“The release of atomic energy has not created a new problem. It has merely made more urgent the necessity of solving an existing one.”

- Albert Einstein

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PHYS 211
Energy is a scalar quantity that describes the current status of one or more objects and can take many forms.
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Energy is conserved but can transform from one type to another.
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Heavier and faster objects carry more energy.
The units of energy are (from $mv^2$) kg - $m^2/s^2$
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James Prescott Joule, not the Crowned Jewels.
Lecture Question 7.1
To see why professional baseball pitchers are remarkable, determine the difference in the kinetic energy of a baseball thrown at speed $v$ and one thrown at $2v$ and express the difference as a percentage [i.e., $(K_2 - K_1)/K_1 \times 100\%$].

(a) 50%
(b) 100%
(c) 200%
(d) 300%
(e) 400%
Work $W$ is defined as the amount of energy transferred to or from an object by means of a force.

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This is positive work; what would be negative?
The scalar product indicates that only the component of \( \vec{F} \) parallel to \( \vec{d} \) matters.
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The component of the force perpendicular to the motion does no work.
If two or more forces act on the object, the net work is the sum of the individual works done by each force.
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Remember: work can be zero or even negative.
Work

**Work-kinetic energy theorem:** *the change in kinetic energy of an object is equal to the net work done on that object.*

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Positive work gives an increase in KE; negative work gives a decrease in KE.
Lecture Question 7.2
Two wooden blocks (masses $m$ and $2m$) are sliding with the same kinetic energy across a horizontal frictionless surface. The blocks then slide onto a rough horizontal surface. Let $x_A$ be the distance that the light block slides before coming to a stop and $x_B$ the distance that the heavy block slides before it stops. Then,

(a) $x_A = x_B$
(b) $x_A = 2x_B$
(c) $x_A = 4x_B$
(d) $x_A = 0.5x_B$
(e) $x_A = 0.25x_B$
Like all forces, gravity can do positive or negative work on an object.
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\[ W_g = mgd \cos(\theta) \]
The force \textbf{from} a spring is given by $F_s = -kx$, where $k$ is the spring constant (stiffness) and $x$ is how far the spring is stretched/compressed.

![Diagram of a spring in different states: Unstretched, Compressed, Stretched](https://example.com/spring_diagram.png)
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The force always points in the opposite direction of the displacement.
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Each small amount of work is $\Delta W = F\Delta x$ or $dW = Fdx$. 
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\[ W = \int F(x) \, dx \]

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We compute the integral along a line of motion.
The work done by a spring is therefore:

\[ W = \int_{x_1}^{x_2} F(x) \, dx \]
Work Examples

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\[ W = \int_{\vec{r}_1}^{\vec{r}_2} \vec{F} \cdot d\vec{r} \]

\[ = \int_{x_1}^{x_2} F_x dx + \int_{y_1}^{y_2} F_y dy + \int_{z_1}^{z_2} F_z dz \]
Power

Power is the rate of work done, defined as

\[ P = \frac{dW}{dt} \quad \text{or} \quad P_{\text{avg}} = \frac{W}{\Delta t} \]

The unit of power is J/s which is known as the watt (W).

1 horsepower = 746 watts
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**Power**

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= F \cos(\theta) \frac{dx}{dt}
\]

\[
P = F v \cos(\theta)
\]

But in 3 dimensions,

\[
P = \vec{F} \cdot \vec{v}
\]
Lecture Question 7.4
A car is accelerated from rest to a speed $v$ in a time interval $t$. Neglecting air resistance effects and assuming the engine is operating at its maximum power rating when accelerating, determine the time interval for the car to accelerate from rest to a speed $2v$.

(a) $2t$
(b) $4t$
(c) $2.5t$
(d) $3t$
(e) $3.5t$