Lebanese University
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الجامعة اللبنانية
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Entrance Exam: 8 September 2016

Physics: CE - IEM - CCNE **Time: 1h30**

N.B.: All questions are obligatory

Exercise I (5 points)

A square coil, with a side a = 20 cm and carrying N = 100 turns, is placed in a uniform magnetic field normal to the plane of the turns, figure 1a. The value B of the magnetic field varies periodically as a function of time as shown in figure 1b.

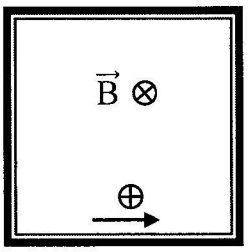

Figure 1a

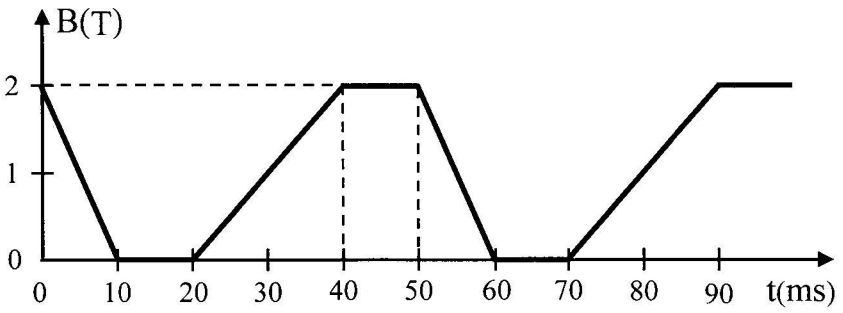

Figure 1b

1) What is the period T of the magnetic field $\vec{B}$?

2) Determine, as a function of $\frac{dB}{dt}$, the expression of induced electromotive force e in the coil.

3) Deduce the values of the electromotive force induced in the interval [0, T].

4) Indicate the direction of the induced current i in the coil in the interval [0, T].

Exercise II (5 points)

A bullet, of mass m = 9.5 g, moving with a horizontal velocity $\vec{V}_0$, undergoes a collision with a solid of mass M = 5.4 kg, attached to a spring, of constant k = 1000 N/m, as shown in figure 2. After the collision, the bullet and the solid form one body and the spring is compressed to the maximum, where this body is moved to the maximum distance d_m = 15 cm. We neglect the frictional forces.

The horizontal plane passing through the spring axis is taken as the reference level of the gravitational potential energy.

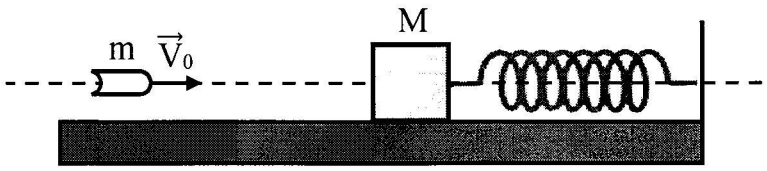

Figure 2

1) Calculate the speed V of the system (m, M) just after the collision.
2) Deduce the speed V_0 of the bullet.
3)
a) The collision is not elastic. Justify, by calculation, this affirmation.
b) How appears in the system (m, M), the variation in the kinetic energy?

Exercise III (10 points)

We consider a resistor of resistance R = 100 Ω, an inductor L = 72 mH and resistance r, a capacitor of capacitance C and an LFG delivers an alternating sinusoidal voltage of effective value U_0 and of frequency f.

We connect by the preceding dipoles the circuit represented in figure 3a. We connect an oscilloscope to the circuit to observe the voltage u_G across the LFG and u_R across the terminals of the resistance R.

In figure 3b we represent the oscillograms displayed by the oscilloscope, where the vertical sensitivity of the two channels: S_v = 1 V/div and the horizontal sensitivity is: S_h = 5 ms/div.

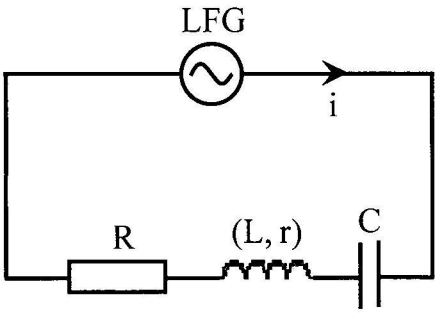

Figure 3a

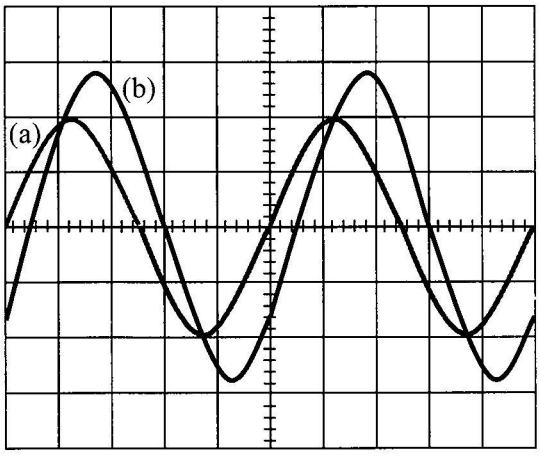

Figure 3b

1) Draw a figure showing the connections of the oscilloscope.
2) Why can we say that:
a) The voltage u_R follows the variation of the intensity i of the current of the circuit?
b) Oscillogram (a) corresponds to u_R? Justify.
3)
a) Calculate the effective value U_0 and the frequency f of the voltage u_G (given: $\sqrt{2} = 1.4$).
b) Calculate the maximum intensity I_m of the current i and its phase difference φ with respect to the voltage u_G.

4) Knowing that: $u_G = U_m\cos(\omega t)$ expressed in SI.

a) Give the expression of the intensity of the current i as a function of time t.

b) Show that the voltage across the terminals of the capacitor is: $u_C \cong \frac{8.10^{-5}}{C}\sin\left(80\pi t + \frac{\pi}{5}\right)$.

c) Applying the law of addition of voltages and giving $\left(80\pi t + \frac{\pi}{5}\right)$ two particular values; calculate the values of the resistance r and the capacitance C.

Exercise IV (10 points)

A simple pendulum (P), of length L = 80 cm, and mass m = 50 g, is at the position IA of angular displacement $\alpha = 60^\circ$ measured with the vertical IO, where L = IO. We release the pendulum (P) with a speed $V_0 = 2$ m/s as indicated in figure 4.

The horizontal plane passing through O is taken as the zero reference level for the gravitational potential energy. Take the acceleration of gravity $g = 10$ m/s^2.

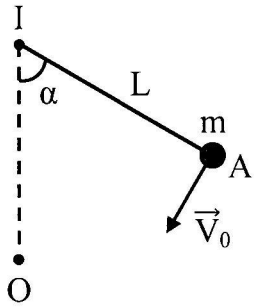

Figure 4

1) The mechanical energy of the system (Earth, P) is conserved; calculate the speed V_1 of the mass m when it passes through O.

2) Determine the maximum angular elongation α_1 of the pendulum.

3) Determine the value of α at which the potential energy of the system (Earth, P) is equal to its kinetic energy.

4) The pendulum (P) oscillates. We fix at O a horizontal, plane, and rough piece of carton. Each time the mass m passes over the carton, the maximum elongation decreases by 5 % from its previous value.

a) What is this decrease in the amplitude due to? Is the mechanical energy conserved?

b) The first amplitude of the pendulum is α_1. Prove that the nth amplitude has the expression: $\alpha_n = (0.95)^{n-1}\alpha_1$.

c) Calculate the variation of the mechanical energy of the system (Earth; P) between the 1st and 20th amplitude.