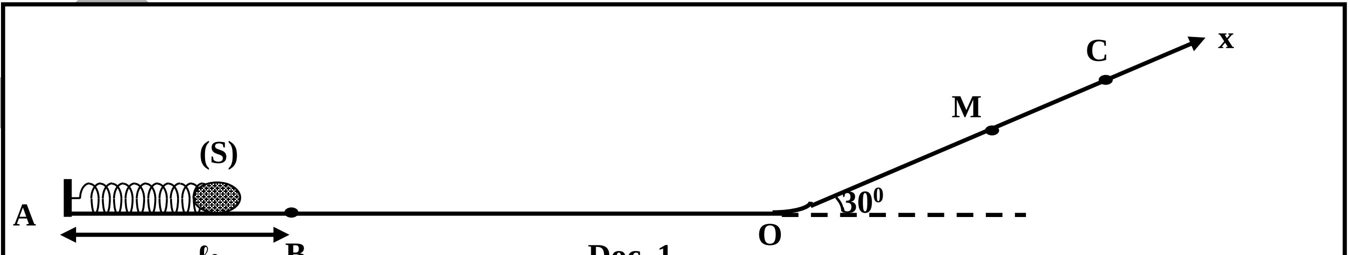
Exercise 1 **Conservation and non-conservation of ME**

Consider an object (S) taken as particle of mass m = 100 g and a massless spring (R), of force constant k = 20 N/m and natural length ℓ_0, fixed from one of its ends to a support at A with the other end free. A rail AOB located in a vertical plane composed of two straight parts: a horizontal part AO and an inclined part OB making an angle $\alpha = 30^0$ with the horizontal as shown in (Doc.1). Take the horizontal plane containing O as the reference level for gravitational potential energy. $g = 10\ m/s^2$.



Doc. 1

1- Launching particle (S)

In order to launch (S), it is placed against the free end of the spring, the spring is compressed by a distance d = 35 cm, and then the system [Spring - (S)] is released from rest. When the spring returns to its natural length ℓ_0, (S) leaves the spring with a velocity $\vec{V}_B$. (S) moves without friction on the rail AB.

1.1) Calculate the mechanical energy of the system [(S), (R), support, Earth].

1.2) Determine the value of the speed V_B at point B.

1.3) Determine the value of $\Delta\ell$ compression of the spring for which the kinetic energy of (S) is equal to the elastic potential energy.

2- Motion between B and O.

(S) moves along a plane BO and reaches point O with speed V_O = 3 m/s where BO = 2 m.

2.1) Prove the existence of friction force.

2.2) Determine the variation of internal energy of the system [(S), Earth, Track, Atmosphere] during the motion of (P) between B and O.

2.3) Determine the magnitude f of the force of friction $\vec{f}$, supposed constant and parallel to the displacement, exerted on (P) during its motion between B and O.

3- Motion between O and C.

We neglect resistive forces along track OC where the C is the highest point reached by (S).

3.1) The mechanical energy at any point between O and C is constant. Why?

3.2) Determine the expression of the gravitational potential energy of the system [(S), Earth], at instant t, in terms of x, where x= OM is an abscissa of point M along the x-axis.

3.3) Determine the expression of kinetic energy of (P), at instant t, in terms of x.

3.4) Deduce the value of OC.

3.5) Determine the value of x for which the kinetic energy of (S) is equal to the gravitational potential energy of the system [(S), Earth]. Deduce the height h.

3.6.1) Determine the variation of the gravitational potential energy ΔPEg of the system system [(S), Earth] between O and C.

3.6.2) Determine the work done by the weight $W_{m\vec{g}}$ between O and C.

3.6.3) Compare ΔPEg and $W_{m\vec{g}}$.