Lebanese University
Faculty of Agronomy

Entrance Exam 2021-2022
Physics GS

August 2021
Duration 90 min

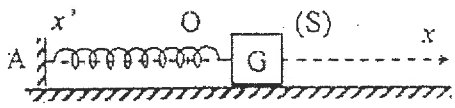
SPECIFIC INSTRUCTIONS

يتضمن كل سؤال إجابة صحيحة. ضع علامة (✓) في المربع المناسب لكل سؤال على ورقة الأجابة المرفقة **(Answer sheet)**

- All of the blank pages on the back of this topic can be used for drafting if you wish. No draft will be distributed to you.
- The use of the non-programmable calculator is authorized
-In order to eliminate random answer strategies, each correct answer is rewarded with **3 points**, while each wrong answer is penalized by the withdrawal of **1 point**.

Mechanical oscillator

A- A horizontal oscillator consists of a solid (S) of mass M = 0.760 kg and of center of inertia G attached to a spring (R), of stiffness k = 8.3 N/m and of negligible mass. (S) can slide without friction on a support and G can move on a horizontal x'x axis. When (S) is in equilibrium, its center of inertia G is located at the point O considered as the origin of the abscissas. (S) is moved in the positive direction by x_0 = 3.7 cm from its equilibrium position, then it is released without velocity at the instant $t_0 = 0$. At an instant t, G passes by a point of abscissa x with a velocity $\vec{V} = V\,\vec{i}$, ($V = \frac{dx}{dt} = \dot{x}$). The horizontal plane containing x'x is chosen as the reference level for the gravitational potential energy.

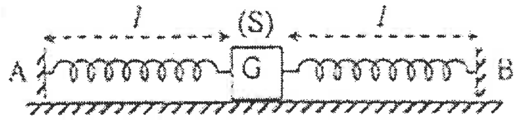


1. The differential equation that governs the motion of G is given by:
a) $\ddot{x} + 10.92\,x = 0$; (x in m);
b) $\ddot{x} + 0.092\,x = 0$; (x in m);
c) $\ddot{x} + 12.5\,x = 0$. (x in m).

2. The proper (natural) period T_0 of the oscillations is given by:
a) $T_0 = 1.90$ s;
b) $T_0 = 3.30$ s;
c) $T_0 = 0.95$ s.

3. The time equation of motion of G is:
a) $x = 3.7\cos(3.30\,t + \frac{\pi}{2})$, x in cm;
b) $x = 3.7\sin(1.90\,t)$, x in cm;
c) $x = 3.7\cos(3.30\,t)$, x in cm.

B- (S) is attached to two springs identical to (R), each of natural length ℓ_0. The length of each spring at equilibrium, is ℓ ($\ell > \ell_0$). We consider the same preceding conditions (x_0 = 3.7 cm and $V_0 = 0$). The two springs are always stretched and (S) oscillates without friction along AB.

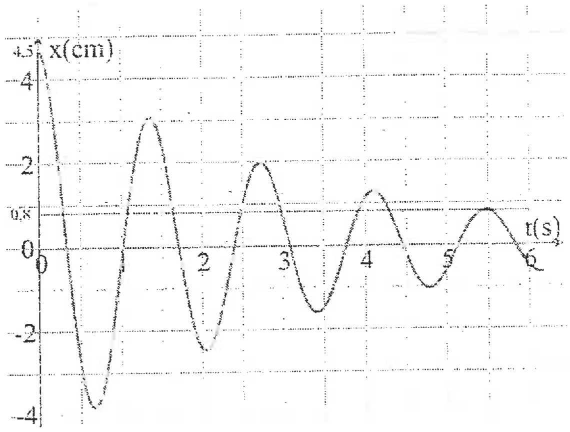


4. The differential equation that governs the motion of G and the value of the natural period T_0' of this oscillator, are:
a) $\ddot{x} + \frac{2k}{M}x = 0$ and $T_0' = 1.34$ s;
b) $\ddot{x} + \frac{k}{2M}x = 0$ and $T_0' = 0.67$ s;
c) $\ddot{x} + \frac{k}{M}x = 0$ and $T_0' = 1.98$ s.

5. Free oscillations

The adjacent figure gives the recording of the abscissa of the center of inertia G of (S) as a function of time. The pseudo-period T is equal to:

a) T = 1.33 s;
b) T = 1.34 s;
c) T = 1.38 s.



6. Sustained oscillations

A suitable device, connected to the oscillator, provides energy to maintain its oscillations. The average power P_{av} received by the oscillator is:

a) P_{av} = 1.48 mW;
b) P_{av} = 2.96 mW;
c) None of these two values.

Verification of Newton's second law

We consider an inclined plane forming an angle $\alpha = 30^{o}$ with the horizontal plane. A particle (S), of mass m = 0.5 kg, is launched from O, the lowest point of the plane, at the instant $t_0 = 0$, with a velocity $\vec{V}_0 = V_0\,\vec{i}$ along the line of greatest slope (OB) of the inclined plane. Let A be a point of (OB) such that OA = 5 m (Fig. 1). The position of (S), at an instant t, is given by $\overrightarrow{OM} = x\,\vec{i}$ where x = f(t).

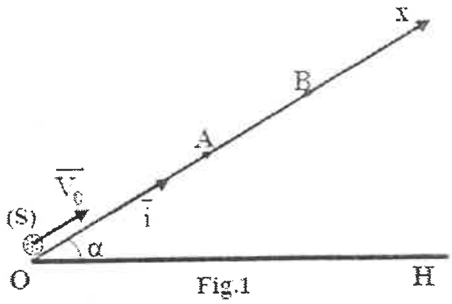


Fig.1

The variation of the mechanical energy of the system [(S), Earth], as a function of x, is represented by the graph in Figure 2.

Take:

- The horizontal plane passing through OH as the reference level for the gravitational potential energy;
- $g = 10\ m.s^{-2}$.

7. Referring to the graph in Figure 2, the variation ΔE_m of the mechanical energy of the system [(S), Earth] between the dates of passage of (S) through the points O and A is:

a) ΔE_m = -20 J.
b) ΔE_m = +10 J.
c) ΔE_m = -10 J.

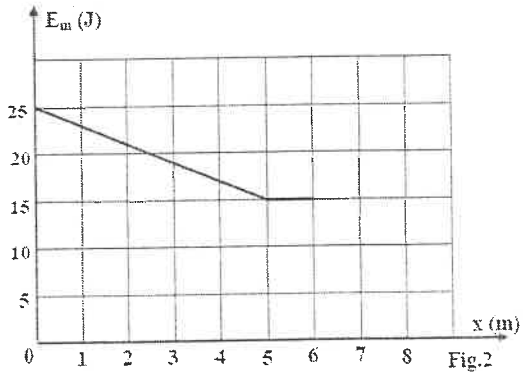


Fig.2

8. The magnitude of the force of friction, supposed constant between O and A, is equal to:

a) f = 2 N
b) f = 3 N
c) f = 5 N

9. For $0 \le x \le 5$ m, the expression of the mechanical energy E_m of the system [(S), Earth] is:

a) $E_m = -3x + 25$ (E_m in J; x in m);
b) $E_m = -2x + 25$ (E_m in J; x in m);
c) $E_m = -5x + 15$ (E_m in J; x in m).

10. The speed of (S) at the point of abscissa x = 6 m is:

a) v = 3.5 m/s;
b) v = 0 m/s;
c) None of the two answers.

Let v be the speed of (S) when it passes through the point M of abscissa x such that $0 \leq x \leq 5$ m.

11. The relation between v and x is given by:

a) $0.25\ v + 4.5\ x - 25 = 0$;

b) $0.5\ v^2 + 4.5\ x - 25 = 0$;

c) $v^2 + 18\ x - 100 = 0$.

12. The algebraic value a of the acceleration of (S) is constant at any time and it is equal to:

a) $a = -9$ m.s^{-2};

b) $a = +9$ m.s^{-2};

c) $a = -4.5$ m.s^{-2}.

13. The speed of (S) at O is:

a) v(at O) = 9 m/s;

b) v(at O) = 10 m/s;

c) v(at O) = 4.5 m/s.

14. The speed of (S) at A is:

a) v (at A) = 3.16 m/s;

b) v (at A) = 2.56 m/s;

c) v (at A) = 2.24 m/s.

15. Knowing that $V_0 = 10$ m.s^{-1} and that the speed of (S), at an instant t, is given by $v = at + v_0$, then the duration $\Delta t = t_A - t_0$ of the displacement of (S) during its climb from O to A is:

a) $\Delta t = 1.11$ s;

b) $\Delta t = 1.52$ s;

c) $\Delta t = 0.76$ s.

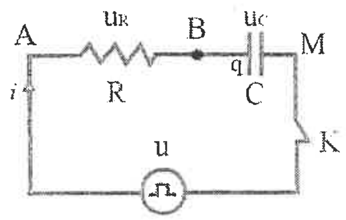
16. Knowing that the linear momentum of (S) at A is 1.58 kg.m/s, then the sum of the external forces applied to (S), $\vec{F} = \Sigma\vec{F}_{ext}$, which is constant at any time, is equal to:

a) $\vec{F} = -9\,\vec{i}$ (F in N);

b) $\vec{F} = -4.5\,\vec{i}$ (F in N);

c) $\vec{F} = -3.10\,\vec{i}$ (F in N).

RC series circuit



A series circuit is formed of the components, a switch (K), a resistor (R) of resistance R and a capacitor (C) of capacitance C.

This circuit is fed by a low frequency generator (LFG) delivering across its terminals a square wave.

$u = U$ for $0 \leq t \leq T/2$;

$u = 0$ for $T/2 \leq t \leq T$, where $T \geq 5$ RC.

(K) is closed at the instant $t_0 = 0$.

The differential equation that describes the evolution of voltage $u_C = u_{BM}$ across the capacitor as a function of time t and the expression of the solution of this differential equation are given respectively by:

17. For $0 \leq t \leq T/2$:

a) $\frac{du_C}{dt} + \frac{1}{RC}u_c = \frac{1}{RC}U$ and $u_C = U\,(1-e^{-t/RC})$;

b) $\frac{du_C}{dt} + \frac{1}{RC}u_c = 0$ and $u_C = U\,e^{-t/RC}$;

c) $\frac{du_C}{dt} + \frac{1}{RC}u_c = U$ and $u_C = U\,(1-e^{-t/RC})$.

18. For $T/2 \le t \le T$:

a) $\frac{du_C}{dt} + \frac{1}{RC}u_c = \frac{1}{RC}U$;

b) $\frac{du_C}{dt} + \frac{1}{RC}u_c = 0$;

c) a) $\frac{du_C}{dt} + \frac{1}{RC}u_c = U$.

19. For $T/2 \le t \le T$:

a) $u_C = U\,(1 - e^{-(t - \frac{1}{2}T)/RC})$;

b) $u_C = U\,(1 + e^{-(t - \frac{1}{2}T)/RC})$.

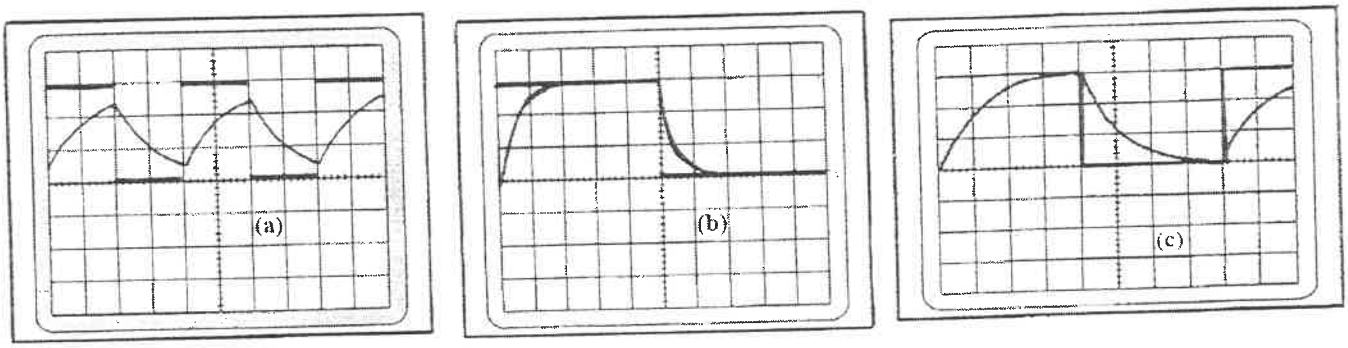
c) $u_C = U\,e^{-(t - \frac{1}{2}T)/RC}$;

20. For $T >> 2\,RC$, the shape of u_C in terms of time is:

a) the waveform (a);

b) the waveform (b);

c) the waveform (c).



Determination of the characteristics of an unknown component

An electric component (D), of unknown nature, can be a resistor of resistance R', a coil of inductance L and of resistance r or a capacitor of capacitance C. To determine its nature and characteristics, it is connected in series with a resistor of resistance $R = 10\ \Omega$ across a generator G as shown in Figure 1. Using an oscilloscope, we can measure the voltage $u_g = u_{AM}$ across the generator and the voltage $u_R = u_{BM}$ across the resistor.

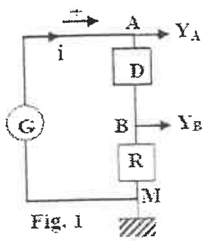


Fig. 1

Case of a DC voltage

The generator G delivers a DC voltage U_0. On the screen of the oscilloscope, we observe the waveforms of figure 2.

21. In steady state, the value of the voltage U_0 delivered by the generator and that of I, the current in the circuit are:

a) $U_0 = 12$ V and $I = 0.28$ A;

b) $U_0 = 4.8$ V and $I = 0.56$ A;

c) $U_0 = 12$ V and $I = 0.56$ A.

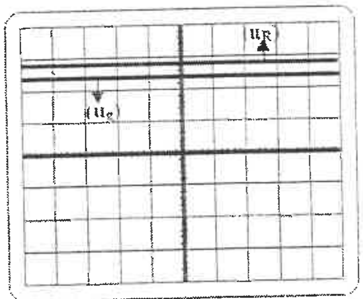


Fig.2 Ch A: $S_V = 5$ V/div
Ch B: $S_V = 2$ V/div

22. The electric component (D) can be:

a) a coil;

b) a resistor;

c) a coil or a resistor.

23. The resistance R_D of the component (D) is:

a) $R_D = 11.43\ \Omega$.

b) $R_D = 21.37\ \Omega$.

c) $R_D = 10.12\ \Omega$.

Case of an alternating voltage

The generator G delivers now an alternating sinusoidal voltage.
On the screen of the oscilloscope, we observe the waveforms of figure 3.

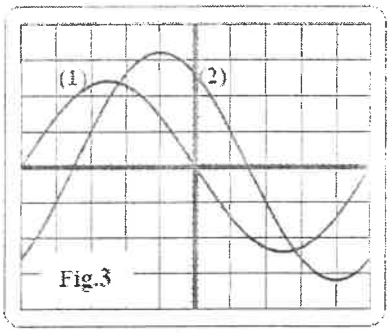


Fig.3

Ch A: S_V = 5 V/div
Ch B: S_V = 1 V/div
Horizontal sensitivity: S_h = 2 ms/div

24. Referring to these waveforms, we can say that (D) is:
a) a coil;
b) a resistor;
c) a coil or a resistor.

25. The waveform (2) represents the variation of the voltage:
a) $u_{AB} = u_D$ across (D);
b) $u_{BM} = u_R$ across the resistor;
c) $u_{AM} = u_g$ across the generator.

26. In steady state, the expression of the voltage u_g is given by:
a) $u_g = 3.2 \sin(50\pi t)$ (u in V);
b) $u_g = 3.2 \cos(100\pi t)$ (u in V);
c) $u_g = 12 \sin(100\pi t)$ (u in V).

27. In steady state, the expression of the current i as a function of time is given by:
a) $i = 0.32 \sin(50\pi t + 0.942)$ (i in A);
b) $i = 0.32 \sin(100\pi t - 0.942)$ (i in A);
c) $i = 1.6 \cos(100\pi t + 0.942)$ (i in A).

28. By applying the law of addition of voltages and by giving ωt the two values 0 and $\pi/2$ rad, we find the two following relations:
a) For $\omega t = 0$: $59.1\,L - 0.259\,(R+r) = 0$ and for $\omega t = \pi/2$: $12 = 0.188L + 81.3\,(R+r)$;
b) For $\omega t = 0$: $59.1\,L - 0.259\,(R+r) = 0$ and for $\omega t = \pi/2$: $12 = 81.30L + 0.188\,(R+r)$;
c) For $\omega t = 0$: $0.259L - 59.1\,(R+r) = 0$ and for $\omega t = \pi/2$: $12 = 81.30L + 0.188\,(R+r)$.

29. The value of the inductance L of (D) is:
a) $L \approx 0.097$ H;
b) $L \approx 0.063$ H;
c) $L \approx 0.086$ H.

30 The value of the resistance r of (D) is:
a) $r \approx 22\ \Omega$;
b) $r \approx 12\ \Omega$;
c) $r \approx 18\ \Omega$.

Answer sheet

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