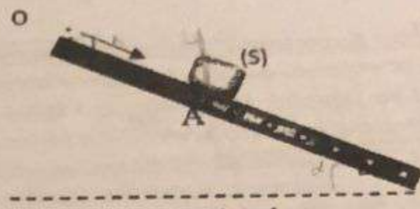
FIRST EXERCISE :(10pts)

A solid of mass m =2K can slide on an inclined plane making an angle $\alpha=30^0$ with respect to the horizontal. An apparatus allows to register the positions and the velocities of the center of mass G of the solid. The constant time interval which separates two consecutive positions is $\tau=1S$. The solid is released without initial velocity from the point O of the inclined plane.
The position of the center of mass G is defined by its abscissa x.

	Time (s)	Position (m)	speed (m/s)
Point (A)	1	1	2
Point(B)	2	4	4



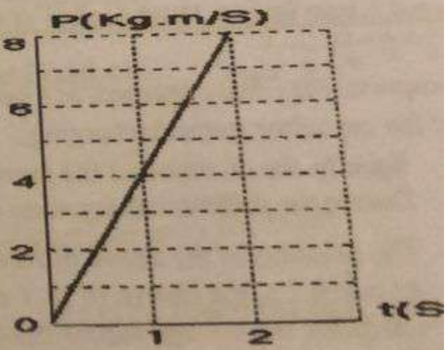
Take the horizontal plane passing through O as reference level for the gravitational potential energy.

A – Mechanical energy.

1- Calculate the mechanical energy of the system (solid, earth) at position A.
2- Calculate the mechanical energy at position B.
3- The motion is performed with friction. Justify.
4- Calculate the intensity of the force of friction, assumed to be constant.
5- Determine, in terms of x, the work done by the frictional force for the displacement x.
6- Find, as function of x, the expression of the gravitational potential energy.
7- Find, as function of x, the expression of the kinetic energy.
8- Trace the curves that represent the variations of the kinetic energy, potential energy and the mechanical energy.

B- Linear momentum.

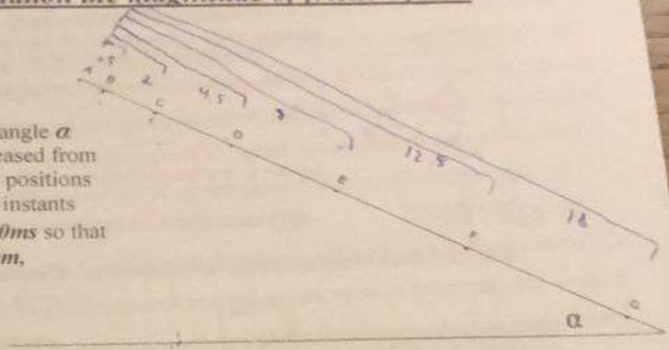
1- Determine the linear momentum of the solid at position A.
2- Determine the linear momentum at position B.
3- Is the linear momentum conserved? Justify.
4- The adjacent diagram represents the variation of the linear momentum as function of time.
a- Determine, graphically, the linear momentum of the solid as function of time.
b- Deduce the resultant of the external forces exerted on the solid.
c- Deduce the force of friction.



Grade12(Gs and Ls) Subject : physics

Date: 4/11/2023 Duration: 100 minutes

First Exercise:(5 points) determination the magnitude of friction force



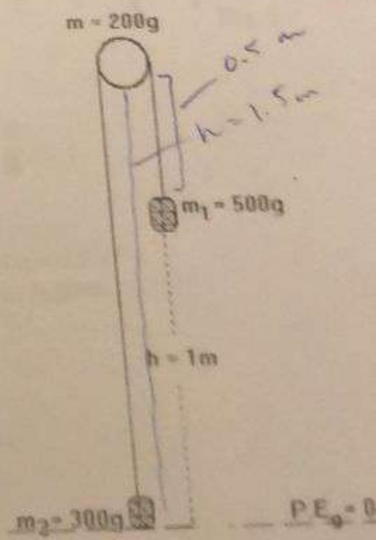
The adjacent figure shows an inclined track of angle α with the horizontal. A puck of mass 2kg is released from rest at point A, and the dot-prints showing the positions of its center of mass are obtained at successive instants separated by equal intervals, each being $\tau = 50ms$ so that

$AB = 0.5cm$, $AC = 2cm$, $AD = 4.5cm$, $AE = 8cm$,
$AF = 12.5cm$, $AG = 18\ cm$…

Given $\sin\alpha = 0.6$ and that $g = 10\ m/s^2$.

1. Determine the linear momentum vector of the center of mass of the puck at the positions B, C, D and E along the axis of the motion directed positively downwards.
2. How does the magnitude of the linear momentum vary with time? Plot the graph of its variation between $t = 0$ and $t = 6\tau$.
3. What is the slope of the curve?
4. Deduce that this rectilinear motion is not valid if friction is negligible.
5. Determine, using Newton's second law, the average value of the force of friction.

Second Exercise:(2 points) collision



A small sphere of mass $m_1 = 100g$ is moving along a horizontal axis with the speed $40m/s$. enters in a head-on elastic collision with another small sphere of mass $m_2 = 200g$ moving in the opposite direction at $5\ m/s$.

1. Determine the velocities of each of m_1 and m_2 right after impact
2. Calculate the average force received by each of m_1 and m_2 if the collision lasted 0.02 seconds

Third Exercise:(4 points) conservation of mechanical energy.

In the adjacent figure we have a string of negligible mass passing over a pulley of mass $m = 200g$.connects two point masses:

$m_1 = 500g$ and $m_2 = 300g$. The center of the pulley is 1.5 m above ground.

Initially, m_1 is $1m$ above the ground and m_2 is just touching the ground so that the string remains under tension. The system is released from rest and ground level is taken as a gravitational potential energy reference for the system (S) that is formed of [*pulley - masses - Earth*]. We neglect all friction.

1. Calculate the initial gravitational potential energy of the system (S).
2. Deduce the initial mechanical energy of the system (S)
3. Calculate the gravitational potential energy of the system (S) as m_1 reaches the ground.
4. The mechanical energy of the system (S) is conserved. Why?
5. Show that the speed of m_1 or m_2 is $2m/s$ as it reaches the ground knowing that Kinetic energy of the pulley is $\frac{1}{2}mv^2$ where m is the mass of the pulley and v is the speed of $\mathbf{m_1}$ or $\mathbf{m_2}$.

SOLVE THE FOLLOWING EXERCISE:

LINEAR MOMENTUM AND MECHANICAL ENERGY

A solid (S_1) of mass m_1=2Kg is released without initial speed from point O on an inclined plane making an angle α= 30° with the horizontal.(Figure -1-)

Figure-2- represents the variation of the linear momentum of solid (S_1) as a function of time during its motion from O to B. Take g=10m/s².

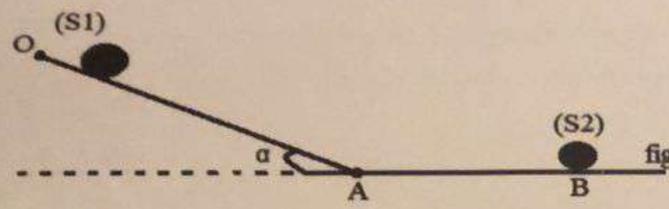


figure-1-

Motion from O to A:

1. Use the graph given by figure-2- to determine the resultant of external forces acting on the solid (S_1).
2. Deduce that friction exists. Calculate its value f supposed constant.
3. Calculate the mechanical energy of the system (S_1, Earth) at A. Take the horizontal plane passing through A a potential energy reference level.
4. Calculate the distance OA.

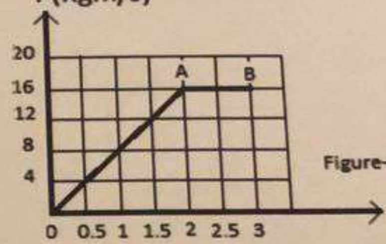


Figure-2-

Motion from A to B:

1. Determine the speed V_1 of S_1 at B just before collision with S_2.
2. Verify that the motion from A to B occurs without friction.

Collision:

Solid S_1 enters into elastic collision with solid S_2 of **mass m_2=6Kg initially at rest.**

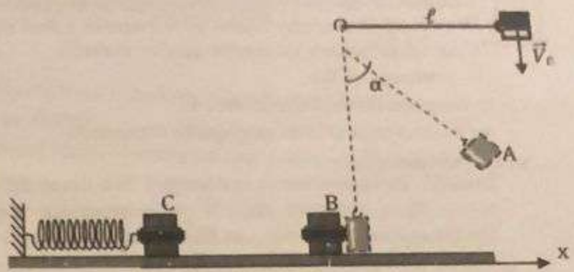
1. Determine the velocities $\overrightarrow{V'_1}$ and $\overrightarrow{V'_2}$ of S_1 and S_2 respectively after collision, knowing that these velocities are collinear.
2. Determine the average force exerted by S_1 on S_2 if the collision lasts for 0.1s.(knowing that $\frac{dp}{dt}=\frac{\Delta p}{\Delta t}$)
3. Determine the speed of the center of mass of the system (S_1, S_2) just after collision.
4. In this part, the solid S_1 combine with S_2 just after collision. The following registrations represent the positions occupied by the system (S_1, S_2) just after collision at equal successive intervals of time τ=10ms.

Grade 12 (L.S) Date : 1 /6/2023

Subject: Physics Duration: 2 hours

First Exercise: From one pendulum to another:[8 pts]

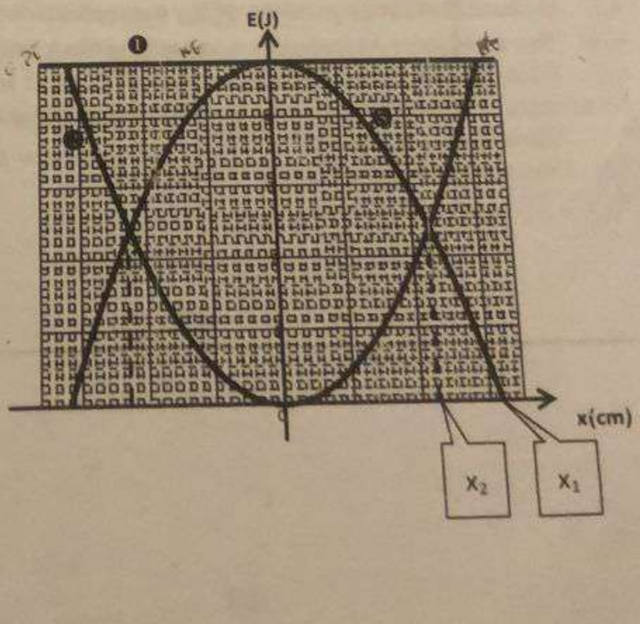
A simple pendulum is constituted of a string of negligible mass and of length ℓ = 1.8m, fixed at its upper extremity to a support while its lower one attached to a particle A of mass m_1 = 200g. The pendulum is shifted from its position of equilibrium to attain a horizontal position and then released with a speed V_0 = 8 $m.s^{-1}$ oriented vertically downward.



By the time it passes through its position of equilibrium, A enters in a head-on elastic collision with a particle B of mass m_2 = 300g which rests on the horizontal plane considered as a reference level for E_{PG}.

Frictional forces are neglected and given g = 10 $m.s^{-2}$.

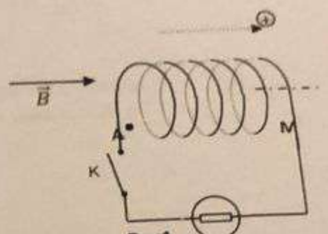
1) Calculate the mechanical energy of the system (A, Earth) at any instant t.
2) Calculate the speed of A just before collision with B. Write the expression of $\vec{V}_A$.
3) Calculate $\vec{V}'_A$ and $\vec{V}'_B$, the respective velocities of A and B just after collision.
4) Deduce the position of A (find α) for which its speed becomes nil for the first time, after collision.
5) After collision, B moves along the x-axis and enters in collision with C of mass m_3=300g, initially at rest, and thus form one solid (S) of mass $m=m_2+m_3$. A horizontal elastic pendulum of constant K=120N.m^{-1} and mass m is thus formed.
a) Suppose that B attains C with a speed of 8$m.s^{-1}$, determine the speed of m just after collision.
b) Is the collision between B and C elastic? Justify.
c) Determine the maximum compression of the spring.
6) The figure below shows three graphs . Identify with justification to what form of energy of the system (S, spring) does each graph corresponds?
7) Determine the values of x_1 and x_2.



Grade12(Gs) **Date: 16/11/2023**

Subject : physics **Duration: 50 minutes**

Electromagnetic induction methods



Doc1

Consider a coil of **1000 turns**, each of area $S = 10cm^2$ and of resistance $r = 50\ \Omega$ and a lamp L acts as a resistor of resistance $R = 100\ \Omega$.

The coil and the lamp are connected as shown in doc 1.

The coil is within a magnetic field $\vec{B}$, parallel to its axis having the direction as the normal $\vec{n}$ to the plane of its turn.

The magnitude $B_{(mT)}$ of $\vec{B}$ varies periodically as a function of time as shown in figure 2.

1. Show that the flux due to $\vec{B}$ crossing the coil is $\varphi = B$.
2. Give, with justification, the name of the phenomenon that takes place in the coil and specify the inducing source and the inducing circuit.

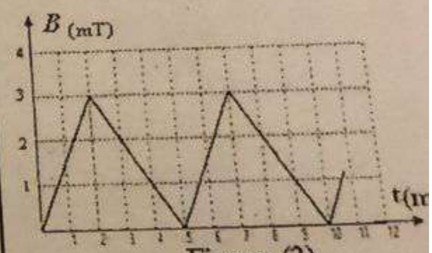


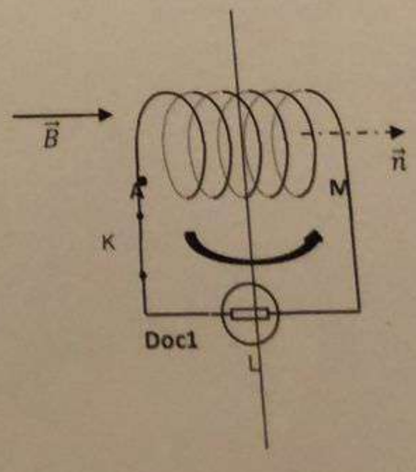
Figure (2)

3. Determine the emf e induced in the coil between:

[0, 2ms] and [2ms; 5ms]

4. The switch k is closed
   - **4.1.** Specify, with justification, the direction and the magnitude of the induced current between: **2ms and 5ms.**
   - **4.2.** Determine the voltage U_{AM} between: **2ms and 5ms.**
   - **4.3.** The coil is equivalent to a generator. Represent this generator by a diagram in the time interval: [2ms; 5ms]

5. Rotation of the coil:



Doc1

Now keeping the value of B on a constant value 3 mT and same direction, we fix the coil on a vertical axis perpendicular to the axis of the coil and passing through its center and we start to rotate it with a constant frequency of 180 rotations per minute:

5.1. Determine in hertz the frequency of rotations.
5.2. Deduce ω the angular speed in rad/s.
5.3. Determine in terms of B, ω and t the expression of magnetic flux .
5.4. Deduce the expression of the induced emf and the induced current i in terms of B, ω ,t, R and r .
5.5. What is the type of the produced voltage?

6 Find the maximum value of i and find the maximum value of emf

Electromagnetic induction

We intend to study the phenomena of electromagnetic induction and self-induction. For this we use two resistors of resistances $R_1 = R_2 = 1\Omega$, coil of inductance L formed of ***1000 turns*** each of area $0.01m^2$ and of negligible resistance, a bar magnet, an ***L.F.G*** and connecting wires.

A. First Experiment

We connect the circuit represented in figure ***(1)***: ***K*** is a switch, ***A*** is an ammeter and ***S-N*** is a bar magnet moved towards one of the faces of the coil. The positive direction of the normal to the turns of the coil is indicated.

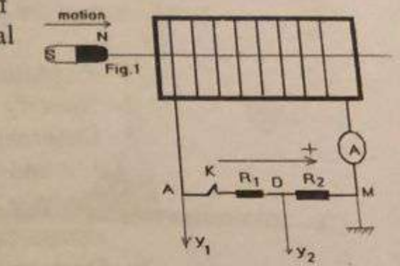


Fig.1

1) Represent the magnetic field $\vec{B}$ due to the *N-pole* inside the coil.

2) During the motion of the bar magnet, the ammeter indicates a current i.
Explain the phenomenon that gives rise to this current.

3) Give the expression of the flux Φ and the ***e.m.f*** induced in the coil as a function of $\frac{dB}{dt}$.

4) Deduce the expression of i as a function of R_1, R_2 and $\frac{dB}{dt}$.

5) Indicate the direction of the current in both faces of the coil.
What happens if the switch is open?

6) The value of B is made to vary as indicated in ***(Fig 2)***

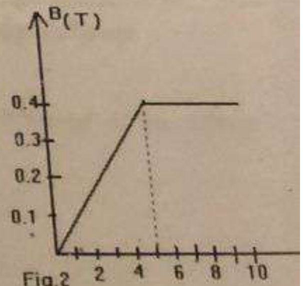


Fig.2

i) What voltage is displayed on each channel? Which one represents i?

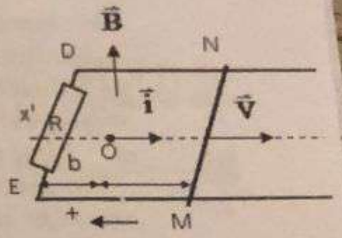
ii) Draw, on the same graph, the waveforms obtained on each channel between $t = 0$ and $t = 10s$.

Take a scale:
1s/div. on the time axis and ***0.2V/div*** on the vertical axis for both channels.

iii) If the switch is opened, what modifications will take place on ***(ii)***?

induced current

A rod MN slides without friction on two straight parallel and horizontal rails DD' and EE' that are separated by a distance l. The rod MN, the rails and a resistor R form a closed circuit that is placed in a uniform vertical magnetic field $\vec{B}$ of magnitude B=0.5 T. The position of the center of mass G of DE on $\overrightarrow{Ox}$, is defined by $\overrightarrow{OG}$=x$\vec{i}$. Neglect the resistance of the rails DD' and EE' and of MN, relative to R.



1- Explain why an induced current passes in the circuit.
2- Specify the direction of this induced current.
3- Determine the expression of the magnetic flux Φ in terms of B, l, x and b.
4- Deduce in terms of B ,l and V the expression of the e.m.f e across the rod MN. Where V is the speed of the rod.
5- Deduce the expression of the induced current in the circuit in terms of B,l,V and R.
6- What are the forces acting on the rod MN? What is the force $\vec{F}$ that must act on MN to maintain the constant velocity. Recall that the electromagnetic force:$\vec{F}_{e.m}$=i.$\vec{l}$^$\vec{B}$.
7- Calculate e and F. Take l=10cm; V=1.5 m.s^{-1} and R=5Ω.
8- A voltmeter is connected across R between D and E. Give the expression of u_{ED} in terms of B ,l and V.
9- The resistor R is removed. The voltmeter, of very large resistance is kept between A and C.
   i) Does a voltage u_{ED} appear when MN is moved? If yes, give its value.
   ii) Does an induced current flow?
   ii) Is a force$\vec{F}$ still needed to maintain the speed of MN? Why?

ONLY FOR GENERAL SCIENCES STUDENTS

IV- [7.5 pts] Induction and self induction

A flat coil is formed of 500 circular turns of surface $s = 10\ cm^2$ each. The normal $\vec{n}$ is directed as indicated in the figure.

The coil turns with a constant angular speed ω_1 around a vertical axis (Δ) in a horizontal, uniform and constant magnetic field $\vec{B}$. The extremities A and C of the coil are connected to the input of an oscilloscope. Let θ be the angle between $\vec{n}$ and $\vec{B}$.

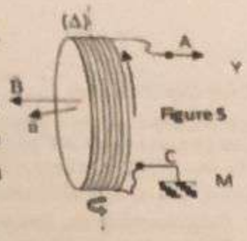
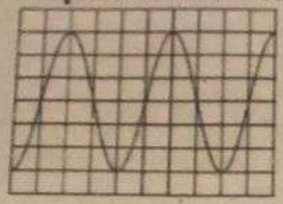


Figure 5

1. Express θ in terms of ω_1 and t.



2. Justify qualitatively the existence of a voltage between A and C during the rotation of the coil.
3. Determine the expression of the emf induced across the coil.
4. Using figure 6, determine: Sh=10ms/div, SV=1V/div
   a. the angular speed ω_1 of the coil.
   b. the value B of the magnetic field.

Figure 6

5. We decrease the speed of the coil two times less ($\omega_2 = \omega_1/2$). Without changing the adjustments of the oscilloscope, give with justification the shape of the wave form.

Self induction

The coil of negligible resistance and of inductance L is connected in series with the resistor of resistance R. : 100Ω

The whole is connected to a generator that delivers a triangular signal. We study the variations of the voltages u_1 across the extremities of R and u_2 across the extremities of the coil by using an oscilloscope.

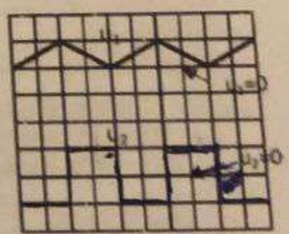


Figure 7

1. Establish the differential equation verifying the current i (t) when the generator delivered a voltage: $u_{AB} = e(t)$.
2. Using the voltages u_1 and u_2 observed on the oscilloscope:
   . express u_1 and u_2 in terms of L, R, i and di/dt;
3. what does it mean: i is the image of U1?
4. Verify that $u_2 = -\frac{L}{R}\frac{du_1}{dt}$
5. Calculate the value of L.(Sh=10ms/div..Sv_1=1V/div and Sv_2=10mv/div
6. What is the difference between the two phenomena ?.

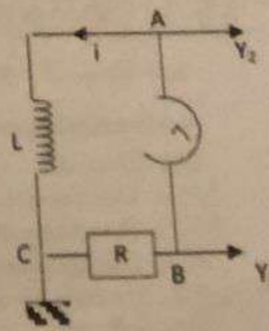


Figure 8

Exercise 3 (5 pts) **Self induction**

We consider a coil of inductance L and resistance r, a resistor of resistance $R = 8\ \Omega$, a switch K, an incandescent lamp and an ideal battery (G) of electromotive force $E = 10$ V.

The aim of this exercise is to study the effect of the coil on the brightness of the lamp in a DC series circuit, and to determine its characteristics.

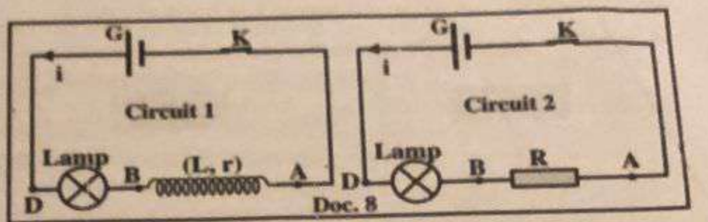
1) Brightness of the lamp

We set up successively circuit 1 and circuit 2 of document 8.

Statements 1 and 2 below describe the brightness of the lamp after closing K.

<u>Statement 1</u>: The lamp glows instantly at the instant of closing the switch.

<u>Statement 2</u>: After closing the switch, the brightness of the lamp increases gradually and becomes stable after a certain time.



Doc. 8

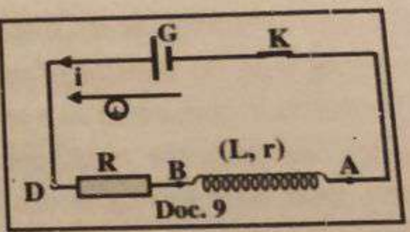
Match each statement to the convenient circuit.

2) Determination of L and r

We connect the coil and the resistor in series across (G) as shown in document 9.

At the instant $t_0 = 0$, K is closed.

At an instant t, the circuit carries a current i.



Doc. 9

2.1) Prove, by applying the law of addition of voltages, that the differential equation that describes the variation of the voltage $u_{DB} = u_R$ is: $\frac{L}{R}\frac{du_R}{dt} + \left(\frac{R+r}{R}\right)u_R = E$.

2.2) Deduce that the expression of the voltage across the resistor in the steady state is: $U_{Rmax} = E\frac{R}{R+r}$.

2.3) The solution of this differential equation is $u_R = U_{Rmax}(1 - e^{\frac{-t}{\tau}})$, where $\tau = \frac{L}{R+r}$.

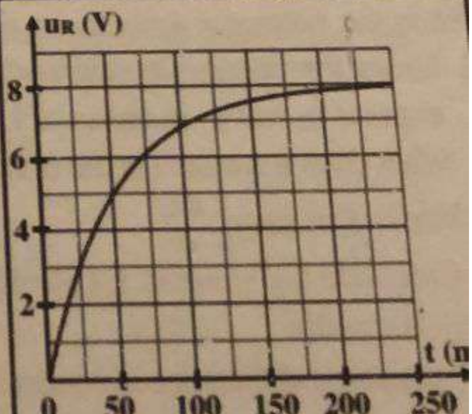
A convenient apparatus draws u_R as a function of time (Doc. 10).

2.3.1) Use document 10 to indicate the value of U_{Rmax}.

2.3.2) Determine the value of r.

2.3.3) Use document 10 to determine the value of τ.

2.3.4) Deduce the value of L.



Doc. 10

First exercise: (7 points)

The flash of a camera

The electronic flash of a camera is made primarily of a capacitor of capacitance C, a flash lamp and of an electronic circuit which transforms the constant voltage $E = 3$ V provided by two dry cells into a constant voltage $U_0 = 300$ V. The aim of this exercise is to show the importance of the electronic circuit in the electronic flash of a camera.

A – Determination of the value of the capacitance C of the capacitor

To determine the value of the capacitance C of the capacitor, we connect the circuit of figure 1 where the resistor has a large resistance R, the DC generator maintains across its terminals a constant voltage $E = 3$ V. An appropriate device allows to plot the curve representing the variations of the current i as a function of time. The capacitor, being uncharged, at the instant $t_0 = 0$, we close the circuit. We obtain the graph of figure 2.

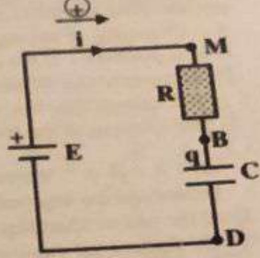


Fig. 1

1) a) Determine the expression of the current i in terms of C and the voltage $u_C = u_{BD}$ across the terminals of the capacitor.

b) By applying the law of addition of voltages, determine the differential equation of the voltage u_C.

2) The solution of this differential equation is given by:

$u_C = E(1 - e^{-\frac{t}{\tau}})$ where $\tau = RC$.

a) Determine, as a function of time t, the expression of the current i.

b) Deduce, at the instant $t_0 = 0$, the expression of the current I_0 in terms of E and R.

c) Using figure 2:

i) calculate the value of the resistance R of the resistor;

ii) determine the value of the time-constant τ of the circuit.

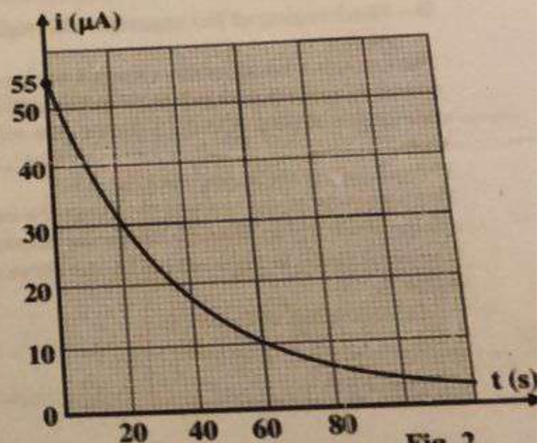


Fig. 2

d) Deduce that $C \approx 641$ μF.

B – Energetic Study

1) Show that the electric energy stored in the capacitor, when it is completely charged under the voltage E is $W \approx 2.9 \times 10^{-3}$ J.

2) The capacitor, being totally charged, is disconnected from the circuit and discharges through a resistor of same resistance R. Calculate:

a) the duration at the end of which the capacitor can be practically completely discharged ;

b) the average power given by the capacitor during the discharging process.

Second exercise: (6.5 points) **Charging and discharging of a capacitor**

We set up the circuit whose diagram is represented in figure 1. G is a generator of constant e.m.f $E = 10$ V and of negligible internal resistance, (C) is a capacitor, initially uncharged, of capacitance $C = 1$ F, (D) is a resistor of resistance $R = 10\ \Omega$, K is a switch and M is an electric motor whose axis is wrapped by a string of negligible mass and carrying a solid of mass $m = 1$ kg (Fig. 1). Take $g = 10\ m/s^2$.

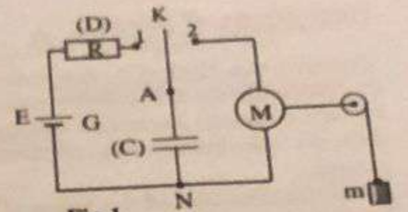


Fig.1

A – Charging of the capacitor

K is in position 1 at the instant $t_0 = 0$.

1) Determine the differential equation that describes the variation of the voltage $u_{AN} = u_C$ across the capacitor.
2) The solution of the differential equation is of the form:
$u_C = A + B\,e^{-\frac{t}{\tau}}$ where A, B and τ are constants.
Determine the expressions of A, B and τ in terms of E, R and C.
3) At the end of charging:
   a) deduce the value of the voltage u_C ;
   b) calculate, in J, the energy stored in the capacitor.

B – Discharging of the capacitor through the motor

The capacitor being totally charged, we turn the switch K to the position 2 at an instant taken as a new origin of time. During a time t_1, the solid is raised by height $h = 1.5$ m. At the instant t_1, the voltage across the capacitor is $u_C = u_1$.

The variation of the voltage u_C across the capacitor during discharging through the motor between the instants 0 and t_1 is represented by the curve of figure 2.

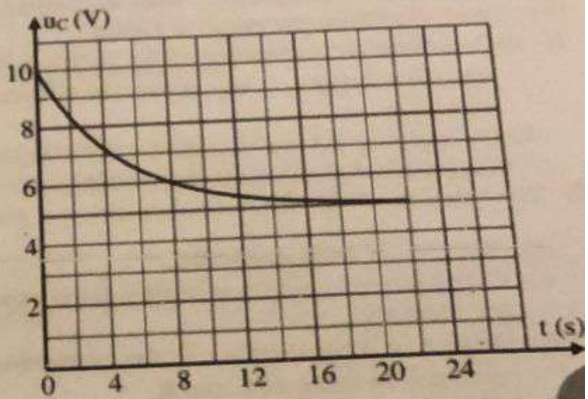


Fig.2

1) Referring to figure 2:

   a) give the value of t_1, at which the voltage u_C attains the minimum value u_1;
   b) give the value of the voltage u_1.
2) At the instant t_1, the capacitor still stores energy W_1.
   a) Tell why.
   b) Calculate the value of W_1.
3) Assume that the energy yielded by the capacitor is received by the motor.
   a) Calculate the value of the energy W_2 yielded by the capacitor between the instants 0 and t_1.
   b) To what forms of energy is W_2 transformed?
   c) Determine the efficiency of the motor.

$r = \frac{mgh}{W}$

Second Exercise: (10 pts)

We build up the circuit represented in the adjacent figure.
C is a capacitor of capacitance C;
G is a generator of emf E and with negligible resistance;
R is a resistor of resistance: $R = 100\Omega$.
L is a lamp acts as a resistor of unknown resistance r.
K is a double switch.

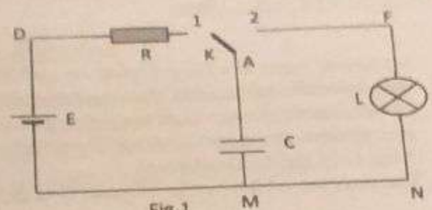


Fig.1

First Experiment: Charging of the capacitor

The switch K is connected to position 1 at t = 0s, so the capacitor starts charging. Fig 2, represents the variation of the current i as a function of time t.

a- Derive the differential equation of the voltage u_c across the capacitor.

b- The solution of the differential equation has the form $u_c = A + B\,e^{-\frac{t}{\tau}}$, where A, B and τ are constants. Determine the expression of A, B and τ as function of E, R and C.

c- Deduce the expression of the current as function of time.

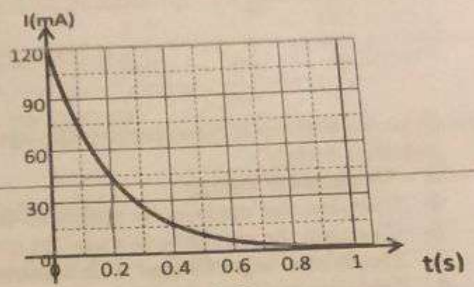


Fig. 2

d- Using figure 2:

i. Indicate the maximum intensity of current.

ii. Deduce the value of E.

iii. Determine the value of τ.

e- Calculate the instant of time at which i = 72 mA, deduce the voltage u_c across the capacitor at this instant.

f- Calculate the voltage when the capacitor is totally charged; deduce the charge Q_m across the capacitor at this instant.

g- Calculate the energy stored in the capacitor, when the capacitor is practically totally charged.

Second Experiment: Discharging of the capacitor, lighting the lamp.

The capacitor is totally charged, at a new instant of time taken as an origin (t = 0), we turn the switch to position 2 and the capacitor starts discharging.

a- Specify the direction of the current in the circuit.

b- Derive the differential equation of the charge q across the capacitor.

c- The solution of the above differential equation has the form $q = Q_m e^{-\frac{t}{\tau}}$, determine the expression of τ.

d- At $t_1 = 0.1$ s, the charge is 18.7×10^{-3} C, calculate τ and deduce the value of r.

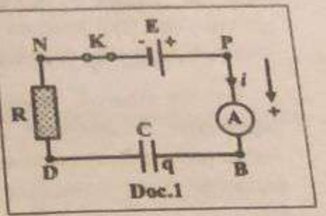
e- Calculate the voltage across the capacitor at the instant $t_1 = 0.1$ s.

f- Suppose that the energy dissipated by the capacitor is taken by the lamp, Determine the power taken b the lamp at $t_1 = 0.1$ s.

Second Exercise: **Capacitors (6.5pts)**

The aim of this exercise is to determine the capacitance C of a capacitor.
We set-up the series circuit of document 1 that includes:

- An ideal battery of electromotive force E.
- A resistor of R.
- A capacitor of capacitance C.
- An ammeter (A) of negligible resistance.
- A switch K.

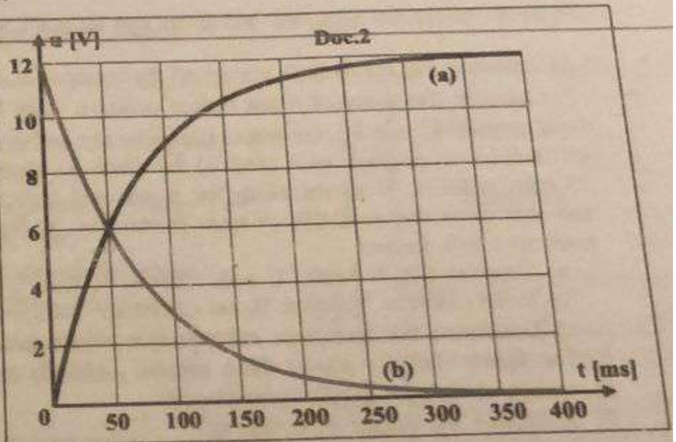


Doc.1

Initially the capacitor is uncharged. We close the switch K at the instant $t_0 = 0$. At an instant t, plate B of the capacitor carries a charge q and the circuit carries a current i as shown in document 1.

A convenient apparatus records the variations, as a function of time, of the voltage $u_C = u_{BD}$ across the capacitor and the voltage $u_R = u_{DN}$ across the resistor.

We obtain the curves shown in document 2.



1- Curve (a) represents the variation of u_C as a function of time. Justify.

2- Determine the value of E.

3- Write the expression of i in terms of C and u_C.

4- Establish the differential equation that governs the variation of u_C.

5- The solution of this differential equation is of the form: $u_C = a + be^{-\frac{t}{\tau}}$. Determine the expressions of the constants a, b and τ in terms of E, R and C.

6-

6.1- Deduce that the expression of the current is: $i = \frac{E}{R}e^{-\frac{t}{\tau}}$.

6.2- The ammeter (A) indicates a value $I_0 = 6mA$ at $t_0 = 0$. Deduce the value of R.

6.3- Write the expression of u_R in terms of E, R, C and t.

7- At an instant $t = t_1$, the voltage across the capacitor is $u_C = u_R$.

7.1- Show that $t_1 = RC \ln 2$.

7.2- Deduce the value of C.

First exercise: (7.5 points)

Charging and Discharging of a Capacitor

The aim of this exercise is to study the charging and the discharging of a capacitor of capacitance $C = 1\ \mu F$. For that we connect the circuit of figure 1 which is formed of the capacitor, an ideal generator of constant voltage E, a resistor of resistance R and a double switch (K).

Take the direction of the current as a positive direction.

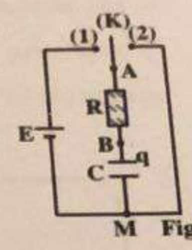


Fig.1

A – Charging of the capacitor

The capacitor is initially neutral and the switch (K) is turned to position (1) at the instant $t_0 = 0$.

A convenient apparatus records the variation of the voltage $u_C = u_{BM}$ across the terminals of the capacitor as a function of time.

1) Derive the differential equation that describes the variation of the voltage u_C as a function of time.

2) The solution of the differential equation is given by:

$u_C = A + B e^{-\frac{t}{\tau}}$, where A, B and τ are constants.
Determine the expressions of these constants in terms of R, C and E.

3) Figure 2 shows the variation of u_C as a function of time t. The straight line OT represents the tangent to the curve $u_C(t)$ at $t_0 = 0$.

a) Determine the value of τ.

b) Deduce the values of E and R.

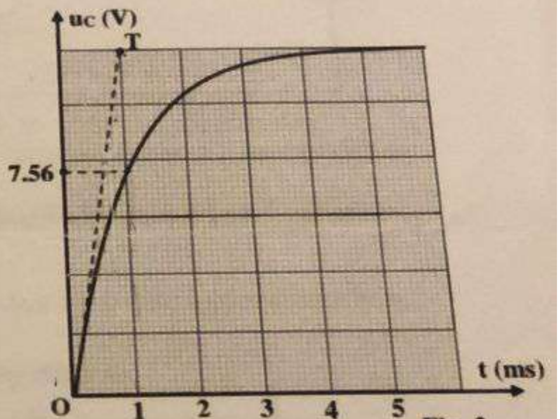


Fig. 2

B – Discharging of the capacitor

The charging of the capacitor being completed, the switch (K) is turned to position (2) at a new origin of time $t_0 = 0$.

At an instant t the circuit carries a current i.

1) Redraw the figure of the discharging circuit and indicate on it the direction of the current i.

2) Show that the differential equation in i has the form:

$$i + RC\frac{di}{dt} = 0.$$

3) Verify that $i = I_0 e^{-\frac{t}{\tau}}$ is a solution of this differential equation, where $I_0 = \frac{E}{R}$.

4) a) Calculate the value of i at $t_0 = 0$ and at $t_1 = 2.5\ \tau$.

b) Deduce the value of u_C at $t_1 = 2.5\ \tau$.

5) Determine the electric energy W_e lost by the capacitor between $t_0 = 0$ and $t_1 = 2.5\ \tau$.

6) The energy dissipated due to joule's effect in the resistor between t_0 and t_1, is given by $W_h = \int_{t_0}^{t_1} R i^2 dt$.

a) Determine the value of W_h.

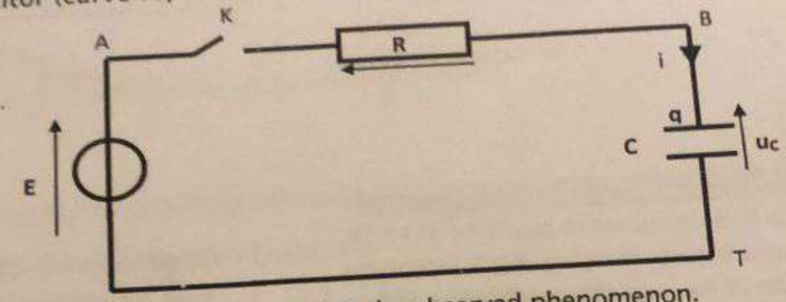
b) Compare W_h and W_e. Conclude.

$U_c = E\tau^{-1}$

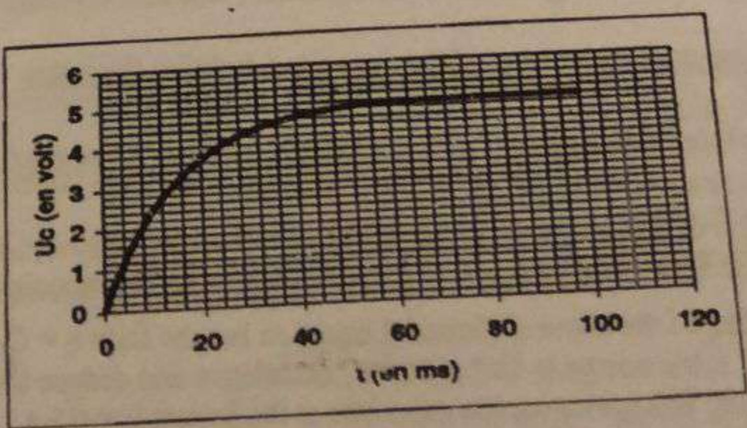
Date: 5/11/2023
work sheet.

Grade: 12
Subject: physics
characteristics of a capacitor.

Consider two components: A resistor of resistance R = 150 Ω and a capacitor of capacitance C. The objective of this exercise is to study the capacitor and its capacitance.
For this reason, we connect the capacitor to an ideal generator of electromotive force E in series with the resistor.
We realize the circuit as shown below. We draw the variation of the voltage across the capacitor (curve represented below).



1. The switch K is closed. Name and explain the observed phenomenon.
2. Derive the differential equation of the variation of the voltage across the capacitor.
3. The solution of the differential equation is given by: $u_c = P + Qe^{Dt}$, determine P, Q and D.
4. Prove by a dimensional analysis that the real $\frac{-1}{D}$ is homogeneous to a time.
5. What is the real: $\frac{-1}{D}$? Give its physical signification.
6. Determine with justification the electromotive force of the generator.
7. Determiner the intensity of electric current after the time $\frac{-1}{D}$.
8. Calculate the value of the capacitance C of the capacitor.
9. After what time the charge q of the capacitor becomes 45% from its maximum value.



THIRD EXERCISE :(7.5pts)

We build up the circuit represented in the adjacent figure.
C is a capacitor of capacitance C;
G is a generator of emf E and with negligible resistance;
R is a resistor of resistance: $R = 100\Omega$,
L is a lamp acts as a resistor of unknown resistance r.
K is a double switch.

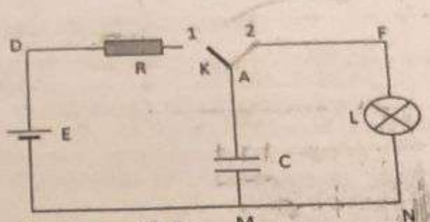


Fig.1

First Experiment: Charging of the capacitor

The switch K is connected to position 1 at $t = 0s$, so the capacitor starts charging. Fig 2, represents the variation of the current i as a function of time t.

a- Derive the differential equation of the voltage u_c across the capacitor.

b- The solution of the differential equation has the form $u_c = A + B\,e^{-\frac{t}{\tau}}$, where A, B and τ are constants. Determine the expression of A, B and τ as function of E, R and C.

c- Deduce the expression of the current as function of time.

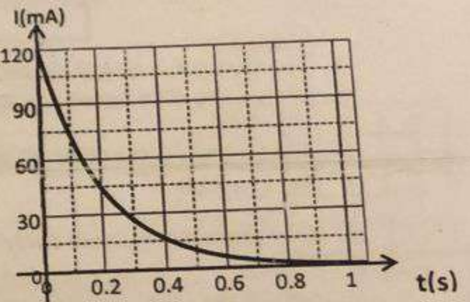


Fig. 2

d- Using figure 2:

i. Indicate the maximum intensity of current.

ii. Deduce the value of E.

iii. Determine the value of τ.

e- Calculate the instant of time at which $i = 72$ mA, deduce the voltage u_c across the capacitor at this instant.

f- Calculate the voltage when the capacitor is totally charged; deduce the charge Q_m across the capacitor at this instant.

g- Calculate the energy stored in the capacitor , when the capacitor is practically totally charged.

Second Experiment: Discharging of the capacitor, lighting the lamp.

The capacitor is totally charged, at a new instant of time taken as an origin ($t = 0$), we turn the switch to position 2 and the capacitor starts discharging.

a- Specify the direction of the current in the circuit.

b- Derive the differential equation of the charge q across the capacitor.

c- The solution of the above differential equation has the form $q = Q_m\,e^{-\frac{t}{\tau}}$, determine the expression of τ.

d- At $t_1 = 0.1$ s, the charge is 18.7×10^{-3} C, calculate τ and deduce the value of r.

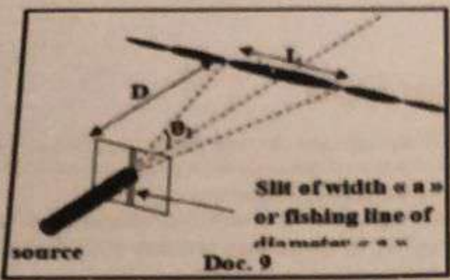
e- Calculate the voltage across the capacitor at the instant $t_1 = 0.1$ s.

f- Suppose that the energy dissipated by the capacitor is taken by the lamp, Determine the power taken by the lamp at $t_1 = 0.1$ s.

Grade :12(Gs and Ls) date: 16/3/20224
Subject : physics Duration: 80 minutes

Exercise :1(5 pts)

Diameter of a fishing line



Doc. 9

The aim of this exercise is to determine whether the fishing line chosen by a fisherman is suitable to catch the trout fish of a specific size using the phenomenon of diffraction.

1) Set-up of diffraction

A monochromatic light, of wavelength λ, falls normally on a vertical narrow slit of width « a ». The diffraction pattern is observed on a screen placed perpendicularly to the incident light beam at a distance D from the slit.

Let «L» be the linear width of the central bright fringe (Doc. 9).

The diffraction angles in this exercise are small.

For small angle, take $\tan\theta \approx \sin\theta \approx \theta$ in radian.

1.1) Describe the diffraction pattern observed on the screen.

1.2) Write, in terms of λ and « a », the expression of the angle of diffraction θ_1 corresponding to the center of the first dark fringe.

1.3) Show that $L = \frac{2\lambda D}{a}$.

2) Diameter of fishing line

A fisherman wants to catch a trout fish of size 50 cm to 55 cm. He bought a thin fishing line made up of 100% copolymer, *but the strength of a fishing line also depends* on its diameter « a ».

To find out if the chosen fishing line is suitable for such a type of fish, he uses the diffraction set-up of document 9 by replacing the slit of width « a » by the fishing line of diameter « a », so he obtains a diffraction pattern similar to that shown in document 9.

The screen is placed at a distance D from the fishing line, the linear width of the central bright fringe is $L_1 = 13$ mm. The screen is displaced by 50 cm away from the fishing line, the linear width of the central bright fringe becomes $L_2 = 19.5$ mm.

2.1) Show that D = 1 m.

2.2) Calculate the diameter « a » of the chosen fishing line, knowing that the wavelength of the used light is λ = 650 nm.

2.3) Referring to the table in document 10, specify if the chosen fishing line is suitable for fishing trout fish of size 50 to 55 cm.

Fishing line (100 % copolymer)	Diameter	Use
Fishing line (1)	0.10 mm	It is suitable to fishing a trout fish of size 35 cm to 40 cm.
Fishing line (2)	0.18 mm	It is suitable to fishing a trout fish of size 50 cm to 55 cm.
Fishing line (3)	0.25 mm	It is suitable to fishing a trout fish of size 65 cm to 70 cm.

https://www.truitesaquaponiques.com/

Doc. 10

Third exercise : (7 pts) Photoelectric Effect

The experiments on photoelectric emission performed by Millikan around the year 1915, intended to determine the kinetic energy K.E of the electrons emitted by metallic cylinders of potassium (K) and cesium (Cs) when these cylinders are illuminated by monochromatic radiation of adjustable frequency ν.
The object of this exercise is to determine, performing similar experiments, Planck's constant (h), as well as the threshold frequency ν_o of potassium and the extraction energy W_o of potassium and that of cesium.

I - *1)* What aspect of light does the phenomenon of photoelectric effect show evidence of ?
2) A monochromatic radiation is formed of photons. Give two characteristics of a photon.
3) For a given pure metal, the incident photons of a monochromatic radiation provoke photoelectric emission. Give the condition for this emission to take place.

II- In a first experiment using potassium, a convenient apparatus is used to measure the kinetic energy K.E of the electrons corresponding to frequency ν of the incident radiation. The obtained results are tabulated in the following table:

ν (Hz)	K.E (eV)
6×10^{14}	0.25
7×10^{14}	0.65
8×10^{14}	1.05
9×10^{14}	1.45
10×10^{14}	1.85

Given : $1 eV = 1.60 \times 10^{-19} J$.

1- Using Einstein's relation about photoelectric effect, show that the kinetic energy of an extracted electron may be written in the form : $K.E = a\nu + b$.

2- *a)* Plot, on the graph paper, the curve representing the variation of the kinetic energy K.E versus ν, using the following scale:

- on the axis of abscissas: 1cm represents a frequency of 10^{14}Hz
- on the axis of ordinates: 1 cm represents a kinetic energy of 0.5 eV.

b) Using the graph, determine:
i) the value, in SI, of h, the Planck's constant.
ii) the threshold frequency ν_o of potassium.

3- Deduce the value of the extraction energy W_o of potassium.

III- In a second experiment using cesium, we obtain the following values: K.E = 1 eV for $\nu = 7 \times 10^{14}$Hz.

1) Plot, with justification, on the preceding system of axes, the graph of the variation of K.E as a function of ν.
2) Deduce from this graph the extraction energy W'_o of cesium.

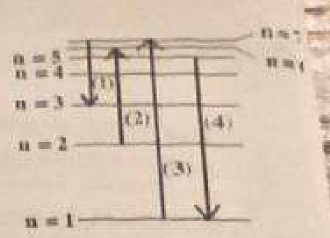
$E_{ph} = h\nu$

$h\nu - W_0$

$h\nu - h\nu_0$

$h(\nu - \nu_0)$

3. Energy levels of the hydrogen atom



The adjacent figure shows some electronic transitions (1, 2, 3, and 4) of the hydrogen atom.

The energy of the hydrogen atom is given by

$E_n = \frac{-13.6}{n^2}$ (E_n in eV and n is a non-zero positive integer).

a) Indicate the transitions that result in emitting a photon.

b) i. To which spectral series does transition (4) belong?

ii. Determine the wavelength of the photon emitted by this transition.

iii. Is this photon visible? Why?

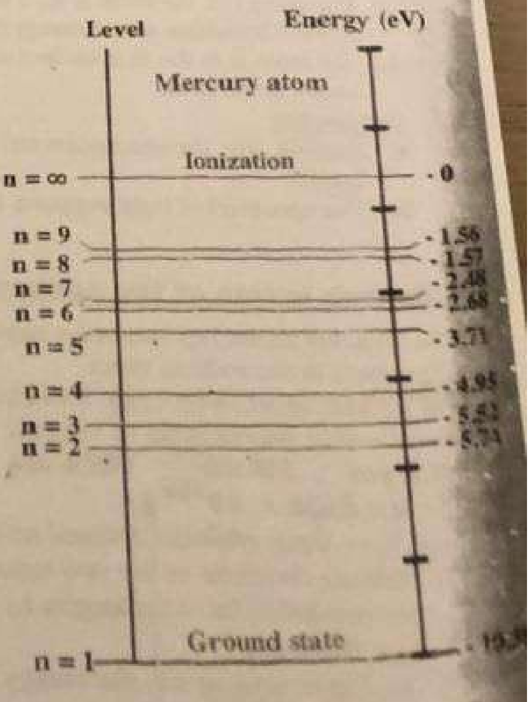
c) To which spectral series does transition (1) belong? Determine the frequency of the emitted photon, and indicate whether it is visible.

d) The hydrogen atom is in the ground state. Determine the minimum energy of a photon capable of

i. exciting the atom

ii. ionizing the atom

4. Energy levels of the mercury atom



The adjacent figure shows the energy-level diagram of the mercury atom.

a) Refer to the figure to conclude that the energy of the mercury atom is quantized.

b) The mercury atom is hit by a photon of energy **3 eV** when it is in the third excited state. Prove that the atom does not absorb this photon.

c) The mercury atom is in the 2^{nd} excited state. Determine the frequency of the photon that must be absorbed by the atom in order to excite it to the 4^{th} excited state.

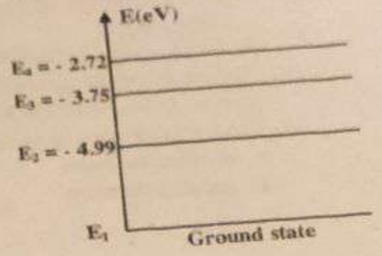
d) The mercury atom is in the ground state.

i. The atom receives a photon of energy **13 eV**. Calculate the kinetic energy of the liberated electron.

ii. The atom is hit by an electron of kinetic energy **5.5 eV**. Determine what would happen to the mercury atom.

...ission and absorption spectra of an atom

...adjacent diagram shows the first four energy levels of an atom of a certain gas.
...range of visible wavelengths in vacuum is $0.4\ \mu m \leq \lambda \leq 0.8\ \mu m$.



...excitation of the atom

a) Can the energy of this atom be -4.5 eV or -3.5 eV? Deduce the meaning of quantized energy.

b) The atom makes a transition from E_3 to E_1. The wavelength of the emitted photon is $\lambda_1 = 1.855 \times 10^{-7}$ m. Prove that $E_1 \cong -10.42$ eV.

c) Calculate, in eV and in J, the energy of the photon emitted by the atom when it passes from E_4 to E_2.

d) In which of the above two downward transitions the emitted photon is visible? Justify.

B. Excitation of the atom

a) The energy of the atom is E_x. The atom is hit by a photon of energy **2.27 eV**, so it makes an upward transition to the energy level E_4. Calculate E_x.

b) The atom is in the first excited state. Determine the longest wavelength of a photon capable of ionizing the atom.

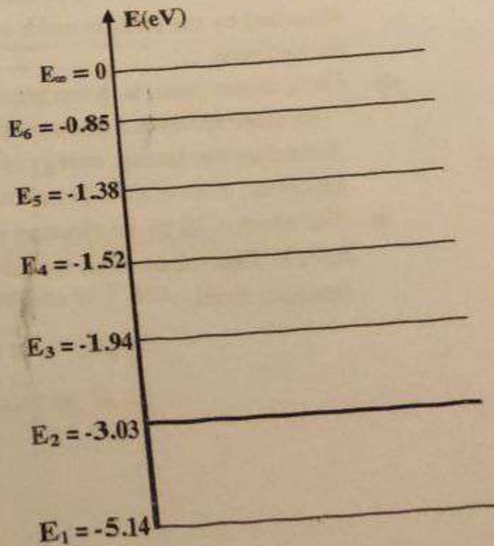
C. Conclusion

a) Explain why the absorption and the emission spectra of this atom are line spectra (consist of lines).

b) The spectrum of light supports a certain aspect of light. Specify this aspect.

5. Energy levels of the sodium vapor lamp ✓

The adjacent figure represents the energy-level diagram of an atom in the sodium vapor.



The sodium vapor lamp emits 4 visible photons having the following wavelengths in vacuum:
568.8 nm ; 589 nm ; 589.6 nm ; 615.4 nm.

Use: $h = 6.626 \times 10^{-34}$ J.s

Take three digits after the decimal point.

a) Indicate the name of the two spectral lines which correspond to the wavelengths $\lambda_1 = 589$ nm and $\lambda_2 = 589.6$ nm.

b)
  i. Determine, in eV, the energy E_{ph} of the photon of wavelength λ_1.
  ii. Compare the value of E_{ph} to that of $(E_2 - E_1)$.
  iii. The photon of wavelength λ_2 is due to the downward transition of the atom from E_n to E_1. Determine the value of E_n.
  iv. Deduce that the energy level E_2 is doublet.

c) The sodium atom is hit by an electron of kinetic energy KE_1 when it is in the ground state. After impact, the electron energy decreases to $KE_2 = 1$ eV and the atom becomes in the 2^{nd} excited state. Determine the value of KE_1. Deduce the speed with which the electron hits the atom.

6- The first fission reaction gives off 3 neutrons (first generation). Suppose that the three neutrons stimulate other fissions similar to the above one. These fissions in turn give off 9 neutrons (second generation), and so on....

6-1) Determine the number N of neutrons given off by the 100^{th} generation.

6-2) Suppose that each one of the above emitted neutrons bombards one uranium-235 nucleus. Deduce the total energy released due to the fission of uranium-235 nuclei bombarded by the above N neutrons.

6-3) In a nuclear power plant, the fission reaction is controlled: on average only one of three neutrons produced by each fission is allowed to stimulate another fission reaction. Suppose that a nuclear power plant operates according to the above fission reaction and has an efficiency of 33 %. In the nuclear reactor, 1.5×10^{25} uranium-235 nuclei undergo fission during one day.

6-3-1) Determine the electric energy E_{elec} delivered by this station during one day.

6-3-2) Deduce the average electric power P_{elec} of the station.

7- Once fusion nuclear reaction started it is difficult to control. Deduce one advantage of fission nuclear reaction over fusion nuclear reaction.

Grade: 12(GS) Date: 7/3/2024

Subject : physics Duration: 50 minutes

Fission of uranium-235

In a nuclear power plant uranium-235 captures a thermal neutron; it forms a new unstable nucleus (Reaction 1).

$^{A}_{Z}X$ is divided into two nuclei krypton and barium (possible fission fragments) with an emission of certain number of neutrons and γ-radiation (Reaction 2).

Reaction 1: $^{1}_{0}n + ^{235}_{92}U \rightarrow ^{A}_{Z}X$

Reaction 2: $^{A}_{Z}X \rightarrow ^{A'}_{36}Kr + ^{141}_{Z'}Ba + 3\,^{1}_{0}n + \gamma$

Given:

the mass of $^{235}_{92}U$ nucleus is 234.99346 u;

the mass of $^{A'}_{36}Kr$ nucleus is 91.90641 u;

the mass of $^{141}_{Z'}Ba$ nucleus is 140.88369 u;

the mass of $^{1}_{0}n$ is 1.00866 u;

$1\ u = 931.5\ MeV/c^2$;

$1\ eV = 1.6 \times 10^{-19}\ J$.

1- Determine the values of A, Z , A', and Z'.
2- Deduce the name of the isotope $^{A}_{Z}X$.
3- The overall equation (fission reaction) of the above reactions is:
$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{A'}_{36}Kr + ^{141}_{Z'}Ba + 3\,^{1}_{0}n + \gamma$.
This fission reaction leads to a chain fission reaction. Why?
4- At least one of the fission fragments is born in the excited state. Why?
5- Show that the energy liberated by the fission of one uranium-235 is $E_{lib} \cong 2.8 \times 10^{-11}$ J.