

Fizik 1 Tekrar

3 temel büyüklük vardır.

- 1- Kütle (kg) 3- Zaman (s)
- 2- Uzunluk (m)

Boyuť Analizi

Büyüklük	Boyuť	Birim
Kütle	Mass	kg
Uzunluk	Length	metre
Zaman	Time	saniye
Alan	L^2	m^2
Hacim	L^3	m^3
Hz	L/T	m/s
Īume	L/T^2	m/s^2
Kurvet	$M \cdot L/T^2$	$kg \cdot m/s^2$

- * Bir esitin her iki tarafının boyutları aynı olmalıdır.
- * Aynı boyuttaki nicelikler toplayıp çıkırlabilir.

Ör/

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

"G" boyut analizini yapınız.

$$\frac{M \cdot L}{T^2} = "G" \cdot \frac{m \cdot L}{L^2}$$

$$\frac{L^3}{M \cdot T^2} = "G"$$

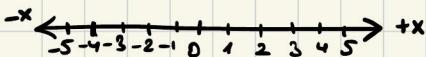
Birim Çevirme

$$1 \frac{1\text{km}}{1000\text{m}} \cdot \frac{3600\text{s}}{1\text{h}}$$

$$1 \text{ m/s} = ? \text{ km/h}$$

$$1 \frac{\cancel{\text{m}}}{\cancel{\text{s}}} \left(\frac{3600\text{s}}{1\text{h}} \right) \cdot \left(\frac{1\text{km}}{1000\text{m}} \right) = 3,6 \text{ km/h}$$

Bir Boyutlu Hareket



1) Yer değiştirmeye: $\Delta x = x_s - x_i$ (metre)

$$\begin{array}{l|l} x_i = \text{ilk konum} & t_i = \text{ilk zaman} \\ x_s = \text{son konum} & t_s = \text{son zaman} \end{array}$$

4) Ortalama ıvme:

$$a_{\text{ort}} = \frac{\Delta v}{\Delta t} = \frac{v_s - v_i}{t_s - t_i} \quad (\text{m/s}^2)$$

2) Ortalama Hız: $v_{\text{ort}} = \frac{\Delta x}{\Delta t} \quad (\text{m/s})$

5) Ani ıvme

$$a = \lim_{\Delta t \rightarrow 0} \frac{\Delta v}{\Delta t} = \frac{d v(t)}{dt}$$

3) Ani Hız: $\lim_{\Delta t \rightarrow 0} v_{\text{ort}} = v$

$$v = \lim_{\Delta t \rightarrow 0} \frac{\Delta x}{\Delta t}$$

Türen Operatörü

★★ $\lim_{\Delta t \rightarrow 0} \frac{\Delta}{\Delta t} = \frac{d}{dt}$

$$\text{Or} / -4t + 2t^2 = x$$

a) 1sn ile 3sn arasında ger degistirmek

$$4t - 4 = \mathcal{V}_l \quad | \quad \begin{array}{l} (t=1) x_i = -2 \text{ m} \\ (t=3) x_s = 6 \text{ m} \end{array}$$

$$4 = a$$

b) Ort hız:

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

$$\frac{8-0}{2} = 4 \text{ m/s}$$

c) $t=2.5$ sn'de cismin hızı

$$\mathcal{V}_l = \lim_{\Delta t \rightarrow 0} \frac{\Delta x}{\Delta t} = \frac{x_s - x_i}{\Delta t}$$

$$x_s = t + \Delta t$$

$$x_s = -4(t + \Delta t) + 2(t + \Delta t)^2$$

$$\mathcal{V}_l = \frac{dx}{dt} \Big|_{t=2.5} \rightarrow -4 + 4t$$

$$\lim_{\Delta t \rightarrow 0} \frac{-4t - 4\Delta t + 2(\Delta t)^2 + 4t + 2\Delta t^2}{\Delta t}$$

$$\frac{\Delta x(-4 + 4t + 2\Delta t)}{\Delta t} = -4 + 4t$$

$$(t=2.5) = 6$$

Sabit i̇ume Hareket ($a = s \cdot b + t$)

- Ortalama i̇ume, ani i̇ume ye eşittir.

$$V_{\text{ort}}(t) = V_i + a t$$

+ anında V hızı
ilk hız + i̇me x zaman

$$V_{\text{ort}} = \frac{x(t) - x_i}{t} = \frac{V_i + V(t)}{2}$$

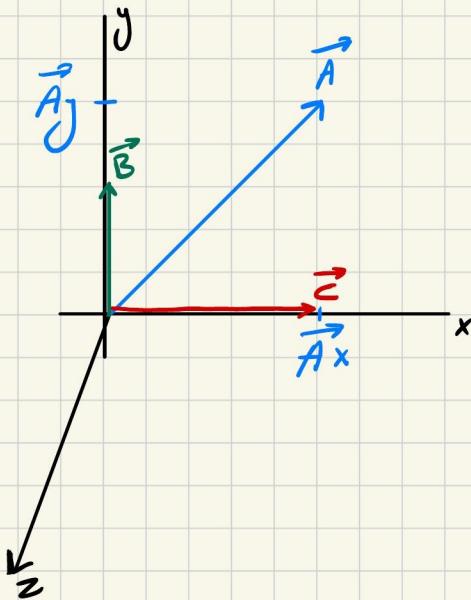
$$x(t) = x_i + V_i t + \frac{1}{2} a t^2$$

$$x_s = x_i + V_0 t + \frac{a t^2}{2}$$

$$V^2 = V_i^2 + 2a(x - x_i)$$

zamansız hız
formülü

Vektörler



Birim Vektör: $|\hat{i}| = 1 \text{ br}$

$|\hat{j}| = 1 \text{ br}$

$|\hat{k}| = 1 \text{ br}$

$$\begin{aligned} \vec{B} &= 3 \hat{i} \\ \vec{C} &= 4 \hat{j} \end{aligned} \quad \left. \begin{array}{l} \vec{A} = A_x \hat{i} + A_y \hat{j} + \\ \qquad \qquad \qquad A_z \hat{k} \end{array} \right\}$$

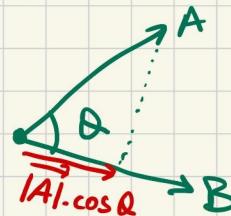
$$|\vec{A}| = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

\vec{A} 'nın uzunluğu

Vektörlerde Çarpım

1) Skaler Çarpım (iq çarpımı)

$$\vec{A} \cdot \vec{B} = |\vec{A}| \cdot |\vec{B}| \cdot \cos Q$$



$$\hat{i} \cdot \hat{i} = |\hat{i}| \cdot |\hat{i}| \cdot \cos 0^\circ = 1$$

$$\hat{j} \cdot \hat{j} = |\hat{j}| \cdot |\hat{j}| \cdot \cos 0^\circ = 1$$

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

$$\hat{i} \cdot \hat{j} = |\hat{i}| \cdot |\hat{j}| \cdot \cos 90^\circ = 0$$

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

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

$$\vec{A} \cdot \vec{B} = A_x B_x \hat{i} \cdot \hat{i} + A_x B_y \hat{i} \cdot \hat{j} + A_x B_z \hat{i} \cdot \hat{k} + A_y B_x \dots$$



$$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z$$

Ör/

$$\vec{A} = 2\hat{i} + 3\hat{j} - \hat{k}$$

$$\vec{B} = 3\hat{i} - 4\hat{j} + 5\hat{k}$$

4 9 1
1 16 25

a) $6 - 12 - 5 = -11$

$$-11 = \sqrt{14} \cdot \sqrt{50} \cos \theta$$

$\overbrace{\cos^{-1}\left(\frac{-11}{\sqrt{14} \cdot \sqrt{50}}\right)}^{} = \theta$

a) A ve B skaler çarpım

b) A, B arası açı kaç derecedir?

b) $\sqrt{3^2 + (-4)^2 + 5^2} = \sqrt{7.07}$

$$\sqrt{2^2 + 3^2 + (-1)^2} = \sqrt{3.74}$$

$$-11 = (\sqrt{7.07})(\sqrt{3.74}) \cdot \cos \theta$$

$$\cos \theta = -0.38$$

$\theta = 112.3^\circ$

2) Vektörel Çarpım

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

Vektörel Çarpının Özellikleri:

1) İki vektör çarpımı da bir vektördür.

2) $|\vec{C}| = |\vec{A} \times \vec{B}| = |\vec{A}| \cdot |\vec{B}| \cdot \sin \theta$

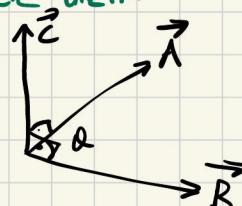
3) İki vektör çarpımı diğer vektörlere dikdir.

Yani aynı düzleme değildir.

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

$$|\hat{j} \times \hat{j}| = |\hat{j}| \cdot |\hat{j}| \cdot \sin 0^\circ = 0$$

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



$$\hat{i} \times \hat{j} = \hat{c}$$

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

$$|\vec{c}| = |\hat{i}| \cdot |\hat{j}| \cdot \sin 90^\circ = 1$$

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

$$\vec{A} = 2\hat{i} + 3\hat{j}$$

$$\vec{B} = \hat{i} - 5\hat{j}$$

$$\vec{A} \times \vec{B} = (2\hat{i} + 3\hat{j}) \times (\hat{i} - 5\hat{j})$$

$$\vec{A} \times \vec{B} = -13\hat{k}$$

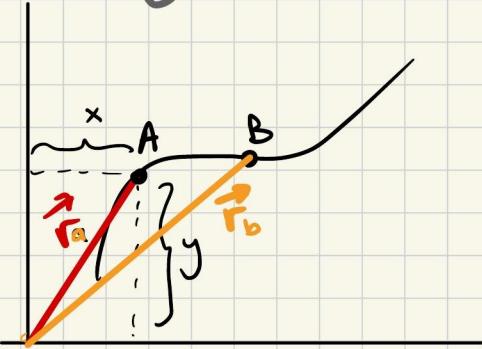
$$|\vec{A} \times \vec{B}| = 13$$

$$(\vec{A} \times \vec{B}) \cdot \vec{A} = ?$$

$$\underbrace{\vec{c}}_{\vec{c} \perp \vec{A}} \cdot \vec{A} = 0$$

$$\begin{matrix} \vec{c} \\ \vec{c} \end{matrix} \perp \begin{matrix} \vec{A} \\ \vec{B} \end{matrix}$$

iki Boyutlu Hareket



$$\vec{r} = x \hat{i} + y \hat{j} + z \hat{k}$$

$$|\vec{r}| = \sqrt{x^2 + y^2 + z^2}$$

1) Yer değiştirmeye

$$\Delta \vec{r} = \vec{r}_B - \vec{r}_A = (x_B \hat{i} + y_B \hat{j}) - (x_A \hat{i} + y_A \hat{j})$$

2) Ortalama hız

$$\overline{\vec{v}}_{\text{ort}} = \frac{\Delta \vec{r}}{\Delta t} = \frac{\Delta x}{\Delta t} \hat{i} + \frac{\Delta y}{\Delta t} \hat{j} + \frac{\Delta z}{\Delta t} \hat{k}$$

$$\overline{\vec{v}}_{\text{ort}} = v_{\text{ort},x} \hat{i} + v_{\text{ort},y} \hat{j} + v_{\text{ort},z} \hat{k}$$

3) Anlık hız

$$\vec{v} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{r}}{\Delta t} = \frac{d \vec{r}}{dt}$$

$$\vec{v} = v_x \hat{i} + v_y \hat{j} + v_z \hat{k}$$

4) Ortalama ivme

$$\overline{\vec{a}}_{\text{ort}} = \frac{\Delta \vec{v}}{\Delta t} = a_{\text{ort},x} \hat{i} + a_{\text{ort},y} \hat{j}$$

5) Anlık ivme

$$\vec{a} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{v}}{\Delta t} = \frac{d \vec{v}}{dt}$$

$$|\vec{a}| = \sqrt{a_x^2 + a_y^2}$$

$$\vec{a} = \frac{d v_x}{dt} \hat{i} + \frac{d v_y}{dt} \hat{j}$$

Sabit i̇umeli iki Boyutlu Hareket

$$x = x_0 + v_{0x} t + \frac{1}{2} a_x t^2$$

$$\vec{r} = x \hat{i} + y \hat{j}$$

$$v_x = v_{0x} + a_x t$$

$$y = y_0 + v_{0y} t + \frac{1}{2} a_y t^2$$

$$v_y = v_{0y} + a_y t$$

$$\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2} \vec{a} t^2$$

a)

$$\begin{aligned} x &= x_0 + v_{0x} t + \frac{1}{2} a_x t^2 \\ &= 20t + \frac{1}{2} \cdot 4t^2 \\ &= 20t + 2t^2 \end{aligned}$$

b)

$$\begin{aligned} y &= y_0 + v_{0y} t + \frac{1}{2} a_y t^2 \\ &= -15t + \frac{1}{2} \cdot 0t^2 \\ &= -15t \end{aligned}$$

c)

$$\begin{aligned} \vec{r} &= \vec{r}_0 + \vec{v}_0 t + \frac{1}{2} \vec{a} t^2 \\ &= \vec{r}_0 + (20\hat{i} - 15\hat{j}) t + \frac{1}{2} (4\hat{i}) t^2 \\ &= \vec{r}_0 + (20\hat{i} - 15\hat{j}) t + 2t^2 \hat{i} \end{aligned}$$

$$a_x = 4 \text{ m/s}^2$$

$t=0$ anında originde başlayın

$$a_y = 0$$

$$v_{0x} = 20 \text{ m/s}$$

$$v_{0y} = -15 \text{ m/s}$$

a) Herhangi bir andaki hız vek. yazınız.

$$20\hat{i} - 15\hat{j}$$

b) ($t=5$) için hız, sırasıyla x eksenile göre.

c) Konum vek?

$$\vec{a} = 4\hat{i}$$

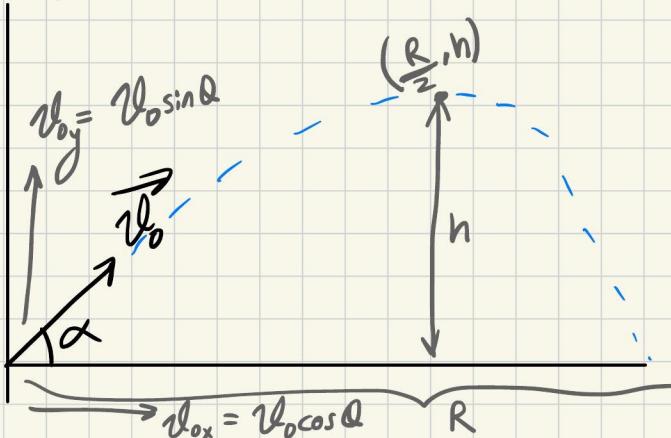
$$\vec{v} = \vec{v}_0 + \vec{a} t$$

$$\vec{r} = (20\hat{i} - 15\hat{j}) + (4\hat{i} t)$$

$$339,5^\circ = \alpha$$



Yatay Atış Hareketi



$$a = -g = -9.8 \text{ m/s}^2$$

$$x = x_0 + V_0 t + \frac{1}{2} g t^2$$

$$x = V_0 \cos \alpha \frac{V_0 \cdot \sin \alpha \cdot 2}{g}$$

$$x = \frac{V_0^2 \cdot \sin(2\alpha)}{g}$$

Maksimum uzaklık

- 1) Cismin ıumesi "g" ve sbt+
- 2) Hava Direnci ihmal

$$V_y = V_{0y} + gt$$



+ anında hızın
eleşenindeki
değeri

$$V_y = V_0 \sin \alpha - gt$$

tepe noktasında $V_y = 0$

$$0 = V_0 \sin \alpha - gt_q$$

$$t_q = \frac{V_0 \sin \alpha}{g} = t_i$$

atış = iniş süresi

$$y = y_0 + V_{0y} t + \frac{1}{2} g t^2$$

$$t = t_q \text{ olursa } y = h$$

$$h = V_0 \sin \alpha \cdot \frac{V_0 \sin \alpha}{g} - \frac{1}{2} g \frac{V_0^2 \cdot \sin^2 \alpha}{g^2}$$



$$h = \frac{V_0^2 \cdot \sin^2 \alpha}{2g}$$

Maksimum yükseklik

Bir top yere 20° atılarak ($V_0 = 11 \text{ m/s}$)

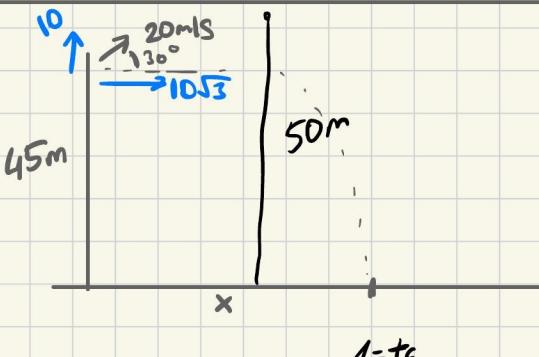
a) Yatayda ne kadar uzaga düşer?

$$V_0 = 11 \text{ m/s}$$

$$x = \frac{V_0^2 \sin 40^\circ}{g} = \frac{121 \cdot \sin 40^\circ}{9.8} = 7.93 \text{ metre}$$

b) Topın maks yükseliğidir

$$h = \frac{V_0^2 \cdot \sin^2 Q}{2g} = \frac{121 \cdot \sin^2 20^\circ}{9.8} = 0,72 \text{ m}$$



a) Top ne zaman yere çarpar?

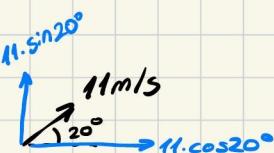
$$t_g = 15 \text{ s}$$

$$h_{\max} = 45 + 10 - 5 = 50 \quad | \quad 3.16 + 1 = \underline{\underline{4.16}}$$

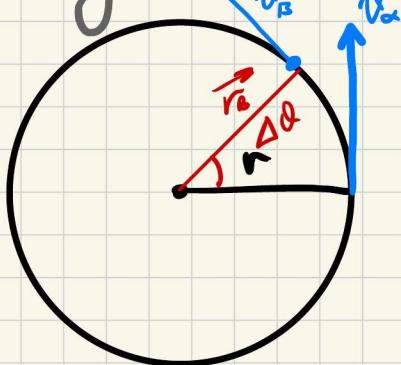
b) Topın yere çarpmaya hızı nedir?

$$31.35 \text{ m/s}$$

$$10 \cdot 1 - \frac{1 \cdot 10 \cdot 1}{2} = \underline{\underline{5 \text{ m}}}$$

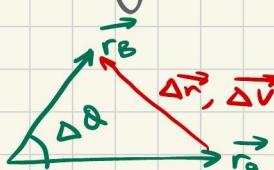


Dürgün Dairesel Hareket



$$\vec{a} = \frac{d\vec{v}}{dt}$$

merkezil iume: dairenin merkezine doğru olan iume



$$|\vec{v}_A| = |\vec{v}_B| = \varphi$$

$$|\vec{r}_A| = |\vec{r}_B| = r$$

$$\frac{|\Delta \vec{r}|}{r} = \frac{|\Delta \vec{v}|}{\varphi}$$

$$|\vec{a}_{\text{ort}}| = \frac{|\Delta \vec{v}|}{\Delta t}$$

$$\varphi = \lim_{\Delta t \rightarrow 0} \frac{|\Delta \vec{r}|}{\Delta t} = \frac{|\vec{dr}|}{dt} \quad \left. \right\} \text{anlitik hız}$$

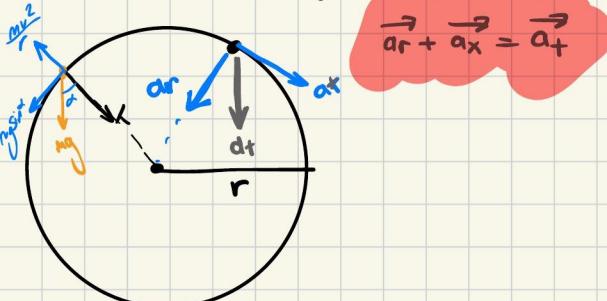
$$|\vec{a}_{\text{anlitik}}| = \frac{\varphi^2}{r} \quad \left. \right\} \text{merkezil iume}$$

Dürgün olmayan dairesel hareket

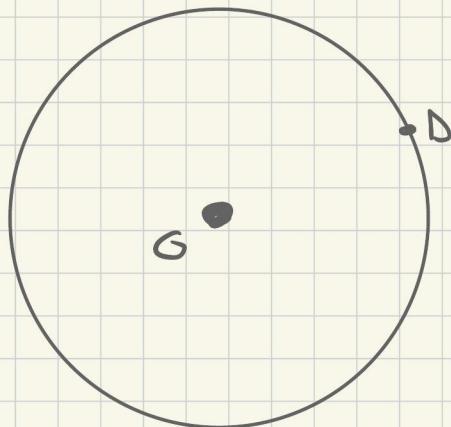
1- Hızın büyüklüğünün değişmesinden iume $\vec{a}_1 = \frac{d\vec{v}}{dt}$

2- Hızın yönünden dolayı iume

$$\vec{a}_2 = \frac{\varphi^2}{r} \vec{r}$$



Dünya'nın, güneş etrafında dönmesi sonucu merkezil iplerin galaktik nedir?



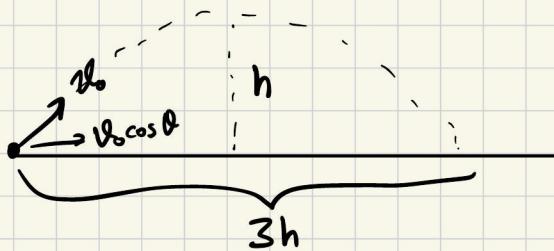
$$a = \frac{v^2 r}{r} \rightarrow$$

$$a = \frac{4\pi^2 r^2}{T^2 \cdot r}$$

$$\underbrace{2\pi r}_{\text{jol}} = \cancel{v} \cdot T$$

$$a = 5.93 \cdot 10^{-3} \text{ m/s}^2$$

Bir top yere den belli bir açıyla fırlatıldığında menzil uzaklığı yüksekliğinin 3 katı oluyor. $A\sin\theta = ?$



$$\frac{v_0^2 \cdot \sin 2\theta}{g} = 3h$$

$$\frac{3v_0^2 \cdot \sin^2 \theta}{2g} = 3h$$

$$\frac{3v_0^2 \cdot \sin^2 \theta}{2g} = \frac{v_0^2 \cdot \sin 2\theta}{g}$$

$$3 \sin^2 \theta = 2 \sin 2\theta$$

$$3s^2 = 2 - 4s^2$$

$$7s^2 = 2$$

$$s = \sqrt{\frac{2}{7}}$$

Orjinde

$$\vec{a} = 3\hat{j} \text{ m/s}^2$$

$$\vec{v}_0 = 5\hat{i} \text{ m/s}$$

ise

a) herhangi anda konum vek

$$x = \vec{r}_0 + \frac{1}{2}at^2$$

$$\vec{r} = 5\hat{i} + \frac{3\hat{j}}{2}t^2$$

b) hiz vek

$$\vec{v} = 5\hat{i} + 3\hat{j}t = \frac{d\vec{r}}{dt}$$

c) $t=2$ için koordinat, sürat

$$(10\hat{i}, 6\hat{j}) / 5\hat{i} + 6\hat{j} = \vec{v}$$

$$\sqrt{25+36} = |\vec{v}|$$

$$\text{m/s} = |\vec{v}|$$

Hareket Yasaları

Kuvvet: \vec{F}

- 1) Temas Kuvvetleri
- 2) Alan Kuvvetleri

1- Eylemsizlik

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

$$\vec{a} = \vec{0}$$

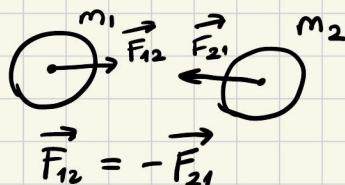
Kütle: Cismin hızının değişimine karşı gösterdiği direnç

2- $F = m \cdot a$ ($\text{kg}/\text{m.s}^2$)

$$m_1 \rightarrow a_1 \quad \frac{m_1}{m_2} = \frac{a_2}{a_1}$$

$$m_2 \rightarrow a_2$$

3- Etki/Tepki Prensibi



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

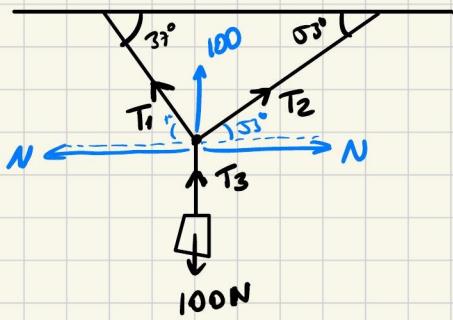
4- Kütle Gekim Kuvveti

$$\vec{F}_g \quad \vec{a} = \vec{g}$$

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

$$\vec{F}_g = m \cdot \vec{g}$$

$$\text{Ağırlık} = m \cdot g$$



$$\begin{aligned} T_2x &= T_2 \cos 53^\circ \\ T_2y &= T_2 \cdot \sin 53^\circ \end{aligned} \quad \left. \right\} =$$

$$T_1x = T_1 \cdot \cos 33^\circ$$

$$T_1y = T_1 \cdot \sin 33^\circ$$

$$T_1 = \frac{T_2 \cdot \sin 53^\circ}{\cos 33^\circ} = \frac{3T_2}{4}$$

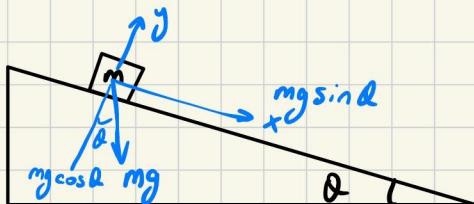
$$\frac{4}{5} (T_1 + T_2) = 100$$

$$\frac{3T_2}{4} + T_2 = 100$$

$$\frac{7T_2}{4} = 100$$

$$\frac{500}{7} = T_2$$

$$\frac{1500}{28} = T_1$$

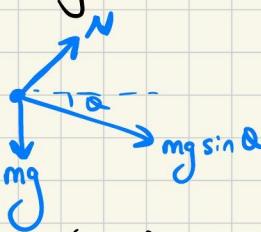


b) eğik düzleme "d" kadar yol
katederse hızı ne olur.

$$v^2 = v_0^2 + 2\alpha_x \cdot \underbrace{(x_s - x_0)}_d$$

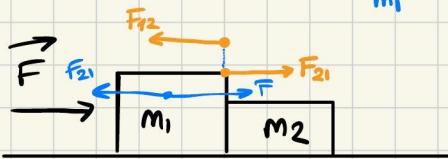
$$v = \sqrt{2g \sin \theta d}$$

a) bloğın hanesi:



$$\begin{aligned} mg \sin \theta &= m \cdot a_x \\ g \sin \theta &= a_x \end{aligned}$$

$$F_{12} \leftarrow \overrightarrow{F} \quad m_1$$



a) sistem hanesi:

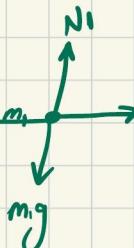
$$\sum F_x = m \cdot a_x$$

b) 1.'nin 2.'ye uyguladığı
kuvvet?

$$F = (m_1 + m_2) \cdot a_x$$

$$\frac{F - F_{21}}{m_1} = a_1 = a_x$$

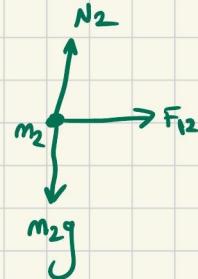
$$F_{21} \leftarrow \overrightarrow{F} \quad m_1$$



$$\frac{F}{m_1 + m_2} = \frac{F - F_{21}}{m_1}$$

$$F_{21} = F_{m_1} + F_{m_2} - F_{21}m_1 - F_{21}m_2$$

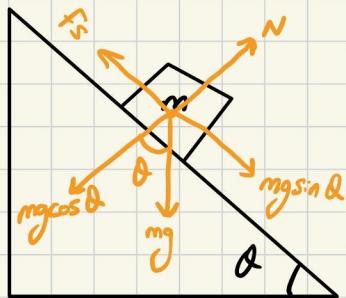
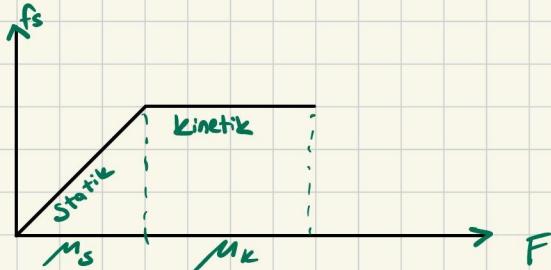
$$F_{21} = \left(\frac{m_2}{m_1 + m_2} \right) \cdot F \quad \rightarrow$$



$$\frac{F_{12}}{m_2} = \frac{F}{m_1 + m_2}$$

$$F_{12} = -F \left(\frac{m_2}{m_1 + m_2} \right)$$

Sürünme Kuvveti



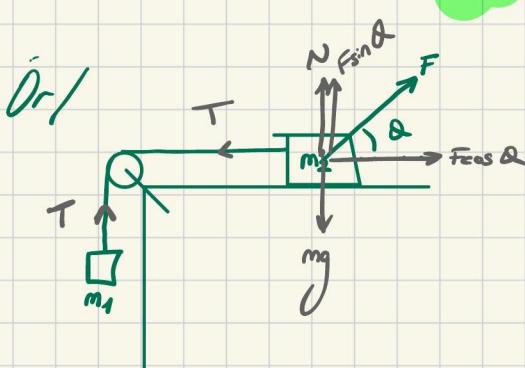
Ör/ $N = mg \cos \theta$

$f_s = \mu_s N = \mu_s mg \cos \theta$

Eğer $\sum F_x = D$ ise hiz kesit yoldur.

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

$\mu_s = \tan \theta_c$



İnmeleri gösteriniz.

$$\frac{T - m_1 g}{m_1} = \frac{F \cos \theta - T - \mu(m_2 g - F \sin \theta)}{m_2}$$

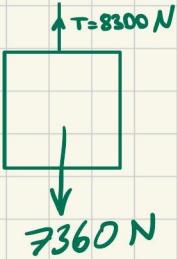
$m = 3 \text{ kg}$ $\alpha = 50^\circ$
 static sürtünme k = 0,25 ise
 cisim dengede tutacak muhtemel F nedir?

$N = F \cos \alpha$
 $f_s = \mu F \cos \alpha$
 $f_s = F \sin \alpha + mg = \mu F \cos \alpha$
 $F = \frac{mg}{\mu \cos \alpha + \sin \alpha} = 31.72 \text{ N}$

$F \sin \alpha = mg + \mu F \cos \alpha$
 $F = 48.56 \text{ N}$

1. Durum

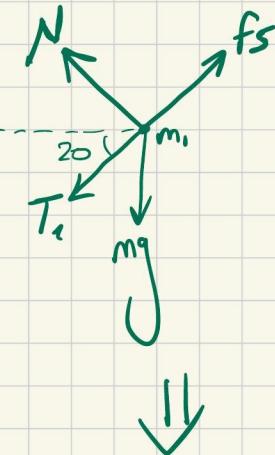
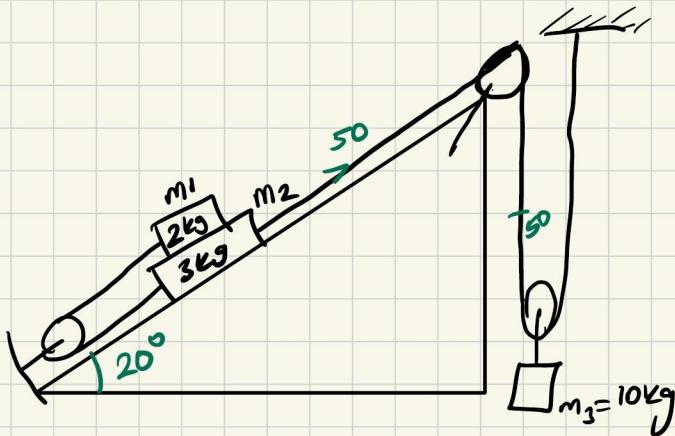
Or/
75 kilo insan taşımak isteniyor.



$$\frac{940}{750} = \frac{1,25 \text{ m/s}^2}{9,8}$$

$$\underline{+ \frac{}{11,05 \text{ m/s}^2}}$$

$$11,05 \cdot 75 = 82,8 \text{ N}$$



$$m_1 a = T_1 + m_1 g \sin 20^\circ - \mu_k m_1 g \cos 20^\circ$$

$$2a - 2 = T_1$$

$$m_2 a = T_2 - m_2 g \sin 20^\circ - F_{s2} - F_{s1} - T_1$$

$$3a = T_2 - 75 - T_1$$

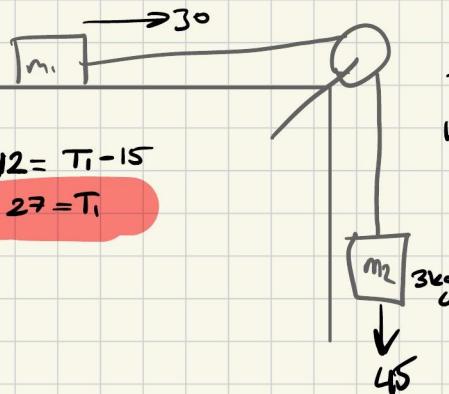
$$F_{s2} = \mu_k N_2$$

$$m_3 g - 2T_2 = m_3 \cdot \frac{a}{2}$$

Sekilde yukarıda doğru $A = 5 \text{ m/s}^2$ 'lik ivmeyle hareket etmekte olan asansörin içinde serbest bırakılan sistende jatayoların kinetik sürtünme katsayısı 0,5

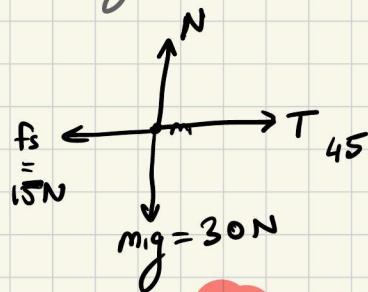
$$m_1 = 2 \text{ kg}$$

$m_2 = 3 \text{ kg}$ old. göre blokların ivmeleri bireydir.



$$12 = T_1 - 15$$

$$27 = T_1$$



$$\frac{30}{5} = 6$$

$$45 - T_1 = 18$$

$$T_1 = 27$$

2 koşu sporcusu durgun holden aynı anda 100 metre koşuyor başlıyor.
 Her iki sporcunun 10.2 sn'de koşuyor oluyor. 1. koşucunun hızı = $2sn$
 2. koşucunun hızı = $3sn$
 ve sonra sırasıyla hızda ilerliyorlar. Koşucuların hızları nedir?

$$x_{s_1} = \frac{1}{2} a_1 t^2 = 2a_1$$

$$x_{s_2} = \frac{1}{2} a_2 t^2 = 4,5a_2$$

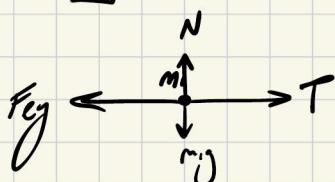
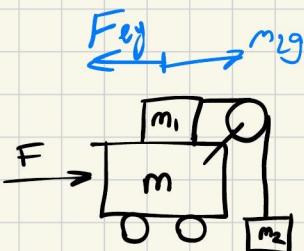
$$x_1 = \sqrt{0_X^{(82)} + 2a_1} = 100$$

$$x_2 = \sqrt{0_Y^{(7.2)} + 4,5a_2} = 100$$

Blokların orabanga göre hareketsiz kalabilmesi için uygulanması gereken $F = ?$

(Top yüzüleri, tekerlekler, makaslar sürünmezdir.)

(iptek gerilmesi m_1 kütlesi meydana getirir)



$$F = (m + m_1 + m_2) a$$

$$a = \frac{F}{m+m_1+m_2}$$

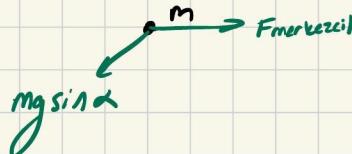
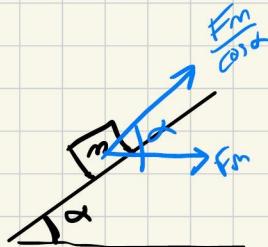
$$F_{\text{ey}} = \frac{F \cdot m_1}{m + m_1 + m_2} = T$$

$$m_2 g =$$

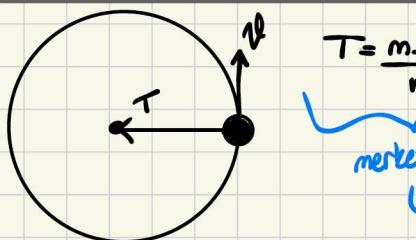
Bir mühendis arabaların sürütmeye gücüksizin saatlarda dönebileceğini
ğünlük bir otogel istiyor.

$$v = 134 \text{ m/s'lik hız}$$

$$\text{virajın yarıçapı} = 50 \text{ m}$$



Dairesel Hareket



$$T = \frac{m \cdot v^2}{r}$$

$$\text{merkezil kuvvet } (F_r) = m \cdot a_r = \frac{m \cdot v^2}{r}$$

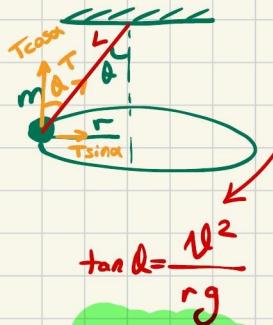
$$T_2 = mg \left(\frac{v^2}{r \cdot g} - 1 \right)$$

$$T_1 = mg \left(1 + \frac{v^2}{r \cdot g} \right)$$

$$T - mg \cos \alpha = \frac{m \cdot v^2}{r}$$

$$T_3 = mg \left(\cos \alpha + \frac{v^2}{r \cdot g} \right)$$

$$v = \sqrt{r \cdot g}$$



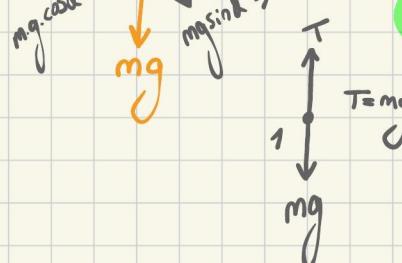
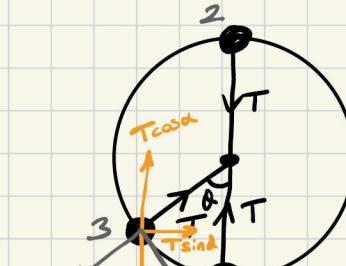
$$T \sin \alpha = \frac{m v^2}{r}$$

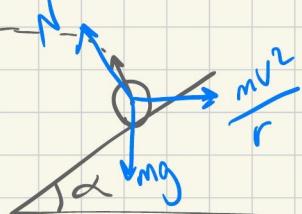
$$T \cos \alpha = mg$$

$$\tan \alpha = \frac{v^2}{r \cdot g}$$

$$v = \sqrt{r \cdot g \cdot \tan \alpha}$$

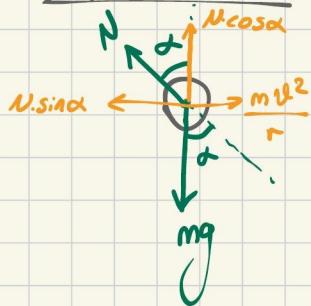
$$v = \sqrt{L \cdot g \cdot \sin \alpha \cdot \tan \alpha}$$





Tekerteyle y/! arasında sırtlanmaz ortamda
ilerlemesi için ağırlığı? $\alpha = ?$

$$v = 13.4 \text{ m/s} \quad r = 35 \text{ m}$$



$$\frac{N \sin \alpha}{N \cos \alpha} = \frac{mv^2}{r g} = \tan \alpha = \frac{v^2}{rg}$$

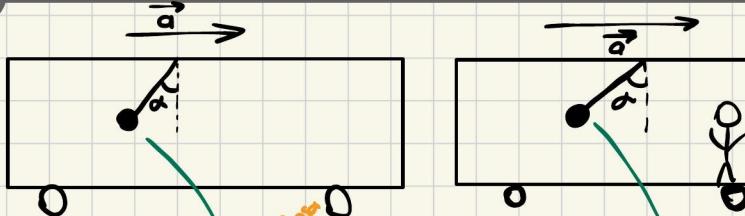
$$N \cos \alpha = mg$$

$$v = \sqrt{rg \tan \alpha}$$

$$13.4 = \sqrt{35(9.8) \tan \alpha}$$

$$\alpha = 27.6^\circ$$

Eşemli referans Sisteminde Hareket



$$F_y = m \cdot a$$

$$T \cos \alpha = mg$$

$$T \sin \alpha = M \cdot a$$

$$T \cos \alpha = mg$$

$$T \sin \alpha = M \cdot a$$

$$\sum F_y = 0 \Rightarrow T \sin \alpha = mg$$

$$T \cos \alpha = M \cdot a$$

$$F_y = T \sin \alpha$$

Direnç Ortamında Hareket

$$R = \text{direnç Kuvveti} \sim v, v^2$$

$$v_0 = 0$$

$$\sum F = m \cdot a$$

$$mg - kv = m \cdot \frac{dv}{dt}$$

$$\frac{dv}{dt} = g - \frac{kv}{m}$$

$$\int \frac{dv}{g - \frac{kv}{m}} = \int dt$$

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

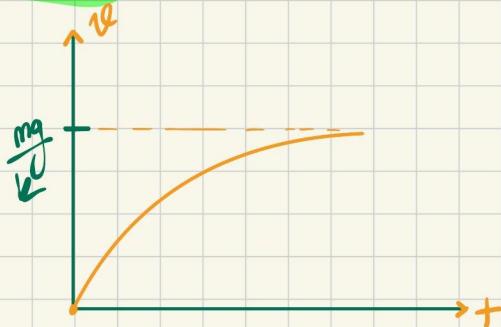
$$\downarrow$$

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

$$v_{\text{limit}} = \frac{mg}{k}$$



$$R = -k \cdot v$$



Cmanın hızının \lim hızın
% 63.2 degerine ulaşması için
gereken süreye zaman sabiti denir.

2 gr kitleli cisim yay içerişinde serbest
birakılıyor. Cisim yaydan bir direnç hissediyor.

$$v_{\text{in}} = 5 \text{ cm/s}$$

a) zaman sabiti:

b) hızın, limit hızın %90'ı ulaşması için geçen

$$\frac{mg}{k} = v_{\text{in}}$$

$$v = v_{\text{in}} \left(1 - e^{-\frac{t}{\tau}} \right)$$

süre

$$\frac{2 \cdot (980)}{5} = 392 \text{ gram/saniye} = k$$

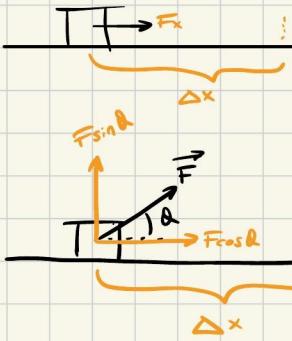
$$t = -5.1 \times 10^3 \ln(0.1) = 0.01 \text{ sn}$$

$$k = \frac{m}{\tau(s)} \rightarrow \text{s/s} \quad \tau = \frac{2}{392} \approx 5.1 \text{ m/s}$$

İz ve Enerji

Sabit Kuvvetin Yaptığı iş

$$W \equiv F_x \cdot \Delta x$$



$$W = F \cos \theta \cdot \Delta x$$

Conclusion

* Kuvvet, yer değiştirmeye gittiğinde iş yapmaktadır.

Skaler çarpım gereklidir.

$$W = F \cdot \Delta r \cdot \cos \theta$$

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

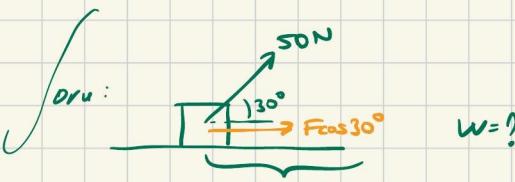
$$W = \vec{F} \cdot \vec{\Delta r}$$

Skaler çarpım

$$W = \vec{F} \cdot \vec{\Delta r}$$

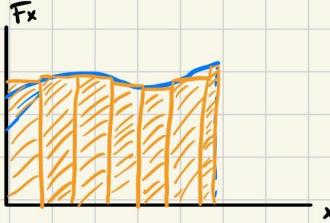
$$N \cdot m = kg \cdot \frac{m^2}{s^2}$$

1 joule = Bir cisim 1 Newton kuvvet uygulaması ile 1 metre yer değiştirmesi sonucu kazandığı enerjiye denir.



$$50 \cdot \cos 30^\circ \cdot 3 = \frac{150\sqrt{3}}{2} = 75\sqrt{3}$$

Degisken Kuvvetin Yaptigi is



$$W \approx \Delta x_1 \cdot F_1 + \Delta x_2 \cdot F_2 + \dots$$

$$W \approx \sum_{i=1}^n F_i \Delta x_i$$

$$W = \lim_{\Delta x_i \rightarrow 0} \sum_{i=1}^{\infty} F_i \Delta x_i$$

$$\vec{F} = F_x \cdot \hat{i} + F_y \cdot \hat{j} + F_z \cdot \hat{k}$$

$$d\vec{r} = dx \cdot \hat{i} + dy \cdot \hat{j} + dz \cdot \hat{k}$$



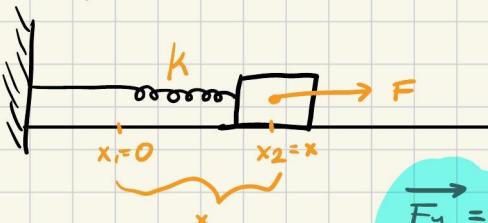
$$\vec{F} \cdot d\vec{r} = F_x \cdot dx + F_y \cdot dy + F_z \cdot dz$$

Vektörel Görümlü

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

||
↓

Yay Kuvvetinin Yaptigi is



$$\vec{F} = F_x \cdot \hat{i}$$

$$F \sim x$$

$$\vec{F}_y = -k \cdot x \cdot \hat{i}$$

$$W = \int \sum \vec{F} \cdot d\vec{r}$$

$$W = -k \int_0^x x \cdot dx$$

$$W = -\frac{1}{2} k x^2$$

İş - Kinetik Enerji Teoremi

$$W = \int \sum \vec{F} \cdot d\vec{r}$$

$$\sum \vec{F} = m\vec{a} = m \cdot \frac{d\vec{v}}{dt}$$

$$W = \int m \cdot \frac{d\vec{v}}{dt} \cdot d\vec{r}$$

$$W = m \int d\vec{v} \cdot \frac{d\vec{r}}{dt}$$

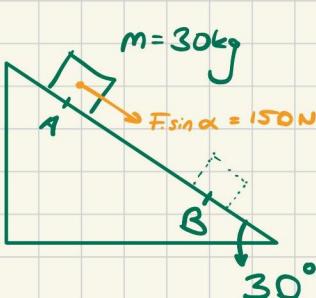
$$W = m \int_{v_i}^{v_s} v \cdot d\vec{v}$$

$$W = \frac{m \cdot v^2}{2} \Big|_{v_i}^{v_s}$$

$$W = \frac{1}{2} m \cdot v_s^2 - \frac{1}{2} m \cdot v_i^2$$

$$K_{(\text{kinetik enerji})} = \frac{1}{2} m v^2$$

$$W = \Delta K = K_s - K_i$$



$$\Delta x = 15 \text{ m}$$

$$v_A = 2 \text{ m/s}$$

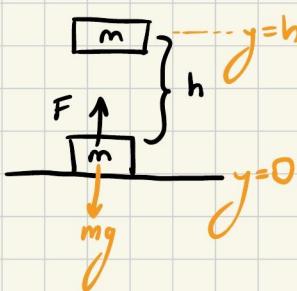
$$v_B = ?$$

$$150 \cancel{N} = \frac{30 \cdot 2^2}{2} - \frac{30 \cdot v_B^2}{2}$$

$$150 = \frac{30(4 - v_B^2)}{2}$$

$$12.08 = \sqrt{146} = v_B$$

Kütte Getim Potansiyel Enerjis:



$$W = \int \sum \vec{F} \cdot d\vec{r}$$

$$\sum \vec{F} = \vec{F}_g = mg\hat{j}$$

$$d\vec{r} = dy\hat{j}$$

$$W = mgh$$

$$U_{(\text{pot. enj})} = mgh$$

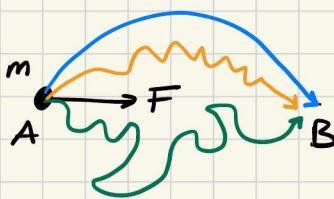
Elastik Potansiyel Enerji



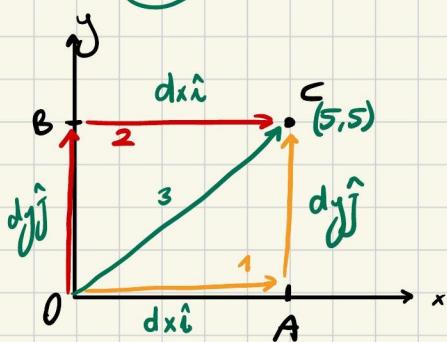
$$W = k \int_0^x x \, dx = \frac{1}{2} kx^2$$

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

Korunumlu Kuvvetler



Yapılan iş, yola bağlı değilse, yani giden yoldan bağımsızsa **Korunumlu Kuvvet** denir.



$$\vec{F} = 2y\hat{i} + x^2\hat{j}$$

Bu cisim üç farklı yolla gitmektedir. Korunumlu kuvveti arastırınız.

$$W_{OA} = \int \vec{F} \cdot d\vec{r}$$

$$W_{OA} = \int_0^5 (2y\hat{i} + x^2\hat{j}) \cdot (dx\hat{i})$$

$$W_{OA} = 2 \int_0^5 y \, dx = 0$$

$O \rightarrow A$ 'da j iderken
is j palpated.

$$W_{AC} = \int_0^5 (2y\hat{i} + x^2\hat{j}) \cdot dy\hat{i} = x^2 \int_0^5 dy = x^2 \left(y \Big|_0^5 \right)$$

$W_{AC} = 5^2 \cdot 5 = 125 \text{ Joule}$

$W_{OB} = \int (2y\hat{i} + x^2\hat{j}) \cdot (dy\hat{j})$ $\int x^2 \, dy = 0$	$W_{BC} = \int (2y\hat{i} + x^2\hat{j}) \cdot dx\hat{i}$ $2y \int_0^5 dx = 2 \cdot 5 \cdot 5 = 50 \text{ Joule}$
--	---

Korunaklı Kuvvetler bir sistemin potansiyel enerji fonksiyonlarından türetilirler.

$$\Delta K + \Delta U = 0$$
$$W = \int \vec{F} \cdot d\vec{r} = \Delta K = -\Delta U (x, y, z)$$
$$\vec{F} \cdot d\vec{r} = -dU (x, y, z)$$
$$\Downarrow$$
$$F_x dx + F_y dy + F_z dz = -dU (x, y, z)$$
$$\vec{F} = -\vec{\nabla} U$$

$\int \partial r^U:$ $U(x, y) = 3x^3y - 7x$ sisteme etki eden kuvveti bulunuz.
pot. enj fonksiyonu

$$\vec{F} = - (9x^2y - 7) \hat{i} - (3x^3) \hat{j}$$

$$\vec{F}_x = -9x^2y + 7$$
$$\vec{F}_y = -3x^3$$

Soru: Bir cisimme $F = 4x\hat{i} + 3y\hat{j}$ etki ediyor.
 $x=5$ noktasında hareket ediyor. işi bulunuz.

$$W = \int \sum \vec{F} \cdot d\vec{r}$$

$$\sum \vec{F} = 4x\hat{i} + 3y\hat{j}$$

$$d\vec{r} = d\vec{x}$$

$$W = \int_0^5 4x \, dx \quad 2x^2 \Big|_0^5 = 50 \text{ Joule}$$

Soru: 3 kg kütleyeli cismin hız vektörü $\vec{v} = (6\hat{i} - 1\hat{j}) \text{ m/s}$ ile hareket ediyor. 555 J

a) Cismin $K = ?$

$$\frac{mv^2}{2} \rightarrow \frac{1}{2} \cdot 3 \cdot \underbrace{[(6\hat{i} - \hat{j}) \cdot (6\hat{i} - \hat{j})]}_{3 \Rightarrow} = \frac{101}{2} = 55.5 \text{ Joule}$$

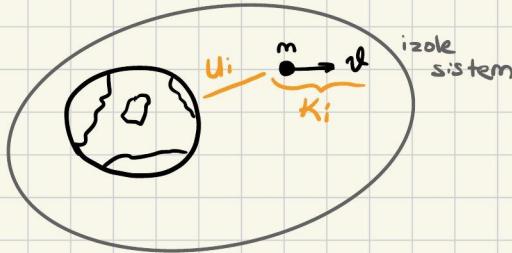
b) Cismin hızı $(8\hat{i} + 4\hat{j}) \text{ m/s}$ değerine değişirse ne kadar iş yapılmıştır?

$$\frac{3}{2} \cdot (8\hat{i} + 4\hat{j})^2 = 120 \text{ Joule}$$

$$120 - 55.5 = 64.5$$

Enerji Korunumu

izole Oluşan Sistem

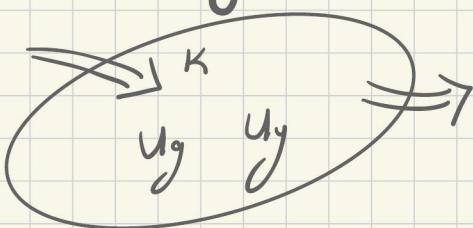


$$\sum E_i = \sum E_s$$

$$K_i + U_i = K_s + U_s$$

$$\Delta K + \Delta U_g + \Delta U_y = 0$$

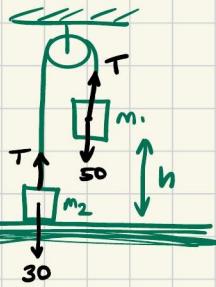
izole Olmayan Sistem



$$W = \int \sum \vec{F} \cdot d\vec{r}$$

$$W_s = - \int f \cdot ds$$

Joru:



$$m_1 = 5 \text{ kg}$$

$$m_2 = 3 \text{ kg}$$

$$h = 4 \text{ m}$$

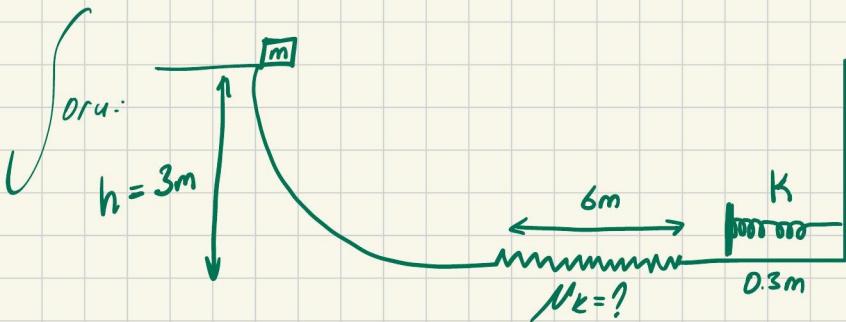
m_1, m_2 aynı yükseklikte hızları ne olur?

$$E_1 = E_s = 50 \cdot 4 = 200 \quad V_1 = V_2 = V$$

$$200 = 80 \cdot 2 + \frac{m_1 V_1^2}{2} + \frac{m_2 V_2^2}{2}$$

$$40 = 4V^2$$

$$\sqrt{10} = V$$



$$m = 10 \text{ kg}$$

$$E = 300 \text{ J}$$

$$E_{\text{Säntinne}} = 600 \cdot M_K$$

$$(U_{j_s} - U_{j_i}) + (U_{y_s} - U_{y_i}) + (K_s - K_i) = 0$$

$$300 - 600 M_K = \underbrace{\frac{1}{2} k \cdot x^2}_{101.25}$$

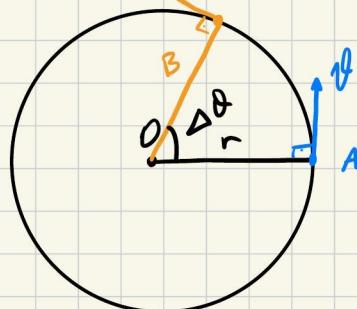
$$M_K = 0.33$$

$$300 - 600 M_K = \frac{1}{2} 225 \cdot \frac{9}{10}$$

$$M_K = 0.33$$

Düzgün Dairesel Hareket

- Hizin büyüklüğü sabittir.



$$\vec{r}_A - \vec{r}_B = \Delta \vec{r}$$

$$|\vec{v}_A| = |\vec{v}_B| = v$$

$$|\vec{r}_A| = |\vec{r}_B| = r$$

$$\frac{|\Delta \vec{r}|}{r} = \frac{|\Delta \vec{\vartheta}|}{\ell}$$

$$|\Delta \vec{\vartheta}| = \frac{\ell}{r} |\Delta \vec{r}|$$

$$|\vec{a}_{\text{ort}}| = \frac{\Delta v}{\Delta t}$$

$$|\vec{a}_{\text{ort}}| = \frac{\ell}{r} \cdot \frac{|\Delta \vec{r}|}{\Delta t}$$

$$a = \frac{\ell^2}{r}$$

merkezil iume büyüğlüğü



1) Hızın büyüklüğünün
değişiminden dolayı sahip olduğu iume

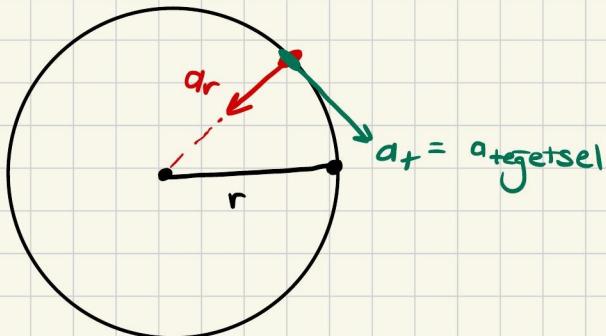
$$a_1 = \frac{d\mathcal{V}}{dt}$$

2) Hızın yönünün değişmesinden dolayı sahip olduğu iume

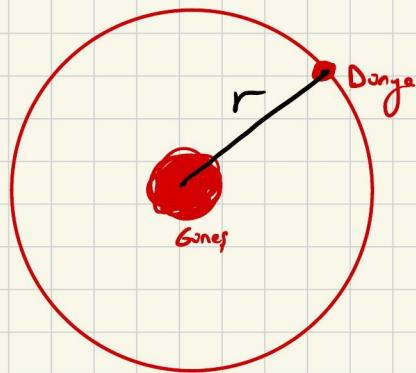
$$a_{toplam} = \vec{a}_1 + \vec{a}_2$$

$$a_2 = \frac{\mathcal{V}^2}{r}$$

Dairesel Hareket



Dünyanın Güneş etrafında dönmesi sonucu sahip olduğu merkezil ıvme nedir?

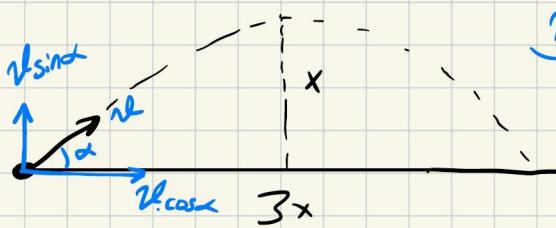


$$a = \frac{v^2}{r}$$

$$2\pi r = vt$$

$$\frac{\left(\frac{2\pi r}{t}\right)^2}{r} = \frac{4\pi^2 r}{t^2} = a$$

Bir t saniye yerden belli bir açıyla fırlatılmış



$$\underbrace{v \sin \alpha}_{10} t - \frac{g t^2}{2} = x$$

$$v \sin \alpha = 10t$$

$$\underbrace{10t^2 - 5t^2}_{5t^2} = x$$

$$\tan \alpha = \frac{10}{2} \cdot \frac{2}{3}$$

$$v \cos \alpha \cdot 2 = 15t$$

$$v \cos \alpha = \frac{15}{2} +$$

$$\alpha = 53^\circ$$

Başlangıçta bir paracagının $\vec{a} = 3\hat{j} \text{ m/s}^2$

x konum vektörü = ?

h_{12} vektörü = ?

$t=2$ saniye koordinat = ?

$t=2$ saniye sırası = ?

$$x = 0 + 5t + \frac{3\hat{j} t^2}{2}$$

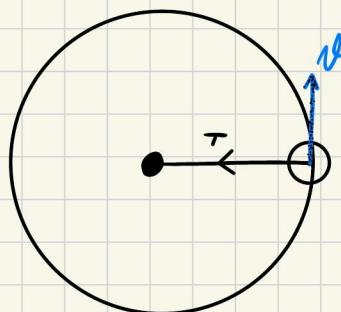
$$x = 5t\hat{i} + \frac{3t^2}{2}\hat{j}$$

$$\vec{v} = 5\hat{i} + 3\hat{j}$$

$$(10, 6)$$

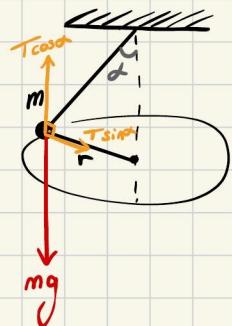
$$(5\hat{i} + 6\hat{j}) = h_{12}$$

$$\sqrt{25+36} = \sqrt{71} = \text{sırası}$$

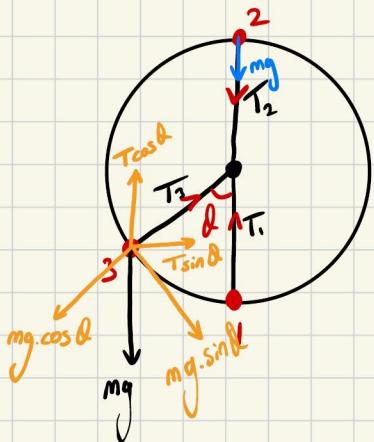


$$T = \frac{m \cdot \mathcal{V}^2}{r}$$

$$F_r = m \cdot a_r = \frac{m \cdot \mathcal{V}^2}{r}$$



$$\begin{aligned} T \sin \alpha &= \frac{m \cdot \mathcal{V}^2}{r} \\ T \cos \alpha &= mg \end{aligned} \Rightarrow \mathcal{V} = \sqrt{r \cdot g \cdot \tan \alpha}$$

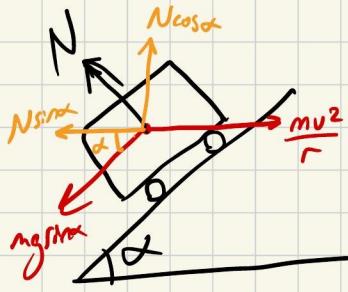


$$3) T - mg \cos \alpha = \frac{m \cdot \mathcal{V}^2}{r}$$

$$T_3 = mg \left(\cos \alpha + \frac{\mathcal{V}^2}{g} \right)$$

$$T_1 = mg \left(1 + \frac{\mathcal{V}^2}{rg} \right) = mg + \frac{m \cdot \mathcal{V}^2}{r}$$

$$T_2 = \left(\frac{m \cdot \mathcal{V}^2}{r} - mg \right)$$



$$v = 13.4 \text{ m/s}$$

$$r = 35 \text{ m}$$

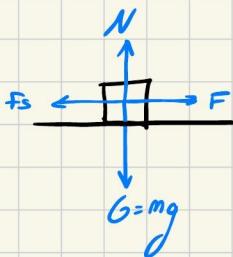
$$N \sin \alpha = \frac{mv^2}{r}$$

$$N \cos \alpha = mg$$

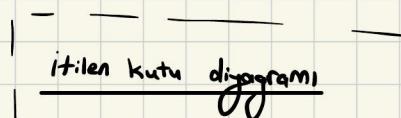
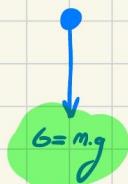
$$\tan \alpha = \frac{v^2}{rg}$$

Serbest Cism Diyagramı

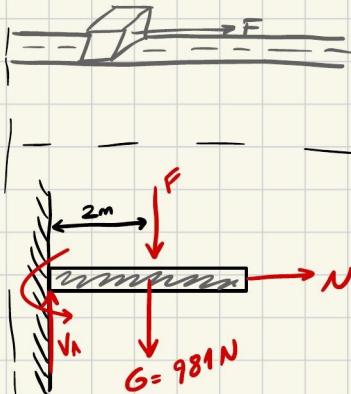
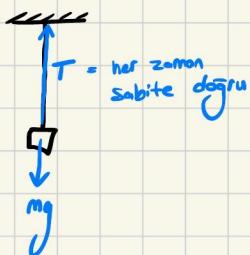
Üstünde cisme etki eden bütün kuvvetler ölçeksiz gösterilir.

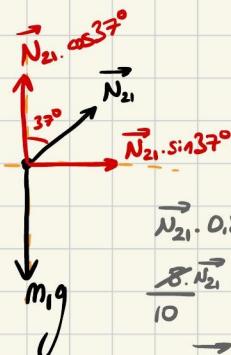
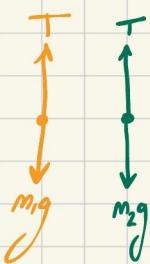
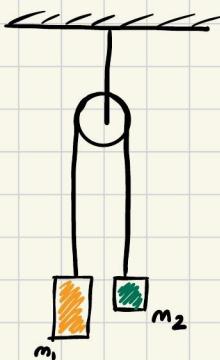
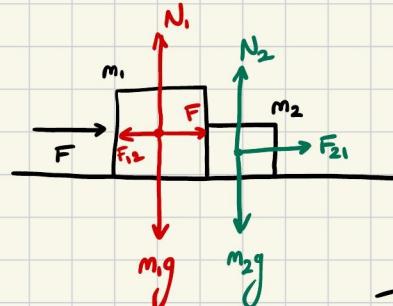
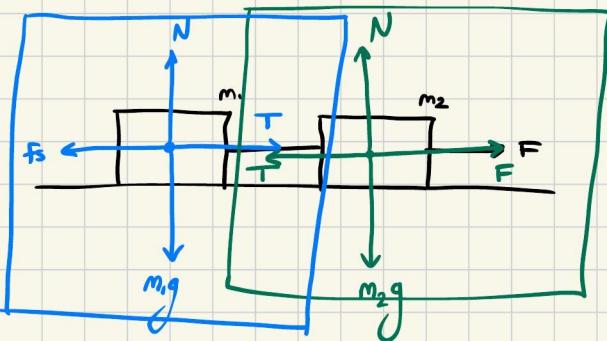
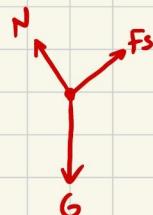
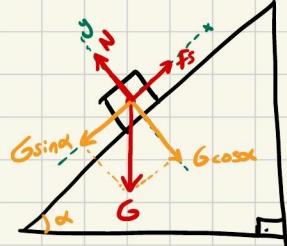
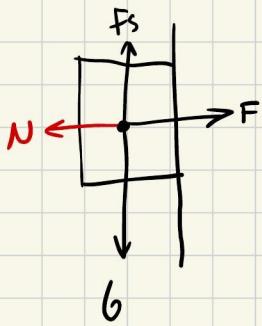


Tas binanın tepesinden bırakılıyor. Tasa etkiyen kuvvet diyagramı = ?



Tavandaki avize serbest cisim diyagramı





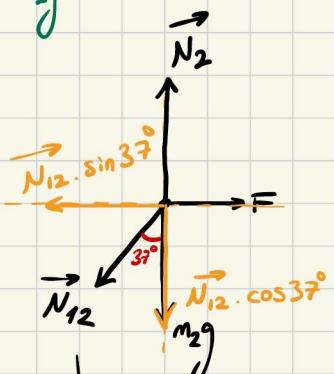
$$\frac{N_{21} \cdot 0,8}{10} = m_1 \cdot g$$

$$\frac{8 \cdot N_{21}}{10} = 24$$

$$N_{21} = 30 \text{ N}$$

$$\frac{N_{21} \cdot 6}{10} = 2,4 \cdot g$$

$$\frac{30}{4} = \frac{3}{0,4} = \frac{18}{2,4} = 9$$

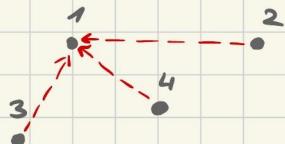


$$F - \frac{N_{12} \cdot 6}{10} = 4 \cdot 30$$

$$-\frac{-30 \cdot 6}{10} = 30$$

$$F = 48$$

Lineer Momentum ve Korunumu



$$\sum \vec{F}_1 = \cancel{\vec{F}_{21}} + \cancel{\vec{F}_{31}} + \cancel{\vec{F}_{41}}$$

$$\sum \vec{F}_2 = \cancel{\vec{F}_{32}} + \cancel{\vec{F}_{12}} + \cancel{\vec{F}_{42}}$$

Bir kuvetsiz düzlemede kütlelerin birbirine uyguladığı toplam kuvvet "0" dir.

$$+$$

$$\sum \vec{F}_1 + \sum \vec{F}_2 + \sum \vec{F}_3 = 0$$

$$m_1 \vec{a}_1 + m_2 \vec{a}_2 + m_3 \vec{a}_3 = 0$$

$$m_1 \frac{d\vec{v}_1}{dt} + m_2 \frac{d\vec{v}_2}{dt} + m_3 \frac{d\vec{v}_3}{dt} = 0$$

$$\frac{d}{dt} (m_1 \vec{v}_1 + m_2 \vec{v}_2 + m_3 \vec{v}_3) = 0$$

$$M \cdot \vec{V} = \vec{P}$$

$$* a = \frac{dV}{dt}, \alpha = \frac{d\omega}{dt}$$

Kuvetsiz sisteme $P_i = P_s$

* Dışardan kuvvet uygulanmıyorsa lineer momentum muhakkak eşittir.

Soru: Sürünmesiz düzlemede 50kg okun 0,5kg katlet bir ok fırlatıyor. Okun hızı 50m/s ise okunun hızı?

$$50 \cdot x \xleftarrow{\text{kg.m/s}} 0,5 \cdot 50 = 25 \text{ kg.m/s}$$

$$x = -0,5 \text{ m/s}$$

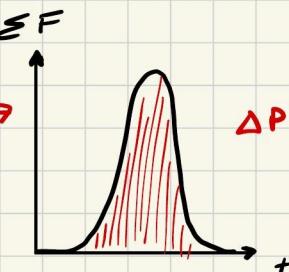
$$\sum \vec{F} = m \cdot \frac{d\vec{U}}{dt}$$



$$\sum \vec{F} = \frac{d\vec{P}}{dt}$$



$$\int_{P_i}^{\vec{P}_s} d\vec{P} = \int_0^+ \sum F \cdot dt$$



$$\Delta P = itme$$

$$F_{ort+} = \frac{1}{\Delta t} \int_{t_1}^{t_2} \sum F \cdot dt$$

itme (Impuls) =
anlık
momentum değişimi

1500kg otomobil duvara çarptırılıyor. Otomobilin çarpışmadan önceki ve sonraki hızları

$$\vec{v}_i = -15 \hat{i} \text{ m/s}$$

$$\vec{v}_s = 2.6 \hat{i} \text{ m/s}$$

Eğer çarpışma 0.15sn süreyörən çarpışma itmeyi ve otomobile etki eden ortalama kuvveti bulunuz.

$$2) 26500 = \frac{15}{100} \cdot F_{ort+} \quad 1)$$

$$-22500 \hat{i} \text{ kg.m/s} \xleftarrow[1500 \cdot -15 =]{\quad} \xrightarrow{\quad} 3900 \hat{i} \text{ kg.m/s}$$

$$176000 N = F_{ort+}$$

$$\Delta P = 26400 \hat{i}$$

Garpisimalar



$$\sum \vec{P}_i = \sum \vec{P}_s$$

* Dışarıdan kuvvet bulunmazsa
tüm lineer durumlarda

$$m_1 v_{1i} + m_2 v_{2i} \dots = m_1 v_{1s} + m_2 v_{2s} \dots$$

eğer esnekse kinetik enerji korunacağından:

$$\frac{m_1 v_{1i}^2}{2} + \frac{m_2 v_{2i}^2}{2} + \dots = \frac{m_1 v_{1s}^2}{2} + \frac{m_2 v_{2s}^2}{2} + \dots$$

$$\vec{v}_{1i} + \vec{v}_{1s} = \vec{v}_{2i} + \vec{v}_{2s} = \dots$$



$$v_{1s} = \left(\frac{m_1 - m_2}{m_1 + m_2} \right) v_{1i} + \left(\frac{2m_2}{m_1 + m_2} \right) v_{2i}$$

$$v_{2s} = \left(\frac{m_2 - m_1}{m_2 + m_1} \right) v_{2i} + \left(\frac{2m_1}{m_1 + m_2} \right) v_{1i}$$

1. Durum



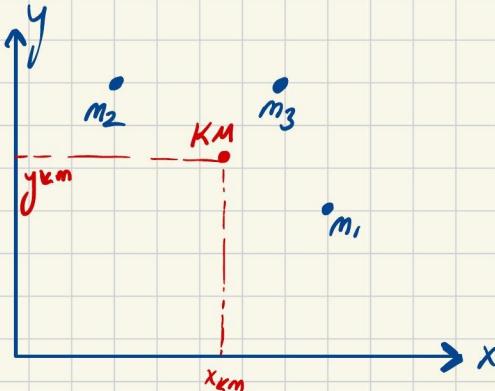
* m₂ ihmal edilebilecek kadar küçük

$$v_{1s} = -v_{1i}$$

$$v_{2s} \approx 0$$

$$v_{2s} \approx 0$$

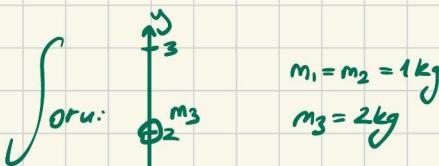
Kütle Merkezi



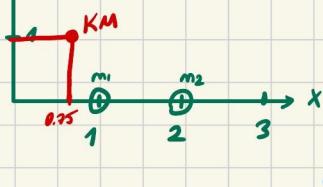
$$x_{km} = \frac{m_1 x_1 + m_2 x_2 + \dots}{m_1 + m_2 + m_3 \dots}$$

$$x_{km} = \frac{1}{M} \sum_{i=1}^n m_i x_i$$

$$y_{km} = \frac{1}{M} \cdot \sum_{i=1}^n m_i y_i$$



$$\begin{aligned} m_1 &= m_2 = 1 \text{ kg} \\ m_3 &= 2 \text{ kg} \end{aligned}$$



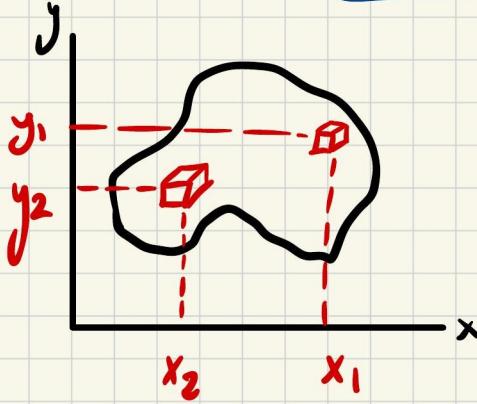
$$x_{km} = \frac{3}{4} = 0,75 \text{ m}$$

$$y_{km} = \frac{4}{4} = 1 \text{ m}$$

$$\vec{r}_{km} = x_{km} \hat{i} + y_{km} \hat{j} + z_{km} \hat{k}$$

Sürekli Kütle Dağılımına Sahip Cisimlerin

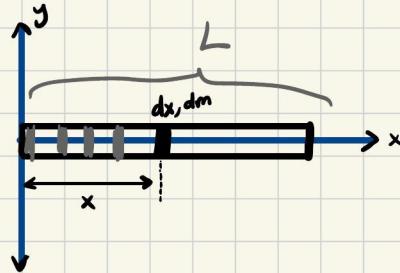
Kütle Merkezleri



$$x_{km} \approx \frac{1}{M} \sum_{i=1}^n \Delta m_i x_i$$

$$x_{km} \approx \frac{1}{M} \cdot \lim_{\Delta m_i \rightarrow 0} \sum_{i=1}^{\infty} \Delta m_i x_i$$

$$x_{km} = \frac{1}{M} \int y \, dm$$



$$\frac{L}{dx} > \frac{M}{dm}$$



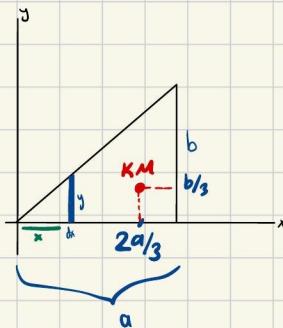
$$dm = \frac{M}{L} dx \quad | \quad dm = \lambda dx$$

gizisel kütte yoğunluğu

$$X_{KM} = \frac{1}{M} \int x dm$$

$$X_{KM} = \frac{1}{M} \int_0^L x \lambda dx$$

$$X_{KM} = \frac{\lambda}{M} \cdot \frac{L^2}{2} = \frac{1}{2} L$$



$$dm = \nabla dA$$

$$\nabla = \frac{M}{A}; \quad dA = y dx$$

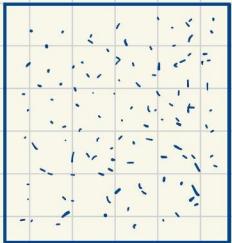
$$dm = \nabla y dx$$

$$X_{KM} = \frac{1}{M} \int x dm$$

$$X_{KM} = \frac{\nabla}{M} \int_0^a x y dx$$

$$X_{KM} = \frac{2a}{3}$$

$$y_{KM} = \frac{b}{3}$$



$$\vec{r}_{km} = \frac{1}{M} \sum_{i=1}^n m_i \vec{r}_i$$

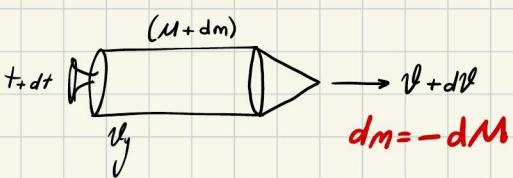
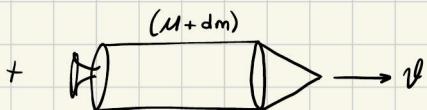
$$\overline{\vec{v}_{km}} = \frac{d\vec{r}_{km}}{dt} = \frac{d}{dt} \left[\frac{1}{M} \sum_i m_i \vec{r}_i \right]$$

$$M \overline{\vec{v}_{km}} = \sum_i m_i \vec{v}_i$$

$$\vec{a}_{km} = \frac{d\overline{\vec{v}_{km}}}{dt} = \frac{d}{dt} \left[\frac{1}{M} \sum_i m_i \vec{v}_i \right]$$

$$M \vec{a} = \sum_i m_i \vec{a}_i \rightarrow \vec{F} = \sum_i \vec{F}_i$$

Roket Hareketi:



$$dm = -dM$$

+ anında

$$(M+dm)v = M(v+dv) + dm(v - v_f)$$

$$v_f = v_i + v_f \ln \left(\frac{M_i}{M_f} \right)$$

$$T = M \cdot \frac{dv}{dt} \rightarrow T = \left| v_f \frac{dM}{dt} \right|$$

Roket hızı $3 \cdot 10^3 \text{ m/s}$

Bu anda roket atesleniyor.

Roketin yakıtı $5 \cdot 10^3 \text{ m/s}$ 'lik hızla terk ediyor

Roketin hızı: yanıyor düşerse yere göre hızı = ?

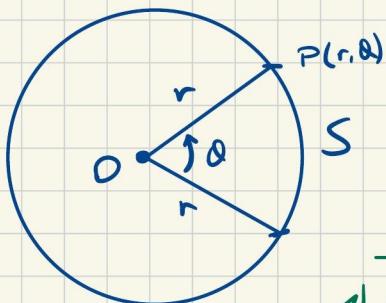
$$V_s = V_i + g_L \ln \left(\frac{M_i}{0.5 M_f} \right)$$

$$(3 \cdot 10^3) + (5 \cdot 10^3) \cdot \ln 2 = 6.5 \cdot 10^3 \text{ m/s}$$

Roket yakıtı 50 kg/s oranında yanıyorsa itme kuvveti = ?

$$\left| g_L \frac{dm}{dt} \right| = T = 50 \cdot 5 \cdot 10^3 = 25 \cdot 10^4 \text{ N}$$

Katı Bir Cismenin Sabit Eksenle Dönmesi



Tam bir tur iken

$$2\pi r = r \cdot Q$$

$$2\pi = Q \quad (\text{radyan})$$

$$S = r \cdot Q$$

θ birimi
 θ radyan

1) Açısal Yer Değiştirme

$$\Delta Q = Q_s - Q_i$$

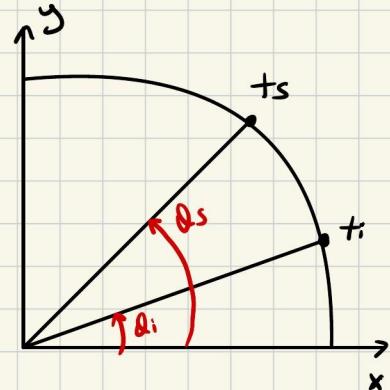
2) Ortalama Açısal Hız

$$w_{\text{ort}} = \frac{\Delta Q}{\Delta t} \quad (\text{rad/s})$$

3) Anı Açısal Hız

$$w = \lim_{\Delta t \rightarrow 0} \frac{\Delta Q}{\Delta t} = \frac{dQ(t)}{dt}$$

+tərəf operatorü



4) Ortalama Açısal İme

$$\alpha_{\text{ort}} = \frac{\Delta w}{\Delta t} \quad (\text{rad/s}^2)$$

5) Anı Açısal İme

$$\alpha = \lim_{\Delta t \rightarrow 0} \frac{\Delta w}{\Delta t} = \frac{dw(t)}{dt}$$

Sabit Aksal i̇mel: Dönme Hareketi

Dönme Hareketi

$$\omega_s = \omega_0 + \alpha t$$

$$\theta_s = \theta_0 + \omega_0 t + \frac{\alpha t^2}{2}$$

$$\omega_s^2 = \omega_0^2 + 2\alpha(\theta_s - \theta_i)$$

$$(\alpha = s b +)$$

değilse;

$$\omega = \frac{d\theta}{dt}$$

$$\alpha = \frac{d\omega}{dt}$$

Öteleme Hareketi

$$v_s = v_i + \alpha t$$

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

$$v_s^2 = v_0^2 + 2\alpha(x - x_0)$$

$$(\alpha = s b +)$$

değilse;

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

$$\alpha = \frac{dv}{dt}$$

Soru: $\alpha = 3,5 \text{ rad/s}^2$

$$t_0 = 0 \Rightarrow \omega_0 = 2 \text{ rad/s}$$

a) $t = 2 \text{ sn}'deki \Delta \theta = ?$

$$\theta_s = \theta_i + \omega_0 t + \frac{\alpha t^2}{2}$$

$$\Delta \theta = 4 + \frac{3,5 \cdot 4}{2} = 11 \text{ rad}$$

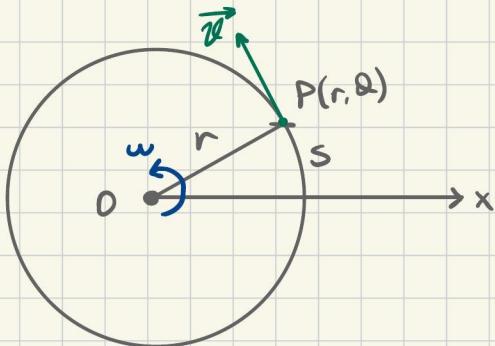
b) $t = 2 \text{ sn}$, kaç tur atar?

$$\frac{11}{2\pi} \text{ derece yani } \frac{180 \cdot (11)}{\pi} = 630^\circ$$

1.75 tur

c) $t = 2 \text{ sn}$
açısal hız = ?

$$\begin{aligned} \omega_s &= \omega_0 + \alpha t \\ \omega_s &= 2 + 7 \\ \omega_s &= 9 \text{ rad/s} \end{aligned}$$



$$S = r \cdot Q$$

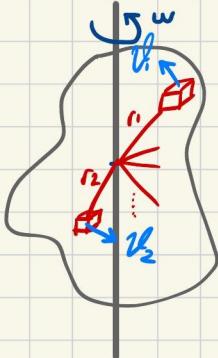
$$\frac{ds}{dt} = r \cdot \frac{dQ}{dt}$$

$$v = r \cdot \omega$$

$$\frac{d\theta}{dt} = r \cdot \frac{dw}{dt}$$

$$a = \alpha \cdot r$$

Dönme Kinetik Enerjisi



$$K \approx \frac{1}{2} \Delta m_1 v_1^2 + \frac{1}{2} \Delta m_2 v_2^2 + \dots$$

$$K \approx \sum_i^N \frac{1}{2} \Delta m_i v_i^2$$

$$K \approx \frac{1}{2} \left(\sum_i^N \Delta m_i r_i^2 \right) \omega^2$$

$$K = \frac{1}{2} \left(\lim_{\Delta m_i \rightarrow 0} \sum_{i=1}^{\infty} \Delta m_i r_i^2 \right) \cdot \omega^2$$

- Sadece " ω " hepsinde
aynılık.

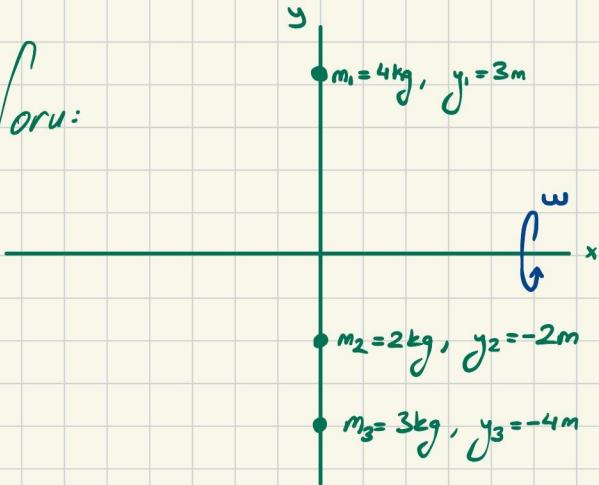
$$\int r^2 dm = I$$

- eylemsizlik momenti

$$K = \frac{1}{2} I \omega^2$$

$$\sum_i m_i r_i^2 = I$$

İoru:



$$\omega = 2 \text{ rad/s}$$

Sistemin kinetik enerjisi kaç $J = ?$

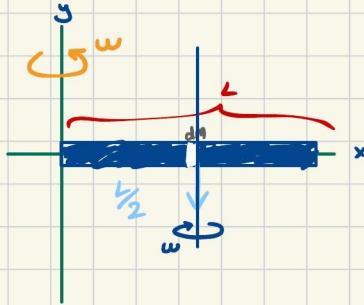
$$K = \frac{1}{2} I \omega^2$$

$$I = \sum_i m_i r_i^2 \text{ ise,}$$

$$\frac{4 \cdot 9}{36} + \frac{2 \cdot 4}{8} + \frac{3 \cdot 16}{48} = 92 \text{ kg.m}^2$$

$$\frac{1}{2} 92 \cdot 2^2 = 184 \text{ J}$$

İoru:



Eylemsizlik momenti nedir?

$$I = \int x^2 dm$$

$$I = \lambda \cdot \frac{L^3}{3}$$

$$I = \frac{1}{3} M L^2$$

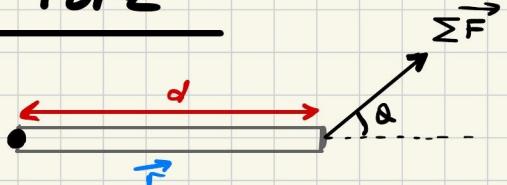
$$I = \int x^2 dm$$

$$dm = \frac{M}{L} \cdot dx$$

$$I = \int_0^L x^2 \frac{M}{L} dx$$

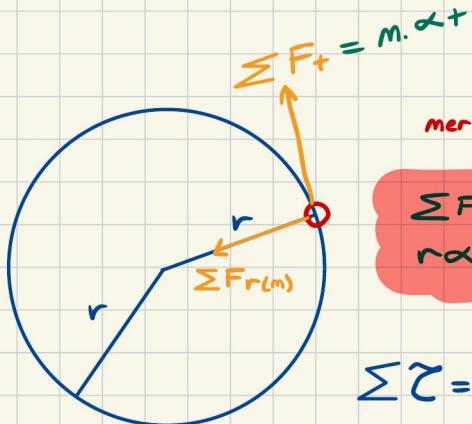
$$\frac{x^3}{3} \Big|_0^L = \frac{L^3}{3} \cdot \frac{M}{L} = \frac{ML^2}{3}$$

Tork



$$\tau = (\sum F \cdot \sin \alpha) \cdot d$$

$$\tau = \vec{r} \times \sum \vec{F}$$



merkezcil kuvvet tork üretmez.

$$\sum F_r = m \cdot \alpha$$

$$r \alpha = a$$

$$\sum \tau = (m \cdot r^2) \alpha$$

$$\sum \tau = I \alpha$$

Soru: m küteli cubuk yatayla paralelken serbest bırakılıyor. Anteç ağırlık i̇meyi ve cubugun en ucunun çizgisi bulunuz.



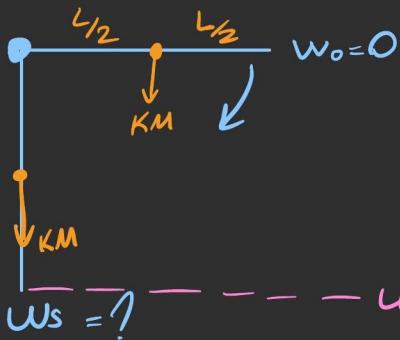
$$I = \frac{1}{3} m L^2$$

$$\tau = I \cdot \alpha = mg \cdot \frac{L}{2}$$

$$\frac{3g}{2L} \cdot L = \frac{3g}{2}$$

$$\frac{1}{3} m L^2 \cdot \alpha = mg \cdot \frac{L}{2}$$

$$\alpha = \frac{3g}{2L}$$



$$\Delta E = 0$$

$$mgL = K + mg \frac{L}{2}$$

$$\frac{mgL}{Q} = K$$

$$\frac{mgL}{Z} = \frac{I}{Z} \omega_s^2$$

$$\frac{3mgK}{mLZ} = \omega_s^2$$

$$\sqrt{\frac{3g}{L}} = \omega_s$$

r. $\omega = \sqrt{K}$

$$\frac{L}{2} \cdot \sqrt{\frac{3g}{L}} = \sqrt{K_{KM}}$$

$$\sqrt{\frac{3g}{L}} = \sqrt{K_p}$$

Diren katı cismin üzerindeki herhangi bir noktası bir sabit eksekle yelpaze, açının zamanla değişimi:

$$\theta = (5 + 10t + 2t^2) \text{ rad}$$

$$(t=3) \text{ sn ikin}$$

açılısal konum, hızı, ivme

$$\omega = 10 + 4t \rightarrow 22$$

$$\alpha = 4 \rightarrow \alpha = 4$$

$$\theta = 53 \text{ rad}$$

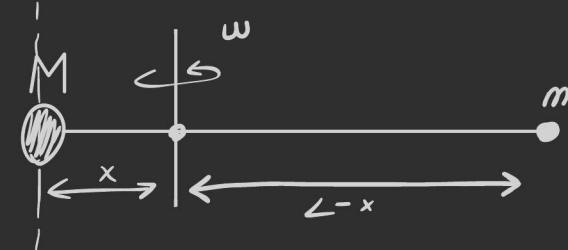
$$\alpha = (10 + 6t) \text{ rad/s}^2$$

$$10 + 6t = \frac{d\omega}{dt}$$

$$\omega(t) = (10t + 3t^2) \text{ rad/s}$$

$$\theta(t) = (5t^2 + t^3) \text{ rad}$$

$$\theta(4) = 144 \text{ rad}$$



$$I = M L^2 \quad M = \frac{Mm}{m+M}$$

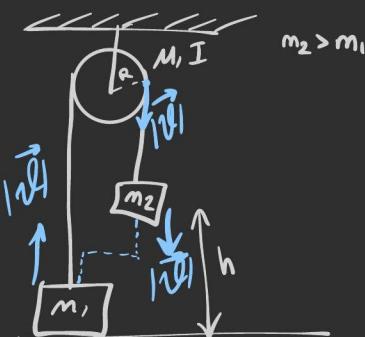
$$I = \sum_i m_i r_i^2$$

$$I = Mx^2 + m(L-x)^2$$

$$\frac{dI}{dx} = 2Mx + 2m(L-x)(-1)$$

$$Mx = mL - mx$$

$$x = \left(\frac{m}{m+M} \right) L$$



$$m_2 > m_1$$

$$m_2 gh = \frac{m_2 gh}{2} + \frac{m_1 gh}{2} + \frac{m_1 v^2}{2} + \frac{m_2 v^2}{2} + \frac{I \omega^2}{2}$$

$$r \cdot \omega = v$$

$$\sqrt{\frac{(m_2 - m_1)gh}{m_1 + m_2 + I/R^2}} = \sqrt{v}$$

$$840 = \underline{\underline{320 J}} \frac{2040.9}{2}$$

$$320 + 180 = \underline{\underline{500 J}} = \frac{20}{40 \cdot 18^2}$$

$$\boxed{24=5}$$

$$\cancel{48} \cdot \cancel{5} = \cancel{48} \cdot \cancel{4}$$

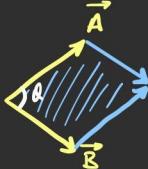
$$\vec{F}_1 \times \vec{r}_1 =$$

$$\begin{matrix} i & j & k \\ 0 & 3 & 0 \\ 2 & 0 & 0 \\ i & j & k \\ 0 & 3 & 0 \\ \hline i & j & k \\ 4 & 0 & 0 \\ 0 & x & 0 \\ i & j & k \\ 2 & 0 & 0 \\ \end{matrix} \quad 4k$$

Açısal Momentum

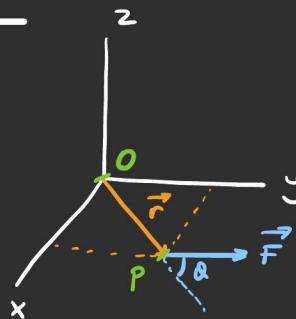
$$\vec{C} = \vec{A} \times \vec{B}$$

$$C = A \cdot B \cdot \sin \theta$$



$$*\vec{A} \times (\vec{B} \times \vec{C}) = \vec{A} \times \vec{B} + \vec{A} \times \vec{C}$$

$$*(\vec{A} \times \vec{B}) \frac{d}{dt} = \frac{d\vec{A}}{dt} \times \vec{B} + \vec{A} \times \frac{d\vec{B}}{dt}$$



$$\sum \vec{C} = \vec{r} \times \vec{F}$$

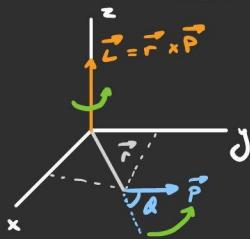
$$\sum \vec{C} = \frac{d}{dt} (\vec{r} \times \vec{P})$$

$$\Downarrow$$

$$\vec{L} \equiv \vec{r} \times \vec{P}$$

↓

$$\sum \vec{C} = \frac{d\vec{L}}{dt}$$



$$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$$

$$\vec{P} = P_x\hat{i} + P_y\hat{j} + P_z\hat{k}$$

$$L_x = (yP_z - zP_y)$$

$$L_y = (zP_x - xP_z)$$

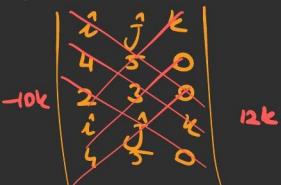
$$L_z = (xP_y - yP_x)$$

Sonuç

$$\vec{F} = (2\hat{i} + 3\hat{j}) N$$

$$\vec{r} = (4\hat{i} + 5\hat{j}) m$$

a) Net tork



12k

Noktasal Parçacıklar ise

$$\vec{L}_{top} = \sum_i \vec{L}_i$$

R_{i,j,i+1} Cisim Açısal Momentumu

$$\vec{L}_i = \vec{r}_i \times \vec{P}_i$$

$$L_i = r_i \cdot \Delta m_i \cdot \dot{\theta}_i = r_i \cdot \Delta m_i \cdot r_i \cdot \omega$$

$$L_{top} \approx \left(\sum_i r_i \Delta m_i \right) \omega$$

$$L_{top} = \left(\lim_{\Delta m_i \rightarrow 0} \sum_i r_i^2 \Delta m_i \right) \omega$$

$$L_{top} = \left(\int r^2 dm \right) \omega \Rightarrow L = I \cdot \omega$$

$\text{C} \omega = 10 \text{ devir/sn} \rightarrow 10 \left(\frac{\text{dev}}{\text{s}} \right) \cdot \left(\frac{2\pi \text{ rad}}{1 \text{ dev}} \right) = \frac{20\pi \text{ rad}}{\text{s}}$

$m = 7 \text{ kg}$
 $R = 0.12 \text{ m}$

$$L = I \cdot \omega$$

$$\downarrow$$

$$\frac{2}{5} \cdot 7 \cdot (0.12)^2 \cdot 20\pi =$$

$$2.53 \frac{\text{kg} \cdot \text{m}^2}{\text{s}} =$$

Soru

Aksiyal momen怛retin.

$$L = I \cdot \omega$$

$$\downarrow$$

$$m_1 \cdot \frac{L^2}{4} + m_2 \cdot \frac{L^2}{4} + M \cdot \frac{L^2}{12} = \frac{3(m_1+m_2)L^2+ML^2}{12} \cdot \omega = L$$

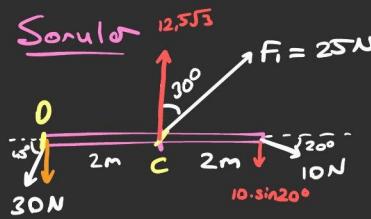
Q aksisi anında sistem aksiyal iumeğine bul.

$$I = I \cdot \alpha$$

$$|m_1 \cos Q g - m_2 \cos Q g| = \frac{3(m_1+m_2)L^2+ML^2}{12} \cdot \alpha$$

$$\sum \vec{F} = \frac{d \vec{L}}{dt}$$

$$\sum \vec{F} = 0 \text{ ise aksiyal momentum sabit}$$



xy düzleminde hareket eder
 $1,5 \text{ kg}$ küteli cisimin hiz vektörü
 $(4,2\hat{i} - 3,6\hat{j}) = \vec{v}$

Orjinden çizilen konum vek = $(1,5\hat{i} + 2,2\hat{j})$

-Açsal Mom=? $\vec{P} = (6,3\hat{i} - 5,4\hat{j})$

$L = I \cdot W$ $\vec{r} = (1,5\hat{i} + 2,2\hat{j})$

$L = \vec{r} \times \vec{P}$ $\vec{L} = -20,43\hat{k}$

$L = I \cdot W = \vec{r} \times \vec{P}$

$$mV = (m+M) \dot{U}_{kop}$$

$$\frac{mV}{m+M} = \dot{U}_{kop}$$

$$\boxed{(m+M) \dot{U}_{kop} \cdot l}$$

$rW = \dot{U}$

$$W = \frac{\dot{U}}{r}$$

Statik Denge ve Esneklik

- * Tüm kuvvetlerin bileskesi sıfır ise cisim dengedir.

$$\sum F = O$$

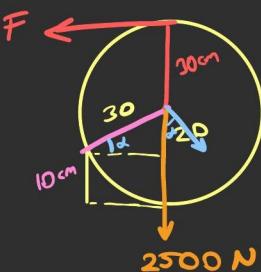
durum
sabit hızlı

- * Statik = Durgun

Cisim → noktasal $\rightarrow \sum F = 0$ geterlidir.
 Cisim → rıgit (gerçek) $\rightarrow \sum F = 0$ ve cismin herhangi bir noktaya göre torku sıfır olmalıdır.

öteleme dengesi: $\sum \vec{F} = \vec{F} \cdot d \quad (F \perp d) = \vec{F} \times \vec{d}$

dönme dengesi: $\sum \vec{\tau} = \vec{F} \cdot d \cdot \sin\alpha$



$$SOF =$$

Esneklik

- * Gerçekte bütün cisimler bozunmaya uğrar.



- * Her bir rıgit cisim, dış kuvvetteki karışı belirtti bir direnç ve rıgitliğini koruma sınırı vardır. Direnç noktası dayanırsız ise kimse bögesine uğrar.

Esneklik Modülü

- * Young modülü: katlan uzaaklığında bir değişimde karşı gösterdiği direnç oranı.

- * Kesme sabiti: Katlan, atomik düzeylerde birbirini üzerinde kayması -enine kesme- ortaya çıkan direnç

- * Hacim modülü: Hacim değişikliklerinde gelebilecek direnç ölçüsü

$$F_S = -k \cdot x$$

$$x = A \cdot \cos(\omega t + \phi)$$

$$T = \frac{2\pi}{\omega}$$

mots. genlik

$$a_{max} = Aw^2$$

$$v_{max} = Aw$$

$$v(t) = -A \cdot \omega \cdot \sin(\omega t + \phi)$$

$$a(t) = -A \cdot \omega^2 \cdot \cos(\omega t + \phi)$$

yay-kötür

$$2\pi \sqrt{\frac{m}{k}} = T = \frac{2\pi}{\omega}$$

anlık konut ugulandısa
aciseli momentum korunur.
ilerleyen cisim
hayaller gerçekler
 $f=0$

Gizisel

$$m\ddot{v}_0 = m\ddot{r} + mWr$$

$$= m\omega d + MWr$$

$$\stackrel{=}{r = \frac{L}{2}}$$

$$\frac{Acisal}{Li = Ls} \quad L = r \times P$$

$$m\ddot{v}_0d = I_a \cdot \omega$$

$$m\ddot{v}_0 = \frac{(1/3ML^2 + md^2) \cdot \omega}{d}$$

$$\frac{(1/3ML^2 + md^2)\omega}{d} = \omega(Md + Mr)$$

$$\frac{1/3ML^2 + md^2}{d} = md + \frac{ML}{2}$$

$$\frac{1/3M}{3d} = \frac{ML}{2}$$

$$d = \frac{2L}{3}$$