Lifting a Box:

A box of book, weighing 60 kg is lifted from the ground to a loading ramp, which is 2 m above ground. Your loader crane exerts a force of 620 N to lift the box to the ramp.

1. What is the work done by the loader?
2. What is the work done by gravity?
3. What is the upward speed of the box after 1 m?
4. What is the minimum power output the loaders motor must produce to lift the box to the ramp in 5 seconds?

Picture the problem first, and draw a free-body diagram for the forces.

(1) Work done by the loader:

The loader applies a force F_{app} of 620 N.

$$W_{app} = F_{app}(\cos 0)\Delta y = 620N \times 1 \times 2m = 1240Nm = 1.24kJ$$

(2) Work done by gravity:

$$W_g = mg(\cos 180)\Delta y = 60kg \times 9.81\frac{m}{s^2} \times (-1) \times 2m = -1177kg\frac{m^2}{s^2} = -1.18kJ$$

Thus, the **total** work is

$$W_{total} = W_{app} + W_g = 0.06kJ = 60J$$

(3) The total work is also given by

$$W_{total} = \Delta E = E_f - E_i = E_f = \frac{1}{2} m v_f^2$$

which relates the **total work** to the **kinetic energy**.
Thus one has

$$v_f = \sqrt{\frac{2E_f}{m}} = \sqrt{\frac{2 \times 60J}{60kg}} = \sqrt{\frac{2kgm^2}{s^2}} = 1.4\frac{m}{s}$$

(4) Assume the speed is constant, i.e. no acceleration. Then

$$v = \frac{\Delta y}{\Delta t} = \frac{2m}{5s} = 0.4\frac{m}{s}$$

Thus the power the motor has to produce is given by

$$P = F \cdot v = 620N 0.4\frac{m}{s} = 248\frac{Nm}{s} = 248\frac{J}{s}$$