This is a Class 1 exam

Lebanon Evangelical School for Boys and Girls

Lebanon Evangelical School

for Boys and Girls — Loueizeh - Baabda

Stage Exam 06

19, 20, 21JUN2023

Do NOT write in this box. Your MARK will be placed here.

Subject :	Physics
Class :	12E
Teacher :	Mr. Ali Moukalled
Duration :	1 hour 30 minutes

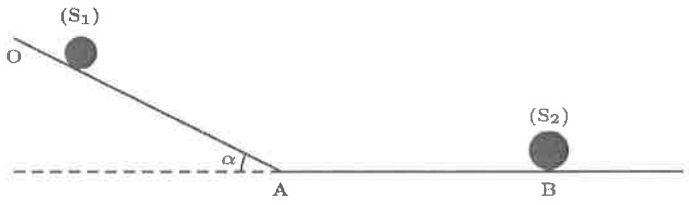
Your name :		*Time taken to complete exam*
Your Class :		
Exam Room :		
How many sheets, including cover sheet :		

- Do not open this paper until the teacher in charge instructs you to do so.
- The most important thing to remember in taking an exam is NEVER PANIC.
- If you are caught cheating in this exam, you will be awarded zero for ALL exams that are taken on this day.

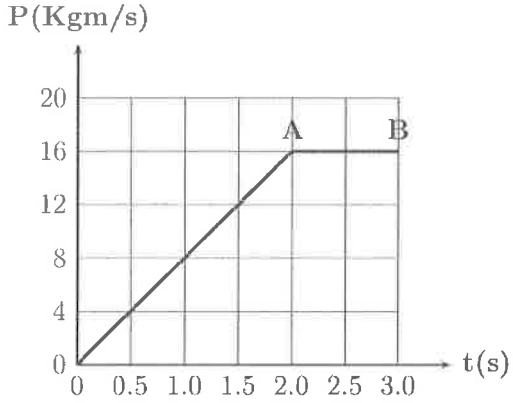
EXERCISE 1 (7.5points)

Linear Momentum and Mechanical Energy

A solid (S_1) of mass $m_1 = 2Kg$ is released without initial velocity from point O on an inclined plane making an angle $\alpha = 30°$ with the horizontal. (Doc.1)
(Doc.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 $g = 10m/s^2$.



Doc.1



Doc.2

I-Motion from O to A

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

II-Motion from A to B

1. Determine using document-2 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 in the absence of friction.

III- Collision

Solid (S_1) enters into head-on elastic collision with solid (S_2) of mass $m_2 = 6Kg$ that is initially at rest.

1. Determine the speed V_1' and V_2' of (S_1) and (S_2) respectively just after collision.
2. Determine the average force $F_{1/2}$ exerted by (S_1) on (S_2) if the collision lasts for 0.1s.
3. Determine the speed of the center of mass of the system (S_1, S_2) just after collision.

EXERCISE 2 **(7.5points)**

Energy dissipated during the charging of a capacitor

The object of this exercise is to determine the energy dissipated, by Joules effect, during the charging of a capacitor.
We charge a capacitor of capacitance $\mathbf{C = 5 \times 10^{-3} F}$, initially neutral, using an ideal generator of constant voltage of e.m.f E through a resistor of resistance $\mathbf{R = 200\Omega}$ (fig.1). At the instant $\mathbf{t_0 = 0}$, the switch K is closed. The circuit thus carries a current i at the instant t.

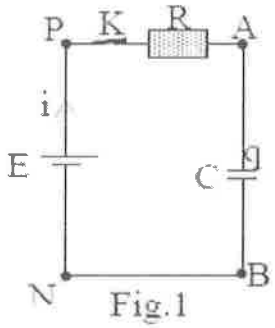


Fig.1

I-Exploiting a waveform

Using an oscilloscope, we display the variations of the voltage $\mathbf{u_R = u_{PA}}$ across the resistor and that of $\mathbf{u_C = u_{AB}}$ across the capacitor. We obtain the waveforms of figure 2.

1. The curve (b) represents the variation of $\mathbf{u_R}$ as a function of time. Why ?
2. Determine, using the waveforms:
   (a) the value of E;
   (b) the maximum value I of i;
   (c) the time constant τ the RC circuit.
3. Give the time at the end of which the capacitor will be practically completely charged.

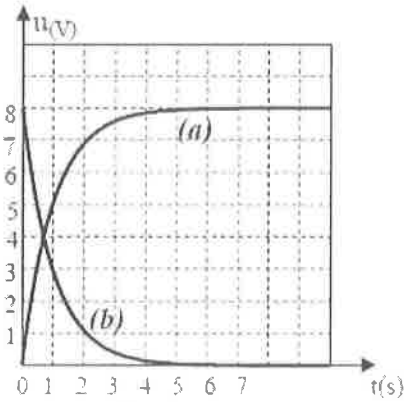


Fig.2

II-Theoretical study of charging

1. Show that the differential equation in $\mathbf{u_C}$ may be written as: $\mathbf{E = RC\frac{du_C}{dt} + u_C}$.
2. The solution of this equation has the form $\mathbf{u_C = Ae^{\frac{-t}{\tau}} + B}$ where A, B, and τ are constants.
   (a) Determine , starting from the differential equation ,the expression of B in terms of E and that of τ terms of R and C.
   (b) Using the initial condition, determine the expression of A in terms E.
3. Show that: $\mathbf{i = \frac{E}{R}e^{\frac{-t}{\tau}}}$.

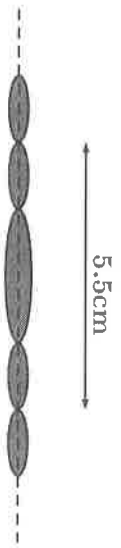
III- Energetic study of charging

1. Calculate the value of the electric energy $\mathbf{W_C}$ stored in the capacitor at the end of the charging process.
2. The instantaneous electric power delivered by the generator at the instant t is $\mathbf{p = \frac{dW}{dt} = Ei}$ where W is the electric energy delivered by the generator between the instants $\mathbf{t_0}$ and t.
   (a) Show that the value of the electric energy delivered by the generator during the whole duration of charging is **0.32J**.
   (b) Deduce the energy dissipated due to Joules effect in the resistor.

EXERCISE 3 (5points)

A laser beam of light, of wavelength in vacuum λ, falls normally on a vertical slit of width $\mathbf{a = 0.2mm}$. The diffraction pattern is observed on a screen placed perpendicularly to the laser beam at a distance $\mathbf{D = 4m}$ from the slit and parallel to it.
Let ℓ be the linear width of the central bright fringe.

1. Which aspect of light does this experiment illustrates?
2. Determine the expression of ℓ in terms of λ, D and a.
3. The adjacent sketch represents the pattern observed on the screen.
   (a) Determine ℓ.
   (b) Deduce λ.
4. If the laser is replaced by white light.
   (a) Specify the color obtained at the center of the central bright.
   (b) Determine the wavelengths that give a black fringe **5cm**, from the center of the central.



GOOD LUCK

SE06/2022 2023/ Physics/12E +12M

$m_1 = 2Kg$, $V_0 = 0m/s$, $\alpha = 30°$

I. Motion from O to A

1) Due to Newton's 2nd law

$$\Sigma \vec{F}_{ext} = \frac{d\vec{P}}{dt} = \frac{\Delta \vec{P}}{\Delta t}$$

$$\Sigma \vec{F}_{ext} = \frac{\vec{P}_A - \vec{P}_B}{t_A - t_0}$$

$$= \frac{16 - 0}{2 - 0} = 8N$$

$$\Sigma \vec{F}_{ext} = 8\vec{i} \quad (1)$$

2) $\Sigma \vec{F}_{ext} = m\vec{g} + \vec{N} + \vec{f}$

project along the x-axis

$+mg\sin\alpha - f = 8$

$2 \times 10 \times \sin 30 - f = 8$

$10 - f = 8$

$f = 10 - 8$

$\boxed{f = 2N}$ (1)

3) $P_A = m V_A = 16$

$$V_A = \frac{16}{m_1} = \frac{16}{2}$$

$V_A = 8m/s$ (0.5)

4) $M.E_A = K.E_A + G.P.E_A$

$$= \frac{1}{2} m_1 V_A^2$$

$$= \frac{1}{2}(2)(8)^2$$

$= 64J$ (0.5)

$\boxed{M.E_A = 64J}$ (1)

5) $\Delta M.E = -f_r \times OA$

$M.E_A - M.E_O = -f_r \times OA$

$mgh_A - 64 = -F_r \times OA$

$mgOA\sin\alpha - 64 = -F_r \times OA$

$OA(mg\sin\alpha + f_r) = 64$

$$OA = \frac{64}{2 \times 10 \times \sin 30 + 2}$$

$OA = 5.3m$ (1)

II - Motion from A to B

1) $V_B = \frac{P_B}{m} = \frac{16}{2} = 8 m/s$ (0.5)

2) $M.E_1 = M.E_2$ (0.5)

III - collision

$m_2 = 6kg \quad V_2 = 0 m/s$

1) $m_1\vec{V_1} = m_1\vec{V_1'} + m_2\vec{V_2'}$

$m_1V_1 = m_1V_1' + m_2V_2'$ (1) alg. form

$m_1(V_1 - V_1') = m_2V_2'$ (2)

The collision is Elastic

$K.E_{bef} = K.E_{aft}$

$\frac{1}{2}m_1V_1^2 = \frac{1}{2}m_1V_1'^2 + \frac{1}{2}m_2V_2'^2$

$m_1(V_1^2 - V_1'^2) = m_2V_2'^2$

$m_1(V_1 - V_1')(V_1 + V_1') = m_2V_2'^2$ (3)

(3)/(2): $V_1 + V_1' = V_2'$

$$\begin{cases} V_1' - V_2' = -V_1 \quad (4) & \times m_2 \\ m_1V_1' + m_2V_2' = m_1V_1 \quad \dots (1) \end{cases}$$

$$\begin{cases} m_2V_1' - m_2V_2' = -m_2V_1 \\ m_1V_1' + m_2V_2' = m_1V_1 \end{cases}$$

$$V_1'(m_1+m_2) = -m_2V_1 + m_1V_1$$

$$V_1' = \frac{-m_2V_1 + m_1V_1}{m_1+m_2} = \frac{-6\times 8 + 2\times 8}{2+6}$$

$$\boxed{V_1' = -4\,m/s}$$ Recoil (1)

Replace in (4)

$$-4 - V_2' = -8$$
$$-4 + 8 = V_2'$$
$$\boxed{V_2' = 4\,m/s}$$ (0.5)

2) (1) Due to Newton's 2nd law

$$\sum \vec{F}_{ext} = \frac{\Delta \vec{P}}{\Delta t}$$

$$F_{1/2} = \frac{\vec{P}_2' - \vec{P}_2}{0.1}$$

$$F_{1/2} = \frac{m_2V_2'}{0.1} = \frac{6\times 4}{0.1}$$

$$\boxed{F_{1/2} = 240N}$$ (0.5)

3) $\vec{P}_{system} = \vec{P}_1' + \vec{P}_2' = \vec{P}_G$

$$m_1\vec{V}_1' + m_2\vec{V}_2' = m_G\vec{V}_G$$
$$2(-4\vec{i}) + 6(4\vec{i}) = 8\vec{V}_G$$

$$\vec{V}_G = 2\vec{i}$$ (0.5)

Exercise 2

I- 1) The current i decreases with time $\Rightarrow$ $u_R = Ri$ is represented by the curve (b). (1)

2) a) at $t = t_{Final}$
$u_c = E = 8V$. (0.5)

b) $u_R = Ri$
$E = RI \Rightarrow I = \frac{8}{200} = 0.04A$

$I = 0.04A$ (0.5)

c) at $t = \tau$
$u_c = 0.63E$
$= 0.63(8)$
$= 5.04V$ (0.5)

3) $t = 5\tau = 5s$ (0.5)

II - 1) due to the law of addition of voltages
$u_G = u_R + u_c$
$E = Ri + u_c$
$E = RC\frac{du_c}{dt} + u_c$ (1)

2) $u_c = Ae^{-t/\tau} + B$
$\frac{du_c}{dt} = -\frac{A}{\tau}e^{-t/\tau}$ (2)

Replacing in the diff. equation $\Rightarrow$ $B = E$ & $\tau = RC$

b) at $t=0$, $u_c=0$

$A+B=0$

$A=-B=-E$

$A=-E$

3) $u_c = E\left(1-e^{-t/\tau}\right)$

$i = C\frac{du_c}{dt} = \cancel{C}\frac{E}{R\cancel{C}}e^{-t/\tau}$

$i = \frac{E}{R}e^{-t/\tau}$ ✓

III - 1) $W_c = \frac{1}{2}CE^2$

$= \frac{1}{2}(5\times10^{-3})(8)^2$

$= 0.16\,J$ (0.5)

2) a) $\frac{dW}{dt} = Ei \Rightarrow W = \int Ei\,dt =$

$W = -CE^2e^{-t/\tau} + cte$

For $t=0$, $W_c=0 \Rightarrow cte = CE^2$

$W = CE^2\left(1-e^{-t/\tau}\right)$ (0.5)

for $t = 5RC$ as $(t\to\infty)$

$W = CE^2 = 0.32\,J$

b) $W_R = W_e - W_c = CE^2 - \frac{1}{2}CE^2 = \frac{1}{2}CE^2 = 0.16\,J$

(0.5)

Exercise 3

$a = 0.2\,mm = 0.2 \times 10^{-3}\,m$

$D = 4m$

1) Wave Aspect of light. (0.5)

2) $\sin\theta_n = \frac{n\lambda}{a}$

$\sin\theta_1 = \frac{n\lambda}{a}$

$\theta_1 = \frac{\lambda}{a}$

$\theta_1 = \frac{\ell/2}{D}$

$\theta_1 = \frac{\ell}{2D}$ (1)

$\ell = \theta_1 \times 2D$

$\ell = \frac{2\lambda D}{a}$

3) a) $2\ell = 5.5$

$\ell = \frac{5.5}{2}$ (0.5)

$\ell = 2.75cm = 2.75 \times 10^{-2}\,m$

b) $\lambda = \frac{\ell \times a}{2D} = \frac{2.75 \times 10^{-2} \times 0.2 \times 10^{-3}}{2 \times 4}$ (1)

$\lambda = 6.875 \times 10^{-7}\,m$ (1)

4) a) white spot

b) 3 radiations will give black points. (1)

(6)