

Problem 8.37

A 3500 N piano is lifted at constant speed by three men who can provide 165 W of power each. If the pulley system allows for only 75% efficiency, how long does it take the piano to be hoisted 25.0 meters?

At constant velocity, conservation of energy yields the theoretical amount of work that has to be done as:

$$\begin{aligned}\sum KE_1 + \sum U_1 + \sum W_{\text{ext}} &= \sum KE_2 + \sum U_2 \\ 0 + 0 + W_{\text{theo}} &= 0 + (mgh) \\ \Rightarrow W_{\text{theo}} &= (mg)h \\ \Rightarrow W_{\text{theo}} &= (3.50 \times 10^3 \text{ N})(25.0 \text{ m}) \\ &= 8.75 \times 10^4 \text{ J}\end{aligned}$$

The amount of power the workers provide collective, reduced to 75% due the inefficiency of the system, is:

$$\begin{aligned}P &= .75(3(P_{\text{1man}})) \\ &= .75(3(165 \text{ W})) \\ &= 371 \text{ W} \\ &= 371 \text{ J/s}\end{aligned}$$

1.)

The time it takes to do the work, then, is:

$$\begin{aligned}P &= \frac{W}{\Delta t} \\ \Rightarrow \Delta t &= \frac{W}{P} \\ &= \frac{(8.75 \times 10^4 \text{ J})}{(371 \text{ J/s})} \\ &= 236 \text{ s} \quad (= 3.93 \text{ minutes})\end{aligned}$$

2.)