Physics 01: Mechanics of point particle.   **University Year 2023-2024**

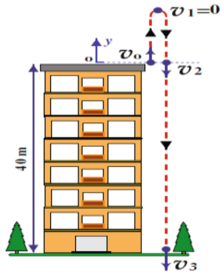
Series N° 02: Kinematics of material point

EXERCISE 01

A cannon fires cannon ball 1 of mass m_1 = 12 kg horizontally at constant velocity $\boldsymbol{v}$ = 20 m/s. At the same time, cannon ball 2 of mass m_2 = 24 kg is dropped from an equal height. The fired ball lands after a time t_1, while the dropped ball lands after a time t_2.
Ignoring air resistance, which of the following is true?
a- $t_1 > t_2$, **b-** $t_1 < t_2$, **c-** $t_1 = t_2$, **d-** It is not possible to determine the relationship between t_1 and t_2.

EXERCISE 02

A ball is thrown upward from the top of a building with an initial velocity $v = 20\ m/s$.The building is 40m high and the ball just misses the edge of the building roof on its way down; see Figure and take g = 10 m/s^2. Neglecting air resistance, find: (a) the time t_1 for the ball to reach its highest point, (b) how high will it rise, (c) how long will it take to return to its starting point, (d) the velocity V_2 of the ball at this instant, and (e) the velocity V_3 and the total time of flight t_3 just before the ball hits the ground.



EXERCISE 03

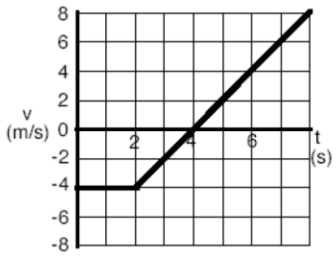
A car moving along the x-axis starts from the position x_i =2m when t_i =0 and stops at x_f = −3m when t_f =2 s. (1) Find the displacement, the average velocity, and the average speed during this interval of time.
(2) If the car goes backward and takes 3 s to reach the starting point, Find the displacement, the average velocity, and the average speed for the whole time interval.

EXERCISE 04 (homework)

The points A and B lie on a straight line, 240 m apart. At t = 0 , a particle passes through A with velocity 4 m/s heading towards B with constant acceleration 0.752 m/s^2. At t = 0, another particle passes through B heading towards A with constant velocity 5 m/s. The particles meet at point C.
1- Determine the distance AC.
2- On a set of suitable axes, draw a detailed displacement time graph for both particles, using A as the origin.

EXERCISE 05

Answer the following based on the velocity vs. time graph.



1- Give a written description of the motion.
2- Determine the average acceleration of the object in each part.
3- Determine the distance travelled in each part.

EXERCISE 06

A particle moves with an acceleration given in Cartesian coordinates by:

$$\vec{a} = e^{-t}\vec{\imath} + 5\sin(t)\,\vec{\jmath} - 3\cos(t)\vec{k}$$

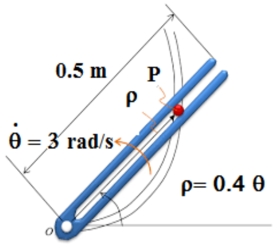
.

At t=0 s, the particle is located at (1, 0, 3) and its velocity is then (1, 2, -1).

1- Determine the velocity and position of the particle whatever t.

EXERCISE 07

- Plot these polar coordinate points on one graph: (2, π /3), (3, π /2), (2,− π /4), (1/2, π), (1, 4 π /3).
- Convert the Cartesian coordinates (2, 2) to polar coordinates.
- Convert the polar coordinate (4, π/2) to a Cartesian coordinates.
- The slotted link is fixed at O and as a result of the constant angular velocity $\dot{\theta} = 3$ rad/s it drives the peg along the spiral path $\rho = 0.4\,\theta$ (ρ is in meter and θ *is in radian*). Determine the velocity and acceleration at the instant it leaves the slot in the link, i.e, when ρ = 0.5 m



EXERCISE 08

A boat travels around a circular path, ρ = 40 m, at a velocity that increases with time, V= 0.0625 t^2

1- Find the magnitudes of the boat's velocity and acceleration at the instant t = 10 s by using the intrinsic coordinates.

2- Determine the curvilinear abscissa S(t). Noted that at t =0, S(t)= 0.

EXERCISE 09

- Plot the points given by the cylindrical coordinates: P(3, π/6, –1), Q(3, π/2, 2) and R(0, π, 3).
- Convert the cylindrical point (r , θ, z) = (2, −π/4, 1) to Cartesian coordinates:
- Convert the Cartesian point (x,y,z)=($-2, 2\sqrt{3}$, 1) to cylindrical coordinates.
- The motion of a particle moving in three-dimensions is described by the following equations:

$$x = R\cos\theta\ , \quad y = R\sin\theta \quad , z = h\theta$$

$$\theta = wt\ , \qquad w\text{: } constant, \qquad h : positive\ constant$$

1- Describe the motion of point M in the (xOy) plane?

2- Describe the motion of point M in the direction of the Oz axis?

3- What is the resulting motion of point M?

4- Determine the cylindrical components and modulus of the vectors: position, velocity and acceleration.

4- What are the tangential and normal components of the acceleration vector?

5- Calculate the radius of curvature of the trajectory.

EXERCISE 10

The spherical coordinates (r, θ,φ) of a moving object are given by:

$$r=R\ , \quad \theta=\frac{\pi}{6} \quad , \varphi= at^2$$

1- Write the expression of the position vector in Cartesian coordinates.

2- Determine the Cartesian components and modulus of the velocity and acceleration vectors.

3- Give the equation of the trajectory. Draw the trajectory.

4- What is the nature of the motion?

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