Lebanese University
Faculty of Technology

الجامعة اللبنانيّة
كلية التكنولوجيا

September-17- 2020

Entrance Exam (Engineering)

<u>Physics Exam</u>

Duration: 1H30

Both exercises 1 and 2 are obligatory
Choose only 2 exercises from the exercises 3, 4 and 5

Exercise 1	***(7points)***

In a vertical plane, referred to an orthonormal coordinate system (O ; $\vec{\imath}$; $\vec{\jmath}$), a particle M, of coordinates (x; y) and of mass m = 500 g, is animated by a movement according to the laws:

$$x = 30t$$
$$y = -5t^2 + 40t$$

where t in seconds, x and y in meters and $\vec{\jmath}$ is an ascending vertical unit vector. The horizontal plane passing through O is taken as a reference level for the potential energy of gravity.

1- Determine the coordinates and the norm of the speed of the particle at times: 0; 2 s; 10 s.
2- Calculate the kinetic energy of the particle at the same times.

Exercise 2	***(7 points)***

Given the circuit of the figure 1 of constant total resistance R = 2 Ω. (T) is a conductor bar moving with a speed *v*.
Given : *v* = 50 cm/s ; B = 0,4 T ; MQ = d = 20 cm et MN = x.

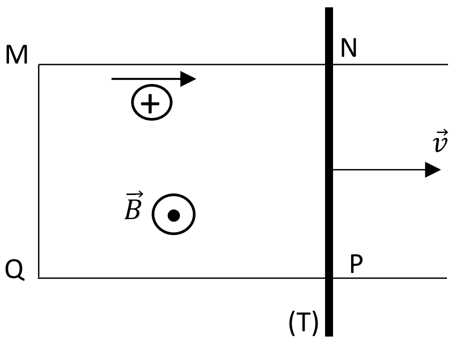

Figure 1

1- Specify the direction of the normal vector $\vec{n}$ at the surface.
2- Write, in terms of **x**, the expression of the magnetic flux through the MNPQ surface.
3- Deduce the value of the induced electromotive force **e**.

Exercise 3	*(8 points)*

An air puck (S) of mass m = 709 g is attached to the free end of a spring (R) of un-jointed turns, of negligible mass and of stiffness k = 7 $N.m^{-1}$. This puck, of center of mass G, may slide without friction on a horizontal rail. The figure 2 shows a horizontal axis Ox of origin O. At equilibrium, G coincides with O.

(S) is shifted 3 cm from O ($\overrightarrow{OG_o} = x_o\vec{i} = 3\vec{i}$) in the positive direction and released without initial velocity at the instant $t_0 = 0$.

At an instant t, x is the abscissa of G and $v = \frac{dx}{dt}$ is the algebraic measure of its velocity. The mechanical energy of the system ((S), (R), Earth) is conserved.

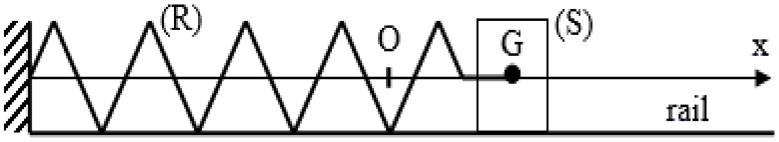

Figure 2

1) Determine the second order differential equation in x.
2) Verify that $x = x_m cos\left(\sqrt{\frac{k}{m}}t + \varphi\right)$ is the solution of this differential equation
3) Calculate the values of the constants x_m et φ.
4) Write the expression of the natural period T_0 of the motion in terms of k and m .Calculate T_0.

Exercise 4	*(8 points)*

Consider an inclined plane that makes an angle α = 30° with the horizontal plane (figure 3).

An object (S), supposed as a particle, of mass m = 0.5 kg is launched from the point O at the instant $t_0 = 0$, with a velocity $\vec{V_0} = V_0\vec{i}$ along the line of the greatest slope (OB). Let A be a point of OB such that OA = 5 m.

The position of (S), at the instant t, is given by $\overline{OM} = x\vec{i}$ 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 of figure 4.

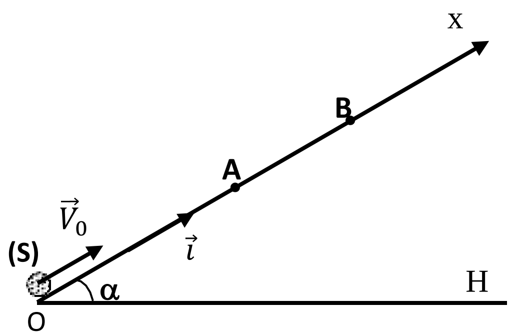

Figure 3

Take:

• The horizontal plane passing through OH as a gravitational potential energy reference;

• g = 10 ms^{-2}.

1) Using the graph of figure 4:

a) Show that (S) is submitted to a force of friction between the points of abscissas $x_0 = 0$ and $x_A = 5$ m.

b) Calculate the variation of the mechanical energy of the system [(S), Earth] between the instants of the passage of (S) through the points O and A.

c) Deduce the magnitude of the force of friction, supposed constant, between O and A.

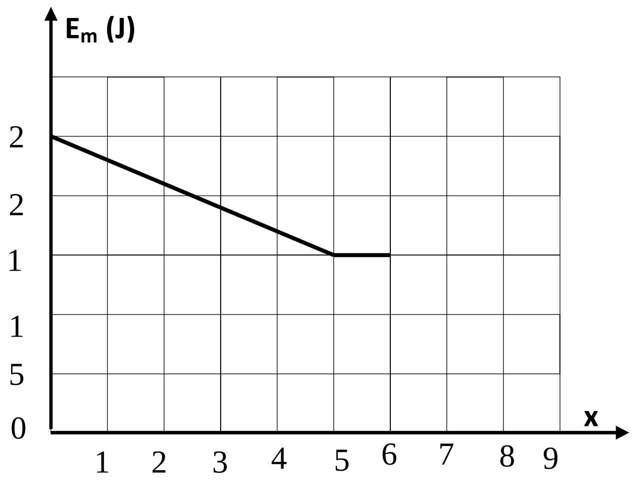

Figure 4

2) Determine, for $0 \leq x \leq 5$ m, the expression of the mechanical energy of the system [(S), Earth] as function of x;

3) Determine the speed of (S) at the point of abscissa x = 6 m.

Exercise 5	***(8 points)***

The circuit, represented in the adjacent document (figure 5), includes in series:

- A generator (G) delivering, across its terminals, an alternating voltage, $u_{AF} = u_G = 8\sin(2\pi ft)$ (S.I.);
- A capacitor of capacitance C = 0.265 μF;
- A coil of inductance L = 31.833 mH and of negligible resistance;
- A resistor of resistance R = 100 Ω.

The circuit carries then an alternating current i of expression: $i = I_m \sin(2\pi ft + \varphi)$ (S.I.).
The aim of this exercise is to study the effect of the frequency f of u_G on the amplitude I_m of i and on the phase difference φ between i and u_G.

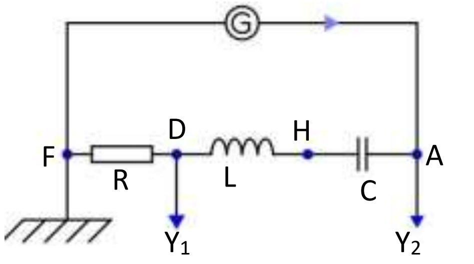

Figure 5

An oscilloscope, connected as shown in the document (figure 5), is used to display the voltages u_G and $u_R = u_{DF}$. The vertical sensitivity, of both channels, is the same in all the experiments: $S_V = 2$ V/div.

I- 1[rst] experiment we set the frequency at $f = f_1 = 1500$ Hz. We observe on the screen of the oscilloscope the waveforms displayed on the figure 6.

a) Identify the waveforms (a) and (b).
b) Determine the phase difference φ1 between i and u_G.
c) Calculate the amplitude I_{1m} of the current i.

II- 2[nd] experiment. The frequency f is increased to $f = f_0$, f_0 being the proper frequency of the (RLC) series circuit. We notice that the waveforms obtained coincide.
The circuit is thus the seat of a certain phenomenon.

a) Give the name of the physical phenomenon obtained.
b) Give the value of the new phase difference φ_2 between i and u_G.
c) Deduce the value of f_0 and the new amplitude I_{2m} of i.

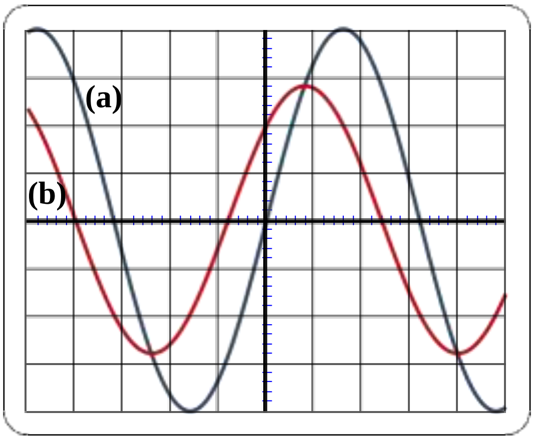

Figure 6