Lebanese University
Faculty of Technology

الجامعة اللبنانيّة
كلية التكنولوجيا

Entrance Exam (TSE)

Physics Exam

Grade/30

September 9, 2025 **Duration: 1H30**

All questions are obligatory

Question 1 ***(10 points)***

We consider the circuit of figure 1, formed by a capacitor of capacity C, a very large resistance R and a supply voltage E = 3 V. The capacitor, being uncharged, at the instant $t_0 = 0$, we close the circuit. We obtain the evolution of the current i on the graph of figure 2.

1) a) Determine the expression of the current i in terms of C and the voltage $u_c = u_{BD}$ across the terminals of the capacitor.

b) By applying the law of addition of voltages, determine the differential equation of the voltage u_c.

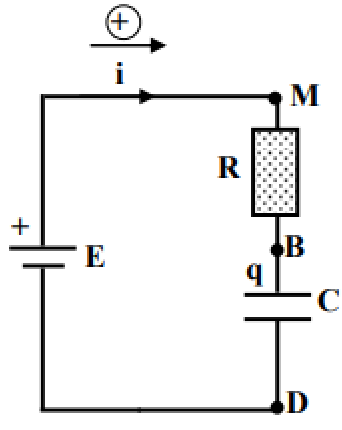

Fig.1

2) The solution of this differential equation is given by:

$u_c = E(1 - e^{-\frac{t}{\tau}})$, where τ = RC.

a) Determine, as a function of time t, the expression of the current i.

b) Deduce, at the instant $t_0 = 0$, the expression of the current I_0 in terms of E and R.

c) Using figure 2:

i) calculate the value of the resistance R of the resistor.

ii) determine the value of the time-constant τ of the circuit.

d) Deduce that C ≈ 641 μF.

3) Show that the electric energy stored in the capacitor, when it is completely charged under the voltage E is W ≈ 2.9×10^{-3} J.

4) The capacitor, being totally charged, is disconnected from the circuit and discharges through a resistor of same resistance R. Calculate:

a) the duration at the end of which the capacitor can be practically completely discharged;

b) the average power given by the capacitor during the discharging process.

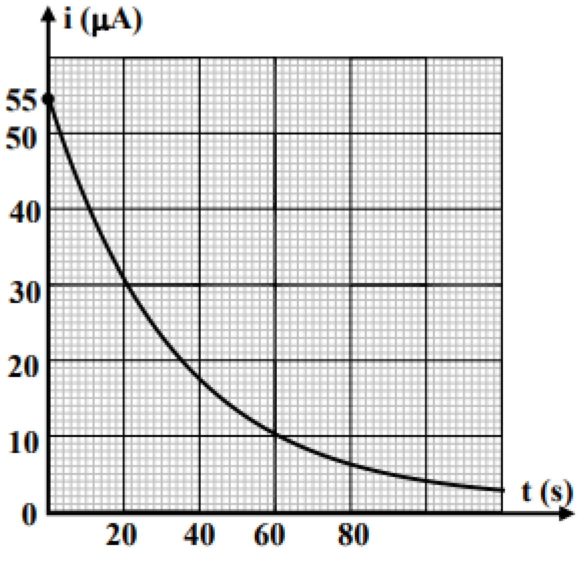

Fig.2

Question 2	*(10 points)*

In order to study the collision between two bodies, we consider a horizontal air table equipped with a launcher and two pucks (A) and (B) of respective masses $m_A = 0.4$ kg and $m_B = 0.6$ kg (figure 3).
(A), launched with the velocity $\overrightarrow{V_1} = 0.5\,\vec{i}$, collides with (B) initially at rest.
(A) rebounds with the velocity $\overrightarrow{V_2} = -\,0.1\,\vec{i}$ and (B) moves with the velocity $\overrightarrow{V_3} = 0.4\,\vec{i}$ (V_1, V_2 and V_3 are expressed in m/s).
Neglect all frictional forces.

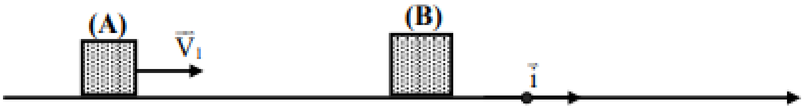

Fig.3

A – Linear momentum

1) a) Determine the linear momentums:

i) $\overrightarrow{P_1}$ and $\overrightarrow{P_2}$ of (A), before and after collision respectively.

ii) $\overrightarrow{P_3}$ of (B) after collision.

b) Deduce the linear momentums $\vec{P}$ and $\overrightarrow{P'}$ of the system [(A), (B)] before and after collision respectively.

c) Compare $\vec{P}$ et $\overrightarrow{P'}$. Conclude.

2) a) Name the external forces acting on the system [(A), (B)].

b) Give the value of the resultant of these forces.

c) Is this resultant compatible with the conclusion in question (1-c)? Why?

B – Type of collision

1) Determine the kinetic energy of the system [(A), (B)] before and after collision.

2) Deduce the type of the collision.

C – Principle of interaction

The duration of collision is $\Delta t = 0.04$ s; we can consider that $\frac{\Delta\vec{P}}{\Delta t} \cong \frac{d\vec{P}}{dt}$.

1) Determine during Δt:

a) The variations $\Delta\vec{P}_A$ and $\Delta\vec{P}_B$ in the linear momentums of the pucks (A) and (B) respectively;

b) the forces $\vec{F}_{A/B}$ exerted by (A) on (B) and $\vec{F}_{B/A}$ exerted by (B) on (A).

2) Deduce that the principle of interaction is verified.

Question 3	*(10 points)*

Nuclear reactions

Given: mass of a proton: $m_p = 1.0073$ u; mass of a neutron: $m_n = 1.0087$ u;

mass of ${}^{235}_{92}U$ nucleus: $m_U = 235.0439$ u; mass of ${}^{90}_{36}Kr$ nucleus: $m_{Kr} = 89.9197$ u;

mass of ${}^{142}_{Z}Ba$ nucleus $m_{Ba} = 141.9164$ u; molar mass of ${}^{235}_{92}U$: M = 235 g/mole;

Avogadro's number: $N_A = 6.022\times10^{23}$ mol^{-1}; 1u = 931.5 MeV/c^2 = 1.66×10^{-27} kg; 1 MeV = 1.6×10^{-13} J.

A – Provoked nuclear reaction

As a result of collision with a thermal neutron, a uranium 235 nucleus undergoes the following reaction:

$${}^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{90}_{36}Kr + {}^{142}_{Z}Ba + y\,{}^{1}_{0}n$$

1) a) Determine y and Z.

b) Indicate the type of this provoked nuclear reaction.

2) Calculate, in MeV, the energy liberated by this reaction.

3) In fact, 7% of this energy appears as a kinetic energy of all the produced neutrons.

a) Determine the speed of each neutron knowing that they have equal kinetic energy.

b) A thermal neutron, that can provoke nuclear fission, must have a speed of few km/s; indicate then the role of the "moderator" in a nuclear reactor.

4) In a nuclear reactor with uranium 235, the average energy liberated by the fission of one nucleus is 170 MeV.

a) Determine, in joules, the average energy liberated by the fission of one kg of uranium ${}^{235}_{92}U$

b) The nuclear power of such reactor is 100 MW. Calculate the time Δt needed so that the reactor consumes one kg of uranium ${}^{235}_{92}U$.

B – Spontaneous nuclear reaction

1) The nucleus krypton ${}^{90}_{36}Kr$ obtained is radioactive. It disintegrates into zirconium ${}^{90}_{40}Zr$, by a series of β^- disintegrations.

a) Determine the number of β^- disintegrations.

b) Specify, without calculation, which one of the two nuclides ${}^{90}_{36}Kr$ and ${}^{90}_{40}Zr$ is more stable.

2) Uranium ${}^{235}_{92}U$ is an α emitter.

a) Write down the equation of disintegration of uranium ${}^{235}_{92}U$ and identify the nucleus produced.

Given:

Actinium ${}_{89}Ac$	Thorium ${}_{90}Th$	Protactinium ${}_{91}Pa$

b) The remaining number of nuclei of ${}^{235}_{92}U$ as a function of time is given by: $N = N_0\, e^{-\lambda t}$ where N_0 ,is the number of the nuclei of ${}^{235}_{92}U$ at $t_0 = 0$ and λ is the decay constant of ${}^{235}_{92}U$.

i) Define the activity A of a radioactive sample.

ii) Write the expression of A in terms of λ, N_0 and time t.

c) Derive the expression of $\ell n(A)$ in terms of the initial activity A_0, λ and t.

d) The figure 4 represents the variation of $\ell n(A)$ of a sample of ${}^{235}_{92}U$ as a function of time.

i) Show that the shape of the graph of figure 4, agrees with the expression of $\ell n(A)$.

ii) Using the figure 4 determine, in s^{-1}, the value of the radioactive constant λ.

iii) Deduce the value of the radioactive period T of ${}^{235}_{92}U$.

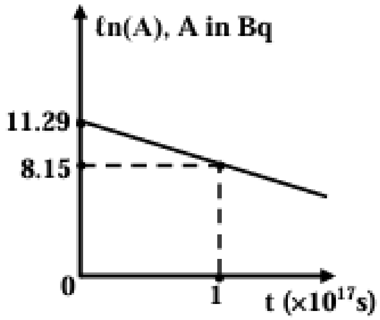

Fig.4