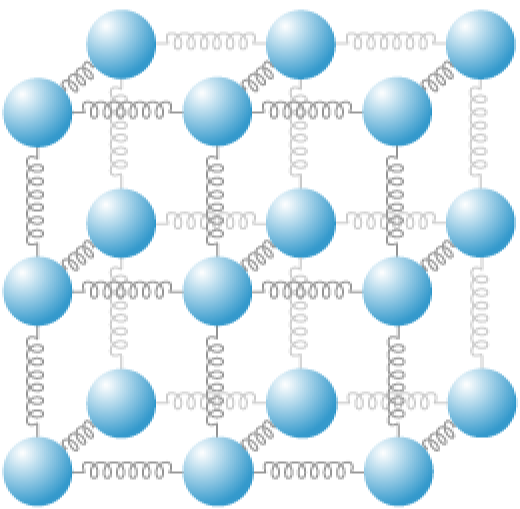
Heat has many manifestations

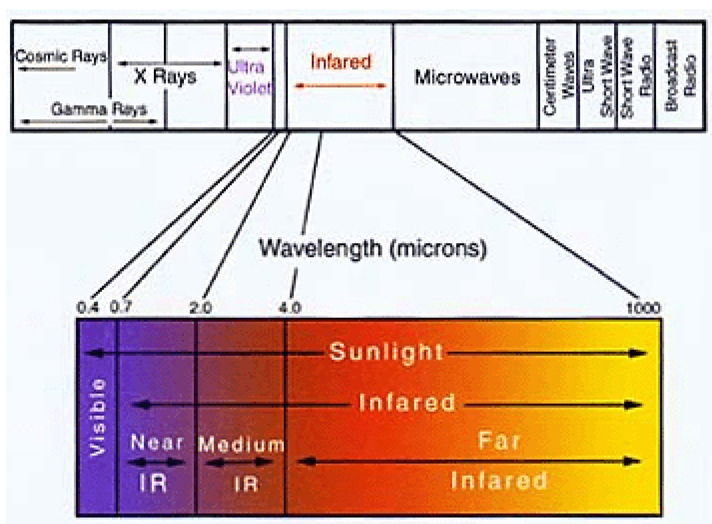
•Translational kinetic energy: velocity squared of molecules in a gas.

•Vibrational kinetic/potential energy of bonds between molecules in a solid/liquid.

•Latent heat: energy required to change the phase (liquid/solid/gas) of a substance. If bonds break, energy is required; if bonds form, energy is released.

•Infrared 'band' EM radiation. All object at non-zero temperatures (K) radiate EM waves wherever there is a temperature difference (disequilibrium).





Energy: Power is just energy per second

•Energy is conserved because the laws of physics have never been found to change over time. Repeat: no one has EVER done an experiment where energy is not conserved (constant). In addition, to violate conservation of energy you would have to disprove a mathematical theorem (Noether's) which would gut the foundations of mathematics.

•Energy is neither made nor destroyed: it is conserved both local and on the scale of the entire universe.

•Energy can be exchanged into different forms: Kinetic, potential gravity, heat, electromagnetic and elastic waves. This is the power of viewing physics from an energy viewpoint; one can track the change in time of the energy into different forms.

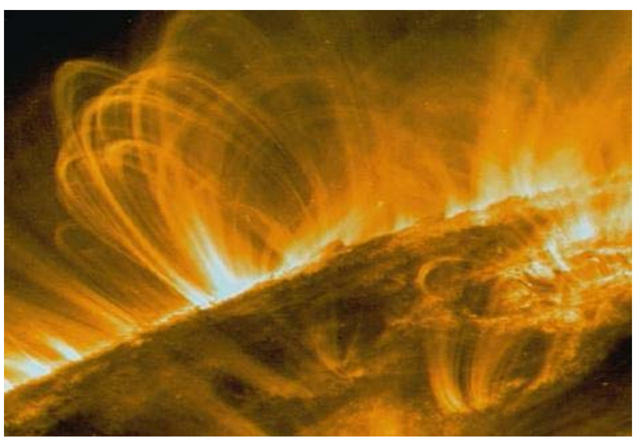
•No one EVER REALLY USES energy because that implies the energy is somehow destroyed!

•What we mean is we DEGRADE energy (electrical or chemical) into a more dispersed form, usually heat!

•The energy from burning gasoline in an engine ends up in two new places: 1) doing work in pushing the car in the gravity field up and down hills; 2) combustion makes heat which comes out the exhaust pipe and the radiator.

Energy: name the energy change?

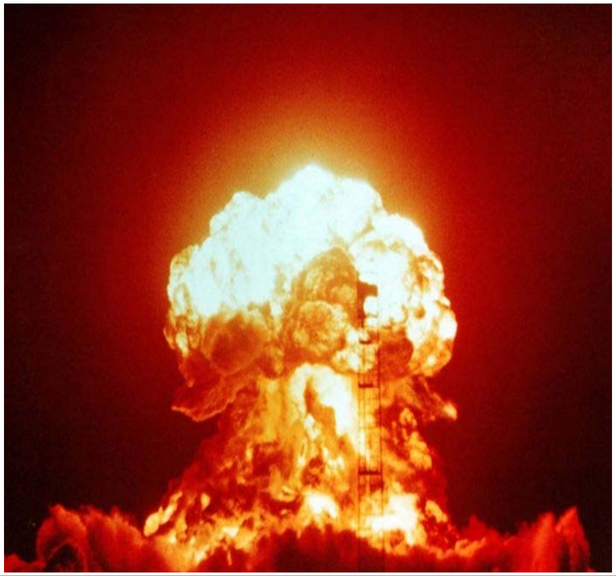


Energy exchange examples

The kinetic energy of the air (proportional to velocity squared) does work on the turbine blades that turn an electrical generator (magnet around a wire coil) to transduct the kinetic energy to electrical energy

So what energy powers the wind?



Strong force (nuclear) energy is changed into heat/KE/E-M energy. This energy comes from the splitting (fission) of the nucleus that binds the proton/neutrons together in Uranium 235 nucleus. The new fissioned elements weigh a bit less than before. That binding mass is released in the bomb's heat/radiation and waves.

Electrical energy powers electromagnetic radiation that when in visible band is called light. Where does this energy go ?

And, what makes the electrical energy?

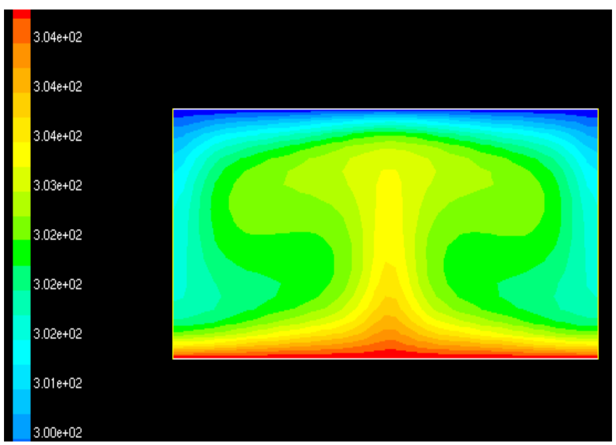
What is a (force) field?

In physics, a **field** is a physical quantity associated to each point of spacetime.[1] A field can be classified as a scalar field, a vector field, or a tensor field, according to whether the value of the field at each point is a scalar, a vector, or, more generally, a tensor, respectively.

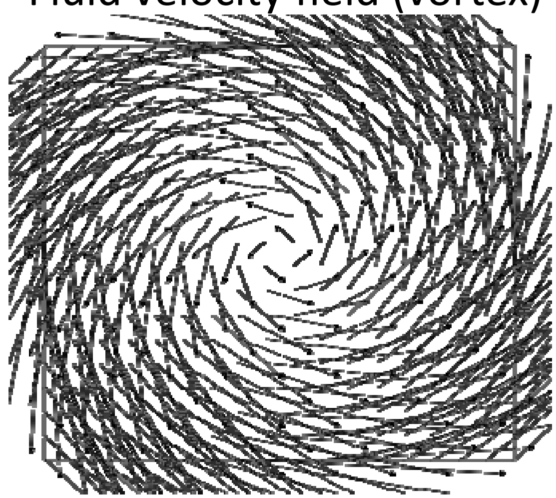
A field cannot be seen, but nonetheless it is real and can do work (by applying forces) on objects and exchange energy.

It took scientist along time to accept field (1890's).

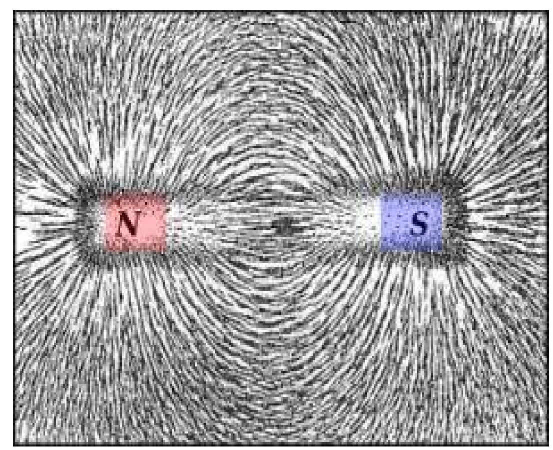
Scalar field (temperature)



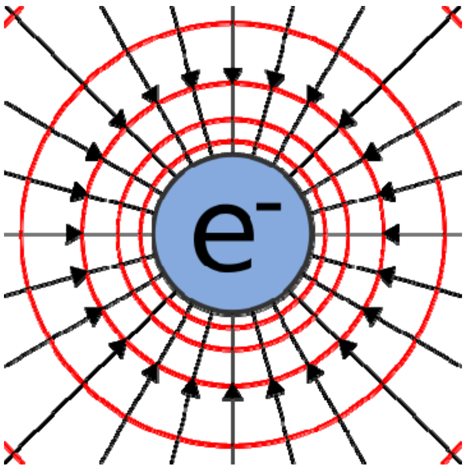
Fluid velocity field (vortex)



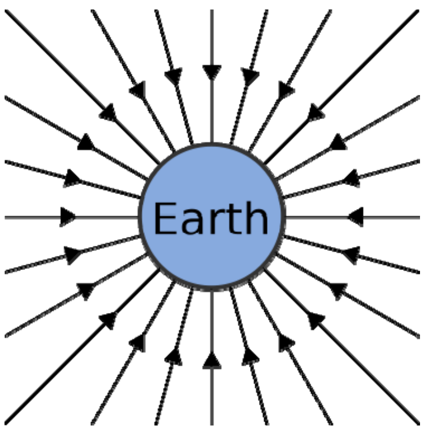
Dipole magnetic field



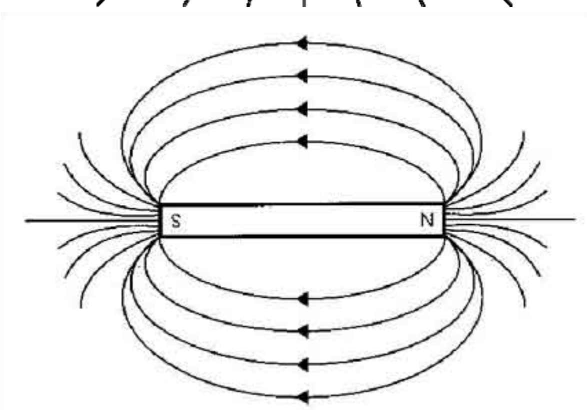
Fields emanate from their charges or dipole



Electrical. Vector. Two charges: plus (proton) minus(electron)
Field falls off from charge as 1/r*2 and field can be attractive or repulsive depending on sign of charges.
If you accelerate the charge you'll add a magnetic field to the electric field.



Gravity. Vector. One charge (mass). Field falls off from mass charge as 1/r*2 and field is always attractive (no such thing as negative mass). If you accelerate the mass you'll make a ripple in the space-time continuum.



Magnetic. Vector. No charges!! Always a dipole with a 'N' and 'S' end to make a magnetic dipole. Field falls off from dipole as 1/r*3. If you accelerate a magnetic field near a conductor, an electrical current will be inducted (a generator!).

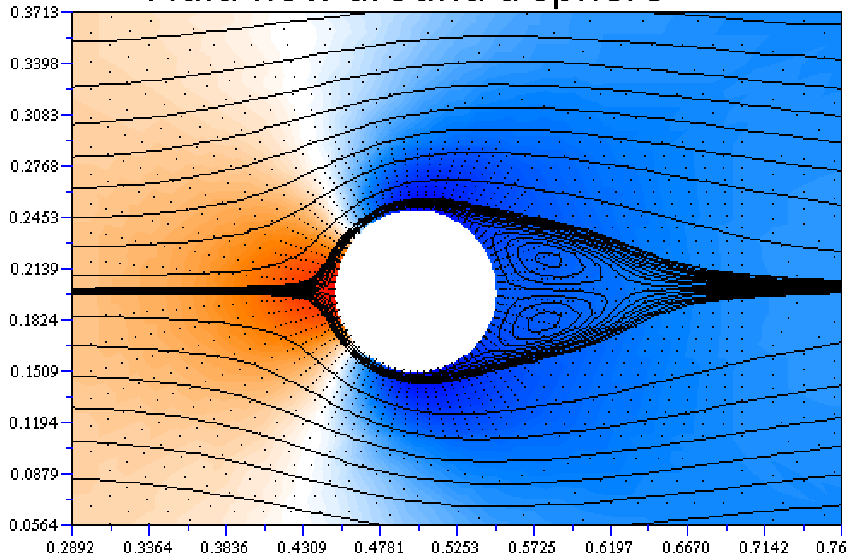
electrical

gravity

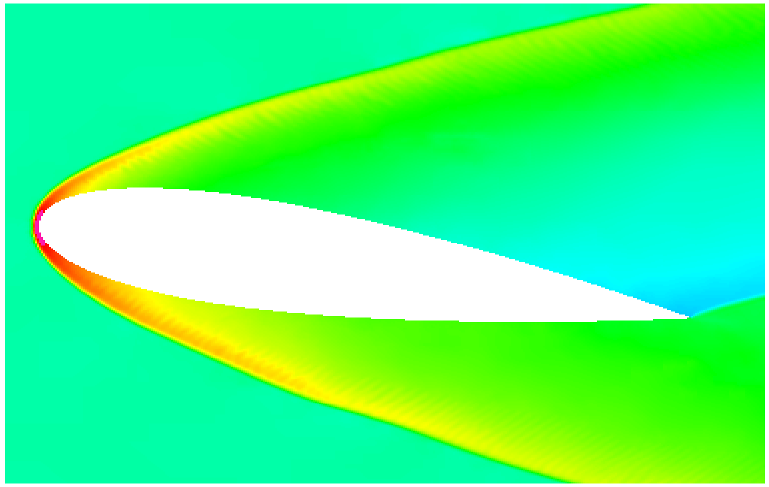
magnetic

Pressure (scalar) fields

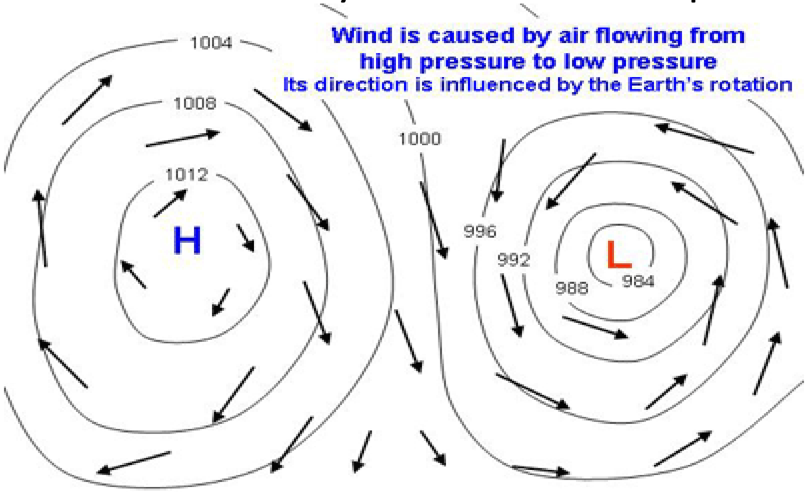
Fluid flow around a sphere



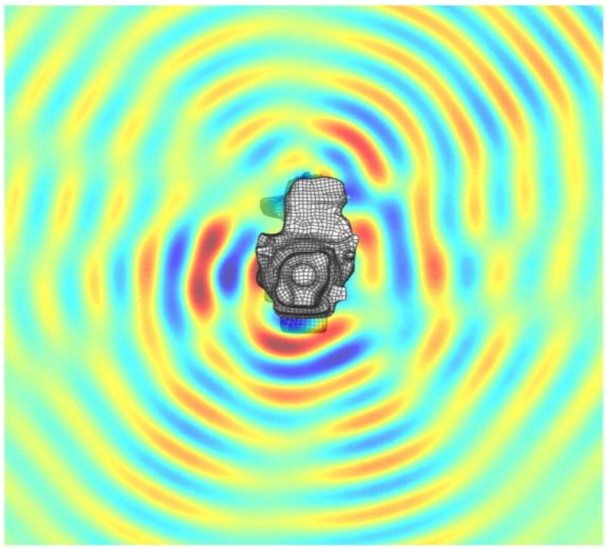
Air flow around a wing



Pressure and velocity vectors in atmosphere



Acoustic air waves around a drive shaft



Summary

•When energy is used, we mean that we degrade it into other forms (e.g., heat), but energy is always conserved.

•Many different forms of energy: Kinetic, gravitational, electrical, magnetic, heat, strain, nuclear, electro-magnetic.

•Electromagnetic waves transmit energy at the speed of light. Light is an E-M wave that our eyes are sensitive too. Other EM waves types: radio, microwave, infared.

•Fields that transmit force and can do work on objects exist even though you cannot directly see them.

•Two main kinds of fields:

- •the scalar field which is just a number (temperature, pressure)
- •a vector field (velocity, gravity, magnetic, electrical).

•The strength of a field is proportional to the amount of charge (coulombs or kg).

•Field lines for a certain force never cross themselves, but when magnetic field line touch they reform.