Physics with Synno – Motion-2 – Lesson 22

M.7.6 Power (mechanical)

The rate at which work is done on, or by a body is called power.

$$\text{Power} = \frac{\text{Work done}}{\text{Time taken}}$$

or $$P = \frac{w}{t} = \frac{\Delta E}{t}$$

Units of power are joule per second = Watts (W)

Example
The fastest woman to scale the Rialto building stairs in the Great Rialto Stair Trek, in a particular year climbed the 1222 steps, which are a total of 247 m high, in 7 min 58 s. Given that her mass is 60 kg, at what rate was she using energy to overcome the gravitational force alone?

$$P = \frac{\Delta E}{t}$$
$$\Delta E = U_g = m\,g\,h = 60 \times 9.8 \times 247 = 145236\ J$$
$$t = (7 \times 60) + 58 = 478$$
$$P = \frac{\Delta E}{t}$$
$$P = \frac{145236}{478}$$
$$P = 303.8\ W$$

M.7.6.1 Efficiency

In the real world all of the energy is never transformed to the new type. The percentage that is transformed into what you want is called efficiency.

$$Efficiency\ (\eta) = \frac{useful\ energy\ out}{total\ energy\ in} \times 100\ \%$$

Example
An electric kettle uses 23.3 kJ of electrical energy as it boils water. The efficiency is 18%. How much of this energy is actually transferred to the water as heat?

$$Efficiency\ (\eta) = \frac{useful\ energy\ out}{total\ energy\ in} \times 100\ \%$$
$$18 = \frac{useful\ energy\ out}{23.3\times10^3} \times 100$$
$$useful\ energy\ out = \frac{18\ \times\ 23.3\times10^3}{100}$$
$$useful\ energy\ out = 4194\ J = 4.194\ kJ$$

M.7.6.2 Power force and Average Speed

In everyday situations friction is involved. A force is required to keep things moving at constant speed. In this case power can be calculated from force and speed.

$$P = \frac{Work}{time} \quad \text{and} \quad work = F\,x$$

so $$P = \frac{F\,x}{time} \quad \text{but} \quad v_{ave} = \frac{x}{t}$$

Thus $$P = F\,v_{ave}$$

Example
Calculate the power required to keep a car moving at an average speed of 22 m/s if the force of friction is 1200 N.

$$P = F\,v_{ave}$$
$$P = 1200 \times 22$$
$$P = 26400 = 26.4\ kW$$

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