Ministry of Higher Education and Scientific Research

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Mechanics of a Particle (Physics 1)

Problems & Exercises (of Chap 2)

Characteristics of Motion, Rectilinear Motion, Motion in the (Plane, Space)

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PART 1: Characteristics of Motion

Exercise 1

The position of the material point ***M*** is defined in a direct orthonormal coordinate system $\mathscr{R}(O, \vec{i}, \vec{j}, \vec{k})$, with ***x*** and ***y*** in centimeters and ***t*** in seconds.

$$x(t) = 2t - 2$$

$$y(t) = t^2 - 2t + 3$$

1. Write the equation for the motion's trajectory, $y = f(x)$, and determine its nature.
2. Provide the expression of the position vector $\overrightarrow{OM}$.
3. Determine the components of the velocity vector $\vec{v}$ and deduce its magnitude $|v|$.
4. Determine the components of the acceleration vector $\vec{a}$ and its magnitude $|a|$.
5. Calculate the radius of curvature $\rho = v^3 / |\vec{v} \wedge \vec{a}|$ at the instant $t = 0$.

Exercise 2

In a plane ***(P)*** with an orthonormal coordinate system ***xOy***, there is a mobile point ***M*** moving in this plane. At time ***t***, its coordinates are defined as follows:

$$x = \sqrt{2}\cos(t/2)$$
$$y = 2\sqrt{2}\sin(t/2)$$

a/ What is the trajectory?

b/ Calculate the coordinates at time ***t*** of the velocity vector $\vec{v}$ and the acceleration vector $\vec{a}$ of this mobile point.

What is the relationship between $\overrightarrow{OM}$ and $\vec{a}$? How long does it take the mobile point to return to the same position on the curve?

c/ Between the times $t_1 = 0$ and $t_2 = 4\pi$, determine the positions of the mobile point and the coordinates of $\vec{v}$ to have an acceleration vector of length $\sqrt{5}/4$.

PART 2: Rectilinear Motion

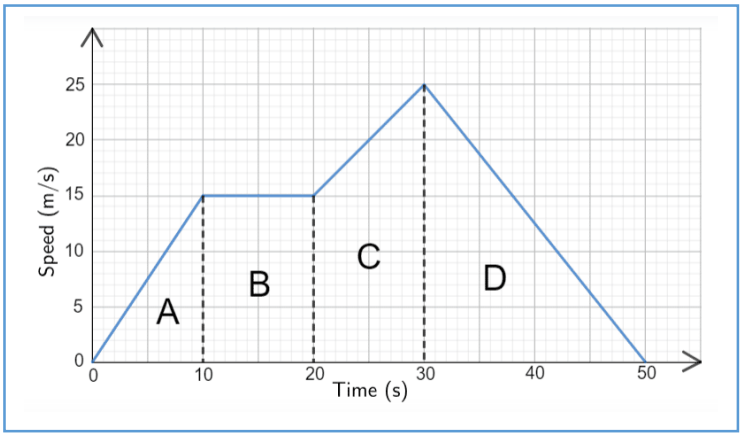
Exercise 3

The speed-time graph shows a 50-second car journey.

1/ Describe the 50 second journey.

2/ Find which section of the graph has the greatest acceleration.

3/ Calculate the total distance travelled over the 50 seconds.



Exercise 4

A man at the top of a building vertically throws a ball upward with a velocity of **12 m/s**. The ball reaches the ground **4.25 seconds** later. ($g = 9.8\ m/s^2$)

1/ What is the maximum height reached by the ball?

2/ What is the height of the building?

3/ With what velocity does it reach the ground?

PART 3: Motion in the Plane

Exercise 5

The flat trajectory of a material point in polar coordinates is given by the equation:

$\rho\ cos^2\ \frac{\theta}{2} = a$, where a is a constant.

It is assumed that the magnitude v of the velocity of this material point is proportional to ρ:

$v = k\ \rho$, where k is a positive constant.

Calculate the normal v_ρ and transverse v_θ components of the velocity vector.

PART 5: Motion in the Space

Exercise 6

Consider a mobile point M in motion such that:

$$\overrightarrow{OM} = 3\cos 2t\ \vec{i} + 3\sin 2t\ \vec{j} + (8t - 4)\ \vec{k}$$

1/ Determine the nature of the trajectory of M in space (O, x, y, z).

2/ Provide, in cylindrical coordinates, the expression for the velocity. Calculate its magnitude.

3/ Provide, in cylindrical coordinates, the expression for the acceleration. Calculate its magnitude.