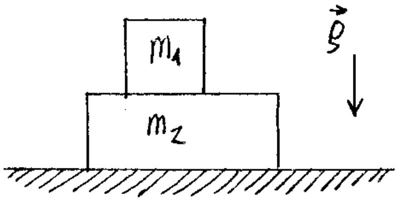
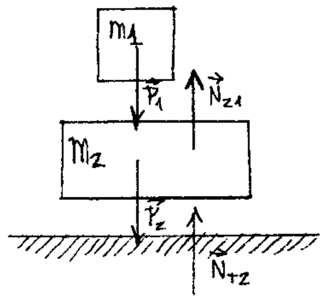
DINAMICA - INTERACCIONES

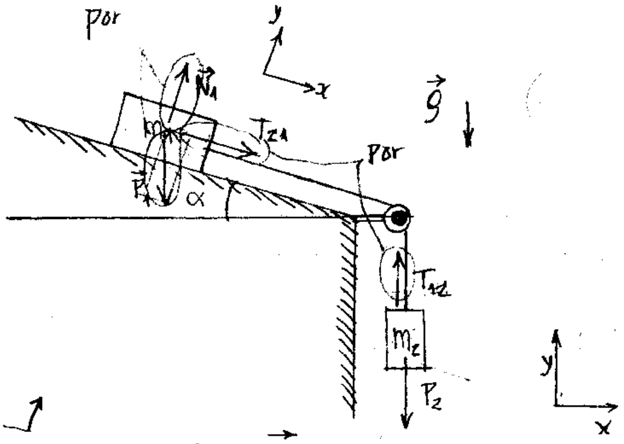
1.

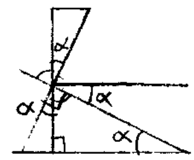




$$\vec{P}_1 = \vec{N}_{21} = m_1 . \vec{g}$$
$$\vec{P}_2 = \vec{N}_{T2} = m_2 . \vec{g}$$

2.





$$P_{1x} = P_1 . \text{sen}\,\alpha$$
$$P_{1y} = P_1 . \cos\alpha$$

a) b)

$$m . \vec{a} = \vec{F}$$

$$m_1 . \vec{a}_1 = \vec{N}_1 + \vec{P}_1 + \vec{T}_{21} \qquad (1)$$
$$m_2 . \vec{a}_2 = \vec{P}_2 + \vec{T}_{12} \qquad (2)$$

(1) $m_1 . a_{1x} = \underbrace{N_{1x}}_{0} + P_1 . \text{sen}\,\alpha + T_{21} \Rightarrow \quad m_1 . a_{1x} = m_1 . g . \text{sen}\,\alpha + T_{21}$

$m_1 . \underbrace{a_{1y}}_{0} = N_{1y} - P_1 \cos\alpha \Rightarrow \quad N_1 = m_1 . g . \cos\alpha$

(2) $m_2 . \underbrace{a_{2x}}_{0} = \underbrace{P_{2x}}_{0} + \underbrace{T_{12x}}_{0} = 0$

$m_2 . a_{2y} = -m_2 . g + T_{12y} = -m_2 . g + T_{12}$

Cuerda inextensible $\therefore$ $|\vec{a}_1| = |\vec{a}_2|$ $\Rightarrow$ $a_{1x} = a_{2y} = a$
masa soga $\cong 0$ $\therefore$ $|\vec{T}_{21}| = |\vec{T}_{12}|$ $\quad T_{21} = T_{12} = T$

a_{1x} siempre $\rightarrow$
a_{2y} siempre $\downarrow$
(tienen el mismo sentido pero diferente signo porque son ejes distintos)

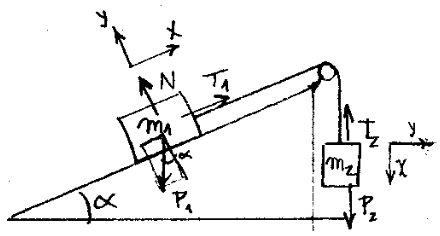
$$\begin{cases} m_1 . a = m_1 . g . \text{sen}\,\alpha + T \\ m_2 . a = -m_2 . g + T \end{cases}$$

$$a(m_1 - m_2) = g\left(m_1 \text{sen}\,\alpha + m_2\right)$$

$$\boxed{a = \frac{g\,(m_1 . \text{sen}\,\alpha + m_2)}{(m_1 - m_2)}}$$

3.

$$\frac{m_1}{m_2} = 9 \qquad \sum \vec{F} = m.\vec{a} \qquad P_x = \operatorname{sen}\alpha . P_1$$



1

$\hat{x})\ m_1 . a_x = T_1 - m_1 . g . \operatorname{sen}\alpha$

$\hat{y})\ m_1 . \underbrace{a_y}_{0} = N_1 - m_1 . g . \cos\alpha$

$N_1 = m_1 . g . \cos\alpha$

soga inextensible

soga de masa $\to 0 \ \therefore\ |\vec{T_1}| = |\vec{T_2}|$

2

$\hat{x})\ m_2 . \overset{0}{a_y} = 0$

$\hat{y})\ m_2 . a_x = -T_2 + m_2 . g .$

sistema A

$V_0 = 0$

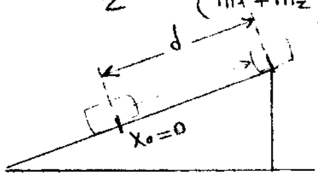
$V(t) = V_0 + a.t$

$X(t) = \underbrace{X_0}_{0} + \underbrace{V_0}_{0}.t + \frac{1}{2}.a.t^2$

$a(m_1 + m_2) = g(-m_1 . \operatorname{sen}\alpha + m_2)$

$a = g\frac{(m_2 - m_1 . \operatorname{sen}\alpha)}{(m_1 + m_2)}$

$X(t) = \frac{g}{2} . \frac{(m_2 - m_1 \operatorname{sen}\alpha)}{(m_1 + m_2)} . t^2 \Rightarrow d = 4.9 . \frac{(m_2 - m_1 . \operatorname{sen}\alpha)}{(m_1 + m_2)} T^2$



2

$\hat{x})\ m_2\, a_x = T_1 - m_2 g . \operatorname{sen}\alpha$

$\hat{y})\ m_2 . \underbrace{a_y}_{0} = N_1 - m_2 . g . \cos\alpha$

sistema B

1

$\hat{x})\ m_1 . \overset{0}{a_x} = 0$

$\hat{y})\ m_1 . a_x = -T_2 + m_1 g$

$X(t) = \frac{g}{2} . \frac{(m_1 - m_2 . \operatorname{sen}\alpha)}{m_2 + m_1} t^2$

$d = 4.9 . \frac{(m_1 - m_2 \operatorname{sen}\alpha)}{(m_2 + m_1)} . \frac{T^2}{16}$

$a(m_2 + m_1) = g(-m_2 \operatorname{sen}\alpha + m_1)$

$a = g\frac{(m_1 - m_2 . \operatorname{sen}\alpha)}{(m_2 + m_1)}$

$\Rightarrow$

$\cancel{4.9} . \frac{(m_1 - m_2 \operatorname{sen}\alpha)}{\cancel{(m_2 + m_1)}} \frac{\cancel{T^2}}{16} = 4.9 . \frac{(m_2 - m_1 \operatorname{sen}\alpha)}{\cancel{(m_1 + m_2)}} . \cancel{T^2}$

$m_1 - m_2 \operatorname{sen}\alpha = 16 m_2 - 16 m_1 . \operatorname{sen}\alpha$

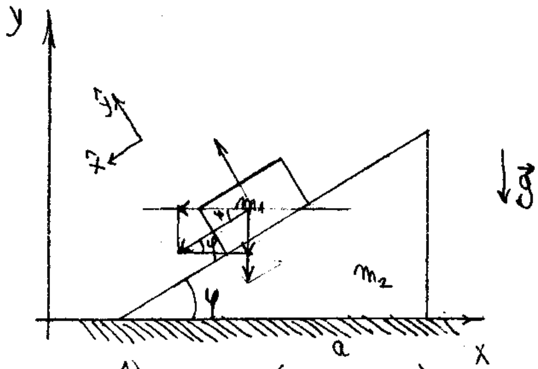
$m_1 - 16 m_2 = -16 m_1 \operatorname{sen}\alpha + m_2 \operatorname{sen}\alpha$

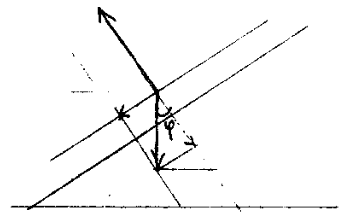
$m_1 - 16 m_2 = -\operatorname{sen}\alpha\,(16 m_1 + m_2)$

$\cancel{m_2}(9 - 16) = \operatorname{sen}\alpha . \cancel{m_2}(-16.9 + 1)$

$\left(\frac{-7}{-143}\right) = \operatorname{sen}\alpha \Rightarrow \boxed{\alpha = 2°48'21''}$

4.

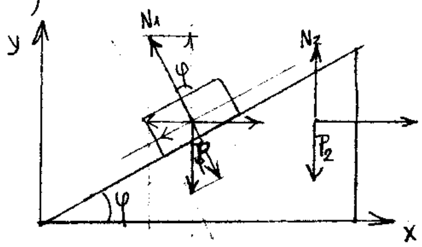




1) $\hat{x}$) $-\cos\varphi.(\text{sen}\,\varphi.m_1.g)$ $\hat{y}$) $-\text{sen}\,\varphi.(\text{sen}\,\varphi.m_1.g)$

$$|\vec{a}| = \sqrt{\cos^2\varphi\, m_1^2 g^2 + \text{sen}^2\varphi\, m_1^2 g^2} = \sqrt{\text{sen}^2\varphi + \cos^2\varphi}\cdot\sqrt{m_1^2\, g^2.\,\text{sen}^2\varphi}$$

ii) a)



m_1

$\hat{x}$) $-\text{sen}\,\varphi.\overbrace{N_1}^{\cos\varphi.m_1.g} = m_1.a_{1x}$

$\hat{y}$) $\cos\varphi.\overbrace{N_1}^{\cos\varphi.m_1.g} - m_1.g = m_1.a_{1y}$

m_2 ($+m_1$ porque está encima)

$\hat{x}$) $-N_1.\text{sen}\,\varphi = m_2.a_{2x}$

$\hat{y}$) $N_2 - m_2.g + N_1.\cos\varphi = m_2.a_{2y}$

El plano no se mueve en $\hat{y}$ $\Rightarrow$ $a_{2y}=0$

$$a_{1x}.m_1 = m_2.a_{2x}$$

$$a_{1x} = \frac{m_2}{m_1}.a_{2x}$$

$$a_{1x} = \frac{-m_2.N_1.\text{sen}\,\varphi}{m_1.m_2} = \frac{-m_2.\cos\varphi.m_1.g.\text{sen}\,\varphi}{m_1.m_2}$$

$$a_{1x} = \frac{-m_2.g.\tan\varphi.\cos^2\varphi}{m_2} = \frac{-m_2.g.\tan\varphi.}{m_2.\frac{1}{\cos^2\varphi}}$$

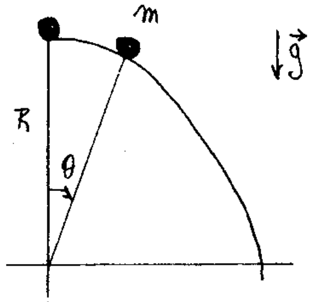
$$= \frac{-m_2.g.\tan\varphi.m_1}{m_2.\sec^2\varphi.m_1} = \frac{\qquad}{m_2(1+tg^2\varphi)m_1}$$

$$= \frac{-m_2.g.\tan g\,\varphi.m_1}{m_2.m_1 + m_1.tg^2\varphi} = \frac{\qquad}{\qquad}$$

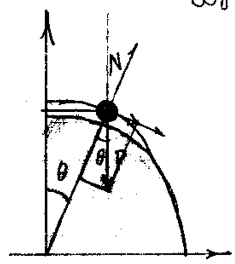
$\sec^2\varphi = \dfrac{1}{\cos^2\varphi}$

$$= \frac{\qquad}{\qquad}$$

6.



a)



$V_0 = 0$

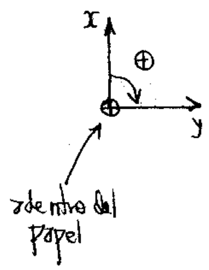
$\omega_0 = 0$

$R = k \Rightarrow \dot{R} = \ddot{R} = 0$

$\vec{V} = (R\,\dot{\theta})\,\hat{\theta}$

$\vec{a} = (-R\cdot\dot{\theta}^2)\cdot\hat{r} + (R\ddot{\theta})\cdot\hat{\theta}$

ángulo de despegue es donde la $N = 0$



$\hat{r}$)

$N_r - P_r = -m \cdot R \cdot \omega^2$

$N_r - \cos\theta \cdot m \cdot g = -m \cdot R \cdot \omega^2$

$\hat{\theta}$)

$P_\theta = m \cdot R \cdot \alpha$

$\operatorname{sen}\theta \cdot \cancel{m} \cdot g = \cancel{m} \cdot R \cdot \alpha$

$N_r = \cos\theta \cdot m \cdot g - m \cdot R \cdot \omega^2$

$N_r = m\left(\cos\theta \cdot g - R \cdot \omega^2\right)$

$\omega^2 = \left(\frac{V}{r}\right)^2$

$\alpha = \frac{a}{r}$

$0 = m\left(\cos\theta \cdot g - R \cdot \omega^2\right)$

$\cos\theta \cdot g = R\,\omega^2$

[1] $\cos\theta = \frac{R}{g} \cdot \omega^2$ $\triangleright$ el ángulo depende de la ω

$\cos\theta = \frac{\cancel{R}}{g} \cdot \frac{V^2}{R^{\cancel{2}}}$

$R \cdot \alpha = a = g \cdot \operatorname{sen}\theta$

$\frac{d^2\theta}{dt^2} = \frac{d\omega}{dt} = \frac{d\omega}{d\theta} \cdot \frac{d\theta}{dt}$

$R \cdot \frac{d^2\theta}{dt^2} = R \cdot \frac{d\omega}{dt} = \frac{d(R\omega)}{dt} = \frac{dV}{dt}$

$a = \frac{dV}{dt} = R \cdot \frac{d\omega}{d\theta} \cdot \frac{d\theta}{dt}$

$R \cdot \frac{d\omega}{d\theta} \cdot \overbrace{\frac{d\theta}{dt}}^{\omega} = g \cdot \operatorname{sen}\theta$

$R \cdot \omega \cdot d\omega = g \cdot \operatorname{sen}\theta \cdot d\theta$

$R \int_{\omega_0}^{\omega} \omega \cdot d\omega = g \cdot \int_{\theta_0 = 0}^{\theta} \operatorname{sen}\theta \cdot d\theta$

$R \cdot \frac{\omega^2}{2} - \frac{\omega_0^2}{2} = g \cdot \left(-\cos\theta + \cos\overset{0}{\theta_0}\right)$

$\frac{1}{2} \cdot R \cdot \omega^2 = g\left(1 - \cos\theta\right)$

$\omega^2 = \frac{2g \cdot (1 - \cos\theta)}{R}$

Reemplazando en [1]

$\cos\theta = \frac{\cancel{R}}{\cancel{g}} \cdot \frac{2\cancel{g}}{\cancel{R}}(1 - \cos\theta)$

$\cos\theta = 2 - 2\cos\theta$

$3\cos\theta = 2$

$\theta = \arccos\left(\frac{2}{3}\right) \Rightarrow \boxed{\theta = 48°\,11'\,22''}$

b) $\omega^2 = \frac{2g}{R}$ sobre el suelo en $\theta = 90°$

$\boxed{\omega = \sqrt{\frac{2g}{R}}}$ $\boxed{V = \sqrt{R\,2g}}$

aceleración tangencial

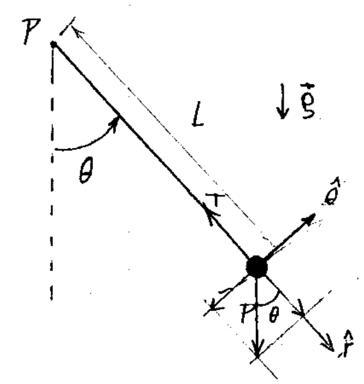
$(R.\ddot{\theta}).\hat{\theta}$ $\qquad a_t = R.\ddot{\theta}$

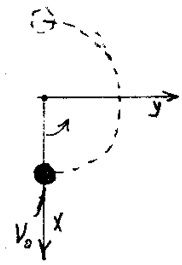
$R.\alpha = R.g.\text{sen}\,\theta$

en el suelo $\qquad \boxed{a_t = R.g}$

c) Para ordenador personal

7)





$\cos\theta = \frac{P_r}{P}$

a) $\vec{V} = R.\dot{\theta}.\hat{\theta}$

$\vec{a} = -R.\dot{\theta}^2.\hat{r} + R.\ddot{\theta}.\hat{\theta}$

$\hat{r})\quad -T + P_r = -m.R.\omega^2$

$-T + \cos\theta.m.g = -m.R.\omega^2$

$\hat{\theta})\quad -\text{sen}\,\theta.\cancel{m}.g = \cancel{m}.R.\alpha$

V o ω se anulan $\Rightarrow$

$-T + \cos\theta.m.g = 0$

$\cos\theta.m.g = T \qquad [1]$

$a = R.\alpha = \text{sen}\,\theta.g$

$R.\frac{d\omega}{d\theta}.\frac{d\theta}{dt} = -\text{sen}\,\theta.g$

$R.\omega.d\omega = -g.\text{sen}\,\theta.d\theta$

$R\int_{\omega_0}^{\omega}\omega.d\omega = -g\int_{\theta_0=0}^{\theta}\text{sen}\,\theta.d\theta$

$R.\left(\frac{\omega^2}{2} - \frac{\omega_0^2}{2}\right) = -g.\left(-\cos\theta + \cos 0\right)$

$\frac{R.\omega^2}{2} - \frac{R\,\omega_0^2}{2} = -g.(1-\cos\theta)$

$\omega^2 - \omega_0^2 = \frac{2.g}{R}(\cos\theta - 1)$

$R.\omega^2 = R.\omega_0^2 + 2g(\cos\theta - 1)$

$\omega = f(\theta)\ \blacktriangleright \qquad \omega = +\sqrt{\omega_0^2 + \frac{2g}{R}(\cos\theta - 1)}$

$\omega = 0 \Leftrightarrow \qquad \omega_0^2 = -\frac{2g}{R}(\cos\theta - 1)$

$\frac{R.\omega_0^2}{2g} - 1 = -\cos\theta$

$\text{ARCO COS}\left(-\frac{R.\omega_0^2}{2g} + 1\right) = \theta$

$R = L \Rightarrow$

$\boxed{\text{ARCO Cos}\left(-\frac{V_0^2}{2gL} + 1\right) = \theta_c}$

$-1 \leq -\frac{R.\omega_0^2}{2g} + 1 \leq 1$

$-2 \leq -\frac{R.\omega_0^2}{2g} \leq 0$

$-4g \leq -R.\omega_0^2 \leq 0$

$4g \geq R.\omega_0^2 \geq 0$

b) $\cos\theta.\cancel{m}.g = -\cancel{m}.R.\left[\omega_0^2 + \frac{2g}{R}(\cos\theta - 1)\right]$

$g.\cos\theta = -R.\omega_0^2 - 2g\cos\theta + 2g$

$3g.\cos\theta = -R.\omega_0^2 + 2g$

$\omega = \frac{V}{r}$

$\omega^2 = \frac{V^2}{R^2}$

$R^2.\omega^2 = V^2$

$R.\omega^2 = \frac{V^2}{R}$

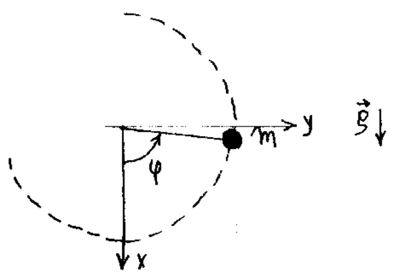
$$\cos\theta = -\frac{R\,\omega_0^2}{3g} + \frac{2}{3}$$

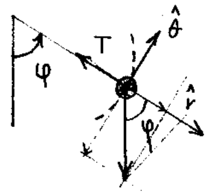
$$\theta = \text{ARCO}\cos\left(-\frac{R.\omega_0^2}{3g} + \frac{2}{3}\right)$$

$$\boxed{\theta = \text{ARCO}\cos\left(-\frac{V_0^2}{3gL} + \frac{2}{3}\right)}$$

c) En la carpeta

8. M.C.U ω





a) $\hat{r}$

$$P_r - T = m.a_r$$
$$\cos\varphi.m.g - T = m.-R.\dot{\theta}^2$$

$\hat{\theta}$

$$-P_\theta = m.a_t$$
$$-\text{sen}\,\varphi.\cancel{m}.g = \cancel{m}.R.\ddot{\theta}$$

$$\boxed{\begin{aligned} m.g.\cos\varphi + m.R.\omega^2 &= T \\ -g.\text{sen}\varphi - R.\alpha &= 0 \end{aligned}}$$

$R = k$
$\omega = k$
$\alpha =$

$$\alpha = g.\frac{\text{sen}\,\varphi}{R}$$

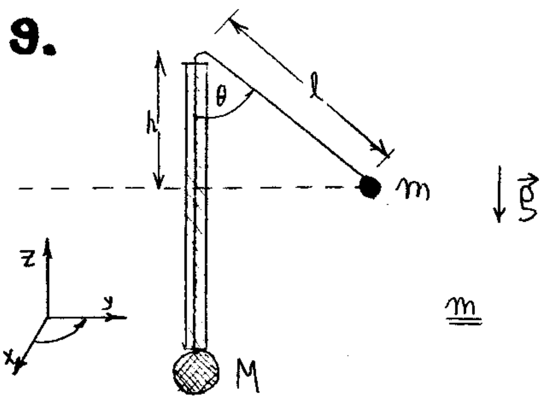
$$\frac{d\omega}{d\theta}.\frac{d\theta}{dt} = g.\frac{\text{sen}\,\theta}{R}$$

$$\int \omega.d\omega = g\int \frac{\text{sen}}{R}\,\theta.d\theta$$

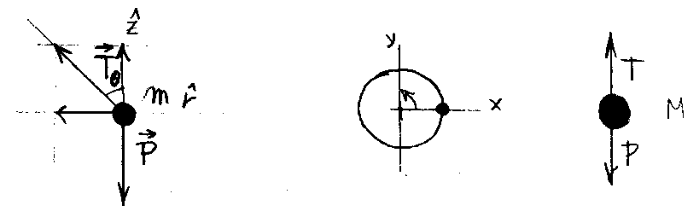
$$\frac{\omega^2}{2} - \frac{\omega_0^2}{2} = \frac{g}{R}.\left(-\cos\theta + 1\right)$$

b) $\boxed{T = m\left(g.\cos\varphi + R.\omega^2\right)}$

9.



a)



Dan período $\Rightarrow$ es M.C.U

$\underline{\underline{m}}$

$\hat{z}$) $T.\cos\theta - m.g = 0$
$T.\cos\theta = mg$

$\hat{r}$) $-T.\text{sen}\theta = m.(-R.\dot{\theta}^2)$
$T.\text{sen}\theta = m.R.\omega^2$

si $\cos\theta \neq 0$

$$\cancel{m}.g.\frac{\text{sen}\theta}{\cos\theta} = \cancel{m}.R.\omega^2$$

$$tg\theta = \frac{R.\omega^2}{g}$$

$$l^2 = h^2 + R^2$$
$$R = \sqrt{l^2 - h^2}$$

$$\frac{h}{l} = \cos\theta$$

$$\frac{h}{\cos\theta} = l$$

$\underline{\underline{M}}$

$\hat{z}$) $T - P = 0$
$T = M.g$

período τ

Aquí T es la tensión

$$M.\cancel{g}.\cos\theta = m.\cancel{g}$$
$$\cos\theta = \frac{m}{M}$$

$$\boxed{\theta = \text{ARCO}\cos\left(\frac{m}{M}\right)}$$

b)

$$[l] = [m]\cdot\frac{\frac{1}{[t]^2}}{[m]\cdot\frac{[l]}{[t]^2}}$$

$$\tau = \frac{2\pi}{\omega} \qquad \tau^2 = \frac{4\pi^2}{\omega^2}$$

$$\tau^2 = \frac{m.R.4\pi^2}{T.\operatorname{sen}\theta} = \frac{m.\cancel{R}.4\pi^2}{\frac{M}{g}.\frac{\cancel{R}}{l}}$$

$$\boxed{\frac{M.\tau^2}{4\pi^2.m.g} = l} \Leftarrow \tau^2 = \frac{m.g.l.4\pi^2}{M}$$

c)

$$\tau^2 = 4\pi^2 g.\frac{m}{M}.l \qquad \frac{m}{M} = \cos\theta = \frac{h}{l} \qquad \operatorname{sen}\theta = \frac{R}{l} =$$

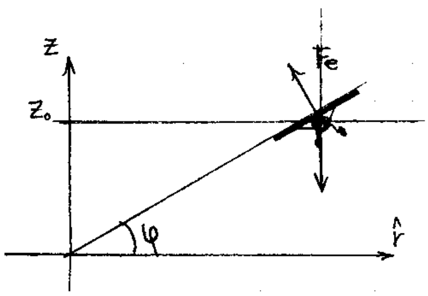
$$\tau^2 = 4\pi^2.g.\cos\theta.l \qquad \cos\theta.l = h$$

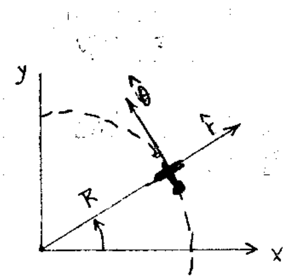
$$\boxed{\tau^2 = 4\pi^2.g.h}$$

$$\tau = +\sqrt{4\pi^2.g.h} \Rightarrow \boxed{\tau = 2\pi\sqrt{g.h}}$$

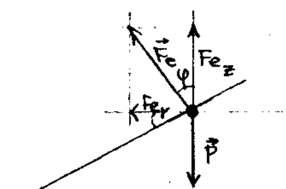
10. En la carpeta

11.





a)



$$\hat{z})\quad Fe_z - P = m.\underset{\text{0 no se mueve en z}}{a_z}$$

$$\hat{\theta})\quad 0 = m.(R.\ddot{\theta} + 2\dot{R}.\dot{\theta})$$

$$\hat{r})\quad -Fe_r = m.(\ddot{R} - R.\dot{\theta}^2)$$

vínculos

$$R = k \Rightarrow \dot{R} = \ddot{R} = 0$$

$$|\vec{V}| = k \Rightarrow |R.\vec{\omega}| = |\vec{V}| = k$$

$$|\dot{\theta}| = |\vec{\omega}| = k$$

$$\Rightarrow \ddot{\theta} = 0$$

$$\hat{z})\quad Fe.\cos\varphi - m.g = 0$$

$$\hat{r})\quad -Fe.\operatorname{sen}\varphi = -m.R.\omega^2$$

$$Fe.\cos\varphi = m.g \quad\wedge\quad Fe.\operatorname{sen}\varphi = m.R.\omega^2$$

$$\frac{\cancel{m}.g}{\cos\varphi}.\operatorname{sen}\varphi = \cancel{m}.R.\omega^2$$

$$\operatorname{tg}\varphi = \frac{R}{g}.\omega^2 = \frac{V^2}{g.R}$$

$$\boxed{\varphi = \operatorname{arco}\operatorname{tg}\left(\frac{V^2}{g.R}\right)}$$

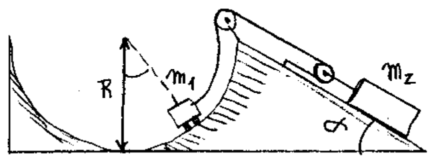
b)

$$\varphi = \operatorname{arco}\operatorname{tg}\left[\frac{\left(60\,\frac{m}{s}\right)^2}{9.8\frac{m}{s^2}.1000m}\right]$$

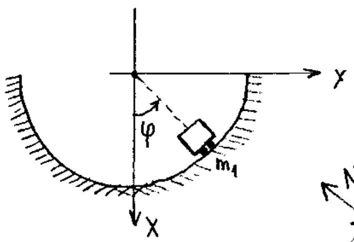
$$\boxed{\varphi = 20^\circ\,10'\,14''}$$

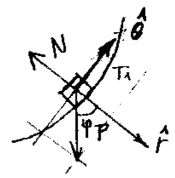
12.

a)



$\underset{\sim\sim}{m_1}$





$\hat{r})\quad -N_1 + P_r = m_1 \cdot a_r$

$-N_1 + m_1 . g . \cos\varphi = m_1 . (-R . \dot{\theta}^2)$

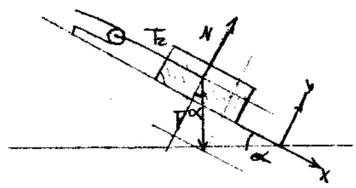
$\hat{\theta})\quad T_1 - P_\theta = m_1 . a_\theta$

$T_1 - m_1 . g . \text{sen}\,\varphi = m_1 . \underbrace{R . \ddot{\theta}}_{a_T}$

vínculo

$r = R = k \qquad \boxed{\dot{r} = \ddot{r} = 0}$

$\underset{\sim\sim}{m_2}$

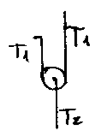


$\hat{y})\quad N_2 - m_2 . g . \cos\alpha = m_2 . \underbrace{a_y}_{0}$

$N_2 = m_2 . g . \cos\alpha$

$\hat{x})\quad m_2 g . \text{sen}\,\alpha - T_2 = m_2\, a_x$

Polea



$2T_1 - T_2 = \overbrace{m . a}^{0}$

$\boxed{2T_1 = T_2}$

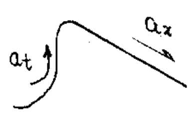
vínculo

b) m_1 en reposo $\Rightarrow$ $R . \ddot{\theta} = 0 \quad \therefore \quad T_1 = m_1 . g . \text{sen}\,\varphi$

m_2 en reposo $\qquad T_2 = m_2 . g . \text{sen}\,\alpha \qquad 2T_1 = 2m_1 . g . \text{sen}\,\varphi = m_2 . g . \text{sen}\,\alpha$

$$\boxed{\varphi = \text{ARCO sen}\left(\frac{m_2\,(\text{sen}\,\alpha)}{2 . m_1}\right)}$$

c) Supongamos que: a_t de m_1 es igual en módulo a la a_x de m_2 por estar conectados por una soga inextensible a la tracción (pero que no es rígida a la compresión) $\therefore$



$2T_1 - 2m_1 . g . \text{sen}\,\varphi = m_1\, a_t$

$-T_2 + m_2\, g\, \text{sen}\,\alpha = m_2 . a_t$

$m_2\, g\, \text{sen}\,\alpha - 2m_1\, g\, \text{sen}\,\varphi = a_t\,(m_1 + m_2)$

$$\frac{g\,(m_2\,\text{sen}\,\alpha - 2m_1\,\text{sen}\,\varphi)}{(m_1 + m_2)} = R . \ddot{\varphi}$$

$$= R . \frac{d\omega}{d\varphi}\,\frac{d\varphi}{dt} = R . \omega . \frac{d\omega}{dt}$$

$$\int \frac{g . m_2 . \text{sen}\,\alpha}{(m_1 + m_2)} . d\varphi - g \int \frac{2m_1 . \text{sen}\,\varphi}{(m_1 + m_2)} . d\varphi = R \int \omega . d\omega$$

$$\frac{g . m_2 . \text{sen}\,\alpha}{m_1 + m_2} . \varphi - \frac{2m_1\, g}{m_1 + m_2}\left(-\cos\varphi\right) + C_1 = R . \frac{\omega^2}{2} + C_2$$

si $\varphi=0 \Rightarrow$
$\Rightarrow \omega=0$

porque la soga no trabaja a la compresión

$$+\frac{2m_1 g}{m_1+m_2} = 0^2 + C_2$$

$$\frac{2m_1 g}{m_1+m_2} = C_2$$

$$R.\omega^2 = \left(\frac{2 m_2 g \operatorname{sen}\alpha}{m_1+m_2}\right)\varphi + \frac{4m_1 . g . \cos\varphi}{m_1+m_2} - \frac{4m_1 g}{m_1+m_2}$$

$$\boxed{R.\omega^2 = \left(\frac{2.m_2.g.\operatorname{sen}\alpha}{m_1+m_2}\right).\varphi + \frac{4m_1 g}{m_1+m_2}.\left(\cos\varphi - 1\right)}$$