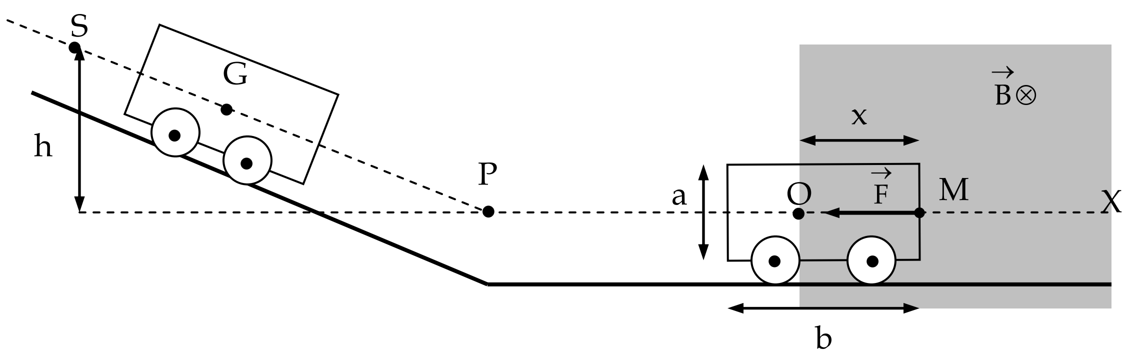
Physics Unified Exam for LS

First exercise (6,5 points)
A braking chariot in a magnetic field

A chariot (C), is formed of a rectangular loop, of dimensions (a = 40 cm and b = 1 m) and of resistance R = 0, 3 Ω, equipped by brakes on the wheels. The chariot is placed on a track that is situated in the same vertical plane of the loop. The total mass of (C) is M = 1 kg.

(C), released, without initial speed and its center of gravity G describes, without friction, the trajectory SPOX as indicated in the figure below.



The height of the point S with respect to a horizontal plane passing through is h = 1, 8 m.

At O, the loop enters a region of a uniform, horizontal magnetic field $\vec{B}$, perpendicular to the plane of the loop and is of intensity B.

Given: The potential energy reference level is taken to be the horizontal plane passing through PX. g = 10 m/s².

I – A Study before the chariot enters the magnetic region

a) Name the forces acting on (C).

b) Applying the conservation of mechanical energy, calculate the speed V_0 of (C) on the segment PO.

II – A study during the entrance of the chariot to the magnetic region

At the instant t_0 = 0, the chariot enters the magnetic region, it is then subjected to an additional force $\vec{F}$ as indicated in the figure above.

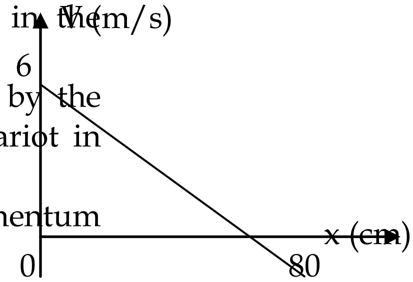
1) Justify the existence and the orientation of the force $\vec{F}$.

2) **a)** Calculate as a function of B, a, and x, the magnetic flux traversing the loop.

b) Deduce the value of the electromotive force as a function of B, a, and the speed V of the chariot at an instant t.

c) Calculate as a function of B, a, V and R the intensity of the current induced in the coil and deduce the expression F of the force $\vec{F}$.

3) The change of the speed of the chariot as a function of the position x = OM is given as given in the figure.



a) What is, graphically, la distance covered by the chariot in the magnetic region? Is the chariot in the magnetic field region totally? Justify.

b) Express V as a function of x then the momentum of the chariot as a function of x.

c) Applying Newton's second law, $\sum \vec{F}_{ex} = \frac{d\vec{P}}{dt}$, on the chariot, verify that B = 3,75 T.

Second exercise (6, 5 points)
Hydrogen Atom

Planck's constant: $h = 6,6 \times 10^{-34}$ J. s;
The speed of light in vacuum: $c = 3 \times 10^{8}$ m/s;
Mass of an electron: $m_e = 9,1 \times 10^{-31}$ kg;
Equivalence of energy: 1 *e V* = $1,6 \times 10^{-19}$ J;
The wavelengths of the visible light spectra, in vacuum, ranges between 400 nm and 800 nm.

The energy levels of the hydrogen atom are given by the relation: $E_n = -\frac{13,6}{n^2}$ with E_n in *e V*, n is more than or equal to 1.

1) The preceding expression, states that the energy levels of the hydrogen atom are quantized. Justify.
2) Represent, on a figure and without respecting a scale, the energy diagram of the first four energy levels of the hydrogen atom.
3) The atom is in its ground state, it absorbs a monochromatic radiation of wavelength λ = 102, 36 nm.
   a) Precise the new state of the hydrogen atom after the absorption of the radiation.
   b) One of the possible emitted spectra, after the de-excitation of the atom to its ground state is formed of two rays. Determine the wavelengths λ_1 and λ_2 de of these rays.
   c) The solar light is dispersed using a prism and is sent through a tube containing hydrogen gas. The study of the absorption spectra reveals the presence of dark lines.
   Precise, with justification, a wavelength corresponding to one of the dark lines.
4) An electron moves with a speed V towards the hydrogen atom, taken in the ground state, after its interaction its speed becomes V' = $4,6 \times 10^{5}$ m/s and the hydrogen atom is in its first excited state.
   a) Is V greater or less than V'? Justify.
   b) Is the kinetic energy of the electron quantized? Justify.

c) Using the conservation of energy of the (atom – electron) system calculate V.

Third exercise (7 points)
A study of a Radon 219 sample

A – A Study of the stability of the Radon 219 nucleus

The mass of Radon $^{219}_{86}Rn$ is 219,009481 u;
The mass of a free proton is 1,007825 u;
The mass of a free neutron is 1,008665 u; 1 u = 931, 5 MeV/c^2.

1) Calculate the binding energy per nucleon for the Radon nucleus.
2) The nuclide Radon 219 is not stable. Justify.

B – The period of Radon 219

We measure at different instants, separated by a constant duration of 8 seconds, the activity of the Radon 219 sample, we come upon the results in the table below :

t : time (s)	**0**	**8**	**16**	**24**	**32**
A : activity (Ci)	10000	2500	625	156,25	39,0625
Ln(A)	9,2	7,8	6,4	5	3,7

Given: 1 Ci = 3,7x10^{10} Bq.

1) Define the activity of a sample and its half life T.
2) Trace, in an orthonormal system, the curve representing Ln(A) as a function of time t. Scale: abscissa: 1 cm ↔ 4 s, and ordinate: 1 cm ↔ 1 unit of Ln(A)
3) Deduce, graphically, that the value of the period of radon 219 is T = 4s and calculate the constant of disintegrationλ.
4) Deduce the number of nuclides N_0, Radon 219, which existed in the sample at the instant t = 0.

C – The disintegration of Radon 219

The Radon nucleus $^{219}_{86}Rn$ is an α emitter and it transforms into polonium Po. After the measurement of the maximum distance covered by an α particle in a room filled with bubbles we are able to determine its kinetic energy.

1) Write, listing the laws used the equation of disintegration of the Radon 219 nucleus.
2) The daughter nuclei can be either in the ground or in the excited state.
   a) What is the nature of the emitted radiation by the daughter nuclei after de-excitation?

b) To what form of energy is the energy liberated by the disintegration of the Radon 219 nuclei transformed to if the daughter nuclei are in their : i) ground state? ; ii) excited state?

c) During the disintegration of the Radon 219 sample, the kinetic energies of the emitted α particles are: 6, 82 MeV ; 6, 55 MeV and 6, 43 MeV.

1. Deduce the energy liberated by the disintegration of a Radon 219 nucleus and calculate the energies of the emitted γ rays.
2. Calculate at the instant t = 8 s, the power of the sample.

Given: 1MeV = $1,6\times10^{-13}$ J