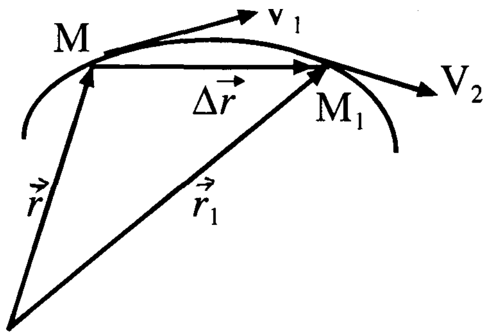
<u>**2 - ma'ruza**</u>

<u>**Darsning maqsadi.**</u>

<u>**Mavzu: Egri chiziqli harakat. Normal va tangensial tezlanishlar. Aylanma harakat kinematikasi. Burchak tezlik, chiziqli tezlik orasidagi bog'lanish. Burchak tezlanish.**</u>

EGRI ChIZIQLI HARAKATDA TEZLIK , NORMAL VA TANGENSIAL TEZLANISh

Moddiy nuqtaning egri chiziqli trayektoriyasi bo'ylab harakatidagi tezlik va tezlanishni aniqlaylik (1-chizma). Moddiy nuqtaning t vaqt oralig'idagi M vaziyati, radius - vektor $r = r(t)$ orqali aniqlanadi. Δt kichik vaqt oralig'idagi M_1 vaziyat, radius – vektor $r_1 = r(t+\Delta t)$ orqali aniqlanadi.



1 – chizma

Moddiy nuqtaning vaziyatini aniqlovchi radius - vektorning o'zgarishi $\Delta\vec{r} = \vec{r}_1 - \vec{r}$ ga teng bo'ladi.

U vaqtda Δt ichidagi harakatning o'rtacha tezligi quyidagicha aniqlanadi:

$$V_{ypm} = \frac{\Delta r}{\Delta t} = \frac{r(t+\Delta t) - r(t)}{\Delta t} \qquad \textbf{(1)}$$

$\Delta t \to 0$ da o'rtacha tezlik chegarasi, radius - vektordan vaqt bo'yicha olingan birini tartibli hosilaga teng:

$$V = \frac{dr}{dt} = \lim_{\Delta t \to 0} \frac{\Delta r}{\Delta t} \qquad \textbf{(2)}$$

bo'ladi.

(2) formula moddiy nuqtaning oniy tezligi deyiladi. Bu tezlik, harakatdagi nuqta trayektoriyasiga urinma bo'ylab yo'naladi.

Egri chiziqli harakatda tezlanish quyidagicha aniqlanadi. Bu harakatda tezlanish (a), tezlikdan vaqt bo'yicha birinchi tartibli, radius - vektor (r) dan ikkinchi tartibli hosilaga teng bo'ladi:

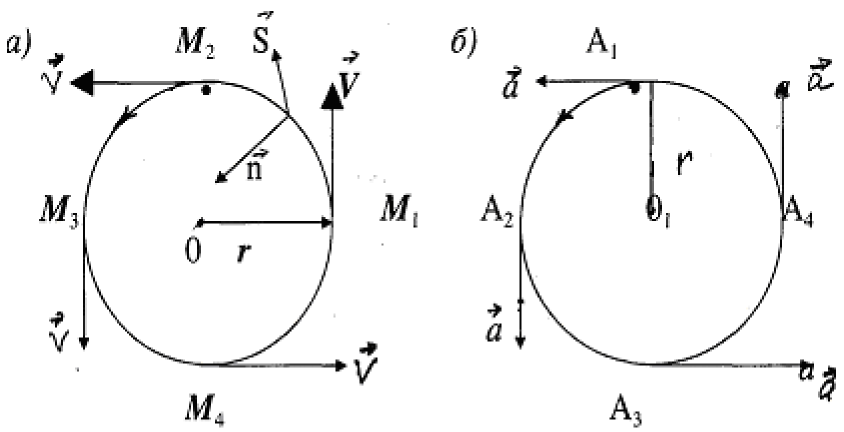
$$a = \frac{dV}{dt} = \lim_{\Delta t \to 0} \frac{\Delta V}{\Delta t} \qquad \textbf{(2)}$$

$$a = \frac{d^2 r}{dt^2} \qquad \textbf{(3)}$$

TO'G'RI ChIZIQLI HARAKATDA ME'YoRIY VA TANGENSIAL TEZLANIShLAR

Moddiy nuqtaning aylana bo'ylab tekis harakatida tezlanish trayektoriyaga perpendikulyar bo'lib, markazga qarab yo'nalgan bo'ladi

(2-chizma *a,b)*.



2 – chizma

Agarda tezlik kattalik jihatdan o'zgarsa, tezlik vektorini quyidagicha yozamiz:

$$\vec{V} = V \cdot \vec{S} \qquad \textbf{(1)}$$

Bu yerda $\vec{S}$ - aylanaga urinma bo'lgan birlik vektor.
(1) dan ko'paytma hosilasidan foydalanib, tezlanishni quyidagicha aniqlaymiz:

$$a = \frac{d}{dt}(V \cdot S) = \frac{dV}{dt} S + V \frac{dS}{dt} \qquad \textbf{(2)}$$

bo'ladi.

(2) **dan** $\frac{dS}{dt} = \frac{v}{r} n$ **ga teng bo'ladi** **(3)**

Bu yerda n - aylana trayektoriyasiga me'yoriy bo'lgan birlik vektor.
U vaqtda (2) va (3) dan

$$a = \frac{dV}{dt} \cdot S + \frac{V^2}{r} \cdot n \qquad \textbf{(4)}$$

hosil bo'ladi.

(4) dan ko'rinadiki, tezlanish vektoriga *a, S* va n vektor bilan tekislikda yotadi, ya'ni tekisliklar ustma-ust tushadi. *a* - tezlanish, trayektoriyaga burchak ostida yunalgan (4) dan

$$\frac{dV}{dt} \cdot S = a_t \qquad \textbf{(5)}$$

bo'ladi.

$$a_t = \frac{dv}{dt} \qquad \textbf{(5}^a\textbf{)}$$

Bu trayektoriyaga urinma bo'lib yo'nalgan urinma yoki tangensial tezlanish deyiladi (3-chizma). (4) dan

$$\frac{V^2}{r} \cdot n = a_n \qquad \textbf{(6)}$$

bo'ladi.

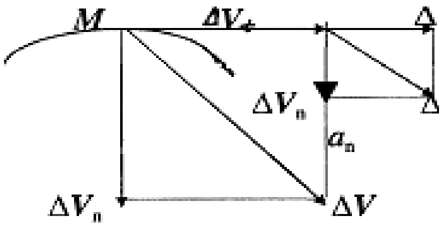
$$a_n = \frac{V^2}{r} \qquad \textbf{(6}^a\textbf{)}$$

Bu trayektoriyaga me'yoriy bo'lib yo'nalgan tezlanish me'yoriy tezlanish deyiladi (3-chizma).

$$a^2 = a_n^2 + a_t^2 \qquad \textbf{(7)}$$

$$a = \sqrt{a_n^2 + a_t^2} \qquad \textbf{(8)}$$

$$a = \sqrt{\left(\frac{V^2}{r}\right) + \left(\frac{dV}{dt}\right)^2} \qquad \textbf{(9)}$$

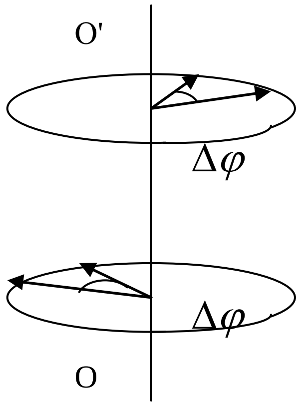


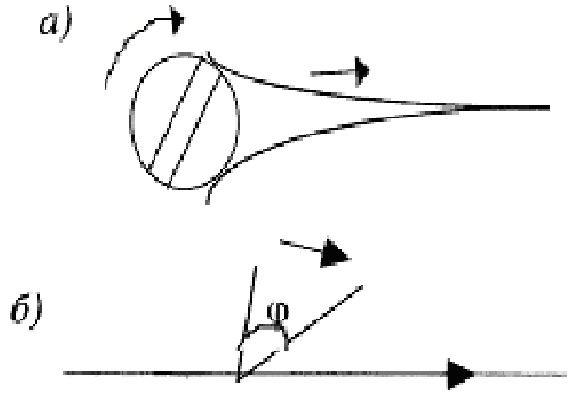
3 - chizma

Tangensial tezlanish tezligini kattalik jihatdan o'zgartiradi, me'yoriy tezlanish tezlikni yo'nalish jihatdan o'zgartiradi.

AYLANMA XARAKAT KINEMATIKASI

Har bir moddiy nuqtaning radius - vektori Δt vaqt ichida $\Delta\varphi$ burchakka, qattiq jismning burilish burchagiga buriladi (4-chizma):



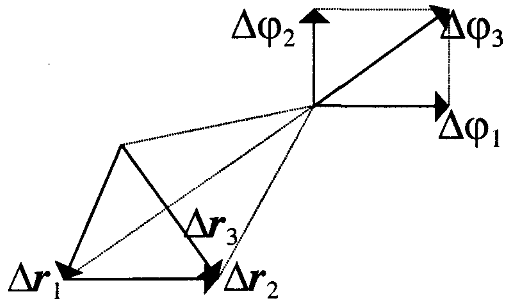


O’q atrofida burilish yo’nalishi va kesmaning yo’nalishi o’ng vint qoidasi orqali aniqlanadi (5-chizma *a,b).*

Shunday qilib, jismning burilishini qiymat va yo’nalishiga ega deb olish mumkin. Burilishni vektor deb qarash juda yetarli emas. Juda kichik burilish vaqtida jismning istalgan nuqtasi o’tgan yo’lni tug’ri chiziq deb hisoblash mumkin. Bunda juda kichik burilishlar vektorlar deb qaraladi, ya’ni $\Delta\overline{\varphi}$ yoki $d\overline{\varphi}$ deb yozish mumkin.

Parallelogram qoidasiga asosan $\Delta\varphi_1$ va $\Delta\varphi_2$ dan hosil bo’lgan $\Delta\varphi_3$ kuchishga, $\Delta r_1 + \Delta r_2$ yuzaga keltirish Δr_3 teng bo’ladi (6-chizma).

V, a va r lar <u>kutb</u> vektorlar deyiladi.



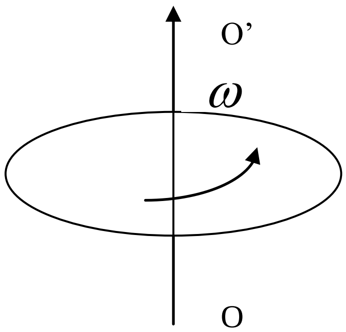
6 - чизма

$d\varphi = |d\vec{\varphi}|$ ga o’xshab, yo’nalish aylanish, yo’nalishi bilan bog’lanadigan vektorlar aksial vektorlar deyiladi.

$$|\Delta\vec{\varphi}| = \Delta\varphi \cdot |d\vec{\varphi}| = d\varphi$$ deb qabul qilamiz.

<u>**Burchak tezlik**</u> quyidagicha aniqlanadi (7 chizma).

$$\omega = \lim_{\Delta t \to 0} \frac{\Delta\varphi}{\Delta t} = \frac{d\varphi}{dt} \qquad \textbf{(1)}$$



7-chizma

Agarda tekis aylanish davri T bo'lsa, Δt =T ga $\Delta\varphi = 2\pi$ burilish

Burchagiga mos kelsa $\omega = \dfrac{2\pi}{T}$ **(2)**

yoki

$$T = \frac{2\pi}{\omega} \qquad \textbf{(3)}$$

bo'ladi.

Aylanishlar soni V quyidagicha:yoki $\nu = \dfrac{1}{T} = \dfrac{\omega}{2\pi}$ **(4)**

$$\omega = 2\pi\nu \qquad \textbf{(5)}$$

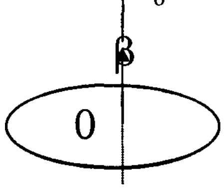
(3) va (4) ni notekis aylanma harakat uchun ham saqlab qolsa bo'ladi.

Agarda ω vektor, Δt vaqtda $\Delta\omega$ orttirma olsa, burchak tezligining vaqt bo'yicha o'zgarishi <u>burchak tezlanipini</u> keltirib chiqaradi.

$$\beta = \lim_{\Delta t \to 0} \frac{\Delta\omega}{\Delta t} = \frac{\Delta\omega}{\Delta t} \qquad \textbf{(6)}$$

Bu vektorning moduli

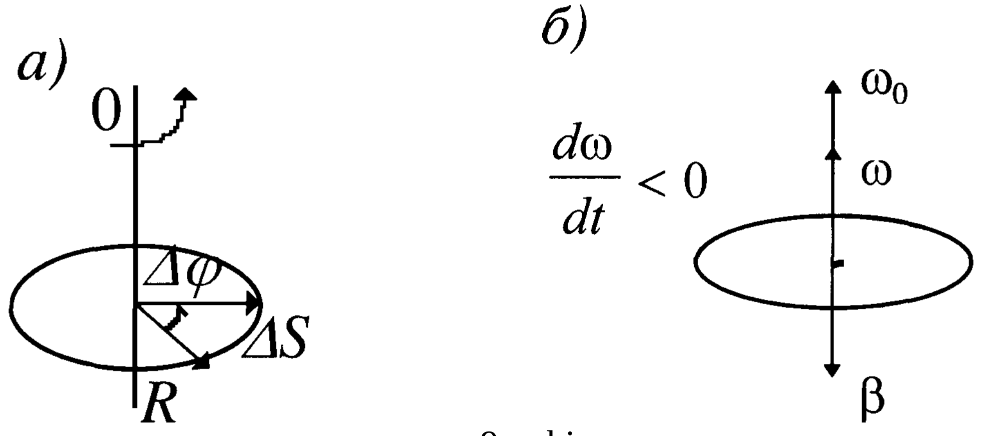
$\frac{\Delta\omega}{dt} \rangle 0$



8-chizma

β vektor ham ω kabi aksial vektor (8 - chizma).

NUQTANING ChIZIQLI TEZLIGI



9 - chizma

Δt kichik vaqt oralig'ida jism $\Delta\varphi$ burilish burchagi (9-chizma *a,b)*

$$\Delta S = R \cdot \Delta\varphi$$ ga teng bo'ladi **(7)**

Nuqtaning chiziqli tezligi:

$$V = \lim_{\Delta t \to 0} \frac{\Delta S}{dt} = \lim_{\Delta t \to 0} R\frac{\Delta\varphi}{\Delta t} = R\lim_{\Delta t \to 0} \frac{\Delta\varphi}{\Delta t} = R\frac{\Delta\varphi}{dt} = R \cdot \omega \qquad \textbf{(8)}$$

bo'ladi.

Me'yoriy tezlanish:

$$a_n = \frac{V^2}{R} = \frac{R^2 \cdot \omega^2}{R} = \omega^2 R \qquad \textbf{(9)}$$

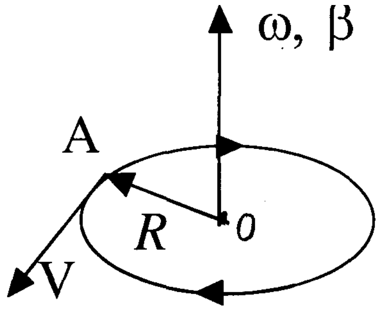
Tangensial tezlanish:

$$a_t = \left|\lim_{\Delta t \to 0} \frac{\Delta V}{\Delta t}\right| = \left|\lim_{\Delta t \to 0} \frac{\Delta(\omega R)}{\Delta t}\right| = \left|\lim_{\Delta t \to 0} R\frac{\Delta\omega}{\Delta t} = R\left|\lim_{\Delta t \to 0} \frac{\Delta\omega}{\Delta t}\right|\right| = R \cdot \beta$$

$$a_\tau = R \cdot \beta \qquad \textbf{(10)}$$

(9)*дан* $\left.\begin{aligned} \omega &= \frac{V}{R} \\ \beta &= \frac{a}{R} \end{aligned}\right\}$ hisobga olib $\omega = \omega_0 + \beta t$ **(11)**

$$\varphi = \omega_0 t + \frac{\beta t^2}{2} \qquad \textbf{(12)}$$



10 - chizma

Moddiy nuqtaning aylana bo’ylab tekis o’zgaruvchan harakatida Parma qoidasi;(10-chizma).