Answer to Question #80939, Physics / Mechanics | Relativity

Question:

A bungee jumper of mass m, jumps without an initial speed from a bridge at time t0=0; his Centre of gravity G is situated at height h0 in relation to the river that passes under the bridge. From t0 to t1; the elastic is not stretched and the diver is in free fall. At time t1 the diver is at a point G, with height h1 and his speed is null. From t1 to t2, the elastic is stretched and slows the fall of the diver, at time t2 the point G is at h2; the elastic has a negligible mass with regard to that of the jumper and it has a elasticity constant k=60N/m and length L0=25m without the load. Given, m=75kg , h0=70m and g=9.8m/s2

a)Calculate the value of the variation of potential energy of gravity of the system during the first phase.

b) Also calculate the speed v1 reached by the jumper at time t1.

c) Calculate the value of the stretch, L. Ignore all friction in this exercise.

Solution:

a) During the first phase (from t0 to t1) the elastic is not stretched and the diver is in free fall. Considering the length of the elastic one can figure out that in the first phase the jumper fell down by L0=25m so the variation of potential energy of gravity of the system during the first phase **can be calculated as**

$$\Delta U = mg\Delta h = mg(\mathrm{h}_0 - \mathrm{h}_1) = \mathrm{mgL}_0 = 75*9.8*25 = 18375\,J$$

b) Until t1 the potential energy of the jumper is totally transformed in to his kinetic energy so

$$\Delta U = mgL_0 = \frac{m{v_1}^2}{2} = \Delta K$$

Then the speed at t1 can be calculated as

$$v_1 = \sqrt{\frac{2\Delta U}{m}} = \sqrt{490} = 22.14\,m/s$$

c) The total stretch can be calculated considering the fact that when the maximal stretch is achieved the kinetic energy of the diver is zero (his speed is zero) so all the gravitational potential energy of the diver is transformed in to the energy of elastic deformation of the rope. The energy of the elastic deformation of the rope can be calculated as

$$\Delta U_{El} = \frac{kL^2}{2}$$

Where L is the stretch. Considering that the diver is falling vertically we can write

$$mg(L + L_0) = \frac{kL^2}{2}$$

$$\frac{kL^2}{2} - mgL - mgL_0 = 0$$

This equation can be solved with the roots

$$L_1 = \frac{mg + \sqrt{m^2 g^2 + 2kmL_0}}{k}$$

$$L_2 = \frac{mg - \sqrt{m^2 g^2 + 2kmL_0}}{k}$$

L_2 does not fit us as it is negative **So finally**

$$L = L_1 = \frac{mg + \sqrt{m^2 g^2 + 2kmL_0}}{k} = 39.86\,m$$