**Lebanese University**
**University Institute of Technology**

**الجامعة اللبنانية**
**المعهد الجامعي للتكنولوجيا**

**Entrance Exam (Engineering)**

**July 25, 2017** **Physics Exam** **Time: 1.5 hours**

***N.B.: All questions are obligatory*.**

## **Exercise I** (5 points)

A nucleus α of kinetic energy $E_{C\alpha} = 5.31$ MeV is captured by a beryllium nucleus $^{9}_{4}Be$ initially at rest. A nucleus $^{a}_{b}X$ begins with the emission of a radiation γ of wavelength $\lambda = 8.51\times10^{-14}$ m.

**1)** Write the balanced equation of the previous nuclear reaction and identify the nucleus $^{a}_{b}X$.
**2)** Calculate the energy liberated $E_{\ell}$ by this nuclear reaction.
**3)** Calculate the energy $E_{\gamma}$ of the radiation γ.
**4)** By applying the total energy conservation of the nuclear reaction, calculate the kinetic energy $E_{cX}$ of the nucleus $^{a}_{b}X$.

We give:
1 u = 931.49 MeV/$c^2$, 1 MeV = $1.60\times10^{-13}$ J, velocity of light in air $c = 3\times10^8$ m/s, Planck's constant $h = 6.62\times10^{-34}$ J.s, $m_\alpha = 4.0026$ u, $m_{Be} = 9.0121$ u and $m_X = 13.0033$ u.

## **Exercise II** (6 points)

A Young's slit system in air is used to achieve light interferences from a laser of red light beam S placed on z'z axis with a wavelength λ = 650 nm. Two identical slits $F_1$ and $F_2$, symmetrical with respect to the axis z'z, are separated by the distance a = 0.15 mm and placed at distance d = 20 cm from the laser source. Alternately, bright and dark fringes are observed on a screen E at distance D = 1.4 m from the slits plane. This system is shown in Figure 1.

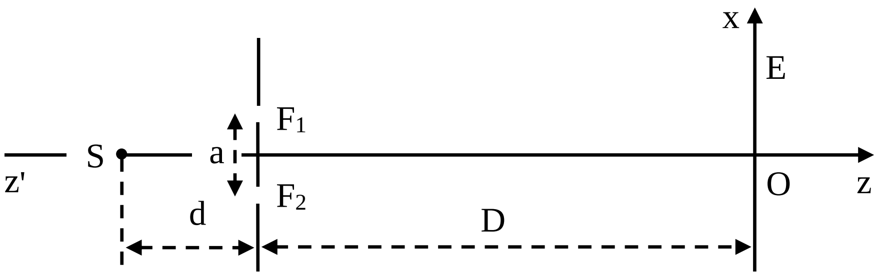


Figure 1

**1)** What is the interest of using Young's slits to observe light interferences?

**2)** What is the condition on the optical path difference for the interferences to be constructive? Destructive?

**3)** What is the nature of the fringe at point O? Justify.

**4)** What does the interfringe represent? And what is its expression?

**5)** The position of a point on the screen is indicated by its abscissa x with respect to the point O.

**a)** Write the expression of the optical path difference $\delta$ for a point of abscissa x.

**b)** Determine the nature and the order of the fringe at the point M of abscissa $x_M = 9.1$ mm.

**6)** Now we use a polyethylene Terephthalate film, similar to a plate with parallel faces, of refraction index n = 1.61 and thickness e = 0.90 μm, which is placed parallel to the slits plane and located on the path of the rays issued from the laser S to the slit $F_1$. Knowing that the expression of the new optical path difference of an abscissa point x is $\delta' = \frac{ax}{D} - (n-1)e$, then calculate the new position O′ of the abscissa $x_{o'}$ of the central fringe. Interpret the result.

## **Exercise III** (7 points)

A capacitor with capacitance C = 50 μF is charged by a battery with constant voltage $U_0$. After reaching its maximum voltage, the capacitor is disconnected from the battery and then connected across a coil at time ($t_0$ = 0 s). The instantaneous voltage at the terminals of the capacitor at time t ≥ 0 is given by: $u_c = 12\cos(250\ t)$ where $u_c$ in volt and t in second. Take $\pi = 3.14$.

**1)** Calculate the voltage $U_0$, the period of the electrical oscillations and the maximum electrical energy in the capacitor.

**2)** Justify the conservation of the total energy in the electrical circuit.

**3)** What are the value of the resistance of the coil and the proper period of the electrical circuit? Justify.

**4)** Calculate the inductance of the coil.

**5)**

**a)** Determine the expression of the instantaneous intensity i of the electric current in the circuit. The current is a flow by an electric charge q such that i and q are same sign. Deduce the maximum magnetic energy of the coil.

**b)** Determine the expression of the instantaneous voltage $u_b$ across the coil. Deduce the phase shift between the voltages $u_b$ and $u_c$.

## **Exercise IV** (12 points)

A small trolley (S) of mass m = 300 g is released without an initial velocity from the top O of an inclined rail OA = 40 cm at an angle $\alpha = 30^o$ to the horizontal.

The resistive forces are negligible on the trolley (S) when moving from point O to point A. On the other hand, the trolley (S) passes the point A on the horizontal rail AB and stops at a point C under the resistive force f = 3 N, as shown in Figure 2a.

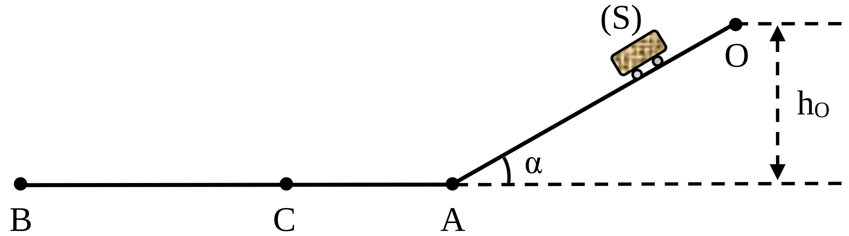


Figure 2a

The reference level of the potential energy is the horizontal plane passing through the rail AB. Take the acceleration of gravity g = 10 m/s$^2$.

**1)** Calculate the mechanical energy of the system (trolley, Earth), when the trolley (S) starts from point O.

**2)** Deduce the velocity of the trolley (S) at point A.

**3)** Calculate the variation of the mechanical energy of the system (trolley, horizontal rail, Earth) when the trolley (S) passes from point A to point C. Deduce the value of the distance AC.

**4)** The system (trolley, horizontal rail, Earth, air) is energetically isolated. Calculate the variation of the internal energy of the system (trolley, horizontal rail, Earth, air) when the trolley (S) passes from point A to point C. Interpret the result.

**5)** The preceding experiment is repeated by releasing the trolley (S) from the point O without an initial velocity. We place on the horizontal rail AB a spring (R) of un-jointed loops of stiffness BI with spring constant k = 20 N/m, such that the distance AI = 10 cm, as shown in Figure 2b. The resistive force to the trolley motion on the rail AB is always f = 3 N.

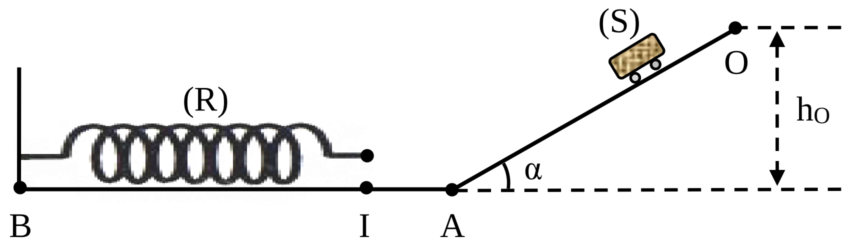


Figure 2b

**a)** Calculate the velocity of the trolley (S) at point I.

**b)** Deduce the value of the maximum compression $x_m$ of the spring, after establishing an equation of the second degree in $x_m$.