مجلس الخدمة المدنية
اللجنة الفاحصة

المباراة المفتوحة لقبول طلاب في شهادة الكفاءة في كلية التربية في الجامعة اللبنانية
للتعيين بوظيفة أستاذ تعليم ثانوي

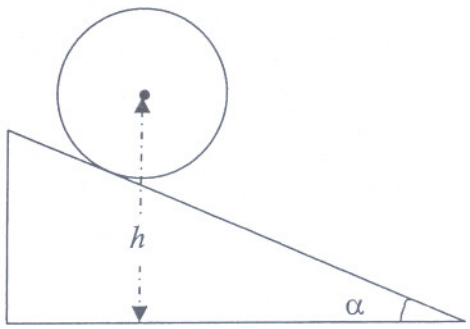
الاختصاص: فيزياء باللغة الانكليزية. الوقت: أربع ساعات

مسابقة في الاختصاص المطلوب.

I- A solid homogenous sphere rolls without slipping along an inclined plane of angle $\alpha=30^{\circ}$ with the horizontal.

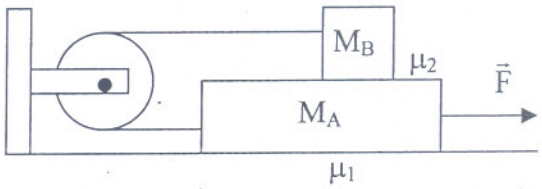
1- Which force is responsible for the rolling of the sphere along the incline? Indicate its direction.

2- The sphere starts from rest at a given point of the incline. Apply the principle of conservation of mechanical energy to find the velocity of the center of the sphere after falling a vertical distance h.



II- Two blocks A and B of masses $M_A=2$ kg and $M_B=1$kg are connected by means of an inextensible and light string which passes over a light pulley. The coefficient of kinetic friction between block A and the horizontal table is $\mu_1=0.2$ and that between A and B is $\mu_2=0.1$.

A horizontal force $\vec{F}$ of magnitude 20N is applied to block A as shown in the figure.

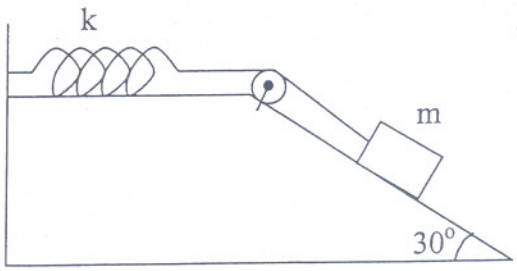


1- Show on two different diagrams the forces acting on each of blocks A and B.

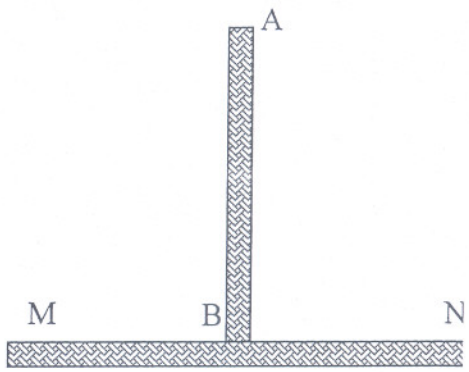
2- Determine the acceleration of the system.

III- A block of mass m = 4 kg is placed along a rough inclined plane of angle 30° with the horizontal. The block is connected to a light string which passes over a light and frictionless pulley fixed at the top of the incline. The second end of the string is connected to a vertical wall by means of a horizontal elastic spring of constant k = 100 N/m. The block is released from rest while the spring was unstretched. The block moves 20 cm on the incline before stopping.

Apply the work-energy theorem to find the force of friction between the block and the incline.

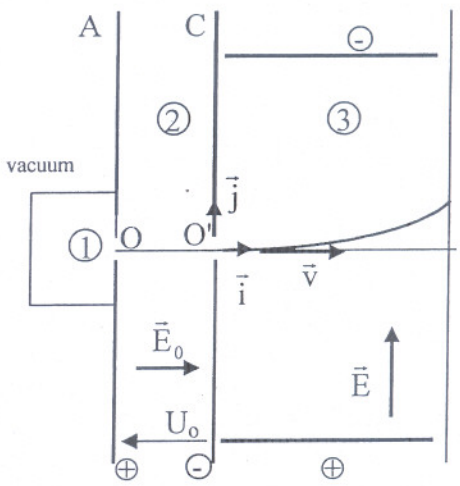


IV- Consider a rigid system made of two identical rods AB and MN, each of mass m and length L, as shown in the figure. B is the midpoint of MN.



1- Determine the position of the center of mass of the rigid system.
2- Determine the moment of inertia of the system with respect to an axis (Δ) perpendicular to the plane of the figure and passing through A.
3- Derive the expression of the period of small oscillations of the system about (Δ).

V- In the ionization chamber ① of the adjacent figure, atoms of lithium are ionized to Li^+(all the ions have the charge q=e). These charges enter with a negligible velocity through the hole O in chamber ② in order to accelerate between the points A and C where the potential difference is U_0.The charged particles leave chamber ② at point O' and enter chamber ③ where the electric field $\vec{E}$ is uniform. The lithium atoms have two isotopes ^6Li and ^7Li of masses m_1 and m_2 respectively.



1- Find the expressions of the speeds v_1 and v_2 of the two isotope ions at the point O'.

2- If the vector $\vec{E}$ is perpendicular to the velocities $\vec{v}_1$ and $\vec{v}_2$, determine in the frame $(O', \vec{i}, \vec{j})$ the trajectory of each isotope in chamber ③.

Can this system be used to separate the isotopes?

VI- A parallel plate capacitor is charged by a 500V battery. The common area between these plates is $200cm^2$ and the distance between them is 1.5mm. If this separation between the plates is increased to 15mm, find the energies of the capacitor before and after increasing the distance in the two following cases:

1- The power supply is disconnected from the capacitor.
2- The power supply remains connected to the capacitor.

VII-

1- In Fig.1 the circuit is formed of a capacitor of capacitance C and of initial charge q_0, an inductor of inductance L, and a resistor of resistance R.

a- Find the differential equation which governs the variation of the charge q of the capacitor in terms of time.

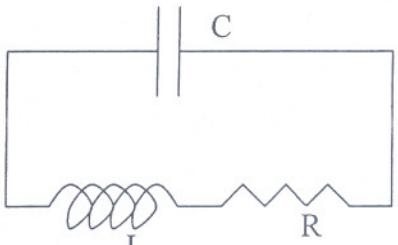


Fig 1

b- For $R^2 < \frac{4L}{C}$, the solution of the differential equation is given by: $q=q_0e^{(-\alpha t)}\cos\omega t$.
Explain the physical meaning of α and ω, and make a rough sketch of the curve of q in terms of time.

2- In Fig.2 a sinusoidal potential difference is applied between the two points M and N.

a- Write the expression of the impedance Z_{MN} in the complex form, and deduce its magnitude.

b- Make a rough sketch of the variations of the magnitude of the main current I as a function of ω in the case where $R \ll L\omega$. Indicate on this curve the particular value of ω where Z is maximum.

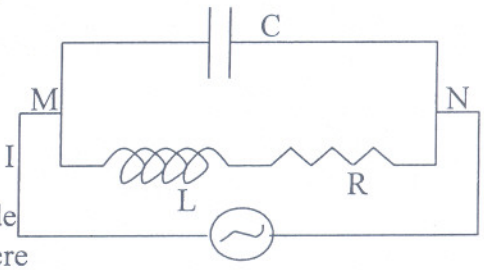
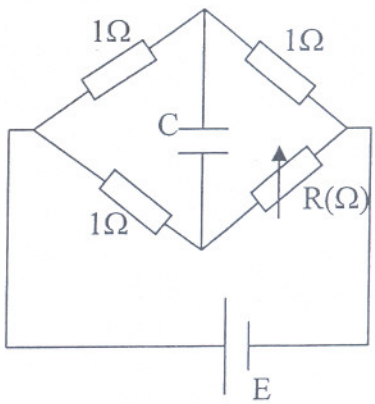


Fig 2

VIII- Consider the adjacent circuit where E = 10V, C = 1μF and R is a variable resistance. Enough time is given until a steady state is reached.



1- Find in terms of R:

a- The current in the resistance R.

b- The main current supplied by the battery.

c- The charge collected at the capacitor.

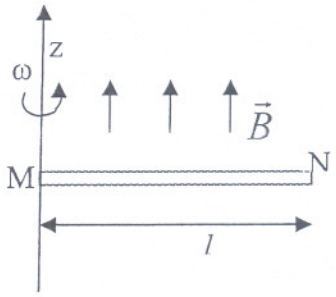
2- Answer the questions 1-a, 1-b and 1-c in each of the following cases:

i- R=1Ω

ii- R> 1Ω

iii- R< 1Ω

IX- A conducting rod MN of length l rotates in a horizontal plane about a vertical z-axis passing through its extremity M with a constant angular velocity ω. The whole region is under the effect of a uniform magnetic field $\vec{B}$ along the vertical z- axis as shown in the figure.



1- Determine the angle of rotation and the area swept by the rod in a time element dt.

2- Deduce the magnetic flux cut by the rod during this interval dt.

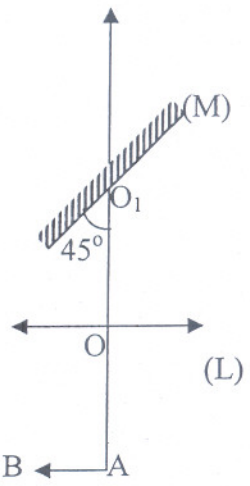
3- Apply Faraday's law to find the induced emf between M and N.

X- A luminous object AB = 2 cm is placed at 16 cm from a thin converging lens (L) of focal length f = 15 cm. A plane mirror (M) inclined at 45° with respect to the vertical optical axis of (L) is placed at 15 cm from (L) (OO_1 = 15 cm).

The final image of AB through the system L and M only is formed on a screen (E).

1- Specify the position of the screen (E) with respect to the optical axis of (L).

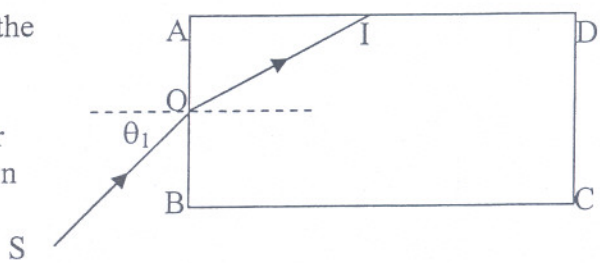
2- Determine the characteristics (direction and magnitude) of the final image.



XI- An incident ray of light SO strikes face AB of a rectangular piece ABCD of a transparent medium at an angle of incidence θ_1. The index of refraction of the medium is n.

1- What is the maximum angle θ_1 for which the ray OI undergoes total internal reflection for n = 1.3?

2- Find the minimum value of the index n for which all rays undergo total internal reflection inside the medium for all values of $\theta_1 \neq 0$.



XII- The marine sediments can be dated by the thorium 230. This nucleus is a descendant of the uranium 238 along the following reactions.

$$^{238}_{92}U \xrightarrow{\alpha} {}^{A_1}_{Z_1}X_1 \xrightarrow{\beta^-} {}^{A_2}_{Z_2}X_2 \xrightarrow{\beta^-} {}^{A_3}_{Z_3}X_3 \xrightarrow{?} {}^{230}_{90}Th \xrightarrow{\alpha} {}^{A_5}_{Z_5}X_5$$

The half life of thorium is: $T = 7.52\times10^4$ years.

In the sea water the concentration of thorium 230 is constant. The thorium is not soluble in sea water; it is deposited in the sediments. On the contrary the uranium is soluble in sea water and is not deposited in the sediments. Because of the absence of the uranium in the sediments, the thorium is not renewable and its concentration decreases since it is radioactive.

1- Write the consecutive reactions of disintegrations.

2- A sample of sediment taken from the surface contains a mass $m_0 = 20$ μg of thorium 230. A sample of the same size extracted from deeper sediments contains a mass of $m = 1.2$ μg. What is the age of these deeper sediments?

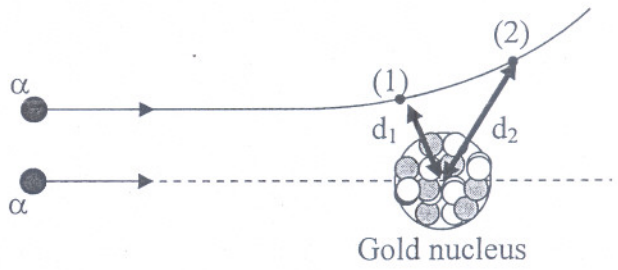
Z	88	89	90	91	92
element	Radium Ra	Actinium Ac	Thorium Th	Protactinium Pa	Uranium U

XIII- A beam of α (^4_2He) particles of kinetic energy 5 MeV is directed towards a stationary gold nucleus ($^{197}_{79}Au$).

1- Find the distance of closest approach between the α particle and the gold nucleus for a head on collision.

2- Draw the force exerted by the gold nucleus on the α particle, in the positions (1) and (2) ($d_2 = 2\,d_1$)

Given: $k = \dfrac{1}{4\pi\varepsilon_0} = 9\times10^9$ SI units.



XIV- The following expression gives the displacement of a traveling wave which vibrates along the z- axis and propagates along an arbitrary direction in the x-y plane, where r is the distance to the origin, and t is the time.

$$z(r,t) = 0.15e^{-3r}\cos(20\pi t - 10\pi r)$$

1- Is the wave transverse or longitudinal? Why?

2- What are the two physical quantities whose numerical values are given by 20π and 10π in the above expression? What are their SI units?

3- Sketch $z(0,t)$ roughly at the origin ($r = 0$)

4- Sketch $z(r,0)$ roughly at $t = 0$.

5- Write down the expression of the velocity of vibrations at any t and r.

6- Calculate the velocity of propagation of the wave.

XV- In the classical model of the hydrogen atom (Bohr's model), the electron describes a circular path of radius r around the proton under the action of an electrostatic force $\vec{F}$.
m_e is the mass of the electron, (-e) is its charge and v is its speed.

1- What is the total mechanical energy of the electron?

2- Let $\vec{L} = \vec{r} \times \vec{p}$ be the angular momentum of the electron, with $\vec{p} = m\vec{v}$.

According to Bohr's second postulate: $|\vec{L}| = mvr = n\hbar = n\frac{h}{2\pi}$, where n is a positive integer. Show that the expressions of total energy E and the orbital radius r of the electron are now given by $E = -\frac{k_1}{n^2}$ and $r = k_2 n^2$, where k_1 and k_2 are constants to be determined in terms of m_e, e, h and ε_0.

XVI- The mean life-time of a π- meson particle in its own frame of reference is 2.6×10^{-8} s.
If the meson moves with a speed of 0.98 c, where $c = 3\times10^8 m/s$

1- What is the mean lifetime as measured by an observer on Earth?

2- What is the average distance traveled by the particle before decay, as measured by an observer on Earth?

3- What distance would the particle travel in its proper frame?

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