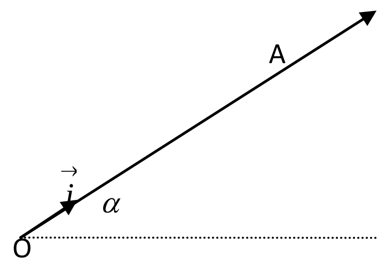
Class: Life-Science
Subject: Physics

First year (6 pts):

Graphic design of an energy exchange

A particle (B) of mass m =200g moves on an inclined plane of an inclined angle $\alpha = 30^0$ relative to the horizontal.
We want to study the energy exchange between the system (B, Earth) and the environment



For this purpose, we launch (B) at time t = 0, from O along the line of greatest slope of the inclined plane Ox , with an initial velocity $\vec{v}_0 = 6\,\vec{i}$ m / s. Frictional forces are equivalent to $\vec{f}$ at an opposite direction to the velocity and of value f =0,2N.

1 . The mechanical energy of the system (B, Earth) is not conserved . Justified?
2 . Determine the mechanical energy of the system at point O.
3 . The ball (B) passes at a time t by a point A of abscissa OA = x .
a) Determine as function of x , the expression of the mechanical energy of the system (B, Earth) at time t .
b) Determine as function of x , the expression of the gravitational potential energy of the system at time t.
4 a) Draw in the same system of axis the curves giving the variations, depending on x , of Em and Epp.

scale on the x-axis : 1 cm……. 1 m
on the energy axis : 1 cm…….1j

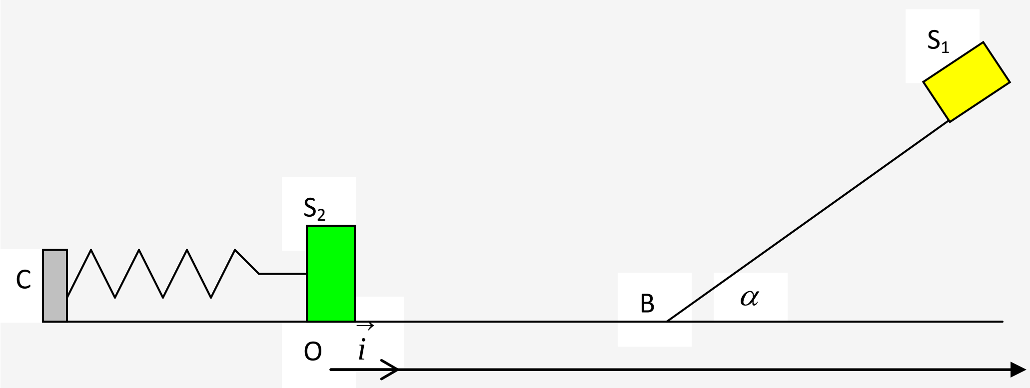
b) Use the graph to determine the speed of (B) at x = 2 m.
c) From the graph , determine the value Xm of x for which the speed is nill.
d) The system (B, Earth) then exchange energy with the environment. In what form and how much?

Second year (7 pts)
Collision and mechanical oscillator

- ABC a track is constituted by a horizontal plane BC, and inclined plane AB by an angle $\alpha = 30^0$ with the horizontal such that AB = 90 cm .
- A mass less spring of stiffness K= 1000 N / m . it is fixed at one end in C , the other end being connected to a punctual solid (S_2) of mass m_2 = 400g . The origin O of the reference position coincides with the center of inertia of the solid (S_2) when the spring is at rest. We neglect all the forces of friction on (CB) .
- A punctual solid (S_1) of mass m_1 = 600 g placed in A.

The horizontal plane BC is taken as the reference level of the gravitational potential energy of the system . (g = 10 m/s^2) .

A- Neglecting all friction on (AB) :



1 . (S_1) , let go from A without initial speed. Determine the velocity vector $\vec{v}_1$ of (S_1) in O.

2 . It compresses the spring 6 cm, then left the mass m_2 without initial speed. Determine the velocity vector of (S_2) at O.

3 . (S_1) comes into a frontal collision with (S_2) at O (equilibrium position), thus forming a single material point (S) . Determine the velocity vector of (S) immediately after the shock.

4 . The set (S , R) form a horizontal spring pendulum , (S) oscillating around its equilibrium position O.

a) Establish the differential equation of x of the oscillations .

b) The solution of the differential equation is of the form x = Xm cos ($\frac{2\pi}{T_0}t + \varphi$)

i- Give the meaning of each term in this expression.

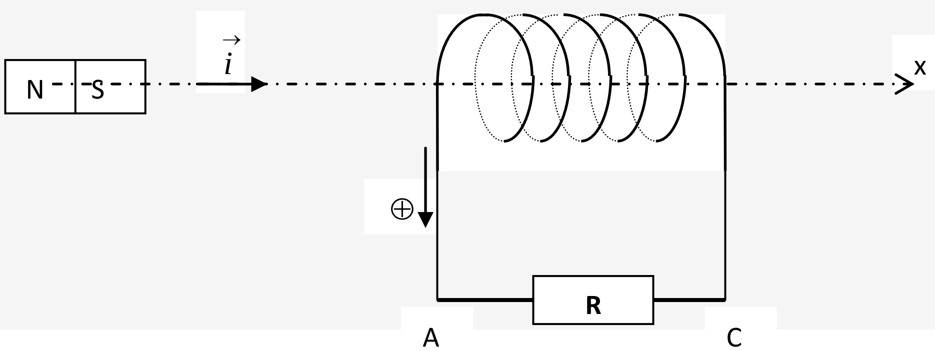
ii- Determine the expression of the proper period T_0 and calculate its value .
iii- Determine numerically the constants Xm and φ own the experience. Derive the numerical expression of x (t).
B- In fact , the speed of (S_1) in O is 2 m / s . friction are not negligible in (AB) :
a) Calculate the value of the assumed constant friction.
b) the system (S , R) does not oscillate after impact. Justified?

Third year (7pts)

Use of a coil

A- First Experience

A bar magnet may be moved along the axis of a coil (x axis) , the terminals A and C are connected to an ohmic conductor of resistance R = 3Ω

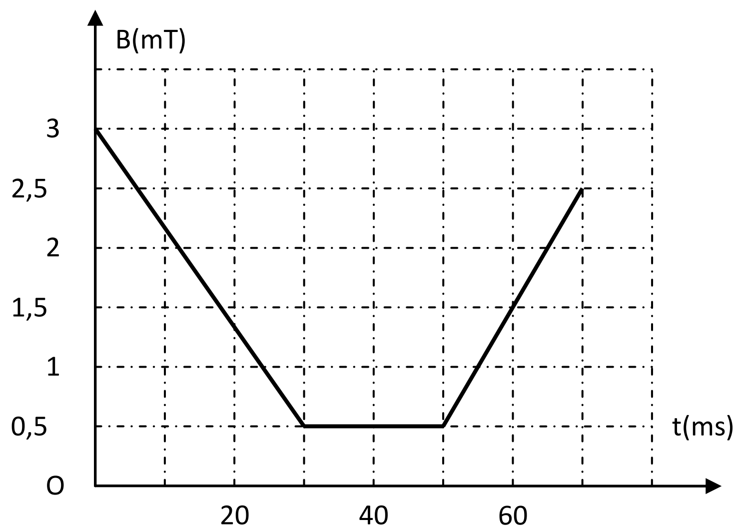


The south pole of the magnet is approached to the side A of the coil
1 . Give the name of the phenomenon demonstrated in this experiment?
2 . Indicate the inducting source and the inductor.
3 . Is there appearance of a current in the circuit? Why?
4 . Indicate and justify the direction of the induced current in R.
5 . Represent the proper magnetic field created in the coil.

B- Second experiment

The coil is formed by N =100 turns at each section of S = 10 cm^2 , and internal resistance of r = 2Ω .
Assume that the magnet during its movement through the coil creates a uniform magnetic field parallel to x'x of vector $\vec{B} = B\vec{i}$. The variation of B as a function of time is shown in the graph in the figure against .
1) Indicate on the segment the line of action and the direction of the normal vector $\vec{n}$
2) Determine the magnetic flux (φ) in the time interval [0, 30ms], [30 ms , 50 ms] and [50ms , 70ms]

3) Determine the induced electromotive force (e) in the preceding intervals.
4) Calculate in the previous intervals, the intensity of the induced current and determine the direction of the induced current in R.
5) Represent the voltage U_{AC} as function of time .



Good Luck

The Correction

Premier exercise

1. We have friction forces (+)
2. System (B, Earth)
   Reference level

$$E_m\left(o\right)=E_c\left(o\right)+E_{pp}\left(o\right) \qquad (+)$$

$$=\frac{1}{2}mv^2+0 \qquad (+)$$

$$=\frac{1}{2}0,2.36=3,6j \qquad (1/2)$$

3. a) we apply the variation of mechanical energy between 0 et t:

$$\Delta E_m=E_m\left(t\right)+E_m\left(o\right)=w_{\vec{f}} \qquad (+)$$

$$E_m=E_m\left(o\right)-f\,.x \qquad (+)$$

$$=3,6-0,2x \text{ (x en m; E en j)} \qquad (1/2)$$

   b) $E_{pp}(A) = mgz_A = mgx\sin\alpha = x$ (x en m; E en j) (1/2)

4. a) graph (1^-)

   b) At x = 2 m ; E_{pp} = 2 j et E_m = 3,2 j (1/2)
   $E_c = E_m - E_{pp}$ = 3,2 2 = 1,2 j (+)

$$\frac{1}{2}mv^2=1,2\Rightarrow v=\sqrt{\frac{2.1,2}{0,2}}=3,46\,{}^{m}\!/_{s} \qquad (1/2)$$

   c) v = 0 → E_{pp} = E_m = 3 j. (1/2)
   X_m = 3 m. (+)

   d) heat (+)
   $Q = \Delta E_m$ = 3,6 -3 =0,6 j. (+)

Second Exercise :

A –

1. System (S_1, Earth)

   Reference level

   $\vec{f} \to \vec{0} \Rightarrow E_m$ is conserved (+)

   $E_{mA} = E_{mo}$

   $E_{co} + E_{ppo} = E_{cA} + E_{ppA}$

   $\frac{1}{2}m_1v^2 + 0 = m_1 gAB\sin\alpha$ (+)

   $v_1 = \sqrt{2gAB\sin\alpha} = \sqrt{9} = 3\,m/s$ (+)

   $\vec{v} = -3\vec{i}\ m/s$. (+)

2. System (S_2, Earth)
   $E_m = E_{mo}$

   $\frac{1}{2}kx^2 = \frac{1}{2}m_2v_2^2$ (+)

   $v_2 = x\sqrt{\frac{k}{m_2}} = 3\,m/s$ (+)

   $\vec{v}_2 = 3\vec{i}\ m/s$. (+)

3. Collision : the linear momentum is conserved
   $\vec{P}_{av} = \vec{P}_{ap}$ (+)

   $m_1\vec{v}_1 + m_2\vec{v}_2 = (m_1 + m_2)\vec{v}$ (+)

   $-0{,}6.3\vec{i} + 0{,}4.3\vec{i} = (1)\vec{v}$ (+)

$$\vec{v} = \frac{-0,6}{1}\vec{i} = -0,6\,\vec{i}\ m/s \qquad (+)$$

4. a) System (S, R, Earth)
   $E_m = E_c + E_{pél}$

$$= \frac{1}{2}mv^2 + \frac{1}{2}kx^2 \qquad (+)$$

$$E_m = cte \Rightarrow \frac{dE_m}{dt} = 0 \qquad (+)$$

$$x'(mx'' + kx) = 0 \qquad (+)$$

$$x'' + \frac{k}{m}x = 0 \qquad (+)$$

b) i- X_m : amplitude ; T_o: period ; φ : initial phase (+)

ii- $$x = X_m \cos\left(\frac{2\pi}{T_0}t + \varphi\right)$$

$$x' = -\frac{2\pi}{T_0}X_m \sin\left(\frac{2\pi}{T_0}t + \varphi\right)$$

$$x'' = -\frac{4\pi^2}{T_0^2}X_m \cos\left(\frac{2\pi}{T_0}t + \varphi\right) \qquad (+)$$

$$x'' + \frac{4\pi^2}{T_0^2}x = 0 \qquad (+)$$

$$\frac{k}{m} = \frac{4\pi^2}{T_0^2} \qquad (+)$$

$$T_0 = 2\pi\sqrt{\frac{m_1 + m_2}{k}} = 0,198s. \qquad (+)$$

iii- $$\begin{cases} x(0) = 0 \\ v(0) = -0,6\,m/s \end{cases} \qquad (+)$$

$$\begin{cases} x(0) = X_m \cos\varphi = 0 \Rightarrow \cos\varphi = 0 \Rightarrow \varphi \begin{cases} \frac{\pi}{2} \\ \frac{-\pi}{2} \end{cases} \\ v(0) = -X_m \dfrac{2\pi}{T_0} \sin\varphi = -0,6 \Rightarrow \sin\varphi \rangle 0 \Rightarrow \varphi = \dfrac{\pi}{2} \end{cases}$$ (1/2)

$$X_m = 1,65cm$$ (+)

$$x(t) = 0,0165\cos\left(33,3t + \frac{\pi}{2}\right)$$ (+)

B-

a) System (S_1, Earth)
We have friction between A et B.

We apply the variation of mechanical energy A et B.

$$\Delta E_m = w\left(\vec{f}\right)$$

$$E_{m0} - E_{mA} = -f .AB$$ (+)

$$\frac{1}{2}m_1v^2 - m_1 gAB\sin\alpha = -f .AB$$

$$0,5.0,5.4 - 5.0,9.0,5 = -0,9.f$$

$$f = \frac{1,25}{0,9} = 1,389N.$$ (+)

b) The speed of S after collision

$$\vec{P}_{av} = \vec{P}_{ap}$$

$$m_1\vec{v}_1 + m_2\vec{v}_2 = (m_1 + m_2)\vec{v}$$

$$0,6.\left(-2\vec{i}\right) + 0,4.3\vec{i} = 1.\vec{v}$$

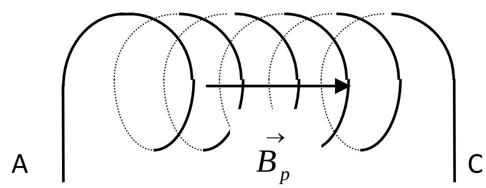
$$0\vec{i} = 1\vec{v} \Rightarrow \vec{v} = 0\vec{i}$$

The speed of S after collision is null at O then the system does not oscillate. (+)

Third exercise

A-

1. Electromagnetic induction (+)
2. magnet: source of inducting ; coil: inductor (+)
3. when we displace the magnet close to the coil→ the value of $\vec{B}$ varied in the coil → the flux varied, close circuit ; we have current in the circuit (+)
4. According to Lenz law le pole the current i passes in R from C toA. (+)
5.



(+)

B-

1. Figure (+)
2. $\left(\vec{n},\vec{B}\right)=0^0$

$\varphi = NSB\cos\left(\vec{n},\vec{B}\right)=0,1B$ (+)

Pour $t\in[0;30ms]$

$B_1=-8.10^{-2}t+3.10^{-3}\,(SI)$ (+)

$\varphi_1=-8.10^{-3}t+3.10^{-4}\,(SI)$ (+)

Pour $t\in[30ms;50ms]$

$B_2 = 5.10^{-4} T$ (+)

$\varphi_2 = 5.10^{-5} wb$ (+)

Pour $t \in \left[50ms ; 70ms\right]$

$B_3 = 0{,}1t - 45.10^{-4} \left(SI\right)$ (+)

$\varphi_2 = 10^{-2} t + 45.10^{-5} \left(SI\right)$ (+)

3. Faraday's law $e = -\dfrac{d\varphi}{dt}$

   $t \in \left[0ms ; 30ms\right] \Rightarrow$ e = 8.10^{-3} v. (+)

   $t \in \left[30ms ; 50ms\right] \Rightarrow$ e = 0. (+)

   $t \in \left[50ms ; 70ms\right] \Rightarrow$ e = -10^{-2} v. (+)

4. $u_b = u_R \Rightarrow e - ri = Ri$ (+)

   $i = \dfrac{e}{r + R}$ (+)

   $i_1 = \dfrac{8.10^{-3}}{5} = 1{,}6.10^{-3} A$ i circulate in the positive direction (+)

   $i_2 = 0$ (+)

   $i_3 = \dfrac{-10^{-2}}{5} = -2.10^{-3} A$ i circulate in the negative direction (+)

5. u_R = Ri (+)

   u_1 = $4{,}8.10^{-3}$ v. (+)

   u_2 = 0 v. (+)

   u_3 = -6.10^{-3} v. (+)

   figure (1/2)