Lebanese University
Faculty of Engineering

Entrance Exam 2020-2021
Physics

September 2020
Duration 60 min

SPECIFIC INSTRUCTIONS

-- You must choose and answer 20 questions among the 30 proposed to obtain the maximum score.
If you are dealing with more than 20 questions, only the first 20 will be taken into account.
- All of the blank pages on the back of this topic can be used for drafting if you wish. No draft will be distributed to you.
- The use of the non-programmable calculator is authorized
-In order to eliminate random answer strategies, each correct answer is rewarded with **3 points**, while each wrong answer is penalized by the withdrawal of **1 point**.

First exercise: RL and RLC circuits

The objective of this study is to find experimentally the capacitance of a capacitor and the inductance and the resistance of a coil.

The available equipments are an ideal generator of e.m.f. E = 10 V, a coil of inductance L and resistance r, a capacitor (C) of capacity C = 10 μF, a resistor (R) of resistance R = 1 kΩ, a switch (K) and connecting wires.

A. Experimental study of an RL circuit

The circuit is shown in figure 1. At the instant $t_0 = 0$, the switch K is closed. Let i be the current carried by the circuit at an instant t.

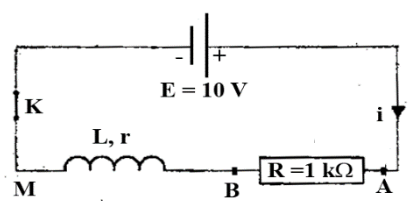

Figure 1

1. The differential equation that governs the variations of the voltage $u_R = u_{AB}$ across the resistor is:

a) $E = \frac{R}{R+r}u_{AB} + \frac{L}{R}\frac{du_{AB}}{dt}$

b) $E = \frac{R+r}{R}u_{AB} + \frac{L}{R}\frac{du_{AB}}{dt}$

c) $E = \frac{R+r}{R}u_{AB} + \frac{R}{L}\frac{du_{AB}}{dt}$

2. The solution of this differential equation is of the form:

a) $u_{AB} = E\, e^{-\frac{R+r}{L}t}$

b) $u_{AB} = E(1- e^{-\frac{R+r}{L}t})$

c) $u_{AB} = E(1- e^{-\frac{L}{R+r}t})$

3. At the instant $t_0 = 0$ s, we record, using a given system, the variation of the voltage u_R across the resistor (R) and that of u_B across the coil as a function of time. We obtain the waveforms shown in figure 2. The curve (1) represents the voltage across:

a) the resistor;
b) the coil;
c) the generator.

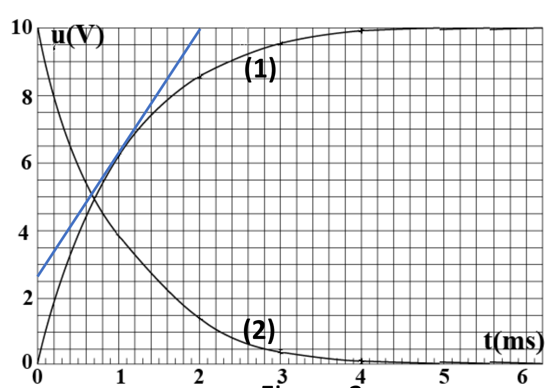

Figure 2

4. At the instant t = 1 ms, the value of the derivative of i with respect to time ($\frac{di}{dt}$) is equal to :

a) 4.1 A/s;
b) 3.7 A/s;
c) 3.3 A/s.

5. Knowing that r is negligible compared to R, the value of L is:

a) 1.04 H;
b) 1.10 H;
c) 1.21 H.

6. By measuring the acurate value of the voltage $u_L = u_{BM}$ across the coil using the recording system, we find that, in steady state, u_{BM} = 10 mV. Then, the value of r is:
a) 8.0 Ω;
b) 5.0 Ω;
c) 1,0 Ω.

7. At the instant t = 1 ms, the value of the voltage u_{BM} across the coil and the magnetic energy W_m it stores, are:
a) u_{BM} = 6.3 V and $W_m = 6.9\times10^{-6}$ J;
b) u_{BM} = 3.7 V and $W_m = 6.9\times10^{-6}$ J;
c) u_{BM} = 3.7 V and $W_m = 2.0\times10^{-5}$ J.

B. Study of the oscillating circuit
The set up corresponding to the diagram of figure 3 is then carried out. At the instant $t_0 = 0$, the switch (K) is placed on position 1 to charge the capacitor.

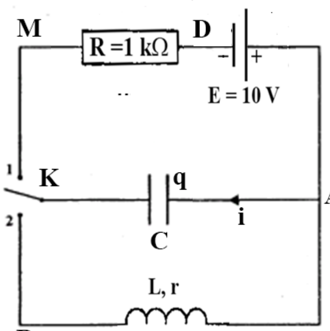

Figure 3

1. At the end of the charging of the capacitor, the electric energy W_0 stored by (C) and its electric charge Q_0 are respectively:
a) $W_0 = 1.0\times10^{-3}$ J and $Q_0 = 1.0\times10^{-4}$ C;
b) $W_0 = 5.0\times10^{-4}$ J and $Q_0 = 1.0\times10^{-4}$ C;
c) $W_0 = 5.0\times10^{-4}$ J and $Q_0 = 5.0\times10^{-4}$ C.

2. At an instant considered as a new origin of time, $t_0 = 0$, the switch is turned to position 2. With the recording system, we obtain, starting from the instant $t_0 = 0$, the graph of figure 4, representing the variation of the voltage u_C across the capacitor as a function of time t.

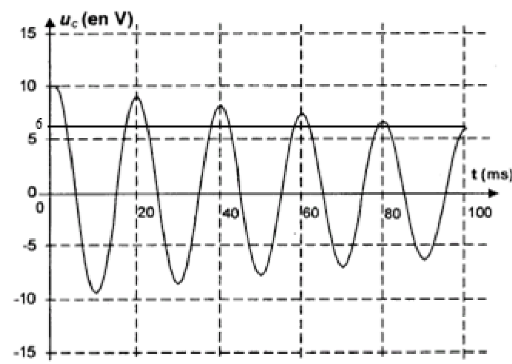

Figure 4

2.1 At the instant $t_0 = 0$, the magnetic energy $W_m(0)$ stored by the coil is:
a) $W_m(0) = 5\times10^{-4}$ J;
b) $W_m(0) = 1\times10^{-3}$ J;
c) $W_m(0) = 0$ J.

2.2 Referring to figure 4, the pseudo angular frequency ω of the oscillations and the average power P_{av} dissipated by the circuit are:
a) ω = 314 rad/s and $P_{av} = 6.4\times10^{-3}$ W;
b) ω = 628 rad/s and $P_{av} = 6.4\times10^{-3}$ W;
c) ω = 314 rad/s and $P_{av} = 3.2\times10^{-3}$ W.

Second exercise: Verification of Newton's second law

We consider an inclined plane forming an angle $\alpha = 30^o$ with the horizontal plane. A particle (S), of mass m = 0.5 kg, is launched from O, the lowest point of the plane, at the instant $t_0 = 0$, with a velocity $\vec{V}_0 = V_0\,\vec{i}$ along the line of greatest slope (OB) of the inclined plane. Let A be a point of (OB) such that OA = 5 m (fig. 1). The position of (S), at an instant t, is given by $\overrightarrow{OM} = x\,\vec{i}$ where x = f(t).

The variation of the mechanical energy of the system [(S), Earth], as a function of x, is represented by the graph in Figure 2.

Take:

- the horizontal plane passing through OH as the reference level for the gravitational potential energy;

- $g = 10\ m.s^{-2}$.

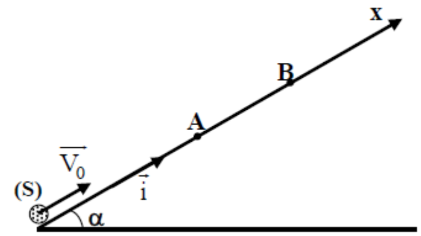

Fig.1

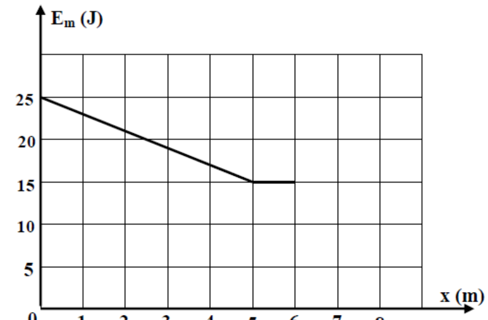

Fig.2

1.1. Referring to the graph in Figure 2, the variation ΔE_m of the mechanical energy of the system [(S), Earth] between the dates of passage of (S) through the points O and A is:

a) $\Delta E_m = -20$ J.

b) $\Delta E_m = +10$ J.

c) $\Delta E_m = -10$ J.

1.2. The magnitude of the force of friction, supposed constant between O and A, is equal to:

a) f = 2 N

b) f = 3 N

c) f = 5 N

1.3. For $0 \le x \le 5$ m**,** the expression of the mechanical energy E_m of the system [(S), Earth] is:

a) $E_m = -3x + 25$. (E_m in J; x in m);

b) $E_m = -2x + 25$. (E_m in J; x in m);

c) $E_m = -5x + 15$. (E_m in J; x in m).

1.4. The speed of (S) at the point of abscissa x = 6 m is:

a) v = 3.5 m/s;

b) v = 0 m/s;

c) None of the two answers.

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2. Let v be the speed of (S) when it passes through the point M of abscissa x such that $0 \le x \le 5$ m.

2.1. The relation between v and x is given by:

a) 0.25 v + 4.5 x -25 = 0;

b) $0.5\ v^2 + 4.5\ x - 25 = 0$;

c) $v^2 + 18\ x - 100 = 0$.

2.2. The algebraic value a of the acceleration of (S) is constant at any time and it is equal to:

a) $a = -9\ m.s^{-2}$;

b) $a = +9\ m.s^{-2}$;

c) $a = -4.5\ m.s^{-2}$.

3.1.1. The speed of (S) at O is:

a) v(at O) = 9 m/s;

b) v(at O) = 10 m/s;

c) v(at O) = 4.5 m/s.

3.1.2. The speed of (S) at A is:
a) v (at A) = 3.16 m/s;
b) v (at A) = 2.56 m/s;
c) v (at A) = 2.24 m/s.

3.1.3. Knowing that V_0 = 10 m.s^{-1} and that the speed of (S), at an instant t, is given by v = at + V_0, then the duration $\Delta t = t_A - t_0$ of the displacement of (S) during its climb from O to A is:
a) Δt = 1.11 s;
b) Δt = 1.52 s;
c) Δt = 0.76 s.

3.2. Knowing that the linear momentum of (S) at A is 1.58 kg.m/s, then the sum of the external forces applied to (S), $\vec{F} = \Sigma\vec{F}_{ext}$, which is constant at any time, is equal to:
a) $\vec{F} = -9\,\vec{i}$ (F in N);
b) $\vec{F} = -4.5\,\vec{i}$ (F in N);
c) $\vec{F} = -3.10\,\vec{i}$ (F in N).

Third exercise: The Chernobyl accident, 34 years later
When, on April 26, 1986, the reactor No. 4 of the Chernobyl power plant in Ukraine exploded, humanity then experienced the most serious civil nuclear disaster ever recorded in the world.
An explosion and fire occur. In the core, the fuel rods are fragmented. …. In the absence of a containment, radioactive debris from the reactor core (iodine 131, cesium 134 and 137, ruthenium 103 and 106), some of which are very volatile, are released into the environment….
In this problem, it is proposed to analyze the environmental impact 34 years later of two radioactive "debris" produced during the Chernobyl disaster.

Masses: m($^{235}_{92}U$) = 234.9933 u ; m(^{95}Zr) =94.8860 u ; m(^{138}Tl) = 137.9011 u ; m($^{1}_{0}n$) = 1.00866 u.
1 u = 1.66054×10^{-27} kg = 931.5 MeV/c^2; c=3.00 10^8 m/s; 1 eV = 1.60×10^{-19} J; h = 6.62×10^{-34} J.s.
N_A = 6.022×10^{23}.
1. At the core of the reactor.
In a slow neutron nuclear power plant, the fuel is enriched uranium; it contains 3% of fissile uranium 235 ($^{235}_{92}U$) and 97% 0f fertile (non -fissile) uranium 238 ($^{238}_{92}U$).

1.1. During the impact of a neutron on a uranium 235 nucleus, several fission reactions are possible. The most frequent leads to zirconium 95 and tellurium 138 nuclei as well as to k neutrons. The equation for this fission reaction is:
a) $^{1}_{0}n + ^{235}_{92}U \rightarrow ^{95}_{39}Zr + ^{138}_{52}Tl + ^{1}_{0}n$;
b) $^{1}_{0}n + ^{235}_{92}U \rightarrow ^{95}_{40}Zr + ^{138}_{51}Tl + 2^{1}_{0}n$;
c) $^{1}_{0}n + ^{235}_{92}U \rightarrow ^{95}_{40}Zr + ^{138}_{52}Tl + 3^{1}_{0}n$.

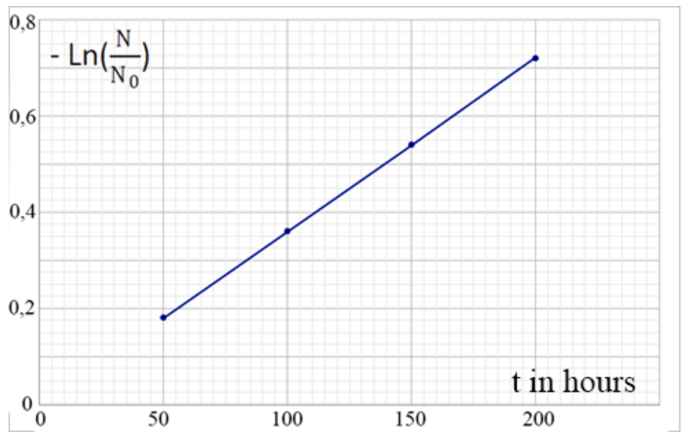
1.2. The energy E_1 released by this nuclear reaction is:
a) E_1 = 185.6 MeV;
b) E_1 = 175.9 MeV;
c) E_1 = 196.8 MeV.

1.3. Knowing that the mass of a uranium 235 atom is 235,043 u, then the energy E_2 released by the fission of 200 kg of uranium 235 present in the core of the reactor during the Chernobyl accident is:
a) 1.44×10^{16} J;
b) 1.52×10^{16} J;
c) 1.61×10^{16} J.

1.4. Knowing that a ton of TNT releases an energy $Q = 4.2\times10^{6}$ J, the equivalent mass of TNT is:
a) 3.62×10^{9} kg of TNT;
b) 3.44×10^{9} kg of TNT;
c) 3.93×10^{9} kg of TNT.

1.5. Iodine 131 ($^{131}_{53}I$), one of the radioactive wastes released during the nuclear accident, is a β^- emitter and the daughter nucleus is xenon (Xe). The decay reaction of an iodine 131 nucleus is:
a) $^{131}_{53}I \rightarrow ^{131}_{54}Xe + ^{0}_{-1}e + ^{0}_{0}\nu$
b) $^{131}_{53}I \rightarrow ^{131}_{54}Xe + ^{0}_{-1}e + ^{0}_{0}\bar{\nu}$
c) $^{131}_{53}I \rightarrow ^{131}_{52}Xe + ^{0}_{1}e + ^{0}_{0}\bar{\nu}$

2. Let N_0 be the average number of nuclei present at the instant $t_0 = 0$. At an instant t, the average number of iodine nuclei 131 present is N; we obtain the adjacent graph showing $-\ln(\frac{N}{N_0})$ as a function of time.



2.1. Using the graph and the radioactive decay law, we find that the radioactive constant of iodine 131 is:
a) $\lambda = 0.036$ hour^{-1};
b) $\lambda = 1.08\times10^{-5}$ s^{-1};
c) $\lambda = 0.0036$ hour^{-1}.

2.2. The half-life $t_{1/2}$ of iodine 131 has the value:
a) $t_{1/2} = 96.3$ days;
b) $t_{1/2} = 192.5$ h;
c) $t_{1/2} = 385.7$ h.

3. During the explosion, the number of iodine 131 nuclei emitted is estimated to be $N = 4.1\times10^{26}$ nuclei.
3.1. The activity A_0 of iodine 131 during the explosion is:
a) $A_0 = 4.1\times10^{20}$ Bq;
b) $A_0 = 1.5\times10^{24}$ Bq;
c) $A_0 = 1.5\times10^{22}$ Bq.

3.2. The activity A of iodine in the atmosphere 1 month later is:
a) $A = 1.13\times10^{23}$ Bq;
b) $A = 3.07\times10^{19}$ Bq;
c) $A = 1.13\times10^{21}$ Bq.

3.3. The activity A of iodine in the atmosphere 34 years later is:
a) $A = 1.46\times10^{19}$ Bq;
b) $A = 1.46\times10^{10}$ Bq;
c) $A \approx 0$.

Université Libanaise	Examen d’entrée 2020-2021	Septembre 2020
Faculté d’ingénierie	**Physique (1)**	**Durée 60 min**

CONSIGNES SPECIFIQUES

- Vous devez choisir et répondre à 20 questions parmi les 30 proposées pour obtenir la note maximale. Si vous traitez plus de 20 questions, seules les 20 premières seront prises en compte. Cocher la bonne réponse par (X).

- L’usage de la calculatrice non programmable est autorisé.

-Afin d’éliminer les stratégies de réponses au hasard, chaque bonne réponse est gratifiée de **3 points**, tandis que la mauvaise réponse est pénalisée par le retrait **d’1 point**.

Premier exercice : Circuits RL et RLC

Questions	(a)	(b)	(c)	Notes
A.1		X		
A.2		X		
A.3	X			
A.4		X		
A.5	X			
A.6			X	
A.7			X	
B.1		X		
B.2.1			X	
B.2.2			X	

Deuxième exercice : Vérification de la deuxième loi de Newton

Questions	(a)	(b)	(c)	Notes
1.1			X	
1.2	X			
1.3		X		
1.4		X		
2.1			X	
2.2	X			
3.1.1		X		
3.1.2	X			
3.1.3			X	
3.2		X		

Troisième exercice : : L'accident de Tchernobyl, 34 ans plus tard

Questions	(a)	(b)	(c)	Notes
1.1			X	
1.2		X		
1.3	X			
1.4		X		
1.5		X		
2.1			X	
2.2		X		
3.1	X			
3.2		X		
3.3			X	