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# NUQTANING IMPULS MOMENTINI SLINDRIK KOORDINATALAR SISTEMASIDA ISODALASHNING YANGI PEDAGOGIK USULLARI

**Saidov Qurbon Sayfulloyevich**

Buxoro davlat universiteti Fizika kafedrasi dotsenti

**Bekmurodova Manzura Bahodir qizi**

Buxoro davlat universiteti Fizika kafedrasi o'qituvchisi

manzurabekmurodova93@gmail.com

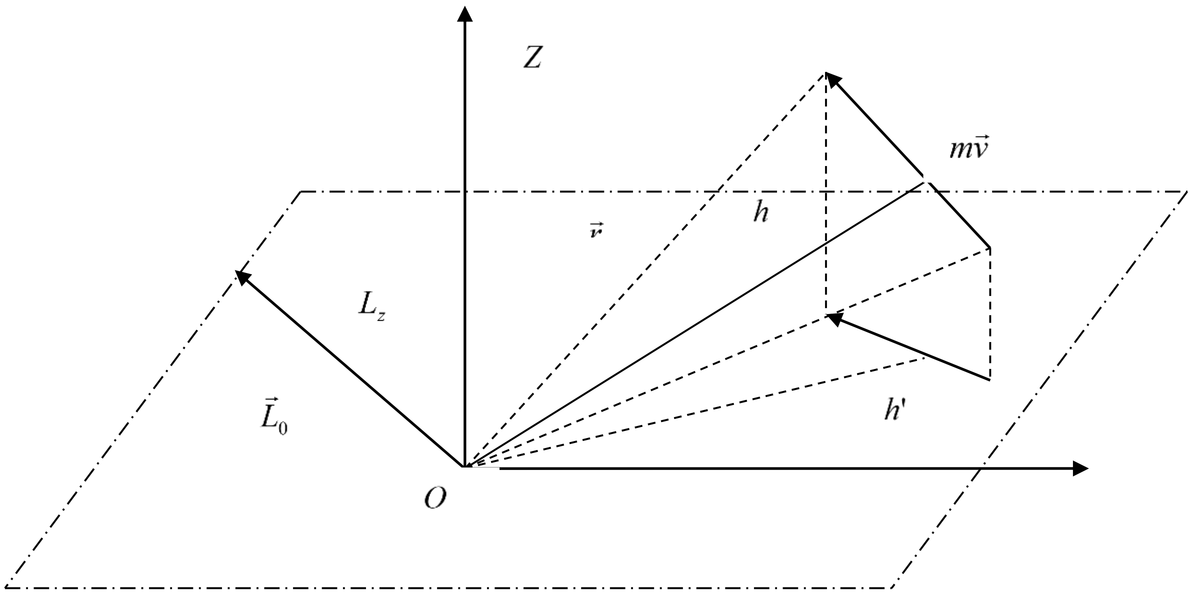
**Annotatsiya:** Nuqtaning impuls momentini slindrik koordinatalar sistemasida ifodalashda "matreshka", "ketma-ket maydalash" kabi metodlardan foydalanish talabalarningo'zlashtirish ko'rsatkichini oshirish imkonini beradi.

**Kalit so'zlar:** Nuqtaning impuls momentini, slindrik koordinatalar sistemasida, rus matrushkasi, ketma-ket maydalash.

Barchamizga ma'lumki fizika fanida o'zlashtirish ko'rsatkichini oshirishda interfaol metodlar va matematika qonunlariga murojaat qilishga to'g'ri keladi. Chunki, talabalar tomonidan fizika fanini o'zlashtirishda qator murakkabliklar vujudga keladi. Shu jumladan, nazariy fizika kursining nazariy mexanika faninini talabalar tomonidan o'zlashtirishda qator qiyinchiliklar mavjud. Bunga sabab talabalarning bu kursga qadar faqat bir o'lchovli, ikki o'lchovli fazo bilan ishlaganliklaridadir. Bundan tashqari, nazariy mexanika faninini tushunchalarini shakllantirishda oliy matematika kursi, algebra fani, vektorlar algebrasi, funksiyaning differensiali, koordinatalar sistemasi haqidagi tushunchalarga murojaat qilishga to'g'ri keladi. Bunday muammolarni bartaraf etish uchun interfaol metodlardan foydalanish o'zining samarali natijasini beradi. Nazariy mexanika fanining talabalar tomonidan o'zlashtirish ko'rsatkichini yuqori qilish uchun "Baliq skeleti", "BBB", "Sherigini top" kabi metodlardan foydalanish mumkin. Ammo shunday kattaliklar borki , ularni turli xil koordinatalar sistemasida ifodalash uchun bu metodlardan ham yuqoriroq natija beradigan "rus matrushkasi" va "ketma-ket maydalash " usullaridan foydalanish maqsadga muvofiqdir. Shunday kattaliklardan biri markazga nisbatan nuqtaning impuls momenti. Bu kattalik haqida to'liq tushuncha hosil qilish uchun talabada vektorlar algebrasi, determinantlar ustida amallar mavzulari elementlari to'liq shakllangan bo'lishi kerak. Biror markazga nisbatan nuqtaning impuls momenti impuls vektori va markaz yotgan tekislikka perpendikulyar vektordir. Uning yo'nalishida Parma harakati o'rinli. Nuqtaga nisbatan impuls momenti vektori va uning modulini quyidagicha yozish mumkin

$$\vec{M} = [\vec{r}, m\vec{v}] \qquad (1)$$

Nuqtaga nisbatan impuls momenti vektorining dekart koordinatalar sistemasidagi ko'rinishi talabalarning o'zlashtirishi uchun murakkablik tug'dirmaydi. Ammo, slindrik koordinatalar sistemasida nuqtaga nisbatan impuls momenti vektorining ifodalanishida talaba vektorlar algebrasi va determinantlar ustida amallar, funksiyaning differensiallash mavzularini to'liq o'zlashtirgan bo'lishi lozim. Chunki, impuls momentining uchta o'qdagi ko'rinishini ifodalash uchun vektorlar algebrasi, funksiyaning differensialiga va determinantlar ustida amallarga murojaat qilishga to'g'ri keladi.




Rasm 1. Nuqtaga nisbatan impuls momenti vektori.

Shunday jarayonlar mavjudki bunday holatlarda (1) formuladagi impuls momenti ifodasi orqali $\{M_x, M_y, M_z\}$ larni slindrik koordinalar orqali ifadalashga to'g'ri keladi. Bunda slindrik kordinatalar sistemasi va dekart koordinatalar sistemasi orasidagi quyidagi bog'liqlikka murojaat qilamiz. Dekart (x,y,z) va slindrik (r,$\varphi$,z) koordinatlar quyidagicha bog'langan:

$$x = r\cos\varphi, \quad y = r\sin\varphi, \; z = z \qquad (2)$$

kabi bog'liqlikni ifodalab olamiz.

Shundan so'ng (1,1) ifodani determinant ko'rinishida ochamiz

$$\vec{M} = \begin{vmatrix} \vec{\imath} & \vec{\jmath} & \vec{k} \\ x & y & z \\ mv_x & mv_y & mv_z \end{vmatrix} \qquad (3)$$

Determinantlarni hisoblashning "ketma-ket maydalash" usulidan foydalanamiz va $(\vec{\imath}, \vec{\jmath}, \vec{k})$ ortlarga mos ravishda $\{M_x, M_y, M_z\}$ larni ifodalaymiz.

$$\vec{M} = \begin{vmatrix} \vec{\imath} & \vec{\jmath} & \vec{k} \\ x & y & z \\ mv_x & mv_y & mv_z \end{vmatrix} = \vec{\imath}\begin{vmatrix} y & z \\ mv_y & mv_z \end{vmatrix} - \vec{\jmath}\begin{vmatrix} x & z \\ mv_x & mv_z \end{vmatrix} + \vec{k}\begin{vmatrix} x & y \\ mv_x & mv_y \end{vmatrix} \quad (4)$$

ko'rinishga keladi.

Determinantni yechish uchun quyidagiga ega bo'lishimiz kerak

$$v_x = \dot{x},\ v_y = \dot{y},\ v_z = \dot{z} \qquad (5)$$

$$M_x = \begin{vmatrix} y & z \\ mv_y & mv_z \end{vmatrix} = y \times mv_z - z \times mv_y \qquad (6)$$

(5) ifodani inobatga olsak ifoda quyidagicha bo'ladi

$$M_x = m(y\dot{z} - z\dot{y}) \qquad (7)$$

(2) ifodadagi bog'lanishdan foydalanib quyidagiga ega bo'lamiz:

$$M_x = m(r\sin\varphi\,\dot{z} - z(r\sin\dot{\varphi})) \qquad (8)$$

Hosilani hisoblashda "Matreshka" usulidan foydalanamiz. Bu usul quyidagicha: $F(q(k(r(x,y,z)))'_x$ funksiyadan x bo'yicha hosila olsak $F'_q \times q'_k \times k'_r \times r'_x$ kabi ko'rinishga keladi. Har bir qavsni ochib oldingi funksiyadan ko'rinib turgan funksiya bo'yicha bo'yicha hosila olinadi. Bu rus matrushkasini eslatadi. 1-rasmdagi matrushkalarni eng kichkinasini 1 deb ketma-ket raqamlaymiz. Hosila masalasiga esa quyidagicha tadbiq qilamiz: 5-matrushkadan 4-matrushka bo'yicha hosila, 4-matrushkadan 3-matrushka bo'yicha hosila, 3-matrushkadan 2-matrushka bo'yicha hosila va 2-matrushkadan 1-matrushka bo'yicha hosila. Xuddi yuqoridagi murakkab funksiyaning hosilasiga o'xshaydi. $(M(\varphi(t))$ kabi ko'rinishdagi funksiyadan hosila olishga tog'ri keladi.

Shu metodni qo'llasak quyidagiga ega bo'lamiz:

$$M_x = m(r\sin\varphi\,\dot{z} - z\dot{r}\sin\varphi - zr\cos\varphi\,\dot{\varphi}) \qquad (9)$$

Ifodani soddalashtirsak

$$M_x = m\sin\varphi\,(r\dot{z} - z\dot{r}) - mzr\cos\varphi\,\dot{\varphi}) \qquad (10)$$

(10) ifoda slindrik koordinatalar uchun impuls momenti vektorining x o’qdagi ko’rinishi

Xuddi shunday y o’qdagi qiymatini topish uchun “ketma-ket maydalash” usuliga murojaat qilamiz:

$$M_y = -\begin{vmatrix} x & z \\ mv_x & mv_z \end{vmatrix} = -(x \times mv_z - z \times mv_x) \qquad (11)$$

(5) ifodani inobatga olsak ifoda quyidagicha bo’ladi :

$$M_y = m(z\dot{x} - x\dot{z}) \qquad (12)$$

(2) ifodadagi bog’lanishdan foydalanib quyidagiga ega bo’lamiz:

$$M_y = m(z\dot{(r\cos\varphi)} - r\dot{z}\cos\varphi) \qquad (13)$$

Hosilani hisoblashda “rus matrushkasi” usulidan foydalanamiz

$$M_y = m(z\dot{r}\cos\varphi - zr\sin\varphi\dot{\varphi} - r\dot{z}\cos\varphi) \quad (14)$$

Ifodani soddalashtirsak

$$M_y = m\cos\varphi(z\dot{r} - r\dot{z}) - mzr\sin\varphi\dot{\varphi} \qquad (15)$$

(15) ifoda slindrik koordinatalar uchun impuls momenti vektorining y o’qdagi ko’rinishi.

Xuddi shunday z o’qdagi qiymatini topish uchun “ketma-ket maydalash” usuliga murojaat qilamiz:

$$M_z = \begin{vmatrix} x & y \\ mv_x & mv_y \end{vmatrix} = x \times mv_y - y \times mv_x \qquad (16)$$

(5) ifodani inobatga olsak ifoda quyidagicha bo’ladi:

$$M_z = m(x\dot{y} - y\dot{x}) \qquad (17)$$

(2) ifodadagi bog’lanishdan foydalanib quyidagiga ega bo’lamiz:

$$M_z = m(r\cos\varphi\,\dot{(r\sin\varphi)} - r\sin\varphi\,\dot{(r\cos\varphi)}) \qquad (18)$$

Hosilani hisoblashda “rus matrushkasi” usulidan foydalanamiz

$$M_z = m[r\cos\varphi\,(\dot{r}\sin\varphi + r\dot{\varphi}\cos\varphi) - r\sin\varphi(\dot{r}\cos\varphi + r\varphi\sin\varphi] \qquad (19)$$

Ifodani soddalashtirsak

$$M_z = mr^2\dot{\varphi} \qquad (20)$$

(20) ifoda slindrik koordinatalar uchun impuls momenti vektorining z o'qdagi ko'rinishi.

Nuqtaga nisbatan impuls momenti vektorining slindrik koordinatlar orqali umumiy ifodasi quyidagicha:

$$\vec{M} = (m\sin\varphi\,(r\dot{z} - z\dot{r}) - mzr\cos\varphi\,\dot{\varphi})\vec{\imath} +$$

$$+(m\cos\varphi(\,z\dot{r} - r\dot{z}) - mzr\sin\varphi\dot{\varphi})\vec{\jmath} + mr^2\dot{\varphi}\vec{k} \qquad (21)$$

(20) ifodadan quyidagicha munosabat keltirib chiqarish mumkin. Agar biz moddiy nuqtaning slindrik sistemadagi Lagranj funksiyasi ifodasini yozadigan bo'lsak quyidagicha bo'ladi:

$$L = \frac{m}{2}(\dot{x}^2 + \dot{y}^2 + \dot{z}^2) - U(x, y, z) \qquad (22)$$

(2) ifodadan foydalansak quyidagiga ega bo'lamiz

$$L = \frac{m}{2}\left((r\dot{\cos}\,\varphi)^2 + (r\dot{\sin}\,\varphi)^2 + \dot{z}^2\right) - U(r, \varphi, z) \qquad (23)$$

(23) ifodani hosila qoidalaridan foydalanib ifodani quyidagi ko'rinishga keltiramiz:

$$L = (\dot{r}\cos\varphi - r\sin\varphi\dot{\varphi})^2 + (\dot{r}\sin\varphi + r\cos\varphi\dot{\varphi})^2 + \dot{z}^2) - U(r, \varphi, z) \qquad (24)$$

Ifodani soddalashtirib quyidagiga ega bo'lamiz

$$L = \frac{m}{2}(\dot{r}^2 + r^2\dot{\varphi}^2 + \dot{z}^2) - U(r, \varphi, z) \qquad (25)$$

(25) ifodani yuqorida topilgan (20) ifoda bilan taqqoslasak quyidagiga ega bo'lamiz:

$$M_z = \frac{\partial L}{\partial \dot{\varphi}} = mr^2\dot{\varphi} \qquad (27)$$

Bundan shunday xulosa qilish mumkin, umumlashgan $\varphi$ koordinataga mos keluvchi umumlashgan impuls $M_z$ ga teng bo'lar ekan.

Nazariy fizika kursidagi yuqoridagiga o'xshash munosabatlarni keltirib chiqarishda "ketma-ket maydalash" va "rus matrushkasi" kabi metodlarga murojaat qilish o'zlashtirish ko'rsatkichini oshirishga yordam beradi.

Matreshka-usulini murakkab hosilaga qo'llanilishi shundan iboratki, har bir matreshka o'zidan oldingisi uchun argument va keyingisi uchun funksiya hisoblanadi. Argument-bola, funksiya esa ona vazifasini bajaradi.

**Foydalanilgan adabiyotlar**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