Answer on Question #76743 - Physics / Optics

Question:

A 1200 kg Toyota Echo is accelerating down a hill. The hill is 150 m long and the total distance in elevation of the hill is 15 m. The car accelerates from a speed of 2.0 m/s at the top to an unknown velocity at the bottom in 11 s. The power of the car is 9.6 kW, while the average retarding force of friction is 600 N. Find the speed of the car at the bottom of the hill.

Solution:

We have:

m = 1200 kg

L=150 m

h = 15 m

v_1 = 2 m/s

t = 11 s

W = 9.6 kW = 9600 W

F_r = 600 N

g = 9.8 $\frac{m}{s^2}$

The kinetic energy at the top of the hill:

$$E_1 = \frac{mv_1^2}{2}$$

Let v_2 is the speed and E_2 is the kinetic energy of the car at the bottom of the hill, then

$$E_2 = \frac{mv_2^2}{2}$$

but the kinetic energy was changed:

a. the kinetic energy is increased on the value of the potential energy

$$\Delta E_h = mgh$$

b. the energy is increased by the power of the car

$$\Delta E_W = Wt$$

c. the energy is decreased by the retarding force

$$\Delta E_r = LF_r$$

So the kinetic energy at the bottom of the hill:

$$E_2 = E_1 + \Delta E_h + \Delta E_W - \Delta E_r$$

or

$$\frac{mv_2^2}{2} = \frac{mv_1^2}{2} + mgh + Wt - LF_r$$

Then

$$v_2 = \sqrt{v_1^2 + 2gh + \frac{2Wt}{m} - \frac{2LF_r}{m}}$$

$$\approx \sqrt{2.0^2 + 2 \cdot 9.8 \cdot 15 + \frac{2 \cdot 9600 \cdot 11}{1200} - \frac{2 \cdot 150 \cdot 600}{1200}} \approx 18 \text{ m/s}$$

Answer: the speed of the car at the bottom of the hill $v_2 \approx 18 \text{ m/s}$