Energy and Conservative Law

Conservation of Energy

Pristine form:

Change in kinetic energy = Total work done by the individual forces

$\Rightarrow$ Change in kinetic energy = Total work done by conservative forces + Total work done by non-conservative forces

$\Rightarrow$ $\Delta KE = -\Delta U +$ Total work done by non-conservative forces

$\Rightarrow$ $\Delta KE + \Delta U =$ Total work done by non-conservative forces

Secondary form

$\Rightarrow \Delta KE + \Delta U = W_{\text{non-conservative forces}}$

This is still *always* correct!

If there is no non-conservative forces:

$\Delta KE + \Delta U = 0 \quad \Leftrightarrow \quad KE + U = \text{constant}$

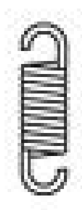
$\Leftrightarrow \quad (KE)_i + U_i = (KE)_f + U_f$

Close system form

This is correct only if there is no non- conservative force.

Three common conservative forces

Spring



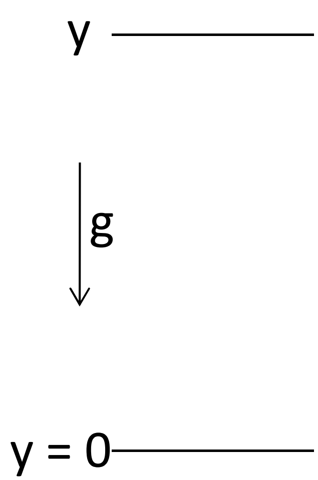
Hooke's Law:

$F = -kx$

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

(U at natural length = 0)

Earth surface

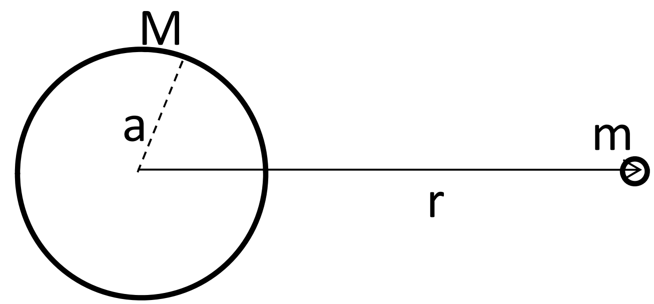


$F = -mg$

$U = mgy$

(U =0 at y = 0)

Uniform spherical object



For r >a only:

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

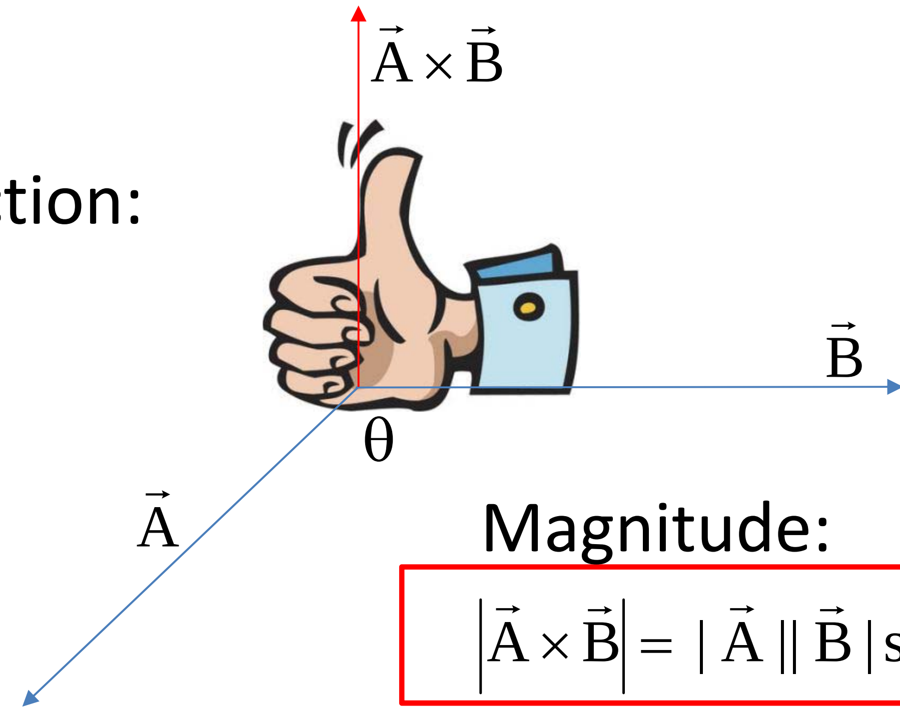
$$U(r) = -G\frac{Mm}{r}$$

$U(\infty) = 0$

Class 3: Torque and rotational motion

cross product between two vectors

Direction:



Magnitude:

$$\left|\vec{A} \times \vec{B}\right| = |\vec{A}||\vec{B}|\sin\theta$$

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix} = \hat{i}\begin{vmatrix} A_y & A_z \\ B_y & B_z \end{vmatrix} - \hat{j}\begin{vmatrix} A_x & A_z \\ B_x & B_z \end{vmatrix} + \hat{k}\begin{vmatrix} A_x & A_y \\ B_x & B_y \end{vmatrix}$$

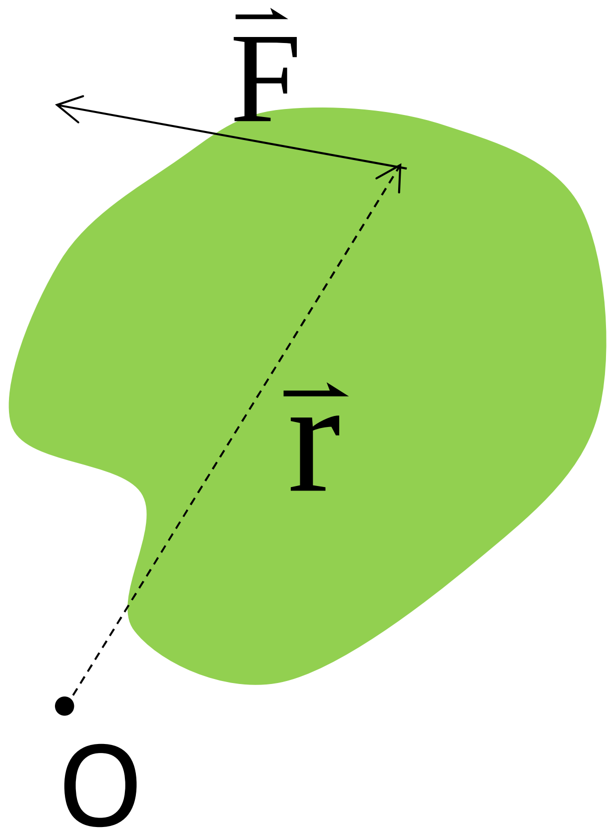
$$\begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc$$

A common symbol

$\otimes$ or $\times$ A vector perpendicular and pointing into the screen /paper.

$\odot$ or $\bullet$ A vector perpendicular and pointing out of the screen /paper.

Torque



$$\tau = \vec{r} \times \vec{F}$$

Torque depends on:
(i) at what point of the rigid body the force is acting on.
(ii) how we choose the origin.