

Work & Energy

Intro to Power

- 1) What is power?

Power is the rate that something does work. $P = \frac{\text{Work}}{\text{time}}$

- 2) What units do we use to measure power?

$$\frac{\text{Work}}{\text{time}} = \frac{\text{Joules}}{\text{sec}} = \text{Watt}$$

Note: In the US, we use the unit of horse power (hp), the conversion is $1 \text{ Hp} = 746 \text{ Watts}$

- 3) What are two ways that we can calculate power?

$$P = \frac{W}{t} \quad \text{However Work is also change in energy} \quad P = \frac{\Delta E}{t}$$

Power Problems

1. A boy's weight is 490 N. If he walks up a flight of stairs 12 m high in 30 seconds, what power has he used? (196 W) $w = F \cdot d = 490 \cdot 12 = 5880 \text{ J}$

$$P = \frac{W}{t} = \frac{5880 \text{ J}}{30 \text{ sec}} = 196 \cdot \frac{\text{J}}{\text{s}} = 196 \text{ W}$$

2. An elevator in the Empire State Building in New York rises to the 80th floor in 50 seconds. If the height is 302 meters, what power must be developed in order to lift 12 people averaging 80 kg each to this floor? (56824 W)

$$P = \frac{\Delta PE}{t} \qquad P = \frac{E}{t} = \frac{2841216}{50} = 56,824 \text{ W}$$

$$PE = mgh = (12 \cdot 80)(9.8)(302) = 2,841,216 \text{ J}$$

3. A 70 kg person runs up a long flight of stairs in 4 seconds. The vertical height of the stairs is 4.5 m, calculate his power output in watts and horsepower. (1.03 Hp)

$$PE = m \cdot g \cdot h = 70 \cdot 9.8 \cdot 4.5 = 3,087 \cdot \text{J} \qquad hp = \frac{\text{watts}}{746} = \frac{772}{746} = 1.03 \cdot hp$$

$$P = \frac{E}{t} = \frac{3087}{4} = 772 \cdot \text{J}$$

4. How long will it take a 2.0 hp motor to lift a 400 kg piano to a sixth story window 20 meters above? (52.6 s)

$$\text{Power} = \frac{\text{Energy}}{\text{time}} \qquad PE = m \cdot g \cdot h = 400 \cdot 9.8 \cdot 20 = 78,400 \cdot \text{J}$$

$$\text{time} \cdot \text{Power} = \text{energy}$$

$$2hp = (2 \cdot hp) \cdot \left(746 \cdot \frac{\text{J}}{hp} \right) = 1492 \cdot \text{J}$$

$$\text{time} = \frac{\text{Energy}}{\text{Power}}$$

$$\text{time} = \frac{\text{Energy}}{\text{Power}} = \frac{78400}{1492} = 52 \text{ sec}$$