UNIVERSITÉ LIBANAISE
Faculty of Sciences
Section 3

الجامعة اللبنانية
كلية العلوم
الفرع الثالث

Course : P1100 **Year: 2023-2024**
Duration: **90 min** **Exam: S2**

***Problem I* : (10 marks)**

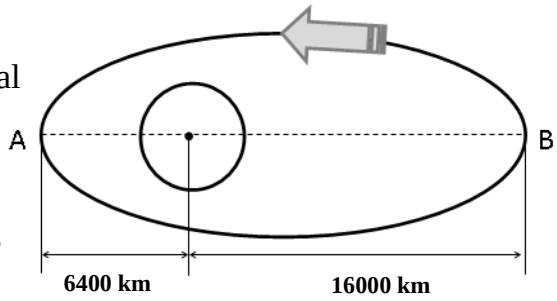
The polar coordinates of a particle are given by $r = \frac{1}{3}t^3$ and $\theta = \frac{1}{2}t^2$.

1. Determine the velocity and acceleration vectors of the particle at ***t = 2 s***.
2. Plot the velocity vector of this particle at ***t = 2 s***.

***Problem II* : (10 marks)**

A rocket is traveling around the earth with an elliptical trajectory. Given: $G = 6.67 \times 10^{-11}\ Nm^2/kg^2$ and $M_{earth} = 5.9 \times 10^{24}\ kg$.

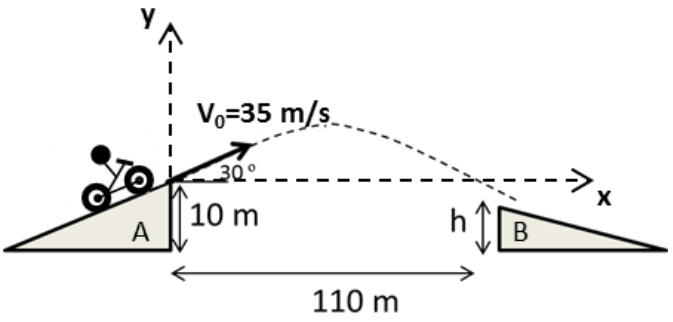
1. Determine its velocity at point A. (figure).
2. Determine the change in speed required to change its orbit to a circle with a radius of 6400 km.



***Problem III* : (25 marks)**

A motorcycle leaves the inclined plane A with a speed 35 m / s at an angle 30° with the horizontal (see figure).
We give g = 10 m/s^2.

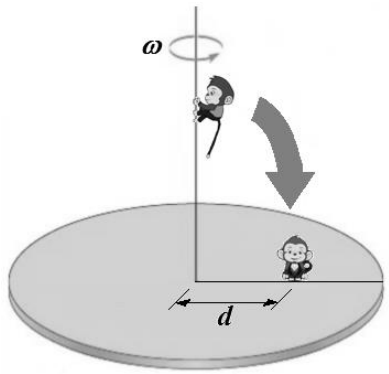
1. Give the position and the velocity vectors of the motorcycle at the moment of departure at instant t=0.
2. Give the position and the velocity vectors of the motorcycle at any instant t.
3. Deduce the height h needed for the motorcycle to arrive at the inclined plane B.
4. At what instant the speed is minimal?
5. Determine the position vector of this particle with respect to a car that is moving at a constant velocity $\vec{v} = 20\,\vec{\imath}$ (m/s).



***Problem IV* : (10 marks)**

A disk with a radius ***r = 1 m*** and a moment of inertia ***I = 10 kg.m²*** rotates with an angular velocity ***ω₁ = 3 rad/s***. A monkey with a mass ***m = 5 kg*** suddenly jumps onto the disk at a distance ***d = 0.5 m*** from the axis of rotation.

1. Determine the new angular velocity of the disk.
2. How does the angular velocity of the disk change if the monkey slowly approaches the axis of rotation?



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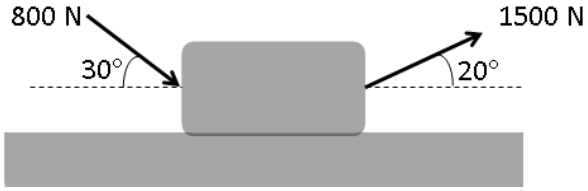
***Problem V** : (20 marks)*

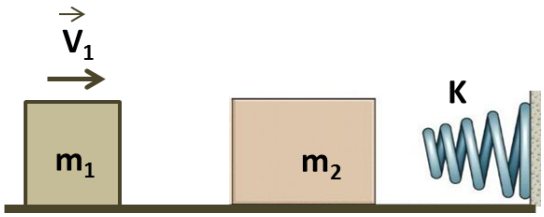
Two forces F_1 = 800 N and F_2 = 1500 N are applied on a block with mass M = 100 kg (figure). The system is initially at rest. The kinetic coefficient between the block and the surface of the ground is μ_k = 0.2.



1. Use the fundamental principle of dynamics to calculate the acceleration of mass M.
2. Determine the velocity ***v*** as a function of time.
3. Determine the distance it slides to reach a speed of v = 6 m/s.

***Problem VI** : (25 marks)*

A mass m_1 with a speed V_1 = 6 m/s, collides with another mass m_2 (m_2 = 2 m_1) at rest. The collision is supposed to be perfectly elastic.



1. Calculate the speed V_2' for the mass m_2 just after the collision.
2. The mass m_2 slides along a smooth plane (no friction) and strikes a non-linear spring with a tension of magnitude $T = kx^2$ where k = 900 N/m^2.
   i- Calculate the work of the tension force T, for a compression of the spring equal to 0.2m.
   ii- Using the theorem of kinetic energy, deduce the speed of the mass m_2 after it has compressed the spring with 0.2m.

Good luck.