# Med Sea High School

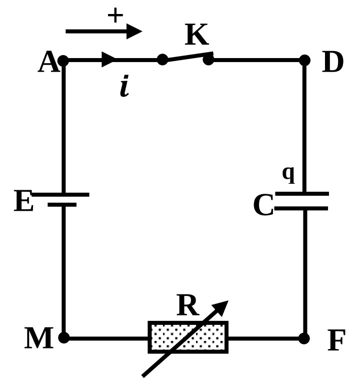
| Physics : T1 | Test | Dec |
|---|---|---|
| Name: | Class: 12 LS | Duration of Exam:120 min |
| | Scholastic Year: 2022/2023 | |

## Exercise 1 ( 7 points): Effect of the resistance on the charging of a capacitor

The aim of this exercise is to study the effect of the resistance of a resistor on the charging of a capacitor.
For this aim, we set-up the circuit of document 1 that includes:

- A capacitor, initially uncharged, of capacitance C = 4μF;
- a resistor of adjustable resistance R;
- an ideal battery of voltage $u_{AM} = E$;
- a switch K.

We close the switch at $t_0 = 0$, and the charging process starts.



Doc.1

**1- Theoretical study**

**1.1-** Derive the differential equation that describes the variation of the voltage $u_{DF} = u_c$ during the charging of the capacitor.

**1.2-** The solution of this differential equation has the form of: $u_C = A + Be^{Dt}$. Determine the constants A, B and D in terms of E, R and C.

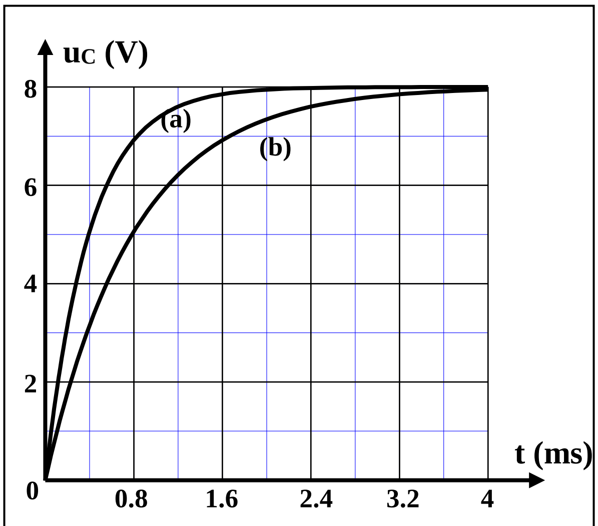
**1.3-** Verify that the capacitor becomes practically fully charged at t = 5RC.

**1.4-** Indicate the effect of the resistance of the resistor on the duration of the charging of the capacitor.

**2- Experimental study**

We adjust R to two different values $R_1$ and $R_2$; an appropriate device allows to trace, for each value of R, the voltage $u_C$ as a function of time (Doc.2).

- curve (a) corresponds to $R = R_1$.
- curve (b) corresponds to $R = R_2$.



Doc.2

**2.1-** Using the curves of document 3:

**2.1.1-** specify the value of E;

**2.1.2-** specify, without calculation, whether the value of $R_2$ is: equal to, greater than, or less than the value of $R_1$;

**2.1.3-** determine the values of $R_1$ and $R_2$.

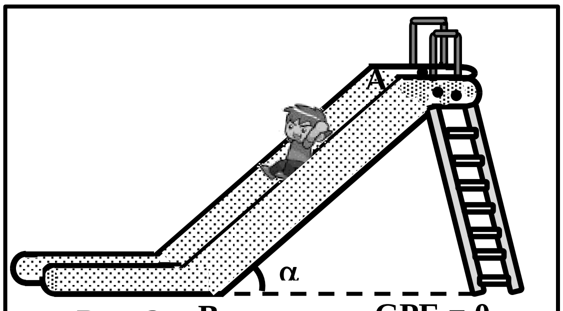
**2.2-** The capacitor is fully charged, the electric energy stored in the capacitor is $W_C$.

**2.2.1-** Is the value of $W_C$ affected by the resistance of the resistor? Justify.

**2.2.2-** Deduce the value of $W_C$.

## Exercise 2 ( 6 points): Motion on a slide

In a park, a child plays on a slide.
The child, considered as a particle, has a mass M = 20 kg.
He climbs to point A the top of the slide, and then slides down without initial velocity to point B at the bottom of the slide at the ground level (Doc. 3). The part AB of the slide is straight and inclined by an angle $\alpha = 30^o$ with respect to the horizontal. The top A of the slide is situated at a height $h_A = 1.8$ m above the ground. Point A is taken as the origin of the x-axis, passing through AB, and of unit vector $\vec{i}$ (Doc.4).

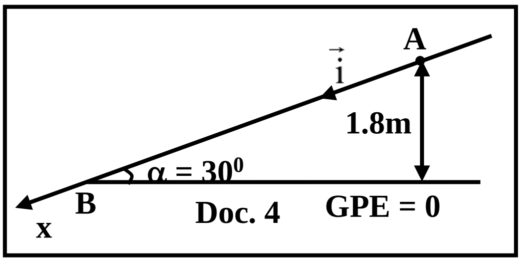


Doc. 3

The aim of this exercise is to determine the duration of motion of the child from A to B in two cases: without friction and with friction.

Take:

- the horizontal plane passing through B as a reference level for gravitational potential energy;
- $g = 10$ m/s$^2$.



Doc. 4

**1)** The child climbs from the ground to point A.

**1.1)** Calculate the variation of the gravitational potential $\Delta$GPE of the system (Child, Earth) between the ground and A.

**1.2)** Calculate the work W done by the weight of the child, when he climbs from the ground to A, knowing that $W = M\,g\,(h_i - h_f)$ where $h_i$ and $h_f$ are the initial and final heights above the ground.

**1.3)** Compare W and $\Delta$GPE.

**2)** Suppose that the child slides without friction from A to B.

**2.1)** Determine the speed $V_B$ of the child when he reaches the ground at B.

**2.2)** Show that the variation of the linear momentum of the child between A and B is $\overrightarrow{\Delta P} = 120\,\vec{i}$ (kg.m/s).

**2.3)** Show that the sum of the external forces vector exerted on the child, during the downward motion from A to B is $100\,\vec{i}$ (N).

**2.4)** Deduce, by applying Newton's second law, the duration $\Delta t_1$ along AB, knowing that $\frac{\Delta\vec{P}}{\Delta t} = \frac{d\vec{P}}{dt}$.

**3)** In reality, the child is submitted to a force of friction $\vec{f}$, supposed constant and parallel to the displacement. During the motion from A to B, the system (Child, Slide, Earth, Atmosphere) loses 25% of its mechanical energy at A.

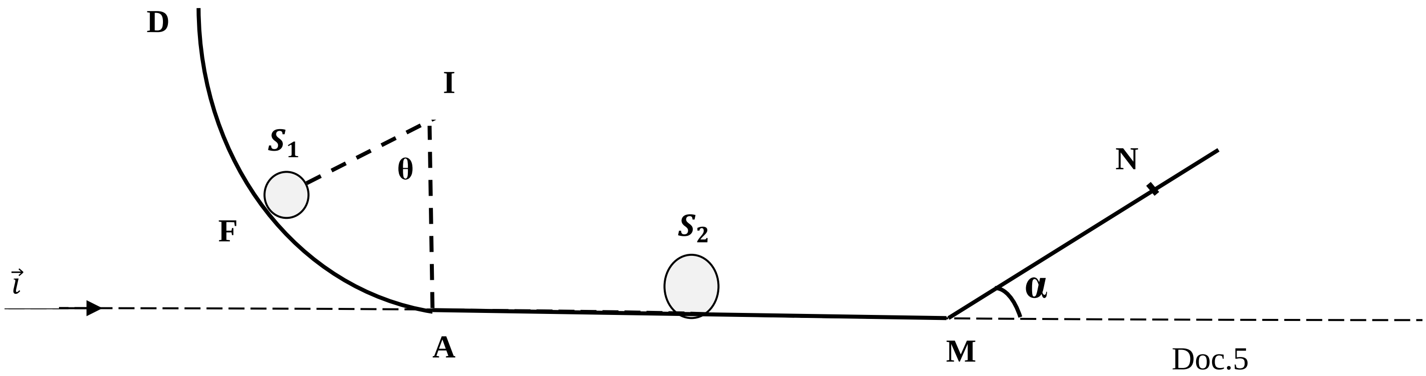
**3.1)** Show that during the downward motion of the child from A to B, the variation in the internal energy of the system (Child, Slide, Earth, Atmosphere) is $\Delta U = 90$ J.

**3.2)** Deduce that the magnitude of the friction force $\vec{f}$ is f = 25 N.

**3.3)** The variation of the linear momentum of the child between A and B, in this case, is $\overrightarrow{\Delta P} = 60\sqrt{3}\,\vec{i}$ (kg.m/s). Determine, by applying Newton's second law, the duration $\Delta t_2$ along AB, knowing that $\frac{\Delta\vec{P}}{\Delta t} = \frac{d\vec{P}}{dt}$.

## Exercise 3 ( 7 points):

A solid $S_1$ of mass $m_1 = 100$ g moves along the track DAMN of document 5. The track DA is circular of center I and radius $R = 0.2m$.The track AM is horizontal; the force of friction is neglected along the track DAM. The track MN is an inclined plane that makes an angle α= $30^\circ$ with the horizontal plane. The horizontal plane passing by the track AM is taken as the reference level of the gravitational potential energy. ( g=10m/s$^2$)



Doc.5

1) The solid $S_1$ is launched without initial velocity from point D where $h_D$=20cm. It passes by point F with a speed 1m/s and makes an angle θ with the vertical plane, then reaches A with velocity $V_1$.
   - **1.1)** The mechanical energy is conserved along the track DA. Justify.
   - **1.2)** By applying the conservation of mechanical energy, determine:
     - **1.2.1)** Determine θ.
     - **1.2.2)** Show that the speed at point A is 2m/s.

2) The solid $S_1$ continues its motion along the track AM with the same speed acquired at A, $S_1$ enters into perfectly elastic collision with another solid $S_2$ initially at rest, just after collision, $S_1$ and $S_2$move with velocities $V_1'$and $V_2'$ respectively where $V_2' = 2\ m/s$ .
   - **2.1**) Name two physical quantities that remains conserved during this collision.
   - **2.2)** Show that $V_2' = \frac{2m_1}{m_1+m_2} V_1$ .
   - **2.3)** Deduce the value of $m_2$ .
   - **2.4)** Justify that $S_1$ comes to rest after collision.

3) The solid $S_2$ continues its motion along the inclined plane to reach the maximum position at N where MN=20cm.
   - **3.1)** Show that the solid is subjected to a force of friction along this track.
   - **3.2)** Determine the force of friction along MN.

**Blessed Efforts**