NAME:.. FIRSTNAME:... GROUP:.........

Physics Midterm n°2

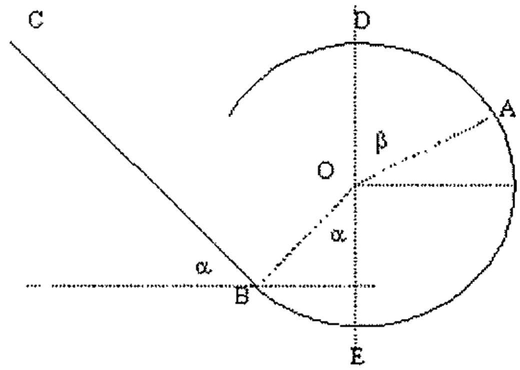
Calculators and extra-documents not allowed.
Answer directly on exam sheets

Exercise 1 (7 points)

A solid of mass m=200g is moving in a slide which is made of a first straight part BC and a second circular part of center O and radius R. **Frictions are neglected.**
The solid starts moving at point C **without initial speed**. Given α=(BOE) and β=(AOD).

1-a) Sketch forces acting on the solid at any point M between C and B.

b) Use the kinetic energy theorem to express speed at point B. Origin of height axis is at point B. Path BC is at a slope of angle α.
Compute for BC = 2m ; g = 10m.s^{-2} ; α = 30°

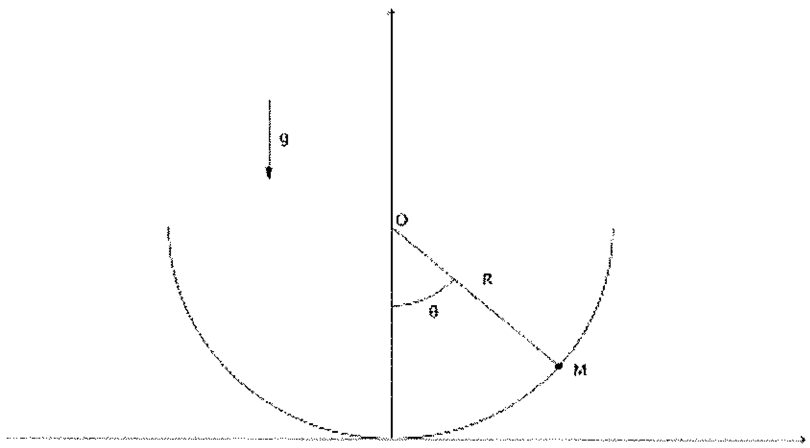


2- a) Use mechanical energy theorem to express speed at point A as function of BC, α, β, R and g.
Compute numerically for R = 0,5m ; β = 60° and g = 10m.s^{-2}.

b) Sketch forces acting on the solid at point A.
c) Use Newton's second law in Frenet's basis $(\vec{u}_T, \vec{u}_N)$ to express the norm of reaction R_N at point A as function of m, g, BC, R, α and β.

3- For which minimal value of mechanical energy at point C can the solid reach point D ?

Exercise 2 ***Study of a damped oscillation*** (6 points).



We are considering the motion of an object M of mass m along a semi-circle of radius R and center O.
Frictions can be modelled by: $\vec{f} = -\alpha\vec{v}$.
The mass m is released at some angle θ_0 without initial speed.

1- Describe the exterior forces acting on point M and sketch them above.

2-a) Write Newton's second law. Then project this equation in Frenet's basis $(\vec{u}_T, \vec{u}_N)$.

b) Deduce from it the reaction R_N and the differential equation which is expressing the angle $\theta(t)$ as a function of its derivatives $\dot{\theta}$ and $\ddot{\theta}$.

c) Consider the case where the mass m is released at small angle θ_0 such that one can use the approximation $\sin(\theta) \approx \theta$. Rewrite the differential equation and discuss the different regimes as function of friction coefficient α.

d) Illustrate those regimes with curves θ(t).

Exercise 3 **Questions 1, 2 and 3 are independent.** (7 points)

1- A calorimeter contains a mass $m_1 = 200g$ of water. The initial temperature of this system is $\theta_1=20°C$. One adds a mass $m_2= 300g$ of water which is at temperature $\theta_2=80°C$.
a) Which temperature θ_e would the total system reach at equilibrium if heat capacity of calorimeter C_{cal} were neglected? Given data : Heat capacity of water $c_w = 4.10^3 JK^{-1}kg^{-1}$.

b) One actually measures a temperature $\theta_e = 50°C$ at thermal equilibrium. Compute the calorimeter heat capacity C_{cal}.

2- A calorimeter, whose capacity is neglected, contains a mass $m_1 = 200g$ of water at temperature $\theta_1 = 70°C$. One put inside an ice cube of mass $m_2 = 80g$ which was in a freezer at temperature $\theta_2 = -23°C$.
Compute the equilibrium temperature θ_e assuming that the whole ice cube has melted.
Data: Fusion latent heat of ice: $L_f = 300.10^3 Jkg^{-1}$.
Heat capacity of water per mass unit: $c_w = 4.10^3 JK^{-1}kg^{-1}$.
Heat capacity of ice per mass unit: $c_i = 2.10^3 JK^{-1}kg^{-1}$.

3- We would like to get a warm bathwater at 37°C of total volume **V** = 250L and which is obtained by mixing a volume $\mathbf{V_1}$ of hot water at initial temperature θ_1=70°C and a volume $\mathbf{V_2}$ of cold water at initial temperature θ_2=15°C.
Find volumes $\mathbf{V_1}$ and $\mathbf{V_2}$ by neglecting all thermal loss while mixing.
Data: Heat capacity per mass unit of water: $c_e = 4.10^3 JK^{-1}kg^{-1}$.
Volumic mass of water: $\rho_e = 1kg/L$.