Fizik I

Mekanik

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Fizik Bölümü

26.9.16

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Kaynak kitaplar: Serway Fizik I

Pearson - Üniversite Fiziği I

Tıp ve Biyolojide Fizik (Davidovitz) → nobel yayınları

Büyük ihtimal ⇒ 2 vize + final

Fizik ~ Doğa → ölçüm → standart

Uzunluk ve kütle ⇒ 1875 toplantı

uzunluk → metre tanımlanıyor

kütle → kg

10cm küp 4°C su kütlesi

prototipler üretiliyor.

platinyum + iridyum alaşımı

~1990-lar prototipler tekrar ölçülüyor.

⇒ Teknolojik/Bilimsel gelişme ile standartlar tekrar tanımlanır

—ara—

⇒ Zaman (saniye) ~ MÖ tarihli

dünya 365 gün 24 saat 60 dk 60 s

yetersiz değil

atom saati!

Cs-133 atomunun 9 192 631 770 kere (defa) titreşimi = 1 s eşit

geçerli tanım

1960-lar ⇒ atom-molekül fiziği lazerler vs

1 metre tanımlanıyor

1 metre ışığın boşlukta 1/299 792 458 saniyede aldığı yoldu

c = 299 792 458 m/s = ışık hızı

en zayıf halka ⇒ kg tanımı

↳ Avogadro projesi

→ yakın "the most spherical object"

yuvarlak; kürenin atom sayısı sabit

ÖLÇÜM - BİRİMLER SI (7) standart birim

1. zaman (s)
2. uzunluk (m)
3. kütle (kg)

} Fizik - mekanik

4. akım (A = amper) → elektrik mühendisliği
5. sıcaklık (K = kelvin) → termodinamik
6. mol (miktar; sayı) → kimya/biyol.
7. kandela (kandil; cd) Aydınlık → astrofizik

1 milyon = 10^6 m (mega)

1 km = 10^3 m

nehir m

mm = 10^{-3} m

(mikro) $\mu m = 10^{-6}$ m } hücre, Biyoloji molekülü boyutu

(nano) $nm = 10^{-9}$ m

Birim çevirme:

saatte 40 km/sa süratteki arabanın hızı m/s cinsinden?

$1\ km/sa = \frac{1000\ m}{60 \times 60\ s} = \frac{1000}{3600}\ \frac{m}{s}$

$1\ km/sa = \frac{1}{3.6}\ m/s$

$40\ km/sa = \frac{40}{3.6}\ m/s \simeq 11\ m/s$

Usain Bolt ~ 11 m/s

Büyüklük mertebesi hesaplama ve tahmin

Pratik üzerine yapılan hesaplama

⇒ tahmin etmek gerekiyor

⇒ hassasiyet önemli değil.

Bir insanın hayatı boyunca aldığı nefes sayısı ortalama (tahmini)

70 yıl = $70\ \text{yıl} \times 365\ \frac{\text{gün}}{\text{yıl}} \times 24\ \frac{\text{sa}}{\text{gün}} \times 60\ \frac{\text{dk}}{\text{sa}} \times 60\ \frac{\text{s}}{\text{dk}}$

$= 70 \times 400 \times 25 \times 360 = 25 \times 10^8$

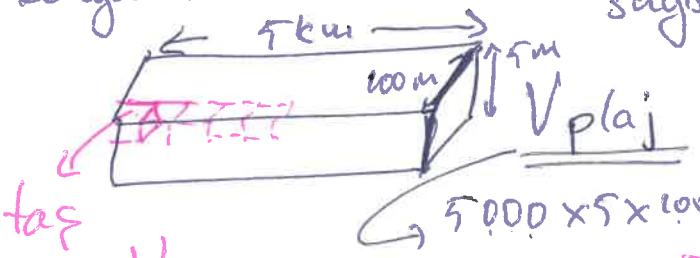
$2\Gamma \times 10^8$ saniye = insan ömrü (2)

1 nefes alma/verme = 3 s

nefes sayısı $= \frac{2\Gamma \times 10^8\ s}{3\ s/nefes} = 8 \times 10^8$ nefes

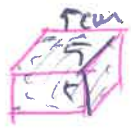
$= 800 \times 10^6 = 800$ milyon

Kongaalti sahilindeki taşların sayısı?



$5000 \times 5 \times 100\ m^3$

$V_{taş}$



$5 \times 5 \times 5\ cm^3$

$1\ cm = 10^{-2}\ m$

$1\ cm^3 = 10^{-6}\ m^3$

taş sayısı $= \frac{V_{plaj}}{V_{taş}} = \frac{2\Gamma \times 10^5\ m^3}{125\ cm^3}$

$= \frac{2\Gamma \times 10^5}{125 \times 10^{-6}} \frac{m^3}{m^3} = \frac{1}{5} \times 10^{11}$

$= \frac{10}{5} \times 10^{10} = 20 \times 10^9$

$= 20$ milyar taş

Insandaki hücre sayısı?

70 kg insan

$1\ dm^3 = 1\ L$

70 Litre hacim $= V_{insan}$

1 kg su = 1 L su

hücre

$10\ \mu m$ = çap

$V_{hücre} = (10\ \mu m)^3$

$V_h = 1000\ \mu m^3$

$V_i = 70\ dm^3$

+3

$$\frac{V_{insan}}{V_{hucre}} = \frac{70\ dm^3}{1000\ \mu m^3} = \frac{70 \times 10^{-3}\ m^3}{10^3 \times 10^{-18}\ m^3}$$

$(1\ dm)^3 = (10^{-1}\ m)^3 = 10^{-3}\ m^3 = 1\ dm^3$

$(1\ \mu m)^3 = (10^{-6}\ m)^3 = 10^{-18}\ m^3$

$$\text{hücre sayısı} = \frac{7 \times 10^{-2}}{10^{-15}} = 7 \times 10^{13}\ \text{tane}$$

$= 70000 \times 10^9$

milyar

100 trilyon insan

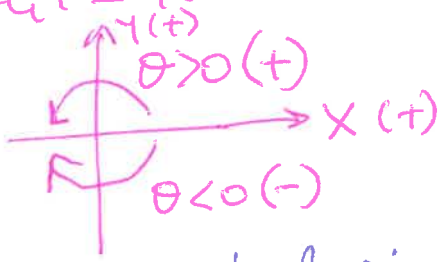
70 trilyon

28.9.16 ISBT

Vektörler → Büyüklük
→ Yön

→ yön
Uzunluk = büyüklük

AÇI = YÖN



!!

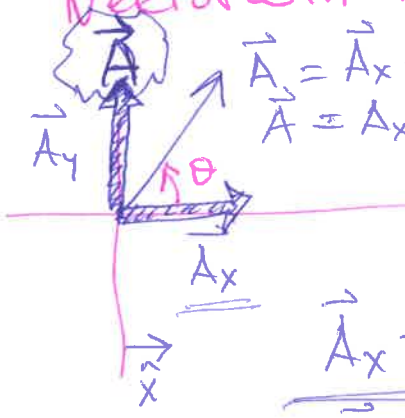
→ vektör İşlemleri
↳ toplama; çıkarma
→ çarpma ↳ skaler)
↓ vektörel (noktasal)

GÖRSEL — MATEMATİKSEL

GÖRSEL
çizim

MATEMATİKSEL
koordinat sist
→ birim vektör.

Vektörlerin Bileşenleri



$\vec{A} = \vec{A}_x + \vec{A}_y$

$\vec{A} = A_x\hat{x} + A_y\hat{y}$ (sayı)

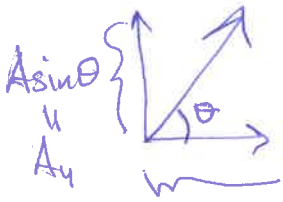
büyüklük

$\vec{A}_x = A_x\hat{x}$

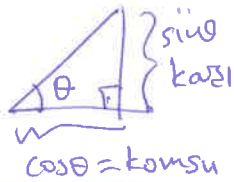
$\vec{A}_y = A_y\hat{y}$

$\hat{x}, \hat{y}$

Birim vektörler
↳ Büyüklüğü 1 olan



$\vec{A}$ büyüklüğü A (1)

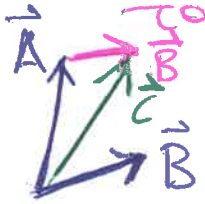


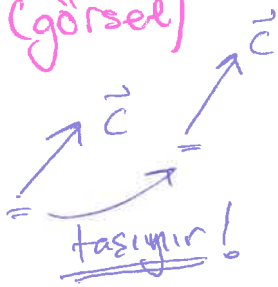
$A_x = A\cos\theta$

$$\vec{A} = A\cos\theta\,\hat{x} + A\sin\theta\,\hat{y}$$

İşlemler

Toplama (görsel)





$\vec{A} + \vec{B} = \vec{C}$
(baş-kuyruk)

Matematiksel:

$\vec{A} = 3\hat{x} + 4\hat{y}$

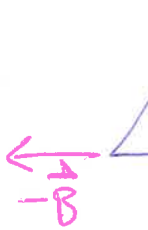
$\vec{B} = 2\hat{x}$

$\vec{A} + \vec{B}$

$5\hat{x} + 4\hat{y}$

$\vec{C}$

Çıkarma:



$\vec{A} + \vec{B} = \vec{A} + (-\vec{B})$

$-\vec{B}$?
yönü 180° değiştir

$\vec{A} - \vec{B} = \vec{D}$

$\vec{A}-\vec{B}=?$ $\vec{A}=3\hat{x}+4\hat{y}$ $\vec{B}=2\hat{x}$

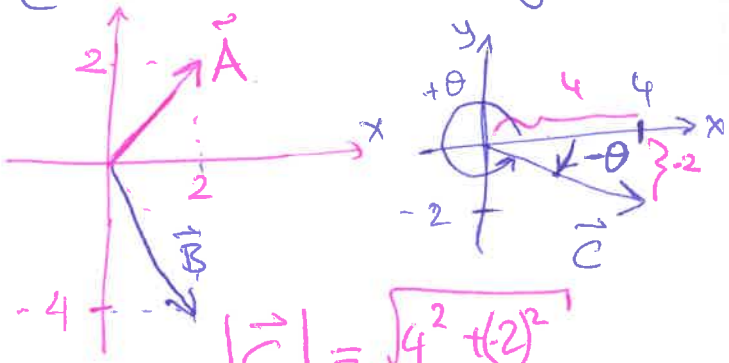
$\vec{A}-\vec{B}=3\hat{x}+4\hat{y}-2\hat{x}$

$\vec{D}=\hat{x}+4\hat{y}$

Ör: $\vec{A}=2\hat{x}+2\hat{y}$ $\vec{B}=2\hat{x}-4\hat{y}$

a) $\vec{A}+\vec{B}$ büyüklük ve yönü?

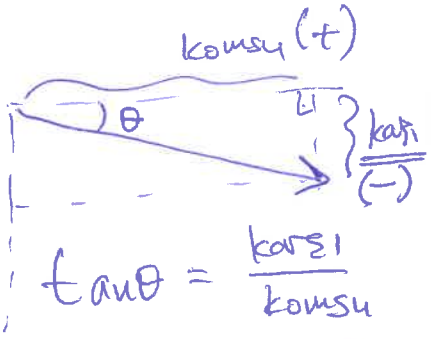
$\vec{C}=\vec{A}+\vec{B}=4\hat{x}-2\hat{y}$



$|\vec{C}|=\sqrt{4^2+(-2)^2}$

Büyüklük $C=|\vec{C}|=\sqrt{20}$

yön? ⇒ AÇI



$\tan\theta=\left(\frac{-2}{4}\right)$ $\tan\theta=\frac{\text{karşı}}{\text{komşu}}$

$\theta=?$

$\theta=\arctan\left(-\frac{2}{4}\right)=\tan^{-1}\left(\frac{-2}{4}\right)$

$\theta=-26.5°$ ↙ $-26.5°$

$\theta=360-26.5°$

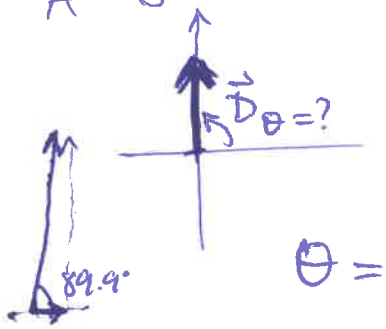
Büyüklük $\sqrt{20}$; $\theta=-26.5°$

$\vec{A}=2\hat{x}+2\hat{y}$

$\vec{B}=2\hat{x}-4\hat{y}$

b) $\vec{A}-\vec{B}$; büyüklük? yön?

$\vec{A}-\vec{B}=\vec{D}=0\hat{x}+6\hat{y}$



$|\vec{D}|=\sqrt{0^2+6^2}=6$

$\theta=\tan^{-1}\left(\frac{6}{0}\right)=90°$

3 boyutta 3 tane birim vektör

$\hat{x}$ $\hat{y}$ $\hat{z}$ ⇒

koordinat sistemi tanımlarlar.

üç birim vektörü birbirine DİKTİR. Birbirleri üzerine izdüşümleri sıfırdır.

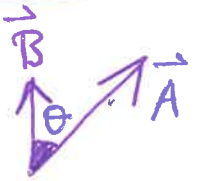
$\vec{A}\Rightarrow 2\vec{A}$ $\frac{\vec{A}}{2}=\frac{1}{2}\vec{A}$

$\vec{A}$ ↗ ↗ $2\vec{A}$ ↗ $\frac{\vec{A}}{2}$

Vektörlerde ÇARPIM

- **Skaler ç.** (noktasal): $\vec{A}\cdot\vec{B}=C$ (sayı / skaler)
- **Vektörel ç.**: $\vec{A}\times\vec{B}=\vec{D}$ (vektör)

Skaler çarpım (izdüşüm)



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

$$C=AB\cos\theta$$ (sayı)

$$\vec{A}\cdot\vec{B}=(A\cos\theta)B$$

$$A(B\cos\theta)$$

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

ne zaman max?
$\cos\theta=1$
$\theta=0^\circ$

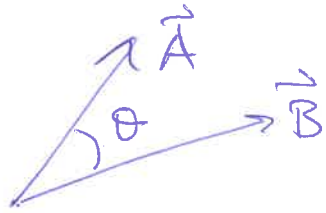
ne zaman min?
$\cos\theta=0$
$\theta=90^\circ$

$$\vec{A}\cdot\vec{A}=?=AA\cos 0=A^2$$

$$\hat{x}\cdot\hat{x}=|\hat{x}|\,|\hat{x}|\cos 0=1$$
$$1\;1\;1$$

$$\hat{x}\cdot\hat{y}=1\;1\cos 90^\circ=0$$

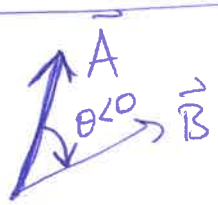
Ör) (5)



$|\vec{A}|=3$
$|\vec{B}|=4$
$\theta=10^\circ$

$\vec{A}\cdot\vec{B}=?$

$\vec{A}\cdot\vec{B}=|\vec{A}|\,|\vec{B}|\cos 10$
$=AB\cos 10$
$=(3)(4)\cos 10=11.8$



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

$\vec{B}\cdot\vec{A}$

$BA\cos\theta$

$$\vec{A}\cdot\vec{B}=\vec{B}\cdot\vec{A}$$ sıralama ÖNEMSİZ

Ör) $\vec{A}=3\hat{x}+4\hat{y}+7\hat{z}$
$\vec{B}=-2\hat{x}+\hat{y}$

$\vec{A}\cdot\vec{B}=?$

$$(3\hat{x}+4\hat{y}+7\hat{z})\cdot(-2\hat{x}+\hat{y})$$

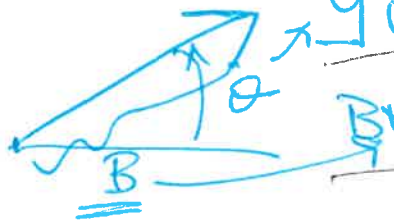
$=(3)(-2)\,\hat{x}\cdot\hat{x}+(3)(1)\,\hat{x}\cdot\hat{y}^{0}$
$+(4)(-2)\,\hat{y}\cdot\hat{x}^{0}+(4)(1)\,\hat{y}\cdot\hat{y}$
$+(7)(-2)\,\hat{z}\cdot\hat{x}^{0}+(7)(1)\,\hat{z}\cdot\hat{y}^{0}$

$\hat{x}\cdot\hat{x}=\hat{y}\cdot\hat{y}=\hat{z}\cdot\hat{z}=1$
$\hat{x}\cdot\hat{y}=\hat{x}\cdot\hat{z}=\hat{y}\cdot\hat{z}=0$

$=(-6)\,1+(4)\,1=-2$

$$\vec{A}\cdot\vec{B}=-2$$

Vektörler



YÖN

BÜYÜKLÜK

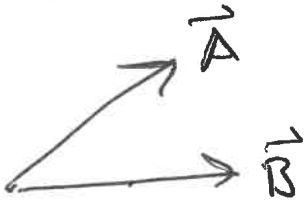
İŞLEM

→ TOPLAMA ÇIKARMA

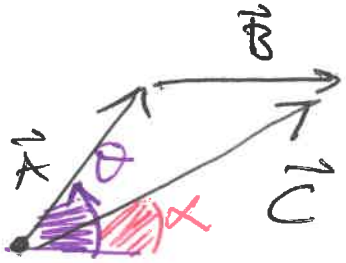
→ ÇARPMA → skaler •

↳ X Vektörel

$$\vec{A} + \vec{B} = \vec{C}$$



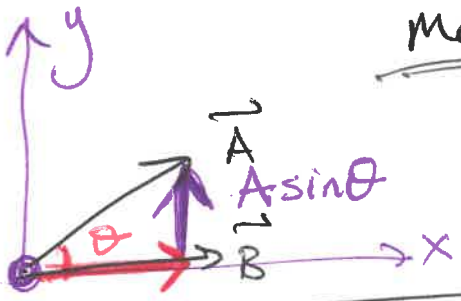
görsel →

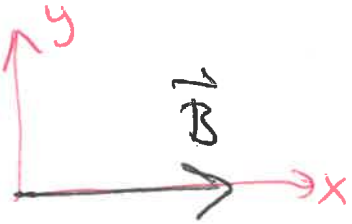


matematiksel

KOORDİNAT sistemi

x, y, z





$$\vec{A} = A\cos\theta\,\hat{x} + A\sin\theta\,\hat{y} \qquad \vec{B} = B\,\hat{x}$$

? ?

$|\hat{a}| = 1$ ← Birim vektörler $\hat{a}$

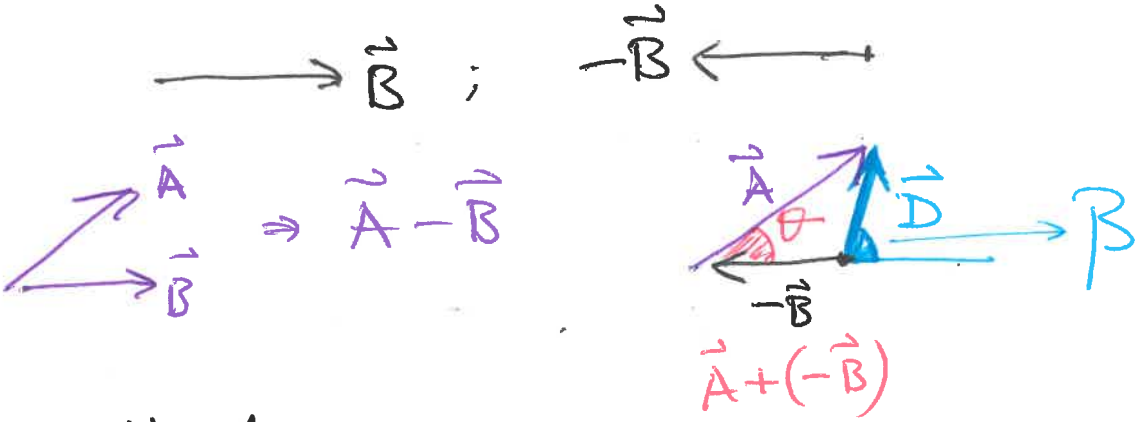
↳ büyüklüğü 1

$$\vec{A} + \vec{B} = A\cos\theta\,\hat{x} + A\sin\theta\,\hat{y} + B\,\hat{x}$$

$$\vec{C} = (A\cos\theta + B)\,\hat{x} + A\sin\theta\,\hat{y}$$

$$\vec{C} = C\cos\alpha\,\hat{x} + C\sin\alpha\,\hat{y}$$

$\vec{A} - \vec{B} = ?$ $\quad \vec{A} + (-\vec{B}) = \vec{D}$



matematiksel

$$\vec{A} = A\cos\theta\,\hat{x} + A\sin\theta\,\hat{y}$$

$$+ \quad -\vec{B} = -B\,\hat{x}$$

$$\vec{D} = (A\cos\theta - B)\,\hat{x} + A\sin\theta\,\hat{y}$$

$$\vec{D} = D\cos\beta\,\hat{x} + D\sin\beta\,\hat{y}$$

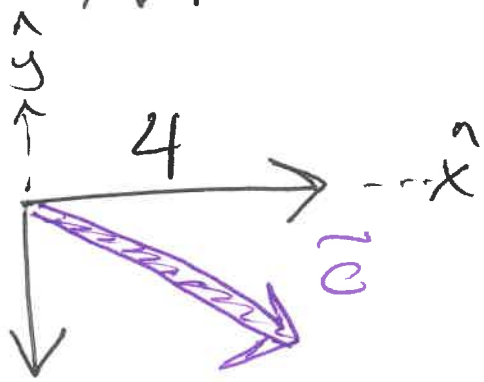
ör

$\vec{A} = 2\hat{x} + 2\hat{y}$ $\quad \vec{B} = (2\hat{x} - 4\hat{y})$

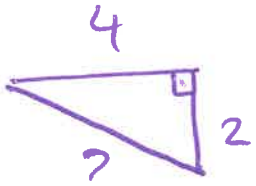
$\vec{A} + \vec{B} = \vec{C} = ?$ $\longrightarrow$ büyüklük $\sqrt{4^2 + (-2)^2}$

yön

$\vec{A} + \vec{B} = 4\hat{x} - 2\hat{y}$



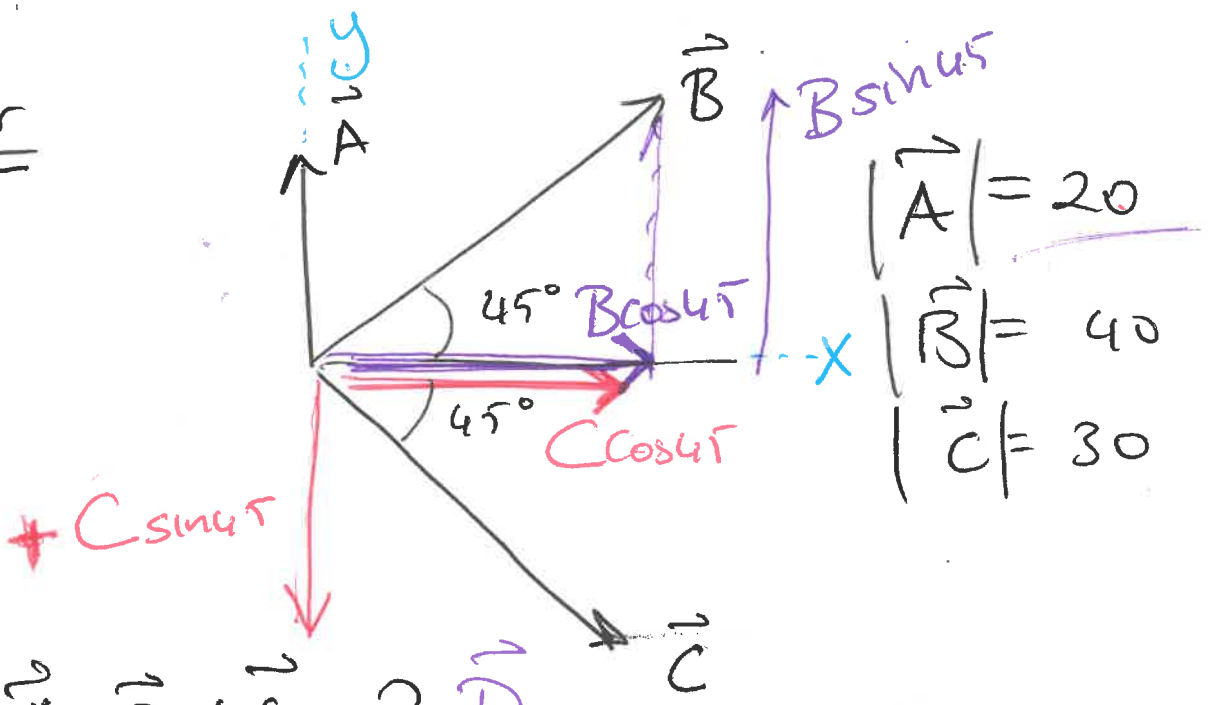
$|\vec{C}| = ?$ büyüklük



2

$\sqrt{2^2 + 4^2} = |\vec{C}|$

ör



$|\vec{A}| = 20$

$|\vec{B}| = 40$

$|\vec{C}| = 30$

$\vec{A} + \vec{B} + \vec{C} = ?\ \vec{D}$

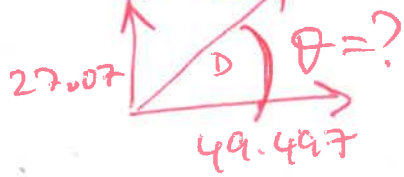
$A\hat{y} + \left(B\cos45\,\hat{x} + B\sin45\,\hat{y}\right) + \left(C\cos45\,\hat{x} + C\sin45\,(-\hat{y})\right)$

$= \left(B\cos45 + C\cos45\right)\hat{x} + \left(A + B\sin45 - C\sin45\right)\hat{y}$

$= \left(40\frac{\sqrt{2}}{2} + 30\frac{\sqrt{2}}{2}\right)\hat{x} + \left(20 + 40\frac{\sqrt{2}}{2} - 30\frac{\sqrt{2}}{2}\right)\hat{y}$

$= 35\sqrt{2}\,\hat{x} + \left(20 + 5\sqrt{2}\right)\hat{y}$

$\vec{D} \Rightarrow$ yönü büyüklüğü ?



$= 49.497\,\hat{x} + 27.07\,\hat{y}$

$|\vec{D}| = \sqrt{(49.497)^2 + (27.07)^2}$

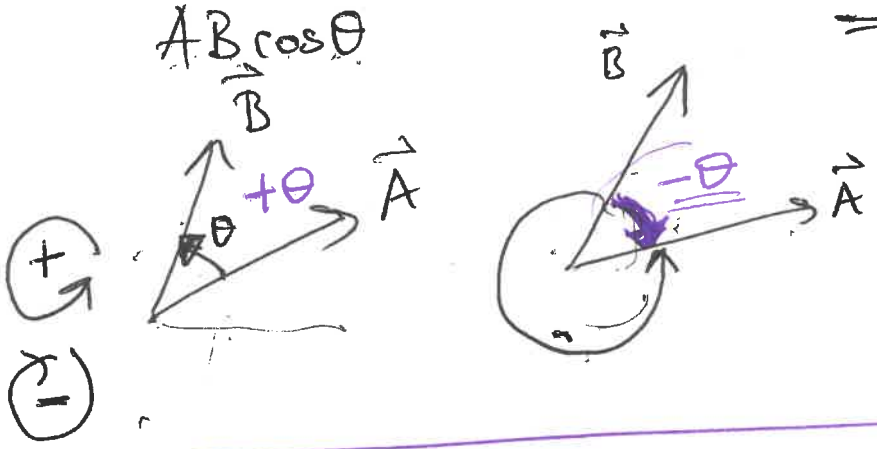
$= 56.4$ | $\tan^{-1}\left(\frac{27.07}{49.497}\right) = 29.2°$

$$\vec{A} \cdot \vec{B} = \vec{B} \cdot \vec{A} = BA\cos(-\theta)$$

$$= BA\cos\theta$$

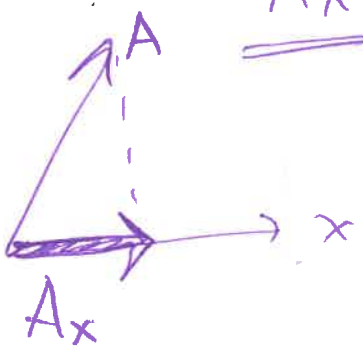
$AB\cos\theta$

$\cos(-\theta) = \cos\theta$



$$\vec{A} = A_x \hat{i} + A_y \hat{j} + A_z \hat{k}$$

$\vec{A}$ nün x ekseni izdüşümü A_x



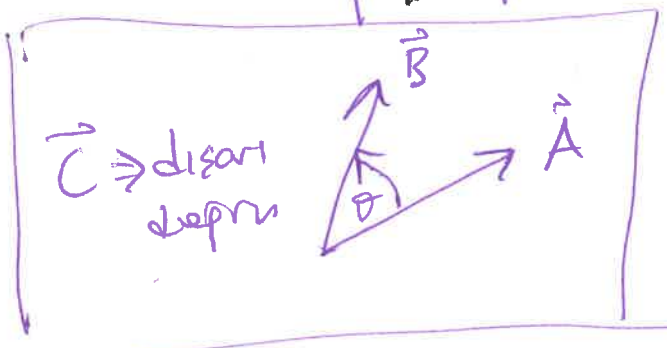
$$\vec{A} \cdot \vec{B} = AB\cos\theta$$

$$= A_x B_x + A_y B_y + A_z B_z$$

Vektörel Çarpım

$\vec{A} \times \vec{B} = \vec{C}$ vektör → yön, → büyüklük

$$|\vec{C}| = AB \sin\theta$$

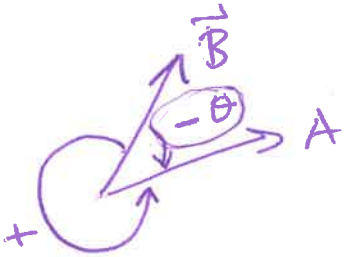


SAĞ el kuralı

$\vec{A} \times \vec{B} = \vec{C}$

↓ baş ↓ işaret ↓ orta

$\vec{B} \times \vec{A} = \vec{D}$



$\vec{D}$ içine doğru

$\vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$

$AB \sin\theta$ • $BA \sin(-\theta)$

• $-BA \sin\theta$

$AB \sin\theta = -(BA \sin(-\theta))$

$\vec{A} \times \vec{A} = 0 = AA \underline{\sin 0}$

0

$\Longrightarrow \theta = 0$

→ A $\theta = 0$ → B

$\vec{A} \times \vec{B} = 0$

$$\vec{A} \times \vec{B} = \vec{C}$$

$$= (A_x \hat{i} + A_y \hat{j} + A_z \hat{k}) \times (B_x \hat{i} + B_y \hat{j} + B_z \hat{k})$$

$\hat{i} \times \hat{i} = \hat{j} \times \hat{j} = \hat{k} \times \hat{k} = 0$

$$= A_x B_x (\hat{i} \times \hat{i}) + A_x B_y (\hat{i} \times \hat{j}) + A_x B_z (\hat{i} \times \hat{k})$$

$ijk \Rightarrow +$

$ikj \Rightarrow -$

$$+ A_y B_x (\hat{j} \times \hat{i}) + A_y B_y (\hat{j} \times \hat{j}) + A_y B_z (\hat{j} \times \hat{k})$$

$$+ A_z B_x (\hat{k} \times \hat{i}) + A_z B_y (\hat{k} \times \hat{j}) + A_z B_z (\hat{k} \times \hat{k})$$

$$= A_x B_y \hat{k} + A_x B_z (-\hat{j})$$

$$+ A_y B_x (-\hat{k}) + A_y B_z (\hat{i})$$

$$+ A_z B_x (+\hat{j}) + A_z B_y (-\hat{i})$$

$i\ j\ k \rightarrow +$

$\hat{j}\ \hat{i} \rightarrow -$

$$\vec{C} = C_x \hat{i} + C_y \hat{j} + C_z \hat{k}$$

$x \rightarrow y \rightarrow z$

$$\sum = (A_y B_z - A_z B_y)\,\hat{i} \quad ; \quad C_x = A_y B_z - B_z A_y$$

$$+ (A_z B_x - A_x B_z)\,\hat{j}$$

$y \rightarrow z \rightarrow x$

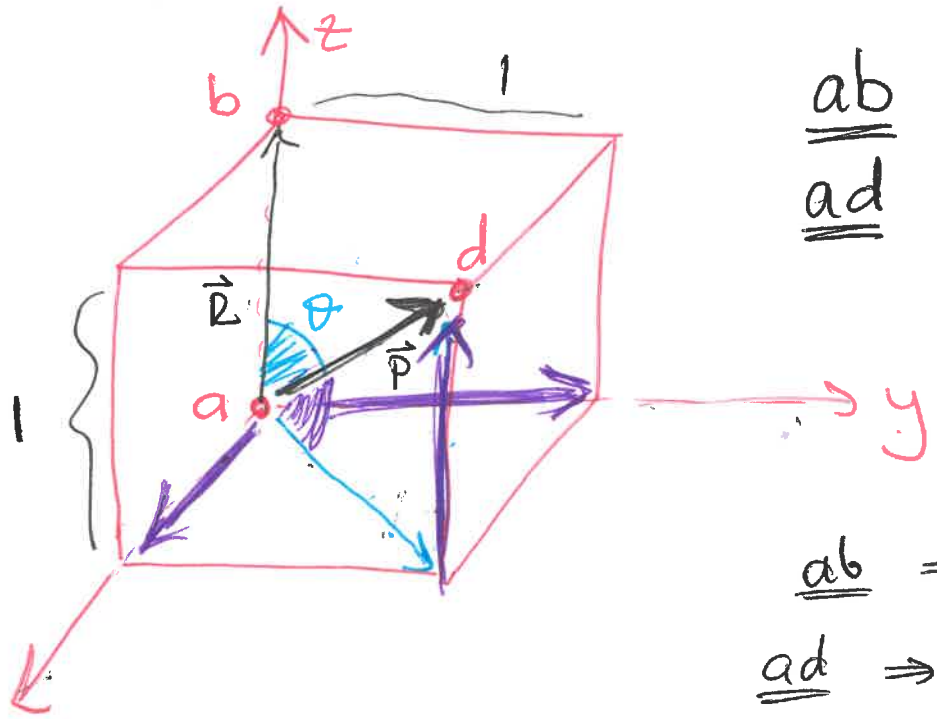
$$C_y = A_z B_x - A_x B_z$$

$$+ (A_x B_y - A_y B_x)\,\hat{k}$$

$z \rightarrow x \rightarrow y$

$$C_z = A_x B_y - A_y B_x$$

KÜP



ab ayrısı ile **ad** ayrısı arasındaki AÇI ?

ab $= \vec{R}$

ad $\Rightarrow$ ~~AD~~ $\vec{P}$

$\vec{R} = (\ 0\ )\hat{i} + (\ 0\ )\hat{j} + (\ 1\ )\hat{k}$

$R_x = 0$
$R_y = 0$
$R_z = 1$

$\boxed{\vec{R} = 1\hat{k}}$ $\quad |\vec{R}| = \sqrt{1^2} = 1$

$\vec{P} = (\ 1\ )\hat{i} + (\ 1\ )\hat{j} + (\ 1\ )\hat{k}$

$\boxed{\vec{P} = 1\hat{i} + 1\hat{j} + 1\hat{k}}$ $\quad |\vec{P}| = \sqrt{1^2 + 1^2 + 1^2} = \sqrt{3}$

$$\vec{A}\cdot\vec{B} = AB\cos\theta = A_xB_x + A_yB_y + A_zB_z$$

$$\vec{P}\cdot\vec{R} = |\vec{P}|\,|\vec{R}|\cos\theta = P_xR_x + P_yR_y + P_zR_z$$

$$= \sqrt{3}\cdot 1\cdot\cos\theta = (1)(0) + (1)(0) + (1)(1)$$

$$\sqrt{3}\cos\theta = 1$$

$$\theta = \cos^{-1}\left(\frac{1}{\sqrt{3}}\right) = \underline{54.7}$$

HAREKET

Bölüm 3-vektör

↳ tek boyut Bölüm 2

→ İki boyut Bölüm 4

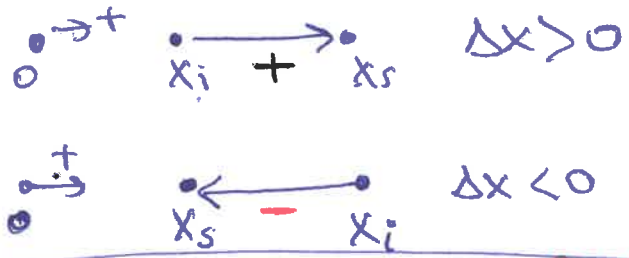
Konum → X

Hareket → konum değişikliği → yer değiştirme.

Δ ≡ SON − İLK bbb

$\Delta X = X_s - X_i$

$\Delta X > 0$; $\Delta X < 0$



zaman

t ; $\Delta t = t_s - t_i$

HIZ → v

ortalama $\bar{v}_x \equiv \frac{\Delta X}{\Delta t}$ ortalama hız

vektör

HIZ ve SÜRAT

↳ + ↳ - ↓ pozitif

gündelik hayatta hız → süratttir

Araba 90km/sa gitsi süratı.

Ör $X_A = 30m$ $t_A = 0s$ ①

$X_F = -55m$ $t_F = 50s$

a) yerdeğiştirme? $\Delta X = X_s - X_i$

$X_F - X_A = \Delta X$

$-55 - (30) = -85\ m$

b) ortalama hız?

$\bar{v} = \frac{\Delta X}{\Delta t} = \frac{-85}{50-0} = \frac{-85}{50}$

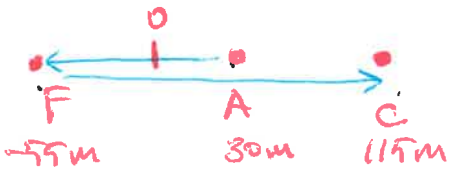
$= -1.7\ m/s$

c) ortalama sürat?

sürat = $\frac{\text{toplam yol}}{\text{toplam zaman}} \Rightarrow \frac{+}{+} = +$

$= \frac{85m}{50s} = 1.7\ m/s$

Ör



A → F → C

$t_A = 0$ 50s 100s

t_F t_C

sürat = ? A → C

ortalama sürat = $\frac{\Sigma \text{ yol}}{\Sigma \text{ zaman}}$

$= \frac{85m + 170m}{100s}$

$= \frac{255m}{100s} = 2.55\ m/s$

türev

$$d(x^n) = n x^{n-1}$$

$$d(x^5) = 5x^4$$

konum → hız → ivme (a)

ortalama ivme: $\bar{a} \equiv \frac{\Delta v}{\Delta t}$; ani ivme: $a = \frac{dv}{dt}$

ani hız: $v = \frac{dx}{dt}$; $a = \frac{d}{dt}\left(\frac{dx}{dt}\right)$

$$a = \frac{d^2x}{dt^2}$$

Ör $v_x = (40 - 5t^2)$ m/s

a) $t=0$s, $t=2$s arası ort. ivme? (Δ)

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v(t=2s) - v(t=0s)}{(2-0)}$$

$$= \frac{[40-5(4)] - [40-5(0)^2]}{2}$$

$$a = \frac{20-40}{2} = -10 \text{ m/s}^2$$

b) $t=2$s 'deki ivme? $v = 40 - 5t^2$

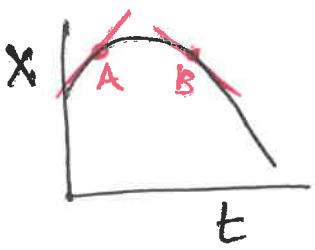
$$a = \frac{dv}{dt} = -5(2)t = -10t$$

$$= -20 \text{ m/s}^2$$

$\bar{v} \equiv$ ort. hız

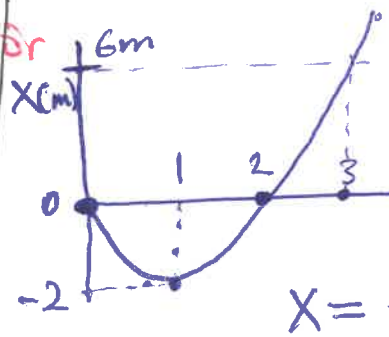
ani hız $v = \frac{dx}{dt}$

↳ konumun zamana göre türevi



eğim!!

ani hız $v_x \equiv \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$



$X = -4t + 2t^2$

a) $t=0$ ve $t=1$s arası Δx = ?

$t=1$s ve $t=3$s arası Δx = ?

$X(t=0) = -4(0) + 2(0)^2 = 0$m

$X(t=1s) = -4(1) + 2(1)^2 = -2$m

$X(t=3s) = -4(3) + 2(3)^2 = 6$m

$\Delta x = -2 - 0 = -2$m

$\Delta x = 6 - (-2) = 8$m

b) $t=0-1$s $\bar{v}$ = ?

$t=1-3$s $\bar{v}$ = ?

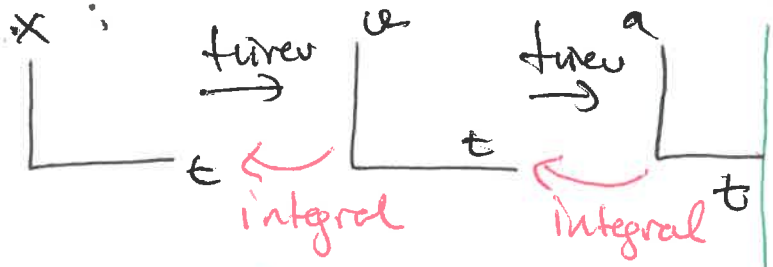
$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{-2}{1} = -2 \text{ m/s}$$

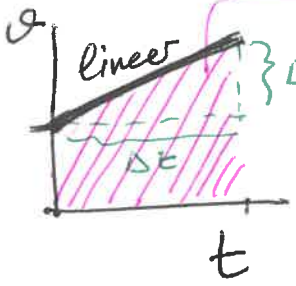
$$\bar{v} = \frac{8}{2} = 4 \text{ m/s}$$

c) $t=2.5$s deki ani hız?

$X = -4t + 2t^2$ $\quad v = \frac{dx}{dt}$

$v = \frac{dx}{dt} = -4 + 4t = 6$ m/s

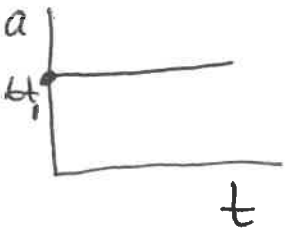




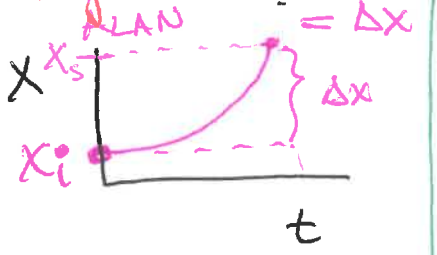
Alan ≡ integral

eğim = ivme = a

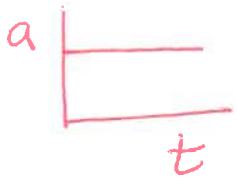
$v = (sbt)t + sbt_2$



integral = Δx = konum



BİR BOYUTTA SABİT İVMELİ HAREKET



$$\bar{a} = \frac{\Delta v}{\Delta t}$$

$$\bar{a} = \frac{v_s - v_i}{t_s - t_i} = a$$

$t_i = 0$; $t_s = t$

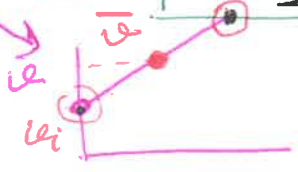
$\bar{a} = a$ (sbt_{ivme})

ort. ani ivme

$$v_s = v_i + at \quad !!$$

i ve s ~~d~~ durumlar arası ortalama hız.

$$\bar{v} = \frac{v_i + v_s}{2}, \quad (a = sbt)$$



$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_s - x_i}{t}$$

$t_i = 0$; $t_s = t$

$$\frac{v_i + v_s}{2} = \bar{v} = \frac{x_s - x_i}{t} \quad (3)$$

$$x_s - x_i = \frac{1}{2}(v_i + v_s)t$$

$v_s = v_i + at$ (1)

$$x_s - x_i = \frac{1}{2}(v_i + v_i + at)t$$

$$x_s - x_i = \frac{2v_i t}{2} + \frac{at^2}{2}$$

$$x_s = x_i + v_i t + \frac{1}{2}at^2 \quad (2)$$

$$x_s - x_i = \frac{1}{2}(v_i + v_s)t$$

Zamansız hız denklemi yazmak için

$$v_s = v_i + at$$

$$t = \frac{v_s - v_i}{a}$$

$$(x_s - x_i) = \frac{1}{2}(v_i + v_s)\left(\frac{v_s - v_i}{a}\right)$$

$$x_s - x_i = \frac{1}{2a}(v_s^2 - v_i^2)$$

$$v_s^2 = v_i^2 + 2a(x_s - x_i) \quad (3)$$

Hatırlamanız gereken 3 denklem

(a) SABİT İVMELİ hareket için

(1) $v_s = v_i + at$

(2) $x_s = x_i + v_i t + \frac{1}{2}at^2$

(3) $v_s^2 = v_i^2 + 2a(x_s - x_i)$

Ör: Bir uçak gemisine, bir jet 63 m/s hız ile 2s'de iniyor.

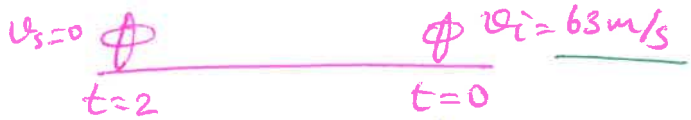
a) Jet 2s sonra duruyorsa ivmesi nedir?

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_s - v_i}{t_s - t_i} = \frac{0 - 63}{2 - 0}$$

ort. ivme

$$\bar{a} = -\frac{63}{2}\ m/s^2$$

b) uçağın yerdeğiştirmesi?



$$\bar{v} = \frac{v_i + v_s}{2} = \frac{x_s - x_i}{t_s - t_i} \quad \Delta x$$

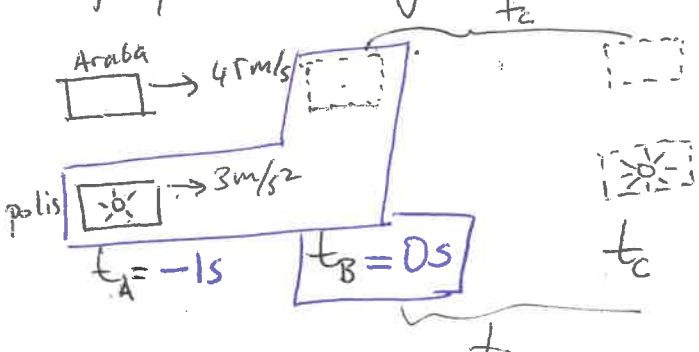
2 0

$$\frac{63 + 0}{2} = \frac{\Delta x}{2 - 0}$$

$$\boxed{\Delta x = 63\ m}$$

Ör 45 m/s sbt hızla giden araba trafik polisini geçiyor. Bundan 1s sonra trafik polisi 3 m/s2 ivme ile arabayı kovalamaya başlıyor.

Trafik polisi arabayı ne zaman yakalar



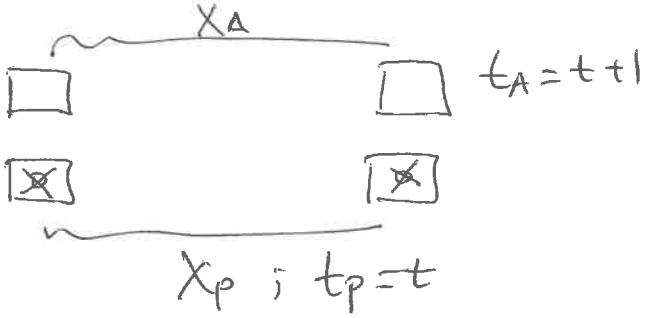
$$X_A = X_{polis} \qquad t_{polis} = t$$

$$t_{araba} = (t+1)s$$

$$X_A = X_p \qquad t = t_p \qquad t+1 = t_A$$

$$\cancel{x_i}^{0} + v_i t_A + \frac{1}{2} a t_A^2 = \cancel{x_i}^{0} + v_i t_p + \frac{1}{2} a t_p^2$$

$$v_i t_A = \frac{1}{2} a t_p^2$$



$$v_i (t+1) = \frac{1}{2} a t^2$$

$$45t + 45 = \frac{1}{2}(3)t^2$$

$$+1.5t^2 - 45t - 45 = 0$$

$$t^2 - 30t - 30 = 0$$

$$ax^2 + bx + c = 0$$

$$x_{1,2} = \frac{-b \mp \sqrt{b^2 - 4ac}}{2a}$$

$$t = \frac{30 \mp \sqrt{30^2 - 4(1)(-30)}}{2}$$

$$= \frac{30 \mp \sqrt{900 + 120}}{2}$$

$$t \simeq 31\ s$$

b) Alınan yol nedir?

$$X_A = X_p$$

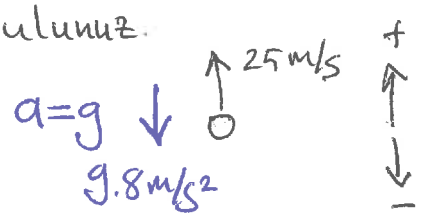
$$45(31+1) = \frac{1}{2} 3 (31)^2$$

$$= 1440\ m$$

Serbest Düşen Cisimler

$a = sbt$; hava sürtünmesi YOK

Bir yukarı doğru 25 m/s hızla atılan topun hızını 1s aralıklarla bulunuz.



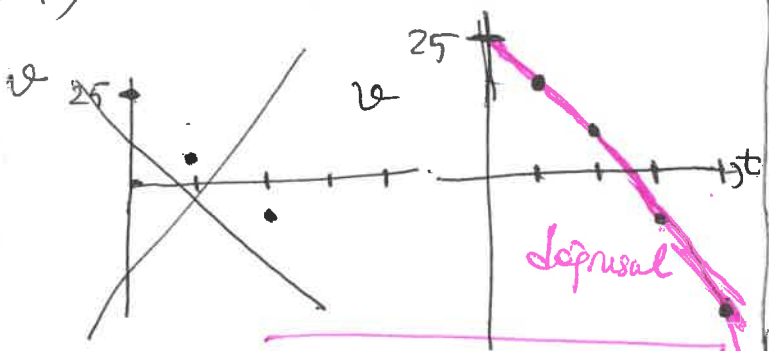
$v_s = v_i + at$

(t=1s) $= 25 + (-9.8)(1) = 15.2$ m/s

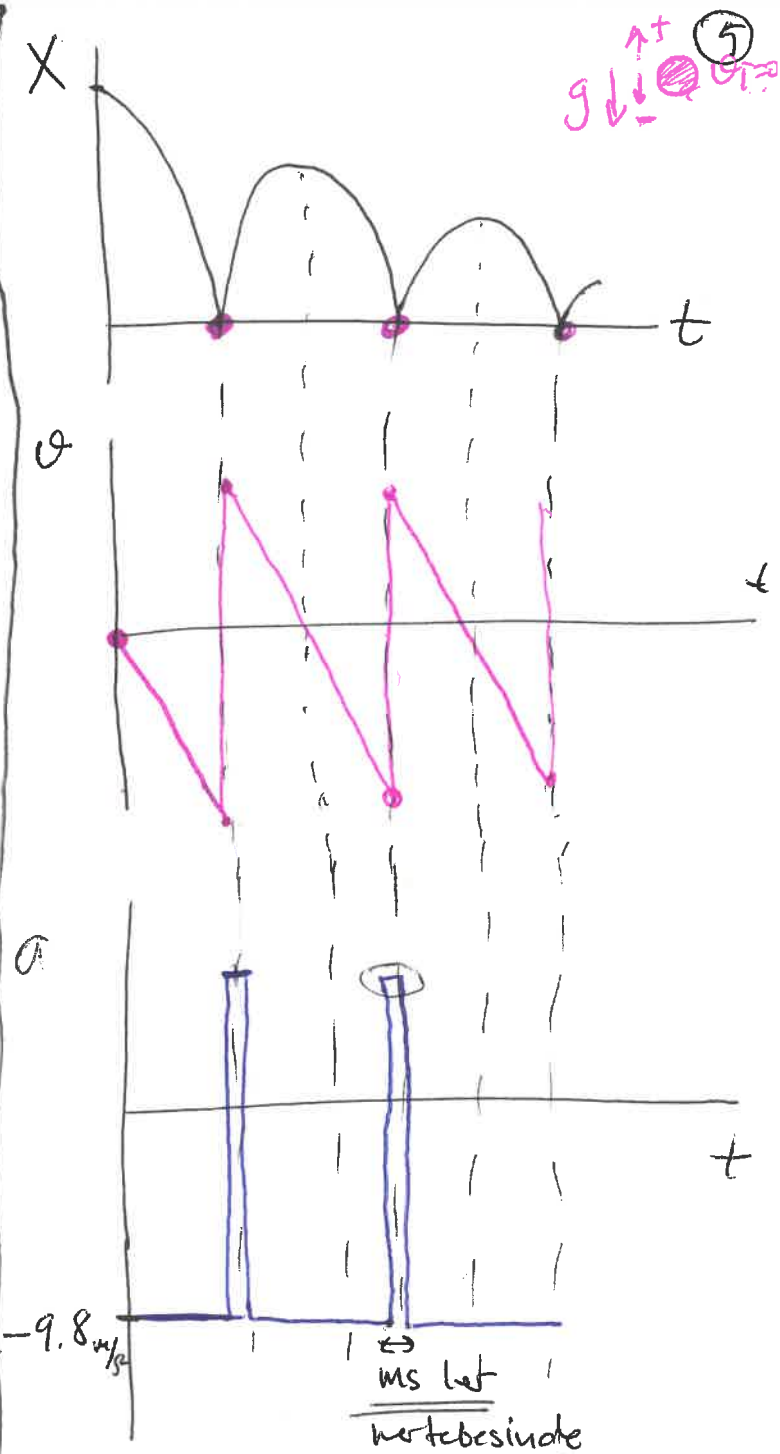
(t=2s) $= 25 + (-9.8)(2) = 5.4$ m/s

(t=3s) $= 25 + (-9.8)(3) = -4.4$ m/s

(t=4s) $= 25 + (-9.8)(4) = 14.2$ m/s

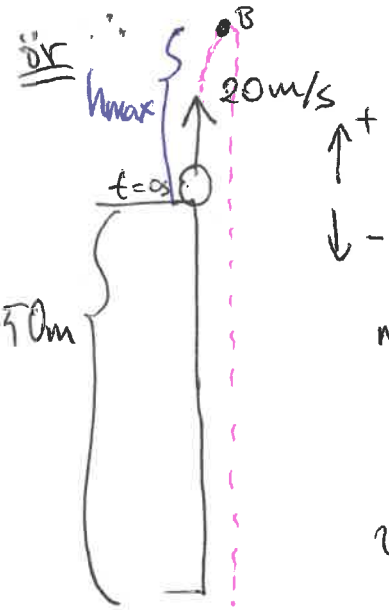


$v_s = 25 - 9.8t$



1.5 m yukarıdan bırakılan top 3 kere zıplamıştır. Topun konumunu, hızını ve ivmesini zamana göre yaklaşık olarak çiziniz.

Ör



a) taşın max. yüksekliğe ulaştığı zaman? $t_B = ?$

max yükseklikte hız SIFIRdır!

$v_s = 0$

$v_s = v_i + at$

$0 = 20 + (-9.8)t$

$t = \frac{20}{9.8} = 2.04s$

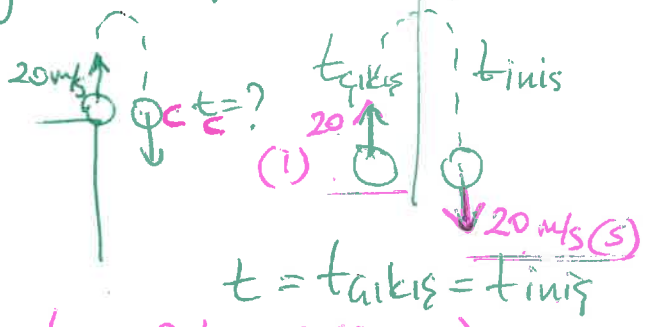
b) max yükseklik?

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

$= 0 + 20(2.04) + \frac{1}{2}(-9.8)(2.04)^2$

$h_{max} = y_s = 20.4\,m$

c) Taşın atıldığı noktaya geri dönüş zamanı?



$t = t_{çıkış} = t_{iniş}$

$t_c = 2t = 2(2.04)$

$= 4.08s$

$v_s = v_i + at$

$-20 = 20 + (-9.8)t$

$t = \frac{40}{9.8} = 4.08s$

$t = 5s$ de taşın hızı ve konumu?

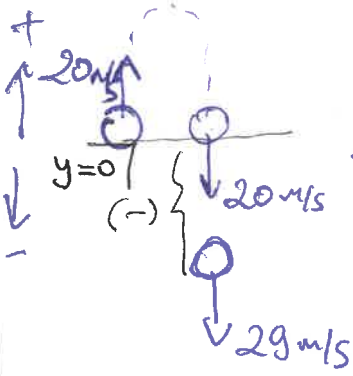
$v_s = ?$ (6)

$y_s = ?$

$v_s = v_i + at$

$= 20 + (-9.8)(5)$

$= -29\,m/s$



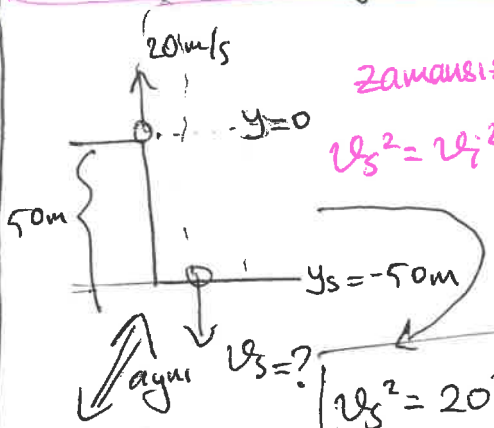
$y_s = y_i + v_i t + \frac{1}{2}at^2$

$= 0 + 20(5) + \frac{1}{2}(9.8)(5)^2$

$y_s = -22.5\,m$

Taşın yere çarpma hızı?

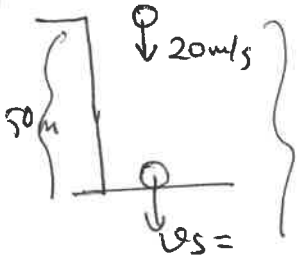
Taşın havada geçirdiği toplam zaman?



Zamansız hız denklemi

$v_s^2 = v_i^2 + 2a(y_s - y_i)$

$v_s^2 = 20^2 + 2(-9.8)(-50-0)$

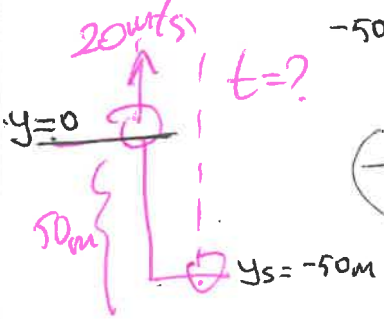


$\Rightarrow v_s^2 = (-20)^2 + 2(-9.8)(-5$

$v_s = -37.1\,m/s$

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

$-50 = 0 + 20t + \frac{1}{2}(-9.8)t^2$



$4.9t^2 - 20t - 50 = 0$

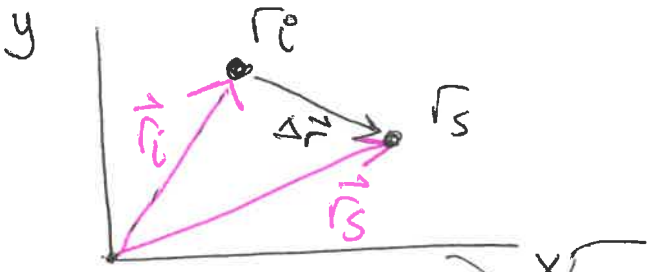
$= \frac{b \pm \sqrt{b^2-4ac}}{2a}$

$t = 5.83s$

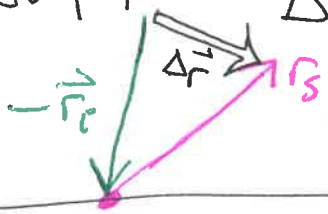
2 Boyutta hareket

1 boyutta yön +, − → vektördü

		1B
konum	$\vec{r}$	x
hız	$\vec{v}$	v
ivme	$\vec{a}$	a



yerdeğiştirme $\Delta\vec{r} = \vec{r}_s - \vec{r}_i$



Hız → ortalama hız

$$\overline{\vec{v}} \equiv \frac{\Delta\vec{r}}{\Delta t}$$

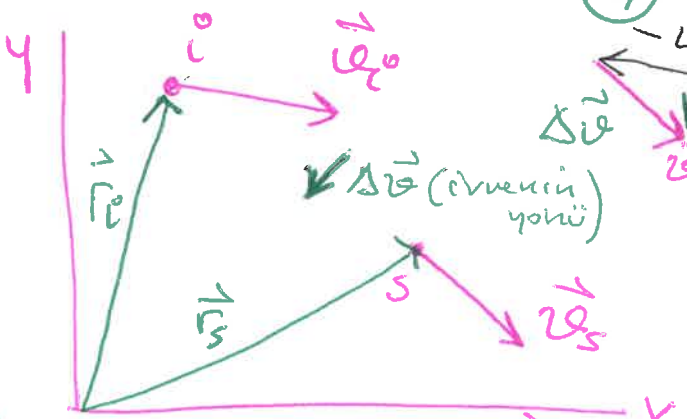
→ ani hız $\vec{v} = \dfrac{d\vec{r}}{dt}$

→ sürat ; $|\vec{v}| = v =$ mutlak değer

İVME ortalama ivme

$$\overline{\vec{a}} = \frac{\Delta\vec{v}}{\Delta t}$$

ani ivme $\vec{a} = \dfrac{d\vec{v}}{dt} = \dfrac{d^2\vec{r}}{dt^2}$



$$\bar{a} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_s - \vec{v}_i}{t_s - t_i}$$

26.7.16

2. Boyutta hareket

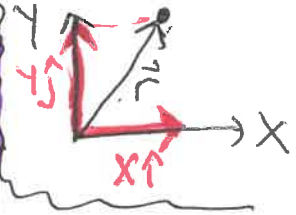
1 boyut	2 boyut – 3 boyut
$x \rightarrow$ konum	$\rightarrow \vec{r}$
$v \rightarrow$ hız	$\rightarrow \vec{v}$
$a \rightarrow$ ivme	$\rightarrow \vec{a}$

1 Boyutta: Hareket Denklemleri

$$x_s = x_i + v_i t + \frac{1}{2} a t^2$$
$$v_s = v_i + at$$
$$v_s^2 = v_i^2 + 2a(x_s - x_i) \quad ***$$

2 Boyut - 3 boyut

$$\vec{r}_s = \vec{r}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2$$
$$\vec{v}_s = \vec{v}_i + \vec{a}t$$



$$\vec{r} = x\hat{i} + y\hat{j}$$
$$\vec{v} = v_x\hat{i} + v_y\hat{j}$$
$$\vec{a} = a_x\hat{i} + a_y\hat{j}$$

2 Boyutta

$$\vec{v}_s = \vec{v}_i + \vec{a}t$$
$$(v_{xs}\hat{i} + v_{ys}\hat{j}) = (v_{xi}\hat{i} + v_{yi}\hat{j}) + (a_x\hat{i} + a_y\hat{j})t$$

$v_{xs}\hat{i} = v_{xi}\hat{i} + (a_x t)\hat{i} \Rightarrow$ x eksenine izdüşüm

$$v_{xs} = v_{xi} + a_x t$$

$v_{ys}\hat{j} = v_{yi}\hat{j} + (a_y t)\hat{j}$

$$v_{ys} = v_{yi} + a_y t \rightarrow \text{y eksenine izdüşüm}$$

$$\vec{r}_s = \vec{r}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2$$

↓ x ↓ y

$$x_s = x_i + v_{xi}t + \frac{1}{2}a_x t^2$$
$$y_s = y_i + v_{yi}t + \frac{1}{2}a_y t^2$$

Ör $v_{xi} = 20\ m/s$, $v_{yi} = -15\ m/s$; $t=0$ s anında orijinden geçiyor; $x_i, y_i = 0$ (1)

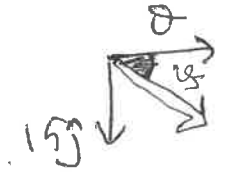
$a_x = 4\ m/s^2$; XY düzleminde hareket ediyor

a) $\vec{v}_s = ?$ (zamanın fonksiyonu olarak yazınız)

$$\vec{v}_s = \vec{v}_i + \vec{a}t$$
$$\vec{v}_s = (20\hat{i} - 15\hat{j}) + (4\hat{i})t$$
$$\vec{v}_s = (20 + 4t)\hat{i} - 15\hat{j}$$

b) $t = 5$ s; paraşütçünün hızının büyüklüğü? yön? ↔ doğrultu?

$$\vec{v}_s = (20 + 4(5))\hat{i} - 15\hat{j}$$
$$\vec{v}_s = 40\hat{i} - 15\hat{j}$$
$$|\vec{v}_s| = \sqrt{40^2 + (-15)^2} = 43\ m/s$$



$$\tan\theta = \frac{-15}{40}$$

Açı: + ↑, − ↓

$$\theta = \tan^{-1}\left(\frac{-15}{40}\right)$$
$$\theta = -21°$$

c) herhangi bir t anında x ve y koordinatlarını ve bu andaki yerdeğiştirme vektörünü bulunuz.

$$x_s = x_i + v_{xi}t + \frac{1}{2}a_x t^2$$
$$y_s = y_i + v_{yi}t + \frac{1}{2}a_y t^2$$

$v_{xi} = 20\ m/s$, $v_{yi} = -15\ m/s$, $a_x = 4\ m/s^2$, $x_i = 0$, $y_i = 0$

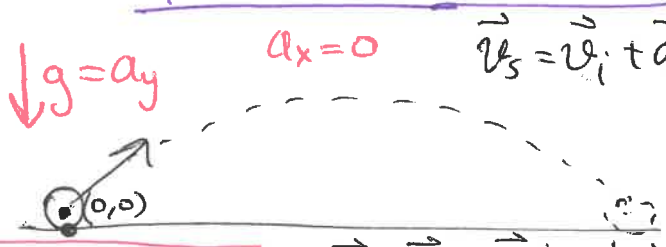
$$x_s = 20t + \frac{1}{2}4t^2 = 20t + 2t^2$$
$$y_s = -15t$$

$$\vec{r}_s = x_s\hat{i} + y_s\hat{j} \quad ; \quad \vec{r}_i = 0 \; (x_i = 0, y_i = 0)$$
$$\vec{r}_s = (20t + 2t^2)\hat{i} + (-15t)\hat{j}$$

$t = 5$ s; $\vec{r}_s = ?$ (büyüklük ve yön)

$$\vec{r}_s = (20(5) + 2(5)^2)\hat{i} - 15(5)\hat{j}$$
$$= 150\hat{i} - 75\hat{j} \quad ; \quad |\vec{r}_s| = \sqrt{150^2 + (75)^2}$$
$$\theta = \tan^{-1}(-75/150)$$

EĞİK atış hareketi



$\vec{r}_s = \vec{r}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2$

X ekseni

$x_s = x_i + v_{xi} t$; $x_i = 0$ alınabilir

$x_s = v_{xi} t$ * $\quad v_{xs} = v_{xi}$ *

$a_x = 0$ için v_x ilk ve son hız aynı
$v_x \rightarrow$ sbt

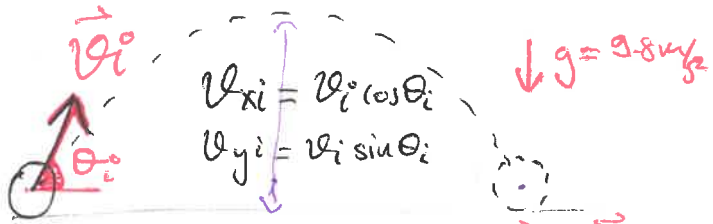
y ekseni $y_s = y_i + v_{yi} t + \frac{1}{2}(-g)t^2$

$+y \uparrow$ $\quad g = 9.8\,m/s^2$; $y_i = 0$ alınabilir

$y_s = y_i + v_{yi} t - \frac{1}{2} g t^2$ **

$v_{ys} = v_{yi} + a_y t = v_{yi} - gt$

$v_{ys} = v_{yi} - gt$ **

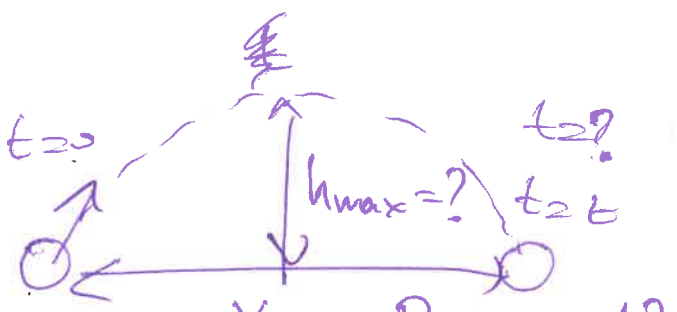


İlgilyacımız olan şeyler $\vec{v}_i$; θ_i

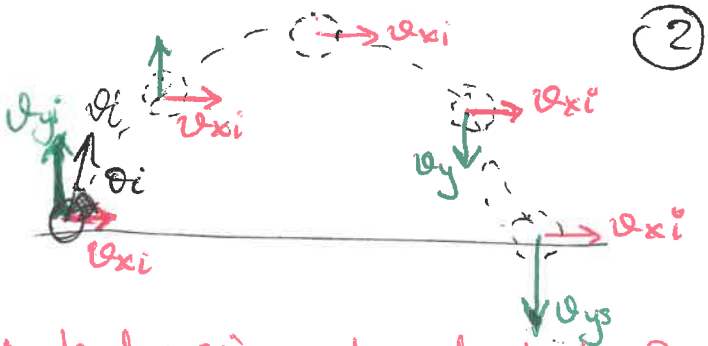
→ ne kadar uzağa düşer?

→ ne kadar yükseğe çıkar?

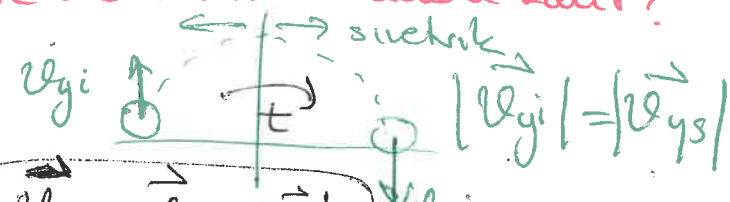
→ ne kadar havada kalır?



$X_{max} = R =$ menzil?



ne kadar süre havada kalır?



$\vec{v}_{ys} = \vec{v}_{yi} + \vec{a}t$ *

$v_{ys} = v_{yi} = v_j$; $a = -g$ $\quad \uparrow +$ $\downarrow -$

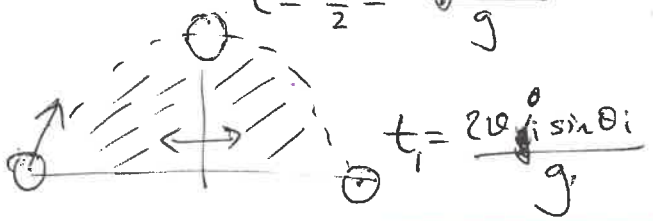
$-v_y = v_y - gt$

$t = \frac{2 v_{yi}}{g}$ (toplam uçuş zamanı).

havada kalma süresi

$t = \frac{2 v_i \sin\theta_i}{g}$

$t = \frac{t_1}{2} = \frac{v_i \sin\theta_i}{g}$



→ ne kadar uzağa düşer menzili nedir?

$x_s = x_i + v_{xi} t + \frac{1}{2} a_x t^2$

x_i 0 alırsak

$x_s = v_{xi} t$

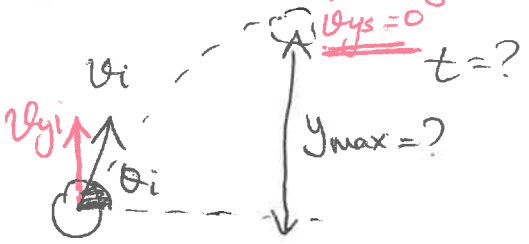
$x_{max} = v_{xi} t_{max}$ → uçuş süresi

$= (v_i \cos\theta_i) \frac{2 v_i \sin\theta_i}{g}$

$$X_{max} = \frac{v_i^2 \, 2 \cos\theta \sin\theta}{g}$$

→ ne kadar yükseğe çıkar

$h_{max} = y_{max} = ?$



$$y_s = y_i + v_{yi}t - \frac{1}{2}gt^2$$

$$v_{ys} = v_{yi} - gt$$

$$0 = v_{yi} - gt \Rightarrow \boxed{t = \frac{v_{yi}}{g}}$$

max yükseklik çıkma süresi

$y_i = 0$ alalım.

$$y_{max} = 0 + v_{yi}\frac{v_{yi}}{g} - \frac{1}{2}g\frac{v_{yi}^2}{g^2}$$

$$y_{max} = \frac{v_{yi}^2}{2g} \longrightarrow \boxed{y_{max} = \frac{v_i^2 \sin^2\theta_i}{2g}}$$

II. YOL: Zamansız hız denklemi

$$v_s^2 = v_i^2 + 2a(y_s - y_i) \quad ; a = -g \ (y)$$

$$v_{ys}^2 = v_{yi}^2 - 2g(y_s - y_i)$$

max yükseklikte ; $v_{ys} = 0$

$y_i = 0$; $y_s = y_{max}$

$$0 = v_{yi}^2 - 2g\,y_{max}$$

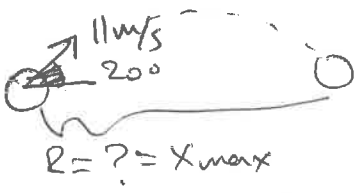
AYNI!

y_{max} h_{max} h

$$\boxed{y_{max} = \frac{v_{yi}^2}{2g} = \frac{v_i^2 \sin^2\theta_i}{2g}}$$

Bir uzun atlama yapan sporcu $\theta_i = 20°$ açı ile 11 m/s hızla atlıyor.

a) sporcu ne kadar uzağa atlar?



$x_{max} = v_{xi}\,t$?

$v_{xi} = v_i \cos\theta_i$

$= 11\cos 20$

$t \Rightarrow$ y ekseni hareketi ile alakalı

$$v_{ys} = v_{yi} - gt$$

$$-11\sin 20 = 11\sin 20 - gt$$

$$t = \frac{22\sin 20}{g} \quad (\text{uçuş süresi}) = 0.38$$

$$x_{max} = v_{xi}\,t$$

$$= (11\cos 20)\left(\frac{22\sin 20}{9.8}\right) \checkmark$$

$$= 7.94\,m$$

$$x_{max} = \frac{v_i^2}{g}\boxed{2\cos\theta\sin\theta} \quad \sin 2\theta$$

x_{max} ; max olması için $\theta = ?$

$$x_{max} = \frac{v_i^2}{\underbrace{g}_{sbt}}\underbrace{\sin 2\theta}$$

max = 1 olabilir

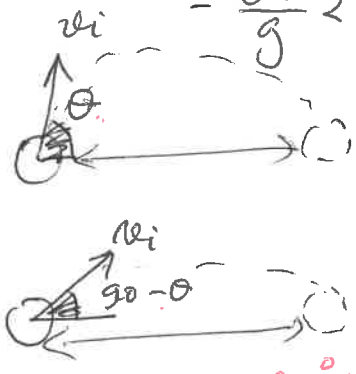
$\sin(90°) = 1$

$\theta = 45°$ olmalı

$\theta = 45°$

$$x_{max} = \frac{v_i^2}{g}\,2\cos\theta\sin\theta$$

$$= \frac{v_i^2}{g}\,2\,\sin(90-\theta)\sin\theta$$



menzilleri AYNI

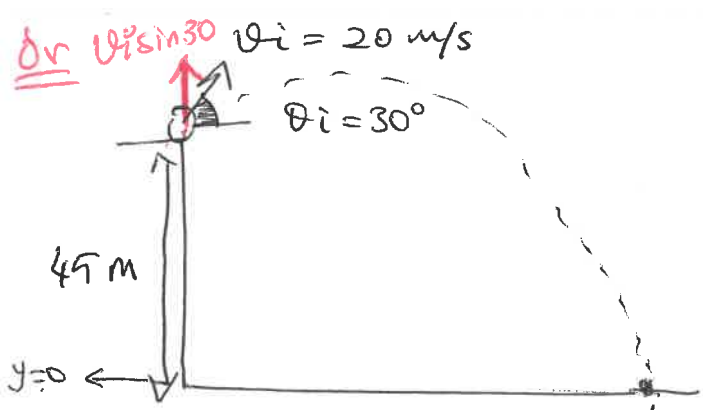
$90 = 60° + 30°$ →

$= 75° + 15°$

$= 85° + 5°$

menzil aynı

Ör $v_i \sin 30$ $v_i = 20$ m/s



a) taş ne kadar süre havada kalır?

$$y_s = y_i + v_{yi}t - \frac{1}{2}gt^2$$

$$0 = 45 + 20(\sin 30)t - \frac{9.8}{2}t^2$$

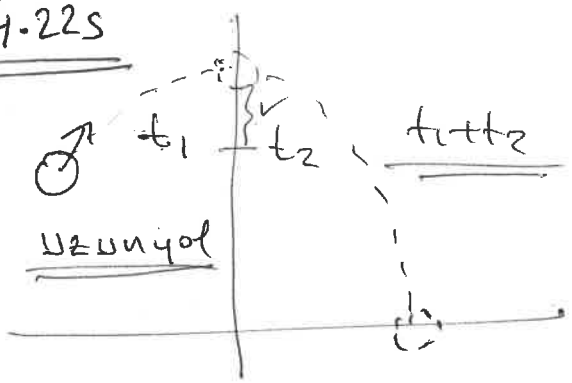
v_2

$$0 = \underbrace{4.9}_{a}t^2 \underbrace{-10}_{b}t \underbrace{-45}_{c}$$

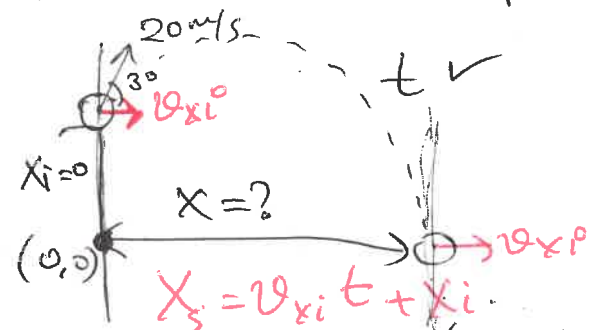
$$ax^2 + bx + c = 0$$

$$x_{1,2} = \frac{b \pm \sqrt{b^2 - 4ac}}{2a}$$

$t = 4.22$s



b) taş ne kadar uzağa gider?

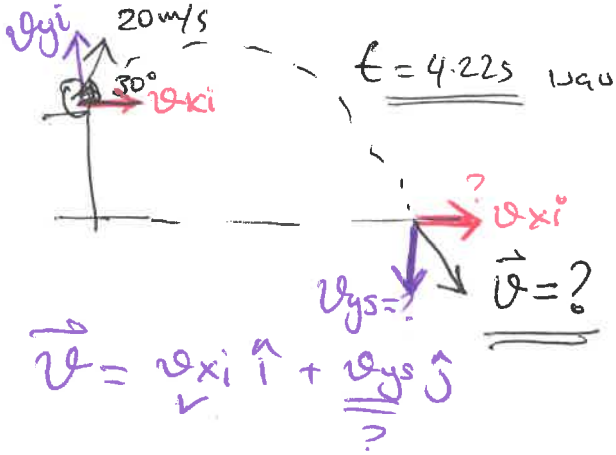


$= 20\cos 30\,(4.22\text{s}) + 0$

$= 73.1$ m

c)

c) Taş zemine çarpmadan hemen önceki hızının yönü, büyüklüğü (4)



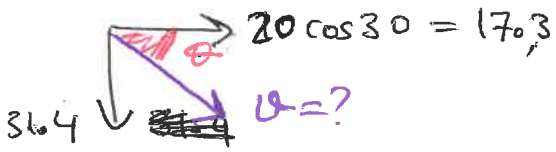
$$\vec{v} = v_{xi}\hat{i} + v_{ys}\hat{j}$$

$$v_{ys} = v_{yi} - gt$$

$$= 20(\sin 30) - (9.8)(4.22)$$

$$= 10 - 41.4$$

$$= -31.4 \text{ m/s}$$



$$\vec{v} = 17.3\hat{i} - 31.4\hat{j}$$

$$|\vec{v}| = \sqrt{(17.3)^2 + (-31.4)^2}$$

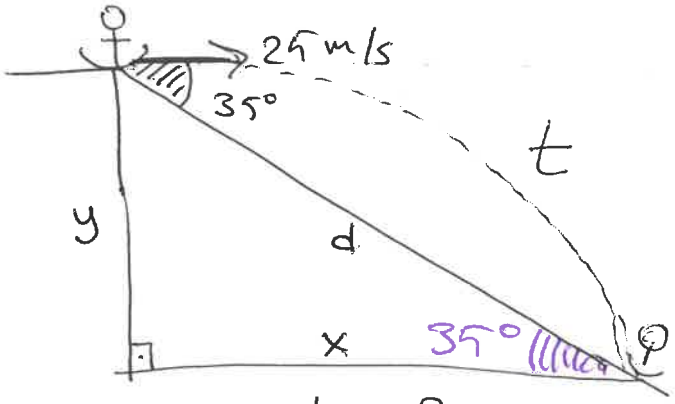
$$= 35.9 \text{ m/s}$$

yönü = ?

$$\theta = \tan^{-1}\left(\frac{-31.4}{17.3}\right)$$

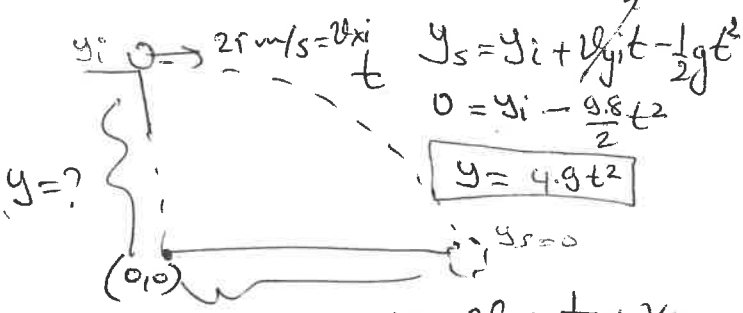
$$\theta = -61.1°$$

Bir Kayak ile atlayış



sporcu nereye düşer?

$\tan 35° = \frac{y}{x}$



$y_s = y_i + v_{yi}t - \frac{1}{2}gt^2$

$0 = y_i - \frac{9.8}{2}t^2$

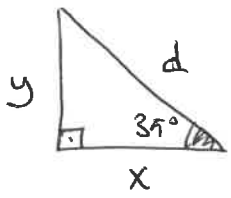
$y = 4.9t^2$

$X = ?$ $\quad X = v_{xi}t + x_i$

$X = 25t + 0$

$\frac{y}{x} = \frac{4.9t^2}{25t} = \tan 35°$ (0.7)

$t = \frac{25(0.7)}{4.9} = 3.57\,s$ havada kalma süresi



$X = 25t = 25(3.57)$

$= 89.3\,m$

$y = 4.9t^2 = 62.5\,m$

$X = d\cos 35$

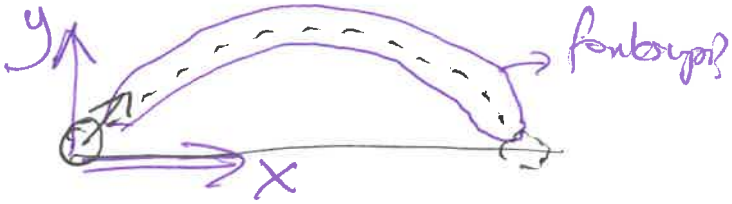
$d = \frac{x}{\cos 35} = \frac{89.3}{0.82} = 108.9\,m$

$d = \sqrt{x^2 + y^2} = 108.9\,m$

28.7.16

Atışlar

Eğik atışta parçacığın yörüngesi?



$y = f(x)$ cinsinden ifade ediniz.

$$y_s = y_i + v_{yi}t - \frac{1}{2}gt^2$$

$$v_{ys} = v_{yi} - gt$$

$$x = v_{xi}\cdot t$$

$$t = \frac{x}{v_{xi}}$$

$$y_s = y_i + v_{yi}\frac{x}{v_{xi}} - \frac{1}{2}g\frac{x^2}{v_{xi}^2}$$

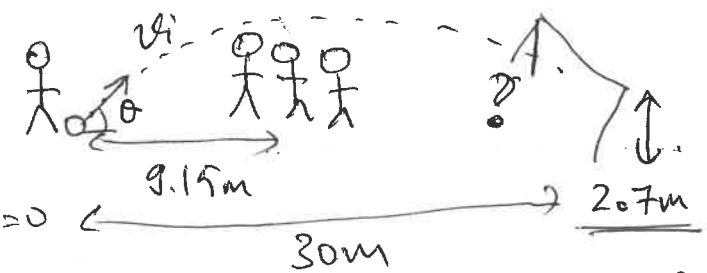
$$y_s = y_i + \frac{v_{yi}}{v_{xi}}x - \frac{1}{2}g\frac{1}{v_{xi}^2}x^2$$

$v_{yi} = v_i \sin\theta$; $v_{xi} = v_i\cos\theta$

$$y_s = y_i + \frac{v_i\sin\theta}{v_i\cos\theta}x - \frac{g}{2v_i^2\cos^2\theta}x^2$$

$$y_s = y_i + \tan\theta\, x - \frac{g}{2v_i^2\cos^2\theta}x^2$$

$$y = c + bx + ax^2$$



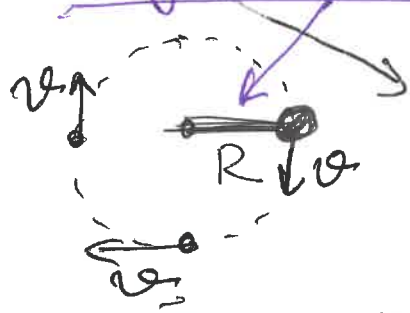
$$y_s = 0 + \tan\theta(30) - \frac{9.8}{2v_i^2\cos\theta}(30)^2$$

$y_s > 2.7$m ⇒ gol olmaz

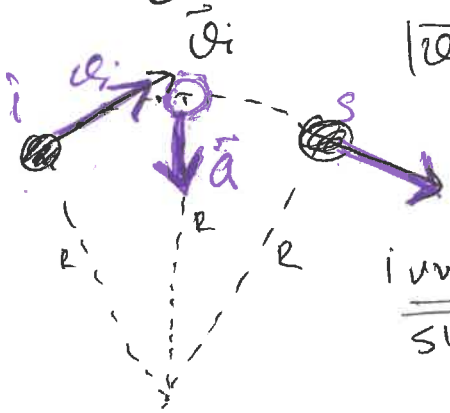
$y_s < 2.7$m ⇒ gol olur

Düzgün Dairesel Hareket

①



Hız büyüklüğü sürat = sbt

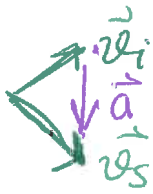


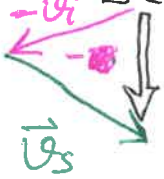
$|\vec{v}_i| = |\vec{v}_s| = v$

İvmesi ?

SIFIR DEĞİL

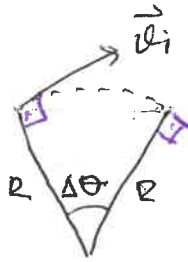
$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_s - \vec{v}_i}{\Delta t}$$

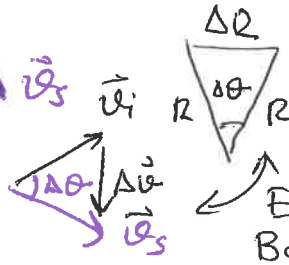




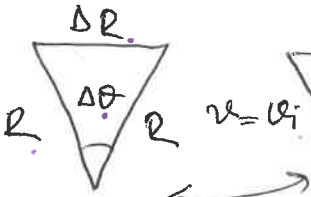
$\vec{v}_s - \vec{v}_i = \Delta\vec{v}$

$\Delta\vec{v}$ yönü ile $\vec{a}$ yönü aynı !!





Eş üçgen Benzeşim



İkizkenar üçgen, Eş üçgen

$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$$

$$\frac{\Delta v}{v} = \frac{\Delta R}{R}$$

$$a = \frac{\Delta v}{\Delta t}$$

$$a = \frac{v}{R}\frac{\Delta R}{\Delta t} = \frac{v}{R}\frac{\Delta R \to \text{yol}}{\Delta t \to \text{zaman}}$$

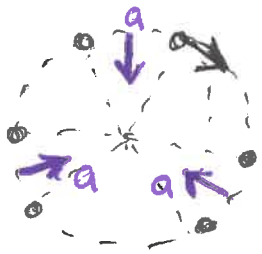
DÜZGÜN DAİRESEL HAREKETİN İVMESİ

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

DDH (Düzgün Dairesel Hareket)

Önemli 2 nokta

*) İvme her zaman MERKEZE doğru!



$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_s - \vec{v}_i}{\Delta t}$$

$\Delta \vec{v}$ her zaman merkeze doğru.

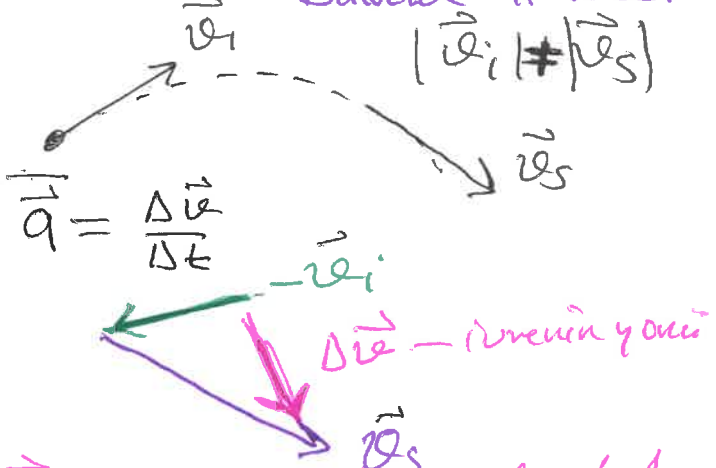
*) İvmenin büyüklüğü $\frac{v^2}{R}$

$$a = \frac{v^2}{R} \quad * \quad (DDH)$$

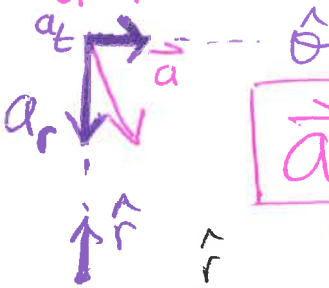
Eğer bir dairesel harekette $|\vec{v}| \neq$ sbt olmazsa ne olur?

DODH = Düzgün olmayan Dairesel Hareket

$|\vec{v}_i| \neq |\vec{v}_s|$



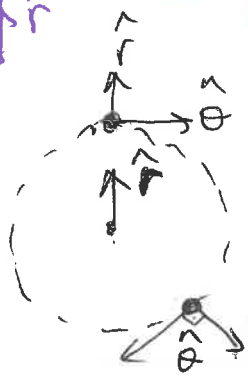
$\vec{a}$ merkeze doğru değil!



$$\vec{a} = \vec{a}_t + \vec{a}_r$$

↓ merkeze DİK! ↓ merkeze doğru

$$|\vec{a}| = \sqrt{a_t^2 + a_r^2}$$



DODH

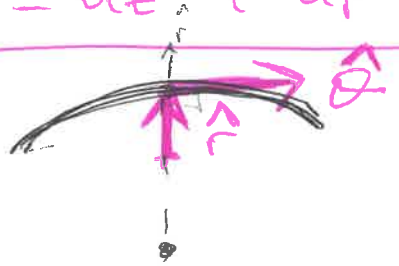
$$\vec{a} = \vec{a}_t + \vec{a}_r \quad (2)$$

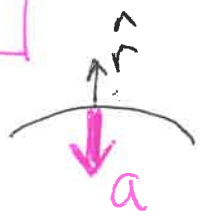
↓ merkeze DİK — ↓ merkeze

$$\vec{a} = \frac{d|\vec{v}|}{dt}\hat{\theta} - \frac{v^2}{R}\hat{r}$$

$v = t$ anındaki hız

$$\vec{a} = \vec{a}_t + \vec{a}_r$$





$$\vec{a} = \frac{d|\vec{v}|}{dt}\hat{\theta} - \frac{v^2}{R}\hat{r}$$

$$\vec{a} = \frac{d|\vec{v}|}{dt}\hat{\theta} + \frac{v^2}{R}(-\hat{r})$$ } DODH ivme

---

Bir SARKAÇ; serbest şekilde salınıyor. θ: açısı anındaki durum.

DODH

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

$R = 0.5$ m; $\theta = 20°$ oldığında $v = 1.5$ m/s dir.

$\vec{a} = ?$

$\vec{a} = \vec{a}_t + \vec{a}_r$

$$a_r = \frac{v^2}{R} = \frac{(1.5)^2}{(0.5)} = 4.5 \text{ m/s}^2$$

$a_t \Rightarrow$ topun hızlanmasının sonucu.

topu hızlandıran şey? g ivmesinden dolayı mg kuvveti

$$|a_t = g\sin\theta|$$

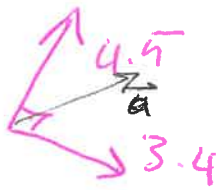
$\theta = 20°$; $R = 0.5\,m$; $v = 1.5\,m/s$

$\vec{a} = \vec{a}_t + \vec{a}_r$

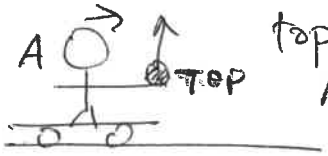
$\vec{a} = (g\sin\theta)\hat{\theta} + \left(-\frac{v^2}{R}\hat{r}\right)$

$\vec{a} = 9.8(\sin 20)\hat{\theta} - (4.5)\hat{r}$

$\vec{a} = (3.4\,\hat{\theta} - 4.5\,\hat{r})\ m/s^2$

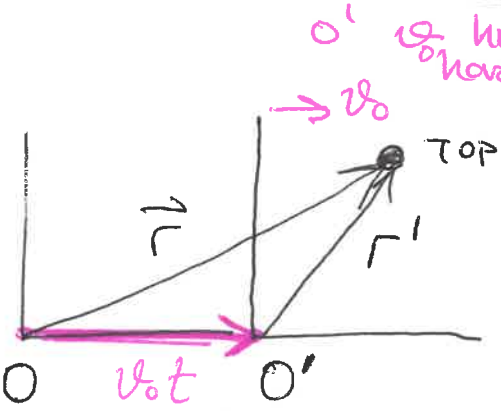


BAĞIL hareket



topun hareketi A'ya göre

topun B'ye hareketi göre



$\vec{r} = \vec{v}_0 t + \vec{r}'$

$\vec{r}' = \vec{r} - \vec{v}_0 t$

P ⇒ cisim ; A ve B kişisi var (koordinatları)

$\vec{r}_{P/A} = \vec{r}_{P/B} + \vec{r}_{B/A}$

$\vec{v}_{P/A} = \vec{v}_{P/B} + \vec{v}_{B/A}$

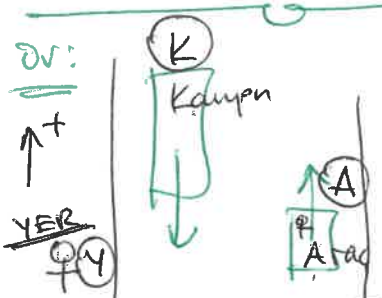
$\vec{a}_{P/A} = \vec{a}_{P/B} + \vec{a}_{B/A}$

P'nin A'ya göre — P'nin B'ye göre — B'nin A'ya göre

konum → türev → hız → türev → ivme

Bağıl hareket; genelde ref. sistemleri birbirine göre SABİT HIZDA hareket edebilir. Birbirine göre İVMELERİ SIFIR

$\vec{v}_{B/A} = sbt$ $\quad \vec{a}_{P/A} = \vec{a}_{P/B}$



Kamyonun yere göre hızı 88 km/sa.

Aracın hızı yere göre 104 km/sa.

Kamyonun araca göre hızı?

$\vec{v}_{K/Y} = -88\,\hat{j}$

$\vec{v}_{A/Y} = 104\,\hat{j}$

$\vec{v}_{K/A} = ?$

$v_{K/A} + v_{A/Y} = v_{K/Y}$

$? + 104\hat{j} = -88\hat{j}$

$v_{K/A} = -192\,\hat{j}$

$(-\hat{j})$ 88 + 104 $= 88\hat{j} - (104\hat{j})$

Ör Kuzeye yönelen tekne nehri suya göre 10 km/sa hız ile karşıya geçiyor. Nehirdeki su doğuya doğru yere göre 5 km/sa hızla akıyor. Tekneuin yere göre hızı?

$$\vec{v}_{T/Y} = \vec{v}_{T/N} + \vec{v}_{N/Y}$$

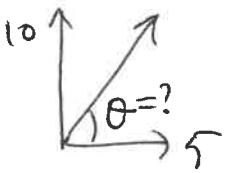
$$10\hat{j} + 5\hat{i}$$

$$\vec{v}_{T/Y} = (5\hat{i} + 10\hat{j})\ km/sa$$

yön ve büyüklüğü

↳ θ

$$|\vec{v}_{T/Y}| = \sqrt{5^2 + 10^2} = 11.2\ km/s$$



$$\tan\theta = \frac{10}{5}; \quad \theta = \tan^{-1}(2)$$

$$\theta \cong 63.4°$$

© Nehir genişliği 3 km ise tekne nehri kaç dakikada geçer?

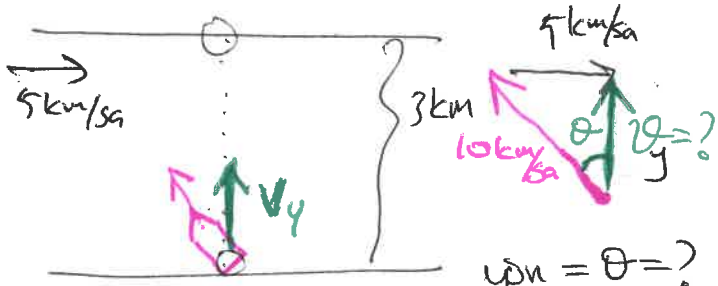
3 km $\quad t = \frac{3\ km}{10\ km/sa}$

$$t = 0.3\ sa$$

$$t = 0.3 \times 60\ dk = 18\ dk$$

$$t = \frac{km}{\frac{km}{sa}} = \frac{1}{1/sa} = sa$$

Ör Bir önceki örnek gibi ④ tekne nehre göre aynı 10 km/sa hızla yol alıyor. Tam olarak kuzeye doğru gitmek isterse baş tarafının gösterdiği yön?



$$\sin\theta = \frac{5}{10}$$

$$\theta = \sin^{-1}\left(\frac{1}{2}\right) = 30°$$

b) tekne karşı kıyıya kaç dk ulaşır?

v_y → karşıya göre hızıdır.

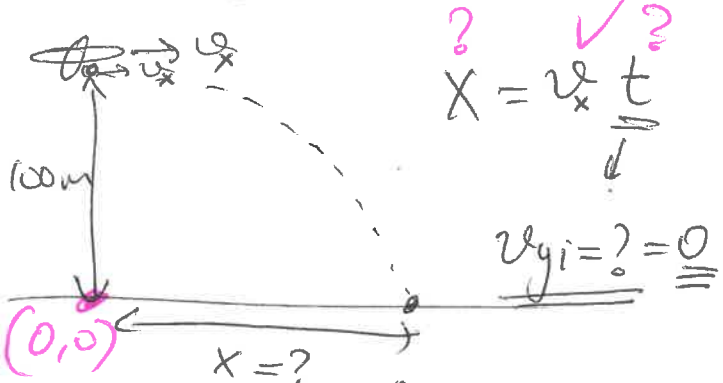
$\frac{yol}{hız}$ = zaman ⇒ $t = \frac{3\ km}{v_y}$

$$V_y = 10\cos 30 = 8.5\ km/sa$$

$$t = \frac{3\ km}{8.5\ km/sa} = 0.35\ sa = 21\ dk$$

Bir ~~Bir kaktan~~

Kaak 100m yukseklikte 40 m/s hızla yatay olarak uçuyor. Bir paket serbest olarak kaaktan bırakılıyor. Bırakıldığı noktadan, çarptığı nokta arası mesafe?



$X = v_x t$? ✓ ?

$v_{yi} = ? = 0$

$y_s = y_i + v_{yi} t - \frac{1}{2} g t^2$

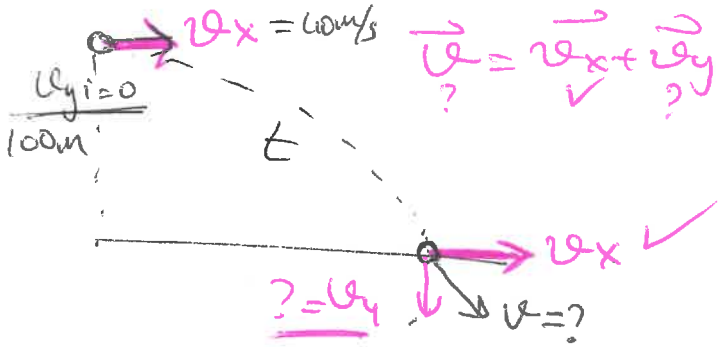
$0 = 100 - \frac{1}{2}(9.8)t^2$

$t = \sqrt{\frac{200}{9.8}} = 4.52\,s$

$X = v_x t = X = 40\,(4.52)$

$= 181\,m$

b) paketin yere çarpma hızının yönü ve büyüklüğü?

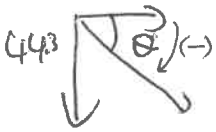


$\vec{v} = \vec{v_x} + \vec{v_y}$? ✓ ?

$v_{ys} = v_{yi} + at = v_{yi} - gt$

$v_{ys} = 0 - (9.8)(4.52)$

$= -44.3\,m/s$



$\theta = \tan^{-1}\left(\frac{-44.3}{40}\right)$

$\cong -48°$

Bir DODH ~~araç~~ (1)

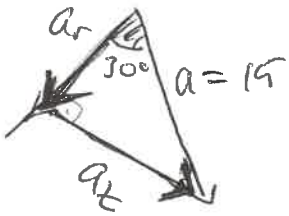
$a = 15\,m/s^2$

$a_r = ?\ a_t = ?$

$v = ?$

$R = 2.5\,m$

$\vec{a} = \vec{a_t} + \vec{a_r}$



$a_r = ?$

$a_r = 15\cos 30°$ $\quad a_t = 15\sin 30$

$a_r = \frac{15\sqrt{3}}{2}\,m/s^2$ ✓ $\quad a_t = \frac{15}{2}\,m/s^2$

$v = ?$ $\quad \boxed{a_r = \frac{v^2}{R}} = \frac{15\sqrt{3}}{2} = \frac{v^2}{2.5}$

$v = 5.7\,m/s$

1.8.16

Şimdiye kadar
- vektörler
- birimler
- hareket → 1 → 2 → 3 } boyut

* formülleri bilmeniz ve uygulayınız.

$$\begin{cases} \vec{v}_s = \vec{v}_i + \vec{a}t \\ \vec{r}_s = \vec{r}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2 \\ v_s^2 = v_i^2 + 2a(x_s - x_i) \end{cases}$$

Bölüm 5 ⇒ Hareket Kanunları – kuvvet *

* Bir kuvvet altında cisim ivmelenir.

Net kuvvet = Toplam kuvvet

* Net kuvvet SIFIR ise, İVME SIFIRdır.

$v = sbt$

DENGE ≡ Net kuvvet = 0 = ivme

KUVVET: Temas kuvvetlerini gözlemliyoruz

Temas ⇒ boşluk mevcut → boşluk

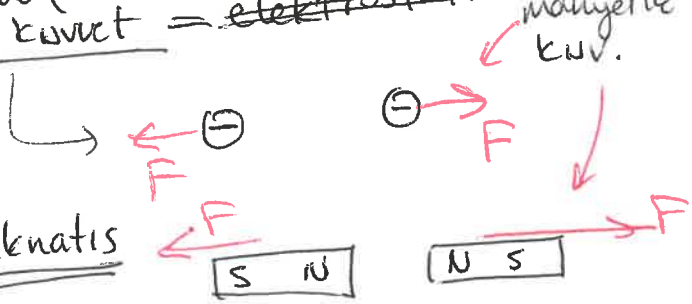
Boşluk

① e⁻ lar itiliği için boşluk var

Fizikteki temel kuvvetler ≡ Alan kuvvetleridir.

Boşluk vardır.

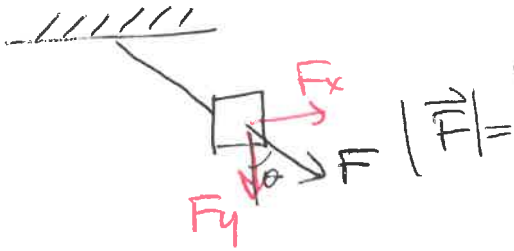
temel kuvvet = ~~elektrostatik~~ Elektro manyetik kuv.



→ Kütle çekim kuv.

→ Fizik 1

Kuvvet ⇒ vektördür → yön, şiddet büyüklük



$|\vec{F}| = \sqrt{F_x^2 + F_y^2}$

Newton'un BİRİNCİ yasası

Bir cisme net kuvvet etki etmezse; durgun ise durgunkal sabit hızlı ise sabit hızda kalır

↳ Net kuvvet = 0 ⇒ ivme = 0

Eylemsizlik (inertia): cismin hızında meydana gelecek değişime karşı koyması EYLEMSİZLİK

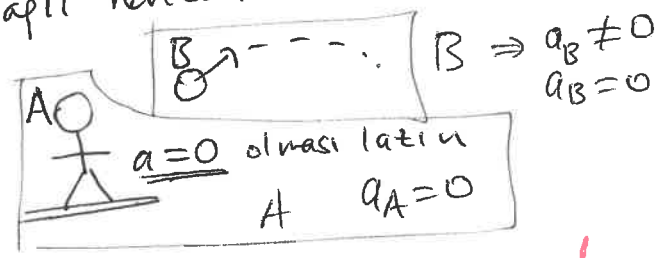
Eylemsiz Referans Sistemleri

↳ ölçüm alınan sistemlerdir.

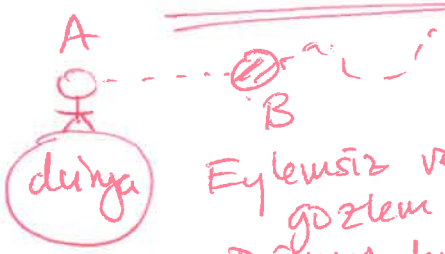
ivmenin SIFIR olduğu sistemlerdir.

Eylemsiz gözlem çerçevesi

Bağıl hareketle biraz bahsetelim.



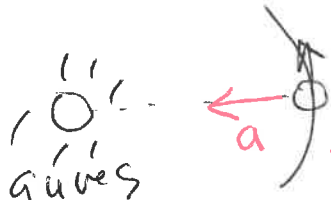
İvmenin sıfır olduğu çerçevede ÖLÇÜM alınır.



Eylemsiz ~~referans~~ gözlem çerçevesi DÜNYA'dır. ✓

Dünyanın ivmesi SIFIR olmalı.

↳ Doğru mu?



I.

merkezcil ivme

Dünyanın güneş etrafında dönmesinden dolayı

$a = \frac{v^2}{R}$ → Dünyanın Güneş etr. Hızı

→ Dünya - Güneş mesafe

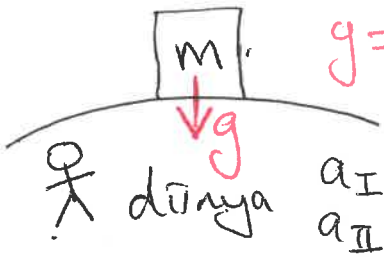
$v = \frac{\text{yol}}{\text{zaman}} \Rightarrow \frac{2\pi R \to (m)}{1\ \text{yıl} \to (s)}$

$a_I = 4.4 \times 10^{-3}\ m/s^2 = 0.0044\ m/s^2$

Dünyanın kendi etrafında dönmesinden dolayı

$a_{II} = 3.37 \times 10^{-2}\ m/s^2$

$= 0.0337\ m/s^2$



$g = 9.8\ m/s^2 \cong 10\ m/s^2$ (2)

$a_I = 0.004\ m/s^2$

$a_{II} = 0.03\ m/s^2$

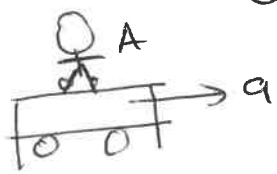
$10 \gg 0.03 ; 0.004$

İhmal ediyoruz.

$a_I = a_{II} = 0$ = kabul ediyoruz.

Böylelikle Dünya eylemsiz gözlem çerçevesi kabul edilir

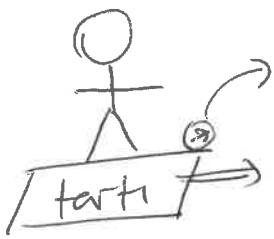
Eylemsiz gözlem çerçevesi olmayan bir durum



KÜTLE : evrenin temel yapıtaşlarından.

Kütle ↔ ağırlık (kuvvet)

normal hayatta karıştırılıyor



80kg = m

kuvvet ölçer kütleyi gösterir.

~~Ağırlık~~ Ağırlık = mg = kuvvet

$80 \times 9.8 = 784\ N$

kütle ≠ ağırlık

kg ≠ Newton = $kg \frac{m}{s^2}$

Kütle; bir cismin sahip olduğu eylemsizliğin ölçüsüdür.
Birimi kg.

eylemsizlik ↔ kütle

Newton'un İkinci Yasası

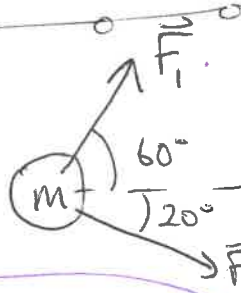
Bir cismin ivmesi ona etki eden net kuvvet ile doğru orantılı, kütlesi ile ters orantılıdır

II. yasa $a = \frac{F}{m}$; $\vec{\Sigma F} = m\vec{a}$ ($\vec{\Sigma F}$: net kuvvet)

F = kuvvet = $\frac{\text{Newton}}{\text{birim}}$ = [N]

$N = kg\,\frac{m}{s^2}$ SI birim sist.

bir)

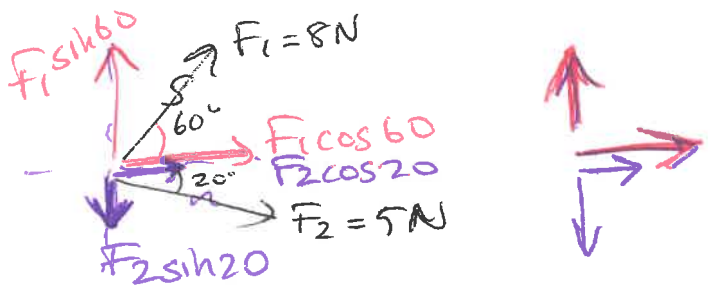


$m = 0.3\,kg$
$|\vec{F_1}| = 8N$
$|\vec{F_2}| = 5N$

$\vec{a} = ?$ büyüklük? yön?

$\vec{\Sigma F} = m\vec{a}$ (yön ∥, sbt, yön ∥)

$\vec{\Sigma F}$ = bulmalı.



$\Sigma F_x = F_1 \cos 60 + F_2 \cos 20$ (3)

$\Sigma F_y = F_1 \sin 60 - F_2 \sin 20$

$\Sigma F_x = 8.7N$; $\Sigma F_y = 5.2N$

$\Sigma F = F_{net} = \sqrt{8.7^2 + 5.2^2}\ N$

$\vec{\Sigma F} = m\vec{a}$ → $\Sigma F_x = ma_x$; → $\Sigma F_y = ma_y$

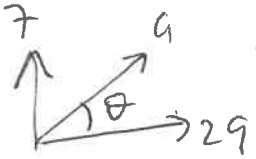
$8.7N = (0.3\,kg)\,a_x$

$5.2 = (0.3)\,a_y$

$a_x = 29\ m/s^2$ $a_y = 17\ \frac{m}{s^2}$

$a = \sqrt{a_x^2 + a_y^2} = 34\ m/s^2$

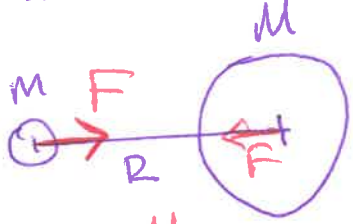
yön



$\theta = \tan^{-1}\left(\frac{17}{29}\right)$

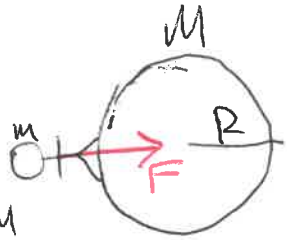
$\theta \simeq 30°$

Ağırlık ve Kütle Çekim



$F = G\frac{mM}{R^2}$ (G: sbt)

F = ağırlık = mg



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

$g = \frac{GM}{R^2}$

$g \simeq 9.8\ m/s^2$ g = sbt

Newtonun ÜÇÜNCÜ yasası

Etki – Tepki kuvvetleri

Eğer iki cisim etkileşiyorsa

2. cismin 1. cisme uyguladığı

$\vec{F}_{21}$;

kuvveti; 1. cismin 2. cisme uyg.

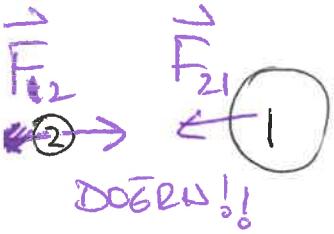
$\vec{F}_{12}$

kuvvetle eşit ve ters yönlüdür.

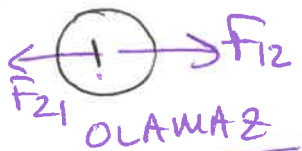
$$\vec{F}_{21} = -\vec{F}_{12}$$

3. yasa

* Etki–Tepki kuvvet çiftleri HERZAMAN FARKLI iki CİSİM ÜZERİNDEDİRLER



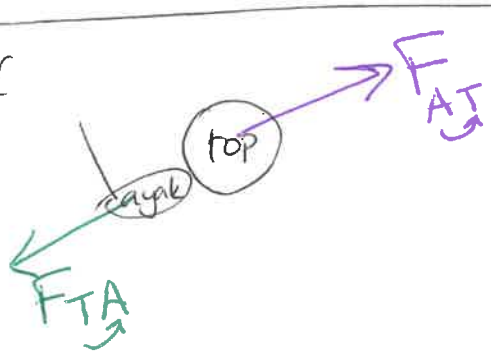
DOĞRU!!



OLAMAZ

YANLIŞ

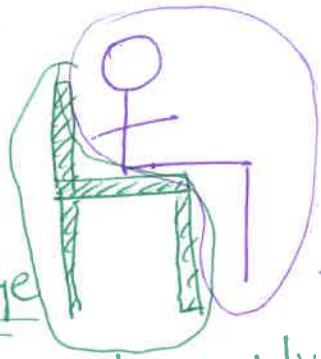
ör



Normal Kuvvet

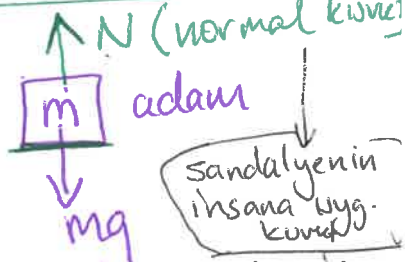
(Dik)

(4)



adama kuvvet uygulıyor ki adam sbt duruyor.

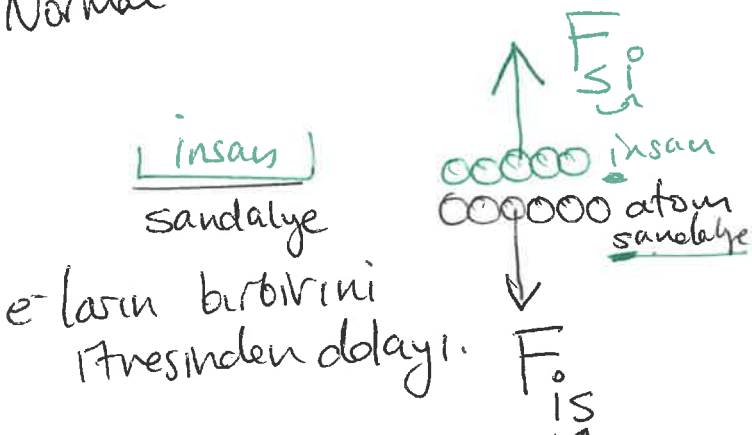
$$\vec{F}_{21} = -\vec{F}_{12}$$



N, mg etki tepki çifti DEĞİLDİR çünkü N, mg aynı cisime etki ediyor.

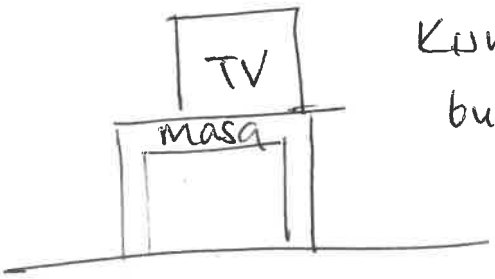
* N ile N' etki tepki çiftidir

Normal kuvvet nedir?



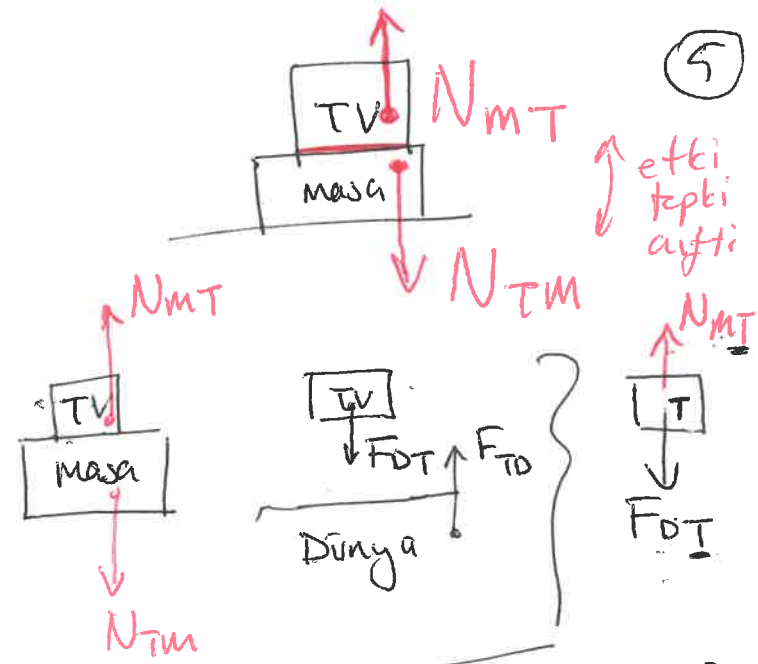
e⁻ların birbirini itmesinden dolayı.

Yüzeyde temas görürseniz; yüzeye dik bir **NORMAL** kuvvet olması lazım!!!



Kuvvetleri bulunuz!

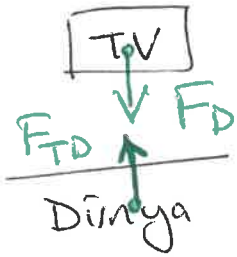
- Kütle çekim kuvveti
- Normal kuvvet



TV uygulanan toplam kuvvet?

TV → masa (yüzey) Normal kuv.

TV → dünya ; yer çekim = ağırlık



$F_{DT} = mg$ = ağırlık

$\vec{F}_{DT} = -\vec{F}_{TD}$ etki tepki

Temas yok; Normal kuvvet yok

TV değede kalacaksa; N, F_{DT} eşit olmalı!

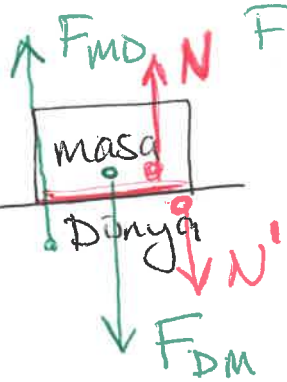
$\sum \vec{F} = 0 = m\vec{a} =$

$F_{DT} = mg$

$N - mg = 0 \Rightarrow N = mg$

$mg > N \Rightarrow$ ne olur.

masa kırılır!



$\vec{F}_{MD} = -\vec{F}_{DM}$

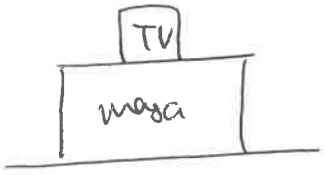
kütle çekim dolayı etki tepki çifti

N = Dünyanın Masaya uyg. Normal kuvvet.

N' = Masanın dünyaya uyg. Normal kuvvet

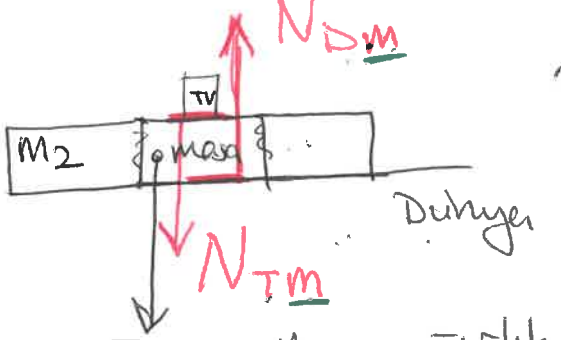
$\vec{N} = -\vec{N}'$ etki-tepki çiftidir.

$\vec{N}_{DM} = -\vec{N}_{MD}$



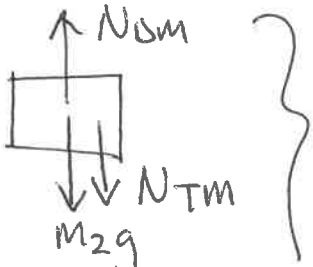
Masaya Uyg. Net (toplam) kuvvet?

Dünya



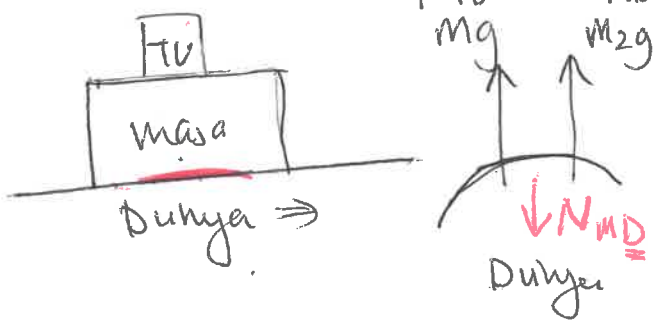
→ 2 tane Normal kuv. yüzey temas

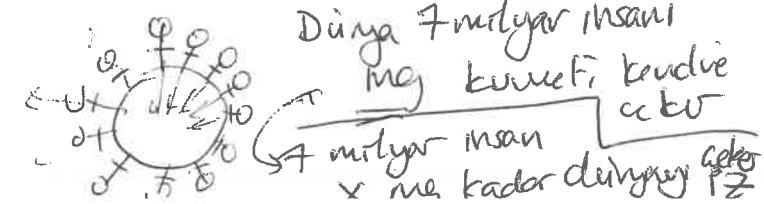
→ 1 tane yerçekim = ağırlık



$$\vec{N}_{DM} + \vec{N}_{TM} + m_2\vec{g} = 0$$

$$+N_{DM} - N_{TM} - m_2 g = 0$$



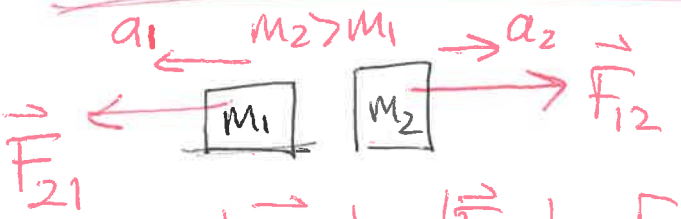


Or

$m_2 > m_1$

m_2; m_1'i ittiriyor, m_1 ivmeli? m_2

F kuv.



$$|\vec{F}_{21}| = |\vec{F}_{12}| = F$$

$$a_1 = \frac{F}{m_1} \quad ; \quad a_2 = \frac{F}{m_2}$$

$$a_1 > a_2 \quad (m_2 > m_1)$$

~~kütlesi~~ kütlesi az olan daha ivmeli ivmelenecek.

Bir Serbest cisim diyagramları

SCD ⇒ bir cismin üzerindeki kuvvetlerin gösterimi

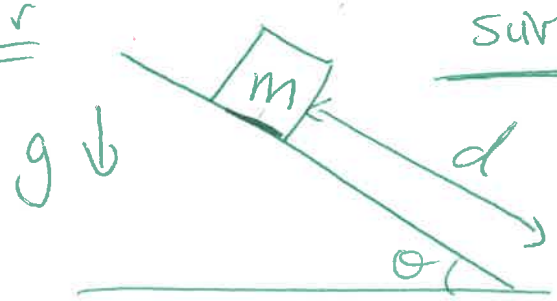
$$\Sigma \vec{F} = m\vec{a}$$

SCD ihtiyaç var

Sürtünme sihirli YOK!

Örn

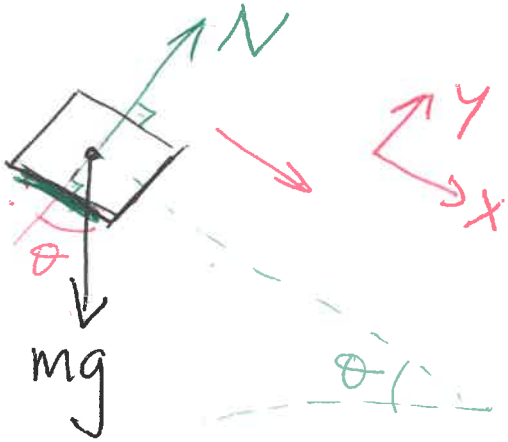
Sürt. yok

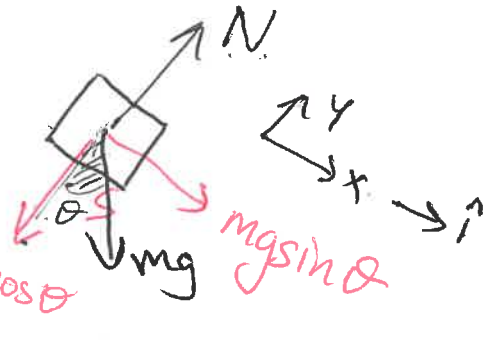


a) İvmesi?

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

SCD





$\sum F_y = ma_y$; $\sum F_x = ma_x$

$N - mg\cos\theta = ma_y$

y yönünde ivme var mı? Yok!

$a_y = 0$

$N - mg\cos\theta = 0$

$N = mg\cos\theta$

$mg\sin\theta = ma_x$

$a_x = g\sin\theta$

$\vec{a} = a_x\hat{i} + a_y\hat{j}$

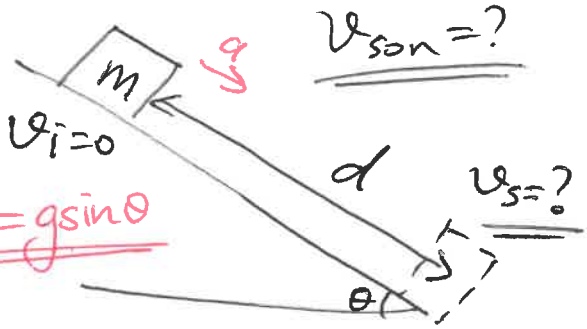
$\vec{a} = (g\sin\theta)\hat{i}$

$\sum \vec{F}$ → bileşenlerini gösteren koordinat sistemi

* kolay olanı tercih edin

eğer eksenlerden bir tanesinde ivme sıfırsa; o koord. sist. tercih edin

b) $v_{son} = ?$

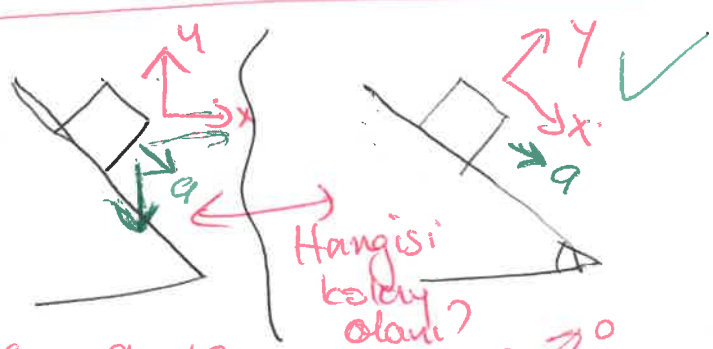


Zamansız hız denklemi

$v_s^2 = v_i^2 + 2a(x_s - x_i)$ (Δx)

$v_s^2 = 0^2 + 2(g\sin\theta)d$

$v_s = \sqrt{2gd\sin\theta}$



1. Kuvvetleri alıp SCD ***
2. Eksen, koord. sis. SEÇ.
3. $\sum \vec{F} = m\vec{a}$ uygula

$\sum F_x = ma_x$; $\sum F_y = ma_y$

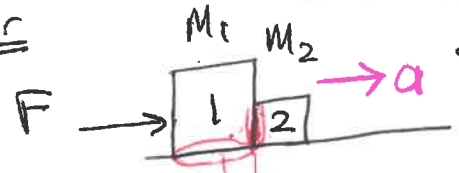
cisim 2.8.16

SCD diyagramları

↳ serbest

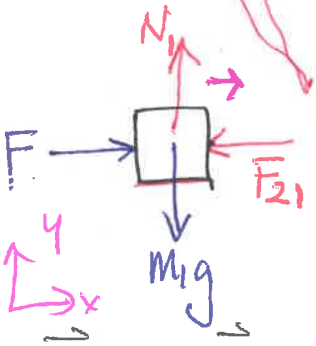
① SCD çiz ② 

③ $\Sigma \vec{F} = m\vec{a}$ → x, → y

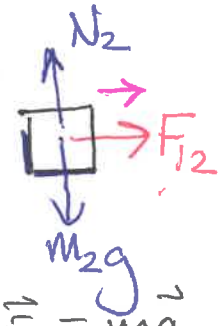
Ör 

sürt. yok.

a) İki bloklu sistemin ivmesi?



temas Normal kuv.



$\Sigma \vec{F} = m_1 \vec{a}$

$\Sigma \vec{F} = m_2 \vec{a}$

$\hat{x}$: ① $F - F_{21} = m_1 a_x$ (x)

$\hat{y}$: $N_1 - m_1 g = m_1 a_y^{\,0}$

$N_1 = m_1 g$

$\hat{x}$: ② $F_{12} = m_2 a_x$

$\hat{y}$: $N_2 - m_2 g = 0$

$N_2 = m_2 g$

m_1, m_2 nin ivmeleri a_x; aynı

temas var; birlikte hareket ediyor

F_{21}, F_{12} etki tepki çifti

$\vec{F}_{21} = -\vec{F}_{12}$; $F_{21} = F_{12} = P$

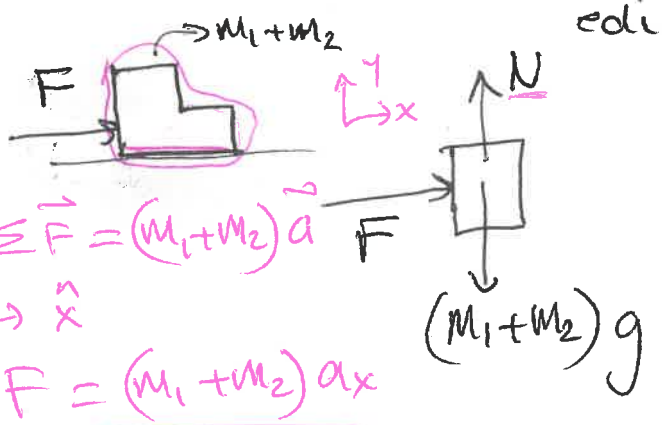
① ve ② $F - P = m_1 a_x$

$+ \quad P = m_2 a_x$

$F = (m_1 + m_2) a_x$

$a_x = \dfrac{F}{m_1 + m_2}$

II. yol; m_1 ve m_2 birlikte ① hareket ediyor.



$\Sigma \vec{F} = (m_1 + m_2)\vec{a}$

↳ $\hat{x}$

$F = (m_1 + m_2) a_x$

$a_x = \dfrac{F}{m_1 + m_2}$ ✓

$\hat{y}$: $N - (m_1 + m_2) g = (m_1 + m_2) a_y^{\,0}$

$N = (m_1 + m_2) g$

$N_1 + N_2 = N$

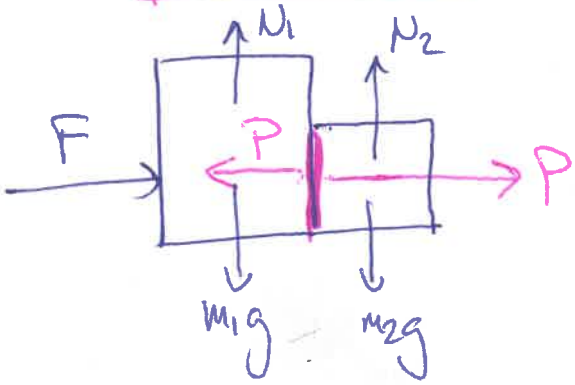
b) m_1 ve m_2 arasındaki temas kuvveti nedir?

I. yoldaki SCD ihtiyaç var. denklemler

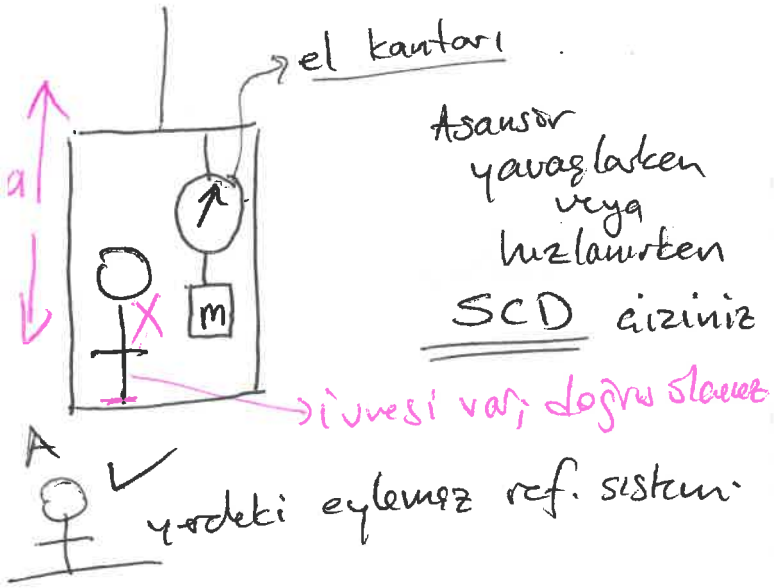
$F - P = m_1 a_x$; $a_x = \dfrac{F}{m_1 + m_2}$

$P = m_2 a_x$

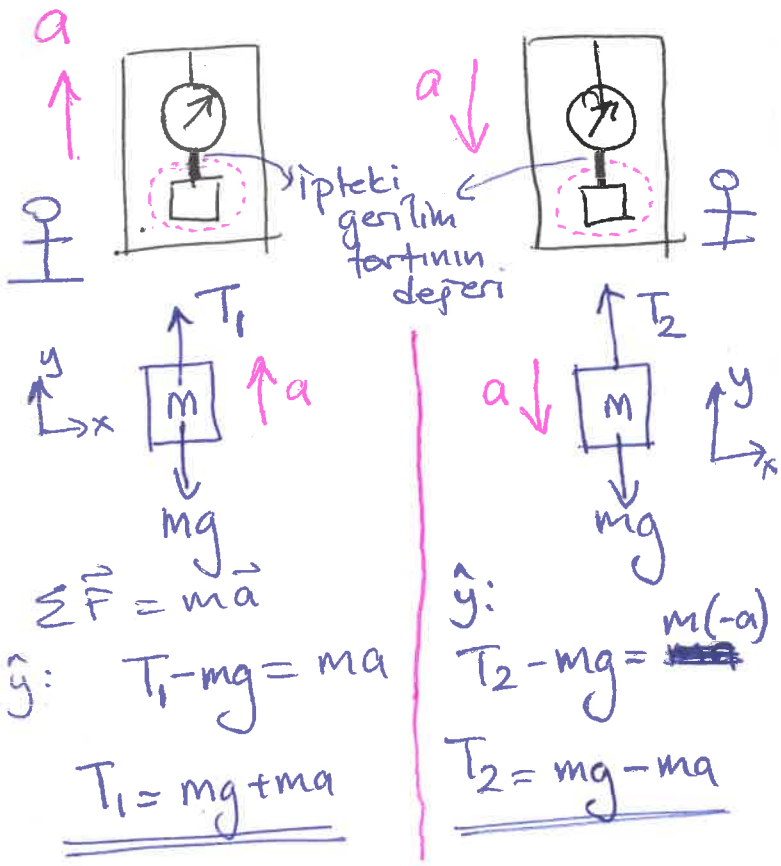
$P = m_2 \dfrac{F}{m_1 + m_2}$



Or Asansör içinde tartılan cisim



Asansör yavaşlarken veya hızlanırken SCD çiziniz



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

$\hat{y}$: $T_1 - mg = ma$

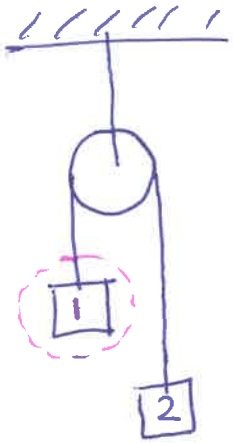
$T_1 = mg + ma$

$\hat{y}$: $T_2 - mg = m(-a)$

$T_2 = mg - ma$

T gerilmeleri tartının değeri olduğu için ; ↑, ↓ ivmelenirken tartı farklı değerler gösterir.

Atwood makinesi ; makara (2)

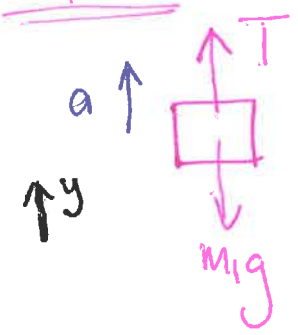


$m_2 > m_1$

a) ivme?

b) ipteki gerilme?

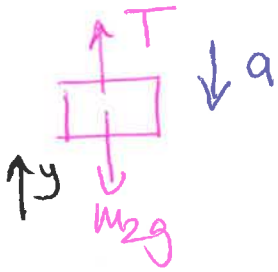
m_1 için



$F_y = m_1 a_y$

$T - m_1 g = m_1 a$

m_2 için



$F_y = m_2 a_y$

$T - m_2 g = m_2(-a)$

① $T - m_1 g = m_1 a$

② $-T + m_2 g = m_2 a$ ← (-1) carp

① + ② $m_2 g - m_1 g = m_1 a + m_2 a$

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

a hangi durumda sıfır? $m_2 = m_1$; $a = 0$

b) T=? ① al; a koy!

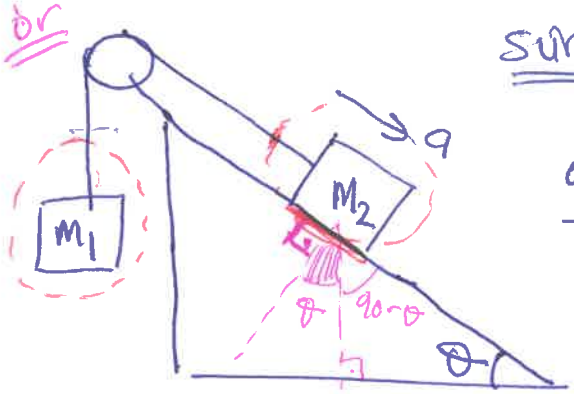
$$T - m_1 g = m_1\left(g\,\frac{m_2 - m_1}{m_1 + m_2}\right)$$

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

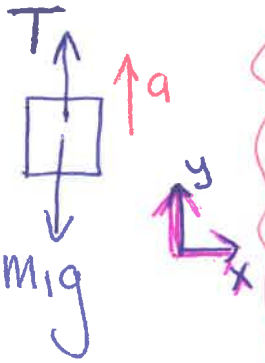
$$T = m_1 g\left(1 + \frac{m_2 - m_1}{m_1 + m_2}\right) = m_1 g\,\frac{2m_2}{m_1 + m_2}$$

bir

sürt. yok

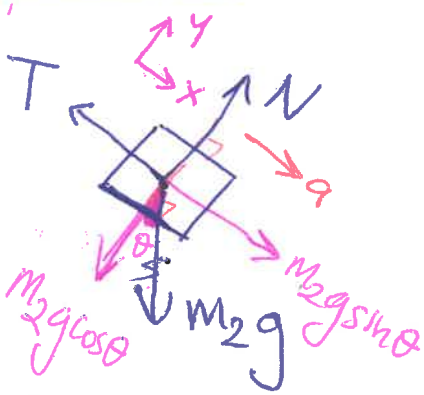


$a = ?$
$T = ?$



$\Sigma F_y = m_1 a_y$

$T - m_1 g = m_1 a$ (1)



$\Sigma F_x = m_2 a_x$

$m_2 g \sin\theta - T = m_2 a$ (2)

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

$N - m_2 g \cos\theta = 0$

$\boxed{N = m_2 g \cos\theta}$

$a = ?$ (1) + (2)

$m_2 g \sin\theta - m_1 g = m_1 a + m_2 a$

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

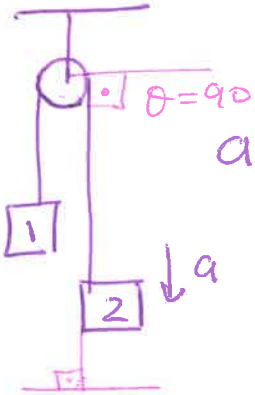
$T = ?$ $\quad T - m_1 g = m_1 a$ (1)

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

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

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

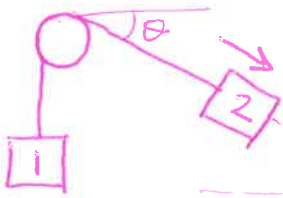
$$\boxed{T = m_1 m_2 g\left(\frac{1 + \sin\theta}{m_1 + m_2}\right)}$$



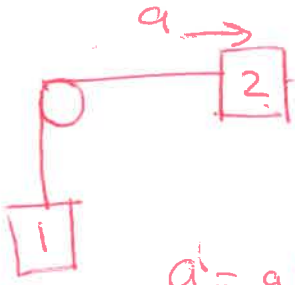
$$a = g\,\frac{m_2 - m_1}{m_1 + m_2}$$

$\theta = 90°$

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



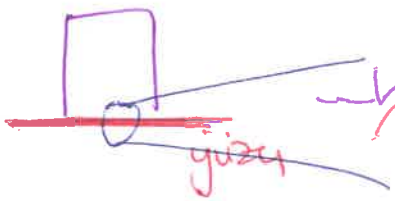
$\theta = 0°$



$$a = g\,\frac{m_2 \sin 0 - m_1}{m_1 + m_2}$$

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

SÜRTÜNME kuvvetleri



Tevelinde elektron etkileşmeleri var.

Elektromanyetik kuvv.

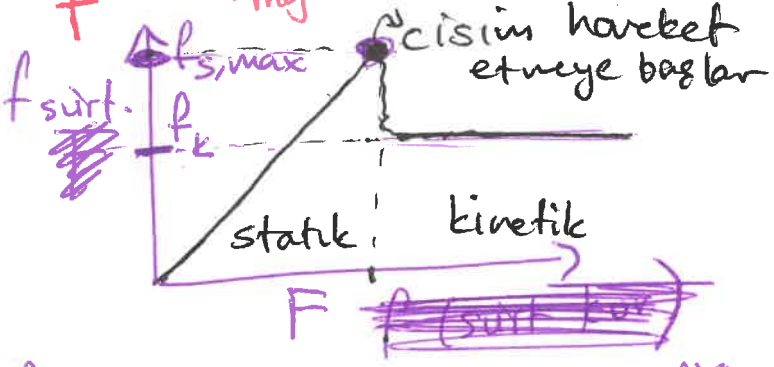
sürtünme kuvv.

- Statik (durgun)
- Kinetik (hareketli)

cisim hareket halindeki sürt. kuvveti ile durgun haldeki sürt. kuvveti farklı.

SÜRT. VAR

F kuv. sıfırdan başlıyor, yavaşça artıralım



$f_{s,max}$ = statik sürt. kuv. MAX.

f_k = kinetik sürt. kuv. (hareketli)

sürt. kuvveti TEMAS ile alakalı YÜZEYİ

$$* \quad f = \mu N \quad *$$

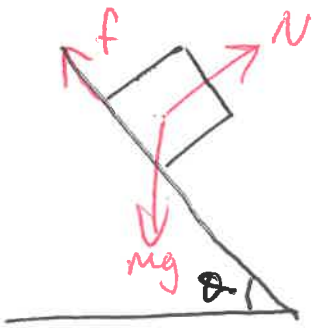
f: temas yüzey kuv.

μ: sbt sürt katsayısı

$$f_s = \mu_s N \; ; \; f_k = \mu_k N$$

statik, duygu; kinetik, hareketli

	μ_s	μ_k
Çelik + çelik	0.74	0.57
Çelik – Alüminyum	0.61	0.47
Beton – Lastik	1.0	0.8 *
Cam – Cam	0.94	0.4
Metal – yağlı metal	0.15	0.06
Buz – Buz	0.1	0.03
Teflon – Teflon	0.04	0.04
İnsandaki eklem bağlantıları	0.01	0.003

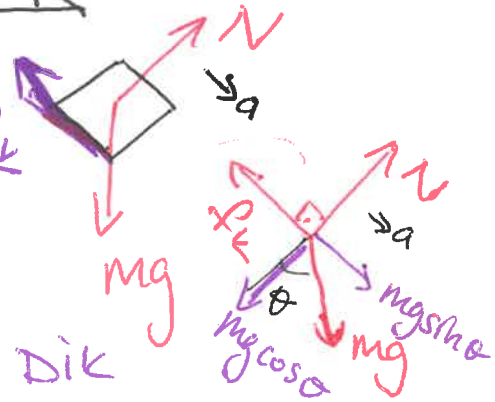


sürt VAR! ④

$a = ?$

μ_k

① SCD



f_k; N'ye DİK

hareket TERS!!

② $\Sigma F_x = ma_x$

$$mg\sin\theta - f_k = ma \quad (1)$$

$$f_k = \mu_k N \; *$$

$\Sigma F_y = ma_y^{\,0}$

$N - mg\cos\theta = 0$

$$N = mg\cos\theta$$

(1) $mg\sin\theta - \mu mg\cos\theta = ma$

f_k: sürt kuv.

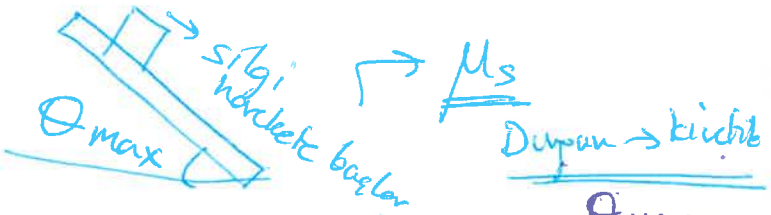
$$a = g\sin\theta - \mu g\cos\theta \quad \checkmark$$

eğer sürt yoksa $\mu = 0$;

$a = g\sin\theta$ (çözmüştük!)

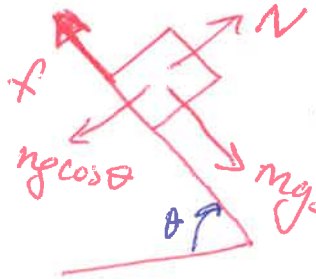
Ör iki cisim arasındaki μ_k ve μ_s için ölçek

kitap - silgi Deney



Durgun → kinetik

θ_{max}



$\sum F_x = 0$

hareket yok

$\sum F_x = ma$

$mg\sin\theta_m - \mu_s N = 0$ $\quad \theta_{max} = \theta_m$

$N = mg\cos\theta_m$

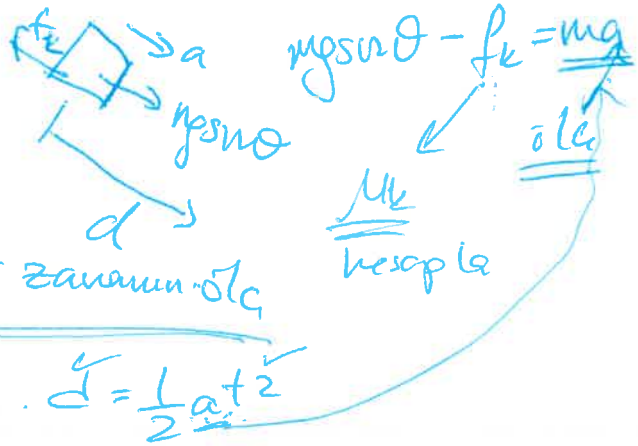
$mg\sin\theta_m - \mu_s mg\cos\theta_m = 0$

$mg\sin\theta_m = \mu_s mg\cos\theta_m$

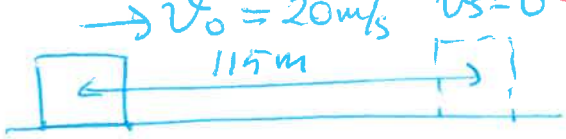
$\mu_s = \frac{\sin\theta}{\cos\theta} = \tan\theta_m$

$\tan 30^\circ = \mu_s$

Hareket halinde iken



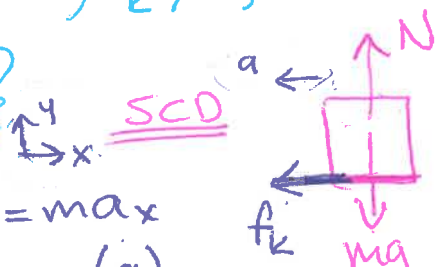
Ör



$\mu_k > 0$; sürt var.

$\mu_k = ?$

SCD



$\sum F_x = ma_x$

$-f_k = m(-a)$

$f_k = ma$

$f_k = \mu_k N$

? ? ?

$\sum F_y = ma_y$

$N - mg = 0$

$N = mg$ ✓

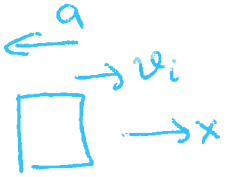
$ma = f_k = \mu_k mg$

$a = \mu_k g$

hareket denk.

$v_s = v_i + at$

$v_s^2 = v_i^2 + 2a(x_s - x_i)$



$0^2 = 20^2 + 2a(115)$

$a = -\frac{400}{230} = -1.73$ m/s²

$a = \mu_k g$

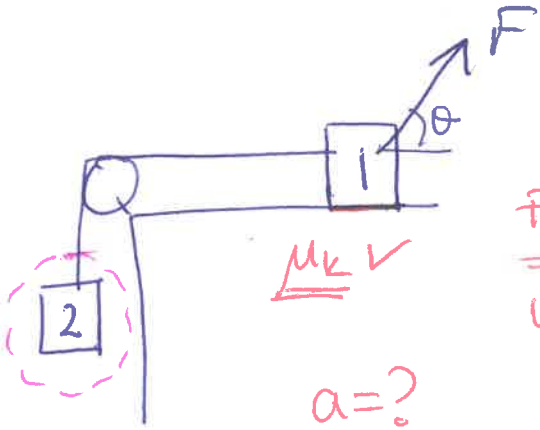
$1.73 = \mu_k (9.8) \Rightarrow \mu_k = 0.17$

μ_k → birimsiz

$f = \mu N$

newton newton

$1 > \mu > 0$



sürtünme

F, θ, g, m_1, m_2 veriliyor.

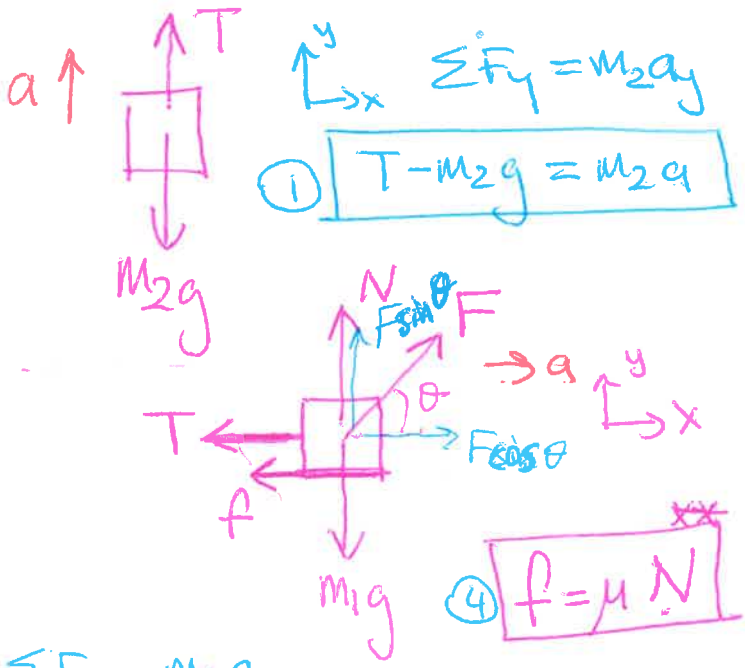
a = ?

ABS sistemi otomatik frenleme sist.

$\mu_s = 1.0$ ABS

$\mu_k = 0.8$ otomatik olarak kaymasını eyeller.

$f = \mu N = (1.0) N = ma$



$\sum F_y = m_2 a_y$

① $T - m_2 g = m_2 a$

④ $f = \mu N$

$\sum F_x = m_1 a_x$

$F\cos\theta - T - f = m_1 a$ ②

$\sum F_y = m_1 a_y^{\,0} \Rightarrow N + F\sin\theta - m_1 g = 0$ ③

$N = m_1 g - F\sin\theta$ ③

④ $f = \mu N = \mu(m_1 g - F\sin\theta)$

→ 2.ci denk. koy.

$F\cos\theta - T - \mu(m_1 g - F\sin\theta) = m_1 a$ ②

$T - m_2 g = m_2 a$ ①

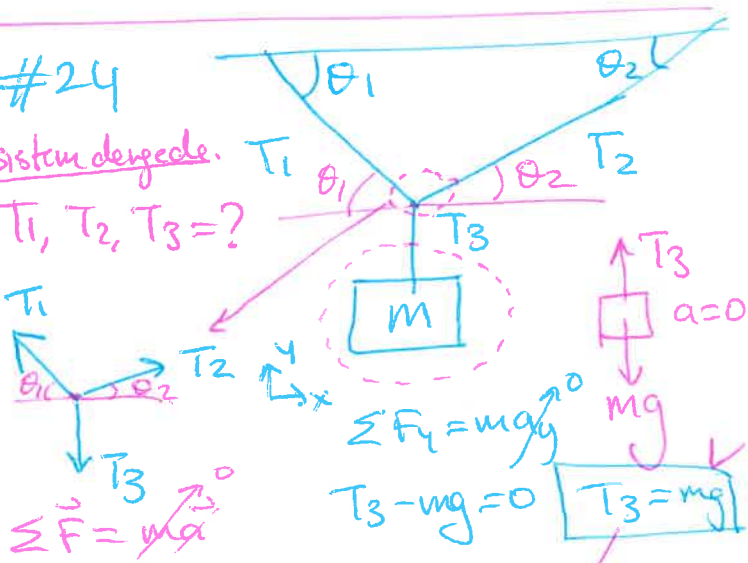
+

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

$$a = \frac{F\cos\theta - m_2 g - \mu[m_1 g - F\sin\theta]}{m_1 + m_2}$$

#24

sistem dengede. $T_1, T_2, T_3 = ?$



$\sum F_y = mg a_y^{\,0}$

$T_3 - mg = 0$ → $T_3 = mg$

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

$\sum F_y = 0$

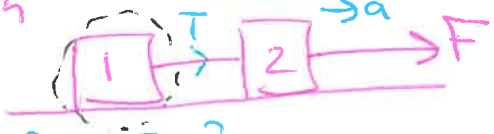
$T_2 \sin\theta_2 + T_1 \sin\theta_1 - T_3 = 0$ ①

$\sum F_x = 0$

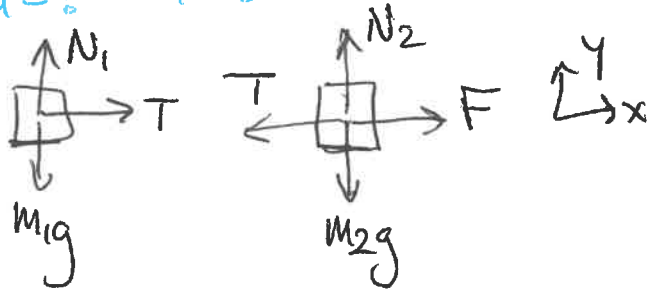
$T_2 \cos\theta - T_1 \cos\theta = 0$ ②

① ve ② T_1, T_2 için mg, θ_1, θ_2

#35 sürt. yok



$a=?$ $T=?$



$\Sigma F_x = m_1 a_x$

$T = m_1 a$ (1)

$\Sigma F_y = m_1 a_y = 0$

$N_1 - m_1 g = 0$

$\Sigma F_x = m_2 a_x$

$F - T = m_2 a$ (2)

$\Sigma F_y = m_2 a_y = 0$

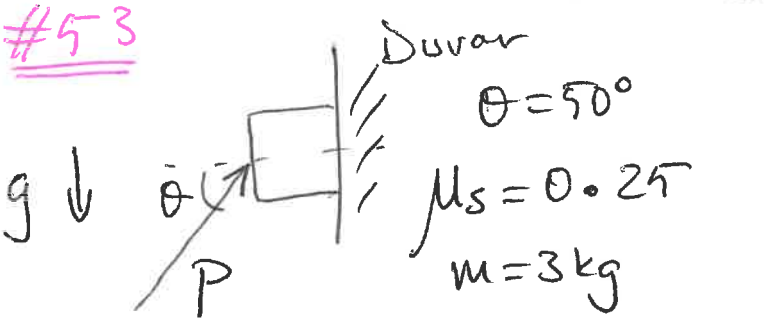
$N_2 - m_2 g = 0$

(1) + (2) $\Rightarrow$ $a = \dfrac{F}{m_1 + m_2}$

(1)'de yerine yaz $\Rightarrow$ $T = m_1 a$

$$T = m_1 \frac{F}{m_1 + m_2}$$

#53

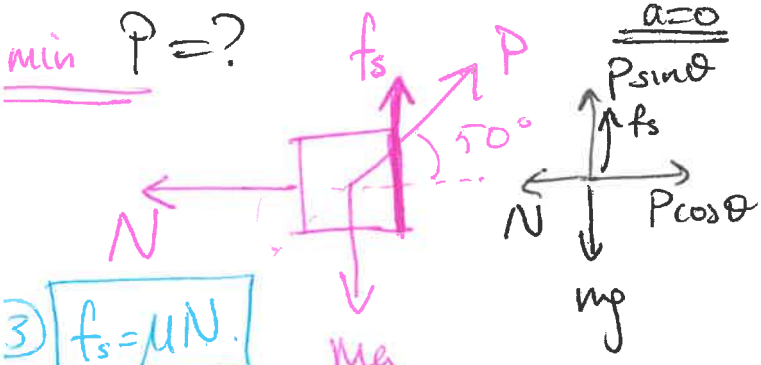


$\theta = 50°$

$\mu_s = 0.25$

$m = 3\,kg$

Cismin düşmemesi için min $P=?$

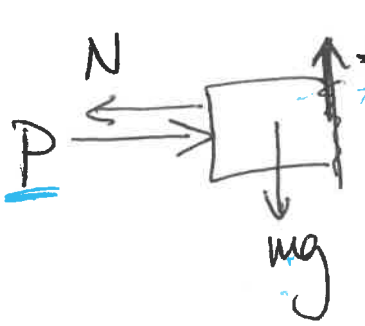


(3) $f_s = \mu N$

$\Sigma F_x = P\cos\theta - N = m a_x = 0$ (1)

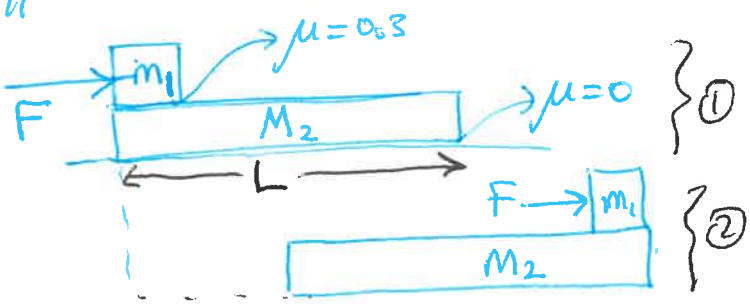
$\Sigma F_y = P\sin\theta + f_s - mg = 0$ (2)

(7)



sürt. yoksa bu cisim burada durmaz.

#65 μ_k var

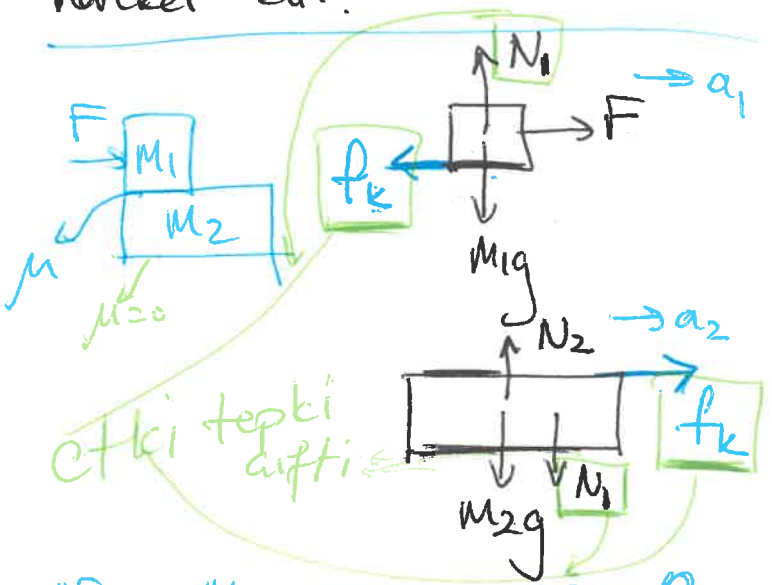


$m_1 = 2kg$, $m_2 = 8kg$; $F = 10N$

m_1 bloğu uzunluklu m_2 bloğu üzerinde 3 m hareket etmiş.

ⓐ ① durundan ② duruncaya geçen süre nedir?

ⓑ Bu süreçte 8 kg blok ne kadar hareket etti?



$\Sigma F_x = m_1 a$

$F - f_k = m_1 a_1$

$f_k = \mu N_1$; $N_1 = m_1 g$

$F - \mu m_1 g = m_1 a_1$

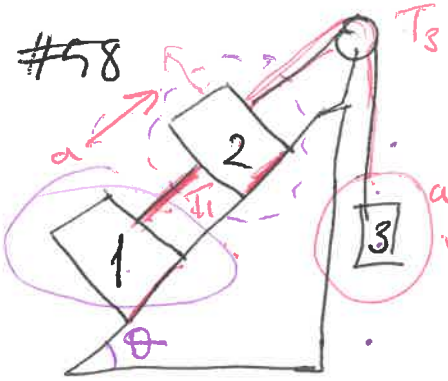
2 cisim için $\Sigma F_x = m_2 a_2$

$\Sigma F_y = 0$

$\mu m_1 g = f_k = m_2 a_2$

4.8.16

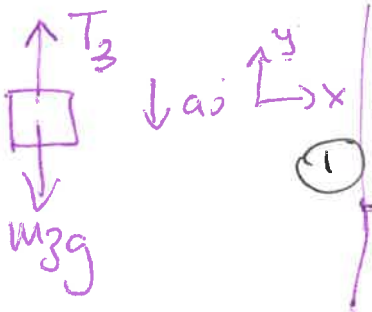
#58



sürtünmesiz

SCD

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



$F_y = m_3 a_y$

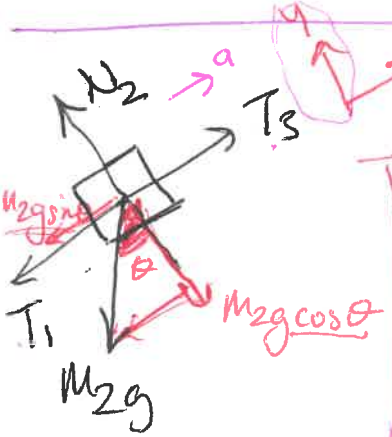
$T_3 - m_3 g = m_3(-a)$ ①

$\Sigma F_x = m_1 a_x$

$T_1 - m_1 g \sin\theta = m_1 a$ ②

$\Sigma F_y = m_1 a_y = 0$

$N_1 - m_1 g \cos\theta = 0$



$\Sigma F_x = m_2 a_x$

$T_3 - m_2 g \sin\theta - T_1 = m_2 a$ ③

$\Sigma F_y = m_2 a_y = 0$

$N_2 - m_2 g \cos\theta = 0$

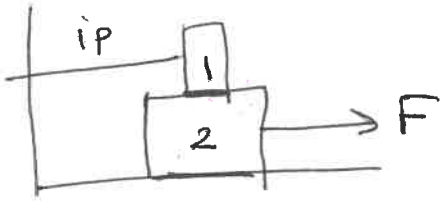
T_1, T_3, a çözebiliriz ③ denklem

①, ②, ③ kullan

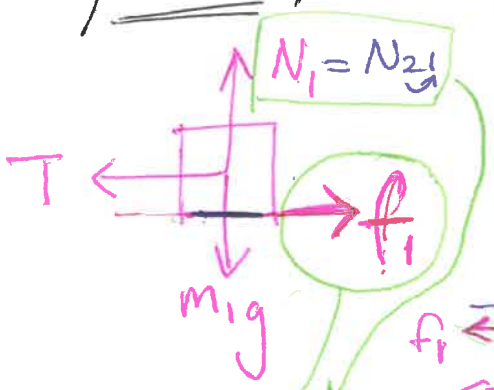
a için çöz

T_1, T_3 bulabiliriz

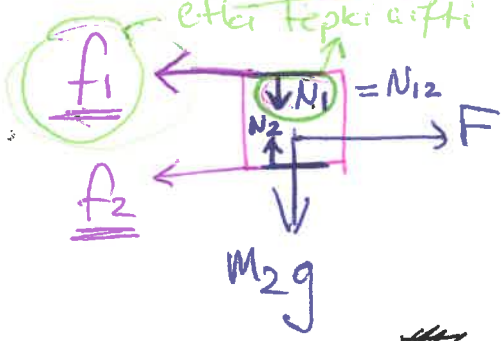
#68



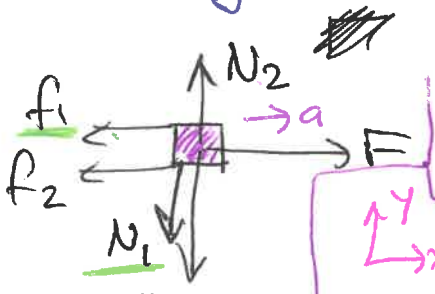
$\mu = 0.2$; bütün yüzeyler için.

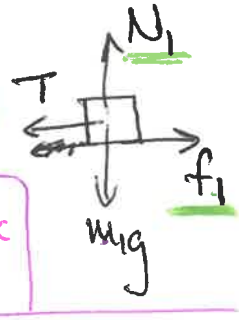


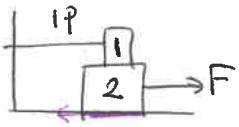
etki tepki çifti



$f = \mu N$







$\Sigma F_x = m_2 a$

$F - f_1 - f_2 = m_2 a$ ④

$\Sigma F_y = m_2 a_y = 0$

$N_2 - N_1 - m_2 g = 0$

$f_2 = \mu N_2$

$N_2 = m_1 g + m_2 g$

$f_2 = \mu g (m_1 + m_2)$ *

$f_1 = \mu g m_1$ *

① cisim için

$\Sigma F_x = m_1 a_x$

$f_1 - T = m_1 (0)$

1. cisim hareket etmez; ipten dolayı

$f_1 = T$

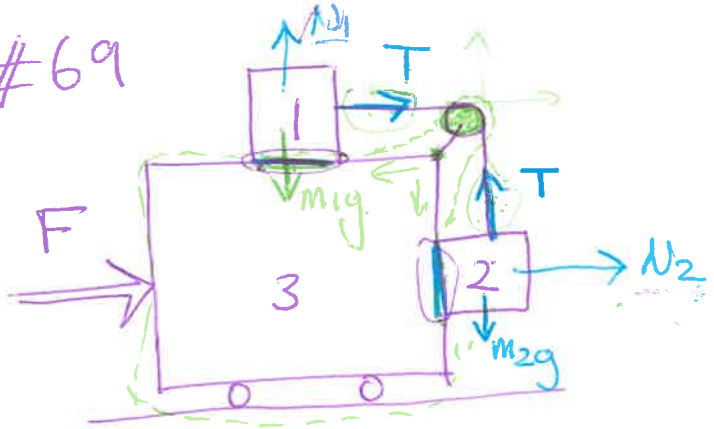
$\Sigma F_y = m_1 a_y = 0$

$N_1 - m_1 g = 0$

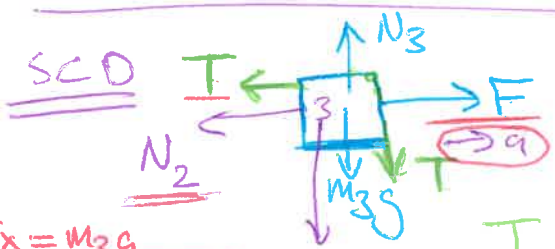
$N_1 = m_1 g$

$f_1 = \mu N_1 = T$

#69



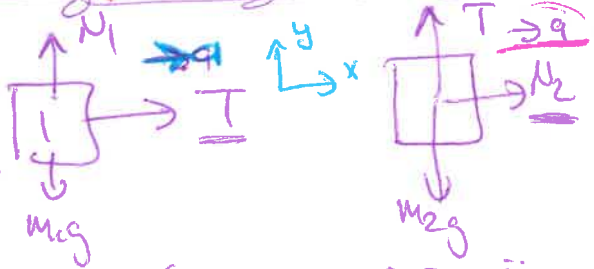
sürtünme yok; 1 ve 2 3'e göre hareketsiz kalıyor.



$\Sigma F_x = m_3 a$

$F - T - N_2 = m_3 a$ (1)

T gerilme makaradan dolayı tepki kuv.



1 ve 2. cisim (masaya göre) 3. göre hareketsiz kalıyor.

$\Sigma F_x = m_1 a_x$

$T = m_1 a$ (2)

$\Sigma F_y = m_1 a_y = 0$

$N_1 - m_1 g = 0$

$\Sigma F_x = m_2 a_x$

$N_2 = m_2 a$ (3)

$\Sigma F_y = m_2 a_y = 0$

$T - m_2 g = 0$

$F - T - N_2 = m_3 a$

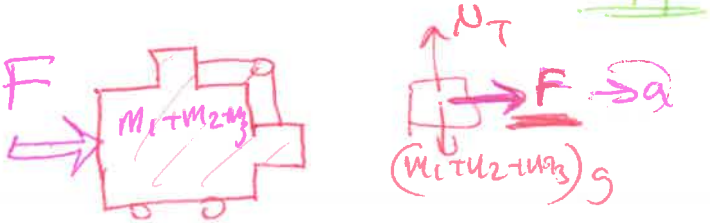
$T = m_1 a$

$N_2 = m_2 a$

+

$F = (m_1 + m_2 + m_3)\, a$

1 ve 2; 3 ile birlikte hareket etti



Dairesel Hareket ve Newton Kanunlarının Uygulaması

(2)

Dairesel Hareket:

DDH = $v = sbt$

Düzgün

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

merkezcil ivme (radyal) "

merkezcil ivme varsa;

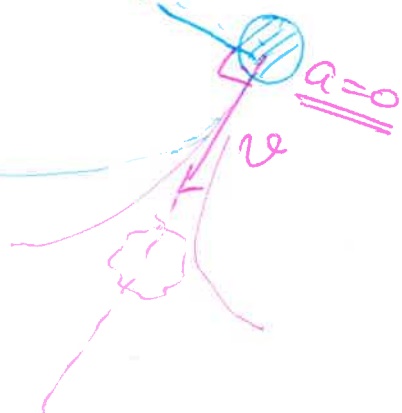
bu merkezcil bir kuvvetin sonucudur

$F \Rightarrow a_r$

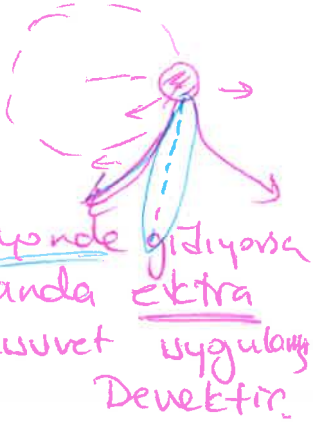
Bütün Dairesel Hareketlerde merkeze doğru net bir kuvvet VARDIR

$\vec{\Sigma F} = m\vec{a} \rightarrow a_r = \frac{v^2}{R}(-\hat{r})$

merkezcil



DDH için



kopttuğunda ekstra bir kuvvet uygulamış Denektir.

Sed

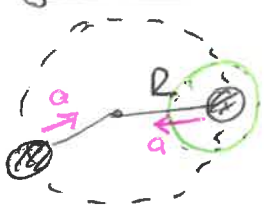
Dr) $m = 0.5\,kg$ top ipe bağlanıyor. $L = 1.5\,m$

Top ve ip yatayda sürtünmesiz masa üstünde döndürülüyor. DDH yapıyor $\Rightarrow v = sbt$

ip max 50N kuvvete dayanıyor. ip kopmadan önce topun ulaşacağı max hız nedir?

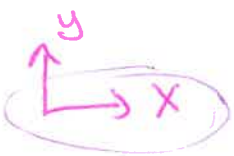
yukarıdan

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



SCD

yandan bakış



$\Sigma F_y = ma_y = 0$

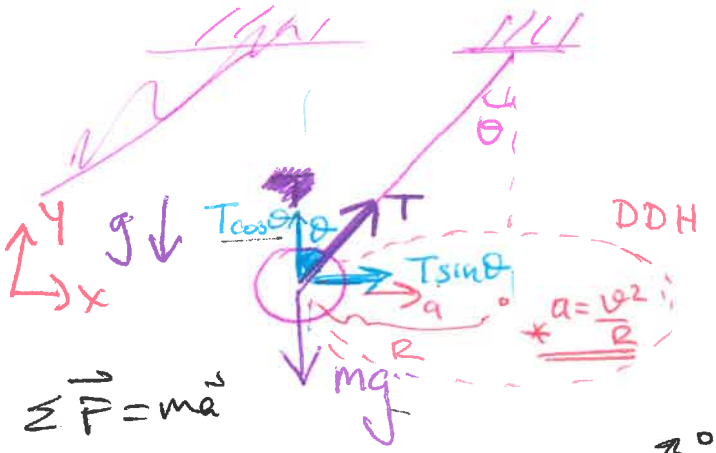
$N - mg = 0$

$\Sigma F_x = ma_x$

$-T = m\left(-\frac{v^2}{R}\right)$

$T = \frac{mv^2}{R}$; $50 = (0.5)\frac{v^2}{(1.5)}$

$v = 12.2\,m/s$ ~~$v = \sqrt{150}\,m/s$~~



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

$\Sigma F_x = ma_x$

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

$\Sigma F_y = ma_y = 0$

$T\cos\theta - mg = 0$

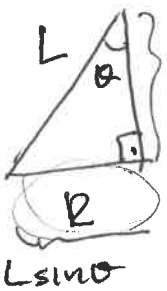
$T = \frac{mg}{\cos\theta}$

$T = \frac{mv^2}{R\sin\theta}$ ⟷ eşit

$\frac{mv^2}{R\sin\theta} = \frac{mg}{\cos\theta}$; $v = ?$

$v^2 = gR\sin\theta/\cos\theta$

L cinsinden olmalı

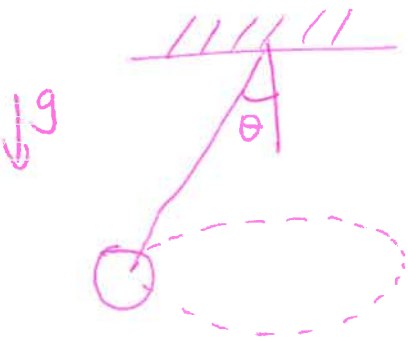


$R = L\sin\theta$

$v = \sqrt{gL\sin\theta\frac{\sin\theta}{\cos\theta}}$

$v = \sqrt{gL\sin\theta\tan\theta}$

Sr) Konik sarkaç

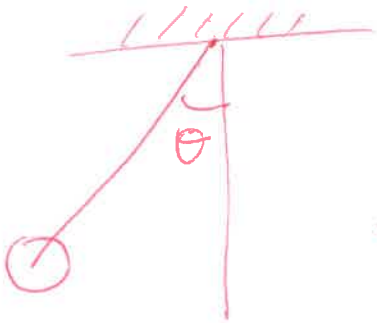


L = ip uzunluğu

DDH yapıyor.

$v = sbt$ dönüyor

v; L, g, θ cinsinden bulunuz

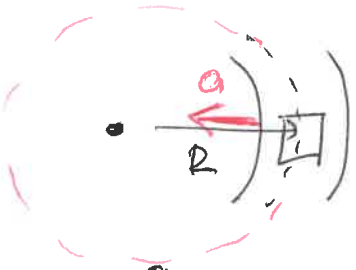


g; L ⇒ sbt

θ↑ ; v↑

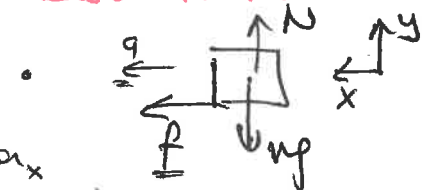
8.)

Düz yolda viraj dönen araba.



a_r = merkezcil merkeze doğru

arabayı viraj döndüren kuvvet tekerler-yol arasındaki sürtünme kuvvetidir. f = sürtünme



$\Sigma F_x = ma_x$

$$f = m\frac{v^2}{R} \quad (1)$$

$\Sigma F_y = ma_y = 0$

(2) $N - mg = 0$

$N = mg$

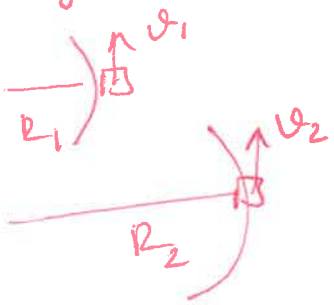
$f = \mu N$ (3)

$f = \mu mg$

$$\mu mg = m\frac{v^2}{R}$$

$$v^2 = \mu g R \; ; \; v_{max} = \sqrt{\mu g R}$$

$\mu, g \Rightarrow$ sbt R değişiyor.

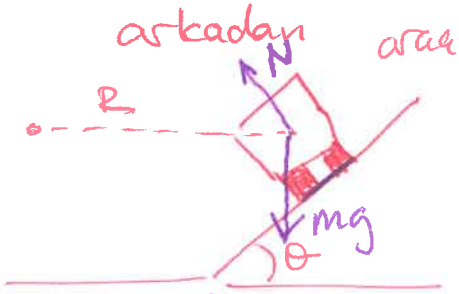


$R \uparrow$; $v \uparrow$

hızınız $v > \sqrt{\mu g R}$ araç kayar!!

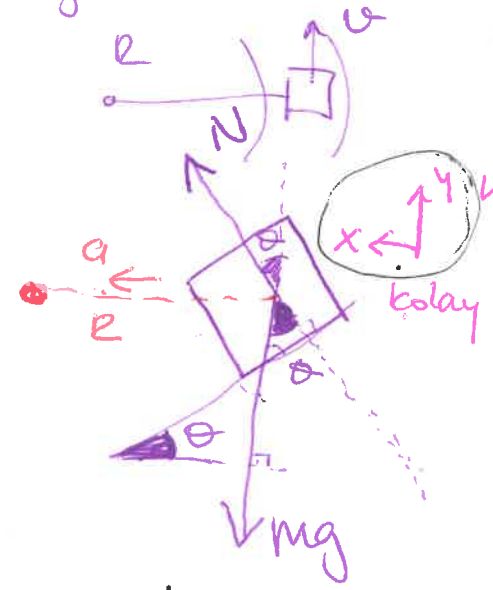
$R = 35\,m$, $\mu = 0.5$, $g = 9.8\,m/s^2$ $\Rightarrow$ $v_{max} = 13.1\,m/s$

Sürtünmesiz eğimli viraj (4)



araç sayfa düzlemi doğrultusunda hareket ediyor.

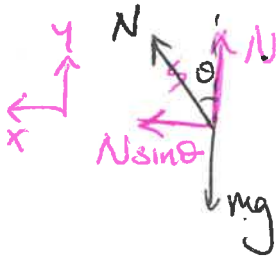
yukarıdan



Sürtünme yok

kolay

zor olmuş



$\Sigma F_y = ma_y = 0$

(1) $N\cos\theta - mg = 0$

$\Sigma F_x = ma_x$

(2) $N\sin\theta = m\frac{v^2}{R}$

(1) $N = \frac{mg}{\cos\theta}$;

$$\left(\frac{mg}{\cos\theta}\right)\sin\theta = m\frac{v^2}{R}$$

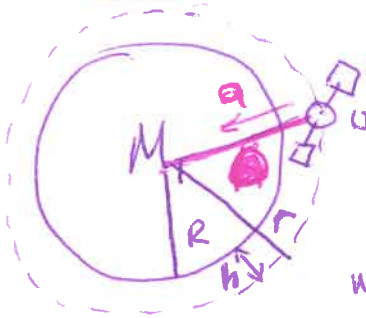
$$v^2 = gR\frac{\sin\theta}{\cos\theta} = gR\tan\theta$$

$$v_{max} = \sqrt{gR\tan\theta}$$

$\theta \uparrow$; $v \uparrow$

9. Uydu Hareketi

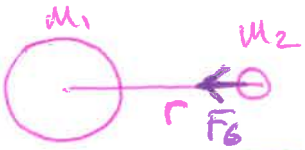
DDH



uydu, m_2 m_1'in merkezinden r kadar uzak

$$r = R + h$$

$$F_G = \text{kütle çekim kuvveti} = G\frac{m_1 m_2}{r^2}$$



$\Sigma F_x = m_2 a_x$

SCD

$F_G = m_2 a$

$$F_G = m_2\left(\frac{v^2}{r}\right)$$

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

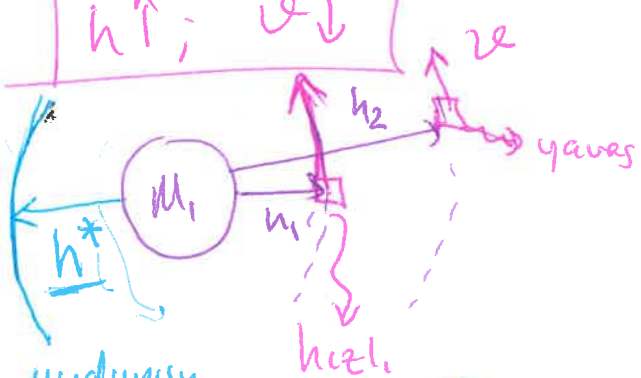
$$v^2 = G\frac{m_1}{r}; \quad v = \sqrt{G\frac{m_1}{r}}$$

$$v_{uydu} = \sqrt{G\frac{m_1}{R+h}}$$

değişiyor

Sbt

$h \uparrow$; $v \downarrow$

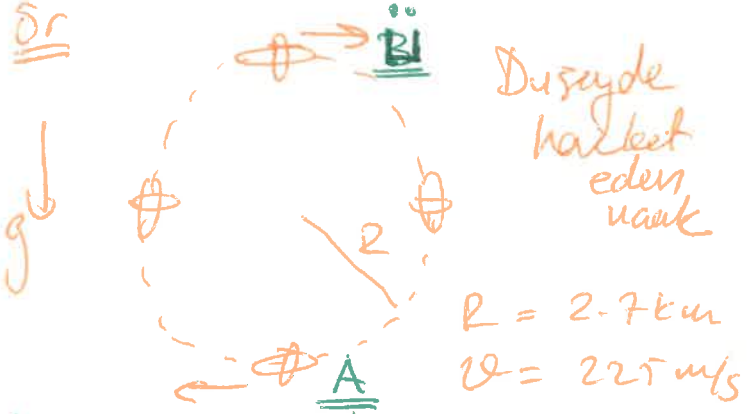


uydunun hızı dünyanın dönme hızı ile AYNI } karıştırılmaz

6-8-16

Dairesel Hareket ve SCİ

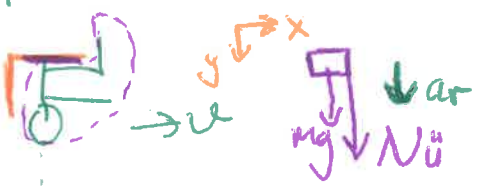
Ör



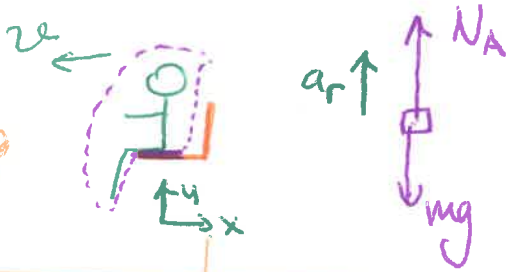
Koltuğun pilota uyguladığı kuvvet → aşağıda?
→ yukarıda?

Sonucu mg ağırlık cinsinden bulunuz.

Üstte



↓g



Aşağıda

AST

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

$F_y = ma_y$

$N_A - mg = ma_r$

$N_A - mg = m\frac{v^2}{R}$

$N_A = m\frac{v^2}{R} + mg$

$N_A = m\left(\frac{v^2}{R} + g\right)$

$N_A = m(18.8 + 9.8)$

$N_A = m(28.6\ m/s^2)$

İST

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

$F_y = ma_y$

$N_ü + mg = ma_r$

$N_ü = m\frac{v^2}{R} - mg$

$N_ü = m\left(\frac{v^2}{R} - g\right)$

$v = 225\ m/s$

$R = 2700m$

$N_ü = m(18.8 - 9.8)$

$N_ü = m(9\ m/s^2)$

$N_A = mg\left(\frac{28.6\ m/s^2}{9.8}\right) = mg(2.9)$

Ağırlığının 3 katı kadar bir kuvvet uygular koltuk.

$N_ü = mg\left(\frac{9\ m/s^2}{9.8}\right) = mg(0.9)$

↳ Ağırlığı kadar bir kuvvet uy

DODH → hareket
→ dairesel
↓ ↳ olmayan
Düzgün

DDH

SBT = $|\vec{v}_1| = |\vec{v}_2| = v$

Sürat = SBT

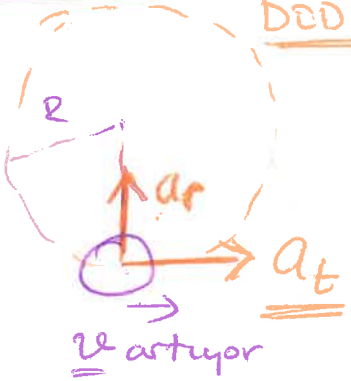
DOOH

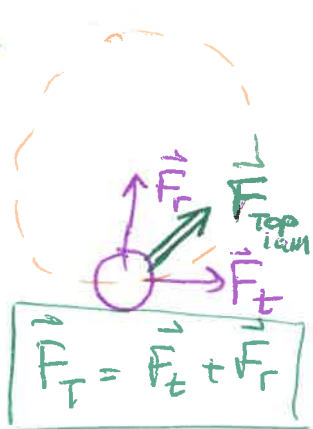
$= |\vec{v}_{i1}| \neq |\vec{v}_2|$

↳ değişiyor.

SÜRAT SBT DEĞİL

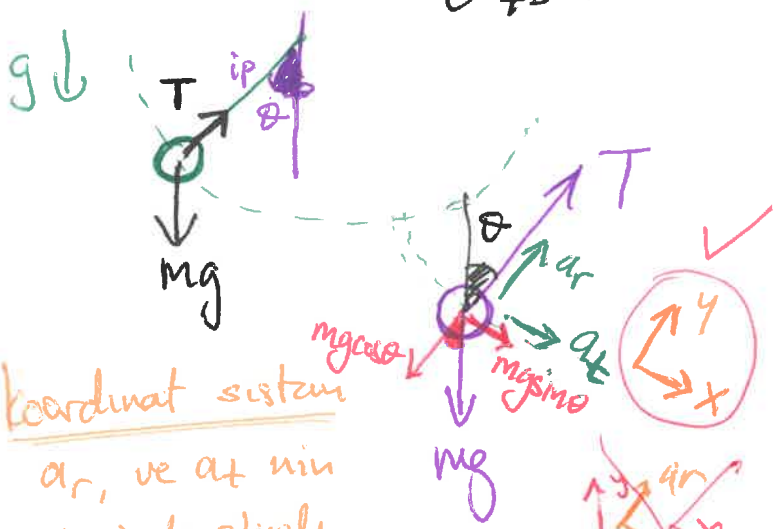
DOOH



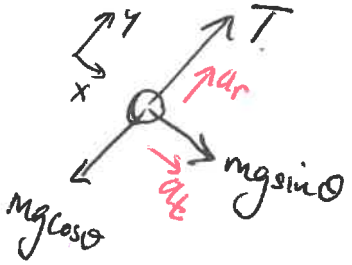


a) Düşeyde Dönen Top

$v \neq sbt$



Koordinat sistemi a_r ve a_t nin yönünde olmalı



$F_x = ma_x$

$mg\sin\theta = ma_t$

$a_t = g\sin\theta$

teğetsel ivme

$F_y = ma_y$

$T - mg\cos\theta = ma_r$

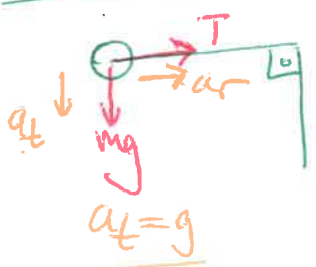
$a_r = \frac{v^2}{R}$

$$T = m\frac{v^2}{R} + mg\cos\theta$$

iplteki gerilme

a_t ; $\sin\theta = 1$; $\theta = 90$ iken

a_{max} $a_t = g$



$\theta = 90$ iken

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

$a_t = g$

ÜST $v_{üst} \neq v_{alt}$ ALT

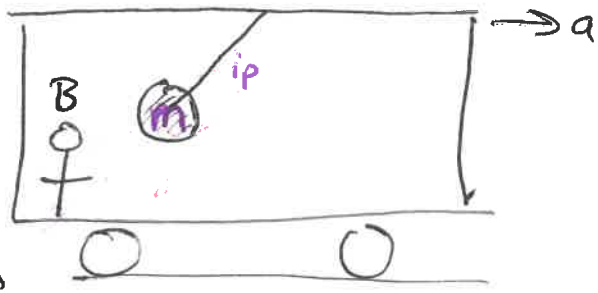
$\theta = 0$ derece

$a_t = 0$

İvmeli Sistemlerde Hareket (2)

Eylemsiz Referans Sistemi

→ gözlem / ölçüm yapacak kişinin ivmesi = SIFIR olmalı!

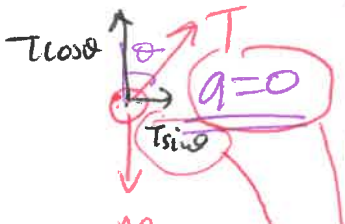


İvmesi = 0

B nin ivmesi a ölçüm/gözlem yapmalı

B'ye göre

SCD



$\Sigma F_y = ma_y^0$

$T\cos\theta - mg = 0$

$\Sigma F_x = ma_x$

$T\sin\theta = 0$?

Çelişki !!!

HAYALÎ KUVVET türetip; üçkağıt yapıyoruz

A'ya göre

SCD

$\Sigma F_y = ma_y^0$

$T\cos\theta - mg = 0$

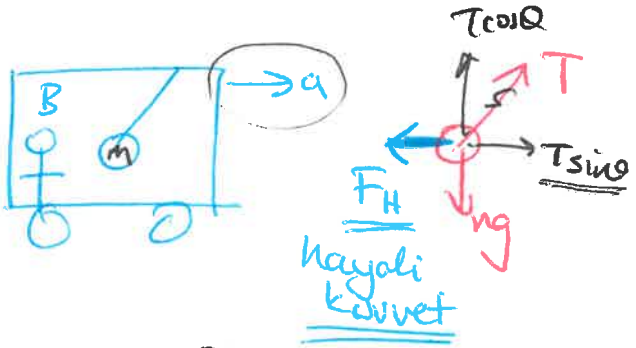
$\Sigma F_x = ma_x$

$T\sin\theta = ma$

$$T = \frac{mg}{\cos\theta}$$

$$mg\frac{\sin\theta}{\cos\theta} = ma$$

$$a = g\tan\theta$$



$\Sigma F_x = ma \to 0$

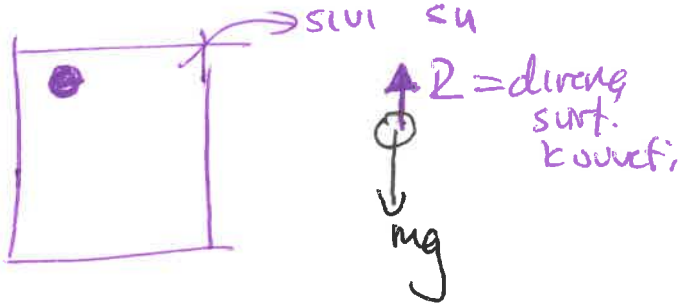
$T\sin\theta - F_H = 0 \quad ; \quad F_H = ma$

$F_H = ma$ hayali kuv. $\longleftrightarrow T\sin\theta$

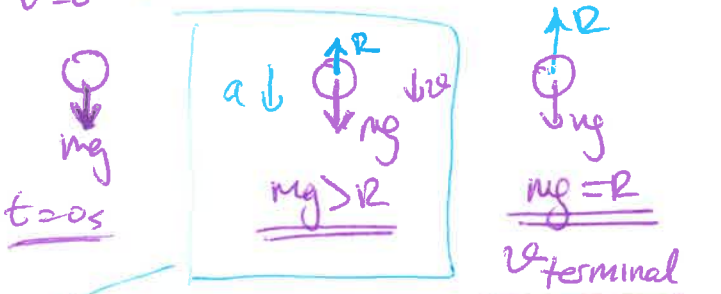
Bunu yapmayacaz. Hayali kuvvet kullanmayacağız !

Sürtünmeli Dirençli ortamlarda Hareket

(3)



R = hıza bağlı



$v_{terminal}$ son hız. $a=0$!!

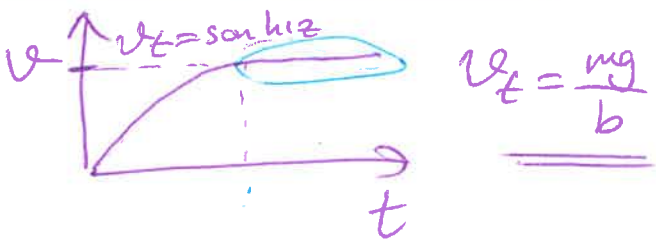
$R = bv$ ↳ hız ↳ sbt

$\Sigma F_y = ma_y \downarrow y$

$mg - bv = ma$

$mg - bv = m\frac{dv}{dt}$ } Diff. denk

$$v = \frac{mg}{b}\left(1 - e^{-\frac{b}{m}t}\right)$$



$v_t = \frac{mg}{b}$

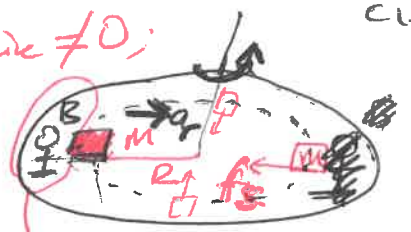
} Hız SBT; $a=0$

Normi $F = bv = mg$

ör Dairesel Hareket

Masa üzerinde dönen cisim.

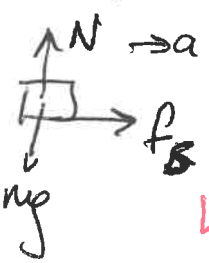
$F_{sürtünme} \neq 0$;



radyal, merkezcil ivme $\neq 0$

$a=0$

Aya göre ✓



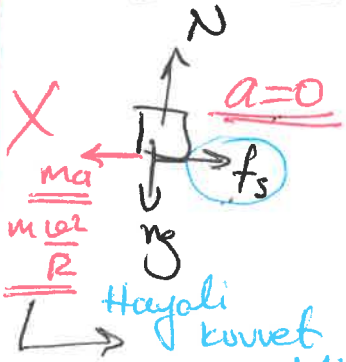
$\Sigma f_x = ma$

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

$\Sigma f_y = ma_y \to 0$

$N - mg = 0$

X B'ye göre



Hayali kuvvet gerekli

$\Sigma F_x = ma_x \to 0$

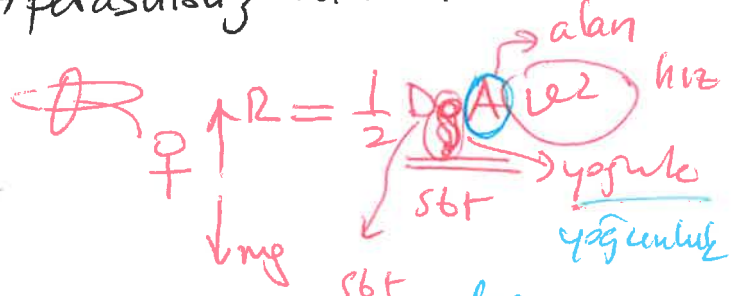
$f_s \overset{?}{=} 0$!!

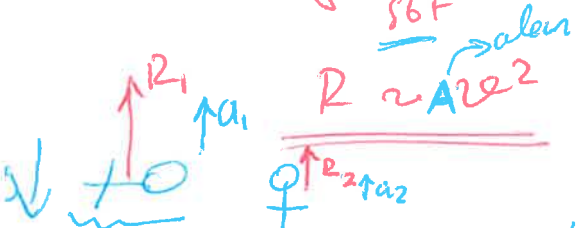
Hayali kuvvet kullanmayacağız

Yüksek Hızlarda Hava Direnci

→ otobandaki kmyon; tır.

→ paraşütsüz atlama





sbt

$R \sim A v^2$ (alan)

$A_1 > A_2$

$R_1 > R_2$

$v_1 < v_2$

Terminal (SON) Hız

$a = 0$ durum

$mg - R = ma$ ($a \to 0$)

$mg = R$ → maksimum düşüş hızı

$mg = b v_t$, $\frac{1}{2} D \rho A v_t^2$

Yağmur taneleri hızı sbt

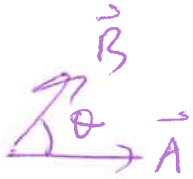
düşerken

---

1. Birimler; olacak...

3. vektörler → toplama, çıkarma, çarpma

$\vec{A} \cdot \vec{B}$ (İzdüşüm) , $\vec{A} \times \vec{B}$ (Dik vektör)



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

$\vec{A} \times \vec{B} = \vec{C} \Rightarrow$ vektörel "4."

Düzlem $|\vec{C}| = AB\sin\theta$

$\hat{i} \cdot \hat{i} = ? \; |\hat{i}||\hat{i}|\cos 0 = 1 \cdot 1 \cdot 1 = 1$

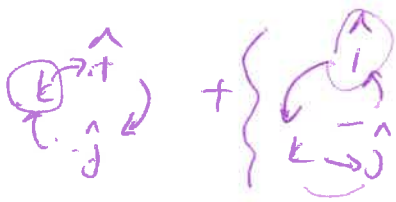
$\hat{j} \cdot \hat{j} = 1$; $\hat{i} \cdot \hat{k} = 1 \cdot 1 \cdot \cos 90^\circ = 0$

$\hat{i} \times \hat{i} \Rightarrow \sin 0^\circ = 0$

$\hat{i} \times \hat{j} = ? \; \hat{k}$

$\hat{j} \times \hat{k} = ? \; \hat{i}$

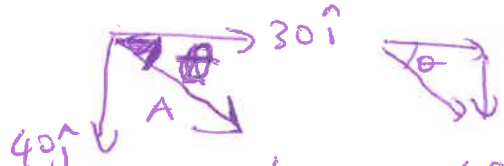
$\hat{k} \times \hat{j} = -\hat{i}$



yön — büyüklük

$\vec{A} = 30\hat{i} - 40\hat{j}$, $50 = \sqrt{30^2 + (-40)^2}$

yön → θ



$\tan\theta = \frac{-40}{30}$

hesap mak. ← Degree radyanla olmalı

$\theta = \tan^{-1}\left(\frac{-40}{30}\right)$

2-2. boyut Hareket

3 formül

① $v_s = v_i + at$; $a \overset{+}{\underset{-}{\rightarrow}}$

② $y_s = y_i + v_{yi}t + \frac{1}{2}a_y t^2$

v_{yi}, $a_y \rightarrow \overset{+}{-}$

③ zamansız hız denklemi

$a \overset{+}{\underset{-}{\rightarrow}}$

$v_s^2 = v_i^2 + 2a(y_s - y_i)$

Temel kavramlar

HIZ = ortalama hız = $\bar{v} = \frac{\Delta x}{\Delta t}$

$v = \frac{dx}{dt}$; $a = \frac{dv}{dt}$

türev

$x = At^3 + Bt^2$ ↓ türev

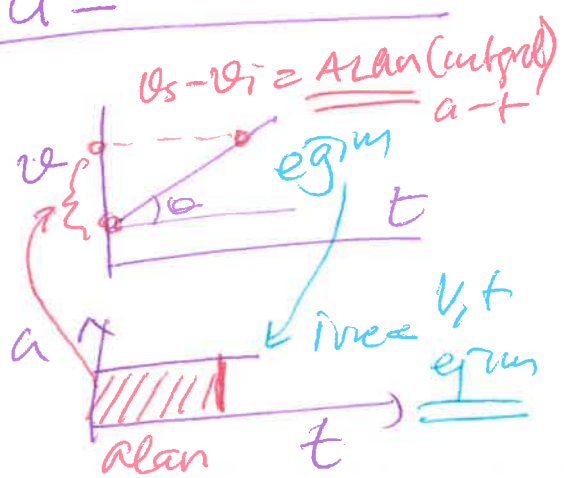
integral ↑ $v = ?$ $v = 3At^2 + 2Bt$

$a = 6At + 2B$

Grafik

$v_s - v_i$ = Alan (altında)

$a = \frac{dv}{dt}$ eğim



ATIŞLAR

Eğik Atış gelecek!!

$\vec{a} = \vec{a_x} + \vec{a_y} = -g$

v_i, θ_i veriliyor, $g = 9.8\ m/s^2$

→ ne kadar uzağa gider.
→ " yüksekte çıkar
→ " havada kalır

$v_i = 20\ m/s$; $\theta_i = 41°$

a) ne kadar havada kalır?

$v_s = v_i + at$ $(a = -g)$

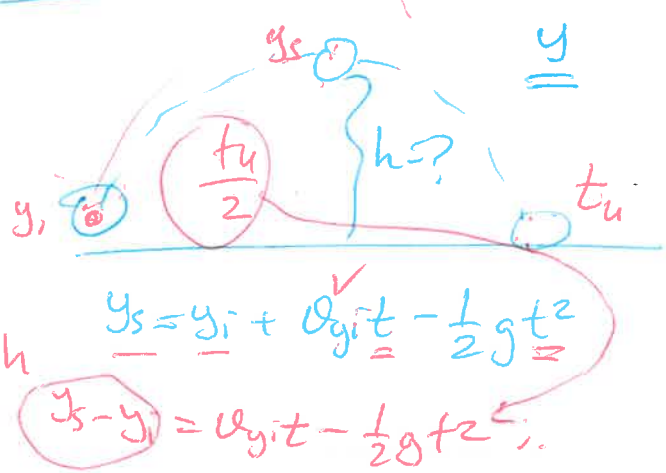
$|\vec{v}_{ys}| = |\vec{v}_{yi}|$ = büyüklük

$\vec{v}_{ys} = \vec{v}_{yi} - gt$

$-v_{yi} = v_{yi} - gt$; $v_{yi} = v_i \sin\theta$

$t = \frac{2v_{yi}}{g} = \frac{2 v_i \sin\theta}{g}$

$t_{uçuş} = \frac{2(20)(\sin 41°)}{9.8}$ s



$y_s = y_i + v_{yi}t - \frac{1}{2}gt^2$

$y_s - y_i = v_{yi}t - \frac{1}{2}gt^2$;

zamansız hız denk.

$$v_{ys}^2 = v_{yi}^2 + 2(a)(y_s - y_i)$$

$$0 = v_{yi}^2 - 2gh$$

$$h = \frac{v_{yi}^2}{2g} = \frac{(v_i \sin\theta)^2}{2g}$$

---

ne kadar uzağa düşer?

tuvaş bilmem lazım

$$X = v_{xi}(t_{uçuş})$$

$$= v_{xi}\frac{2v_{yi}}{g}$$

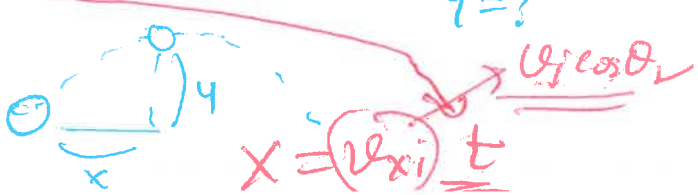
$$X = \left(v_i\cos\theta \; \frac{2v_i\sin\theta}{g}\right) x$$

---

* $v_s = v_i + at$
* $y_s = y_i + v_{yi}t + \frac{1}{2}at^2$
* $v_s^2 = v_i^2 + 2a(y_s - y_i)$

⇒ $v_i = 20$ m/s $\theta = 45°$

$t = 3$s; konumu? $X = ?$ $y = ?$



$X = (v_{xi})\,t$

$$X = 20(\cos 45°)(3)$$

$$y_s = y_i + v_{yi}t + \frac{1}{2}at^2$$

$$y_s = 0 + (v_i\sin\theta)t - \frac{1}{2}gt^2$$

$$y_s = 20(\sin 45°)(3) - \frac{9.8}{2}(3)^2$$

→ örnek soruları tekrar et.

→ 5 tane ~~soru~~ soru çöz

Newton Kanunları

→ eylemsizlik
→ kütle

$\vec{F} = m\vec{a}$ (2. kanun)

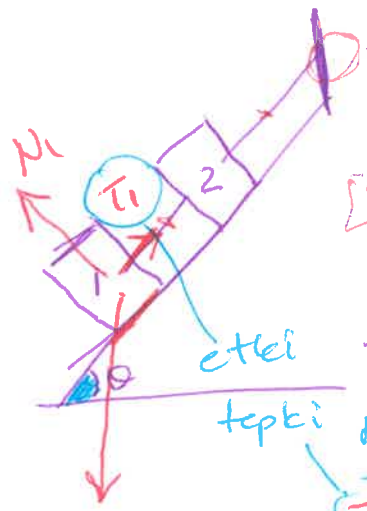
SCD *** ; sürtünme kuvveti

↳ mg yerçekimi

$f = \mu N$ → harekete ters

→ yüzey İTİBARİ dik | Normal kuvvet → $f = \mu N$

→ İP GERGİ



SCD ✓

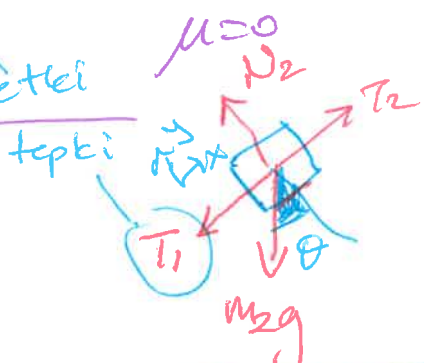
$\Sigma F_x = ma_x = 0$

$T_1 - mg\sin\theta = 0$

$T_1 = mg\sin\theta$

$N_1 - mg\cos\theta = 0$

değerde ↓ $a = 0$



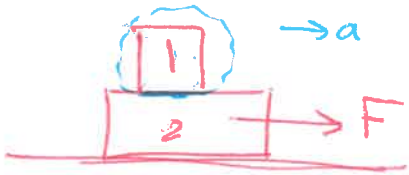
$F_x = ma_x = 0$

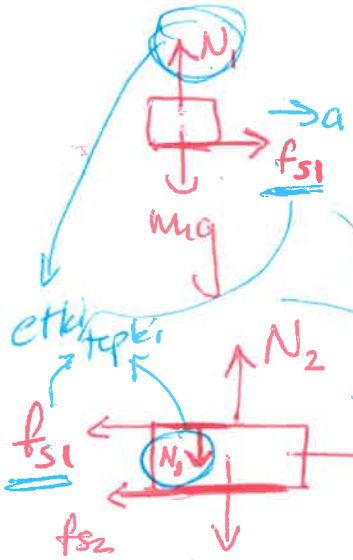
$T_2 - T_1 - m_2 g\sin\theta = 0$

$N_2 - m_2 g\cos\theta = 0$

1 cisim kaymadan 2 cisim üzerinde bir. hareket ediyor

$\mu > 0$





f_{s1} eylemsizlik kuvveti

1 cismi hareket ettiren kuvvettir.

$\mu N_1 = f_{s1} = m_1 a$

$F_x = m_2 a_x$

$F - f_{s1} - f_{s2} = m_2 a$

$F - m_1 a - f_{s2} = m_2 a$

$F - f_{s2} = (m_1 + m_2)a$

$\Sigma F_y = m_2 a_y = 0$

$N_2 - N_1 - m_2 g = 0$

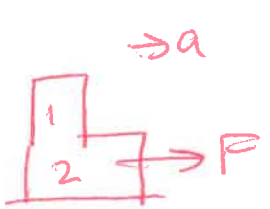
$N_2 = (m_1 + m_2)g$

$f_{s2} = \mu N_2$

$F - \mu N_2 = (m_1 + m_2)g$

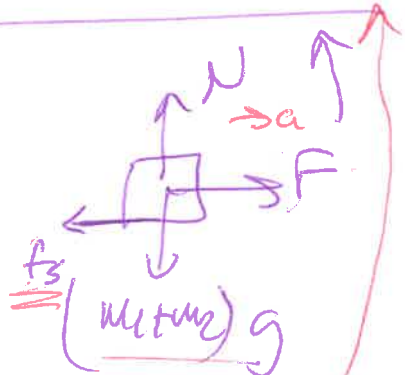
$F - \mu(m_1 + m_2)g = (m_1 + m_2)a$

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



$f_s = \mu N$

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

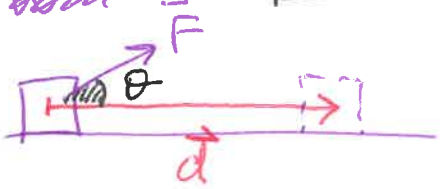


11.8.16

İş ve Kinetik Enerji

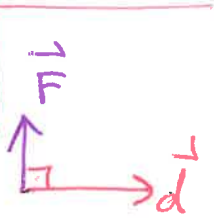
İş = Work

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



;

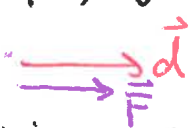
$$W = Fd\cos\theta$$



$\cos\theta = 0$; $\theta = 90°$

F kuvvetinin yaptığı iş $W = 0$

$\cos\theta = 1$; $\theta = 0°$



$W = Fd$

F kuvvetinin yaptığı iş maksimum.

$\cos\theta = -1$; $\theta = 180°$

; $W = -Fd$

F kuvveti negatif bir iş yapmıştır

W; iş enerji aktarımıdır.

→ eğer cisme (sisteme) enerji aktarılırsa; $W > 0$

→ eğer cisimden (sistemden) enerji aktarılırsa; $W < 0$

W Birimi = Joule

$$W = Fd$$

$$[J = N\,m]$$

Fizik 2'de $W = q\,\Delta V$

$$[J = C\,V] = \frac{C^2}{F} \cdots$$

(1)

$$W = Fd$$

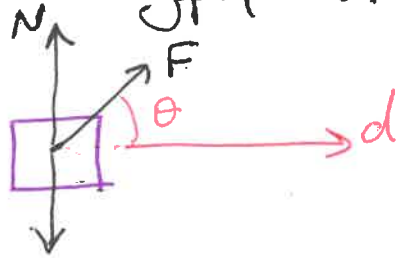
$$[J = N\,m] \quad ; F = ma$$

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

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

Or)

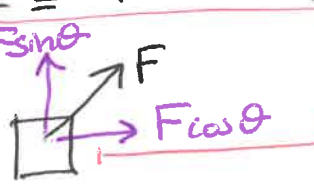
SCD çizimi; bütün kuvvetlerin yaptığı iş?



$$W_N = \vec{N} \cdot \vec{d} = Nd\cos 90° = 0$$

$$W_{mg} = m\vec{g} \cdot \vec{d} = mgd\cos 90° = 0$$

$$W_F = \vec{F} \cdot \vec{d} = Fd\cos\theta \checkmark$$



$\hat{j} \cdot \hat{i} = 0$

$$W_F = \vec{F} \cdot \vec{d} = (F\cos\theta\,\hat{i} + F\sin\theta\,\hat{j}) \cdot d\,\hat{i}$$

$\hat{i} \cdot \hat{i} = 1$

$$W_F = Fd\cos\theta \checkmark$$

Or)

$$\vec{F} = (5\hat{i} + 2\hat{j})\,N$$

$$\vec{d} = (2\hat{i} + 3\hat{j})\,m$$

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

$\hat{j} \cdot \hat{j} = 1$

$$(5\hat{i} + 2\hat{j}) \cdot (2\hat{i} + 3\hat{j})$$

$\hat{i} \cdot \hat{i} = 1$; $\hat{i} \cdot \hat{j} = 0$

$$W = (5)(2) + (2)(3) = 16\,J$$

8r) devamı

$\vec{F}$ ve $\vec{d}$ arasındaki açı?

$W = \vec{F}\cdot\vec{d} = F\,d\cos\theta$

$16 = (?)(?)\cos\theta$

$|\vec{F}| = F = \sqrt{5^2+2^2} = \sqrt{29}$

$|\vec{d}| = d = \sqrt{2^2+3^2} = \sqrt{13}$

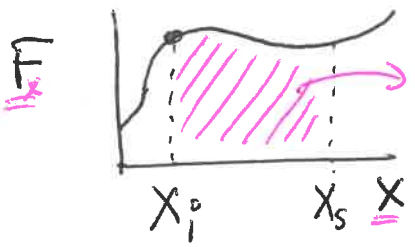
$16 = \sqrt{29}\sqrt{13}\cos\theta$

$\cos\theta = \dfrac{16}{\sqrt{29}\sqrt{13}}$

$\theta = \cos^{-1}\left(\dfrac{16}{\sqrt{29}\sqrt{13}}\right)$

$\theta = 35^\circ$

DEĞİŞKEN bir KUVVETİN YAPTIĞI İŞ



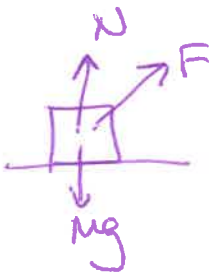
$W = \int_{x_i}^{x_s} F_x\,dx$

$F_x\,dx \Rightarrow$ dx'e izdüşüm yapmış F_x

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

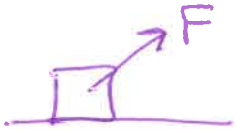
F_x

W_{Net} = yapılan toplam iş = F_{net} kuvvetin yaptığı iş.

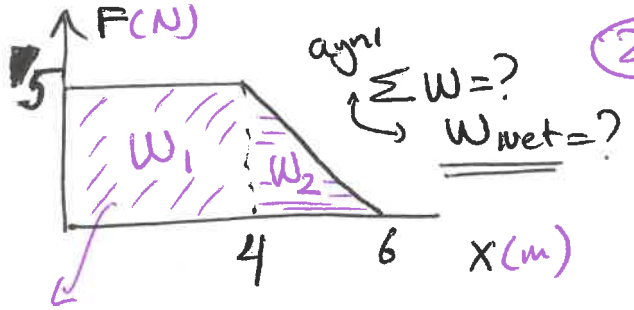


$\vec{F}_{Net} = \Sigma\vec{F} = \vec{N} + \vec{mg} + \vec{F}$

(+) (−)



8r)



aynı

$\Sigma W = ?$

$W_{net} = ?$

(2)

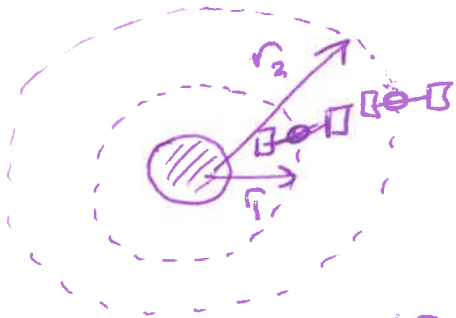
$W_1 = (5)(4)\ J = 20\ J$

$W_2 = (5)(2)\left(\frac{1}{2}\right) = 5\ J$

$25\ J$

$W_{Net} = W_1 + W_2 = 25\ J$

8r)

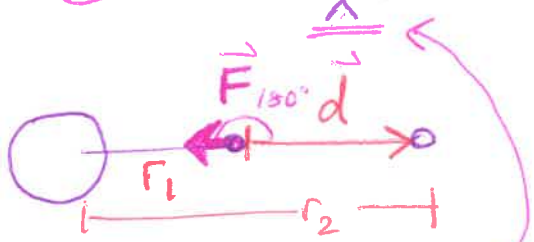


araştırma uydusu $r_1 = 1.5\times10^{11}$ m de

$r_2 = 2.3\times10^{11}$ m uzaklığına gidiş

Gezegenin uydu üzerinde yaptığı iş

$F = \ominus 1.3\times10^{22}\dfrac{1}{x^2}$; $W = ?$



F sbt değil; x'e bağlı

$W = \int_{x_1}^{x_2} F\,dx = -1.3\times10^{22}\int_{x_1}^{x_2}\dfrac{dx}{x^2}$

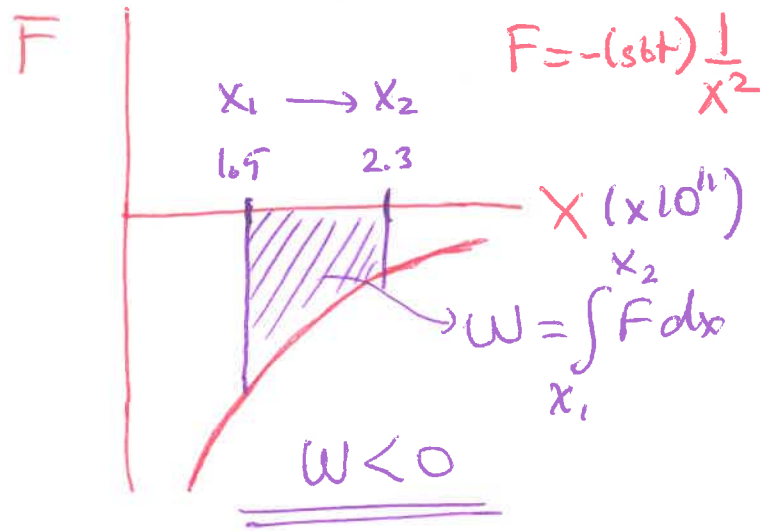
$\int \frac{dx}{x^2} = \int x^{-2}\,dx = \frac{x^{-1}}{-1} = -\frac{1}{x}$

$W = 1.3\times10^{22}\left[\dfrac{1}{x}\right]_{x_1}^{x_2}$

$d(x^{-1}) = -x^{-2}(1)$

$= 1.3\times10^{22}\left[\dfrac{1}{2.3\times10^{11}} - \dfrac{1}{1.5\times10^{11}}\right]$ $= \frac{1}{x^2}$

$W = -3\times10^{10}\ J$

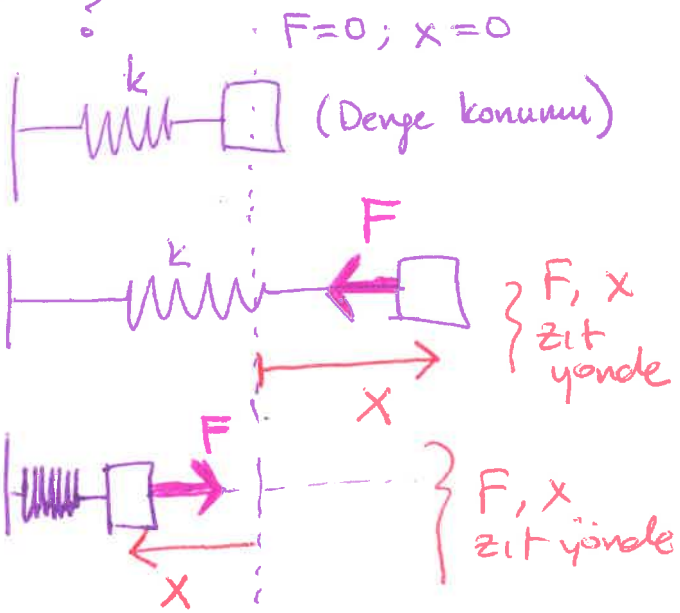


Bir YAYın Yaptığı İş

$F_s = F_{yay} = -kx$

s: spring; sbt; x: denge konumundan çekildiği uzunluk

$F_{yay} = -kx$?



$F=-kx$; (−) işareti F, x zıt yönde olduğunu gösterir.

$$W_y = \int_{x_1}^{x_2} F_y\,dx = \int_{-x_{max}}^{0} F_{yay}\,dx$$

yay $-x_{max}$ kadar sıkıştırılıyor

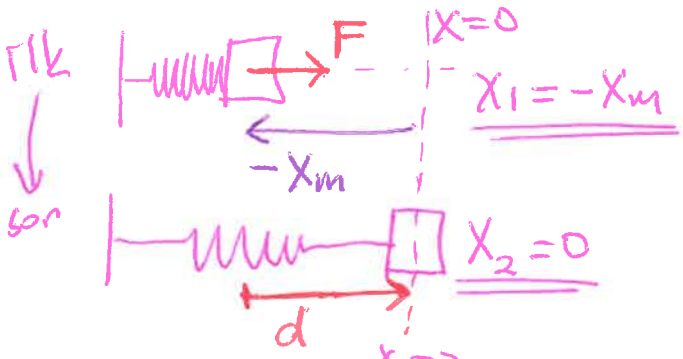
$x_2 = 0 \Rightarrow$ denge konumunda

$$W = \int_{-x_m}^{0} (-kx)\,dx$$

$$= \left[-\frac{kx^2}{2}\right]_{-x_m}^{0}$$

$$= -\frac{k0^2}{2} - \left(-\frac{k(-x_m)^2}{2}\right)$$

$$W = k\frac{x_m^2}{2} \quad ; \quad W>0$$



$$W=\int \vec{F}\cdot\vec{dx} = \int F_x\,dx\cos 0^\circ$$

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

F, d → $W>0$

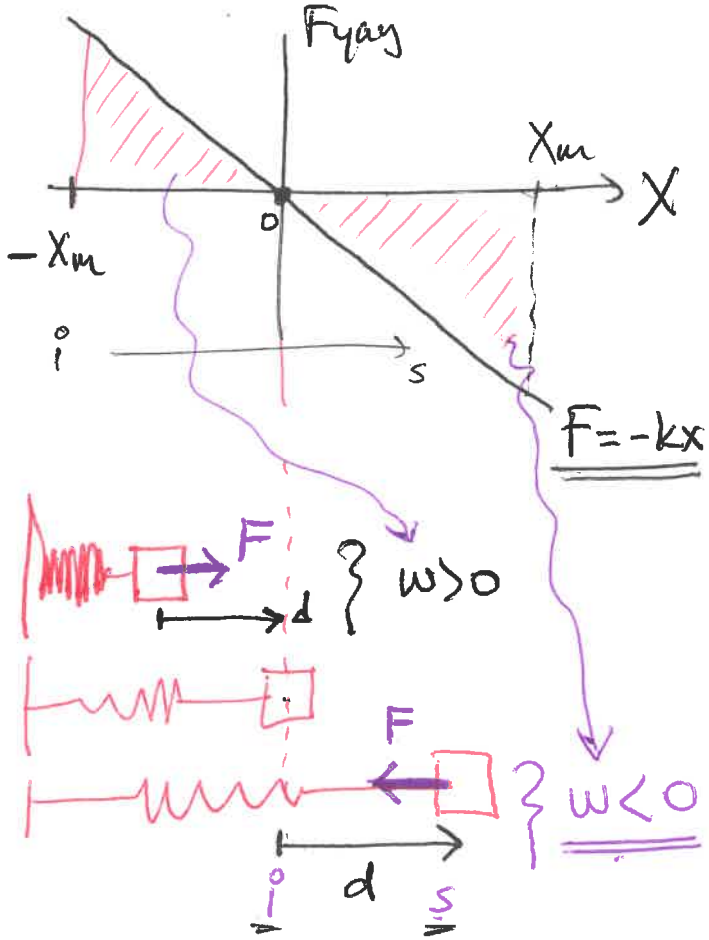
$$W_{yay} = \int_{x_1}^{x_2} (-kx)\,dx =$$

$$= \left[-k\frac{x^2}{2}\right]_{x_1}^{x_2}$$

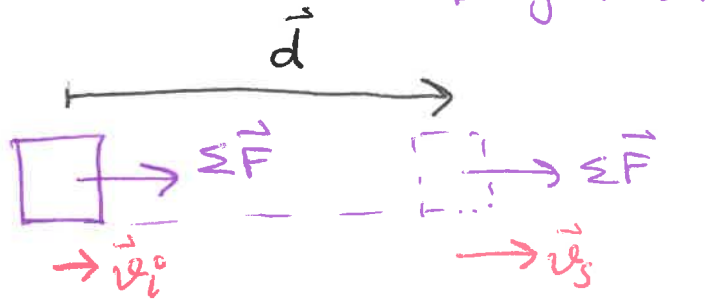
$$= -k\frac{x_2^2}{2} - \left(-k\frac{x_1^2}{2}\right)$$

$$\boxed{W_{yay} = k\frac{x_1^2}{2} - k\frac{x_2^2}{2}}$$

1 (İlk) → 2 (Son)



Kinetik Enerji ve İş - Kinetik Enerji Teorisi



$\Sigma W = (\Sigma F)\, d \quad ; \cos\theta = 1$

$v_s = v_i + at$

$t = \dfrac{v_s - v_i}{a}$

$d = v_{ort}\, t$

$d = \left(\dfrac{v_i + v_s}{2}\right) t$

$d = \left(\dfrac{v_i + v_s}{2}\right)\left(\dfrac{v_s - v_i}{a}\right) = \dfrac{v_s^2 - v_i^2}{2a}$

$\Sigma W = (\Sigma F)\, d$

$\Sigma F = ma$

$\Sigma W = (ma)\, \dfrac{v_s^2 - v_i^2}{2a}$

$\Sigma W = \dfrac{m v_s^2}{2} - \dfrac{m v_i^2}{2}$

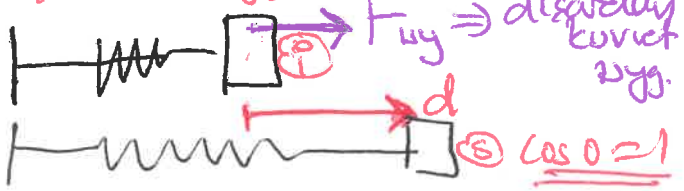
$KE \equiv \dfrac{mv^2}{2}$ (Tanım) — Kinetik enerji

Yapılan toplam iş, KE deki değişime eşittir.

$\Sigma W = \Delta KE = KE_s - KE_i$

---

a) Dışarıdan uyg. kuvvet



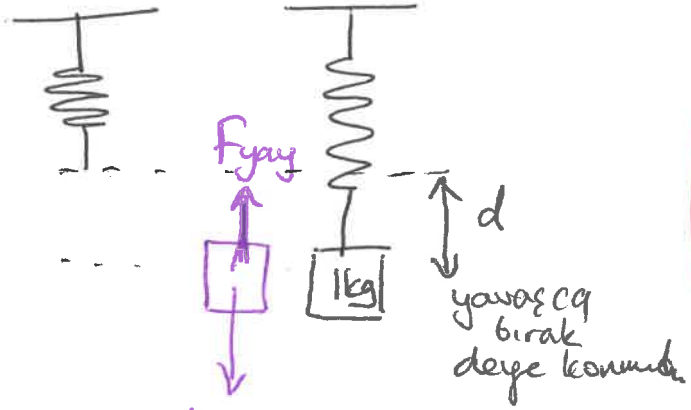
F_{uy} ⇒ dışarıdan kuvvet uyg.

① $\cos 0 = 1$

$W = ?$ $\quad W > 0 \quad W = \dfrac{kx^2}{2}$

---

b) yay sabit nasıl ölçeriz?



$\Sigma \vec{F} = 0$

$\vec{a} = 0$

$F_{yay} - mg = mg$

$kd - mg = 0$

$k = \dfrac{mg}{d}$

$$\Sigma W = \int_{x_i}^{x_s} (\Sigma F_x)\, dx$$ II. YOL

$\Sigma F_x = ma_x$

$$a = \frac{dv}{dt} = \frac{dv}{dx}\frac{dx}{dt}$$

$$\Sigma W = \int_{x_i}^{x_s} m \frac{dv}{dx}\frac{dx}{dt}\,dx$$

$v = \frac{dx}{dt}$

$$\Sigma W = \int_{v_i}^{v_s} m v\, dv$$

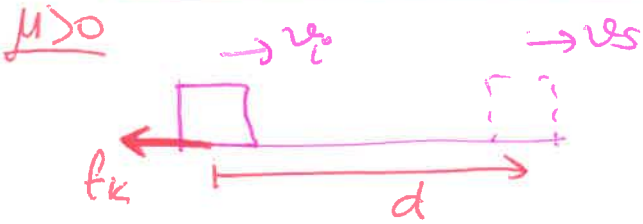
$$\Sigma W = \left[m\frac{v^2}{2} \right]_{v_i}^{v_s}$$

$$\Sigma W = m\frac{v_s^2}{2} - m\frac{v_i^2}{2} = \Delta KE$$

yapılan iş KE değişme eşittir

SÜRTÜNME kuvvetinin YAPTIĞI İŞ

$\mu > 0$



$$W_{fk} = \vec{f_k} \cdot \vec{d} = f_k d \cos 180 \quad (-1)$$

$$W_{fk} = -f_k d$$

sürtünme kuvveti gidilen yola ters!

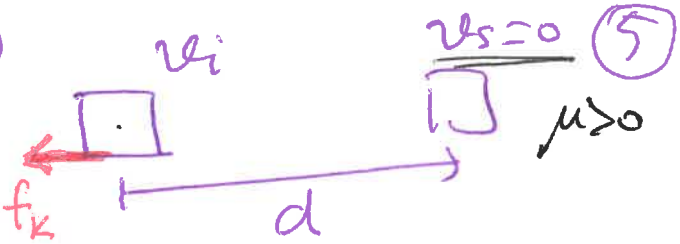
$W_{fk} < 0$!

sizden enerji çalar.

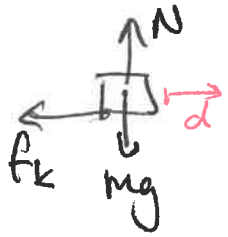
f_k: kinetik sürt kuvveti

* f_s: statik sürt kuv; f_s İŞ yapmaz

or)



$\Sigma W = \Delta KE$ ✓



$\Sigma W = W_{fk} + W_{mg} + W_N$

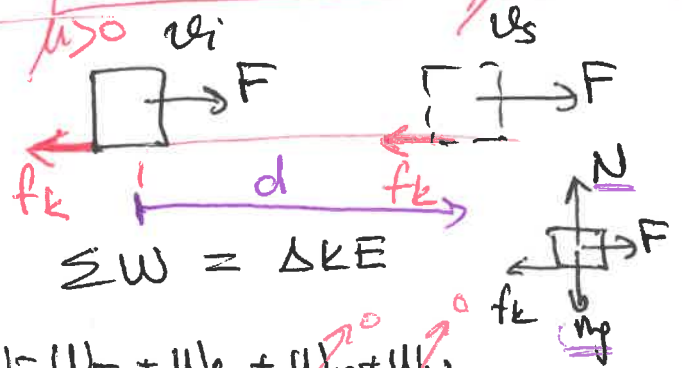
$\Sigma W = W_{fk} = -f_k d = \Delta KE$

$$-f_k d = \frac{1}{2} m v_s^2 - \frac{1}{2} m v_i^2$$

$$-f_k d = -\frac{1}{2} m v_i^2$$

$$v_i = \sqrt{\frac{2 f_k d}{m}}$$

or)



$\Sigma W = \Delta KE$

$\Sigma W = W_F + W_{fk} + W_{mg} + W_N$

$$W_F + W_{fk} = \frac{1}{2} m v_s^2 - \frac{1}{2} m v_i^2$$

$$\vec{F}\cdot\vec{d} + \vec{f_k}\cdot\vec{d} = \frac{1}{2} m v_s^2 - \frac{1}{2} m v_i^2$$

$\cos 0 = 1$ $\cos 180 = -1$

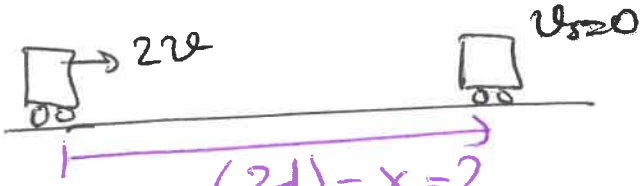
$$+Fd - f_k d = \frac{1}{2} m v_s^2 - \frac{1}{2} m v_i^2$$

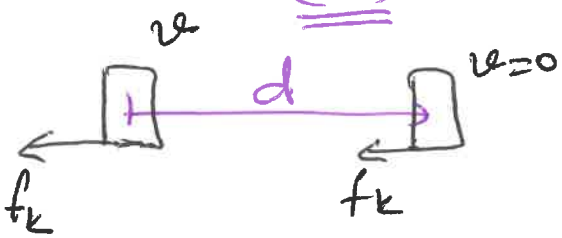
$f_k = \mu N = \mu mg$

Δ = Son − İlk; $\Delta KE = \frac{1}{2} m v_s^2 - \frac{1}{2} m v_i^2$

Ör)

Frene yapıyor ve duruyor.





$$W_{f_k} = \Delta KE$$

$$-f_k d = \frac{1}{2}m0^2 - \frac{1}{2}mv^2$$

$$\boxed{f_k d = \frac{mv^2}{2}}$$

$$W_{f_k} = \Delta KE$$

$$-f_k X = \frac{1}{2}m0^2 - \frac{1}{2}m(2v)^2$$

$$\boxed{f_k X = 4\left(\frac{1}{2}mv^2\right)}$$

$f_k d$

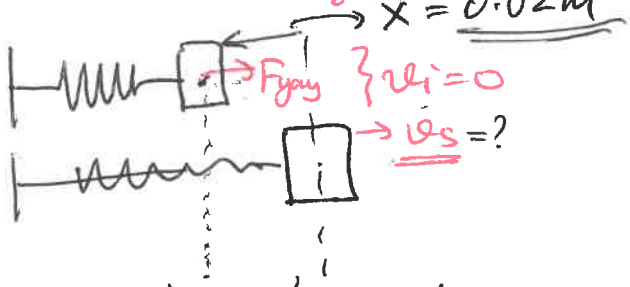
$$f_k X = 4 f_k d$$

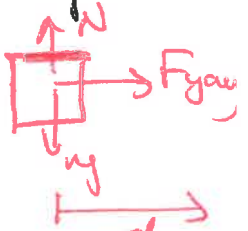
$$\boxed{X = 4d}$$

Ör) $k = 10^3 \frac{N}{m}$; $M = 1.6\ kg$

yay 2cm sıkıştırılıyor ve blok ilk hızsız yatayda hareket ediyor.

a) $\mu = 0$; $x = 0$ denge konumuda geçebilmesi için hızı?





$$\Sigma W = \Delta KE$$

$$W_{mg} + W_N + W_{yay} = \Delta KE$$

$$\left[-\frac{1}{2}kx^2\right]_{x_i}^{x_s} = \left[\frac{1}{2}mv^2\right]_{v_i}^{v_s}$$

$x_i = -0.02m$; $v_i = 0$

$x_s = 0.m$; $v_s = ?$

$$-\frac{1}{2}k x_s^2 + \frac{1}{2}k x_i^2 = \frac{1}{2}m v_s^2 - \frac{1}{2}m v_i^2$$

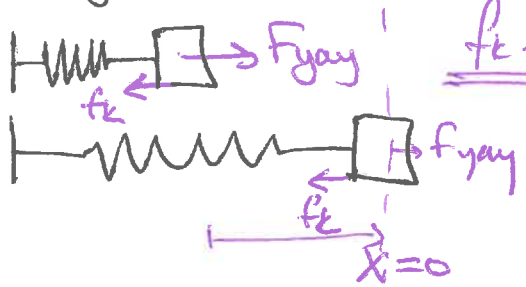
$$\int_{x_i}^{x_s}(-kx)\,dx = \left[-\frac{kx^2}{2}\right]_{x_i}^{x_s}$$

$$\frac{1}{2}k x_i^2 = \frac{1}{2}m v_s^2$$

$$(10^3)(0.02)^2 = (1.6)\,v_s^2$$

$$v_s = 0.5\ m/s$$

b) Bir önceki soruda $\mu > 0$ olsaydı son hız?



$f_k = 4N$

$\Sigma W = \Delta KE$

$W_{mg}^{0} + W_N^{0} + W_{F_{yay}} + W_{f_k} = \Delta KE$

$$\left[-\frac{1}{2}kx^2\right]_{x_i}^{x_s=0} - f_k x = \Delta KE$$

$$\frac{1}{2}kx_i^2 - f_k x = \frac{1}{2}mv_s^2 - \frac{1}{2}mv_i^{2\,0}$$

$$\frac{kx_i^2}{2} - f_k x = \frac{1}{2}mv_s^2$$

$$\frac{(10^3)(0.02)^2}{2} - (4)(0.02) = \frac{(1.6)v_s^2}{2}$$

$$v_s = 0.39\ m/s$$

sürtünme yokken ; $\mu = 0$

sürtünme varken $\mu > 0$

$v_s = 0.57\ m/s \longrightarrow v_s = 0.39\ m/s$

sürtünme enerji alıyor!!

GÜÇ

P = Güç = Power

$$\text{Güç} = \frac{\text{iş}}{\text{zaman}} = \frac{W}{\Delta t}$$

$$\bar{P} = \frac{W}{\Delta t} \quad \text{(ortalama güç)}$$

$$\text{Watt} \equiv \frac{\text{Joule}}{\text{sn}} \; ; \; \left[W = \frac{J}{s}\right]$$

Elektrikli aletlerde P güç belirtir.

Ani güç = $P = \frac{dW}{dt} = \frac{F \cdot dx}{dt}$ ve

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

kuvvet. hız

$$1\ \text{Watt} = 1\ \frac{J}{s} = \frac{kg\ m^2/s^2}{s}$$

$$1\ \text{Watt} = kg\ \frac{m^2}{s^3}$$

1 Beygir Gücü (Horse Power) = 746 W

$$\text{güç} = \frac{\text{iş} = \text{enerji}}{\text{zaman}} \; ;$$

enerji = (güç)(zaman)

= W s = Joule

pratikte enerji = (kW saat)

$1\ kW\,sa = 10^3\ W \cdot 3600\ s = 3.6 \times 10^6\ J$

15-8-16

Kinetik Enerji

$KE = \frac{1}{2} m v^2$

Yapılan net iş VARSA KE değişimi vardır

$\Sigma W > 0 \quad \Delta KE > 0$; CİSİM HIZLANMIŞ

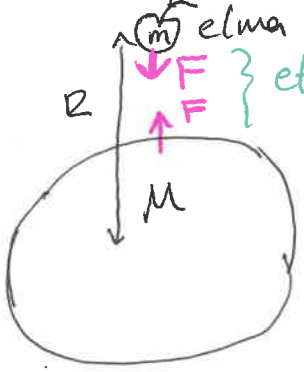
$\Sigma W < 0 \quad \Delta KE < 0$ YAVAŞLAMIŞ

$\Sigma W = \Delta KE$

Potansiyel Enerji ve Enerji Korunumu

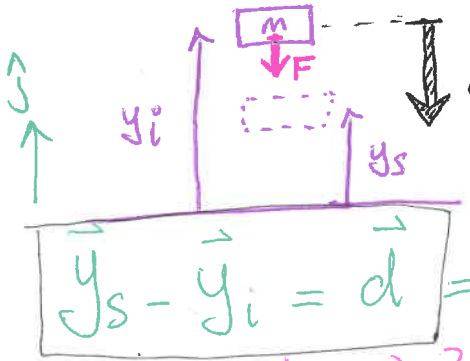
PE = potansiyel enerji $\equiv U$

Kütle çekim kuvvetinden dolayı.



efki tepki çiftleri

$F = G \frac{M_M}{R^2}$

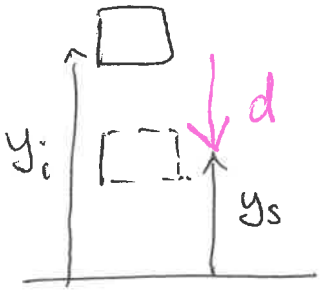


$\vec{y}_s - \vec{y}_i = \vec{d} = -d\hat{j}$

Yerçekiminin yaptığı iş?

$W_g = \vec{F} \cdot \vec{d} = Fd\cos 0 > 0$

$W_g > 0 \rightarrow = mg(-\hat{j}) \cdot d(-\hat{j})$



(1)

$\vec{y}_s - \vec{y}_i = \vec{d}$

$y_s\hat{j} - y_i\hat{j} = d(-\hat{j})$

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

$= mg(-\hat{j}) \cdot d(-\hat{j})$

$= mg(-\hat{j}) \cdot (y_s - y_i)\hat{j}$

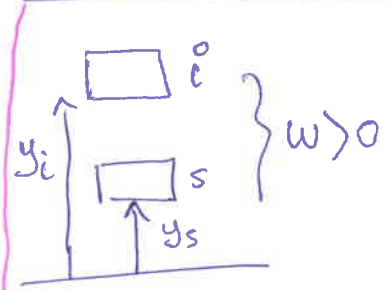
$\hat{j} \cdot \hat{j} = 1$

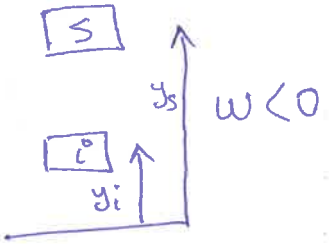
$= mg(y_s - y_i)(-1) = W > 0$

$(y_s - y_i)$ (−) (-1) (−)

$mg(y_i - y_s) = W$

$W_g = mgy_i - mgy_s$ yerçekiminin yaptığı iş





$W_g = U_i - U_s = -(U_s - U_i)$

$W_g = -\Delta U$ yerçekimin yaptığı iş potansiyel enerji değişiminin NEGATİFİNE EŞİT

$U \equiv mgy = PE$ potansiyel enerji

Yerçekim Pot. Enerjisi

Yayın Esneklik Pot. Enerjisi

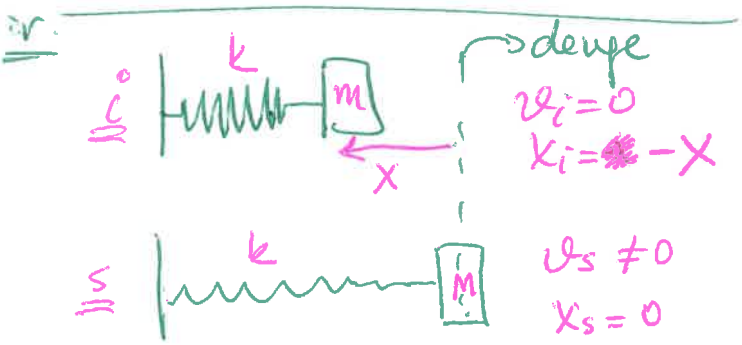
$$U_{yay} = \frac{1}{2} k x^2$$

x = sıkışma; esneme miktarı

Bir önceki dersten.

$$W_{yay} = \frac{1}{2} k x_i^2 - \frac{1}{2} k x_s^2$$

ilk — son



$$\Sigma W = \Delta KE$$

$$W_y = \Delta KE = -\Delta U_{yay}$$

$$\frac{1}{2} k x_i^2 - \frac{1}{2} k x_s^2 = -\Delta U_{yay}$$

$$U_i - U_s = -\Delta U$$

$$\Delta KE = \frac{1}{2} m v_s^2 - \frac{1}{2} m v_i^2 = \frac{1}{2} k (x_i^2 - x_s^2)$$

örneğimizde $v_i = 0$; $x_s = 0$

$$\frac{1}{2} m v_s^2 = \frac{1}{2} k x_i^2$$

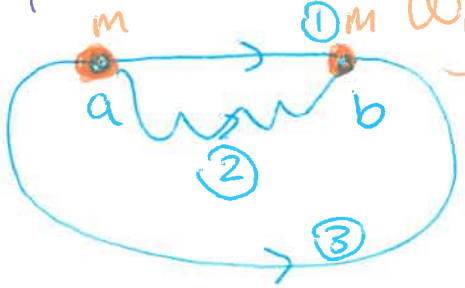
→ Enerji korunumu — biraz sonra

Korunumlu ve Korunumsuz Kuvvetler

(2)

Korunumlu kuvvetler

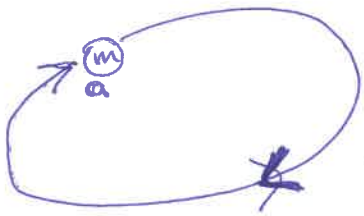
1- Bir kuvvetin herhangi iki nokta arasında hareket eden paraacık üzerinde yaptığı iş, paraacığın aldığı yoldan bağımsızdır.



$W_1 = W_2 = W_3$

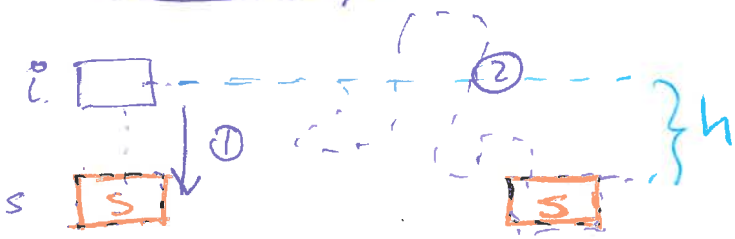
korunumlu kuvvet

2- Kapalı bir yol boyunca korunumlu kuvvetin paraacık üzerine yaptığı iş SIFIRDIR



a → a

$W_a = 0$!



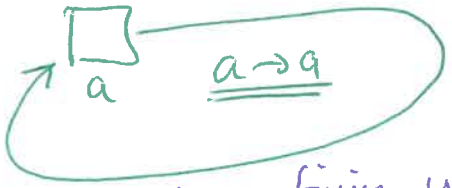
yerçekiminin yaptığı iş

$$W_1 = W_2$$

$$mgh = mgh$$

yerçekim kuvveti korunumlu bir kuvvettir.

Sürtünme kuvveti KORUNUMSUZ bir kuvvettir



$W_{sürt} \neq 0$

sürtünme kuvvetinin yaptığı İŞ ALINAN YOLA BAĞLIDIR.

Korunumlu kuvvetlerin başka bir özelliği de;

- yerçekim
- yay kuvveti

$$W_{KLN} = U_i - U_s$$

korunumlu $= -\Delta U$

MEKANİK Enerji

Pot + kin $\quad E \equiv K + U$

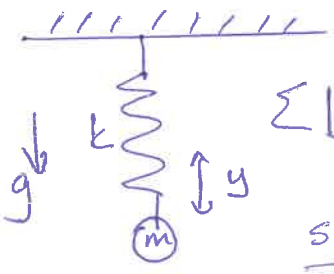
mekanik enerji korunmuş ise

$$E_i = E_s$$

$$K_i + U_i = K_s + U_s$$

Enerji korunumu

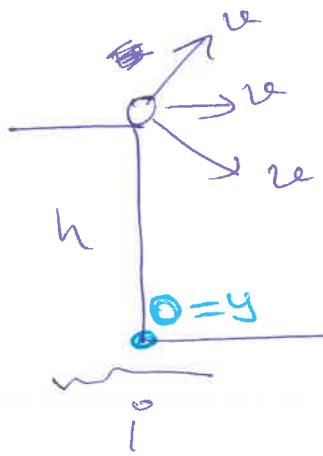
U → yay
↳ yerçekim



$$\Sigma U_i = U_{yay} + U_g$$

sürtünme yoksa

$E_i = E_s$



sürt. yok (3)

cismin yere düşme hızları aynıdır!

$E_i = E_s$

$K_i + U_i = K_s + U_s$

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

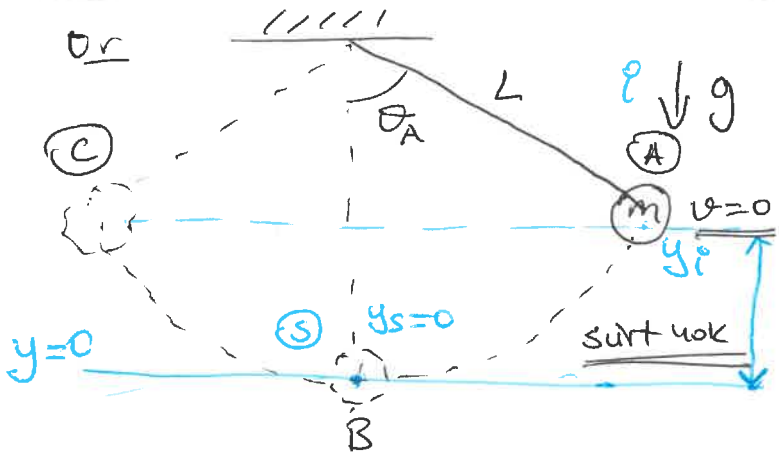
I. yol

II. yol: zamansız hız denklemi

$$v_s^2 = v_i^2 + 2g(y_s - y_i)$$

$y_s - y_i = h$

$$v_s^2 = v^2 + 2gh$$



(B) ye geldiğinde sürati?

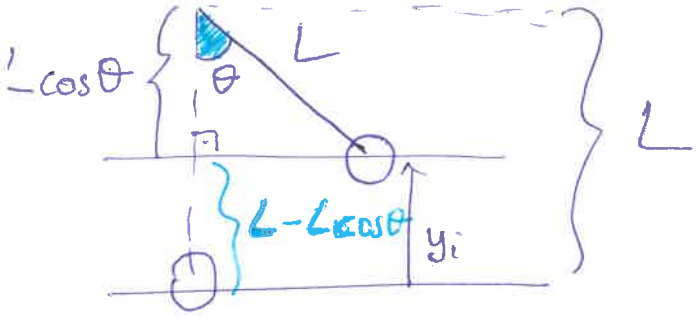
$E_i = E_s \Rightarrow$ koord. sist. neresi SIFIR

$$\frac{1}{2}mv_i^2 + mgy_i = \frac{1}{2}mv_s^2 + mgy_s$$

$v_i = 0; \quad y_s = 0$

$$mgy_i = \frac{1}{2}mv_s^2$$

$$v_s^2 = 2gy_i$$



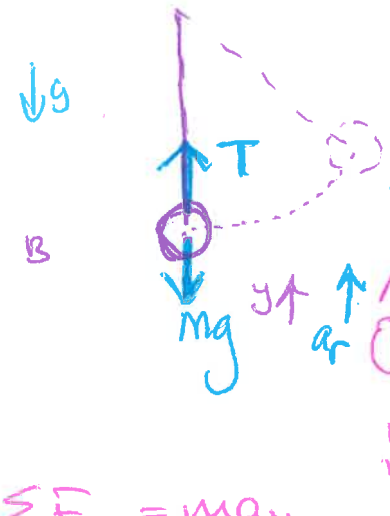
$y_i = L - L\cos\theta$

$v_s^2 = 2g y_i = 2gL(1-\cos\theta)$

$v_s = \sqrt{2gL(1-\cos\theta)}$

$\theta \uparrow$; $v_s \uparrow$

(b) (B) noktasında iplteki gerilme?



DODH

$\vec{a} = \vec{a}_r + \vec{a}_t$

$\Sigma F_x = 0$

$a_t = 0$

$\Sigma F_y = ma_y$

$T - mg = ma_r = m\frac{v^2}{R}$ $(R=L)$

$T = mg + m\frac{v^2}{L}$; $\left[v = \sqrt{2gL(1-\cos\theta)}\right.$ enerji korunumu$\left.\right]$

$T = m\left(g + \frac{2gL(1-\cos\theta)}{L}\right)$

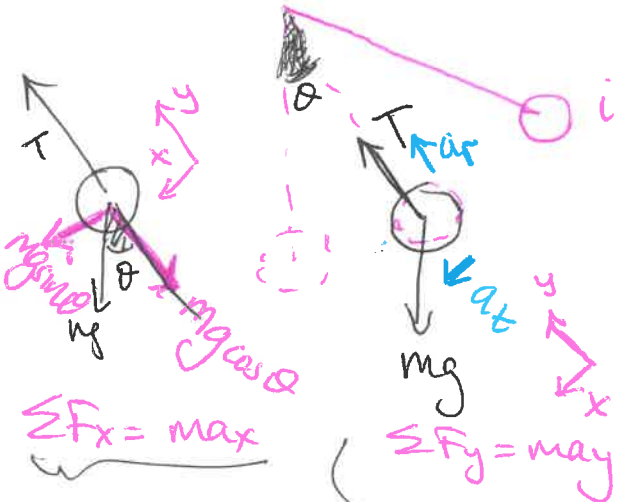
$T = m(g + 2g - 2g\cos\theta)$

$T = mg(3 - 2\cos\theta)$

Hatırlatma: (4)

Düşeyde Dairesel hareket

DODH



$\Sigma F_x = ma_x$

$mg\sin\theta = ma_t$

$g\sin\theta = a_t$

$\Sigma F_y = ma_y$

$T - mg\cos\theta = ma_r$

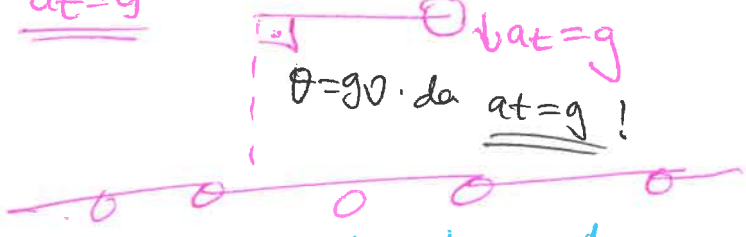
$T - mg\cos\theta = m\frac{v^2}{L}$

$T = mg\cos\theta + m\frac{v^2}{L}$

$a_t = max = \theta = 90°$

$g\sin 90° = a_t$

$a_t = g$



Korunumlu kuvvetler

$E_i = E_s$

$K_i + U_i = K_s + U_s$

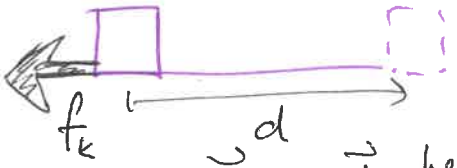
$U_i - U_s = K_s - K_i$

$-\Delta U = \Delta K$

$0 = \Delta K + \Delta U$

Sürtünme kuvveti

Varsa



$\vec{f_k}$ ve $\vec{d}$ her zaman 180°

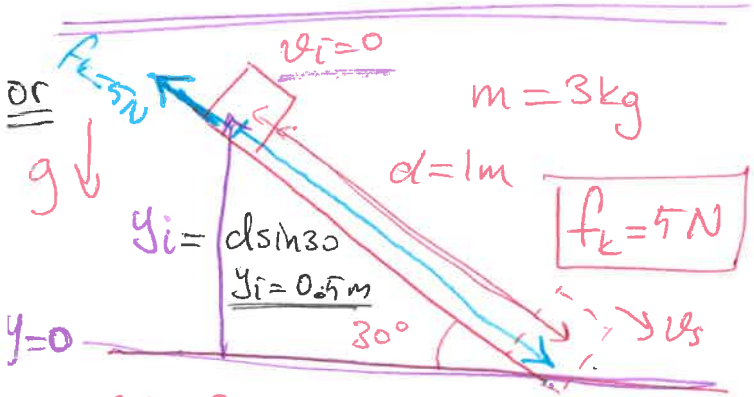
$W_{sürt.} < 0$

Sürtünme enerjiyi **azalır** ⇒ ısıya dönüşür.

$$E_i + W_{sürt} = E_s$$

$$W_{sürt} < 0$$

$$W_{sürt} = E_s - E_i = \Delta E < 0$$



$E_i + W_{sürt} = E_s$

$K_i + U_i + W_{sürt} = K_s + U_s$

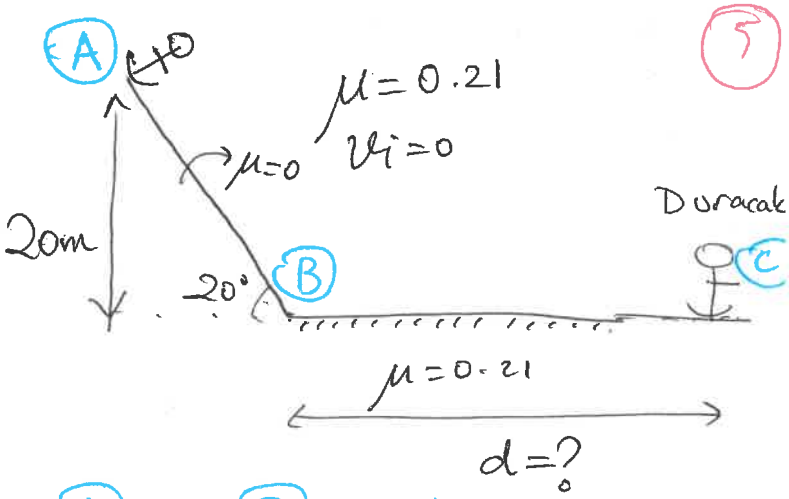
$\frac{1}{2}mv_i^2 + mgy_i + W_{sürt} = \frac{1}{2}mv_s^2 + mgy_s$

($v_i = 0$, $y_s = 0$ nolsun)

$$mgy_i + (f_k d(-1)) = \frac{1}{2}mv_s^2$$

$$(3)(9.8)\left(\frac{1}{2}\right) - (5)(1) = \frac{1}{2}(3)v_s^2$$

$$v_s^2 = \frac{19.4}{3} \Rightarrow \boxed{v_s = 2.5\ m/s^2}$$



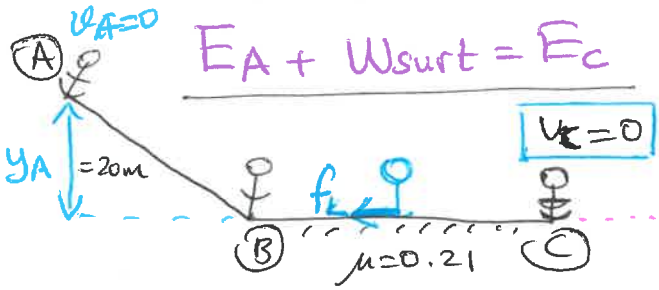
A → B sürt yok.

$E_A = E_B$

B → C sürt var.

$E_B + W_{sürt} = E_C$

$E_A + W_{sürt} = E_C$



$K_A + U_A + W_{sürt} = K_C + U_C$

$$\frac{1}{2}mv_A^2 + mgy_A + (-f_k d) = \frac{1}{2}mv_C^2 + mgy_C$$

$v_A = 0$; $v_C = 0$; $y_C = 0$

$$mgy_A - f_k d = 0$$

$f_k = \mu N$

; $f_k = \mu mg$

$$mgy_A - \mu mgd = 0$$

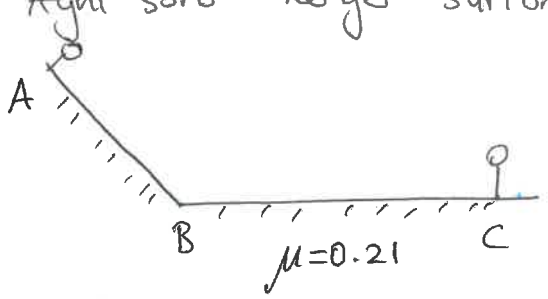
$$mgy_A = \mu mgd$$

$$y_A = \mu d$$

$$20 = (0.21)d$$

$$\boxed{d = 95.2\ m}$$

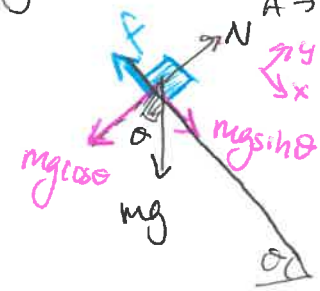
or) Aynı soru herşey sürtünmeli



$E_A + W_{sürt} = E_C$

$A \to B \to C$

$mgy_A + 0 + W_{sürt}^{A\to B} + W_{sürt}^{B\to C} = 0$



$f = \mu N$

$\Sigma F_y = ma_y = 0$

$N - mg\cos\theta = 0$

$N = mg\cos\theta$

$f = \mu mg\cos\theta$

$A \to B$

yol: 2om, d_1, $20°$

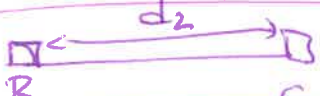
$d_1 = \frac{20}{\sin 20}$

$d_1 = \frac{20}{\sin 20°}$

$W_{A\to B}^{sürt} = -f_k d_1$

$= -\mu mg\cos 20 \frac{20}{\sin 20}$

$W_{A\to B}^{sürt} = -\mu mg(20)\frac{\cos 20}{\sin 20}$



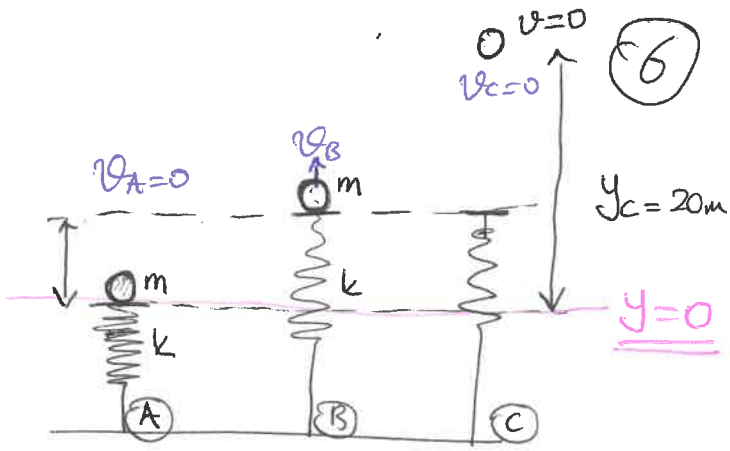
$W_{B\to C}^{sürt} = -\mu mg d_2$

$mgy_A + W_{A\to B}^{sürt} + W_{B\to C}^{sürt} = 0$

$mgy_A - \mu mg(20)\frac{\cos 20}{\sin 20} - \mu mg d_2 = 0$

$20 - (0.21)(20)\frac{\cos 20}{\sin 20} - (0.21)d_2 = 0$

$d_2 = 40.3\text{m}$



(6)

Yay 0.12m sıkıştırılınca, 35g lık kütle ateşlene öncesi konumunun 20m üzerinde maksimum yükseklikte fırlatılıyor.

(a) $k = ?$ sürt yok; korunumlu

$E_A = E_B = E_C$

$K_A + U_A$

↳ yay → U_y

↳ yerçekim → U_g

$K_A + U_{yA} + U_{gA} = K_C + U_{yC} + U_{gC}$

$\frac{1}{2}mv_A^2 + \frac{1}{2}kx_A^2 + mgy_A = \frac{1}{2}mv_C^2 + \frac{1}{2}kx_C^2 + mgy_C$

$x_A = 0.12\text{m}$ sıkışıyor; $v_A = 0$; $y_A = 0$

$v_C = 0$, $x_C = 0$, $y_C = 20\text{m}$

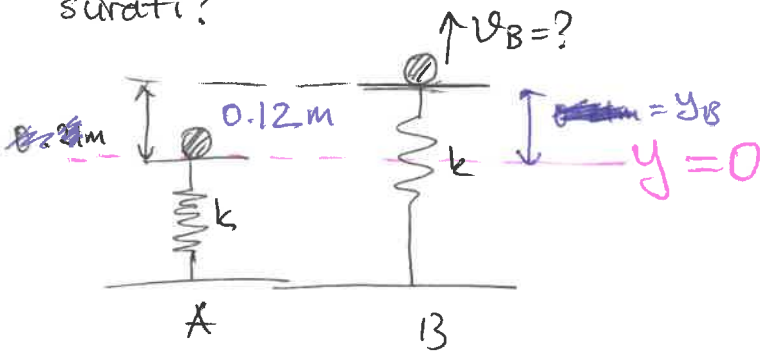
$0 + \frac{1}{2}kx_A^2 + 0 = 0 + 0 + mgy_C$

$\frac{1}{2}k(0.12)^2 = (0.035)(9.8)(20)$

$k = 953\ N/m$

-devamı

b) B noktasından geçerken cismin sürati?



$E_A = E_B$

$K_A + U_{yA} + U_{gA} = K_B + U_{yB} + U_{gB}$

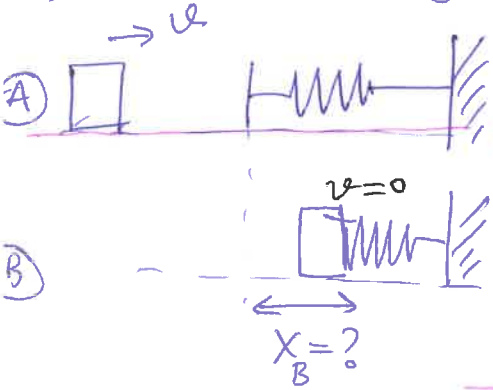
$v_A = 0$; $y_A = 0$; $x_B = 0$

$$\frac{1}{2} k x_A^2 = \frac{1}{2} m v_B^2 + mg y_B$$

$$\frac{1}{2}(953)(0.12)^2 = \frac{1}{2}(0.035) v_B^2 + (0.035)(9.8)(0.12)$$

$$\boxed{v_B = 19.7 \text{ m/s}}$$

ör) Blok - Yay çarpışması



$m = 0.8$ kg

$k = 50$ N/m

$v_A = 1.2$ m/s

$E_A = E_B$

$K_A + U_{yA} = K_B + U_{yB}$

y'de değişmiş yok

$U_g = 0$

$$\frac{1}{2} m v_A^2 + \frac{1}{2} k x_A^2 = \frac{1}{2} m v_B^2 + \frac{1}{2} k x_B^2$$

$x_A = 0$; $v_B = 0$

$$m v_A^2 = k x_B^2$$

$$(0.8)(1.2)^2 = (50) x_B^2$$

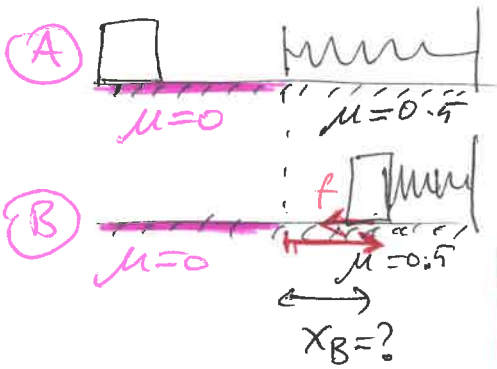
$$\boxed{x_B = 0.15 \text{ m}}$$

---

a) sıkışmada maksimum sıkışma miktarı $x_B = 0.15$ m

b) $\mu = 0.5$ olsaydı, cisim çarptığı andaki hızı $v = 1.2$ m/s

max. sıkışma?



$d = x_B$ alınan yol sıkışma miktarı ile aynı

$W_{sürt} + E_A = E_B$

$$(-f_k x_B) + \frac{1}{2} m v_A^2 + 0 = 0 + \frac{1}{2} k x_B^2$$

$f_k = \mu N = \mu mg$

$$-\mu mg x_B + \frac{1}{2} m v_A^2 = \frac{1}{2} k x_B^2$$

$$-(0.5)(0.8)(9.8) x_B + \frac{1}{2}(0.8)(1.2)^2 = \frac{1}{2}(50) x_B^2$$

$$\boxed{25 x_B^2 + 3.92 x_B - 0.576 = 0}$$

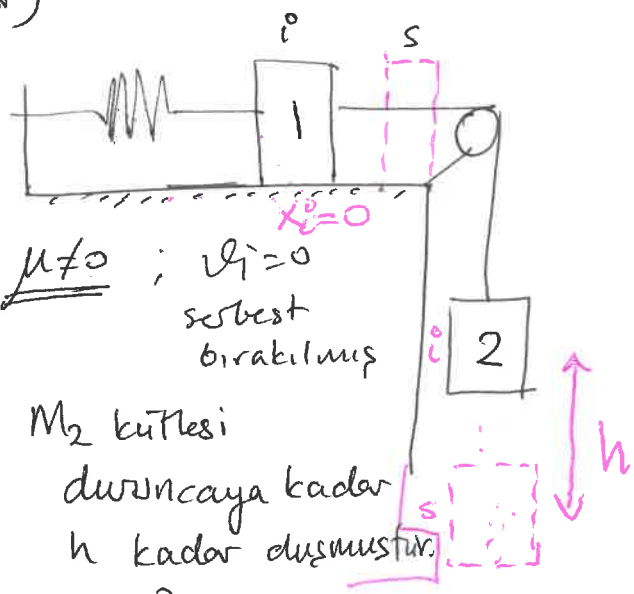
$$ax^2 + bx + c = 0$$

$$x_{1,2} = \frac{-b \mp \sqrt{b^2 - 4ac}}{2a}$$

$$\boxed{x_B = 0.092 \text{ m}} \quad x_B > 0$$

$x_B = -0.25$ m ✗

or)

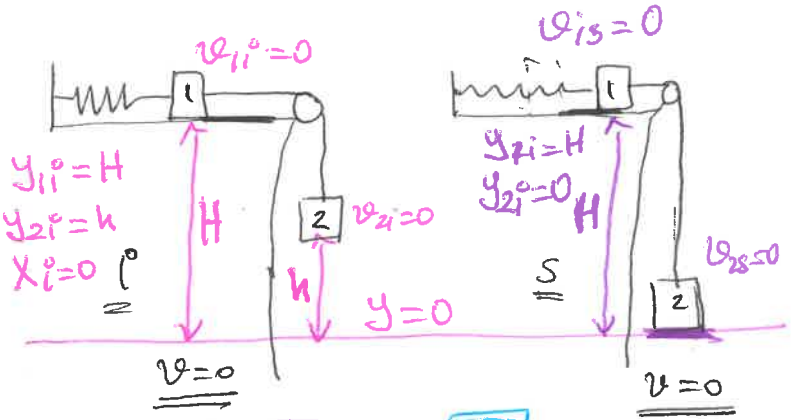


$\mu \neq 0$; $v_i = 0$ serbest bırakılmış

m_2 kütlesi duruncaya kadar h kadar düşmüştür.

$\mu = ?$

$W_{sürt} + E_i^\circ = E_s$



$E_i + W_{sürt} = E_s$

$(K_i + U_{yi} + U_{gi})_{1,2} + W_{sürt} = (K_s + U_{ys} + U_{gs})_{1,2}$

hem 1., hem de 2. cisim yazılacak

$\frac{1}{2} m_1 v_{1i}^2 + m_1 g y_{1i} + \frac{1}{2} m_2 v_{2i}^2 + m_2 g y_{2i}$

E_i $+ \frac{1}{2} k x_i^2 + (-f_k d) = W_{sürt}$

$\frac{1}{2} m_2 v_{2s}^2 + m_1 g y_{1s} + \frac{1}{2} m_2 v_{2s}^2 + m_2 g y_s + \frac{1}{2} k x_s^2$ E_s

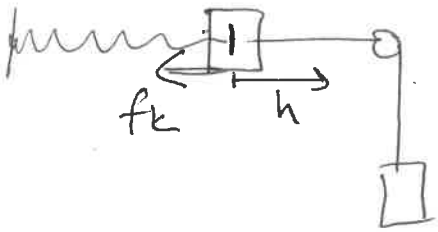
$m_1 g H + m_2 g h - f_k d = m_1 g H + \frac{1}{2} k x_s^2$

$m_2 g h - f_k d = \frac{1}{2} k x_s^2 \Longrightarrow$

$d = h$ m_2 h kadar inerse m_1 h kadar gider

$m_2 g h - f_k h = \frac{1}{2} k x_s^2$

$x_s = h$



$f_k = \mu N$

$f_k = \mu m_1 g$

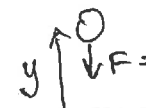
$m_2 g h - \mu m_1 g h = \frac{1}{2} k h^2$

$x_s = h$; 2. cisim h kadar inerse yay h kadar gerilir.

$m_2 g - \mu m_1 g = \frac{1}{2} k h$

$$\frac{\left(m_2 g - \frac{1}{2} k h\right)}{m_1 g} = \mu$$

Korunumlu kuvvet $\longleftrightarrow$ Pot. Enerji



F (−mg) U (mgh)

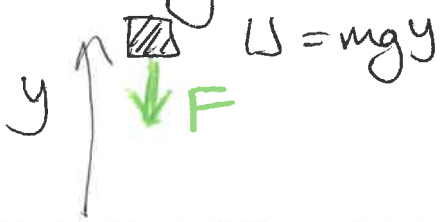
$F_x = -\frac{dU}{dx}$

$W = -\Delta U = -dU$

$W = F dx = -dU$

$F = -\frac{dU}{dx}$

$U = mgy$



$$F_y = -\frac{dU}{dy} = -\frac{d}{dy}(mgy)$$

$$F\downarrow \quad = -mg$$

$$\vec{F} = -\frac{dU}{dx}\hat{i} - \frac{dU}{dy}\hat{j} - \frac{dU}{dz}\hat{k}$$

ÜZET

Mekanik Enerji Korunumu

$E_i = E_s$ (sürt yok)

sürt varsa

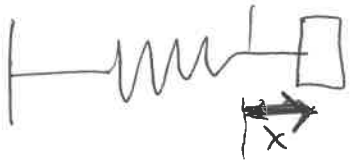
$W_{sürt} + E_i = E_s$ $\quad W_{sürt} < 0$

E_i → K_i → bütün kütleler için

→ U_{gi} → bütün kütleler için

→ U_{yi} → bütün yaylar için

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



$$-\frac{dU}{dx} = -\frac{d}{dx}\left(\frac{1}{2}kx^2\right)$$

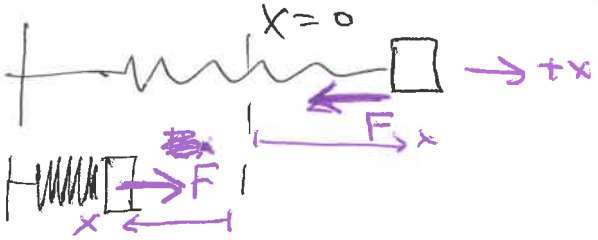
$$= -\frac{1}{2}k\,\frac{d}{dx}(x^2)$$

$2x$

$$= -\frac{1}{2}k(2x)$$

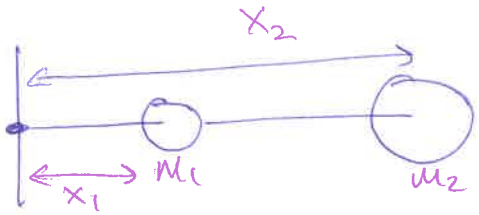
$$F = -kx$$

denge konumundan uzaklık x



18-8-16

Kütle Merkezi



$$X_{km} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

kütle merkezi

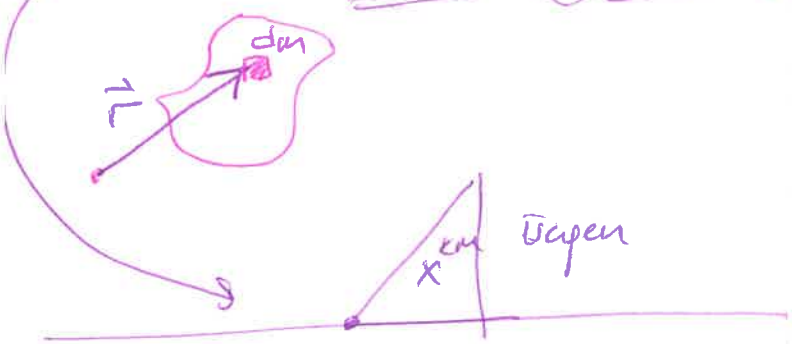
$$X_{km} = \frac{\sum_{i=1}^{N} x_i m_i}{\sum_{i=1}^{N} m_i}$$

$$\vec{r}_{km} = \frac{\sum \vec{r}_i m_i}{\sum m_i} \quad \text{3 boyut}$$

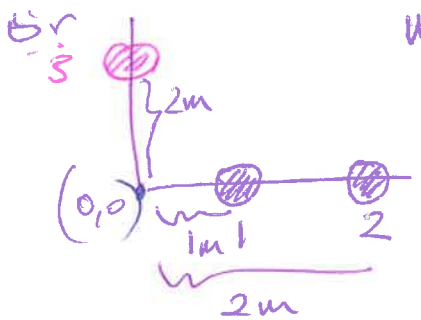
$$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$$

noktasal ; ~~simetrik~~ parçacıklar için

$$\vec{r}_{km} = \int \frac{r\,dm}{M} = \frac{1}{M}\int r\,dm$$



Bir



$m_1 = m_2 = 1\,kg$

$m_3 = 3\,kg$

$r_{km} = ?$

$\vec{r}_{km} = x_{km}\hat{i} + y_{km}\hat{j}$

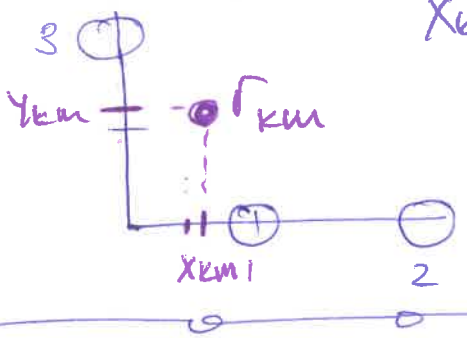
$$X_{km} = \frac{m_1(1) + m_2(2) + m_3(0)}{m_1 + m_2 + m_3} = \frac{3}{5} \text{ metre}$$

(1)

$$Y_{km} = \frac{m_1(0) + m_2(0) + m_3(2)}{m_1 + m_2 + m_3}$$

$Y_{km} = \frac{6}{5}$ metre

$X_{km} = \frac{3}{5}$



Parçacık Sistemlerinin Hareketi

$\vec{r}_{km}$ = kütle merkezinin konumu

$$\frac{d\vec{r}_{km}}{dt} = \vec{v}_{km} \quad (km\ hızı)$$

$$\frac{d}{dt}\left(\frac{1}{M}\sum m_i \vec{r}_i\right)$$

$$\vec{v}_{km} = \frac{1}{M}\sum m_i \frac{d\vec{r}_i}{dt} = \frac{\sum m_i \vec{v}_i}{M}$$

$$M\vec{v}_{km} = \sum m_i \vec{v}_i$$

$\frac{d}{dt}$

$$M\vec{a}_{km} = \sum m_i \vec{a}_i$$

$$M\vec{a}_{km} = \sum m_i \vec{a}_i = \sum \vec{F}_i$$

net kuvvet

$$\frac{d\vec{P}_{toplam}}{dt} = \sum \vec{F}_{dış}$$

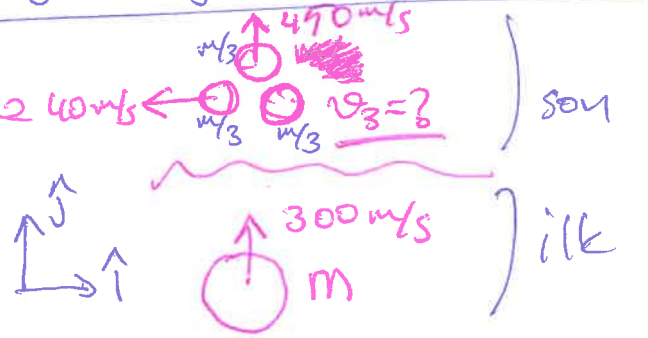
yalıtılmış sistem için $\sum \vec{F}_{dış} = 0 \Rightarrow \vec{P}_{top} = SBT$

$\sum \vec{F}_{dış} = 0 \quad \vec{P}_{top} = SBT$

$\vec{P}_i = \vec{P}_s$

Bir) Roket düşey yukarı doğru ateşleniyor 1000 m yukarıdayken, 300 m/s hıza ulaşıyor. Bu anda roket 3 eşit parçaya ayrılıyor.

1. parça 450 m/s yukarı doğru
2. parça 240 m/s BATIya doğru
3. parça $v_3 = ?$ yönü (3. parçanın)



$\vec{P}_i = \vec{P}_s$

$m\,300\hat{j} = \frac{m}{3}450\hat{j} + \frac{m}{3}240(-\hat{i}) + \frac{m}{3}\vec{v}_3$

$\vec{v}_3 = (300\hat{j} - 150\hat{j} + 80\hat{i})3$

$\vec{v}_3 = (450\hat{j} + 240\hat{i})$ m/s

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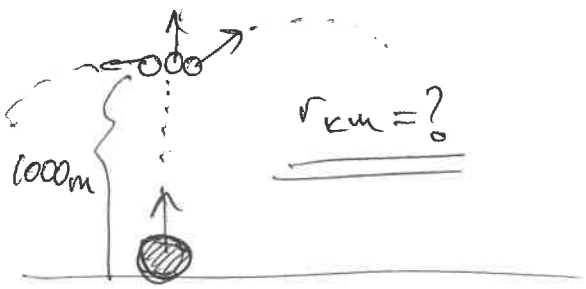
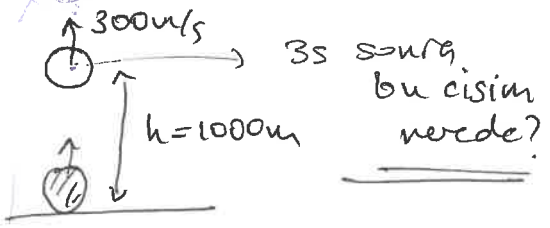
b) parçalanmadan 3s sonra (2)

Kütle merkezinin konumu?



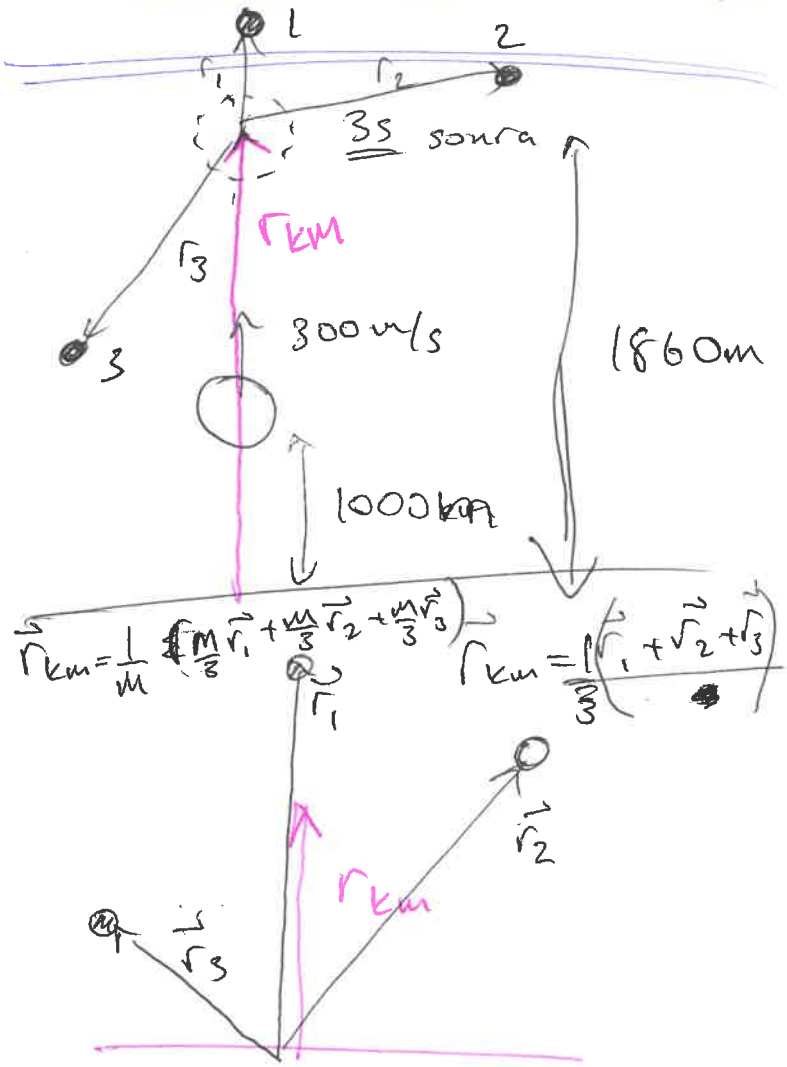
parçalanmadan önceki KM bulursak yetr.



$y_s = y_i + v_i t - \frac{1}{2}gt^2$

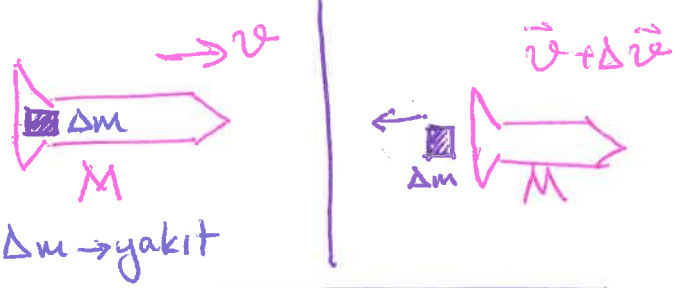
$y_s = 1000 + (300)(3) - \frac{1}{2}(9.8)3^2$

$y_s \cong 1860$ m $\quad$ $y_s = r_{km}$



Uzayda Roket Hareketi

Roket, yakıt atarak ilerler.
Uzayda



♀ yakıtın çıkış hızı roket'e göre sabittir
egzos hızı

v_e = çıkış hızı

$\vec{P}_i = \vec{P}_s$

$$(M+\Delta m)\vec{v} = M(\vec{v}+\Delta\vec{v}) + \Delta m(\vec{v}-\vec{v}_e)$$

$$M\vec{v} + \Delta m\vec{v} = M\vec{v} + M\Delta\vec{v} + \Delta m\vec{v} - \Delta m\vec{v}_e$$

$$\boxed{M\Delta\vec{v} = \Delta m\,\vec{v}_e}$$

$$\boxed{M\,d\vec{v} = dm\,\vec{v}_e}$$

t	M (roket+yakıt)	m
0	500	100
1	500	499
10	500	490

500 kg = M

500 kg = m = yakıt

Δm = son − ilk = < 0

$dm = -dM$ (M = toplam kütle)

$$\boxed{M\,d\vec{v} = (-dM)\,\vec{v}_e}$$ v_e = sbt

$$\frac{1}{v_e}\int_i^s dv = -\int_i^s \frac{dM}{M}$$

$$v_s - v_i = -v_e\left[\ln M\right]_i^s$$

$$= -v_e(\ln M_s - \ln M_i)$$

$$\boxed{v_s - v_i = v_e \ln\frac{M_i}{M_s}}$$

$M_i > M_s$

$v_s > v_i$

$$|M\,d\vec{v}| = |(-dM)\,\vec{v}_e|$$

$$\frac{1}{dt}\,M\,d\vec{v} = (dM)\,v_e\,\frac{1}{dt}$$

$$F = M\frac{dv}{dt} = v_e\frac{dM}{dt} \equiv \text{İTİCİ KUVVET}$$

Ör) $v = 3000$ m/s ; $v_e = 5000$ m/s

a) Roketin kütlesi, yakıt atmadan önceki kütlesinin yarısına düşerse, roketin hızı? (Bütün hızlar, YERE göre) verilmiştir.

$$v_s - v_i = v_e \ln\frac{M_i}{M_s} \quad \rightarrow M_i = M,\ M_s = \frac{M}{2}$$

$$v_s = v_i + v_e \ln\frac{M_i}{M_s}$$

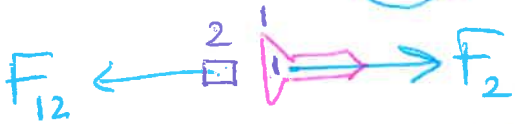
$$= 3000 + 5000\ln\left(\frac{M}{M/2}\right)$$

$$= 3000 + 5000\ln(2)$$

$$v_s = 6500\ \text{m/s}$$

b) Eğer yakıt 50 kg/s hızla tüketilirse, roket üzerindeki itici kuvvet ne olur?

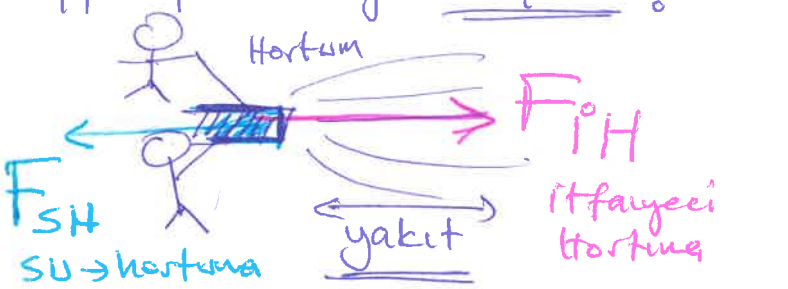
$$F = M\frac{dv}{dt} = v_e\frac{dM}{dt} = \text{itici kuvvet}$$



$$F = \left(5000\ \frac{m}{s}\right)\left(50\ \frac{kg}{s}\right)$$

$$= 250\times10^3\ N$$

8) İki itfaiyeci 3600 L/dk hızla su fışkırtan hortumu sabit tutmak için 600N kuvvet uygulıyorlar. Suyun çıkış hızı?



$F = \text{İtici kuvvet} = v_e \frac{dM}{dt} = F_{İH} = F_{SH}$

$600N = v_e \frac{dM}{dt}$

$\frac{dM}{dt} = \frac{3600\,L}{dk} = \frac{3600\,L}{60\,s} = 60\,\frac{kg}{s}$

$600 = v_e\, 60$

$v_e = 10\,m/s$

ezberlemeyin, sınavda verilecek!

FİNAL → hepsi dahil

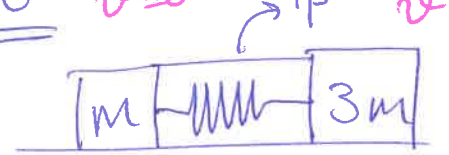
Finalde %60-70 → momentum, iş-enerji, SCD → dairesel, → düzlemsel

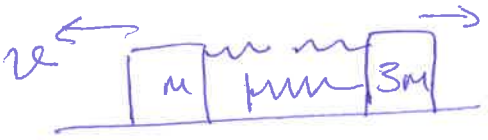
Vize → Newton kanunları, → ATIŞLAR..vs, → vektörler, birler.

Sınav mühendislikte → 3 tane sınıf

Cuma saat 10

#6





$v = ?$

$\vec{P}_i = \vec{P}_s$

$m(0) + 3m(0) = 0$

$\vec{P}_s = m(-v)\hat{i} + 3m(2)\hat{i} = 0$

$+mv\hat{i} = +6\hat{i}$

$v = 6\,m/s$

b) $m = 0.5\,kg$ olsun başlangıçta yayın pot. enerjisi?

$E_i = E_s$ Enerji korunumu

$KE_{1i} + KE_{2i} + U_{yayı} = KE_{1s} + KE_{2s} + U_{ys}$

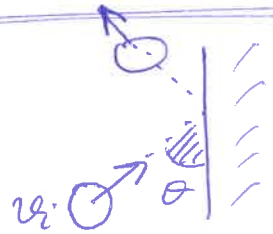
$v=0 \quad v=0$

$0 + 0 + \frac{1}{2}kx^2 = \frac{1}{2}m6^2 + \frac{1}{2}(3m)2^2 + 0$

$\frac{1}{2}kx^2 = \frac{1}{2}(0.5)36 + \frac{1}{2}(1.5)4$

$= 9 + 3 = 12\,Joule$

#11



$m = 3kg$

$\theta = 60°$

$v_i = 10\,m/s$

$v_s = v_i$

Eğer top duvar ile; 0.2s temasta kalırsa, duvarın topa uyg. ortalama kuvvet?

$\vec{I} = \Delta\vec{P} = \vec{F}\,\Delta t$

?

$\Delta\vec{P} = \vec{P}_s - \vec{P}_i$

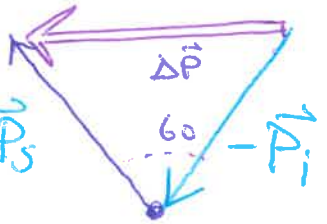
(3)(10)

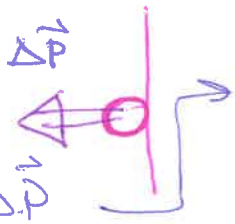
$\vec{P}_i = m\vec{v}_i = m\vec{v}_s = \vec{P}_s$

$\vec{P}_i \neq \vec{P}_s$; $P_i = P_s = 30 \frac{kgm}{s}$

$\Delta\vec{P} = \vec{P}_s - \vec{P}_i$

$\Delta\vec{P} = 30 \frac{kgm}{s}(-\hat{i})$





$\vec{I} = \vec{F}\Delta t = \Delta\vec{P}$

$\vec{F} = \frac{30}{0.2} N$

$\vec{F} = 150N(-\hat{i})$

duvarın topa uyg. kuvvet F_{DT}

Topun duvara uyg. kuvvet $\vec{F}_{TD} = -\vec{F}_{DT}$

$+150N\hat{i} \Rightarrow \vec{F}_{TD}$

#60 $\mu = 0$ 1 2nin üstünden kayıyor (4)

$m_1 = 0.5kg$ $v_{1s} = 4 m/s$

$m_2 = 3kg$ $v_{2s} = ?$

$\vec{P}_i = \vec{P}_s$

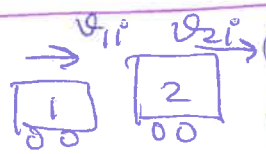
$m_1\vec{v}_{1i}^{\,0} + m_2\vec{v}_{2i}^{\,0} = m_1\vec{v}_{1s} + m_2\vec{v}_{2s}$

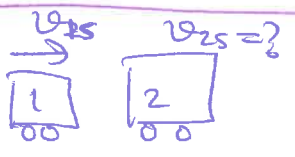
$0 = m_1(4)\hat{i} + m_2\vec{v}_{2s}$

$\vec{v}_{2s} = 4\frac{m_1}{m_2}(-\hat{i})$

$\vec{v}_{2s} = \frac{4(0.5)}{3}(-\hat{i}) = -\frac{2}{3}\hat{i}\ m/s$

Or)





$\vec{v}_{1i} = 25 m/s\ \hat{i}$ $\vec{v}_{1s} = 18 m/s\ \hat{i}$

$\vec{v}_{2i} = 20 m/s\ \hat{i}$ $v_{2s} = ?$

$2m_1 = m_2$

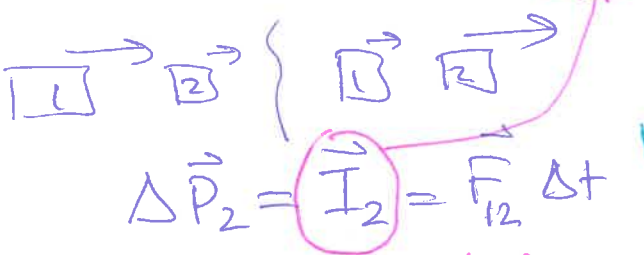
$\vec{P}_i^{\,0} = \vec{P}_s$

$m_1\vec{v}_{1i}^{\,0} + m_2\vec{v}_{2i} = m_1\vec{v}_{1s} + m_2\vec{v}_{2s}$

$(m_1 25) + (2m_1 20) = (m_1 18) + (2m_1 v_{2s})$

$28.5 m/s = \left(\frac{65 - 18}{2}\right) = v_{2s} \rightarrow$

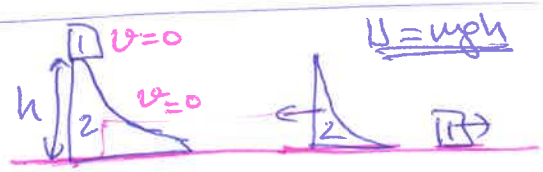
$\Rightarrow$ 1. cismin 2. cisme uyg. itme?



$\Delta\vec{P}_2 = \vec{I}_2 = \vec{F}_{12}\Delta t$

$\Rightarrow$ kaybolan KE ne kadardır?

(b) $h = ?$ $y = 0$



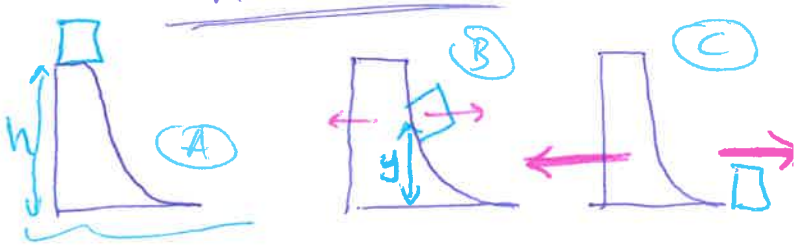
$K = \frac{1}{2}mv^2$; $E_i = E_s$

$K_{1i}^{\,0} + K_{2i}^{\,0} + U_{1i}^{\,0} + U_{2i}^{\,0} = K_{1s} + K_{2s} + U_{1s}^{\,0} + U_{2s}^{\,0}$

$m_1 g h = \frac{1}{2}m_1 v_{1s}^2 + \frac{1}{2}m_2 v_{2s}^2$

$(0.5)(9.8)h = \frac{1}{2}(0.5)4^2 + \frac{1}{2}(3)\left(-\frac{2}{3}\right)^2$

$h \rightarrow$ çözülür



$E_A = E_B = E_C$

Enerji Korunumu

$U_g = mgh$; $U_{yay} = \frac{1}{2}kx^2$

$$\Delta U = -\int_{x_i}^{x_s} F\,dx$$

(x = sıkışma = gerilme)

E = mekanik enerji

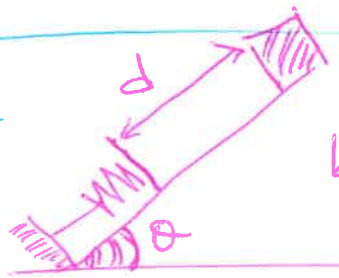
$E = U + K$

↳ g → yerçekimi

↳ yay

$E_i = E_s$ (enerji korunumu)

#12



$m = 3kg$

$k = 400\ N/m$

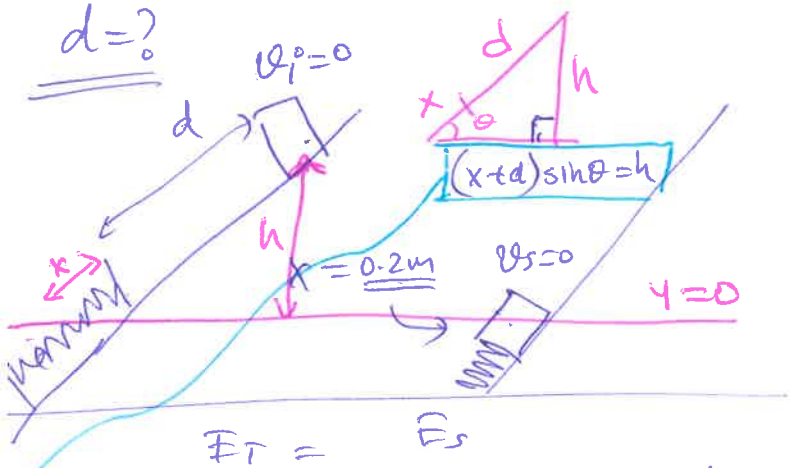
$\theta = 30°$

$\mu = 0$

m kütlesinin ilk hızı SIFIR

m kütlesi yayı 0.2m sıkıştırdıktan sonra anlık olarak duruyor.

$d = ?$



$E_i = E_s$

$K_i + U_{gi} + U_{yi} = K_s + U_{gs} + U_{ys}$

$v=0$, $x=0$, $v_s=0$, $y=0$

$0 + mgh + 0 = 0 + 0 + \frac{1}{2}kx^2$

$mg(x+d)\sin\theta = \frac{1}{2}kx^2$

?

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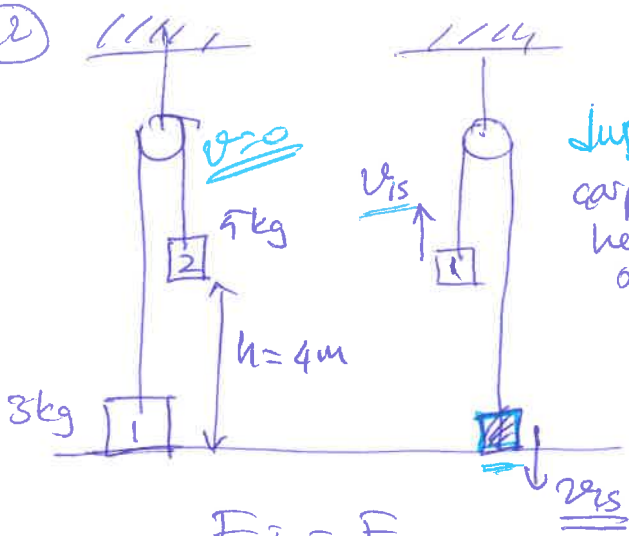
(22)



(6)

Tüpün halde çarpmadan hemen önceki hız?

$E_i = E_s$

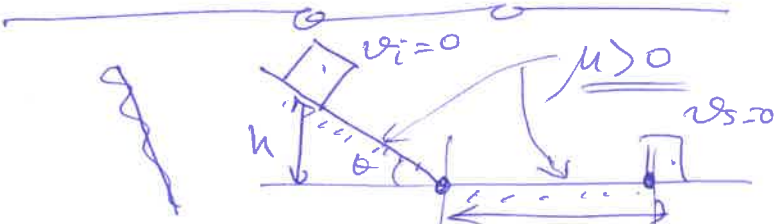
$U_{1i} + U_{2i} + K_{1i} + K_{2i} = U_{1s} + U_{2s} + K_{1s} + K_{2s}$

$m_2 gh = m_1 gh + \frac{1}{2}m_1 v_{1s}^2 + \frac{1}{2}m_2 v_{2s}^2$

$v_{1s} = v_{2s}$

$m_2 gh - m_1 gh = \frac{1}{2}v^2(m_1 + m_2)$

$$\sqrt{\frac{2gh(m_2 - m_1)}{m_1 + m_2}} = v$$



sürtünmeli yüzeyde kayıyor, yatayda d kadar gittikten sonra duruyor.

$d = ?$

$W_{fk} + E_i = E_s$

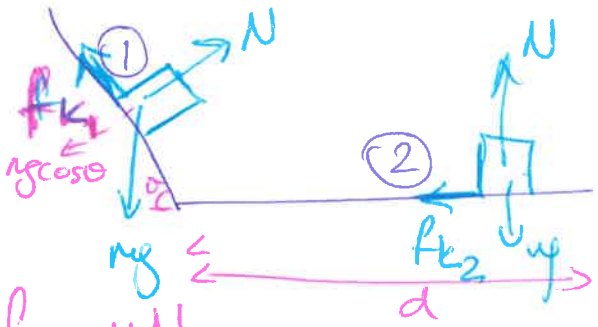
sürt yaptığı iş ; $W_{fk} < 0$

$K_i = 0$; $K_s = 0$, $U_s = 0$

$W_{fk} + mgh^{+0} = 0 + 0$

$W_{fk} = -mgh$

$$W_{fk} = -mgh$$



$f_k = \mu N$

$f_{k_1} = \mu mg\cos\theta$

$W_{fk_1} = -\mu mg\cos\theta \left(\times \frac{h}{\sin\theta}\right)$

$f_{k_2} = \mu N = \mu mg$

$W_{fk_2} = -\mu mg d$

$W_{fk_1} + W_{fk_2} = -mgh$

$+\mu mg\cos\theta \frac{h}{\sin\theta} + (-\mu mg d) = +mgh$

$$\mu h \frac{\cos\theta}{\sin\theta} + \mu d = h$$

③ $\vec{A}\cdot\vec{B} = AB\cos\theta$

$(-12-12) = (\sqrt{4^2+2^2+1^2})(\sqrt{3^2+1^2+4^2})\cos\theta$

(7) (6)

$\cos\theta = \frac{-24}{30}$