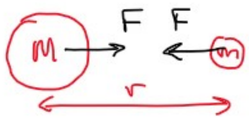
Phys1 -02

Thursday, November 3, 2022 12:52 PM

CHAPTER 4 & 5
NEWTON'S LAWS OF MOTION

- Force is an entity that make objects move; stop etc.
- It's a vector.
- we experience force by contact mostly.



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

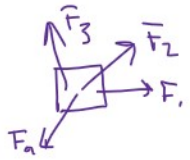
FORCE TYPES

Physics I

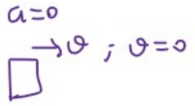
- GRAVITATIONAL → Directly ⇒ mg
- ELECTROMAGNETIC → INDIRECTLY ⇒ FRICTIONAL FORCES ; SURFACE CONTACT FORCES
- WEAK NUCLEAR } –⊖–
- STRONG NUCLEAR } –⊖–

Newton's laws of Motion

1st Law: A body acted on by no net force moves with constant velocity and zero acceleration.



$\underbrace{\sum \vec{F}}_{\text{net force}} = 0$



$\underbrace{\sum \vec{F} = 0}$ equilibrium state

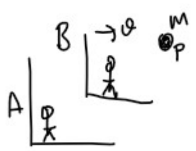
inertia (eylemsizlik) ~ 1st Law 'the tendency to keep its state'

Inertia ~ mass

Inertia < Inertia

m < M

ΣF = net force is the price you pay to win over the inertia



Inertial frame of reference } Should always measure something when your acceleration is ZERO

$$\vec{a}_{P/A} = \vec{a}_{P/B} + \underbrace{\vec{a}_{B/A}}_{0}$$

2nd Law: If a $\underbrace{\text{net force}}$ acts on a body, the body accelerates.

$\Sigma F > 0$; acceleration is propotional to the net force.

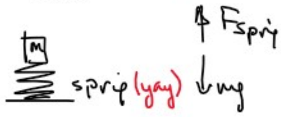
$$\Sigma F = (\dots)\, a$$

$$\boxed{m = \frac{\Sigma F}{a}} \Longleftrightarrow^{*} \boxed{\Sigma F = ma} \;*$$

Force = (mass) (acc.)

Newton ≡ $\left[kg\ \frac{m}{s^2} = N \right]$

$\underbrace{\frac{F_{spring}}{9.8} = m}$

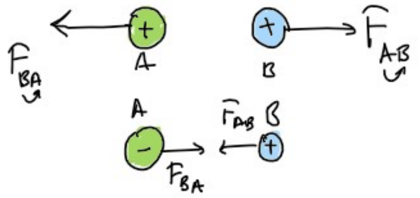


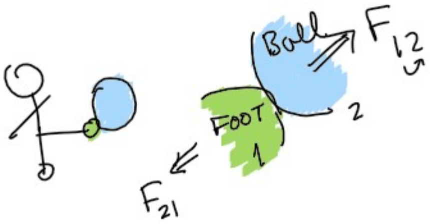
$$\text{Newton} \equiv \left[kg \ \frac{m}{s^2} = N \right]$$

weight ≠ mass
ağırlık ≠ kütle
Force ≠ mass

3rd Law: ACTION–REACTION FORCE PAIRS

when two bodies are interacting
if A exerts a force on B → action
B exerts " " A → reaction
with same magnitude and opposite direction

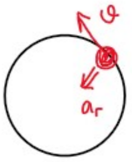




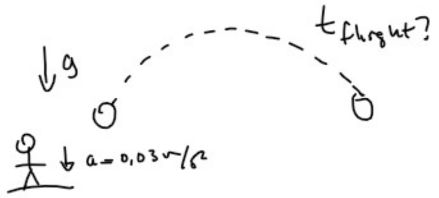
$$\boxed{\vec{F}_{12} = -\vec{F}_{21}}$$

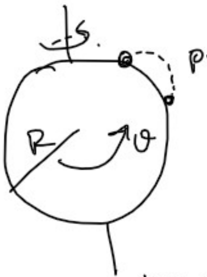
inertial frame of reference: $\vec{a}_{B/A} = 0$ so that $\underset{B}{\text{you}}$ measures correctly.

⇒ UCM



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





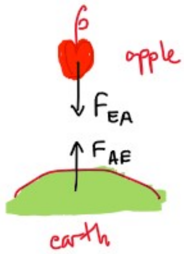
$a \neq 0 \quad a = \frac{v^2}{R} = \frac{4\pi^2 R}{T^2} \simeq 0.03\, m/s$

$R \to 6400\,km$

$T = 24 \times 60 \times 60\,s$

$a \ll g$

we neglect this and
we assume Earth is an "inertial frame of reference"



$\vec{F}_{EA} = -\vec{F}_{AE}$

$m_A \vec{a}_A = -M_E \vec{a}_E$

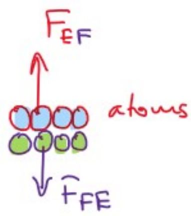
$\vec{a}_E \lll \vec{a}_A$

FORCE

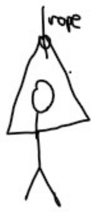
- grav. $\underline{mg}$
- contact force → (EM) (surfaces, rope, friction etc)

all forces

Force ≡ "in contact"



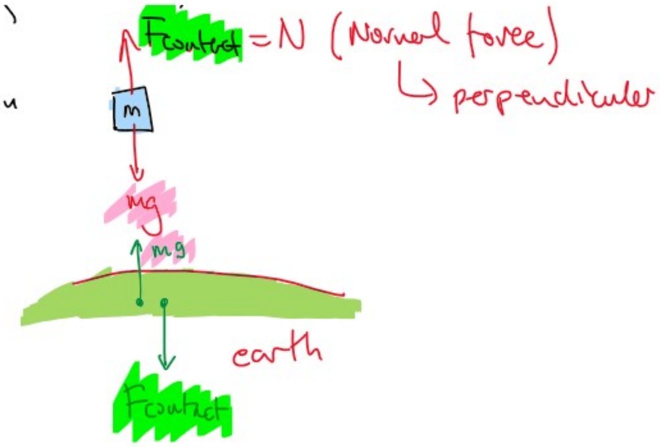
contact = surfaces pushes you



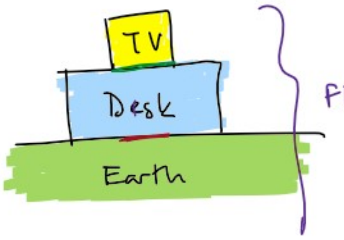
rope pulls you

$F_{contact} = N$ (Normal force)
↳ perpendicular

all forces acting on you

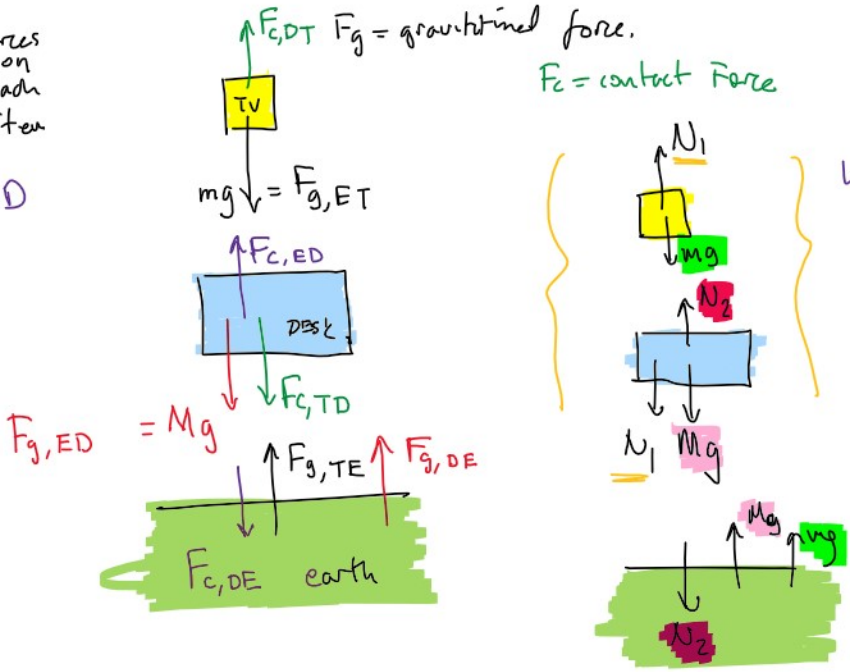


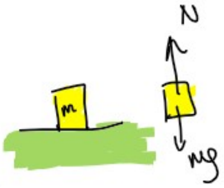
Forces on each item



F_g = gravitational force.

F_c = contact Force

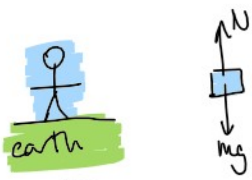




N, mg are NOT action reaction pairs

FREE BODY DIAGRAM (FBD) } showing all the forces acting on an object.

Serbest cisim Diyagramı



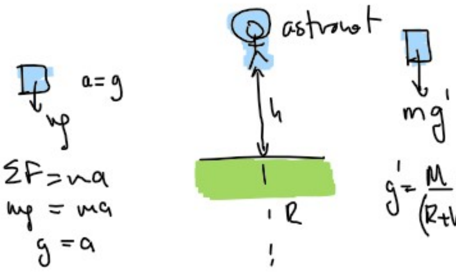
$\Sigma F = 0 \Rightarrow a = 0$

jump in the air $\Rightarrow$

$\Sigma F = ma$

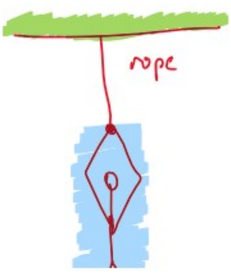
$mg = ma$

$g = a$



$g' = \frac{M}{(R+h)^2} G < 9.8$

N ≡ "is the one we feel our weight"



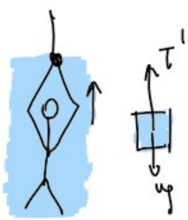
FBD

T = Tension

$\Sigma F = 0$

$a = 0$

pull yourself up



$\Sigma F = T' - mg = ma$

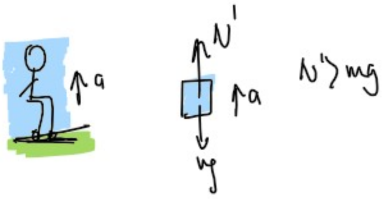
$a > 0$

$\Sigma F = 0$

$a = 0$

$a > 0$

jumping but still in contact



$N' > mg$

Ch4 – Ch5 FBD ; 2nd Law $\Sigma \vec{F} = m\vec{a}$ ⇒ solve for $a = ?$

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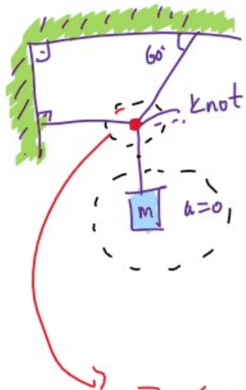
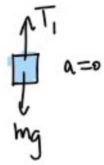
ex



The system is in equilibrium ⟹ $\Sigma F = 0$

tensions of the rope?

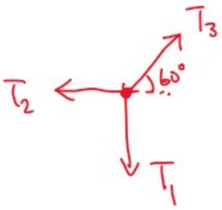
KNOT



$a=0$ $\Sigma \vec{F} = m\vec{a}$ $+y$ $a = a_y$

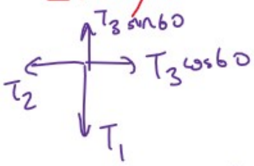
$T_1 - mg = 0$

$\boxed{T_1 = mg}$



knot ⇒ mass = 0

$\Sigma \vec{F} = \cancel{m}\vec{a}^{\,0}$



$\Sigma F_y = 0$

$\Sigma F_x = 0$

$\Sigma F_y = 0$

$T_3 \sin 60 = T_1 = mg$

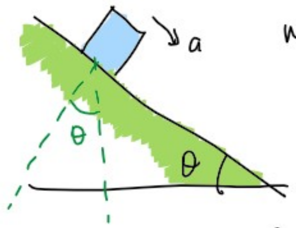
$T_3 = \dfrac{mg}{\sin 60}$ ✓

$\Sigma F_x = 0$

$T_3 \cos 60 - T_2 = 0$

$T_3 \cos 60 = T_2$

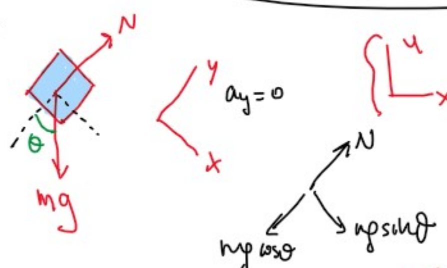
$T_2 = \dfrac{mg}{\sin 60} \cos 60$ ✓ $mg \cot 60 = T_2$



no friction

$a = ?$

FBD



$a_y = 0$

Longer

$\Sigma F_y = m a_y^{\,0}$

$N - mg\cos\theta = 0$

$\boxed{N = mg\cos\theta}$

$\Sigma F_x = m a_x$

$mg\sin\theta = ma$

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

$a = g\sin\theta$

$\theta = 0$ $a = 0$

$a = g\sin\theta$

$\theta = 90°$ $a = g$

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① FBD ⇒ draw forces on the mass

↳ ma ✓

$a = g$

① FBD ⇒ draw forces on the mass

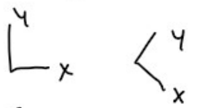
vectors

↳ mg ✓

→ surfaces push; strings pull ✓ } FBD

② $\sum \vec{F} = m\vec{a}$

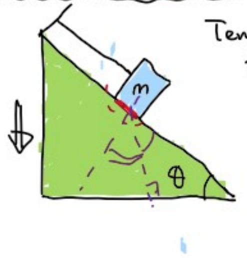
→ pick coord. sys.



one of the a_y, a_x is ZERO

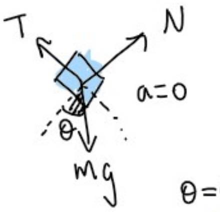
$\underline{\sum F_x = m a_x}$ $\quad \underline{\sum F_y = m a_y}$

③ solve for $a = ?$, $T = ?$, $N = ?$



Tension of the rope ?

FBD ?



$a = 0$

$\sum F_y = m\cancel{a_y}^{0}$

$N - mg\cos\theta = 0 \quad N = mg\cos\theta$

$\sum F_x = m\cancel{a_x}^{0}$

$mg\sin\theta - T = 0 \quad \underline{T = mg\sin\theta}$

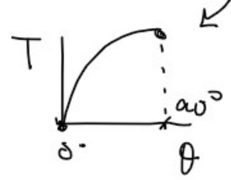
$\theta = 0°$

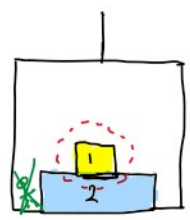
$\theta = 0$

$T = mg\sin\theta = 0$

$\theta = 90°$

$T = mg\sin 90 = \underline{mg}$



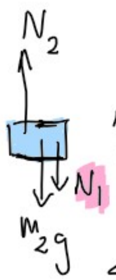


$\uparrow a$

FBD? contact force between $\underline{1}$ & $\underline{2}$?

↳ given $[m_1, m_2, g, a]$

$\uparrow +y$



FBD ✓

$\sum \vec{F} = m\vec{a} \Rightarrow \sum F_y = m_1 a_y$

$\underline{N_1} - m_1 g = m_1 a$ ①

$N_1 = m_1 a + m_1 g$

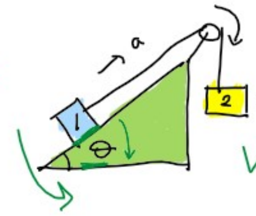
$\boxed{N_1 = m_1 (a+g)}$

$\sum F_y = m_2 a_y$

$N_2 - N_1 - m_2 g = m_2 a$

$N_2 = (m_1 + m_2)(a+g)$

I

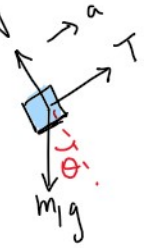


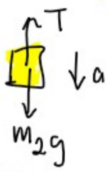
no friction

FBD?

$a = ?$

$T = ?$





$\sum F_x = m_1 a_x \quad \sum F_y = m\cancel{a_y}^{0}$

① $\underline{T - mg\sin\theta = m_1 a} \quad \underline{N = mg\cos\theta}$

$\sum F_y = m a_y$

$+y$ ② $m_2 g - T = m_2 a$

① + ② $\quad m_2 g - m_1 g\sin\theta = (m_1 + m_2) a$

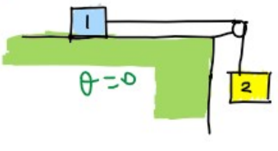
$$\boxed{a = \frac{(m_2 - m_1\sin\theta)}{m_1 + m_2} g}$$

② $\quad m_2 g - m_2 a = T = m_2 (g - a)$

$$= m_2 g \left(1 - \frac{m_2 - m_1\sin\theta}{m_1 + m_2}\right)$$

$$T = m_2 g \, \frac{(m_1 + m_1 \sin\theta)}{}$$

II



$\theta = 0$

✓ $T = \frac{m_1 m_2 g}{m_1 + m_2}$

FBD?

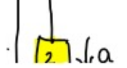
$a = ?$

$a = \frac{m_2}{m_1 + m_2} g$

a_{max}

T_{min}

III



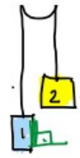
$\theta = 90°$

$a = \frac{m_2 - m_1}{m_1 + m_2} g$

FBD?

$a = ?$

$T = \frac{2 m_1 m_2 g}{}$



FBD?

a=?

a_{min}

T_{max}

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

$$T = m_2 g \frac{(m_1 + m_1 \sin\theta)}{m_1 + m_2}$$

$$\boxed{T = \frac{m_1 m_2 g}{m_1 + m_2}(1 + \sin\theta)}$$

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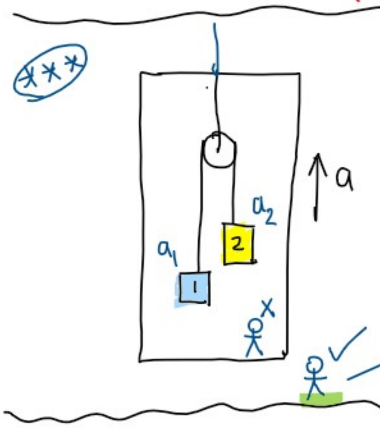
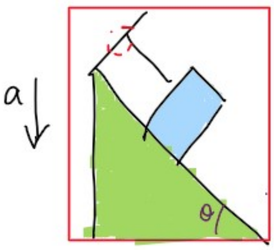


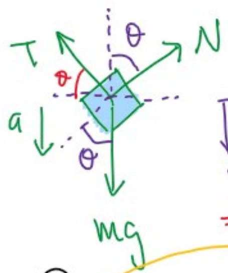
FBD?

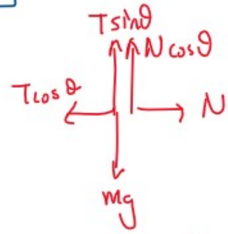
$a_1 = ?$

$a_2 = ?$

How to solve this problem without using ghost force?







① $\Sigma F_x = m a_x^{\nearrow 0}$

$N\sin\theta - T\cos\theta = 0$

② $\Sigma F_y = m a_y$

$mg - T\sin\theta - N\cos\theta = ma$

① $N\sin\theta = T\cos\theta$

$\boxed{T = N\tan\theta}$

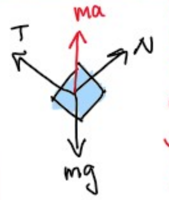
② $mg - \underline{\underline{N}}\tan\theta\sin\theta - \underline{\underline{N}}\cos\theta = ma$

$$m(g-a) = N\left(\frac{\sin^2\theta}{\cos\theta} + \cos\theta\right)$$

$$m(g-a) = \frac{N}{\cos\theta}(\sin^2\theta + \cos^2\theta)$$

$$N = m(g-a)\cos\theta$$

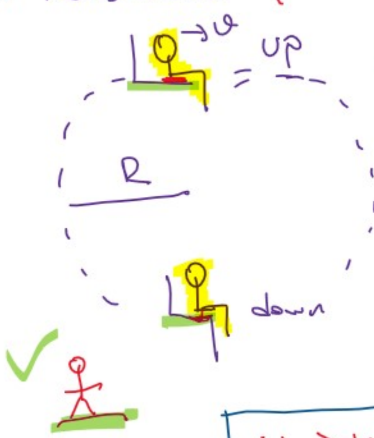
$$T = m(g-a)\sin\theta$$



THIS IS NOT a TRUE FBD. You cannot draw a GHOST force

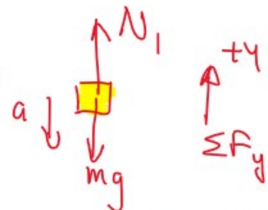
FBD for CIRCULAR MOTION

* Ferris wheel (Dönme dolap)



UCM ; v = const

contact force between person & chair up. down?

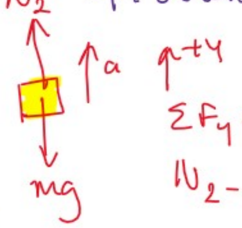


Top

$\Sigma F_y = m a_y$

$N_1 - mg = m(-a)$

Top $\boxed{N_1 = m(g-a)}$



$\Sigma F_y = m a_y$

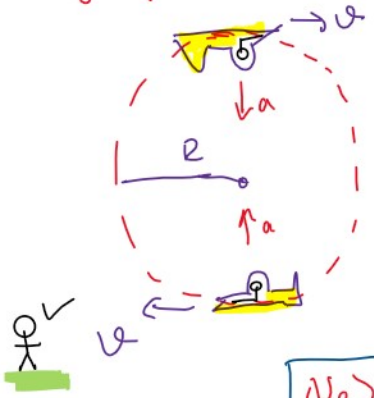
$N_2 - mg = ma \Rightarrow \boxed{N_2 = m(g+a)}$ Bottom

$\boxed{N_2 > N_1}$

* Jet pilot UCM vertically

+y $-mg - N_1 = -ma$

* Jet pilot UCM vertically



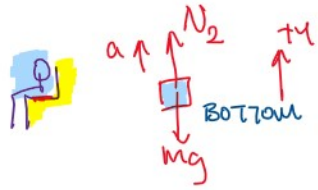
$\boxed{N_2 > N_1}$

$\uparrow +y \quad -mg - N_1 = -ma$

$\Sigma F_y = ma_y$

$mg + N_1 = ma$

$\boxed{N_1 = m(a-g)}$ $\quad \underline{\underline{a > g}}$

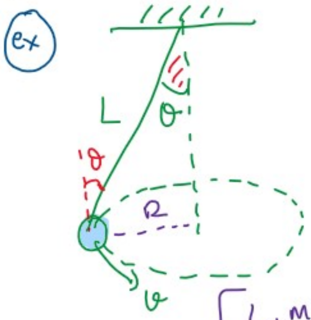


$\Sigma F_y = ma_y$

$N_2 - mg = ma \Rightarrow \boxed{N_2 = m(a+g)}$

---

ex



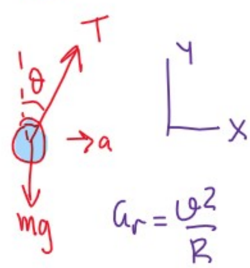
$T = ?$

FBD?

$v = ?$

$[L, m, g, \theta]$

FBD



$\Sigma F_y = m\cancel{a_y}^{\,0}$

① $T\cos\theta - mg = 0$

$\Sigma F_x = ma_x$

$T\sin\theta = ma$

$a_r = \dfrac{v^2}{R}$

$R = L\sin\theta$

② $T\sin\theta = \dfrac{mv^2}{L\sin\theta}$

$\dfrac{mg}{\cos\theta} = T$ ✓

$\dfrac{mg}{\cos\theta}$

$T = \dfrac{mg}{\cos\theta}$ ✓

$\theta\uparrow;\ v\uparrow \Leftarrow v = \sqrt{gL\dfrac{\sin^2\theta}{\cos\theta}}$

$\sqrt{\dfrac{m}{s^2}m} = \dfrac{m}{s}$

$m = 1\,kg$

$g = 9.8\,m/s^2$

$T = ?$ if $\underline{\underline{\theta = 90°}}$

$\theta = 89.9°$

$T = \dfrac{1(9.8)}{\cos 90 \to 0} \to \infty$

<u>MD 1</u>

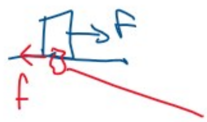
%70 / 60 test $\begin{cases} Ch1 \\ Ch2 \\ Ch3 \end{cases}$

$\left.\begin{matrix} Ch4 \\ Ch5 \end{matrix}\right\} \Rightarrow$ w/o <u>friction</u>

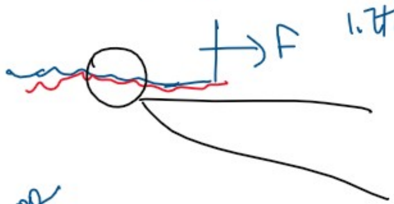
↳ classic <u>%40</u>

30-40

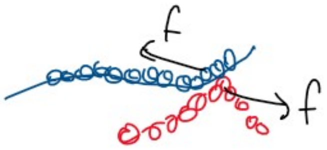
FRICTIONAL FORCES ~ surface roughness



f = frictional force.



little <u>bumps</u>, <u>holes</u> resists the motion



Top layer

Bottom layer

Electromagnetic force

$\boxed{f = \mu N}$

Electromagnetic force

μ = frictional coeff. (mu) N = normal force from surface [EM force]

→ dynamic / kinetic frictional coeff. $\Rightarrow f_k = \mu_k N$

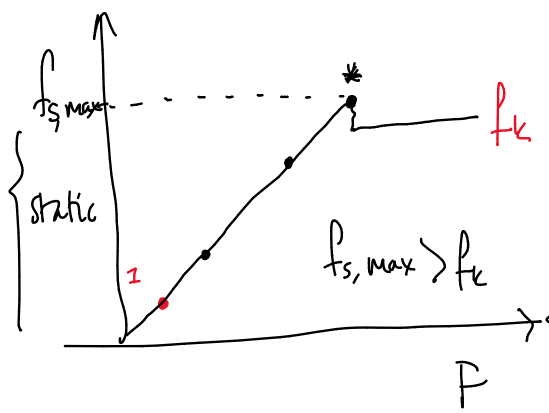
→ static " " $\Rightarrow f_s = \mu_s N$

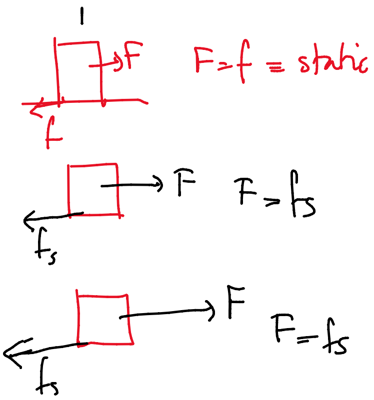
$\mu_s > \mu_k$

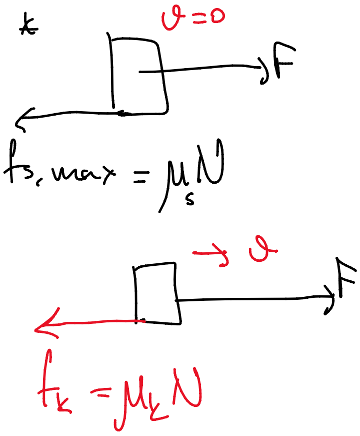
materials	static μ_s	kinetic μ_k
steel – steel	0.74	0.57
Cu – steel	0.53	0.36
glass glass	0.94	0.40
Cu glass	0.68	0.53
Teflon on Teflon	0.04	0.04
Human joints (eklem)	0.004	0.004

material		μ_s	μ_k
Rubber on concrete (asfalt beton)	DRY	1.0	0.8
	WET	0.3	0.25

→ ABS systems of cars.

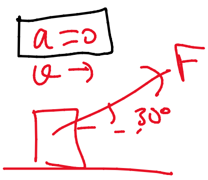






f will oppose to the motion ≡ kinetic friction

ex)

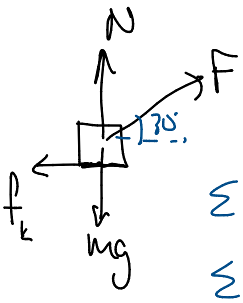


$\mu_k = 0.4$

$mg = 500N$

$F = ?$

FBD



$a = 0$

$\Sigma F_y = 0$

$\Sigma F_x = 0$

$f = \mu N$

$\Sigma F_y = 0$

N, $F\sin 30$

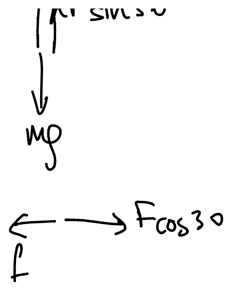
$N - mg - F\sin 30 =$

$\Sigma F_y = 0$

$N = mg - F\sin 30$

$\Sigma F_x = 0$

$F\cos 30 = f = \mu N$



$f = \mu N$

$F\cos 30 = f = \mu\,(mg - F\sin 30) \Rightarrow F(\cos 30 + \mu\sin 30) = \mu mg$

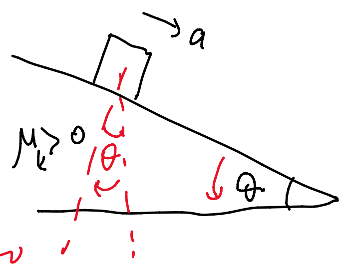
$$F = \frac{\mu mg}{\cos 30 + \mu \sin 30}$$

$$F = \frac{(0.4)(500)}{\sqrt{3}/2 + 0.4(1/2)} = 188N$$

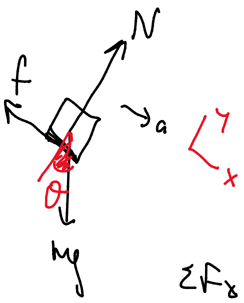
$N = mg - F\sin 30 = 500 - 188(1/2) = \underline{406N}$

$f = 0.4N$
$= 0.4(406)$
$\underline{f = 162.4N}$

ex)



a=?



$a_y = 0$

$a_x = a$

$\Sigma F_y = m a_y^{\,0}$

$N - mg\cos\theta = 0$

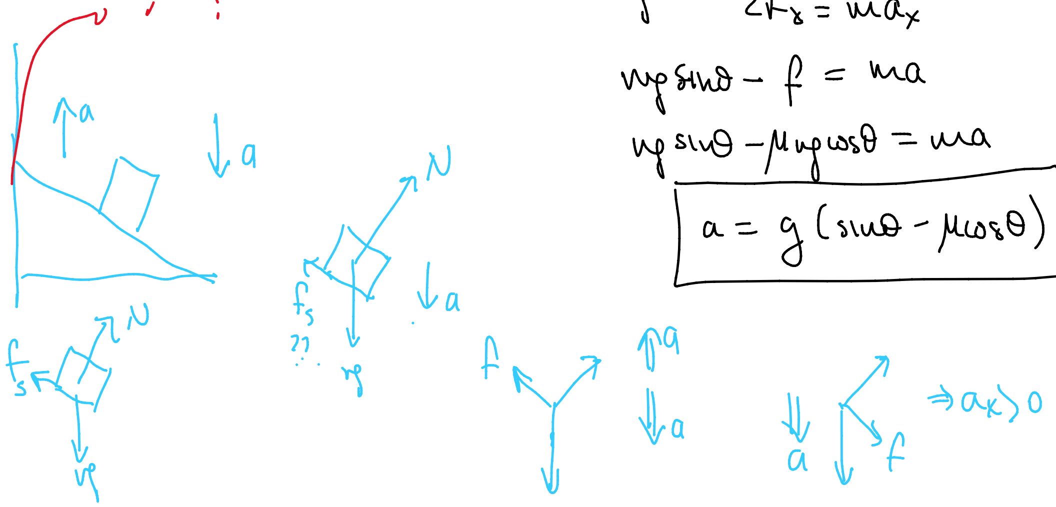
$N = mg\cos\theta$

$\Sigma F_x = m a_x$

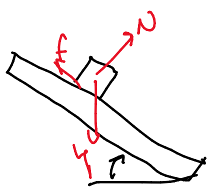
$mg\sin\theta - f = ma$

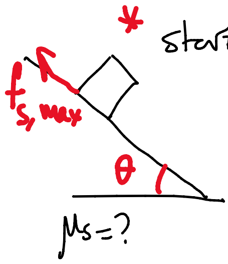
$mg\sin\theta - \mu mg\cos\theta = ma$

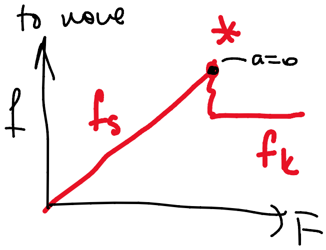
$$\boxed{a = g(\sin\theta - \mu\cos\theta)}$$

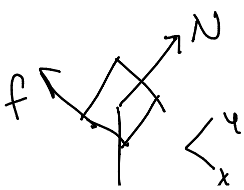


how to measure μ_s =?



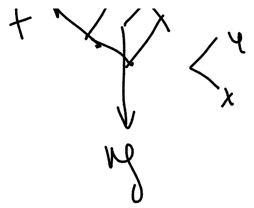






a=0

$N = mg\cos\theta$



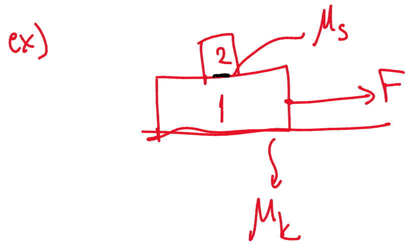
$N = mg\cos\theta$

$\Sigma F_x = m\cancel{a}^{0} = 0$

$mg\sin\theta - \underset{\mu N}{f} = 0 \Rightarrow mg\sin\theta = \mu mg\cos\theta$

$\boxed{\mu_s = \tan\theta}$ $\mu_s \leq 1.0$

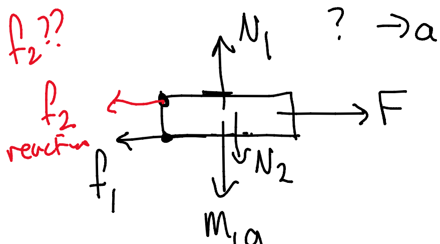
ex)



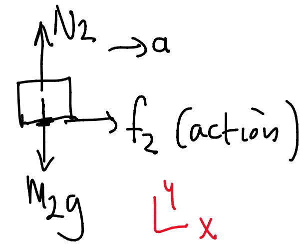
1 & 2 are moving together w/o slipping
same acceleration

$a = ?$

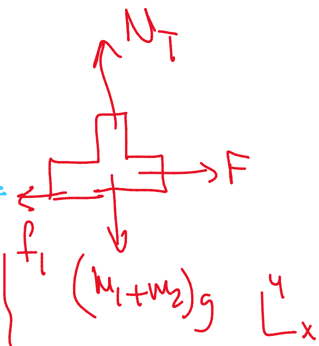
FBD



+



=



$\Sigma F_y = m_1 \cancel{a_y}^{0}$

$N_1 - m_1 g - N_2 = 0$; $N_2 = m_2 g$

$\boxed{N_1 = (m_1+m_2)g}$

$\Sigma F_x = m_1 a$

$F - f_2 - f_1 = m_1 a$

$F - \mu_s N_2 - \mu_k N_1 = m_1 a$

$F - \mu_s m_2 g - \mu_k (m_1+m_2) g = m_1 a$

$$a = \frac{F - \mu_s m_2 g - \mu_k (m_1+m_2) g}{m_1} \quad ①$$

$\Sigma F_y = m_2 \cancel{a_y}^{0}$

$N_2 = m_2 g$

$\Sigma F_x = m_2 a$

$f_2 = m_2 a$

$\mu_s N_2 = m_2 a$

$\mu_s m_2 g = m_2 a$

$② \ \boxed{a = \mu_s g}$

$\Sigma F_y = 0$

$N_T = (m_1+m_2)g = N_1$

$f_1 = \mu_k N_1$

$\Sigma F_x = m_T a$

$F - f_1 = (m_1+m_2)a$

$a = \dfrac{F - \mu_k (m_1+m_2) g}{m_1+m_2}$

$$\Rightarrow a = \frac{F - m_2 a - \mu_k (m_1+m_2) g}{m_1}$$

$(m_1+m_2)a = F - \mu_k (m_1+m_2) g$

$$a = \frac{F - \mu_k (m_1+m_2) g}{m_1+m_2}$$

① = ②

$$\frac{F - \mu_s m_2 g - \mu_k (m_1+m_2) g}{m_1} = \mu_s g$$

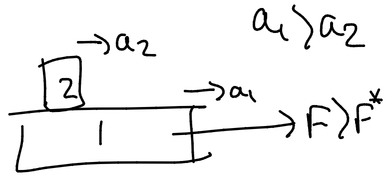
$$F - \mu_s m_2 g - \mu_k (m_1+m_2) g = m_1 \mu_s g \Rightarrow F = \mu_s (m_1+m_2) g + \mu_k (m_1+m_2) g$$

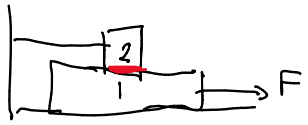
$$\boxed{F^* = (m_1+m_2) g \, (\mu_s + \mu_k)}$$

max force that moves them together and m_1 & m_2 have the same acceleration.

$F > F^*$

$a_1 > a_2$





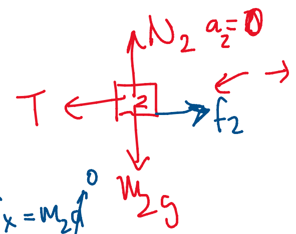
$m_2 \; m_1 \; g \; \mu_k \; F$ given.

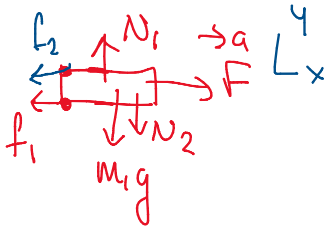
all the surfaces have friction.

FBD?

$a = ?$

$T = ?$ ✓





$\Sigma F_y = m_1 \cancel{a_y}^{0}$

$N_1 = N_2 + m_1 g = (m_1+m_2) g$

$\Sigma F_x = m_2 \cancel{a}^{0}$

$T - f_2 = 0 \quad T = f_2$

$\Sigma F_y = m_2 \cancel{a_y}^{0}$

$N_2 = m_2 g \quad ; f_2 = \mu_k N_2 = T$

$f_2 = \mu m_2 g$

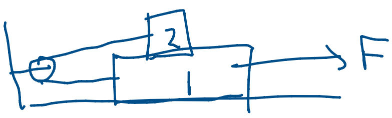
$\Sigma F_x = m_1 a$

$F - f_1 - f_2 = m_1 a$

$F - \mu N_1 - \mu N_2 = m_1 a \qquad \mu = \mu_k$

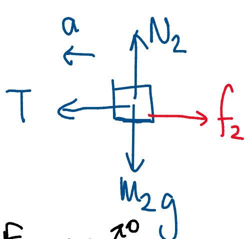
$F - \mu (m_1+m_2) g - \mu m_2 g = m_1 a$

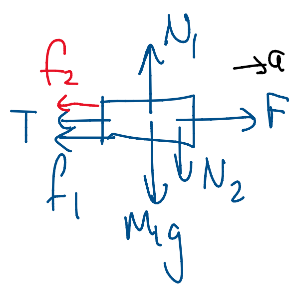
$$a = \frac{F - \mu m_1 g - 2\mu m_2 g}{m_1}$$



FBD? $T = ?$ $a = ?$

$\mu_k > 0$





$\Sigma F_y = m_1 \cancel{a}^{0}$

$N_1 = N_2 + m_1 g$

$N_1 = (m_1+m_2) g$

$\Sigma F_y = m_2 \cancel{a}^{0} \quad N_2 = m_2 g$

$\Sigma F_x = m_2 a$

$T - f_2 = m_2 a$ (1)

$\Sigma F_x = m_1 a$

(2) $F - T - f_1 - f_2 = m_1 a$

(1) + (2) $\to$ F ...

$\Sigma F_x = m_2 a$

$T - f_2 = m_2 a$ (1)

$f_2 = \mu m_2 g$

$f_1 = \mu (m_1 + m_2) g$

$F - T - f_1' - f_2' = m_1 a$

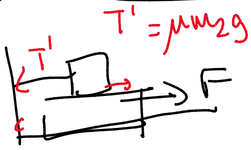
(1) + (2) $\Rightarrow F - f_2 - f_1 - f_2 = (m_1 + m_2) a$

$$a = \frac{F - 2f_2 - f_1}{(m_1 + m_2)}$$

$$a = \frac{F - 2\mu m_2 g - \mu m_1 g - \mu m_2 g}{m_1 + m_2}$$

$$\boxed{a = \frac{F - \mu m_1 g - 3\mu m_2 g}{m_1 + m_2}}$$

$T' = \mu m_2 g$



$$a' = \frac{F - \mu m_1 g - 2\mu m_2 g}{m_1}$$

$a' > a$

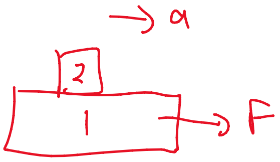
$T - f_2 = m_2 a$

$$T = m_2 \left(\frac{F - \mu m_1 g - 3\mu m_2 g}{m_1 + m_2} \right) + \mu m_2 g$$

$$T = \frac{m_2 \left(F - \cancel{\mu m_1 g} - \cancel{3}^{2}\mu m_2 g + \cancel{\mu m_1 g} + \cancel{\mu m_2 g} \right)}{m_1 + m_2}$$

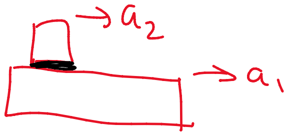
$a > 0$ $\quad F > \mu m_1 g + 3\mu m_2 g$

$$T = \frac{m_2 (F - 2\mu_k m_2 g)}{m_1 + m_2}$$

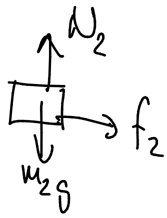


$F^* = (m_1 + m_2)(\mu_s + \mu_k) g$

$F > F^*$ $\quad a_1 > a_2$

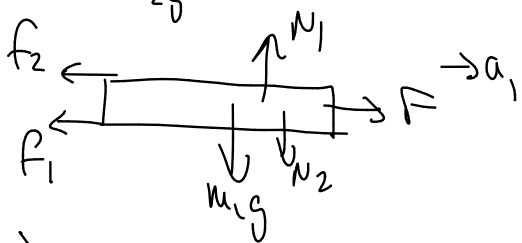


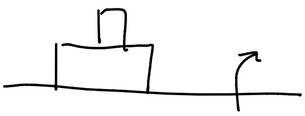
FBD

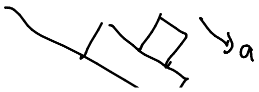


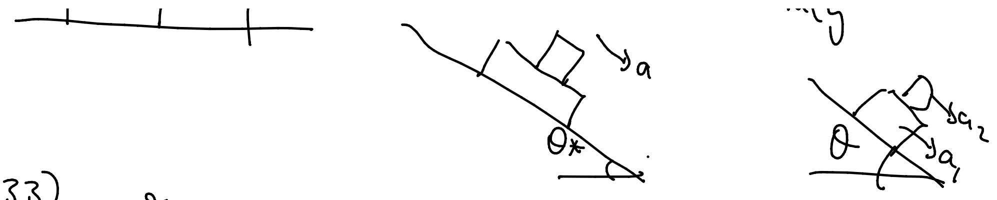
a_2

$F > F^*$

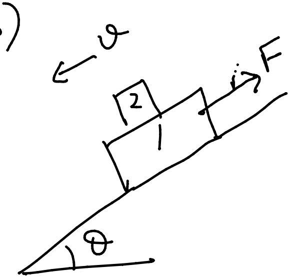








5.33)

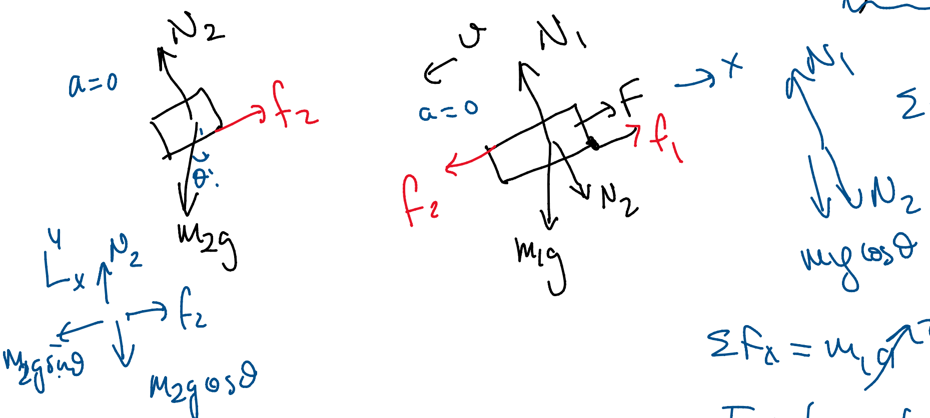


$\mu_s > 0$

$\mu_k > 0$

objects move down together with const. velocity

$F = ?$ FBD? $\mu_s = ?$



$\Sigma F_y = 0$

$N_1 = N_2 + m_2 g \cos\theta$

$N_1 = (m_1 + m_2) g \cos\theta$

$\Sigma F_x = m_1 a \xrightarrow{} 0$

$F + f_1 - f_2 - m_1 g \sin\theta = 0$

$F + \mu_k (m_1 + m_2) g \cos\theta - m_2 g \sin\theta - m_1 g \sin\theta = 0$

$F = (m_1 + m_2) g [\sin\theta - \mu_k \cos\theta]$

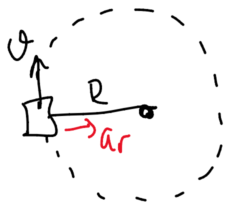
$N_2 = m_2 g \cos\theta$ $\quad \Sigma F_y = 0$

$m_2 g \sin\theta = f_2$ $\quad \Sigma F_x = 0$

$\mu_s m_2 g \cos\theta = f_2 = m_2 g \sin\theta$

$\boxed{\mu_s = \tan\theta}$

Dynamics of circular motion.

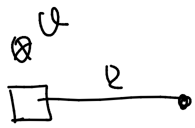


UCM

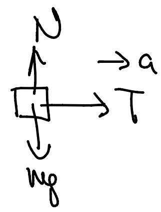
TOP VIEW

no friction!!

side view



$a_r = \frac{v^2}{R}$ = radial acc.



$\Sigma F_y = 0$

$N = mg$

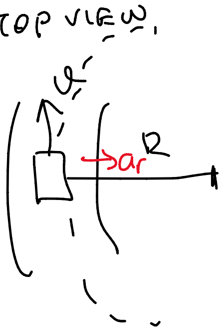
$\Sigma F_x = m a_x$

$T = m a_r$

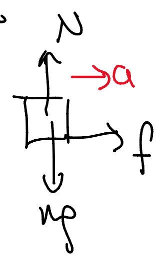
$T = m \frac{v^2}{R}$

Rounding a flat curve (virajı dönmek)

TOP VIEW



side view



$\Sigma F_y = 0 \Rightarrow N = mg$

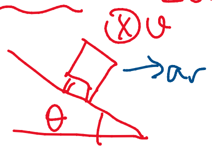
$\Sigma F_x = m a_x = m a_r$

$f_s = m \frac{v^2}{R}$

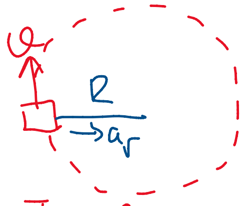
μN

μN
$\mu mg = m\frac{v^2}{R}$
$v = \sqrt{\mu_s g R}$

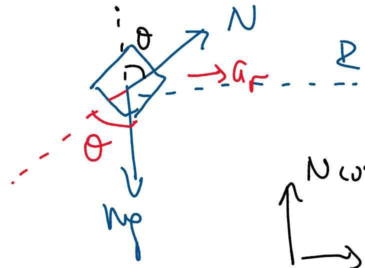
NASCAR Roundup a banked curve.



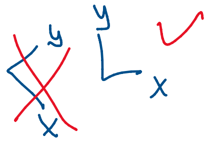
$\mu_s = 0$
no friction

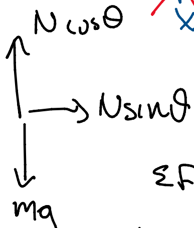


Top view

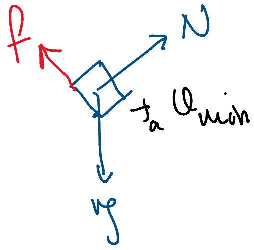


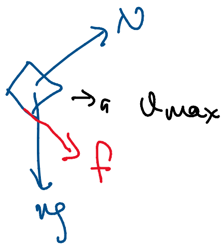
$\Sigma F = ma$





If there's static friction





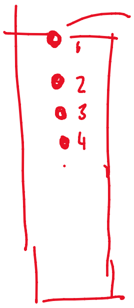
$\Sigma F_y = 0$
$N\cos\theta = mg$
$N = \frac{mg}{\cos\theta}$

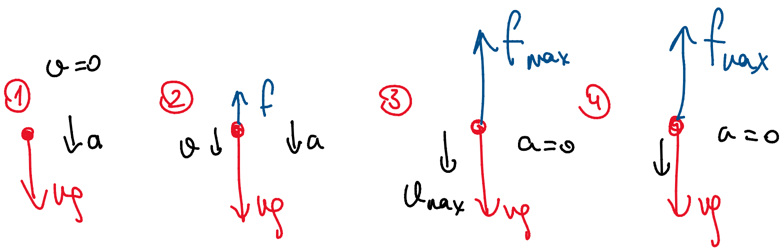
$\Sigma F_x = ma_r$
$N\sin\theta = m\frac{v^2}{R}$
$mg\tan\theta = m\frac{v^2}{R}$

$v = \sqrt{gR\tan\theta}$

AIR RESISTANCE
FLUID "

LIQUID





$\Sigma F = 0$
$mg - f = 0$
$mg = f$
$mg = kv_T$

v_T = terminal velocity

f is a function of velocity

$f = kv$

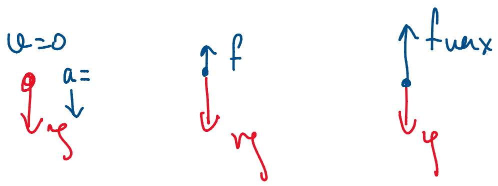
$\left[kg\frac{\cancel{m}}{s^{\cancel{2}}} = \frac{\cancel{m}}{\cancel{s}}k\right]$

$k = [kg/s]$

$$\boxed{v_T = \frac{mg}{k}}$$

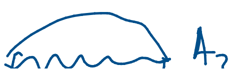
AIR RESISTANCE

$f = Dv^2$



$\Sigma F = 0$
$Dv_T^2 = mg$
$v_T = \sqrt{\frac{mg}{D}}$

D ~ crossectional area ~ A



D ~ cross-sectional area ~ A

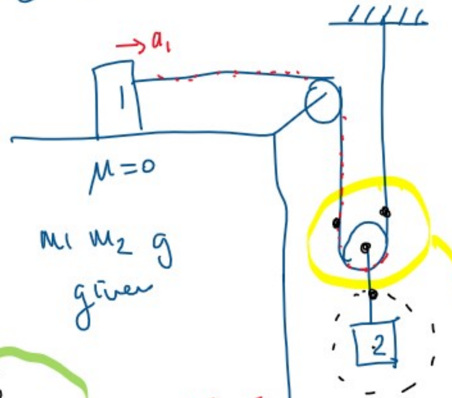
$\vartheta_T = \sqrt{\frac{mg}{D}}$

$A_3 > A_2 > A_1$

$D_3 > D_2 > D_1$

$\vartheta_{T3} < \vartheta_{T2} < \vartheta_{T1}$

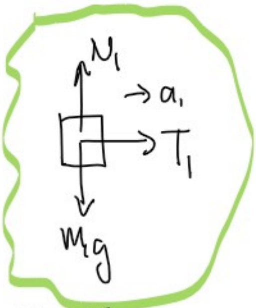
5.91



acc. of m_1 & m_2?

Tension of the rope?

m_1 m_2 g given

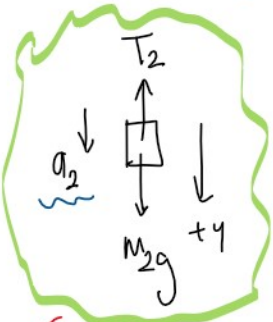


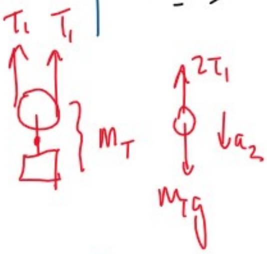
$\Sigma F_y = m_1 a_y^{\nearrow 0}$

$N_1 = m_1 g$

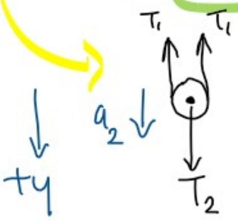
$\Sigma F_x = m_1 a_1$

$\boxed{T_1 = m_1 a_1}$ (1)





m_p = pulley's mass



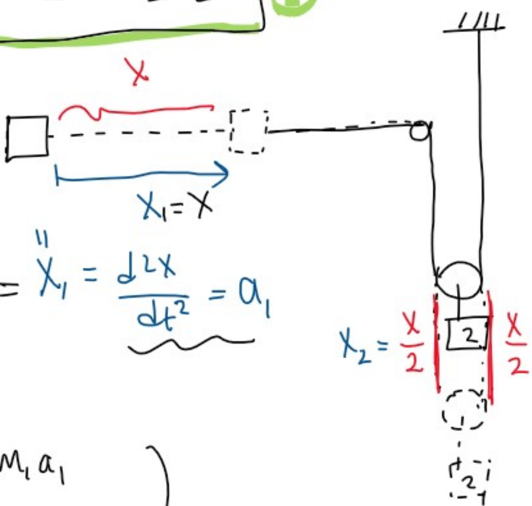
$\Sigma F_y = m_p a$

$$\left\{ \begin{array}{l} T_2 - 2T_1 = m_p a_2 \\ (3)\ T_2 = 2T_1 \quad (m_p = 0) \end{array} \right\}$$

makaranın kütlesi yoksa

{pulley's are massless !!}

$\boxed{m_2 g - T_2 = m_2 a_2}$ (2)



$\ddot{X} = \ddot{X}_1 = \frac{d^2 x}{dt^2} = a_1$

$a_2 = \frac{d^2 x_2}{dt^2} = \ddot{x}_2 = \frac{d^2\left(\frac{x}{2}\right)}{dt^2} = \frac{1}{2}\underbrace{\frac{dx^2}{dt^2}}_{a_1} = a_2$

$\boxed{a_2 = \frac{1}{2} a_1}$

$$\left\{ \begin{array}{l} T_1 = m_1 a_1 \\ m_2 g - T_2 = m_2 a_2 \\ a_1 = 2a_2 \\ 2T_1 = T_2 \end{array} \right\}$$

$\times 2 \quad T_1 = m_1 a_1 = 2m_1 a_2$

$+ \quad m_2 g - 2T_1 = m_2 a_2$

$m_2 g = 4m_1 a_2 + m_2 a_2$

$\boxed{a_2 = \frac{m_2}{4m_1 + m_2} g}$; $a_1 = \frac{2m_2 g}{4m_1 + m_2}$

Akın düzeltti !!

$T_1 = m_1 a_1 = 2m_1 m_2 g$; $T_2 = 4 m_1 m_2 g$

Akın düzeltti !!

$T_1 = m_1 a_1 = \dfrac{2 m_1 m_2 g}{4m_1 + m_2}$; $T_2 = \dfrac{4 m_1 m_2 g}{4 m_1 + m_2}$

F
m_1
m_2
=

$F = 2T$

acc. of pulley $= a_3$

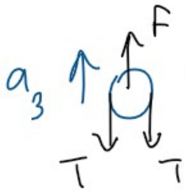
acc. of m_1, $a_1 = ?$

" " m_2, $a_2 = ?$

$\cancel{T = |m_1 - m_2| g}$??

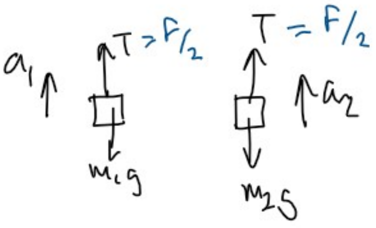
→?

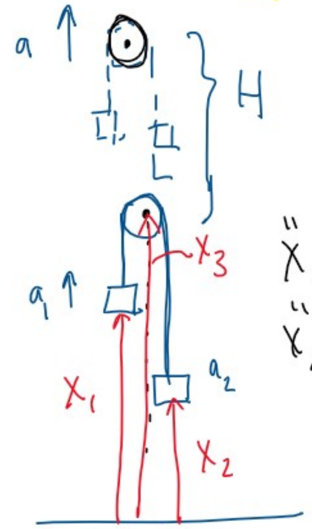
$\cancel{\dfrac{T - m_1 g - m_2 g}{m_1 + m_2} = a}$?



$m_p = 0$

$F = 2T$





$\ddot{X}_1 = a_1$

$\ddot{X}_2 = a_2$

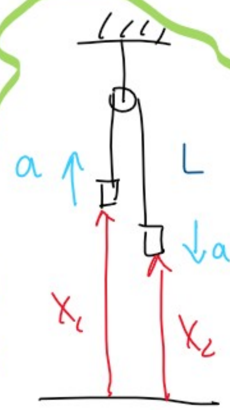
$a_3 = \dfrac{d^2 X_3}{dt^2} = \ddot{X}_3$ (makaranın ivmesi)

$X_1 + L + X_2 = 2X_3$

$\dfrac{d^2}{dt^2}$: $a_1 + 0 + a_2 = 2a_3$

$\boxed{a_1 + a_2 = 2a_3}$

$a_3 = 0$



$X_1 + X_2 + L = \text{const}$

$\dfrac{d^2}{dt^2}$: $a_1 + a_2 + 0 = 0$

$\boxed{a_1 = -a_2}$

If a_3 is given

$a_1 + a_2 = 2a_3$ → $a_2 = 2a_3 - a_1$

$T - m_1 g = m_1 a_1$

$-1/\ T - m_2 g = m_2 a_2$

+

$(m_2 - m_1) g = m_1 a_1 - m_2 a_2 = m_1 a_1 - 2m_2 a_3 + m_2 a_1 = (m_2 - m_1) g$

$a_1 = \dfrac{(m_2 - m_1) g + 2 m_2 a_3}{m_1 + m_2}$

$a_2 = 2a_3 - a_1$

$= \dfrac{(2m_1 + \cancel{2m_2}) a_3 - m_2 g + m_1 g - \cancel{2m_2 a_3}}{m_1 + m_2}$

$a_2 = \dfrac{(m_1 - m_2) g + 2 m_1 a_3}{m_1 + m_2}$

→ $a_3 = 0$

$a_1 = \dfrac{m_2 - m_1}{m_1 + m_2} g$

$a_2 = m_1 - m_2$

$a_1 \uparrow$ $\downarrow a_2$

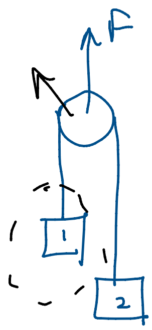
$$a_2 = \frac{(m_1-m_2)g + 2m_1 a_3}{m_1+m_2}$$

$\rightarrow a_3 = 0$

$$a_2 = \frac{m_1-m_2}{m_1+m_2}\, g$$

$a_1 \uparrow \quad \downarrow a_2$

$m_p = 0$



$F = 100\,N$

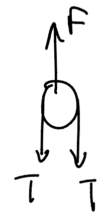
$m_1 = 1\,kg$

$m_2 = 2\,kg$

$a_1 = ?$

$a_2 = ?$

$g = 10\,m/s^2$



$F = 2T$

$T = F/2$

$T = F/2 = 50N$

$\uparrow a_1$

$m_1 g$

$\uparrow 50N$

$\downarrow 10N$

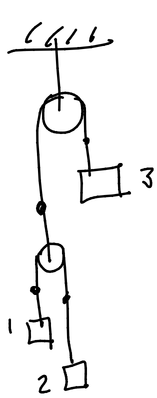
$\Sigma F = m_1 a_1$

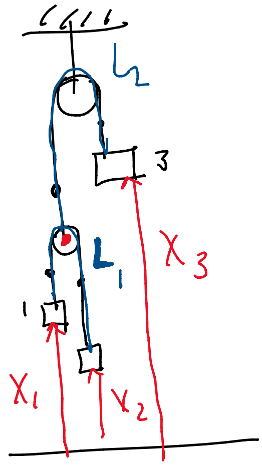
$40 = 1\; a_1 \qquad a_1 = 40\,m/s^2$

$T = 50N$

$m_2 g = 20N$

$30N = m_2 a_2 \qquad a_2 = 15\,m/s^2$





$a_1 \quad a_2 \quad a_3$

end of Ch 4 & 5