TOSHKENT IRRIGATSIYA VA QISHLOQ XO'JALIGINI MEXANIZATSIYALASH MUHANDISLARI INSTITUTI

FAN: NAZARIY MEXANIKA
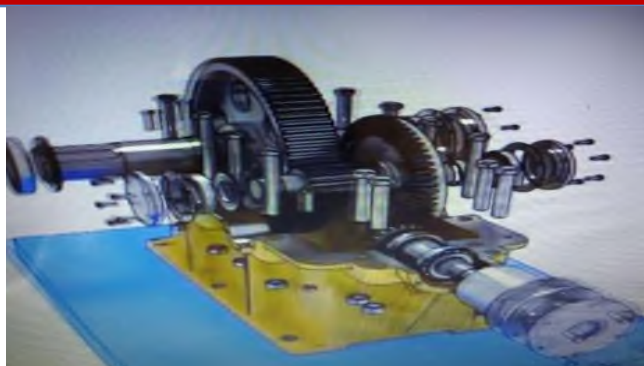
MAVZU

07

Qattiq jismning eng sodda harakatlari

Husanov Q.

TAQDIMOT REJASI

1. **Qattiq jisning harakatini berilishi.**

2. Qattiq jismning ilgarilanma harakati.

3. Qattiq jismning qo'zg'almas o'q atrofidagi aylanma harakati.

4. Qo'zg'almas o'q atrofida aylanuvchi jism nuqtalarining tezlik   va tezlanishi.

Qattiq jisning harakatini berilishi

Agar qattiq jismning barcha nuqtalarining biror sanoq sistemasiga nisbatan fazodagi o'rnini bir qiymatli aniqlovchi koordinatalari vaqtning funksiyasi ko'rinishida aniqlash mumkin bo'lsa, u holda qattiq jismning harakati berildi deb aytiladi.

Qattiq jismning fazodagi o'rnini (konfiguratsiyasi) bir qiymatli aniqlovchi erkli parametrlar soniga jismning erkinlik darajasi deyiladi.

$$s = 3N - a$$

$$A(x_A, y_A, z_A), \quad B(x_B, y_B, z_B) \text{ va } C(x_C, y_C, z_C)$$

$$(x_C - x_B)^2 + (y_C - y_B)^2 + (z_C - z_B)^2 = a^2$$

$$(x_C - x_A)^2 + (y_C - y_A)^2 + (z_C - z_A)^2 = b^2$$

$$(x_B - x_A)^2 + (y_B - y_A)^2 + (z_B - z_A)^2 = c^2$$

$$s = 3N - a$$

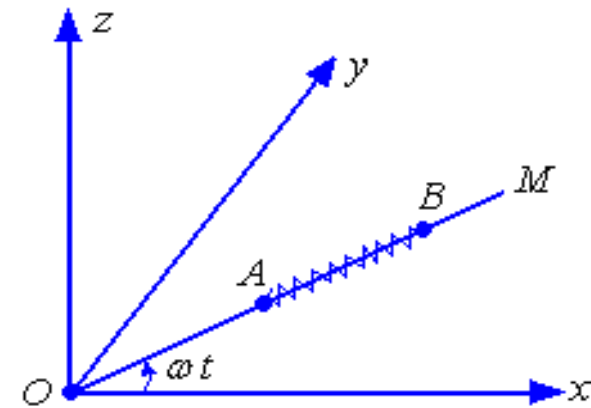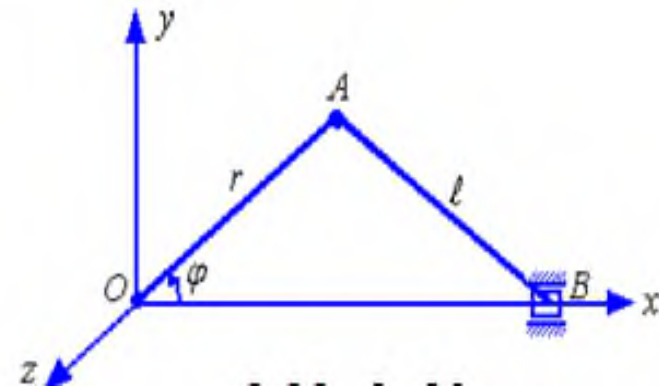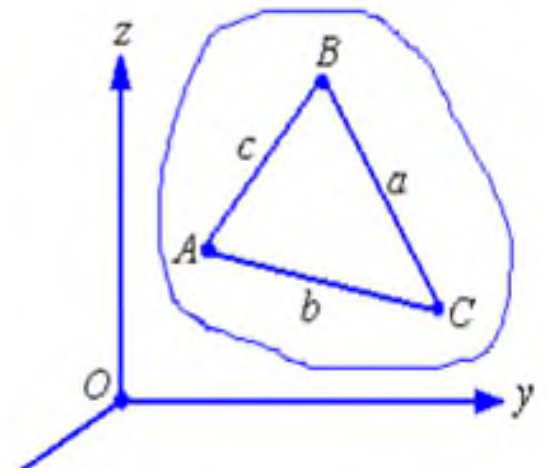$$z_A = 0, \quad z_B = 0, \quad y_B = 0$$

$$x_A^2 + y_A^2 + z_A^2 = r^2,$$

$$(x_B - x_A)^2 + (y_B - y_A)^2 + (z_B - z_A)^2 = \ell^2.$$

$$x_A \cdot \sin(\omega t) - y_A \cdot \cos(\omega t) = 0$$

$$x_B \cdot \sin(\omega t) - y_B \cdot \cos(\omega t) = 0$$

$$z_A = 0 \qquad z_B = 0 \qquad s = 6 - 4 = 2$$

Shunday qilib, qattiq jism uchun yuqorida qo'yilgan kinematikaning ikki asosiy masalasini yechish uchun quyidagi amallarni bajarishga to'g'ri keladi:

1. Jismning erkinlik darajasini aniqlash.

2. Jismning erkinlik darajasi soniga mos holda erkli parametrlar kiritish.

3. Erkli parametrlar soniga mos holda jismning harakat tenglamalarini aniqlash.

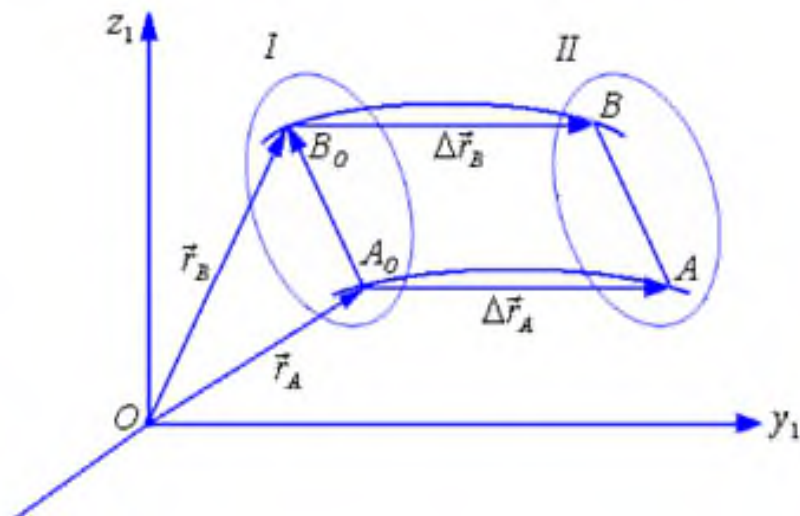4. Aniqlangan harakat tenglamalaridan jism nuqtalarining tezlik va tezlanishini aniqlash.

1. Qattiq jismning ilgarilanma harakati.
2. Qattiq jismning qo'zg'almas o'q atrorfida aylanma harakati.
3. Qattiq jismning tekis parallel harakati.
4. Qattiq jismning sferik harakati.
5. Qattiq jismning murakkab harakati.

Qattiq jismning ilgarilanma harakati

Qattiq jismning harakati davomida uning ixtiyoriy ikki nuqtasidan o'tkazilgan kesma doimo o'zining boshlang'ich holatiga nisbatan parallel ko'chsa, bunday harakatga qattiq jismning ilgarilanma harakati deyiladi.

$$\vec{r}_B = \vec{r}_A + \overrightarrow{A_oB_o} \qquad\qquad \vec{\vartheta}_B = \vec{\vartheta}_A$$

$$\frac{d\vec{r}_B}{dt} = \frac{d\vec{r}_A}{dt} + \frac{d\left(\overrightarrow{A_oB_o}\right)}{dt} \qquad \vec{a}_B = \vec{a}_A$$

$$\frac{d\vec{\vartheta}_B}{dt} = \frac{d\vec{\vartheta}_A}{dt}$$

Demak, *qattiq jismning ilgarilanma harakatida uning barcha nuqtalari bir xil ko'chish, tezlik va tezlanish bilan harakatlanadi.*
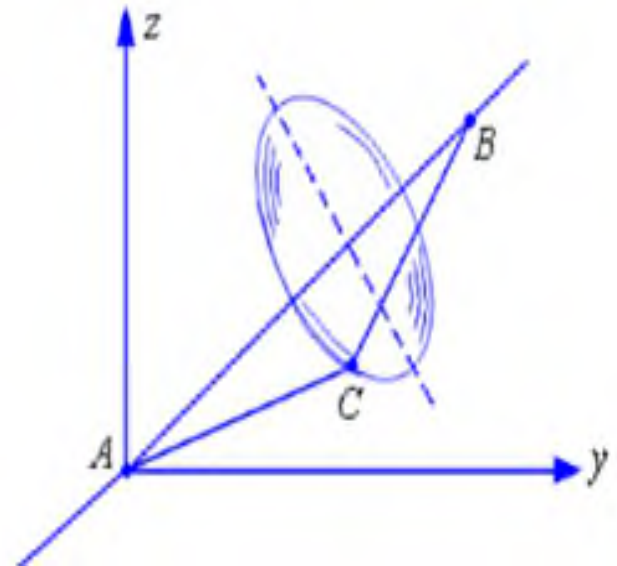
Qattiq jismning qo'zg'almas o'q atrofidagi aylanma harakati

Agar qattiq jismning harakati davomida uning kamida ikki nuqtasi qo'zg'almay qolsa, u holda bunday harakatga qattiq jismning qo'zg'almas o'q atrofidagi aylanma harakat deyiladi.

$$\left(x_A - x_C\right)^2 + \left(y_A - y_C\right)^2 + \left(z_A - z_C\right)^2 = AC^2$$

$$\left(x_B - x_C\right)^2 + \left(y_B - y_C\right)^2 + \left(z_B - z_C\right)^2 = BC^2$$

$$\varphi = \varphi(t) \qquad s = 3N - a$$

$$\omega = \left| \lim_{\Delta t \to 0} \frac{\Delta \varphi}{\Delta t} \right| = \left| \frac{d\varphi}{dt} \right| = |\dot{\varphi}|$$

$$\omega = \frac{2\pi n}{60} = \frac{\pi n}{30} \, rad/s^2$$

$$\varphi = 2\pi \cdot N \qquad d\varphi = \omega \cdot dt$$
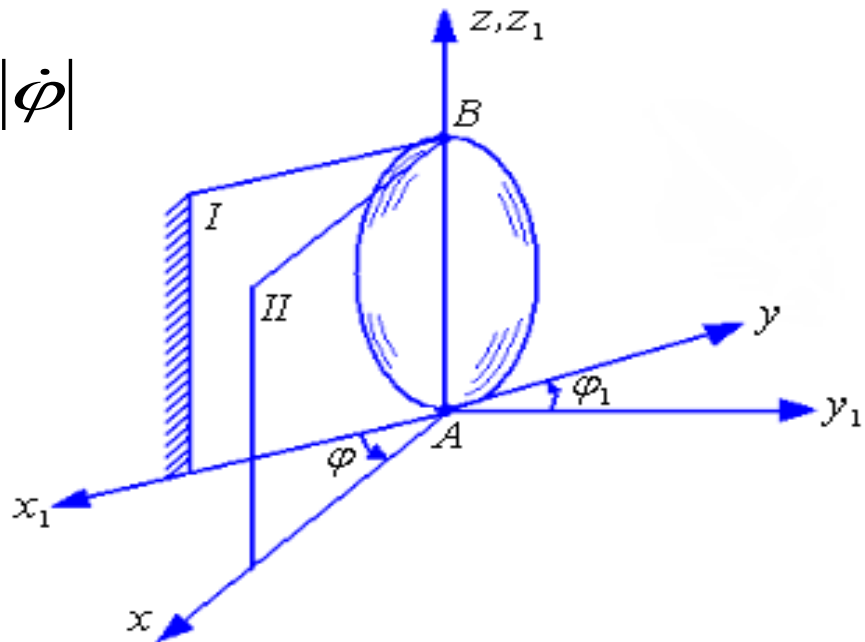
$$\int_{\varphi_0}^{\varphi} d\varphi = \int_{0}^{t} \omega \cdot dt \qquad \Longrightarrow \qquad \varphi = \varphi_0 + \omega t$$

$$\varepsilon = \frac{d\omega}{dt} \qquad \varepsilon = \left| \frac{d^2\varphi}{dt^2} \right| = |\ddot{\varphi}| \qquad \Longrightarrow \qquad \int_{\omega_0}^{\omega} d\omega = \int_{0}^{t} \varepsilon \cdot dt$$

$$\Longrightarrow \qquad \omega = \omega_0 + \varepsilon \, t \qquad \Longrightarrow \qquad \varphi = \varphi_0 + \omega_0 t \pm \varepsilon \frac{t^2}{2}$$

Qo'zg'almas o'q atrofida aylanuvchi jism nuqtalarining tezlik va tezlanishi

$$\vec{\omega} = \left|\frac{d\varphi}{dt}\right| \cdot \vec{k} = \omega_z \cdot \vec{k}$$

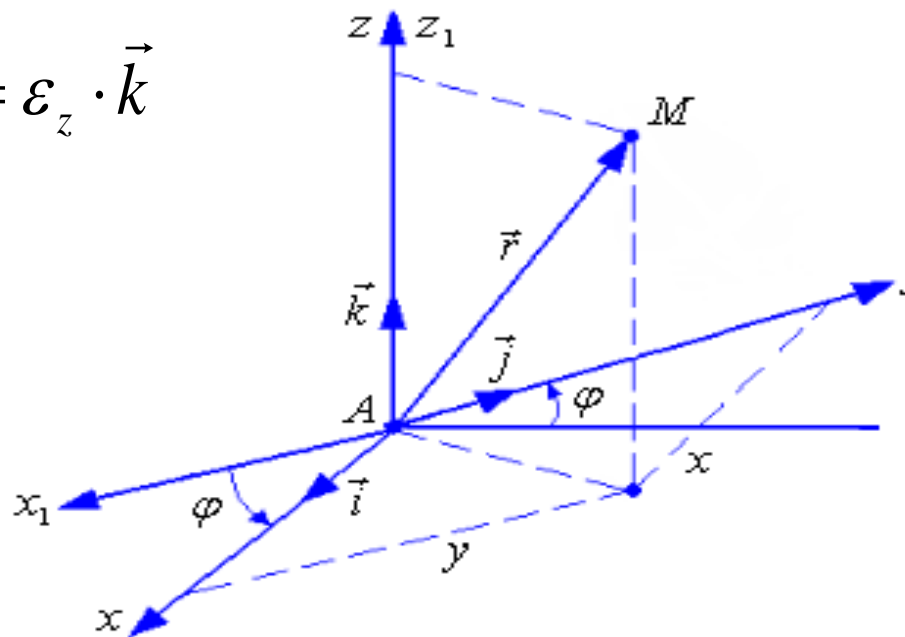$$\vec{\varepsilon} = \frac{d\omega}{dt}\vec{k} = \varepsilon_z \cdot \vec{k}$$

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

$$\vec{\vartheta} = \frac{d\vec{r}}{dt} = x\frac{d\vec{i}}{dt} + y\frac{d\vec{j}}{dt} + z\frac{d\vec{k}}{dt}$$

$$\frac{d\vec{i}}{dt} = \dot{\varphi}\,\vec{j} \qquad \frac{d\vec{j}}{dt} = -\dot{\varphi}\,\vec{i}$$

$$\vec{\vartheta} = x\dot{\varphi} \cdot \vec{j} - y\dot{\varphi} \cdot \vec{i}$$

$$\vec{\vartheta} = \vec{\omega} \cdot \vec{r}$$

$$\vec{\omega} \times \vec{r} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0 & 0 & \omega_z \\ x & y & z \end{vmatrix} = -y \cdot \omega_z \vec{i} + x \cdot \omega_z \vec{j}$$

$$\vec{a} = \frac{d\vec{\vartheta}}{dt} = \frac{d}{dt}(\vec{\omega} \cdot \vec{r}) = \frac{d\vec{\omega}}{dt} \cdot \vec{r} + \vec{\omega} \cdot \frac{d\vec{r}}{dt}$$
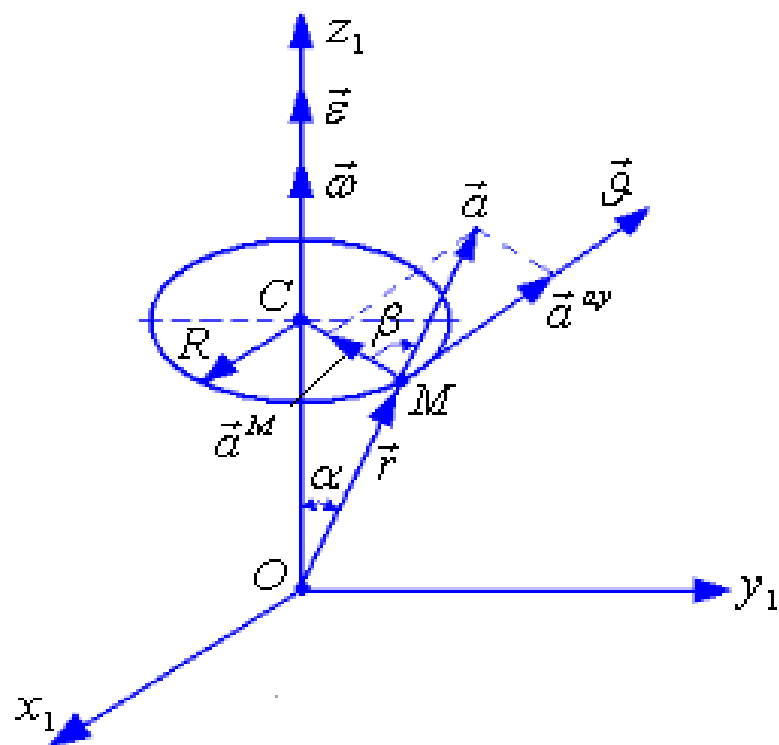
$$\vec{a} = \vec{\varepsilon} \times \vec{r} + \vec{\omega} \times \vec{\vartheta}$$

$$\vec{a} = \vec{a}^{\,ay} + \vec{a}^{\,m}$$

$$a^{ay} = \varepsilon \cdot r \cdot \sin \alpha = \varepsilon \cdot R$$

$$a^{m} = \omega \cdot \vartheta \cdot \sin 90° = \omega \cdot \omega \cdot R = \omega^2 \cdot R$$

$$a = \sqrt{(a^{ay})^2 + (a^{m})^2} = R \cdot \sqrt{\varepsilon^2 + \omega^4}$$

$$tg\beta = \frac{a^{ay}}{a^{m}} = \frac{\varepsilon}{\omega^2}$$

Demak, *qo'zg'almas o'q atrofida aylanuvchi qattiq jismning ixtiyoriy nuqtasining tezlanishi, uning aylanma tezlanishi va markazga intilma tezlanishlarining geometrik yig'indisiga teng bo'lib*, aylanish o'qiga perpendikulyar bo'lgan tekislikda yotadi.

E'TIBORINGIZ UCHUN RAHMAT!

HUSANOV Q.

Nazariy va qurilish mexanikasi kafedrasi dotsenti