A lift cage of mass 540 kg accelerates upwards from rest to a velocity of 6 ms−1 whilst travelling a distance of 13m. The frictional resistance to motion is 220 N. Making use of the principle of conservation of energy, determine:
i) the work done
ii) the tension in the lifting cable
iii) the maximum power developed

Solution:
$\mathrm{m} = 540\ \mathrm{kg} - \text{mass of hte cage};$
$v = 6\frac{\mathrm{m}}{\mathrm{s}} - \text{final velocity of the cage};$
$\mathrm{h} = 13\mathrm{m} - \text{distance traveled by the cage};$
$\mathrm{F} = 220\mathrm{N} - \text{frictional risistance to motion};$
$\mathrm{t} - \text{time of travelling};$
$\mathrm{a} - \text{acceleration of the cage};$

Part I

The lift, after accelerating h upwards gains:

- its potential energy $E_p = mgh$
- its kinetic energy $E_k = \frac{mv^2}{2}$
- in addition its motor needs to work against friction, $W_F = Fh$

The sum of these 3 energies is equal to the driving motor's work W

$$W = E_p + E_k + W_F = mgh + \frac{mv^2}{2} + Fh$$

Let's calculate W $\left(assuming\ g = 9.8\frac{m}{s^2}\right)$

$$W = 540kg \cdot 9.8\frac{m}{s^2} \cdot 13m + \frac{540kg \cdot \left(6\frac{\mathrm{m}}{\mathrm{s}}\right)^2}{2} + 220\mathrm{N} \cdot 13\mathrm{m} = 81.4\ \mathrm{kJ}$$

Part II

The whole amount of work (W) is done by the tension force $\vec{N}$ (pointing upwards) on the distance h. Because $W = N \cdot h$, we've got:

$$N = \frac{W}{h} = \frac{81.4\ \mathrm{kJ}}{13m} = 6262N$$

Part III

Rate equation for the cage:
$0 = \mathrm{V} - \mathrm{at}$

$$\mathrm{t} = \frac{\mathrm{V}}{\mathrm{a}} \qquad (1)$$

Equation of motion for the cage:

$$\mathrm{S} = \frac{\mathrm{at}^2}{2} \qquad (2)$$

(1) in (2):

$$2S = a \cdot \left(\frac{V}{a}\right)^2$$

$$2S = \frac{V^2}{a}$$

$$a = \frac{V^2}{2S} = \frac{\left(6\,\frac{m}{s}\right)^2}{2 \cdot 13m} = 1.4\,\frac{m}{s^2} \Rightarrow$$

$$t = \frac{V}{a} = \frac{6\,\frac{m}{s}}{1.4\,\frac{m}{s^2}} = 4.3s$$

The motor's power P equals " work / time". Therefore:

$$P = \frac{W}{t} = \frac{81.4\ \text{kJ}}{4.3s} = 18.9kW$$

Answer: I) $81.4\ \text{kJ}$ II) $6262N$ III) $18.9kW$.