Conceptual Physics
Energy Sources
Collisions

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Last time

- energy and work
- kinetic energy
- potential energy
- conservation of energy
- energy transfer
- simple machines
- efficiency

Overview

- discussion of energy sources
- momentum and collisions

Sources of Energy

Discussion!

Sources of Energy

Sources of energy:

- oil
- coal
- natural gas
- wood / charcoal / peat
- solar - photovoltaics and heating
- wind
- waves
- hydroelectric
- geothermal
- nuclear - thermonuclear, fission, and fusion(?)

Sources of Energy: Fraction of US Energy supply

Major energy sources and percent share of total U.S. electricity generation in 2014:

- Coal = 39%
- Natural gas = 27%
- Nuclear = 19%
- Hydropower = 6%
- Other renewables = 7%
  - Biomass = 1.7%
  - Geothermal = 0.4%
  - Solar = 0.4%
  - Wind = 4.4%
- Petroleum = 1%
- Other gases < 1%

[1] US Energy Information Administration.

Sources of Energy: Costs

Estimated Grid-Level Systems Cost, 2012 (USD/MWh)[46]:8

Technology	Nuclear		Coal		Gas		Onshore Wind		Offshore Wind		Solar	
Penetration Level	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**	**10%**	**30%**
Backup costs (adequacy)	0.00	0.00	0.04	0.04	0.00	0.00	5.61	6.14	2.10	6.85	0.00	10.45
Balancing costs	0.16	0.10	0.00	0.00	0.00	0.00	2.00	5.00	2.00	5.00	2.00	5.00
Grid connection	1.56	1.56	1.03	1.03	0.51	0.51	6.50	6.50	15.24	15.24	10.05	10.05
Grid reinforcement & extension	0.00	0.00	0.00	0.00	0.00	0.00	2.20	2.20	1.18	1.18	2.77	2.77
Total Grid-level System Costs	**1.72**	**1.67**	**1.07**	**1.07**	**0.51**	**0.51**	**16.30**	**19.84**	**20.51**	**28.26**	**14.82**	**28.27**

[1] Wikipedia, NEA estimates.

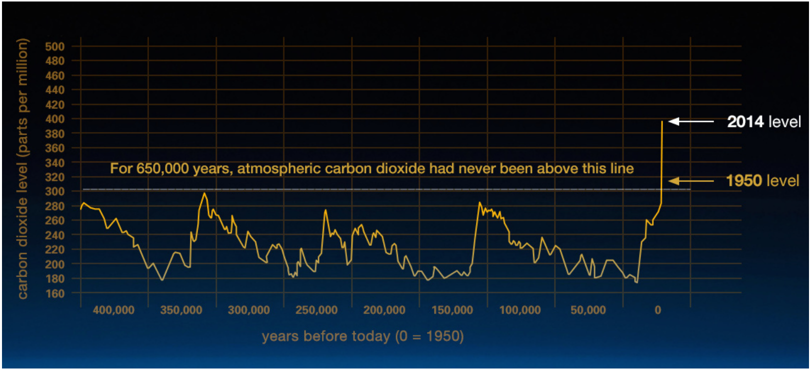
Sources of Energy: Costs

California levelized energy costs for different generation technologies in US dollars per megawatt hour (2007)

Technology	Cost (US$/MWh)
Advanced Nuclear	67
Coal	74–88
Gas	87–346
Geothermal	67
Hydro power	48–86
Wind power	60
Solar	116–312
Biomass	47–117
Fuel Cell	86–111
Wave Power	611
Note that the above figures incorporate tax breaks for the various forms of power plants. Subsidies range from 0% (for Coal) to 14% (for nuclear) to over 100% (for solar).	

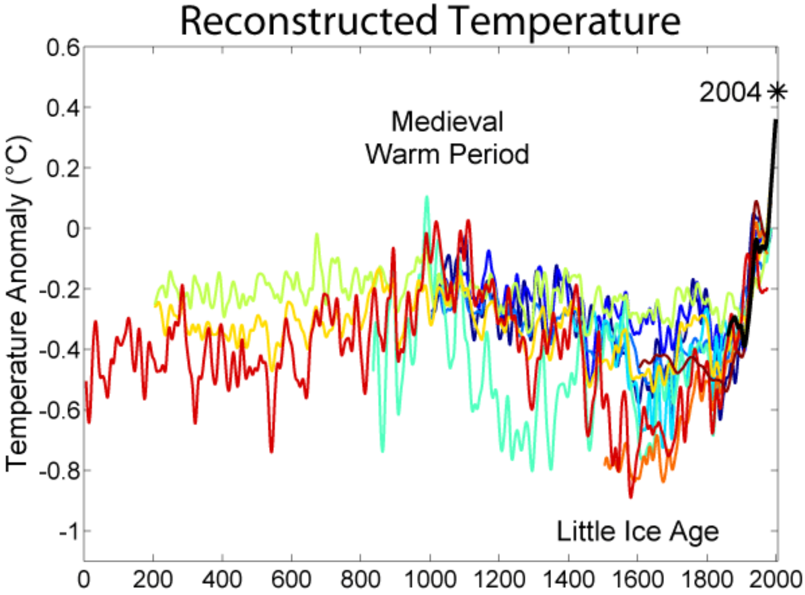
[1] Wikipedia, California Energy Commission estimates.

Carbon Dioxide



[1]Graph from http://climate.nasa.gov/evidence/

Global Temperature Record



[1]Figure by Robert A. Rohde, using data from 11 different studies.

Current Event: Larsen C Ice Sheet Breakup

Just this week (confirmed yesterday) a 6,000-square-kilometer iceberg (about the size of Delaware) broke off of Antarctica.

[1] John Sonntag, NASA

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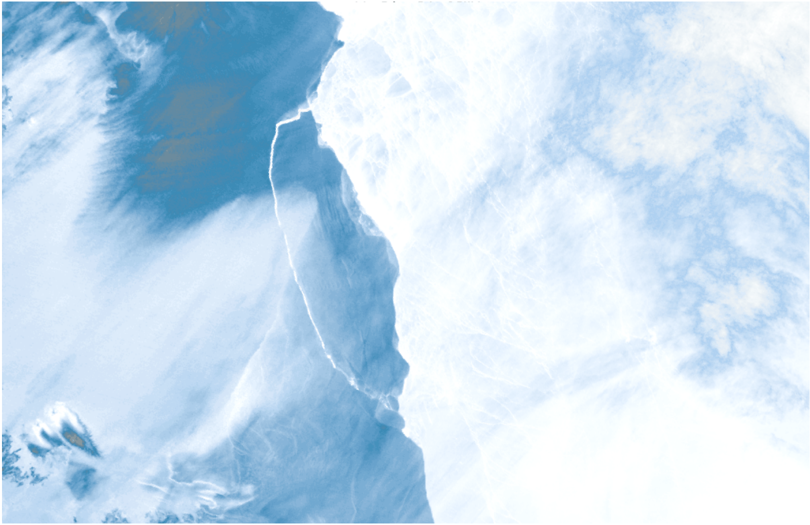

[1]NOAA, NASA CIMSS

Collisions

The conservation of momentum is very useful when analyzing what happens to colliding objects.

In all collisions (with no external forces) momentum is conserved:

$$\text{net momentum before collision} = \text{net momentum after collision}$$

$$\mathbf{p}_{\text{net},i} = \mathbf{p}_{\text{net},f}$$

Types of Collision

There are two different types of collisions:

Elastic collisions

are collisions in which none of the kinetic energy of the colliding objects is lost. $(K_i = K_f)$

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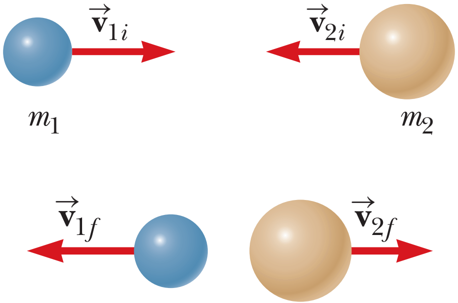
When the colliding objects stick together afterwards the collision is *perfectly inelastic*.

Elastic Collisions



Example: Pool

A pool ball moving at 1 m/s to the right strikes a stationary pool ball in an elastic collision. What is the final velocity of the two pool balls? (Assume they have the same mass.)

[1]Photo by Max Stansell via hsphysicslab.blogspot.com.

Example: Pool

A pool ball moving at 1 m/s to the right strikes a stationary pool ball in an elastic collision. What is the final velocity of the two pool balls? (Assume they have the same mass.)

The motional energy is just transferred from the first ball to the second!

The first ball comes to rest after the collision, and the second moves off to the right at 1 m/s.

Notice that momentum is conserved.

[1] Photo by Max Stansell via hsphysicslab.blogspot.com.

Question

A friend is studying collisions and tells you about the result of one of her experiments.

One ball of mass 1 kg and moving initially with a velocity $u_1 = 5$ m/s moving right collides with another of mass 2 kg and velocity $u_2 = 1$ m/s moving left. After the collision the first ball has a velocity of 3 m/s moving left and the second has a velocity of 3 m/s moving right.

Is this collision physical? (Could it really happen?) What is the initial kinetic energy? Is this an elastic collision?

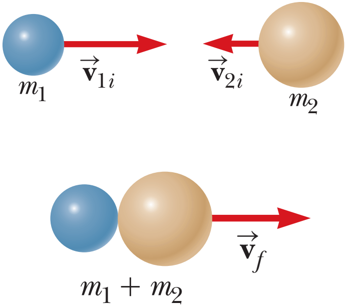
Inelastic Collisions

For general inelastic collisions, some kinetic energy is lost.

But we can still use the conservation of momentum:

$$p_i = p_f$$

Perfectly Inelastic Collisions



Now the two particles stick together after colliding ⇒ same final velocity!

$$p_i = p_f \quad \Rightarrow \quad m_1\mathbf{v}_{1i} + m_2\mathbf{v}_{2i} = (m_1 + m_2)\mathbf{v}_f$$

Inelastic Collision Example

From page 91-92 of Hewitt:

Two freight rail cars collide and lock together. Initially, one is moving at 10 m/s and the other is at rest. Both have the same mass. What is their final velocity?

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$$\begin{aligned} \mathbf{p}_{\text{net},i} &= \mathbf{p}_{\text{net},f} \\ m\mathbf{v}_i &= (2m)\mathbf{v}_f \\ 10m &= 2mv_f \end{aligned}$$

The final mass is twice as much, so the final speed must be only half as much: $v_f = 5$ m/s.

Collision Question

Two objects collide and move apart after the collision. Could the collision be inelastic?

(A) Yes.

(B) No.

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(A) Yes. $\leftarrow$

(B) No.

Question

In a perfectly inelastic one-dimensional collision between two moving objects, what condition alone is necessary so that the final kinetic energy of the system is zero after the collision?

(A) The objects must have initial momenta with the same magnitude but opposite directions.

(B) The objects must have the same mass.

(C) The objects must have the same initial velocity.

(D) The objects must have the same initial speed, with velocity vectors in opposite directions.

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[1] Serway & Jewett, page 259, Quick Quiz 9.5.

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Summary

- sources of energy
- rotational motion

Essay Homework due July 19th.

- Describe the design features of cars that make them safer for passengers in collisions. Comment on how the design of cars has changed over time to improve these features. In what other circumstances might people be involved in collisions? What is / can be done to make those collisions safer for the people involved? Make sure use physics principles (momentum, impulse) in your answers!

Homework Hewitt,

- Ch 6, onward from page 96, Plug and chug: 1, 3, 5, 7; Ranking: 1; Exercises: 5, 7, 19, 31, 47
- Ch 7, onward from page 119. Exercises: 57, 59; Probs: 7, 9