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Course 565/665 Lecture Number ____ Date 2/4/03

Lecturer Dr. Silvia Cavagnero Note Taker Eric Fulmer

## Last Time

Conserved Quantities - Mass, Momentum, and Energy.

**Force** (Newton's 2nd Law)

$$f = ma = m \cdot \frac{d^2 x}{dt^2} \quad ; \text{also} \quad v = \frac{dx}{dt}$$

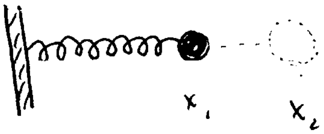
**Work**

$$\delta w = F_{\text{applied}}\, dx$$

Infinitesimal work = Applied force . Infinitesimal Displacement

In the case of a mass on a spring,

$\leftarrow$ $f = -kx$ "Hook's Law"



$$F = -f_{\text{applied}}$$

$f_{\text{applied}} \equiv$ pulling the spring.

$f \equiv$ brings the spring back to the equilibrium position.

$$W = -\int_{x_{\text{initial}}}^{x_{\text{final}}} F\, dx$$

$$W = \int_{x_{\text{initial}}}^{x_{\text{final}}} dw$$

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For simplicity, let $X_{\text{initial}} = 0$

$$W = -\int_0^{x_2} f\,dx = k\int_0^{x_2} x\,dx = \frac{k x_2^2}{2}$$

Conservative Forces

In the absence of dissipative forces (friction or other forces that cause heat production), work is conserved.

$$W = W_{AB} + W_{BA} = -\int_A^B f\,dx - \int_B^A f\,dx$$

$$= -\int_A^B f\,dx + \int_A^B f\,dx$$

$$= 0$$

Kinetic Energy (K) - the work that an object can perform by virtue of its ~~position~~ motion.

$$K = \frac{1}{2}mv^2$$

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Potential Energy (V) - The work that an object can perform by virtue of its position, where this position is in the absense of motion.

$$E_{TOTAL} = K + V = \text{constant} \qquad \text{(Conserved Quantity)}$$

Heat

- Concept of "Calorique" (Incorrect View of Heat) - Heat is matter and it flows.

Kinetic Theory of Gases

- Heat is a form of Energy.
- It has to do with intermolecular collisions.

$$\frac{3}{2}kT = \frac{1}{2}m\langle v^2\rangle$$

↑

heat ≡ thermal energy

Average molecular kinetic energy.

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## Quantum Theory

- At the macroscopic level, energy is quantized.
- Different atoms (or molecules) populate a discrete distribution of energy.

**Example**

| Energy Levels | $\varepsilon_i$ – the energy of each individual level |
|---|---|
| 4 | 26 |
| 3 | 21 |
| 2 | 16 |
| 1 | 5 |
| 0 | 0 |

How does W (Multiplicity) depend on energy?

- 3 distinguishable particles
- U ≡ internal energy.
- See figure 3.7 for the graphic.

$$\boxed{E \propto W}$$

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Example] Why does heat flow from hot to cold objects?

* 10 distinguishable particles.

A $U_A = 2$ COLD

B $U_B = 4$ HOT