Phys1 -03

Wednesday, November 16, 2022 11:51 AM

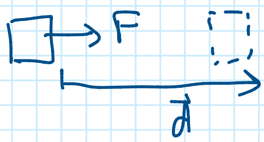
6 & 7

work energy ; kinetic E, pot E ...

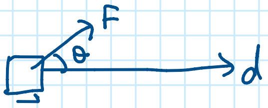
energy conservation.

$\vec{F}\cdot\vec{d}$ ↳ dot product $\Rightarrow$ $W = Fd\cos\theta$

$\text{Work} = \vec{F}\cdot\vec{d} = W$



$AB\cos\theta = \vec{A}\cdot\vec{B}$



$W = Fd\cos\theta$

$\vec{d}$ = displacement $= \Delta\vec{x}$

$W = \vec{F}\cdot\vec{d}$

[Joule $= N\,m = kg\,\frac{m^2}{s^2}$]

$\hat{i}\cdot\hat{i} = |\hat{i}|\,|\hat{i}|\cos 0$

$\quad\quad\; 1 \quad 1 \quad 1$

ex

$\vec{F} = (160\hat{i} - 40\hat{j})\,N \qquad \vec{d} = (14\hat{i} + 11\hat{j})\,m$

$W = \vec{F}\cdot\vec{d} = 160(14)\underbrace{\hat{i}\cdot\hat{i}}_{1} - 40(11)\underbrace{\hat{j}\cdot\hat{j}}_{1} + \overset{\hat{i}\cdot\hat{j}}{0} + \overset{\hat{j}\cdot\hat{i}}{0}$

$= 1800\,J$

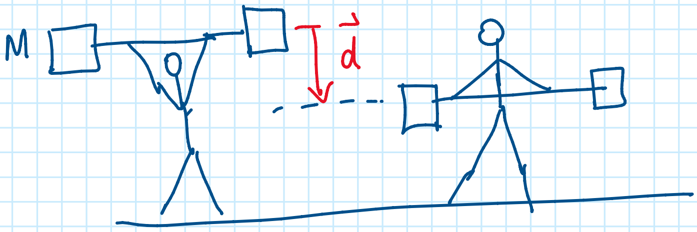
$\theta = ?$

$W = Fd\cos\theta = 1800$

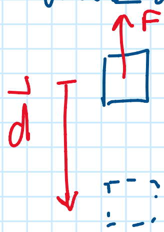
$\sqrt{160^2 + 40^2}\,\sqrt{14^2 + 11^2}\,\cos\theta = 1800$

$\theta = \cos^{-1}\left(\frac{1800}{200(18)}\right) \simeq 30°$

Lowering the weight/dumbell by a person.



Work done by the person?



$W = \vec{F}\cdot\vec{d}$

$= Fd\cos 180$

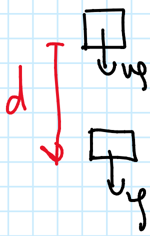
$= -Fd$

$F = mg$

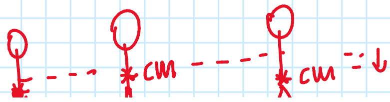
$= -mgd$

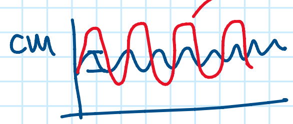
work done by mg force?

$W = m\vec{g}\cdot\vec{d} = mgd$



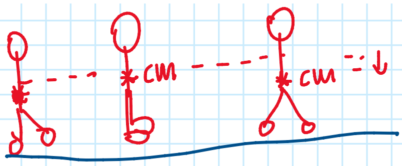
work done by the person when a person walks on a straight path.

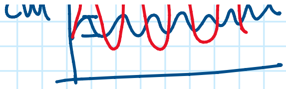




$\uparrow mg = F \quad \uparrow d$

displacement = 5 cm

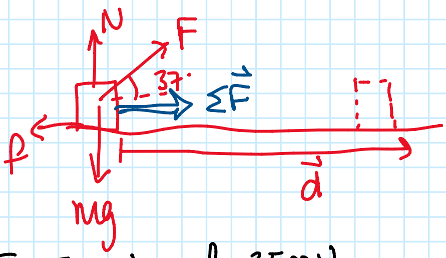




$\uparrow mg = F \quad \uparrow d$

$80\,kg \sim 800\,N \qquad cm = \text{displacement} = 5\,cm$

$W = (800)(0.05) = 40\,J$



$F = 5000\,N \qquad f = 3500\,N$

$d = 20\,m$

$W_N = N(20)\cos 90^\circ = 0$

$W_{mg} = mg(20)\cos 90^\circ = 0$

$W_F = 5000(20)\cos 37^\circ = 80000\,J$

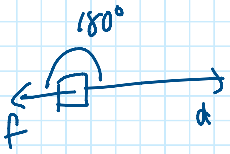
$W_f = 3500(20)\cos 180^\circ = -70000\,J$

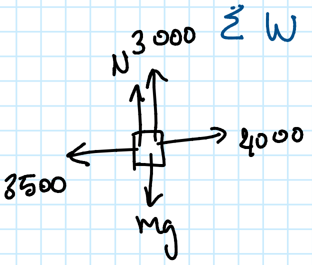
$+$

$\sum W = 10000\,J = \sum \vec{F} \cdot \vec{d}$

$= (500)(20)$

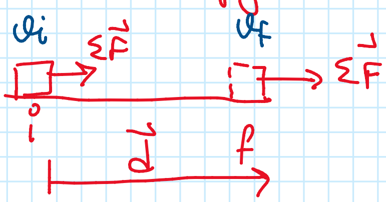
$\sum W = 10000\,J = \sum \vec{F} \cdot \vec{d}$





$\sum \vec{F} = 500\,N\,\hat{i}$

Kinetic energy & the work-energy theorem



$\vec{d} = \vec{s} = \Delta\vec{x} = \Delta\vec{r}$ = displacements.

$v_f > v_i \qquad \sum \vec{F} > 0 \qquad a > 0$

$\sum W = W_{tot} = \sum \vec{F} \cdot \vec{d} > 0$

$; \ \Delta x = d$

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

$\vec{a} = \dfrac{\sum \vec{F}}{m}$

$v_f^2 = v_i^2 + 2a\Delta x$

$v_f^2 = v_i^2 + 2\dfrac{\sum F}{m} d \Rightarrow \sum F d = \dfrac{m}{2}(v_f^2 - v_i^2)$

$W_{tot} = \Delta K$

work-kinetic Energy theorem

$; \ K \equiv \dfrac{mv^2}{2} = $ (tanım)

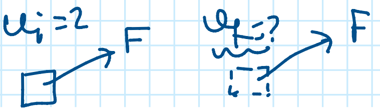
$\underbrace{\sum F d}_{\text{total work done}} = \dfrac{mv_f^2}{2} - \dfrac{mv_i^2}{2} = \Delta K$

$W_{tot} > 0$	$W_{tot} < 0$
$\Delta K > 0$	$\Delta K < 0$
$K_f > K_i$	$K_i > K_f$
$v_f > v_i$	$v_i > v_f$

$K \equiv \dfrac{mv^2}{2}$

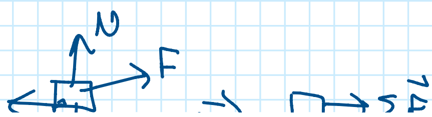
$[J] = kg\,\dfrac{m^2}{s^2}$

ex

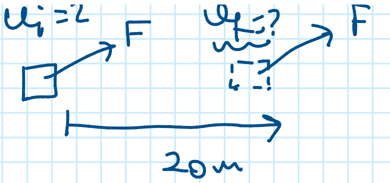


$v_i = 2 \qquad F \qquad v_f = ? \qquad F$

$\sum \vec{F} = 500\,N\,\hat{i}$



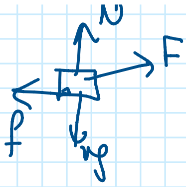
N F



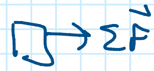
$\sum \vec F = 500N \, \hat i$

$\sum \vec F \cdot \vec d = W_{tot}$

$= 10000 J$



$\Rightarrow$



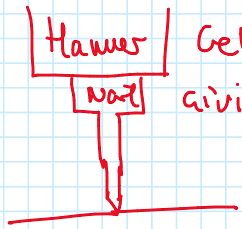
if $mg = 14700N$

$m = \frac{14700}{9.8} = 1500 kg$

$= \frac{m v_f^2}{2} - \frac{m v_i^2}{2} = 10000$

$\underline{\underline{v_f = 4.2 m/s}}$

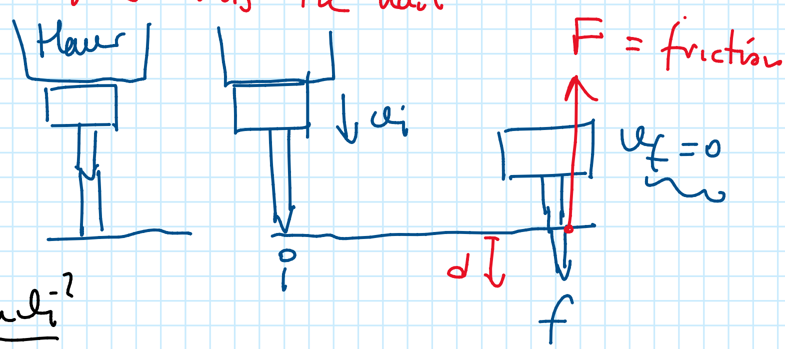
ex)



Çekiç

çivi

after Hammer hits the nail



$W_{tot} = \vec F \cdot \vec d$; $mg \ll F$

F, 180°, d

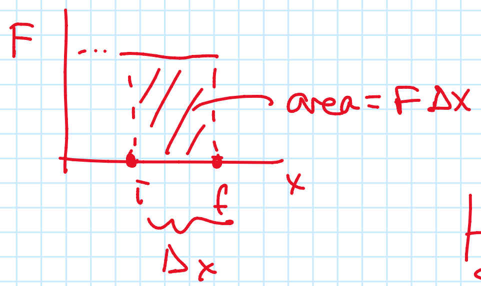
$= -Fd = \Delta K$

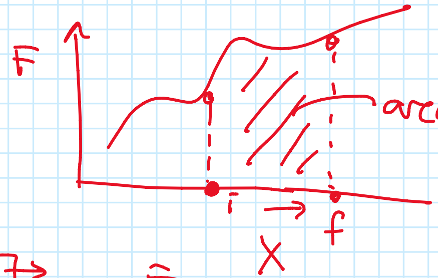
$-Fd = \frac{m \cancel{v_f^2}^{\to 0}}{2} - \frac{m v_i^2}{2}$

$-Fd = -\frac{m v_i^2}{2}$ $\qquad$ $F = \frac{m v_i^2}{2d}$

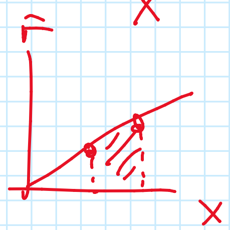
$\left.\begin{aligned} v_i &= 5 m/s \\ m &= 0.01 kg \\ d &= 1cm \end{aligned}\right\}$ $\quad F = \frac{(0.01)\,5^2}{2\,(0.01)} = 12.5N$

$W = \vec F \cdot \Delta \vec x$ = when $\vec F$ is const.



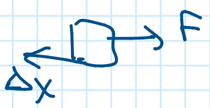


area = $\int \vec F \cdot d\vec x = W$



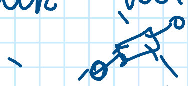
$\int \vec F \cdot d\vec x = W$

$\vec F$; $\vec d$



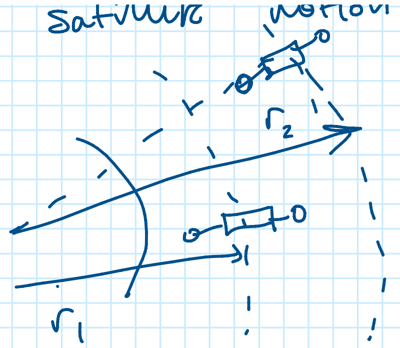
$W < 0$ $\qquad$ $W = \int \vec F \cdot \Delta \vec x$

ex) satellite motion



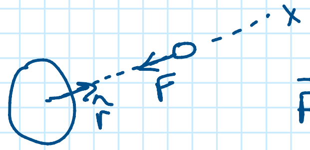
$r_2 > r_1$ $\qquad$ $F_{\substack{on \\ satellite}} = \frac{-1.3\times10^{22}}{x^2}$

ex) satellite motion



$r_2 > r_1$

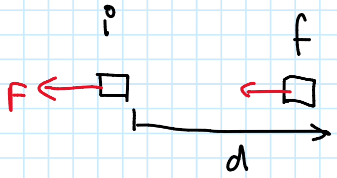
$F_{on\ satellite} = -\frac{1.3\times10^{22}}{x^2}$



$\vec F = -\frac{1.3\times10^{22}}{r^2}\hat r$

what's the work done by f if satellite moves from $r_1 = 1.5\times10^{11}$ m to $r_2 = 2.3\times10^{11}$ m

$W = \int \underbrace{\vec F\cdot d\vec x}_{(-)}$



$W < 0$

$\rightarrow dx \ \hat i$

$\leftarrow F \ -\hat i$

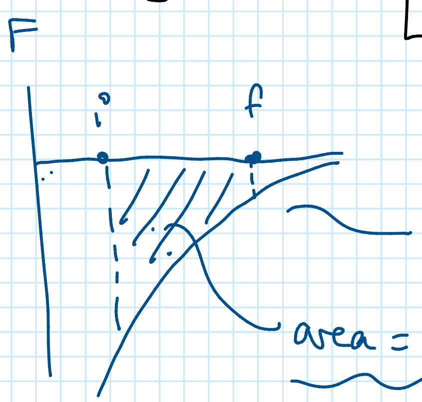
$-\hat i\cdot\hat i = -1$

$= \int \vec F\cdot d\vec x = \int |\vec F| -\hat i \cdot |d\vec x|\hat i = \int |F\,dx|(-1)$

$= -1.3\times10^{22}\int\frac{dx}{x^2}$ $\qquad -\int_i^f \frac{1.3\times10^{11}}{x^2}dx$

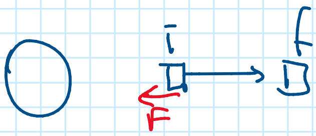
$= -1.3\times10^{22}\left[-\frac{1}{x}\right]_{r_i = 1.5\times10^{11}}^{r_f = 2.3\times10^{11}}$

$= 1.3\times10^{22}\left[\frac{1}{2.3\times10^{11}} - \frac{1}{1.5\times10^{11}}\right] = \left[\frac{1.3}{2.3} - \frac{1.3}{1.5}\right]10^{11}$

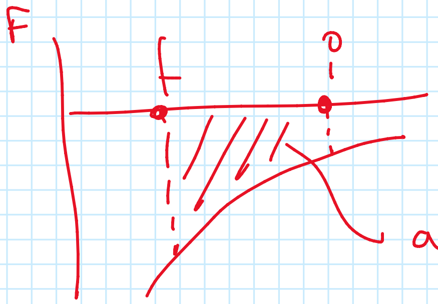


$W_{tot} = -3\times10^{11}$ J < 0

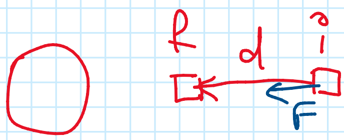
area $= -3\times10^{11}$ J



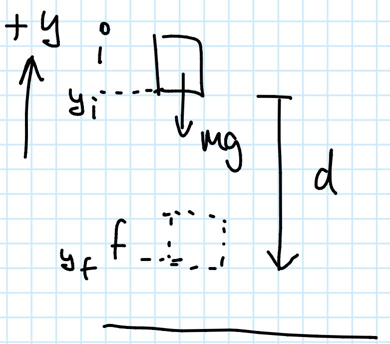
$W < 0$

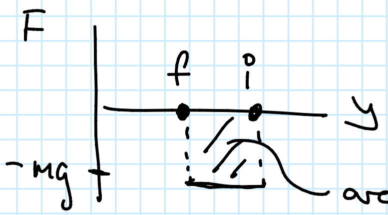


area $= +3\times10^{11}$ J



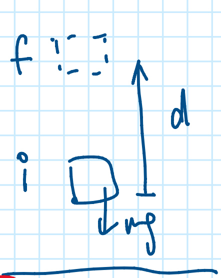
$W > 0$



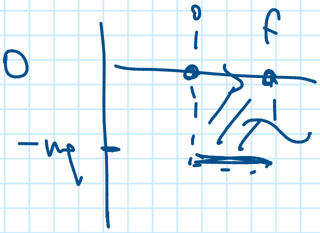


area $= mgd$

$\vec{F} = -mg(\hat{j})$



$W = -mgd < 0$

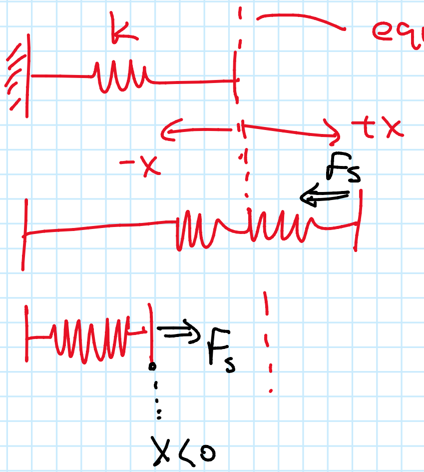


$-mgd = W_{tot}$

SPRING FORCE

equilibrium position = [illegible] $= 0 = X$

$F_s = -kX$

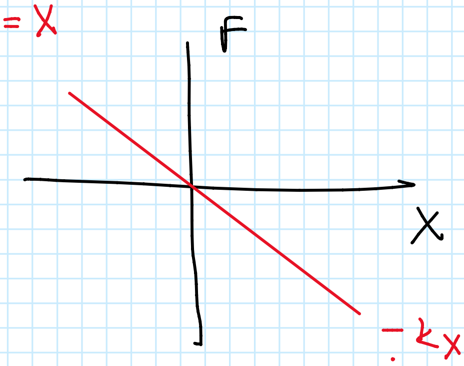


$F_s = -\hat{i}$

$F_s = -kx \;;\; x > 0$

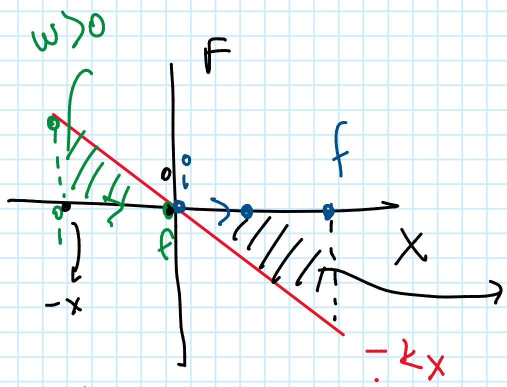
$F_s = -kx \;;\; x < 0$

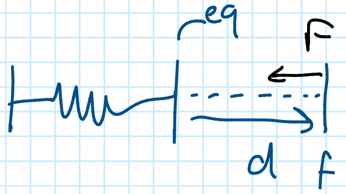
$F_s \; +\hat{i}$



$X_{eq} = 0 \qquad \vec{F}_s = -k\vec{X}$

$X_{eq} = X_0 \qquad \vec{F}_s = -k\Delta\vec{x} = -k(x_f - x_0)$





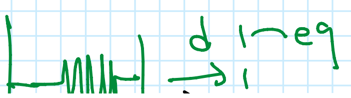
$w < 0$

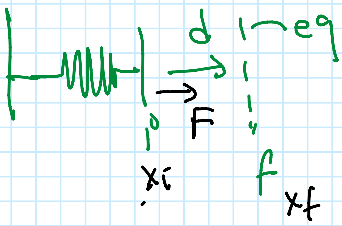
$x_i = 0$

$x_f = x$

$$\int_0^x -kx\,dx = -k\frac{x^2}{2}\Big]_0^x$$

$$W = -k\frac{x^2}{2} < 0$$





$W > 0$

$$W = \int_{-x}^{0} -kx\,dx = -\frac{kx^2}{2}\Big]_{-x}^{0} = -\left[k\frac{0^2}{2} - k\frac{(-x)^2}{2}\right]$$

$W = -\frac{kx^2}{2} < 0$

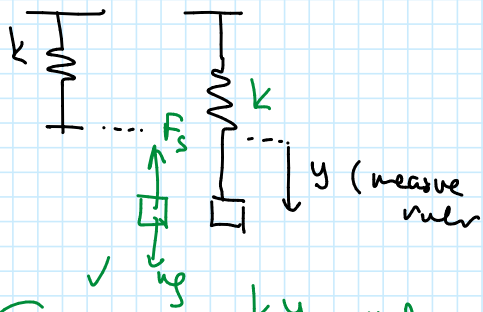
$W = +\frac{kx^2}{2} > 0$

$$W = -\left[\frac{kx_f^2}{2} - \frac{kx_i^2}{2}\right] = \frac{kx_i^2}{2} - \frac{kx_f^2}{2} \qquad |x_f| < |x_i|$$

$x_i = -x \qquad x_f = 0$

$F_s = -kx$

$$\left[k = \text{spring const} = \frac{N}{m} = \frac{kg\,m/s^2}{m} = \frac{kg}{s^2}\right]$$



m is known $\Rightarrow$ measure $\underline{k}$ spring

m_1 is unknown $\quad m_1 = \frac{ky_1}{g}$

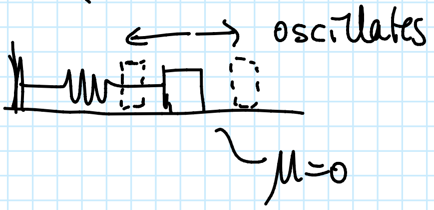
$ky = mg$

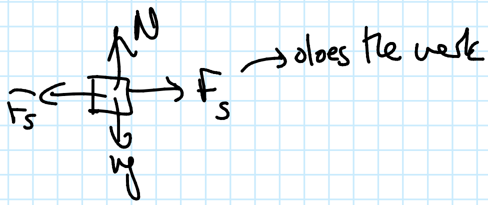
$$\left[\frac{mg}{y} = k\right]$$

$F_s = -kx \quad (x_{eq} = 0)$

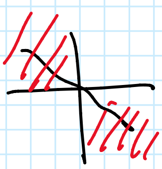
$W_{tot} = \Delta K$

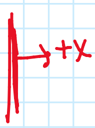
if only spring force does the work





$$W_{tot} = W_{spring} = \underbrace{\frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2}_{\text{work by spring}} = \underbrace{\Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2}_{=\text{change in } K}$$





$$\int_{x_i}^{x_f} -kx\,dx = -k\frac{x^2}{2}\Big]_{x_i}^{x_f} = -\left[\frac{kx_f^2}{2} - \frac{kx_i^2}{2}\right]$$

$$= \frac{kx_i^2}{2} - \frac{kx_f^2}{2}$$

POWER (quiz)

$$P = \frac{\text{work}}{\text{time}} = \frac{W}{t} = \left[\frac{J}{s} = \text{watt}\right]$$

$1\text{hp} = 1\,\text{horsepower} = 746\,W$

$$P_{ave} = \frac{\text{work}}{\text{time}} = \frac{W}{t} = \left[\frac{J}{s} = \text{watt}\right]$$

$1\,hp = 1\,\text{horsepower} = 746\,W$

$100\,hp$ car $= 74600\,W$

$\simeq 75\,kW$

$$P = \frac{dW}{dt} \quad \text{(instantaneous power)}$$

Electric bills (elektrik faturа) = energy = [Joule] = 100 kW.hr

100 1000W 3600 s

100 3.6×10^6 Joules

$$P = \frac{dW}{dt}$$

$W = \vec{F} \cdot \vec{s}$ ($\vec{F}$ const)

$W = \vec{F} \cdot \vec{x} = \int \vec{F} d\vec{x} = \int dW$

$dW = \vec{F} \cdot d\vec{x} = F\,dx$

$$P = \vec{F} \cdot \frac{d\vec{x}}{dt} = \vec{F} \cdot \vec{v} = \vec{F} \cdot \vec{v}$$

ex) Airbus A380 plane $F = 322\,000\,N$

$v = 250\ m/s$

$1\,hp = 746\,W$

$P = \vec{F} \cdot \vec{v}$

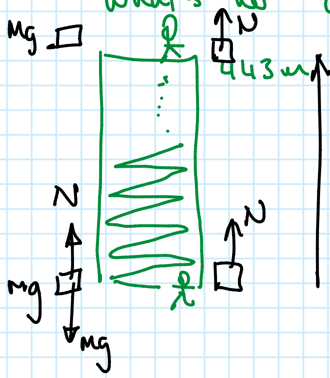
$= F v \cos 0$

$= 8.05 \times 10^7\,W$

$P = 108\,000\ hp$ (plane)

ex) A 50 kg mass of runner, runs up 443 m tall tower in 15 minutes.

What's her average power?



$\frac{W}{t} = P_{ave}$

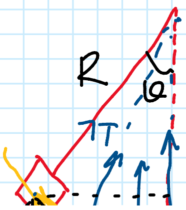
$W = \vec{F} \cdot \vec{x}$

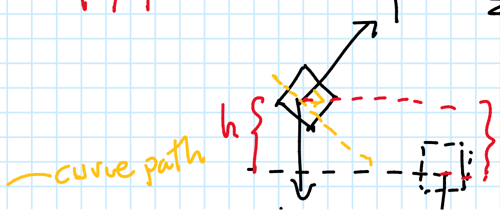
$$\frac{\vec{N} \cdot \vec{Y} = mgh}{\text{time}} = \frac{50(9.8)(443)\ \text{Joules}}{15 \times 60\ \ s} = 241\ \text{Watt} \simeq 0.32\,hp$$

Work – Energy Theorem along a curve path.

$W = \vec{F} \cdot \vec{x}$

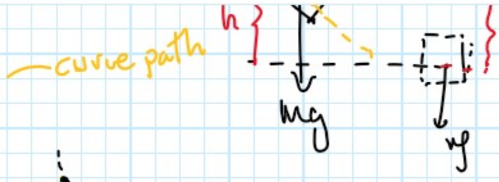
swing / pendulum





$\Sigma W = W_T + W_{mg}$

$\vec{T} \cdot \vec{s} = T s \cos 90° = 0$

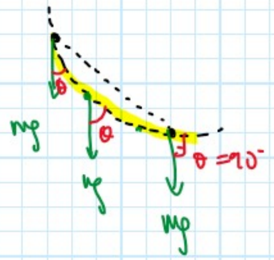


$\} s_{\parallel}$ $T \cdot \vec{s} = Ts\cos 90^\circ = \underline{\underline{0}}$

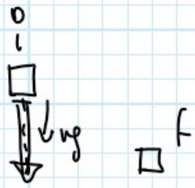
$\sum W = W_{mg} + 0$

$$\vec{mg} \cdot \vec{s} = \int mg\sin\theta \cdot s$$

θ = changing θ_f

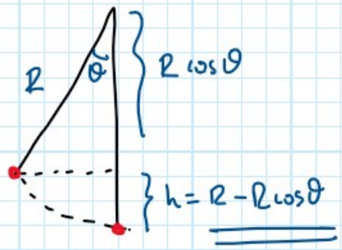


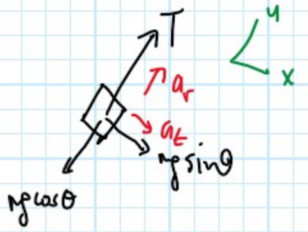
$W_{mg} = ?$



$h = \Delta y$

$$W = \int F\,dx = \int_{\theta_i}^{\theta_f} mg\sin\theta \underbrace{R\,d\theta}_{\text{path length}} = mg\,\Delta y = mg\,\underline{\underline{h}} = \Delta K$$





$\sum F_y = m a_y$

$T - mg\cos\theta = m\dfrac{v^2}{R}$ ✓

$\sum F_x = m a_x = m a_t$ a_t = tangential acc.

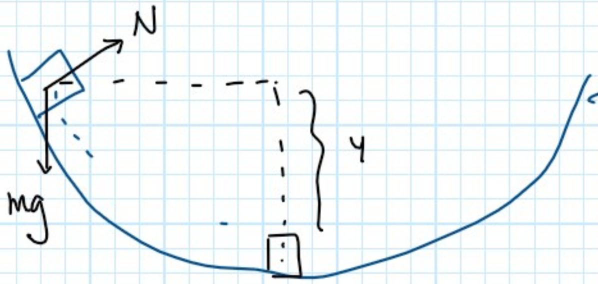
$mg\sin\theta = m a_t$

} NUCM

{Chapter 5}

$\boxed{a_t = g\sin\theta}$

$\theta\uparrow$ $a_t\uparrow$ $a_r\downarrow$ $a_r = \dfrac{v^2}{R}$



$\sum W = W_N + W_{mg}$
$\Downarrow$
0

$N \perp$ curve path

$$\underline{\underline{\sum W}} = W_{mg} + W_N = W_{mg} = mgy = \underline{\underline{\Delta K}} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

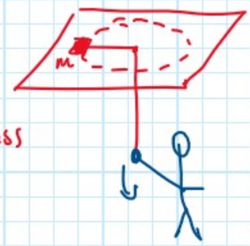
$W_N = \int \vec{N} \cdot d\vec{s}$; $\vec{N} \perp d\vec{s}$

$N\,ds\cos 90 = 0$

END of CH 6

$\boxed{\sum W = \Delta K}$

6.75)



frictionless surface

Block is rotating at a distance of 0.4 m with a speed of 0.7 m/s (v_i)
If the rope is pulled from below and the new radius is 0.1 m $v_{new} = 2.8$ m/s (v_f) $m = 0.09$ kg

a) what's the tension of the rope initially?

$\sum F_x = m a_x$

$\Sigma F_x = m a_x$

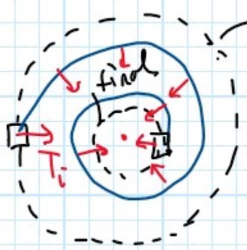
$T = m\frac{v^2}{R} = (0.09)\left(\frac{0.7^2}{0.4}\right) = 0.11\,N$

b) What's the final tension of the rope?

$$T = m\frac{v_f^2}{R_f} = 0.09\,\frac{2.8^2}{0.1} = 7.04\,N$$

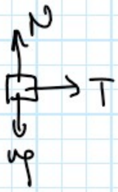
c) How much work is done by the person who pulled the rope?

TOP VIEW



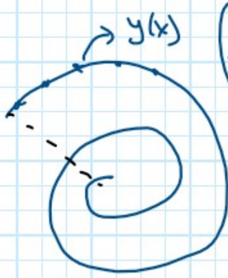
$T_i = 0.11\,N$

$T_f = 7.04\,N$



$$\Sigma W = \underbrace{W_T}_{??} + \underbrace{W_{mg}}_{0} + \underbrace{W_N}_{0} = \Delta K$$

$mg \perp \vec{s}$ $\quad N \perp \vec{s}$

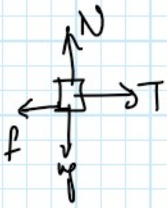


$\int \vec{T}\cdot d\vec{s} = W_T$

HARD

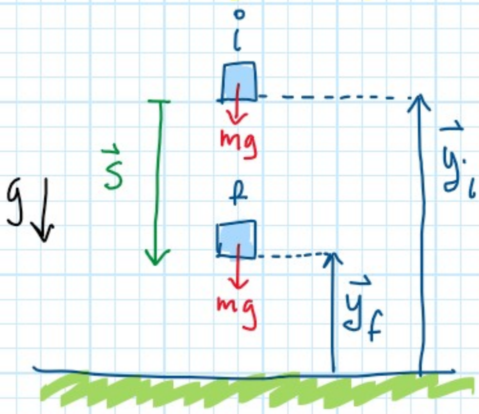
$$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = W_T$$

$$\frac{1}{2}0.09\left(2.8^2 - 0.7^2\right) = W_T = 0.33 \text{ Joules}$$



$$\Sigma W = W_T + W_f + \cancel{W_{mg}}_{0} + \cancel{W_N}_{0}$$

CHAPTER 7 POTENTIAL ENERGY



mass is displaced s closer to ground.

$W_{mg} = \vec{F}\cdot\vec{s}$

$= \vec{mg}\cdot\vec{s} > 0$

$= mgS\cos 0$

$= mgS$

$$\vec{y}_i - \vec{y}_f = -\vec{S}$$

$$\vec{s} = \vec{y}_f - \vec{y}_i$$

$$W_{mg} = \vec{mg}\cdot\vec{s} = \vec{mg}\cdot(\vec{y}_f - \vec{y}_i) = \vec{mg}\cdot\vec{y}_f - \vec{mg}\cdot\vec{y}_i$$

$$= mg\,y_f\underbrace{\cos 180}_{-1} - mg\,y_i\overbrace{\cos 180}^{-1}$$

U = potential energy

$$= mg\,y_f \underbrace{\cos 180}_{-1} - mg\,y_i \cos 180$$

U = potential energy

$$U \equiv mg\,y$$

$$= -mg\,y_f + mg\,y_i$$

$$W_{mg} = mg\,y_i - mg\,y_f$$

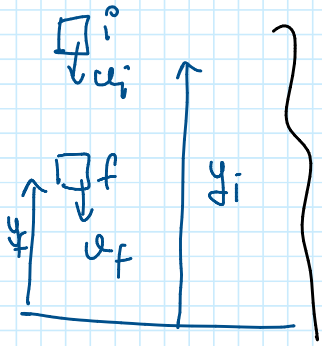
$$W_{mg} = U_i - U_f = \boxed{-\Delta U = W_{mg}}$$

Ch 6 $\quad \Sigma W = \Delta K$

if only force (doing work) is mg

$$\Sigma W = W_{mg} = \Delta K$$

$$-\Delta U = \Delta K \Rightarrow U_i - U_f = K_f - K_i$$



$$\Sigma E_i = \Sigma E_f$$

$$mg\,y_i + \frac{m v_i^2}{2} = mg\,y_f + \frac{m v_f^2}{2}$$

$$* \left\{ U_i + K_i = U_f + K_f \right\} \quad \underbrace{K+U}_{\text{mechanical energy}} \equiv E$$

$$\Sigma E_i = \Sigma E_f$$

energy conservation

$$\Sigma E_i = \Sigma E_f \quad \left\{ \Sigma W = W_{mg} \right\}$$

If there are other forces than mg

$$\Sigma W = \Delta K$$

$$W_{other} + W_{mg} = \Delta K$$

other = F, frictional ....

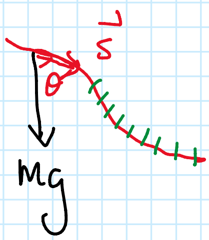
$$W_{other} + (-\Delta U) = \Delta K$$

$$\boxed{W_{other} + U_i + K_i = U_f + K_f}$$

gravitational potential energy

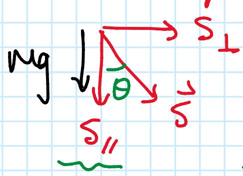
for motion along a curved path.

$$W_{mg} = mg\,S_{\parallel} > 0$$



$$W_{mg} = m\vec{g} \cdot \vec{s} =$$

θ changes



$$m\vec{g} \cdot \vec{s} = mg\,S_{\parallel} + mg\,S_{\perp}$$

$$S_{\parallel} = S\cos\theta \qquad 0$$

$$\Sigma S_{\parallel} = S_{\parallel}$$

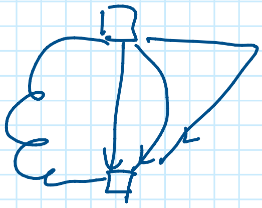
$$S_{\parallel\,\text{total}} = \Sigma S_{\parallel}$$

$$\left[W_{mg} = mg\,S_{\parallel} = -\Delta U \right] \quad \vec{S}_{\parallel} = -\Delta\vec{y}$$

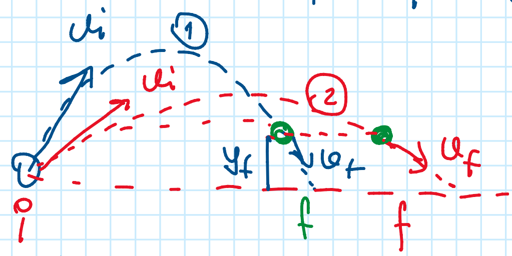
W_{mg} is independent of the path !!

$U = mgy$

$\Delta U = U_f - U_i = mg(y_f - y_i)$



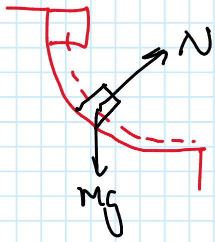
$$\left.\right\} \quad W_{mg} = m\vec{g}\cdot\vec{s}$$



1st path

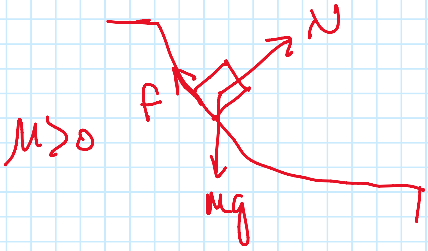
$U_i + K_i = U_f + K_f$

$0 + \frac{1}{2}mv_i^2 = mgy_f + \frac{1}{2}mv_f^2 = mgy_f + \frac{1}{2}mv_f^2$



$\Sigma E_i = \Sigma E_f$

$\Sigma W = W_{mg} + \cancel{W_N}^{\,0}$



$\Sigma W = W_{mg} + \cancel{W_N}^{\,0} + W_f = \Delta K$

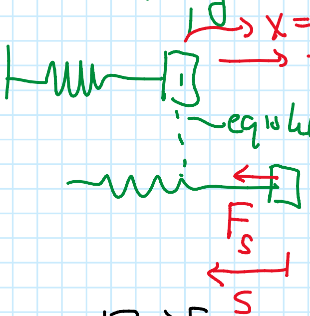
$\Downarrow$

$-\Delta U$

$W_f + U_i + K_i = U_f + K_f$

$W_f < 0$

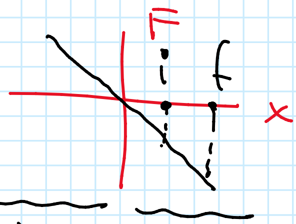
other = spring force (yay kuvveti)



$W_{F_s} > 0$

pulls toward equilibrium point

$F = -kx$



$$W_s = \int_i^f -kx\,dx = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2$$

x −   x +

$W_s = 0 \quad W_s < 0 \quad W_s > 0$

U_{el} = elastic potential energy = spring pot. energy

$U_{el} = \frac{1}{2}kx^2$

$W_{el} = W_s = \underline{\underline{-\Delta U_{el}}}$

$\Sigma W = \Delta K$

$$\sum W = \Delta K$$

$$W_{wp} + W_s + W_{other} = \Delta K$$

$$(-\Delta U_g) + (-\Delta U_{el}) + W_{other} = \Delta K$$

$$mgy_i - mgy_f + \tfrac{1}{2}kx_i^2 - \tfrac{1}{2}kx_f^2 + W_{other} = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2$$

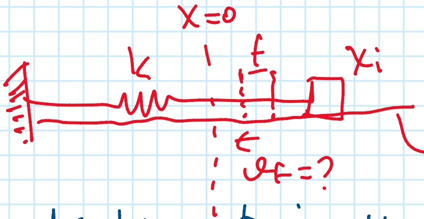
$$W_{other} + mgy_i + \tfrac{1}{2}kx_i^2 + \tfrac{1}{2}mv_i^2 = mgy_f + \tfrac{1}{2}kx_f^2 + \tfrac{1}{2}mv_f^2$$

$\equiv$ $x_i \equiv y_i$

$$* \left\{ W_{other} + U_{g,i} + U_{el,i} + K_i = K_f + U_{el,f} + U_{g,f} \right\}$$

$$U_g = mgy \qquad U_{el} = \tfrac{1}{2}kx^2 = \tfrac{1}{2}ky^2 \ldots$$

ex



spring is stretched 0.1 m

mass is released ($v_i = 0$)

$k = 5\ N/m$ $\quad m = 0.2\,kg$

when $x_f = 0.08\,m$ $\quad v_f = ?$

no displacement in y

$U_g = 0$

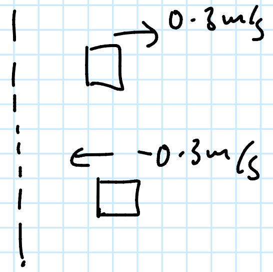
$U_g = 0$

$W_{other} = 0$

$$\tfrac{1}{2}kx_i^2 + \tfrac{1}{2}mv_i^2 = \tfrac{1}{2}kx_f^2 + \tfrac{1}{2}mv_f^2$$

$$\tfrac{1}{2}(5)\,0.1^2 + 0 = \tfrac{1}{2}5(0.08)^2 + \tfrac{1}{2}0.2\,v_f^2$$

$$v_f^2 = 0.09\ m^2/s^2$$

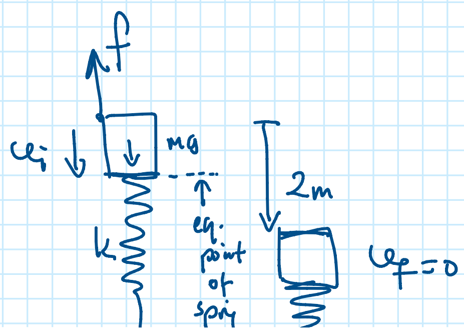


$+0.3\,m/s$

$-0.3\,m/s$

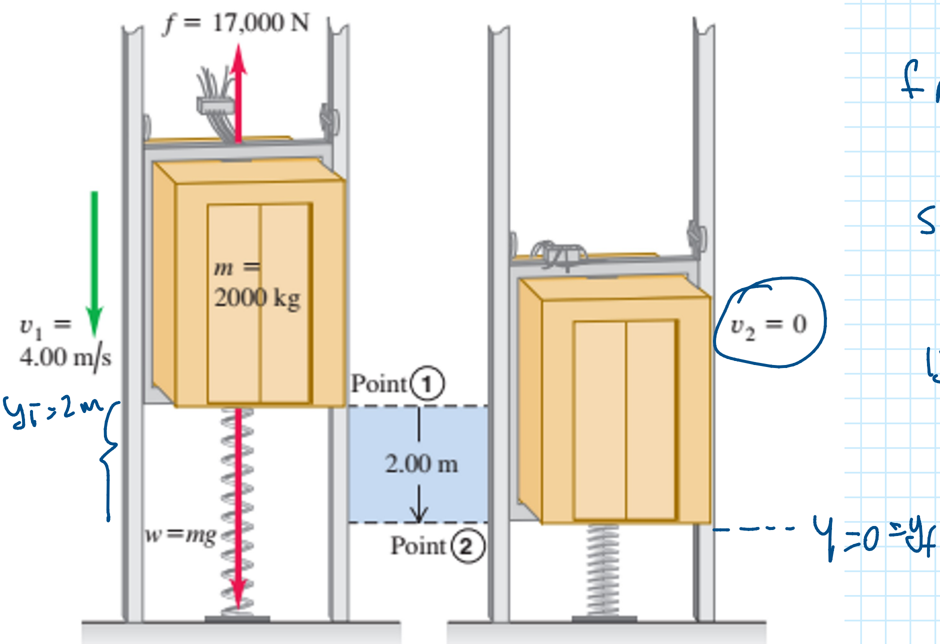
$$W_{other} + U_{g,i} + U_{el,i} + K_i = K_f + U_{el,f} + U_{g,f}$$

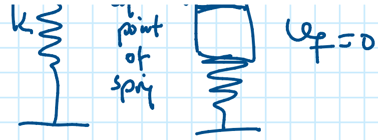
A 2000-kg (19,600-N) elevator with broken cables in a test rig is falling at 4.00 m/s when it contacts a cushioning spring at the bottom of the shaft. The spring is intended to stop the elevator, compressing 2.00 m as it does so (Fig. 7.17). During the motion a safety clamp applies a constant 17,000-N frictional force to the elevator. What is the necessary force constant k for the spring?

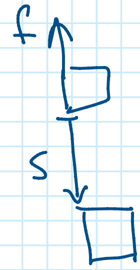


7.17 The fall of an elevator is stopped by a spring and by a constant friction force.

7.17 The fall of an elevator is stopped by a spring and by a constant friction force.







$W_{other} = \vec{f} \cdot \vec{s}$

$= -17000(2)$

$= -34000\ J$

$U_{g,i} = mg y_i$

$= 19600(2)$

$= 39200\ J$

$U_{g,f} = 0 \quad (y_f = 0)$

$K_i = \frac{1}{2} m v_i^2$

$= \frac{1}{2}(2000)\, 4^2 = 16000 J$

$U_{el,f} = \frac{1}{2} k x_f^2$

$= \frac{1}{2} k\, 2^2 = 2k$

$U_{el,i} = \frac{1}{2} k x_i^2 = 0$

$x_i = 0$

$K_f = 0 = v_f = 0$

$W_{other} + U_{g,i} + U_{el,i} + K_i = K_f + U_{el,f} + U_{g,f}$

$-34000 + 39200 + 0 + 16000 = 0 + 2k + 0$

$21200 = 2k$

$k = 10600\ N/m$

what if there was NO FRICTION?

$\hookrightarrow$ $39200 + 16000 = 2k'$ $\quad k' = 27600\ N/m$

FORCES

conservative (korunumLU)

energy is conserved when the object is moved back to initial position

nonconservative (korunumSUZ)

$\longrightarrow$ not conserved

(moved back to initial position)

→ gravitational (mg)
→ spring ($-kx$)
→ electrostatic force ($\frac{kq_1q_2}{r^2}$)

→ frictional forces. (EM force)

① conservative force

$W_{mg} = -\Delta U_g$

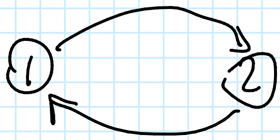
$W_{el} = -\Delta U_{el}$

$W \sim \underset{\text{potential expression.}}{\underline{\underline{U}}}$

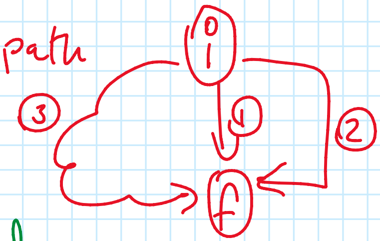
$$\underline{W = -\Delta U}$$

② It's reversible

$0 = W_{1\to2} + W_{2\to1}$



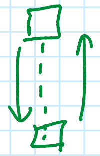
③ independent of path

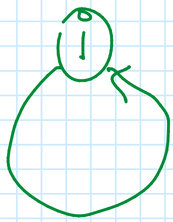


$W^{①}_{mg} = W^{②}_{y} = W^{③}_{y}$

④ when start = end
i = f

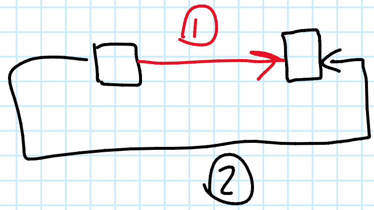
$i = f$





$W_{i\to f} = 0 = W_{i\to i}$

nonconservative force (friction)



W_f depend on path

$W^{②} \neq W^{①}$

$W = -\Delta U = F_x \Delta x \Rightarrow -\Delta U = F_x \Delta x$
$= F_y \Delta y$

$F_x = -\frac{\Delta U}{\Delta x} = -\frac{dU}{dx}$

$U =$

$-\frac{dU}{dx} = F_x \qquad -\frac{dU}{dy} = F_y \qquad -\frac{dU}{dz} = F_z$

$$F_x = -\frac{\partial U}{\partial x} \qquad F_y = -\frac{\partial U}{\partial y} \qquad F_z = -\frac{\partial U}{\partial z}$$ (partial derivatie)

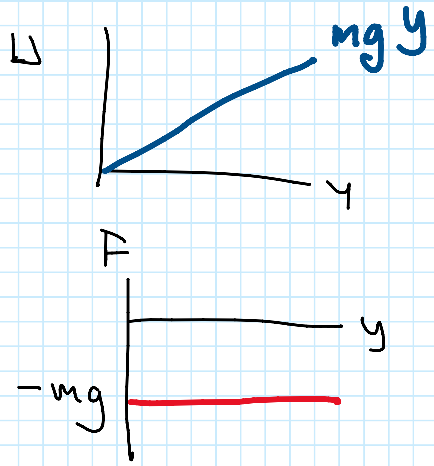
$$U = 5x^2 y$$

$$\frac{dU}{dx} = 10xy + 5x^2 \frac{dy}{dx}$$

$$\frac{\partial U}{\partial x} = 10xy$$

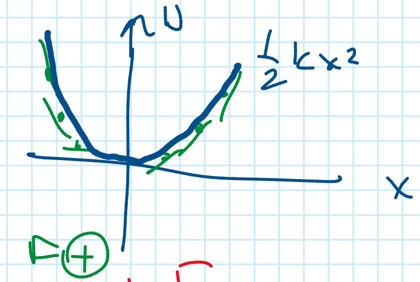
$$U = mgy$$

$$-\frac{\partial U}{\partial x} = 0 \qquad -\frac{\partial U}{\partial z} = 0 \qquad -\frac{\partial U}{\partial y} = -mg$$



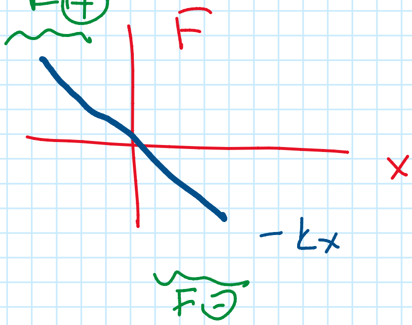
$$U = \frac{1}{2}kx^2$$

$$-\frac{\partial U}{\partial z} = -\frac{\partial U}{\partial y} = 0 \qquad -\frac{\partial U}{\partial x} = -\frac{1}{2}k\,2x = -kx$$

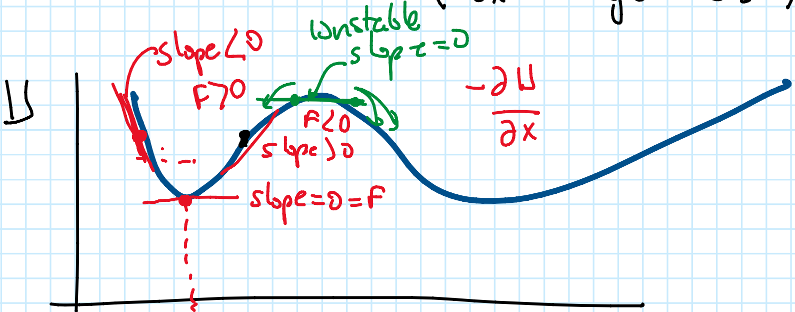


$$-\frac{\partial U}{\partial x}$$
-(eğim)

POTANSİYEL FONK.
→ EĞİM O ANDAKİ KUVVETİ VERİR !!



$$\vec{F} = -\nabla U \qquad \nabla \equiv \left(\frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}\right)$$



$$U = -\frac{A}{r}$$

$$\vec{F} = -\frac{\partial}{\partial r}\left(-\frac{A}{r}\right)\hat{r}$$

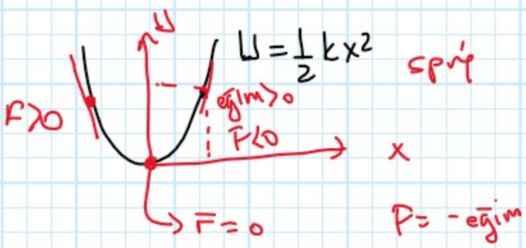
$$= +A\frac{\partial}{\partial r}\left(\frac{1}{r}\right)$$

$$\vec{F} = -A \quad \hat{r}$$

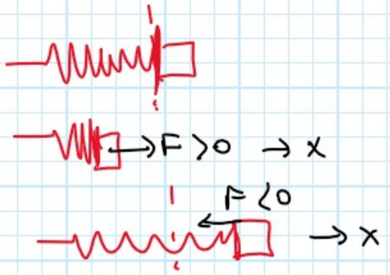
$\frac{\partial U}{\partial x} \equiv$ slope

X

$\vec{F} = -\frac{A}{r^2}\hat{r}$



$\frac{\partial U}{\partial x} = 0 \equiv$ stable



end of Ch7

$v_A = 0$

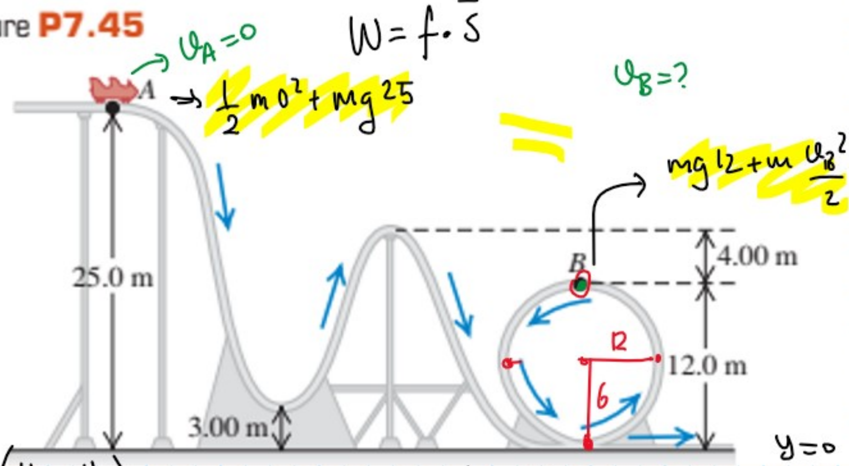
7.45 •• A 350-kg roller coaster starts from rest at point *A* and slides down the frictionless loop-the-loop shown in Fig. P7.45. (a) How fast is this roller coaster moving at point *B*? (b) How hard does it press against the track at point *B*?

$\cancel{W_f}^{0} + E_A = E_B$ only force $\downarrow g$

$W_f = 0$

$W = \vec{f}\cdot\vec{s}$

Figure **P7.45**



$U_A + K_A = U_B + K_B$

$W = \Delta K$

$-\Delta U_g$ grav.

+

$-\Delta U_{el}$ el

+

W_f friction

$-(U_f - U_i)$ $\quad K_f - K_i$

$\underbrace{-\Delta U_g - \Delta U_{el} + W_f}_{W_{tot}} = \Delta K \Rightarrow W_f + U_i + K_i = U_f + K_f$

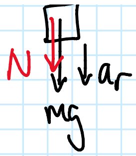
$E_A = E_B \Rightarrow \cancel{m}g\,25 = \cancel{m}g\,12 + \frac{\cancel{m}v_B^2}{2}$ (9.8) $\quad v_B = \sqrt{26g} = 15.96\,m/s$

$g13 = \frac{v_B^2}{2}$ $\quad v_B^2 = 26g$

what's the Normal force @ B?

$\downarrow \Sigma\vec{F} = m\vec{a}$

$N + mg = ma_r = m\frac{v_B^2}{r} \Rightarrow N = m\frac{v_B^2}{r} - mg$



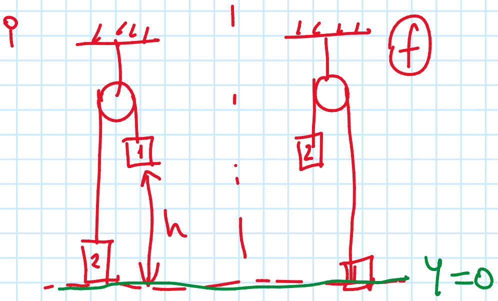
$\downarrow \Sigma \vec{F} = m\vec{a}$

$N + mg = ma_r = \frac{m v_B^2}{R} \Rightarrow N = \frac{m v_B^2}{R} - mg$

$= \frac{(350)(26g)}{6} - 350\,g$

$\underline{N = 11433.3\,N}$

Atwood machine.



$m_1 = 12kg$
$m_2 = 4kg$
$h = 2m$
system is released from rest $\rightarrow v_i = 0$

what are the velocities just before m_1 hits the ground?

$K = \frac{1}{2}mv^2$
$U = mgy$

$E_i = E_f$

$K_{1i} + K_{2i} + U_{1i} + U_{2i} = K_{1f} + K_{2f} + U_{1f} + U_{2f}$

$0 + 0 + M_1 g h + 0 = \frac{m_1 v_f^2}{2} + \frac{m_2 v_f^2}{2} + 0 + m_2 g h$

$v_f = v_i + at$
$y_f = y_i + v_i t + \frac{1}{2}at^2$

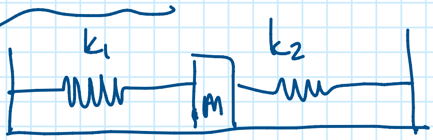
$v_i^2 + 2a\Delta y = v_f^2$, $v_i \to 0$

$\frac{2(12-8)(9.8)2}{12+8} = v_f^2 = \frac{2(m_1 - m_2)gh}{m_1 + m_2}$

$= 2\,a\,h$

$\left\{ a = \frac{(m_1 - m_2)}{m_1 + m_2} g \right\}$

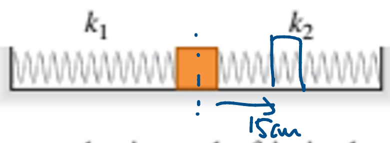
$v_f = 4.4\,m/s$

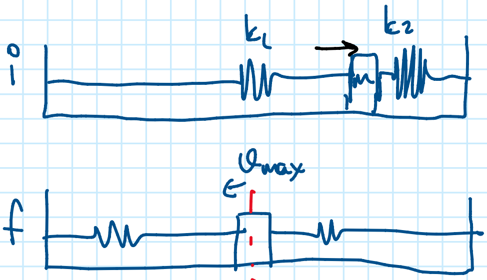


@

7.70 •• A 3.00-kg block is connected to two ideal horizontal springs having force constants $k_1 = 25.0$ N/cm and $k_2 = 20.0$ N/cm (Fig. P7.70). The system is initially in equilibrium on a horizontal, frictionless surface. The block is now pushed 15.0 cm to the right and released from rest ($v_i = 0$). (a) What is the maximum speed of the block? Where in the motion does the maximum speed occur? (b) What is the maximum compression of spring 1?

Figure **P7.70**





$E_i = E_f$

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

$U_{1i} + U_{2i} + K_i = K_f + U_{1f} + U_{2f}$

mum compression of spring 1?

$$U_{1i}+U_{2i}+K_i = K_f+U_{1f}+U_{2f}$$

K_f max, $U_{1f}=U_{2f}=0$ @ equilibrium

$$\frac{1}{2}k_1X^2+\frac{1}{2}k_2X^2+0=\frac{1}{2}m\vartheta_f^2+0+0$$

$$\frac{1}{2}(25)15^2+\frac{1}{2}(20)15^2=\frac{1}{2}3\vartheta_f^2$$

$$\sqrt{\frac{15^2(45)}{3}}=\vartheta_f=15\sqrt{15}\ m/s=58.1\ cm/s$$

$\Longleftrightarrow$

$$k'=k_1+k_2$$

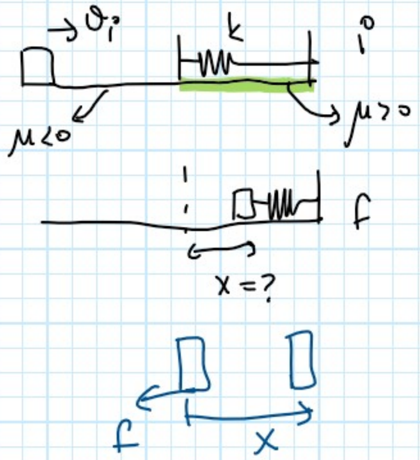
$$E_{total}=U_{1f}+U_{2f}+K_f$$

$$\underbrace{\frac{1}{2}k_1X_i^2+\frac{1}{2}k_2X_i^2+\frac{1}{2}m\vartheta_i^2}_{u_i=0}=\frac{1}{2}k_1X_f^2+\frac{1}{2}k_2X_f^2+\frac{1}{2}m\vartheta_f^2$$

$X \Rightarrow$ max ; $\vartheta_f=0$

$$\frac{1}{2}(k_1+k_2)X_i^2=\frac{1}{2}(k_1+k_2)X_f^2 \Rightarrow X_i=X_f=15\,cm$$

ex



$\mu=0.5$

$m=0.8$ kg

$k=50$ N/m

max compression?

$\vartheta_i=1.2$ m/s

$f=\mu mg$

$$w_f+E_i=E_f$$

$$w_f+U_i+K_i=U_f+K_f$$

$\vartheta_f=0$

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

$$-fx+0+\frac{1}{2}m\vartheta_i^2=\frac{1}{2}kx^2+0$$

$$0=\frac{1}{2}kx^2+fx-\frac{1}{2}m\vartheta_i^2$$

$$0=Ax^2+Bx\ C$$

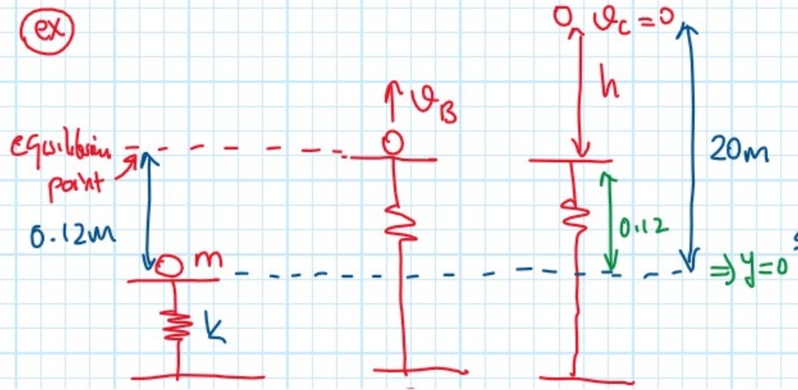
$$0=\frac{1}{2}50\ x2+\overset{\mu}{(0.5)}\overset{m}{(0.8)}\overset{g}{(9.8)}\overset{x}{X}-\frac{1}{2}(0.8)(1.2)^2$$

$$25x2+3.92x-0.576=0$$

$x \to = -0.25m$? ✗ $w_f>0$ ✗

$x \to = 0.092m$? ✓

ex

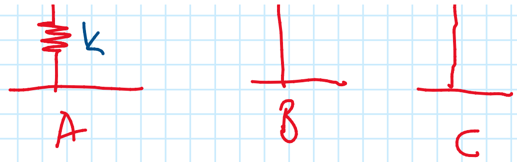


m=35 gr

spring is compressed 0.12m

it is released $\to \vartheta_A=0$

C mass is 20m above them



it is released $\rightarrow v_A = 0$
C mass is 20 m above than point @ A. $v_C = 0$

$k = ?$ $\quad v_B = ?$

$y = 0$ (establish)

$$E = U_{el} + U_g + K$$
$$\frac{1}{2}k(\Delta y)^2 + mgy + \frac{1}{2}mv^2$$
$$E_A = E_B = E_C$$

$$K_A + U_{g,A} + U_{el,A} =$$

$v_C = 0$ $\quad \Delta y = 0$

$$0 + 0 + \frac{1}{2}k(0.12)^2 = \frac{1}{2}m v_B^2 + mg(0.12) + 0 = 0 + mg(20) + 0$$

$$\frac{1}{2}k(0.12)^2 = \frac{1}{2}(0.035)v_B^2 + (0.035)(9.8)(0.12) = 0.035(9.8)(20)$$
$$= 6.86\ \text{J}$$

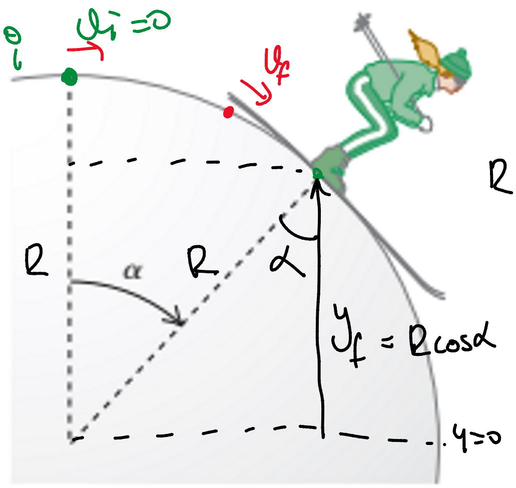
$$k = \frac{6.86 \times 2}{(0.12)^2} = 953\ \text{N/m}$$

$$v_B = \sqrt{\frac{(6.86 - 0.041)\,2}{0.035}}$$
$$= 19.7\ \text{m/s}$$

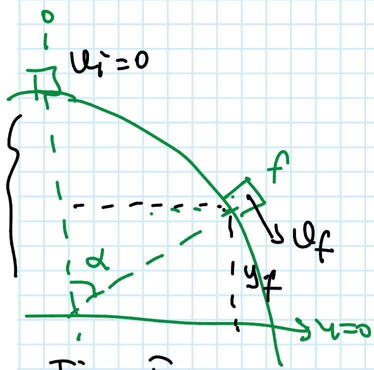
7.63 • **CP** A skier starts at the top of a very large, frictionless snowball, with a very small initial speed, and skis straight down the side (Fig. P7.63). At what point does she lose contact with the snowball and fly off at a tangent? That is, at the instant she loses contact with the snowball, what angle α does a radial line from the center of the snowball to the skier make with the vertical?

$0 \leftarrow$ $\quad \mu = 0$

Figure **P7.63**



$E_i = E_f$



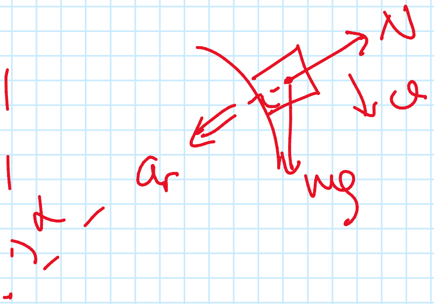
$$E_i = E_f$$
$$K_i + U_i = K_f + U_f$$
$$0 + mgR = \frac{mv_f^2}{2} + mgy_f$$

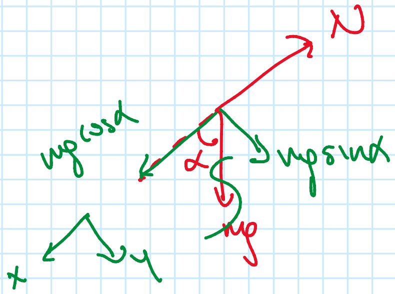
$$\cancel{m}gR = \frac{\cancel{m}v_f^2}{2} + \cancel{m}gR\cos\alpha$$

$$\frac{v_f^2}{2} = gR - gR\cos\alpha \Rightarrow \boxed{v_f^2 = 2gR(1 - \cos\alpha)}$$

N $\quad$ N

$\Sigma F = mg\cos\alpha - N = m a_r$





$\Sigma F_x = mg\cos\alpha - N = m\,a_r$

$mg\cos\alpha - N = m\dfrac{v_f^2}{R}$

$N = mg\cos\alpha - \dfrac{m v_f^2}{R} = 0$ (we want) $\Rightarrow$ $v_f^2 = gR\cos\alpha \Big\}\, N = 0$

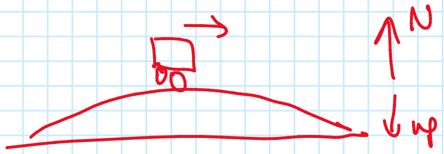
$\alpha = 0$: $\sqrt{gR}$

$\cancel{mg}\cos\alpha = \cancel{m}\dfrac{2\cancel{g}\cancel{R}(1-\cos\alpha)}{\cancel{R}}$

$\cos\alpha = 2(1-\cos\alpha)$

$\cos\alpha = \dfrac{2}{3}$; $\alpha = \cos^{-1}(2/3)$

$\alpha = 48.2°$



Speed bump.

$-N + mg = m\dfrac{v^2}{R}$ $\quad$ $N = mg - \dfrac{mv^2}{R}$