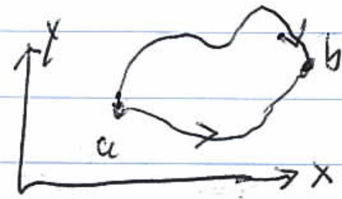
Non-dissipative forces

~~$\vec{F} = x$~~ work ~~going~~ by a force from ~~pt.~~ (a) to point (b)



independent of path

$\int F$

$dW = F_x dx + F_y dy + F_z dz = \vec{F} \cdot d\vec{r}$

$W = \int_{\vec{r}_0}^{\vec{r}} \vec{F} \cdot d\vec{r} = -$ ~~$U(x, y, z)$~~

= − change of potential energy

$= -\left(U(x, y, z) - U(x_0, y_0, z_0)\right)$

~~What are non-dissipative force~~

Forces

(1) gravitational force, (2) spring force ~~$F = -kx$~~ (3) kinetic friction force ~~$F = \mu_k N$~~

(4) drag force of air ~~$F = -\gamma v$~~

which forces are non-dissipative

(a) (1) & (2)   (c) (3) & (4)   ~~(e) (1) & (3)~~

(b) (2) & (3)   ~~(d) (4) & (1)~~

(over)

mechanical energy

(1) ~~transla~~ kinetic energy of ~~and object~~ a point object

(2) potential energy of a point object.

(3) rotational kinetic energy of a finite sized object

non-mechanical energy

(1) heat energy (random motion ~~of ato~~ and random compressions/stretchings of heated objects (thermodynamics

(2) electrical energy

(3) chemical energy 1 ~ calorie 4.18 J

Calori (kilocalorie) 1000 calories (energy content of snicker bars)

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restricted energy principle

conservation of mechanical energy

under the action of conserved force the total mechanical energy of a point particle is conserved

$$\frac{1}{2}mv^2 + U(x,y,z) = \frac{1}{2}mv_0^2 + U(x_0,y_0,z_0) \quad (2)$$

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

If I drop a ball, at rest, from a height h, how fast will it ~~will it~~ be when it hits the ground.

$U = mgy$, let ground be a $y=0$

$mgh = mgy + \frac{1}{2}mv^2$

at $y=0$ $= 0 + \frac{1}{2}mv^2$

$\frac{v^2}{2} = gh$

$v^2 = 2gh$, $v = \sqrt{2gh}$

It is change of potential energy that is important.

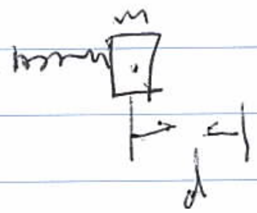
and potential energy is ~~not of~~ only defined to within a constant

e.g ask the same question when

$U = mg(y+y_0)$, can we find same answer

$mg(h+y_0) = \cancel{mg}\ PE(y=0) + \frac{1}{2}mv^2$

$= mgy_0 + \frac{1}{2}mv^2 \therefore, \boxed{v^2 = 2gh,}$ $v = \sqrt{2gh}$



stretch ~~stretched~~ string a distance d then release

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

~~what is~~

what is speed at ~~x=~~ $x=0$

$$\frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kd^2$$

$$v^2 = \frac{kd^2}{m}$$

$$\boxed{v = \sqrt{\frac{k}{m}}\,d}$$

Power $\equiv \frac{dW}{dt}$ = time rate of change on energy

or rate work is done

$$\text{Power} = \vec{F}\cdot\vec{v}$$

$$dW = \vec{F}\cdot d\vec{r}$$

$$\frac{dW}{dt} = \vec{F}\cdot\frac{d\vec{r}}{dt} = \vec{F}\cdot\vec{v}$$

More accurate form of gravitational force

$$|\vec{F}_{12}| = \frac{G m_1 m_2}{r^2}$$ attractive force

$G \simeq 6.67 \times 10^{-11}$ mks/units

what is the basic form of these units?

$$\frac{G \cancel{m_1} m_2}{r^2} = \cancel{m_1} a$$

$$G = \frac{r^2 a}{m} = m^2 \frac{m}{s^2} \frac{1}{kg} = \frac{m^3}{s^2 kg}$$

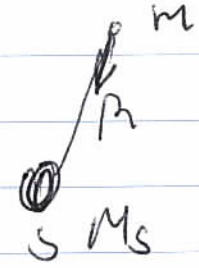
or

$$\frac{G m_1 m_2}{r^2} = N$$

$N = kg \frac{m}{s^2}$

$$G = \frac{N m^2}{kg^2}$$

Period about a celestial body



period

$$\cancel{v}T = 2\pi R$$

$$T = 2\pi \frac{R}{v}$$

frequency $= f = \frac{1}{T} = \frac{v}{2\pi R}$

radian frequency $= \omega = 2\pi f = \frac{v}{R}$

$$ma = G\frac{mM}{R^2}$$

$$a = \frac{v^2}{R}$$

$$\frac{\cancel{m}v^2}{R} = G\cancel{m}\frac{M}{R^2}$$

$$= \frac{v^2}{R^2} = G\frac{M}{R^3}$$

$$\|$$

$$\left(\frac{2\pi}{T}\right)^2 = G\frac{M}{R^3}$$

$$\cancel{T = (GM)^{1/2}}$$

$$T^2 = \frac{(2\pi)^2 R^3}{GM}, \quad T = \frac{2\pi R^{3/2}}{(GM)^{1/2}}$$

This is one of Keplers Laws Period $\propto R^{3/2}$

g related to universal law

Force at edge of sphere same as force due to mass concentrated at center, distance R away

$$F = \frac{G M_E m}{R_E^2} = mg$$

$$g_E = \frac{G M_E}{R_E^2}$$

$$g_{moon} = \frac{G M_M}{R_M^2}$$

$$g_S = \frac{G M_S}{R_S^2}$$

Take $g_E = 10\ m/s^2$, $g_M = 1.6\ m/s^2$

~~The~~

T or F

The weight of a 100 kg person on the surface of the Earth is about 1000 N

T F

The mass of a 100 kg person on the moon is ~~about~~ 100 kg

T F

The weight of a 100 kg person on the moon is about 1000 N

T F

~~$\bar{E}$ sea~~

Gravitational Potential Energy

$$PE_g = -\int_{-\infty}^{\infty} \vec{F} \cdot d\vec{r}$$

$$= GmM \int_{\infty}^{r} \frac{dr'}{r'^2}$$

$$= -GmM \left. \frac{1}{r'} \right|_{-\infty}^{r}$$

$$\boxed{PE_g = -\frac{GmM}{r}}$$

How high can a rocket go when blasted off with a velocity V_0

$\cancel{\frac{1}{2}G}$ $KE_i + PE_i = KE_f + PE_f$

$$\frac{1}{2} m_r V_i^2 - \frac{G M_E m_r}{R_E} = -\frac{G M_E m_r}{R_E + h} \quad + KE = 0$$

$$\boxed{\frac{1}{2} V_i^2 = G M_E \left(\frac{1}{R_E} - \frac{1}{R_E + h} \right)}$$

Solve for $\frac{h}{R_E}$

$$\frac{V_i^2}{2GM_E} = \frac{1}{R_E} - \frac{1}{R_E+h}$$

$$\frac{1}{R_E+h} = \frac{1}{R_E} - \frac{V_i^2}{2GM_E}$$

$$R_E + h = \frac{1}{\frac{1}{R_E} - \frac{V_i^2}{2GM_E}}$$

$$\frac{h}{R_E} = \frac{1}{1 - \frac{V_i^2 R_E}{2GM_E}} - 1$$

$$\boxed{\frac{h}{R_E} = \frac{V_i^2 R_E / 2GM_E}{1 - \frac{V_i^2 R_E}{2GM_E}}}$$

$\frac{h}{R_E} > 0$ if $\frac{V_i^2 R_E}{2GMe} < 1$, ∞

goes ∞ if $V_i^2 \to \frac{2GMe}{Re} = V_{esc}^2$

$$V_i > V_{esc} = \sqrt{\frac{2GM_E}{R_E}}$$

How fast is a escaping rocket far from Earth

~~[illegible]~~

$$\frac{1}{2}mV_i^2 - \frac{G\cancel{m}M_E}{R_E} = \frac{1}{2}mV_\infty^2$$

$$V_\infty^2 = V_i^2 - \frac{2G\cancel{m}M_E}{R_E}$$