Phys141 – Fri 9/29

- **Today: Chapter 7+8 end**

Next week: Lab # 6!!

Extra office hours: Tuesday 10/3 9am-11am

HW solutions available before/after class

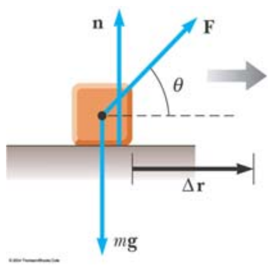
Work

Chapter 7

W=F * Δr

The normal force, **n**, and the gravitational force, *m* **g**, do no work for horizontal motion

The horizontal component of the force **F** does work on the object for horizontal motion



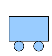
Work that has to be done on a moving car until it comes to rest

$F = ma \rightarrow a = \frac{F}{m}$ Newton 2nd

$v = at \rightarrow t = \frac{v}{a}$ Kinematic

$W = Fx = F\frac{1}{2}at^2 = \frac{F}{2}a\frac{v^2}{a^2} = \frac{F}{a}\frac{v^2}{2} = m\frac{v^2}{2}$

Kinematic

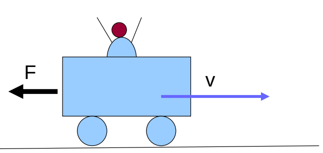


Work needed to stop from speed v
W= 1/2 m v^2

Same Work needed to stop car is the same magnitude but opposite sign as work needed to lift it to starting position

$v = \sqrt{2g\Delta r}$

$W = \frac{m}{2}2g\Delta r = mg\Delta r$



Work Done by a Varying Force

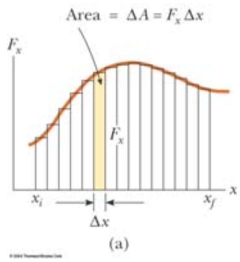
Assume: F is constant during a very small displacement Δx

For that displacement, $W = F\,\Delta x$

For all displacements,

$$W \approx \sum_{x_i}^{x_f} F_x \Delta x$$

$$\lim_{\Delta x \to 0} \sum_{x_i}^{x_f} F_x \Delta x = \int_{x_i}^{x_f} F_x dx$$

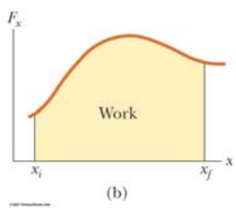


Work Done by a Varying Force

$$\lim_{\Delta x \to 0} \sum_{x_i}^{x_f} F_x \Delta x = \int_{x_i}^{x_f} F_x dx$$

Therefore, $W = \int_{x_i}^{x_f} F_x dx$

The work done is equal to the area under the F vs x curve



More general: $W = \int_{\vec{r}_i}^{\vec{r}_f} \vec{F} \bullet d\vec{r}$

Mechanical Energy

Without friction:

$\Delta E_{mech} = \Delta K + \Delta U = W$

ΔU is the change in all forms of potential energy

Elastic Potential Energy

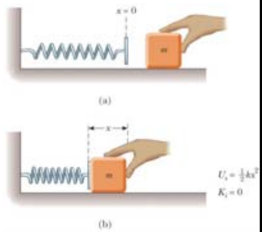
Work done by an external applied force on a spring-block system:
(define spring at rest: x=0)

F=kx (Hooke's law for spring)

$$W = \int F \cdot dr = \int (kx)dx$$

$$W = \frac{1}{2}kx^2$$

-> elastic potential energy:
$U_s = ½ kx^2$



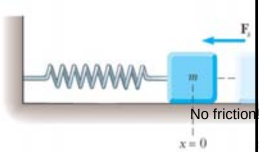
NOTE: Stored potential energy can be converted into kinetic energy

Force: Spatial Derivative of Potential Energy

$$F_x = -\frac{dU}{dx}$$

Spring potential Energy: $U_s = ½ kx^2$

$$F_s = -\frac{dU_s}{dx} = -\frac{d}{dx}\left(\frac{1}{2}kx^2\right) = -kx$$



Kinetic Energy: $K = ½ mv^2$ → $F = ??$

Gravitational potential Energy: $U=mgy$ → $F = \frac{dU}{dy} = mg$

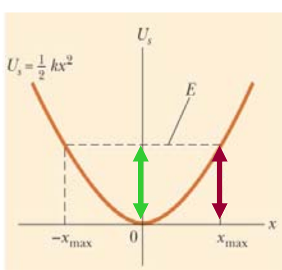
Interpreting Energy U(x)

At the point where U(x) is a minimum

-> *stable equilibrium*

i.e. no force exerted on object at x=0. Just above/below x=0 forces will push object back to x=0

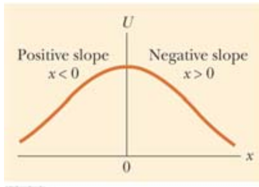
Object of energy E: two points x_{min} and x_{max} where all energy is potential energy, i.e. object does not move -> object moves between those two points



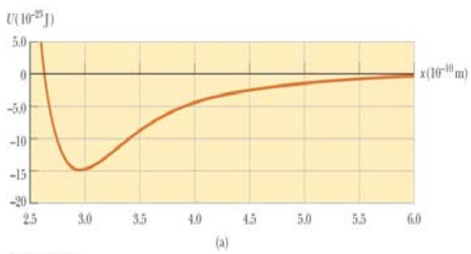
Another Energy Diagram

***U*(*x*) is a maximum**

-> ***unstable equilibrium***



Potential Energy Curve of a neutral atom



- " Lennard-Jones function"

Potential Energy

There are many forms of potential energy, including:

- Gravitational U=mg Δr
- Elastic
- Electromagnetic
- Chemical
- Nuclear

- All associated with ***conservative forces:***

"You always need the same work to get from A to B, no matter what path you take"

Conservative vs non-conservative forces

For **conservative** forces, the work done is independent of the actual trajectory that leads to a displacement Δr

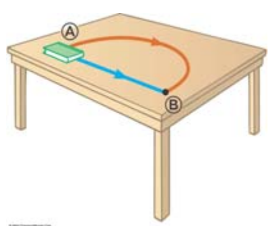
(conservative because they conserve energy)

Examples of **conservative** forces: Gravitational force, electromagnetic force

Example of **non-conservative** force: Friction, drag

Nonconservative Forces

- The work done against friction is greater along the red path than along the blue path
- Because the work done depends on the path, friction is a nonconservative force

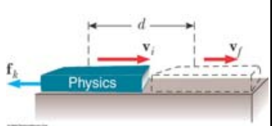


Internal Energy

Energy associated with an object's temperature: *internal energy*, E_{int}

Friction does work and increases the internal energy of the ***object and surface***

(NOTE: Drag does work and increases the internal energy of the ***object and surrounding fluid)***



Internal energy generally will **not** get converted back into useful work!

Mechanical Energy with nonconservative Forces

if friction is acting in a system:

$\Delta E_{mech} = \Delta K + \Delta U = -f_k d$

ΔU is the change in all forms of potential energy

If friction is zero, this equation becomes the same as Conservation of Mechanical Energy