Power

Power is the rate a machine does work

If two machines do the same amount of work but one machine finishes the job faster, then the faster machine is more powerful. Mathematically speaking,

$$P = \frac{\text{Work}}{\text{time}} = \frac{\Delta E}{t}$$

Another useful formula: $P = \frac{\text{Work}}{\text{time}} = \frac{Fd}{t} = F\bar{v}$

Units $\frac{J}{s} = \text{watt (W)}$

An alternative unit of power is "horsepower" (hp). The conversion factor between watts and horsepower is

$$746\,W = 1\,hp$$

EXAMPLE: A car's engine outputs 1 200 000 J of energy in 5.0 seconds. What is the power of the engine in watts and in horsepower?

$$P = \frac{\text{Work}}{\text{time}} = \frac{1\,200\,000\,J}{5.0\,sec} = 240\,000\,\text{Watts}$$

$$240\,000\,\text{Watts} \times \frac{1\,hp}{746\,\text{Watts}} = 321.72\,hp$$

$$\simeq 320\,hp$$

EXAMPLE: A 1600 W hairdryer is used for 35 seconds. How much energy does it use in that time?

$P = \frac{Work}{time}$ $\quad P \times time = work$

$1600W \times 35sec = 56000\,J$

EXAMPLE: How long does it take a 6 hp engine to use 1 000 000 J of energy?

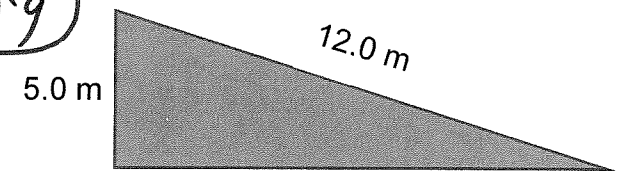
$6hp \times \frac{746W}{1hp} = 4476\,Watts$

$P = \frac{Work}{time} \rightarrow time = \frac{Work}{Power} = \frac{1000000\,J}{4476}$

$= 200\,sec$

EXAMPLE: A student runs up the ramp shown. $m = 76kg$

Their power output is 2300 W. How long will it take them to run up the ramp?



E_p at end $= mgh = 76kg \times 9.8\frac{m}{s^2} \times 5.0m$

$= 3724\,J$

$t = \frac{W}{P} = \frac{3724\,J}{2300\,Watts} = 1.6\,sec$

EXAMPLE: A motor has a maximum power output of 4.9 watts. What is the maximum mass it can lift at 3.0 m/s? What about at 0.5 m/s?

$$P = F\bar{v}$$

$$P = mg\bar{v}$$

$$\frac{P}{g\bar{v}} = m$$

$$\frac{4.9}{9.8 \times 3.0} = 0.17\,kg \qquad \frac{4.9}{9.8 \times 0.5} = 1\,kg$$

EXAMPLE: A 70.0 kg runner increases their speed from rest to 10.0 m/s in 4.0 seconds. What is their power output?

(1) What is increase in E_K?

$$E_K = \frac{1}{2} \times 70.0\,kg \times 10.0^2$$

$$= 3500\,J$$

(2) What is power?

$$P = \frac{Work}{time} = \frac{3500\,J}{4.0\,sec} = 875\,W$$

$$\approx 880\,W$$