Physics Exam 2
Friday January 10, 2025 - Duration : 1h30

Not only will your results be evaluated, but more importantly, your ability to clearly justify them and critically analyze them afterwards will also be assessed. Additionally, every result must be presented in a literal form using only the data provided in the statement. It is also emphasized to pay attention to spelling and presentation quality.

No reference materials are allowed. ***Calculators in exam mode are permitted.***
The grading scale is provided for guidance only.

Exercise 1 : DC circuit (≈ 7 pts.)

1. In the circuit of Figure 1, determine, using the method of your choice and providing justifications, the expressions for the current I and the voltage U_{AB}.
2. Recall under which condition(s) a dipole can act as a receiver. Knowing that $E > 0$ and $I_N > 0$, provide the condition relating E, I_N, and R for the real current source (outlined in dashed lines in Figure 1) to operate as a receiver.

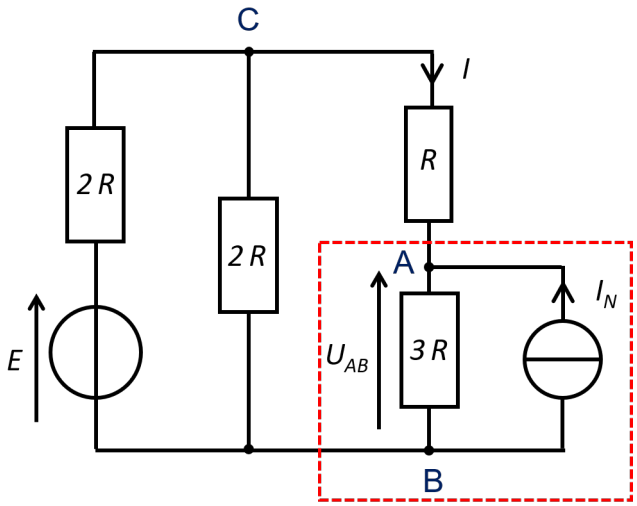

Figure 1 : Circuit to be considered for Exercise 1

Exercise 2 : Discharge of a capacitor through the human body (problem-solving) (≈ 6 pts.)

As with any problem-solving exercise, you should clearly explain all the steps of your approach.

The terminals of a capacitor with capacitance C initially charged to voltage U_0 are connected to a person's hands at time $t = 0$.

The equivalent resistance R of the human body between the two hands is $R = 1\text{k}\Omega$. The capacitor with capacitance $C = 500\ \mu\text{F}$ is initially charged to a constant voltage $U_0 = 100\text{V}$.

Determine the time evolution of the current flowing through the human body, and then discuss the person's fate using Figure 2 as a reference.

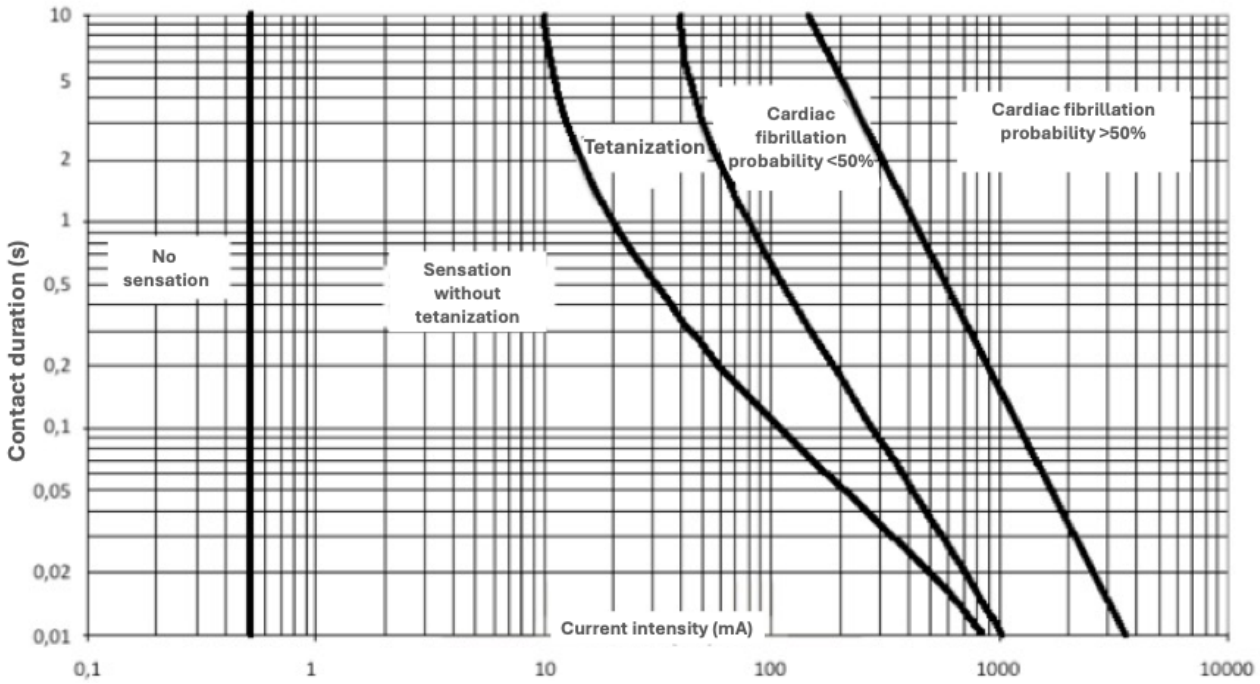

Figure 2 : Effects of electric currents based on their intensity and contact time.

Is your analysis consistent with the following statement? :

"In a first approximation, one could consider that the health of a person of average build is not affected if the person receives an energy amount less than 5 J during an electrification."

Exercise 3 : Mass-spring system on an inclined plane (≈ 7 pts.)

A block assumed to be a point mass of mass $m = (100 \pm 5)$ g is attached to the end of a spring located on an inclined plane making an angle $\alpha = (20.0 \pm 0.5)°$ with the horizontal axis (see Figure 3). The spring has a stiffness k, length ℓ and a length at rest ℓ_0. The standard gravity is $g = 9.81$ m.s^{-2}.

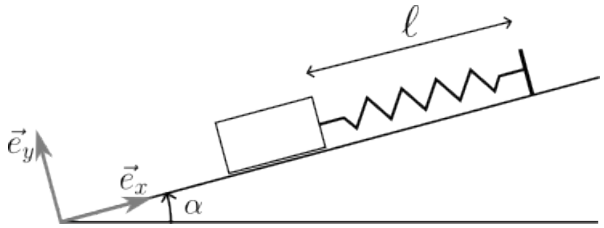

Figure 3 : Mass-spring system of Exercise 3

We first consider that **the contact between the block and the inclined plane is without friction**.

1. An equilibrium position is found for an elongation $\ell - \ell_0 = (27.0 \pm 0.1)$ cm. Determine the value of k with its uncertainty.
2. Is this a stable or unstable equilibrium?

We consider now that **there is friction between the block and the inclined plane**, with a friction coefficient $f = 0.1$, and that all values are known **without uncertainties** ($m = 100$ g, $\alpha = 20°$, $\ell - \ell_0 = 27$ cm).

3. Recall the inequality relating the magnitude of the tangential component of the reaction force, the magnitude of the normal component and the friction coefficient.
4. Accounting for friction, what are the minimum and maximum possible values of k that satisfy the previous equilibrium? Comment on this result.
5. Typical values of the friction coefficient are : 0.03 for steel on ice, 0.1 for steel on Teflon, 0.5 for wood on wood, and 1.0 for glass on glass. In which case(s) can we neglect friction? Justify your answer.