SPECIFIC INSTRUCTIONS

- You must answer the 20 questions so as to be able to obtain the maximum score.

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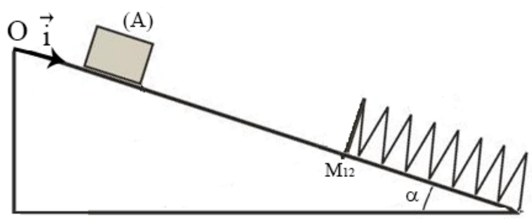
First exercise: Mechanical energy

We propose to determine the variation of the mechanical energy of a system between two given instants.

We have a table inclined by 15° with respect to the horizontal. During its motion, at an instant t, the mobile (A), a point mass of mass m = 220 g, undergoes forces due to friction whose resultant $\vec{f} = -f\,\vec{i}$ is constant and in the opposite direction to $\vec{V} = V\,\vec{i}$ (V > 0), the velocity of the center of mass M of (A) with respect to an axis (O, $\vec{i}$) parallel to the line of greatest slope. An appropriate device records, at equal intervals of time to τ = 40 ms, the abscissa x of M and the value of V. The measurements are registered in the table below. (Take: g = 10 m/s^2).



Instant	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}
Position	M_0	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	M_9	M_{10}	M_{11}	M_{12}
Abscissa x(m)	0.000	0.012	0.027	0.047	0.070	0.097	0.128	0.163	0.201	0.244	0.290	0.341	0.395
V(m/s)	0.242	0.338	0.435	0.532	0.629	0.726	0.823	0.919	1.016	1.113	1.210	1.307	1.403

1. Let P be the algebraic measurement of the linear momentum of (A) at an instant t. The instantaneous variation of the linear momentum, $\Delta\vec{P} = \Delta P\,\vec{i}$, is supposed to be constant; ΔP, at the instant t_6, is equal to:

a) ΔP = 0.0313 kg. m/s;
b) ΔP = 0.0531 kg .m/s;
c) ΔP = 0.0425 kg .m/s.

2. By applying Newton's second law ($\vec{F} = \frac{d\vec{P}}{dt}$), the value of F is:

a) F = 0.665 N;
b) F = 0.531 N;
c) F = 0.426 N.

3. The value N of the normal reaction $\vec{N}$ of the inclined support on (A) is equal to:

a) N = 2.125 N;
b) N = 1.569 N;
c) N = 0.589 N.

4. The algebraic measurement F of the resultant $\vec{F}$ of the forces exerted on (A) is expressed by:

a) F= 0.608 - f;
b) F= 0.569 - f;
c) F= 0.508 + f.

5. The value of f is then:
a) f = 0.021 N;
b) f = 0.038 N;
c) f = 0.058 N.

6. The work $W(\vec{f})$ done by $\vec{f}$ between the points M_0 and M_{12} is equal to:
a) $W(\vec{f}) = -0.023$ J;
b) $W(\vec{f}) = -0.008$ J;
c) $W(\vec{f}) = -0.015$ J.

7. Knowing that the horizontal plane passing through M_{12} is chosen as the reference level for the gravitational potential energy, the mechanical energy of the system (mobile - Earth) at the instant t_{12} is equal to:
a) ME (t_{12}) = 0.184 J;
b) ME (t_{12}) = 0.126 J;
c) ME (t_{12}) = 0.217 J.

8. At the point M_{12}, the mobile (A) hits a spring, of negligible mass and of stiffness constant k. The maximum compression of the spring is of 10 cm. Let C be the point reached then by (A).

8.1. The mechanical energy ME of the system ((A), spring, Earth) at point (C) is expressed by:
a) ME(C) = 0.005k + 0.00569 (ME in J);
b) ME(C) = 0.005k – 0.0569 (ME in J);
c) ME(C) = 0.05k – 0.569 (ME in J).

8.2. The work $W(\vec{f})$ done by $\vec{f}$ between the points M_{12} and C is equal to :
a) $W(\vec{f}) = -0.0021$ J;
b) $W(\vec{f}) = -0.0058$ J;
c) $W(\vec{f}) = -0.0038$ J.

8.3. The stiffness constant k of the spring is equal to :
a) k = 54.0 N/m;
b) k = 31.5 N/m;
c) k = 42.3 N/m.

Second exercise: Role of a coil in a circuit

The circuit shown in figure 1 is carried out where:
(G) is an ideal generator of emf E = 9 V;
(D_1) is a resistor of resistance $R_1 = 90\ \Omega$;
(D_2) is a resistor of resistance R_2;
(B) is a coil of inductance L = 1 H and of negligible resistance;
(K) is a special switch causing no loss of energy when it passes from position 1 to position 2.

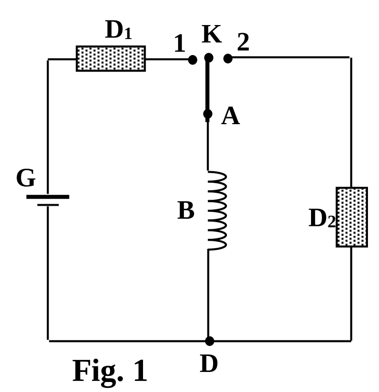


Fig. 1

A- Current growth in the circuit (R_1L)
The switch is placed in position 1 at an instant chosen as the origin of the times ($t_0 = 0$). At an instant t, the circuit carries a current i_1.

1. The differential equation in i_1 is:

a) $E = R_1\frac{di_1}{dt} + L\, i_1$;

b) $0 = L\frac{di_1}{dt} + R_1 i_1$;

c) $E = R_1 i_1 + L\frac{di_1}{dt}$.

2. The solution of the previous differential equation is given by:
a) $i_1 = 0.1\,(1 - e^{-90.t})$ (i_1 in A and t in s);
b) $i_1 = 9\,(1 - e^{-90.t})$ (i_1 in A and t in s);
c) $i_1 = 9\,(1 - e^{-0.011.t})$ (i_1 in A and t in s).

3. In steady state, the value of the current i_1 is:
a) $i_1 = 10$ A;
b) $i_1 = 9$ A;
c) $i_1 = 0.1$ A.

4. In steady state, the magnetic energy W_m stored by the coil is:
a) $W_m = 50$ J;
b) $W_m = 45$ J;
c) $W_m = 5\times10^{-3}$ J.

B - Current decay in the dipole (R_2L) and lighting of a lamp

1. Current decay in the circuit (R_2L)
At an instant chosen as a new origin of the times ($t_0 = 0$), the switch (K) passes from position 1to position 2. At an instant t, the circuit carries then a current i_2.
1.1. The differential equation in i_2 is:

a) $L\frac{di_2}{dt} + (R_1 + R_2)i_2 = 0$;

b) $L\frac{di_2}{dt} + R_2 i_2 = 0$;

c) $L\frac{di_2}{dt} + R_2 i_2 = \frac{E}{R_2}$.

1.2. The solution of this differential equation is of the form:

a) $i_2 = \frac{E}{R_1}\, e^{-\frac{R_2}{L}t}$;

b) $i_2 = \frac{E}{R_2}\, e^{-\frac{R_2}{L}t}$;

c) $i_2 = \frac{E}{R_1}\, e^{-\frac{L}{R_2}t}$.

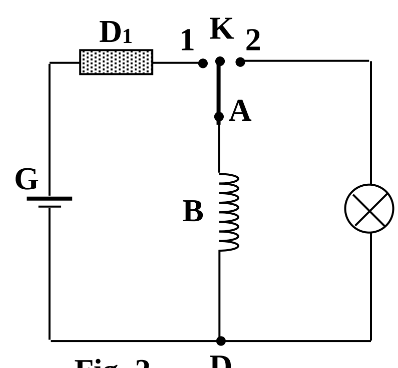


Fig. 2

2. Duration of lighting of a lamp

The resistor D_2 is a lamp of resistance $R_2 = 400\ \Omega$ (Fig. 2).
This lamp stays on as long as it carries a current that is at least equal to 20 mA. The maximum duration of the lighting the lamp is:
a) $\Delta t = 2$ ms;
b) $\Delta t = 4$ ms;
c) $\Delta t = 1$ ms.

C – Oscillating circuit

The resistor (D_2) is replaced by a capacitor of capacitance C (Fig. 3). The switch, placed in position 1, the circuit reaches the steady state. At an instant chosen as the origin of time ($t_0 = 0$), the switch (K) passes from position 1 to position 2. Using a suitable device, we record the variations of the voltage u_C across the capacitor and we obtain the waveform of figure 4.

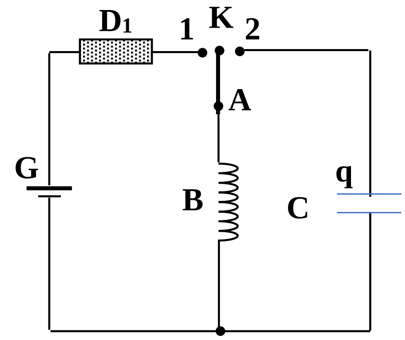


Fig. 3

1. The proper period T_0 of the oscillations of the LC circuit is:

a) $T_0 = 1.25$ ms;

b) $T_0 = 0.63$ ms;

c) $T_0 = 0.5$ ms.

2. The value of the capacitance C of the capacitor is:

a) C = 10 nF;

b) C = 10 μF;

c) C = 10 mF.

3. The maximum value U_0 of the voltage u_C across the capacitor is:

a) $U_0 = 9$ V;

b) $U_0 = 100$ V;

c) $U_0 = 1000$ V.

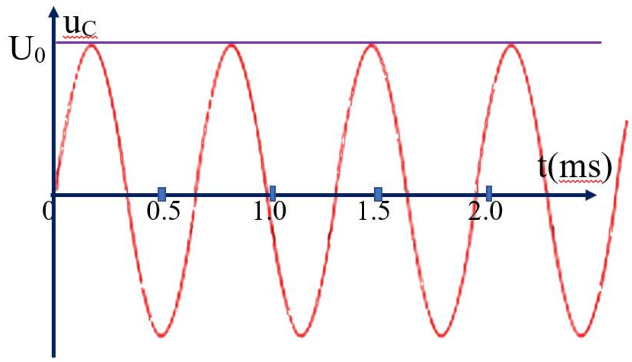


Fig. 4

Solution

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First exercie: Mechanical energy

Questions	(a)	(b)	(c)	Notes
1			X	
2		X		
3	X			
4		X		
5		X		
6			X	
7			X	
8.1		X		
8.2			X	
8.3	X			

Second exercise : Role of a coil in a circuit

Questions	(a)	(b)	(c)	Notes
A.1			X	
A.2	X			
A.3			X	
A.4			X	
B.1.1		X		
B.1.2	X			
B.2		X		
C.1		X		
C.2	X			
C.3			X	