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THE ROLE OF THE COORDINATE SYSTEM IN SOLVING PROBLEMS IN THE DISCIPLINE OF THEORETICAL MECHANICS (CLASSICAL MECHANICS)

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Abstract: Rational selection of the coordinate system is of great importance in solving the problem of any mechanics. Usually the issue is solved very easily in the coordinate system corresponding to its symmetry. Therefore, for movement in the field of central forces, the polar coordinate system should be the most optimal system.

Keywords: Coordinate system, polar coordinates, fixed center, Cartesian coordinates, polar distance, Lagrange function.

Let's check a model consisting of an electron that circulates around the fixed center. Such a movement is central forces, that is, the private state of motion in the field of forces, the direction of which passes all the time through the same point, and the magnitude of which is a function of the distance to this point.

When examining the planetary model of an atom, we use the law of conservation of energy and the law of conservation of the moment of the amount of motion and the law of conservation of the moment of the amount of motion.In order to prepare for this, let's give rise to the expression of energy in the worm coordinates.

In the equation, the position of the point to the Cartesian coordinates $x = r \cdot \cos\varphi$, $y = r \cdot \sin\varphi$ (1)

linked to the relationship r and φ are determined by two polar coordinates. In Cartesian coordinates, kinetic energy is expressed in the following form: $T = \frac{m}{2}(\dot{x}^2 + \dot{y}^2)$. (2)

but based on (1) we find:

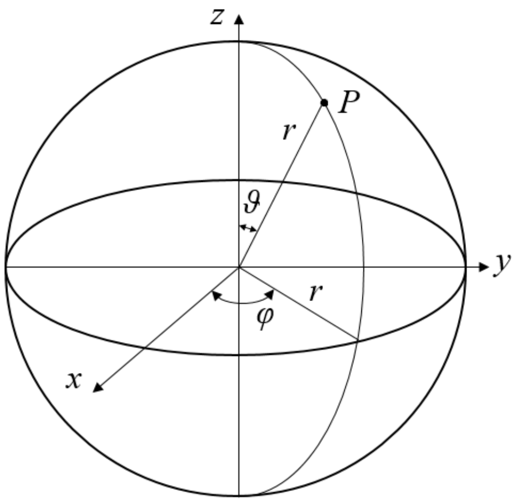
$$\dot{x} = \dot{r}\cdot\cos\varphi - r\cdot\sin\varphi\cdot\dot{\varphi},\ \dot{y} = \dot{r}\cdot\sin\varphi + r\cdot\cos\varphi\cdot\dot{\varphi} \quad (3)$$

By putting this in (2) we find the following expression of kinetic energy after simple calculations:

$$T = \frac{m}{2}(\dot{r}^2 + r^2\dot{\varphi}^2). \quad (4)$$

This is an expression of kinetic energy written through polar coordinates on the plane.
Using formulas (1) and (3) together,

$$x\dot{y} - y\dot{x} = r^2\dot{\varphi}. \quad (5)$$



we can find the relationship.

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The spherical polar coordinates of Point P in space are (in the figure): R is the radius-vector, the polar distance ϑ (the angle that fills the width by 90o), and φ, which is calculated from one First Meridian, is the distance.The relationship between Cartesian coordinates and Polar Coordinates is directly visible from the drawing:

$$x = r\sin\vartheta\cos\varphi,\ y = r\sin\vartheta\sin\varphi,\ z = r\cos\vartheta.$$

Of these:

$$\dot{x} = \dot{r}\sin\vartheta\cos\varphi + r\dot{\vartheta}\cos\vartheta\cos\varphi - r\dot{\varphi}\sin\vartheta\sin\varphi,$$

$$\dot{y} = \dot{r}\sin\vartheta\sin\varphi + r\dot{\vartheta}\cos\vartheta\sin\varphi + r\dot{\varphi}\sin\vartheta\cos\varphi,$$

$$\dot{z} = \dot{r}\cos\vartheta - r\dot{\vartheta}\sin\vartheta.$$

These are written through the Cartesian coordinates of kinetic energy in space $T = \frac{m}{2}(\dot{x}^2 + \dot{y}^2 + \dot{z}^2)$

(6)

by putting it in the expression, we find the expression of kinetic energy in the spherical polar coordinate system after some simplifications:

$$T = \frac{m}{2}(\dot{r}^2 + r^2\dot{\vartheta}^2 + r^2\sin^2\vartheta\cdot\dot{\varphi}^2). \qquad (7)$$

1. For example: for a free particle with a mass of m, let the LaGrange function be formulated in its polar and spherical coordinates, and if the question of writing Lagrange equations is posed to us.

To express the LaGrange function in polar coordinates, we write the connection of these coordinates with the Cartesian coordinates

$$x = rcos\varphi, \quad y = rsin\varphi, \quad z = 0.$$

Derivatives obtained from them by time

$$\dot{x} = \dot{r}cos\varphi - r\dot{\varphi}sin\varphi,$$
$$\dot{y} = \dot{r}sin\varphi + r\dot{\varphi}cos\varphi$$

We write the LaGrange function first in Cartesian coordinates.

Without it$L = T = \frac{m}{2}(\dot{x}^2 + \dot{y}^2 + \dot{z}^2)$

because the potential energy for the free particle it (x, y, z) = 0

$$L = \frac{m}{2}(\dot{r}^2 + \dot{r}^2\dot{\varphi}^2)$$

Lagrange equations $\frac{d\partial L}{dt\partial\dot{q}_i} - \frac{\partial L}{\partial q_i} = 0$ $\quad (i = x, y, z)$

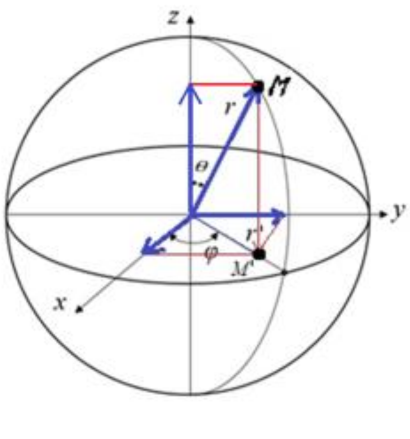
determined by the formula. We have

While Lagrange equations$\ddot{r} = r\dot{\varphi}^2$, $r^2\ddot{\varphi} = 0$in the formwill.

2. **Spherical coordinates** r, θ, φ va Cartesian coordinates

$$x = rsin\theta cos\varphi,$$
$$y = rsin\theta sin\varphi,$$

$z = rcos\theta.$



we know that there will be in a relationship.

Derivatives obtained from them by time: $\dot{x} = \dot{r}sin\theta cos\varphi + r\dot{\theta}cos\theta cos\varphi - r\dot{\varphi}sin\theta sin\varphi,$

$$\dot{y} = \dot{r}sin\theta sin\varphi + r\dot{\theta}cos\theta sin\varphi + r\dot{\varphi}sin\theta cos\varphi, \qquad \dot{z} = \dot{r}cos\theta - r\dot{\theta}sin\theta,$$

Lagrange function while $L = T = \frac{m}{2}(\dot{x}^2 + \dot{y}^2 + \dot{z}^2)$

$$L = \frac{m}{2}(\dot{r}^2 + r^2\dot{\theta}^2 + r^2 sin^2\theta\dot{\varphi}^2)$$

From this we find the Lagrange equation s$\ddot{r} = r(\dot{\theta}^2 + \dot{\varphi}^2 sin^2\theta)$, $\ddot{\theta} = r^2(1 + \dot{\varphi}^2 sin2\theta)$, $\ddot{\varphi} = 0$

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