Common Exam, Friday, April 13, 2007
8:30 – 9:45 A.M. at KUPF 205
Chaps. 6, 7, 8

Bring calculators
Arrive by 8:15

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Power

Work doesn't depend on the time interval

Work to climb a flight of stairs~3000 J

<table>
<thead>
<tr>
<th>Time</th>
<th>J</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 s</td>
<td>3000</td>
</tr>
<tr>
<td>1 min</td>
<td>3000</td>
</tr>
<tr>
<td>1 hour</td>
<td>3000</td>
</tr>
</tbody>
</table>

Power is work done per unit time

### Average Power

\[ P_{\text{avg}} = \frac{W}{\Delta t} \]

### Instantaneous Power

\[ P = \frac{dW}{dt} = F \frac{dx}{dt} = Fv \text{ (in 1D)} \]

<table>
<thead>
<tr>
<th>Units</th>
<th>Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>(\text{J/s}) = 1 Watt</td>
</tr>
<tr>
<td>time</td>
<td>(\text{hp}) = 746 W</td>
</tr>
</tbody>
</table>

In 2D & 3D, Power:

\[ P = \vec{F} \cdot \vec{v} = Fv \cos \theta \]
Work done by a constant force

\[ W = Fd \cos \theta \equiv \vec{F} \cdot \vec{d} \]

Power done by a constant force

\[ P = Fv \cos \theta \equiv \vec{F} \cdot \vec{v} \]

Sample problem 7-11

Two constant forces \( \vec{F}_1 \) and \( \vec{F}_2 \) acting on a box as the box slides rightward across a frictionless floor. Force \( \vec{F}_1 \) is horizontal, with magnitude 2.0 N, force \( \vec{F}_2 \) is angled upward by 60° to the floor and has a magnitude of 4.0 N. The speed \( v \) of the box at a certain instant is 3.0 m/s.

a) What is the power due to each force acting on the box? Is the net power changing at that instant?

b) If the magnitude \( \vec{F}_2 \) is, instead, 6.0 N, what is now the net power, and is it changing?
So far, we learned

*Ch. 7, Kinetic Energy and Work*

During the next two weeks, we learn

*Chapter 8. Potential Energy and Conservation of Energy*

**Concept of Potential Energy**

**Potential Energy**: Hidden energy associated with the position of objects

- Less kinetic energy, but More potential energy
- More kinetic energy, but Less potential energy
**Definition of Potential Energy**

**Potential energy change**

\[ U_f - U_i \equiv -W \]

**General Form:**

\[ W = \int_{x_i}^{x_f} F(x) \, dx \]
\[ \Delta U = -\int_{x_i}^{x_f} F(x) \, dx \]

**Example:**
- Gravitational potential energy
- Spring potential energy

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**Gravitational Potential Energy**

A tomato falling down

**Height:** \( h_i \)

\( v_i \)

\( d \)

\( h_f \)

\( v_f \)

**Gravitational force**

\( F_g = mg \)

**Gravitational potential energy difference:**

\[ U_f - U_i = -W = -mg(h_i - h_f) = mgh_f - mgh_i \]

Gravitational Potential Energy: \( U_g(h) = mgh \)
Elastic Potential Energy Difference

\[ U_f - U_i = -W = -\left( \frac{1}{2} kx_i^2 - \frac{1}{2} kx_f^2 \right) = \frac{1}{2} kx_f^2 - \frac{1}{2} kx_i^2 \]

Elastic Potential Energy

\[ U_{\text{elastic}}(x) = \frac{1}{2} kx^2 \]
Can we define potential energy for **any** force?

**Potential Energy:** Hidden energy associated with the position of objects

\[ U_f - U_i = -W = - \int_{x_i}^{x_f} F(x)dx \]

**Example 1: Gravitational force**

- \( h_1 \)
- \( h_2 \)
- \( h_3 \)
- \( h_4 \)

\[ F_g = mg \]

\( \rightarrow \) Work depends only on initial and final positions, independent of path

\( \rightarrow \) Potential energy at \( h \) can be defined

\( \rightarrow \) Conservative force

**Example 2: Friction force**

- \( F_k = \mu_k F_N \)

\[ \int_{\text{along path}} F(x)dx = - \mu_k F_N (x_4 - 2x_3 + 2x_2 - x_1) \]

\( \rightarrow \) Work depends on path, as well as initial and final positions

\( \rightarrow \) Potential energy at \( x \) cannot be defined.

\( \rightarrow \) Non-conservative force