$\Delta U = U_f - U_i$
$U_i - U_f$

III-8 Conservation of the Mechanical energy

$$\underbrace{\sum W_{\vec{F}}}_{} = \Delta KE = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

For a conservative force

$$W_{\vec{f}} = -\Delta U = U_i - U_f$$

$$\sum W_{\vec{f}} = U_i - U_f = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

if all the force are conservative

$$U_i + \frac{1}{2} m v_i^2 = U_f + \frac{1}{2} m v_f^2$$

$$ME_i = ME_f$$

Non Conservative forces:

$$\sum W_{\vec{F}} = \Delta KE$$

$$W_{\text{conservative forces}} + \underset{\text{non conservative}}{W_{\vec{f}}} = \Delta KE$$

$$U_i - U_f + W_{\vec{f}\,n.c} = KE_f - KE_i$$

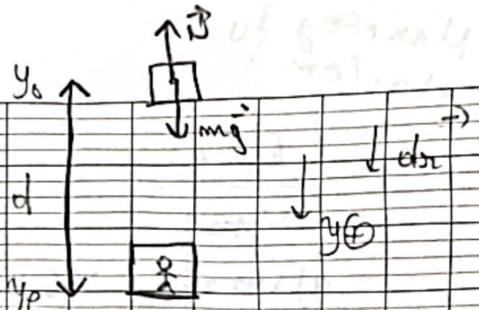
$$\underbrace{W_{\vec{f}}}_{n.c} = ME_f - ME_i = \Delta ME$$

$$W_{\text{non-conservative force}} = \Delta ME$$

the variation of the ME is equal to the work done by the non-Conservative force. the ME is lost by the system and transformed to another form of energy. (internal energy)

Net force = $\sum F_{ext}$

tutorial



Ex 1:

$a = 4\ m/s^2$ $\quad v_0 = 0$ $\quad d = 6\ m$

$W_{m\vec{g}}, W_{\vec{N}}$

$W_{m\vec{g}} = \int m\vec{g} \cdot d\vec{r} = mg\int dr = mgd = 700 \times 6 = 4200\ J > 0$

$W_{\vec{N}} = \int \vec{N} \cdot d\vec{r} = -\int N \cdot dr$

FRD $= \vec{N} + m\vec{g} = m\vec{a}$

proj on y : $-N + mg = ma$

$N = m(g - a) = 70 \times 6 = 420\ N$

$W_{\vec{N}} = -N \cdot d = 420 \times 6 = -2520\ J < 0$

$\vec{N}$ oppoes the mot°

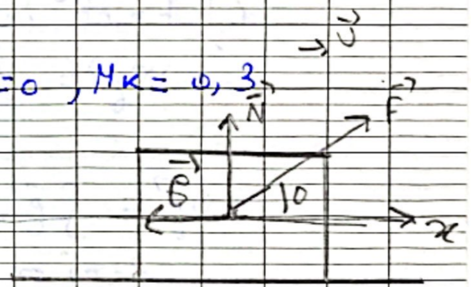
$\sum W_{\vec{F}} = \Delta KE$ $\quad ; a = cst \Rightarrow v_f^2 - v_i^2 = 2ad \Rightarrow v_f = \sqrt{2ad}$

$\Delta KE = 1680\ J = \sum W_{\vec{F}}$; $\sum W_{\vec{F}ext} = 1680\ J > 0$

the net force ($\sum \vec{F}_{ext}$) helps the motion of the man and constibute in increasing his kinetic energy $v \nearrow$; $a > 0$

Ex 3:

$\theta = 10x$ $\quad v_f = ?$ $\quad x = 3m$ $\quad v_i = 0$, $\mu_k = 0,3$



$\sum W_{\vec{F}} = \Delta KE$

$W_{\vec{F}} + \overset{0}{W_{m\vec{g}}} + \overset{0}{W_{\vec{N}}} + W_{\vec{f}} = \frac{1}{2} m v_f^2$

$m\vec{g} \perp d\vec{r}$ $\quad \vec{N} \perp d\vec{r}$

$W_{\vec{F}} = \int \vec{F} \cdot d\vec{r} = \int F \cdot \cos\theta \cdot dx$

$= F \int \cos(10x)\, dx$

$= \frac{F}{10} \sin(10x) \Big|_0^x = \frac{F}{10} \sin(10x)$

$* \; W_{\vec{f}} = \int \vec{f} \cdot d\vec{r} = \int -f \cdot dx$ $\qquad f = \mu_k N$

$= -\mu_k \int_0^x (mg - F\sin(10x))\, dx$ $\qquad$ FRD: $\vec{N} + m\vec{g} + \vec{F} + \vec{f} = m\vec{a}$

$= -\mu_k \left[mgx + \frac{F}{10}\cos(10x)\right]_0^x$ $\qquad$ Proj on y: $N - mg + F\sin\theta = 0$

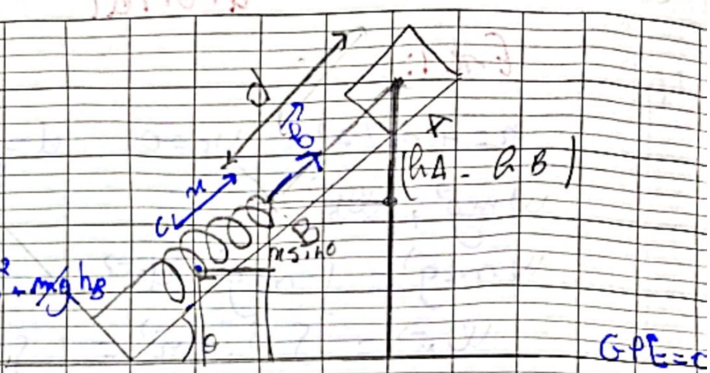
$= -\mu_k \left[mgx + \frac{F}{10}\cos 10x - \frac{F}{10}\right]$ $\qquad N = mg - F\sin\theta$

$\sum W_{\vec{F}ext} = \frac{1}{2} m v_f^2 \Rightarrow \frac{F}{10} \sin 10x - \mu_k \left(mgx + \frac{F}{10}\cos 10x - \frac{F}{10}\right) = \frac{1}{2} m v_f^2$

Max elog } $v=0$
Max Com

Ex 4:

$v_A = 0$



a) $v_B = ??$ $ME_A = ME_B$

$$\frac{1}{2}\cancel{m}\cancel{v_A}^2 + \cancel{m}g h_A = \frac{1}{2}\cancel{m}v_B^2 + \cancel{m}g h_B$$

$$v_B^2 = 2g(h_A - h_B)$$

$$v_B = \sqrt{2g \cdot d\sin\theta} = \sqrt{10}\ m/s$$

b) At C: max Compression. $v_C = 0$.

$x = ?$

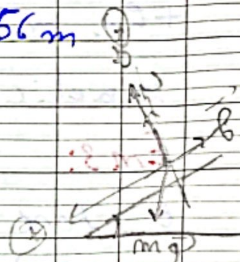
$ME_B = ME_C$ $\quad \frac{1}{2}mv_B^2 + mgh_B = \frac{1}{2}m\cancel{v_C^2} + mgh_C + \frac{1}{2}kx^2$

$$\frac{1}{2}mv_B^2 + mg(h_B - h_C) = \frac{1}{2}kx^2$$

$$\frac{1}{2}mv_B^2 + mgx\sin\theta = \frac{1}{2}kx^2$$

$$25x^2 - 5x - 5 = 0 \qquad x_{max} = 0{,}56\ m$$

c) Frict° is not negligible



$$W_{\vec f} = \Delta ME_{A \to C} = ME_C - ME_A$$

$$W_{\vec f} = \int \vec f \cdot d\vec r = -\int f \cdot dr \qquad \text{FRD}: \vec N + m\vec g + \vec f = m\vec a$$

Proj on: $N - mg\cos\theta = 0 \Rightarrow N = mg\cos\theta$

$$\Rightarrow W_{\vec f} = -\int \mu mg\cos\theta \cdot dr = -\mu mg\cos\theta(d+x)$$

$$W_{\vec f} = ME_C - ME_A$$

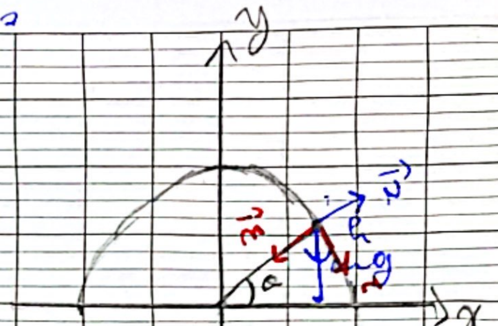
$$-\mu mg\cos\theta(d+x) = \frac{1}{2}m\cancel{v_C^2} + mgh_C + \frac{1}{2}kx^2 - mgh_A - \frac{1}{2}m\cancel{v_A^2}$$

$$\mu = \frac{\frac{1}{2}kx^2 + mg(h_C - h_A)}{-mg\cos\theta(d+x)} = 0{,}3$$

$$[(h_C - h_A) = -(d+x)\sin\theta]$$

إذا طلبه و مناظرها

Radians



Ex 7:

the boy loses contact when

$N \leq 0$

FRD: $\vec{N} + m\vec{g} = m\vec{a}$

proj $\vec{n}$: $-N + mg\sin\theta = m\frac{v^2}{R}$

$N = m\left(g\sin\theta - \frac{v^2}{R}\right) = m\left(g\frac{h}{R} - \frac{v_B^2}{R}\right) = \frac{m}{R}\left(gh - v_B^2\right) \leq 0$

let's find v_B

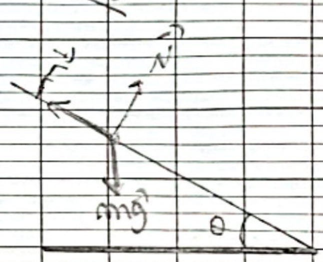
$ME_A = ME_B$ $\quad \frac{1}{2}\cancel{m}v_A^2 + \cancel{m}g.R = \frac{1}{2}\cancel{m}v_B^2 + \cancel{m}gh_B$

$v_B^2 = \cancel{v_A^2}^{\,0} + 2g(R - h_B)$

$N = \frac{m}{R}\left(g h_B - 2gR + 2gh_B\right) \leq 0$

$3h_B - 2R \leq 0$

$h_B \leq \frac{2R}{3}$ $\qquad h_B \leq 9{,}2$



Ex 8:

$P = \vec{F}.\vec{v} = F.v \Rightarrow$

$F = \frac{P}{v} = \frac{250 \times 10^3 (w)}{15} = 16.666\,N$

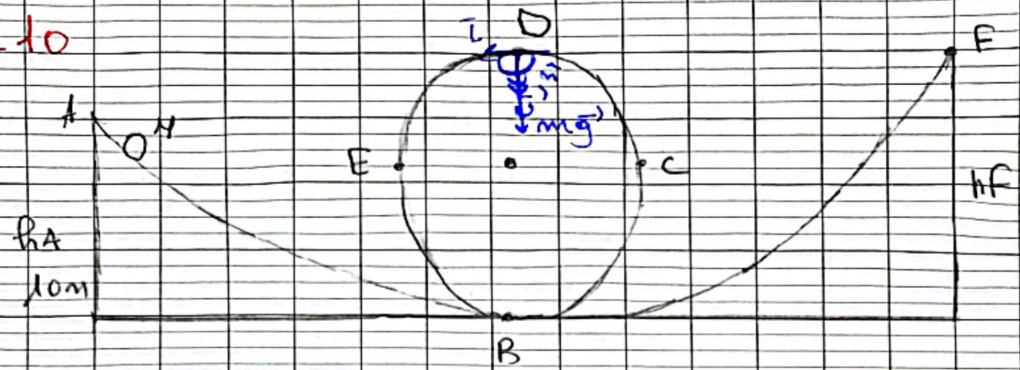
FRD: $m\vec{g} + \vec{N} + \vec{F} = m.\vec{a}$ $\qquad$ proj on x: $-mg\sin\theta + 0 + F = 0$

$\sin\theta = \frac{F}{mg} = 0{,}11$

$\theta = 6{,}3°$

Ex 10:

Ex 10



$r = 10m$, $h_A = 10m$, $h_F = 15m$

a) the ball can reach F if it pass point D and completes the circular part.

$N_D > 0$

FRD at D : $m\vec{g} + \vec{N} = m\vec{a}$

proj on $\hat{n}$ $\quad mg + N = m\frac{V_D^2}{r}$

$N = m\left(\frac{V_D^2}{r} - g\right) > 0$ $\qquad \frac{V_D^2}{r} > g$

$V_A = ??$ $\qquad V_D^2 > rg$

$ME_A = ME_D$ $\qquad \frac{1}{2}\cancel{m}V_A^2 + \cancel{m}gh_A = \frac{1}{2}\cancel{m}V_D^2 - \cancel{m}gh_D$

$V_A^2 \geq V_D^2 + 2g(2R - h_A)$

the ball should be lanched with $V_A > 17,32 m/s$

$V_{A\,min}^2 \geq V_{D\,min}^2 + 2g(2 - h_A)$

$V_{A\,min} = 17,32 m/s$

b) $V_F = ?$ $\quad ME_A = ME_F$

$\frac{1}{2}mV_A^2 + mgh_A = \frac{1}{2}mV_F^2 + mgh_F$

$V_F^2 = V_A^2 + g(h_A - h_F)$

$V_{F\,min} = \sqrt{\quad} = 14,4 m/s$