

Doris Locked raises a 1100 N piano 4.0 m by a system of pulleys. She exerts 250 N of force and pulls 22 m of rope. Calculate:

a. the mechanical advantage of the machine

$$\begin{array}{l|l} F_{out} = 1100 \text{ N} & \\ F_{in} = 250 \text{ N} & \\ d_{out} = 4 \text{ m} & \\ d_{in} = 22 \text{ m} & \\ \hline M.A. = ? & \end{array} \quad M.A. = \frac{F_{out}}{F_{in}} = \frac{1100 \text{ N}}{250 \text{ N}} = 4.4$$

b. work input

$$\begin{aligned} W_{in} &= F_{in} \cdot d_{in} \\ W_{in} &= 250 \text{ N} \cdot 22 \text{ m} \\ W_{in} &= 5500 \text{ J} \end{aligned}$$

c. work output

$$\begin{aligned} W_{out} &= 1100 \text{ N} \cdot 4 \text{ m} \\ W_{out} &= 4400 \text{ J} \end{aligned}$$

d. efficiency

$$Eff = \frac{W_{out}}{W_{in}} \times 100 = \frac{4400 \text{ J}}{5500 \text{ J}} \times 100 = 80\%$$