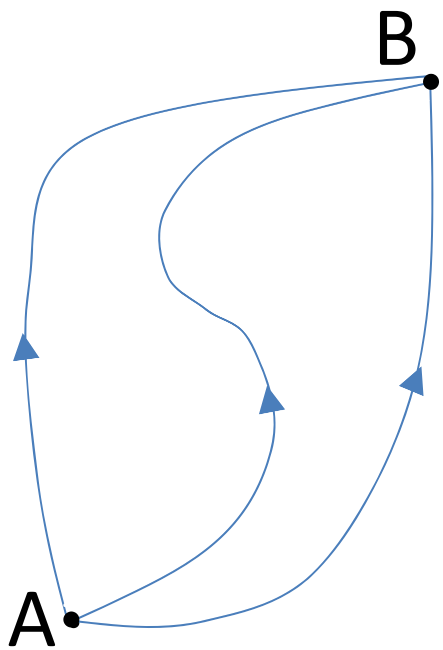
Class 9: Electric potential

Potential Energy U

If $\vec{F}(\vec{r})$ is conservative, the potential energy change ΔU is defined as the *negative* work done by the force $\vec{F}(\vec{r})$, which is path independent.

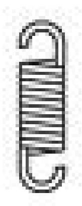


$$\Delta U = -\int_i^f \vec{F}(\vec{r}) \cdot d\vec{r}$$

Pay attention to the negative sign

Three common conservative forces

Spring



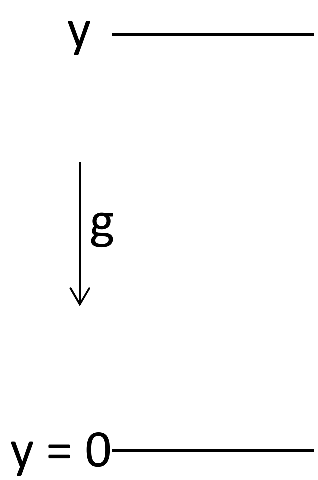
Hooke's Law:

$F = -kx$

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

(U at natural length = 0)

Earth surface

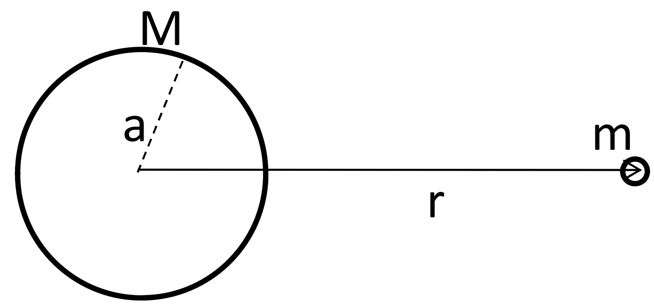


$F = -mg$

$U = mgy$

(U =0 at y = 0)

Uniform spherical object



For r >a only:

$$|F(r)| = G\frac{Mm}{r^2}$$

$$U(r) = -G\frac{Mm}{r}$$

$U(\infty) = 0$

Potential Energy U and Potential V

Force ⟶ Potential energy

↕ ↕

Field ⟶ Potential

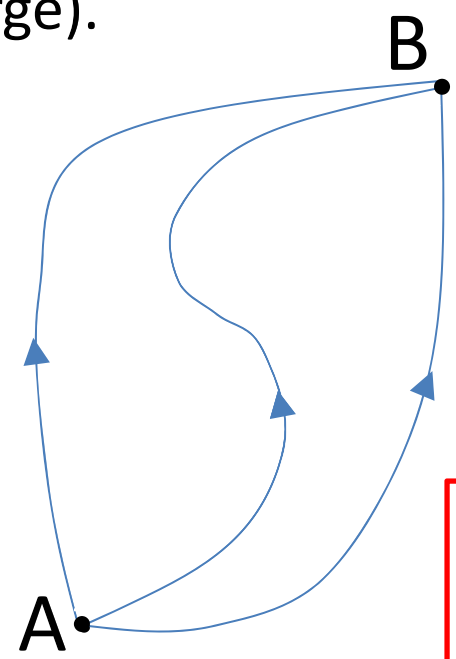
Potential energy (e.g. mgh) depends also on the properties (charge or mass) of the test particle. Potential depends on the source only.

Example:

Potential Energy	Potential
mgy	gy
$-G\frac{Mm}{r}$	$-G\frac{M}{r}$

Electric Potential V

If $\vec{E}(\vec{r})$ is conservative, the potential difference ΔV is defined as the <u>*negative*</u> work done by the force $\vec{F}(\vec{r})$ (which is path independent), divided by the charge (of the test charge).



$$\Delta U = -\int_i^f \vec{F}(\vec{r}) \cdot d\vec{r}$$

Pay attention to the negative sign

$$\Delta V = \frac{\Delta U}{q} = -\int_i^f \vec{E}(\vec{r}) \cdot d\vec{r}$$

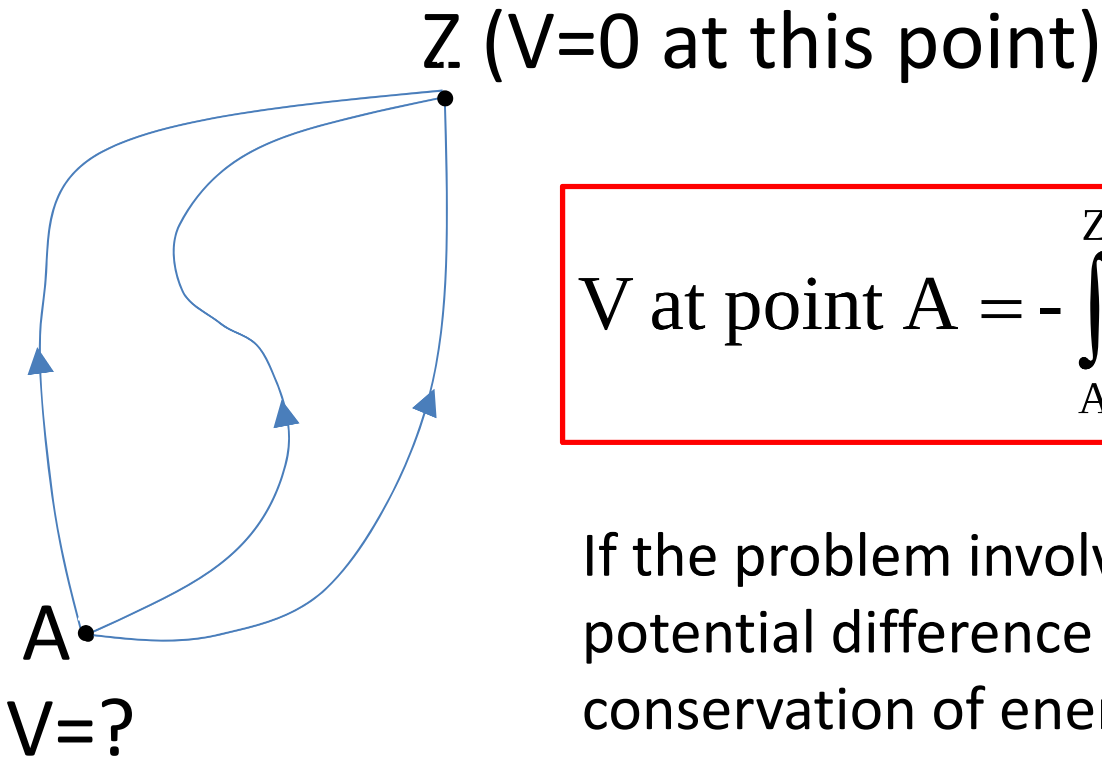
Units of electric potential = J/C =V

Warning

In the discussion here we will assume electric (force) field is a conservative (force) field. This will not be the case if there is a changing magnetic field. We will come to this point later in the semester.

Potential Difference and Potential

If we can define a point Z in space as a point with zero potential, then the potential of all other points in space is defined.



$$\text{V at point A} = -\int_{A}^{Z} \vec{E}(\vec{r}) \cdot d\vec{r}$$

If the problem involves only potential difference (e.g. conservation of energy), the choice of this zero point is not important.