Ibn Khaldoun University-Tiaret
Faculty of Material Sciences
Department of Physics

1st Year LMD-SM
Physics 1: Mechanics of the Point
Academic Year 2025/2026

Physics 1 exam (time allowed: 2h00 minutes)

Exercise 1:

Choose the correct answer:

Q1. Which physical quantity is a vector

A) Speed B) Distance C) Mass D) Velocity

Q2. A particle moves according to $x(t)=2t^2+3t$. What is its velocity at t=2 s

A) 7 m/s B) 10 m/s C) 11 m/s D) 14 m/s

Q3. A 4 kg object is pulled by a horizontal force of 12 N. Neglecting friction, its acceleration is

A) 0.33 m/s B) 3 m/s² C) 12 m/s² D) 48 m/s²

Q4. A particle has velocity $v(t)=3t^2$. The displacement between t=0 and t=2 s is

A) 4 m B) 6 m C) 8 m D) 12 m

Q5. A block slides down a frictionless incline from height h. Its speed at the bottom is

A) $\sqrt{gh}$ B) gh C) $\sqrt{2gh}$ D) 2gh

Exercise 2:

A comet moves in the solar system. Its position vector is given by:

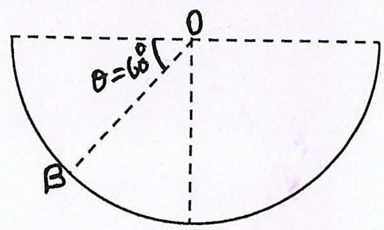
$$\overrightarrow{OM} = (t-1)\vec{e}_x + \frac{t^2}{2}\vec{e}_y$$

Where O is the origin of the reference frame (the Sun) and t represents time expressed in seconds. We assume that the comet remains in the plane (O, x, y)..

1. Determine the expression of the velocity vector $\vec{v}$ and the acceleration vector $\vec{a}$
2. Determine the expression of the tangential acceleration a_t.
3. Deduce the expression of the normal acceleration a_n
4. Plot the trajectory $y = f(x)$ for $0 \leq t \leq 4s$.
5. Draw the velocity vector, the normal acceleration vector, and the tangential acceleration vector at t=0s and t=2s, and deduce the acceleration vector $\vec{a}$ at these instants. Scale: $1\,cm \rightarrow 1\,m/s$, $1\,cm \rightarrow 0.45\,m/s\,2$

Exercise 3:

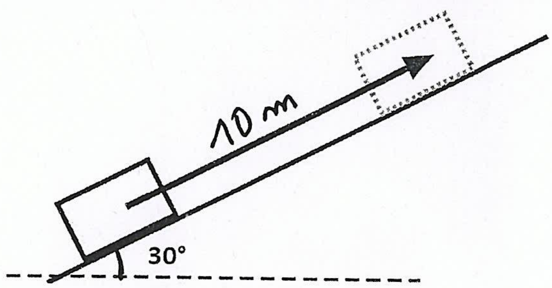
We consider the movement of a particle of mass m = 100g, on a circular track of radius R = 1m (see figure). The particle/track contact is characterized by the friction coefficients μ_d. At a point B of the track identified by the angle $\theta = 60°$, the particle has an acceleration $a = 2{,}8\,m/s^2$, and a speed $v = 1\,m/s$,



1. Using the FRENET referential frame and the fundamental principle of dynamics, determine the reaction force ($\vec{R}$) and the friction force ($\vec{f}$).
2. Represent the forces acting on the particle to scale: : $1cm \rightarrow 0.5N$.
3. Deduce the coefficient of dynamic friction μ_d.

Exercise 4:

A crate of mass $m = 5.0\,kg$ is pulled up a rough incline with an initial speed of $v_i = 3.0\,m/s$. The magnitude of the pulling force is $F = 60.75\,N$ parallel to the incline, which makes an angle of 30.0° with the horizontal. The coefficient of kinetic friction is $\mu_d = 0.30$, and the crate is pulled by distance d=10.0 m.



1. How much work is done by gravity $\vec{P}$?
2. How much energy is lost due to friction force $\vec{f}$?
3. How much work is done by the force $\vec{F}$?
4. What is the change in kinetic energy ΔE_C of the crate?
5. What is the speed v_f of the crate after being pulled 10.0 m?

Typical correction for Physics 1 exam (2025/2026)

Exercise 1:

Q1) ⟶D, Q2) ⟶C, Q3) ⟶B, Q4)⟶ C, Q5) ⟶C

Exercise 2:

The expression of the velocity vector $\vec{v}$ and the acceleration vector $\vec{a}$

$$\vec{v} = \frac{d\overrightarrow{OM}}{dt} = \vec{e}_x + t\vec{e}_y \ and\ \vec{a} = \frac{d\vec{v}}{dt} = \vec{e}_y$$

0,5 0,5

The expression of the tangential acceleration a_t

$$a_t = \frac{d|\vec{v}|}{dt} = \frac{d\sqrt{1+t^2}}{dt} = \frac{t}{\sqrt{1+t^2}}$$ 1

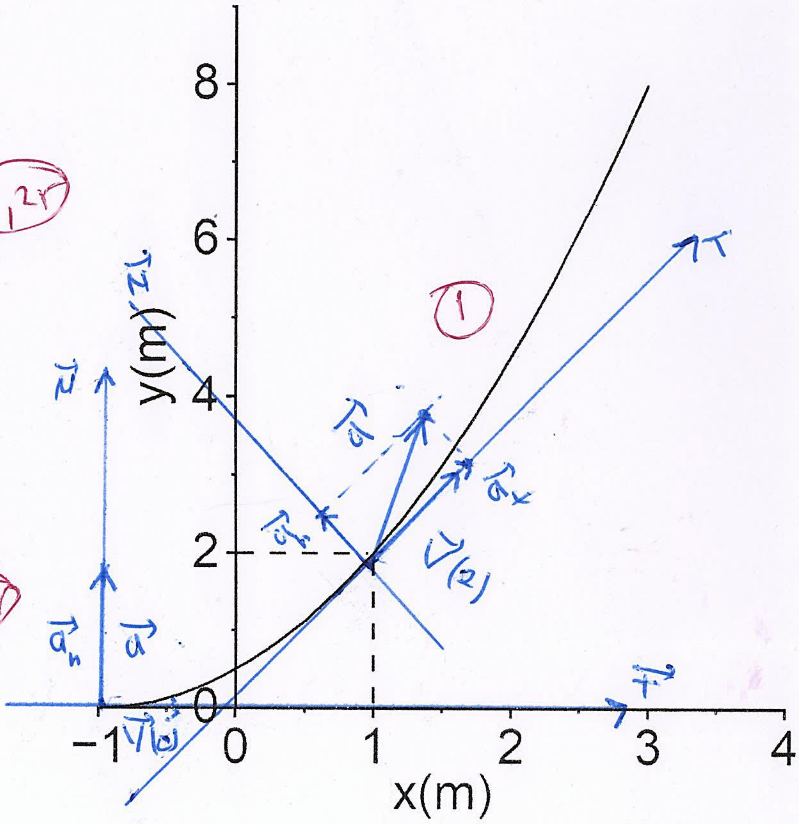
The expression of the normal acceleration a_n

$$a_n = \sqrt{a^2 - a_t^2} = \sqrt{1 - \frac{t^2}{1+t^2}} = \frac{1}{\sqrt{1+t^2}}$$ 1

Plot the trajectory $y = f(x)$ for $0 \leq t \leq 4s$

$$x = t - 1 \Rightarrow t = x + 1$$

$$y = \frac{t^2}{2} = \frac{1}{2}(x+1)^2 = \frac{1}{2}x^2 + x + \frac{1}{2}$$ 1



at $t = 0s,\ x = -1, y = 0$

$$\vec{v}(0) = \vec{e}_x + (0)\vec{e}_y = \vec{e}_x \Rightarrow |\vec{v}(0)| = 1\,m/s$$

$$a_t(0) = \frac{(0)}{\sqrt{1+(0)^2}} = 0\,m/s^2$$

$$a_n(0) = \frac{1}{\sqrt{1+(0)^2}} = 1\,m/s^2$$

1,25

$$a(0) = \sqrt{a_t^2 + a_n^2} = \sqrt{(0)^2 + (1)^2} = 1\,m/s^2$$

at $t = 2s, x = 1, y = 2$

$$\vec{v}(2) = \vec{e}_x + (2)\vec{e}_y \Rightarrow |\vec{v}(0)| = \sqrt{(1)^2 + (2)^2} = 2.24\,m/s$$

$$a_t(2) = \frac{(2)}{\sqrt{1+(2)^2}} = 0.89\,m/s^2$$

$$a_n(2) = \frac{1}{\sqrt{1+(2)^2}} = 0.45\,m/s^2$$

1,25

$$a(2) = \sqrt{a_t^2 + a_n^2} = \sqrt{(0.89)^2 + (0.45)^2} = 1\,m/s^2$$

Exercise 3:

By applying the fundamental principle of dynamics:

$$\sum \vec{F} = m\vec{a} \Rightarrow \vec{P} + \vec{f} + \vec{R} = m\vec{a} \cdots (1)$$ 0,5

By projecting the equation (1) on the axis :

$$\begin{cases} Pcos(\theta) - f = ma_t \cdots (2) \\ R - Psin(\theta) = ma_n \cdots (3) \end{cases}$$

Where

$$a_n = \frac{v^2}{R} = \frac{1}{1} = 1\,m/s^2 \;\; and \;\; a_t = \sqrt{a^2 - a_n^2} = \sqrt{(2.8)^2 - 1} = 2.61\,m/s^2$$

From the equation (2) we have

$$f = mgcos(\theta) - ma_t = 0.1 \times 10 \times cos(60) - 0.1 \times 2.61 = 0.24N$$

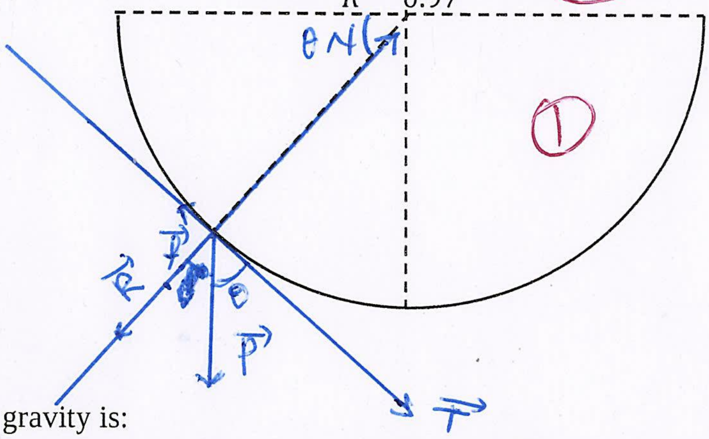
From the equation (3) we have

$$R = mgsin(\theta) + ma_n = 0.1 \times 10 \times sin(60) + 0.1 \times 1 = 0.97N$$

$$P = mg = 0.1 \times 10 = 1N$$

The coefficient of dynamic friction μ_d.

$$\mu_d = \frac{f}{R} = \frac{0.24}{0.97} = 0.25$$



Exercise 4:

1. the work done by gravity is:

$W(\vec{P}) = -mgh$, where $h = 10 \times sin(30) = 5m$, therefore, $W(\vec{P}) = -5 \times 10 \times 5 = -250J$

2. To find the work done by friction, we need to know the force of friction.

By definition :

$$\mu_d = \frac{f}{R} \; where \; R = mgcos(30) \Rightarrow f = \mu_d mgcos(30) = 0.3 \times 5.0 \times 10 \times 0.866 = 13N$$

This force points exactly opposite the direction of the displacement d, so the work done by friction is:

$$W(\vec{f}) = \vec{f} \cdot \vec{d} = fdcos(180) = -13 \times 10 = -130J$$

3. The F=100N applied force pulls in the direction up the slope, which is along the direction of the displacement d. So the work that is does is:

$$W(\vec{F}) = \vec{F} \cdot \vec{d} = Fdcos(0) = 60.75 \times 10 = 607.5J$$

4. by applying the kinetic energy theorem :

$$\Delta E_C = W(\vec{P}) + W(\vec{f}) + W(\vec{F}) + W(\vec{R})$$

Since $(\vec{R})$ is perpendicular to the motion, it did no work therefore $W(\vec{R}) = 0$, $(\vec{R} \perp \vec{d})$, then :

$$\Delta E_C = -250 - 130 + 652.5 + 0 = 227.5J$$

5. The initial kinetic energy of the crate is:

$$E_{Ci} = \frac{1}{2}mv_i^2 = 0.5 \times 5 \times (3)^2 = 22.5J$$

The final speed of the crate v_f,

$$\Delta E_C = E_{Cf} - E_{Ci} = \frac{1}{2}mv_f^2 - 22.5 = 227.5$$

$$\frac{1}{2}mv_f^2 = 250J \Rightarrow v_f = 10m/s$$