Phy100: More on thermal energy

1) Thermal energy simulation: a microscopic point of view;

2) Energy transfer and heat; power.

3) On labs: data fitting.

Simulations on heat and thermal energy

[Friction forces]

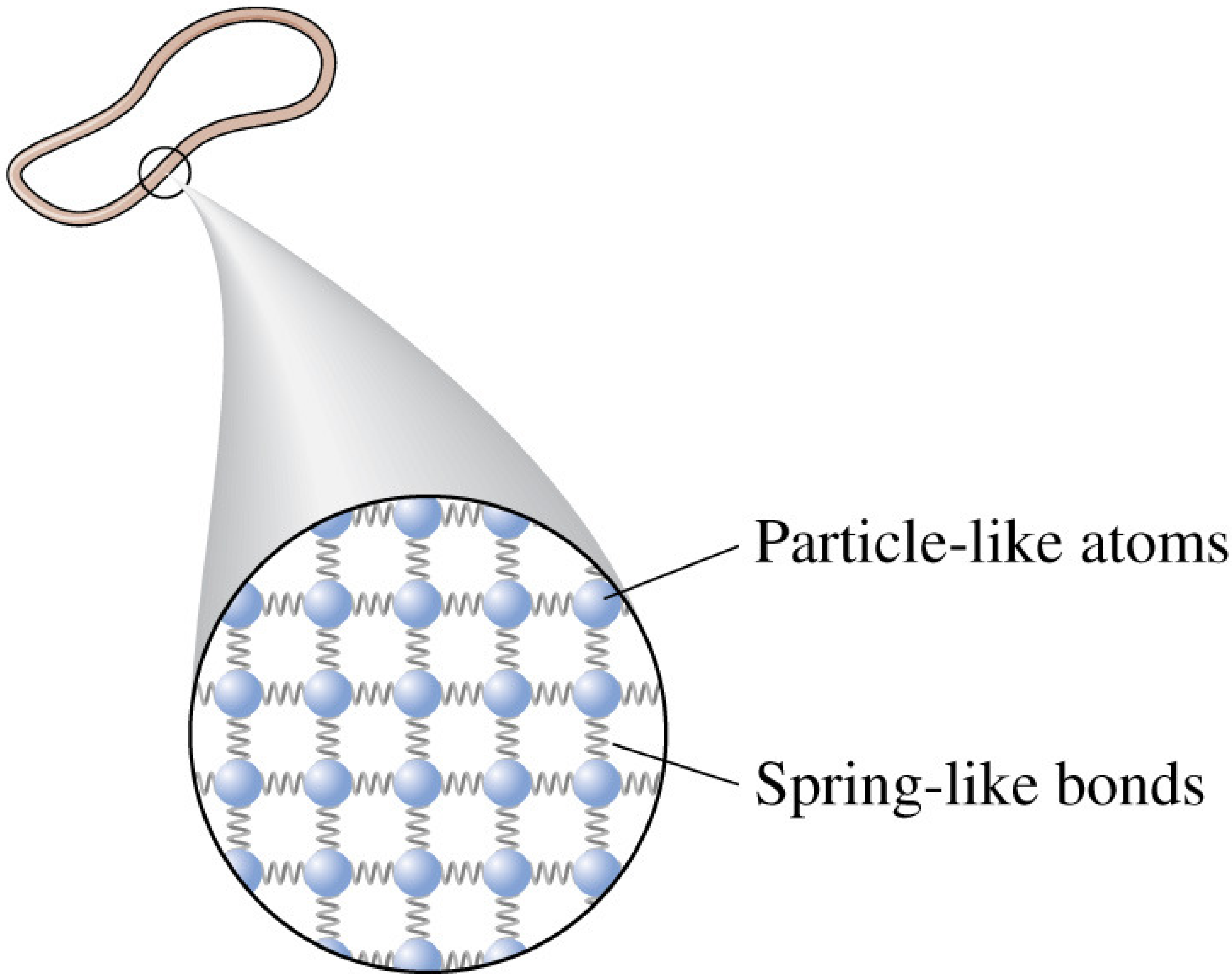
[Microwaves heat up coffee]

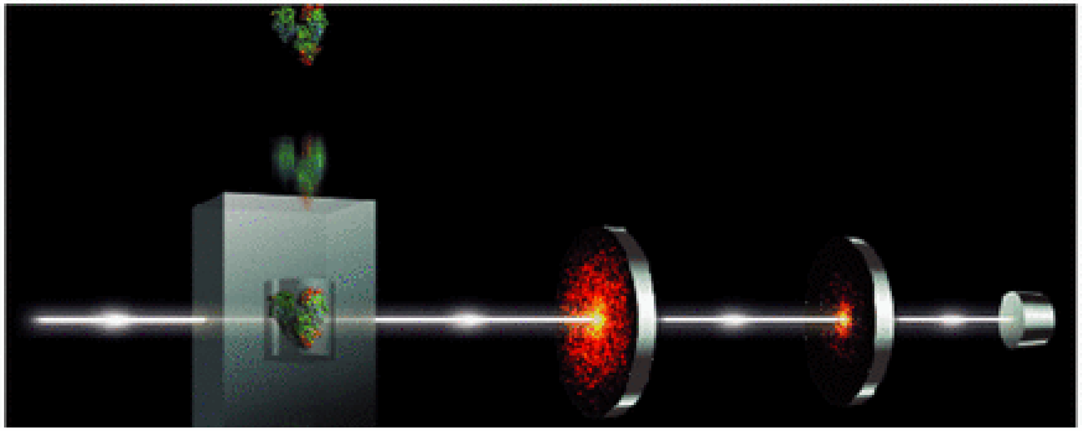
What is thermal energy?

Thermal energy is a measure of how hot an object is. Temperature measured in Kelvin scale or absolute temperature is a quantity that can be used to characterize the amount of thermal energy.

More precisely, thermal energy is the total energy of microscopic motions of atoms or molecules (either vibrational or rotational but at nanometer scales).

HOT <-----> physically, motions of atoms speed up!!
(More atoms occupying excited energy states.)


Particle-like atoms
Spring-like bonds



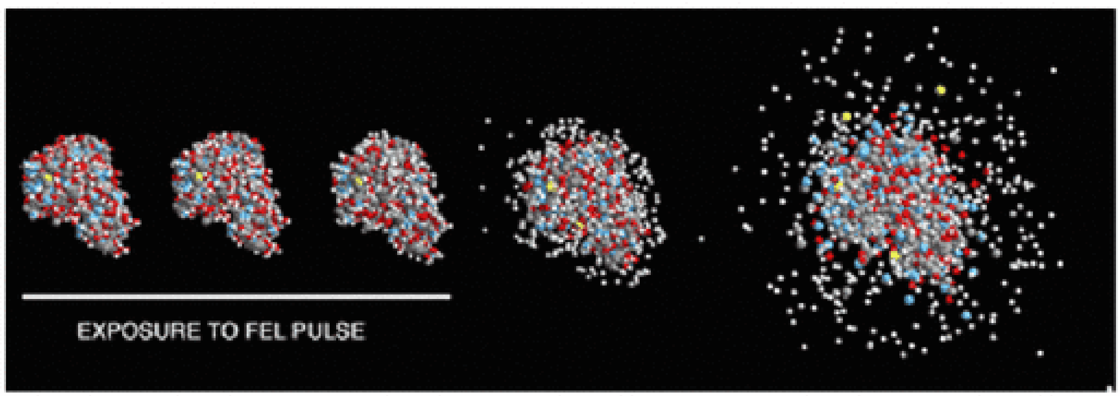


FIGURE 4-5 Artist's depiction of a Coulomb explosion of a protein molecule (lysozyme) exposed to the focused pulse of an XFEL. With a very short x-ray pulse (indicated by the white line), atomic positions remain virtually unchanged during the exposure. SOURCE: SLAC.

Why thermal energy ?

Practically, mechanical energy is always converted into thermal energy or “heat”; an object moving on a surface usually heats the object or the surface (via friction).

Other examples: car engines, electric fan motors etc.

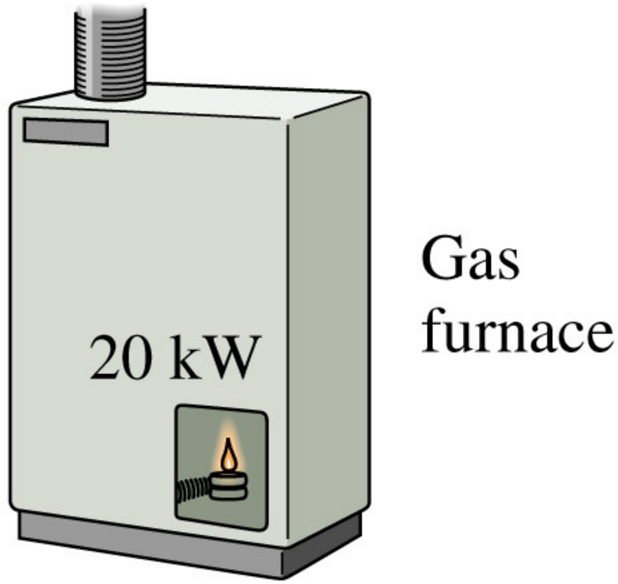
Thermal energy and thermal energy transfer are the keys to understand our house heating bills in winters, Green house effects and global warming, or climate changes in general (materials for week 3-5).

Power as the rate of energy transfer

Electrical energy $\longrightarrow$ light and heat at 100 J/s.

Chemical energy of glucose and fat $\longrightarrow$ mechanical energy at $\approx$350 J/s $\approx \frac{1}{2}$ hp.

Units: 1watt=1W=1J/s

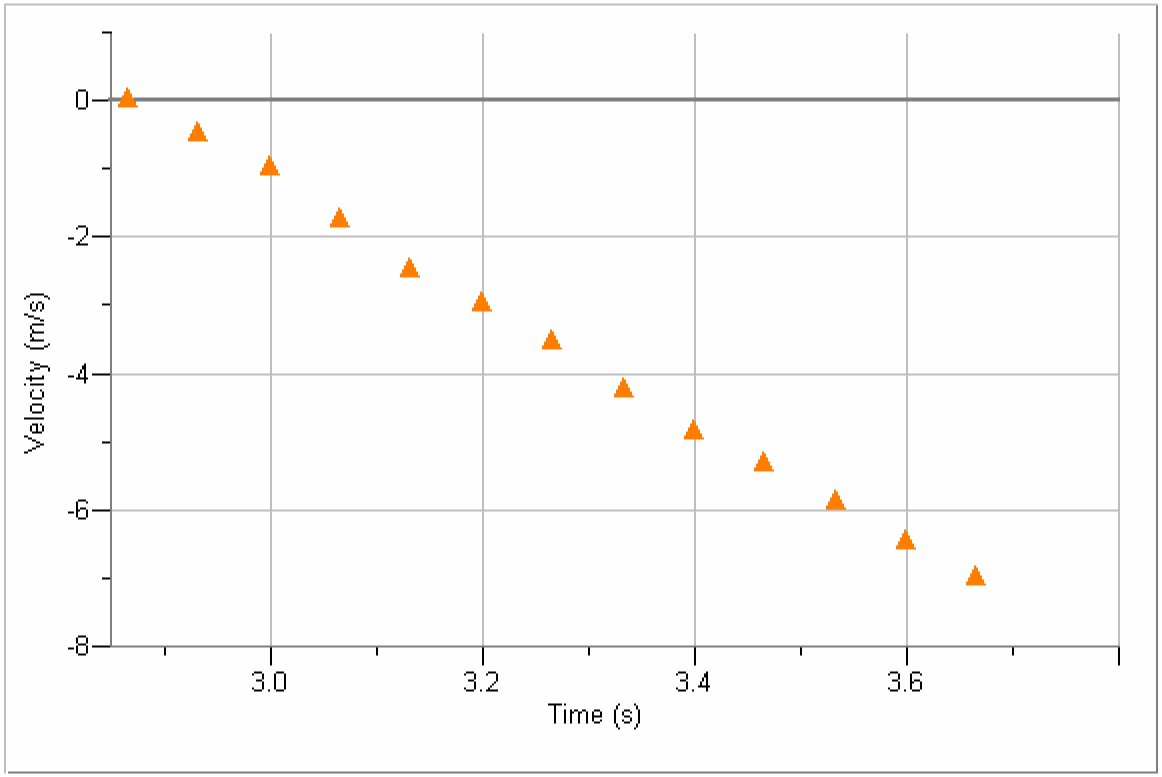


Chemical energy of gas → thermal energy at 20,000 J/s.

Non-mechanical energy transfer--- Heat

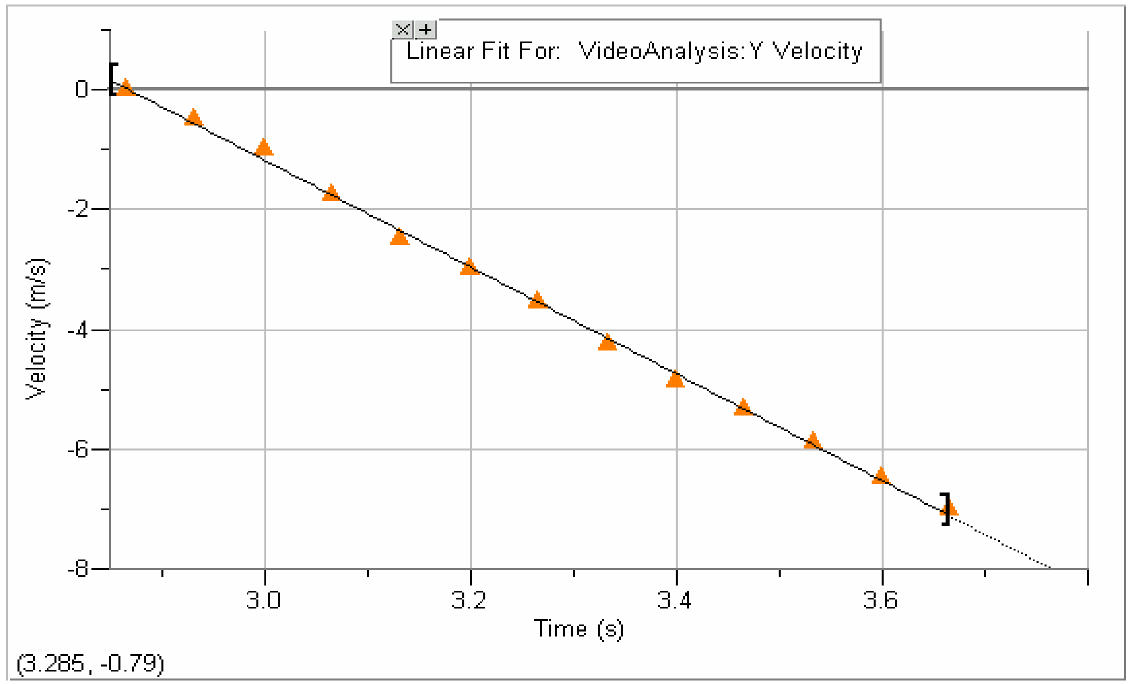
Curve Fitting

Example: Velocity of a falling object as a function of time.



Data: Velocity increases linearly with time (v is directly proportional to t): v(t) = a • t + b

- Linear regression:
  - yields slope a
  - y-intercept b.
  - Interpretation of a and b?



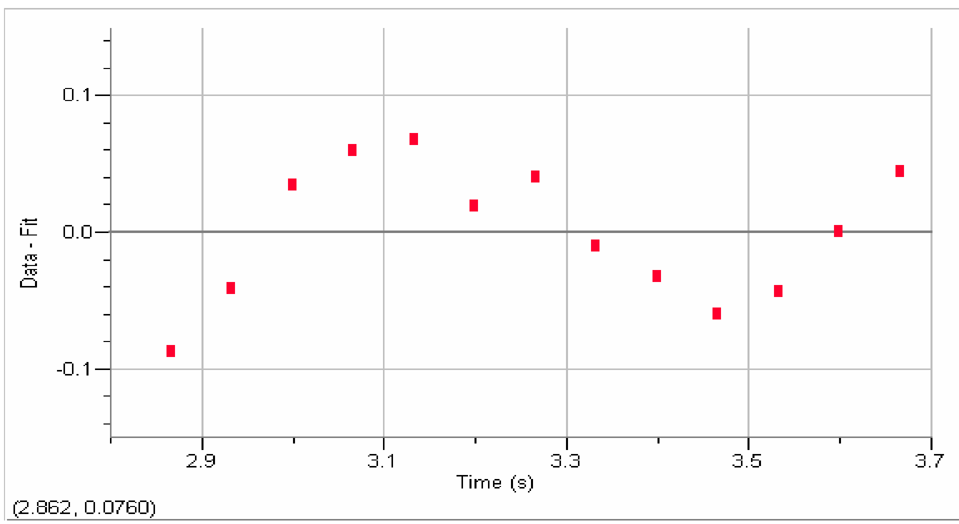
Good Fitting Criteria

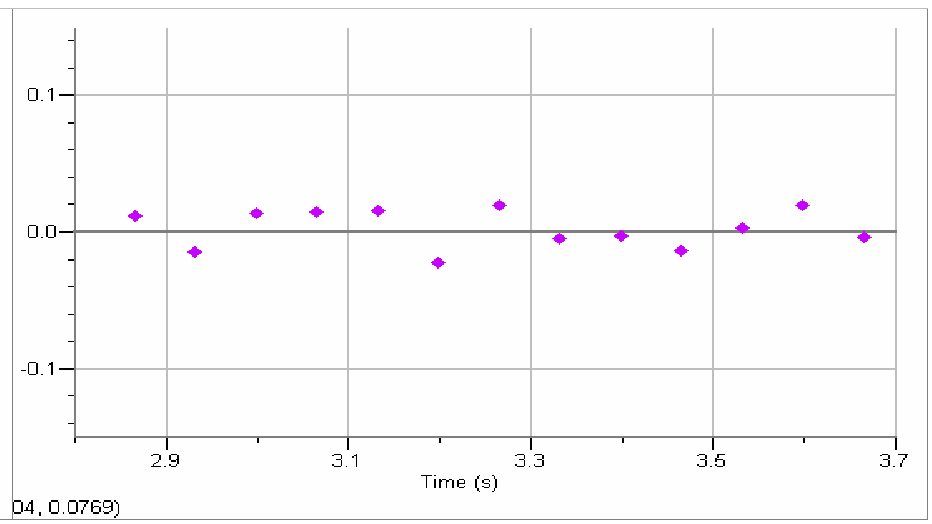
Experimental data randomly distributed around fitted curve.

RMSE value is minimized.

Data - Fit: Exponential function

Data - Fit: Parabola

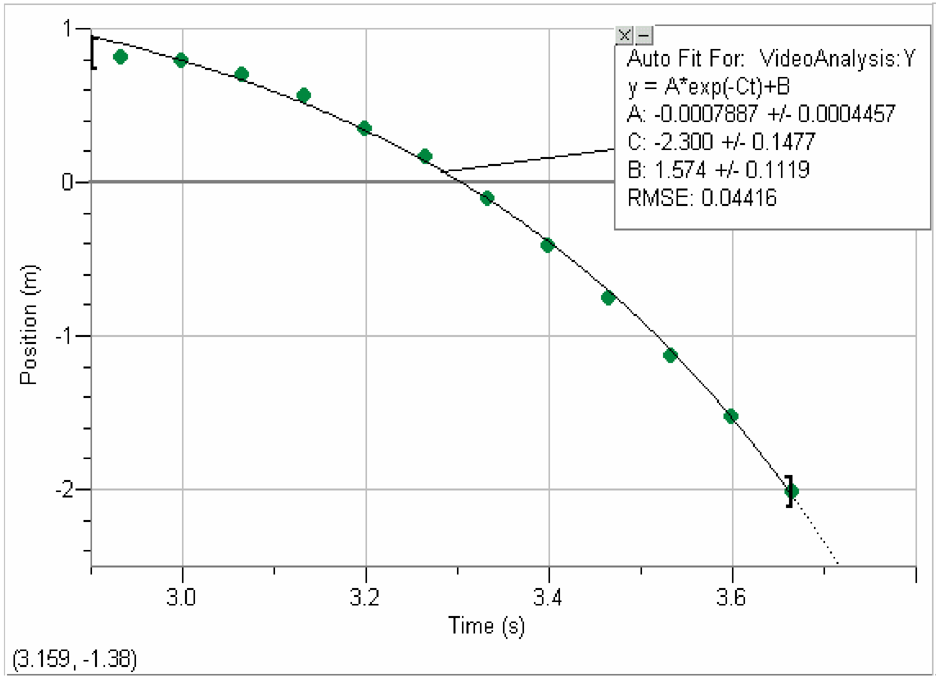




General Curves

- More complicated curves can be fitted.
- Example: position of a falling object as a function of time.
- Correct function?

Exponential function



Parabola