

Work, work, work



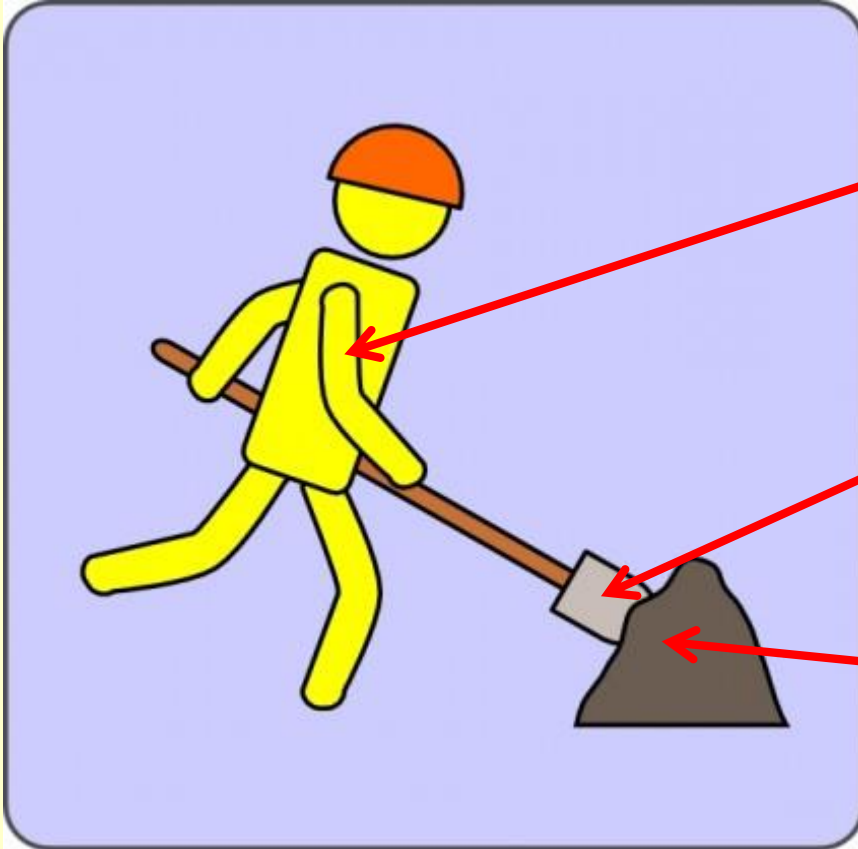
Work, work, work



When a force moves an object it does work and energy is transferred to the object.

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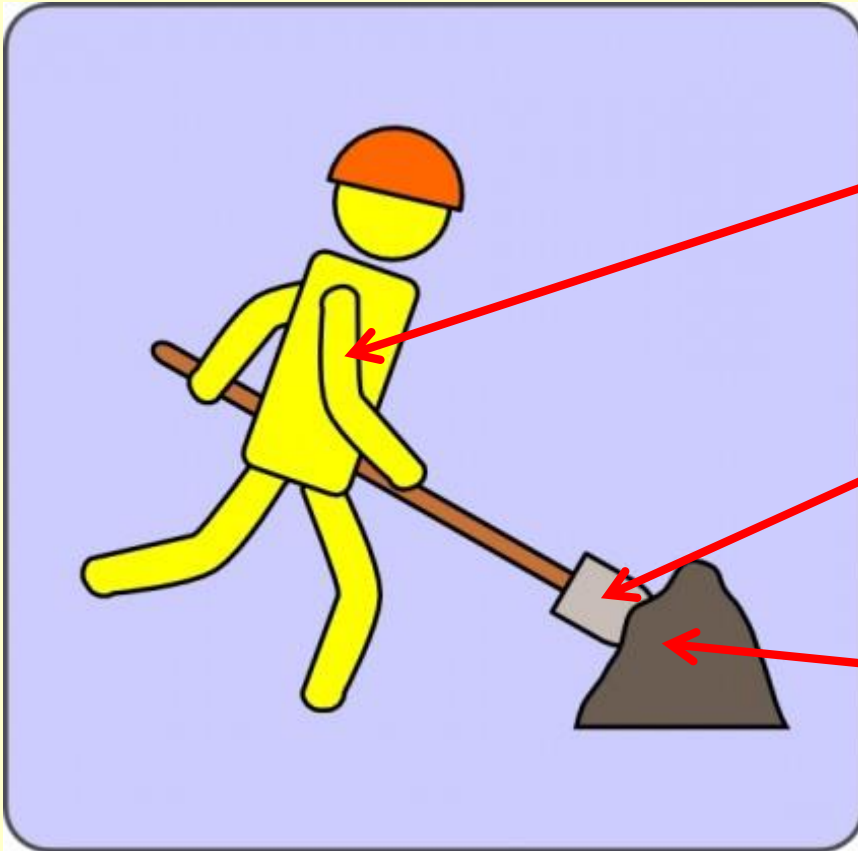
Energy supplied

Work done

Energy transferred

Work, work, work

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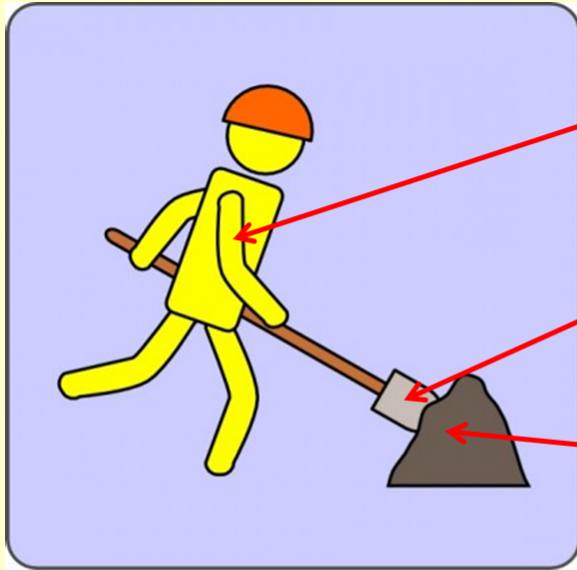
Energy supplied

Work done

Energy transferred

Amount of energy transferred (J) = Work done (J)

Work, work, work



Energy supplied

Work done

Energy transferred

When a force moves an object it does work and energy is transferred to the object.

Amount of energy transferred (J) = Work done (J)

The man shovelling is doing work. If he does 600J of work, then he loses 600J of energy. The substance being shovelled gains energy - but not the full 600J, as some is lost as sound and heat.

Work

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When work is done energy is transferred from one form into another.

Work

Work done = force x distance

$$W = F \times d$$

Work is measured in Joules

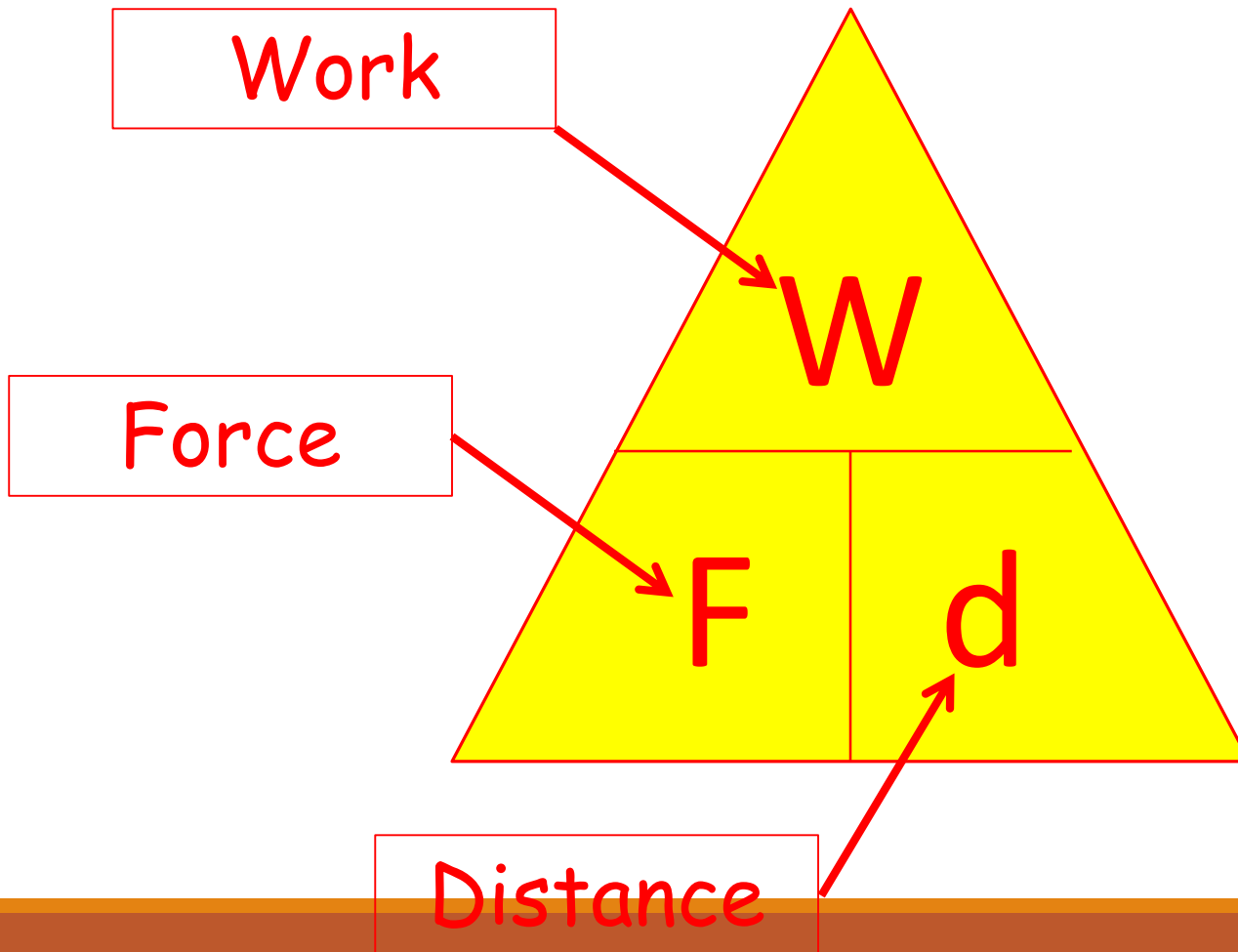
Work

Work done = force x distance

Eg. if a 4 N force moves a distance of 3m

$$W = 4 \times 3 = 12 \text{ J}$$

Work



Work

Work

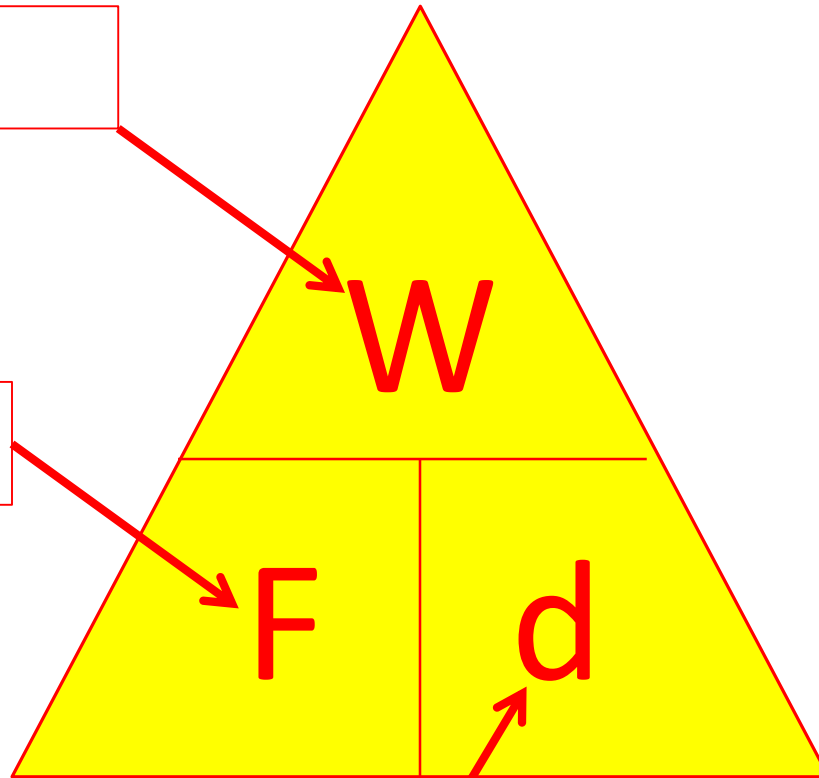
$$W = F \times d$$

Force

F

d

Distance



Work

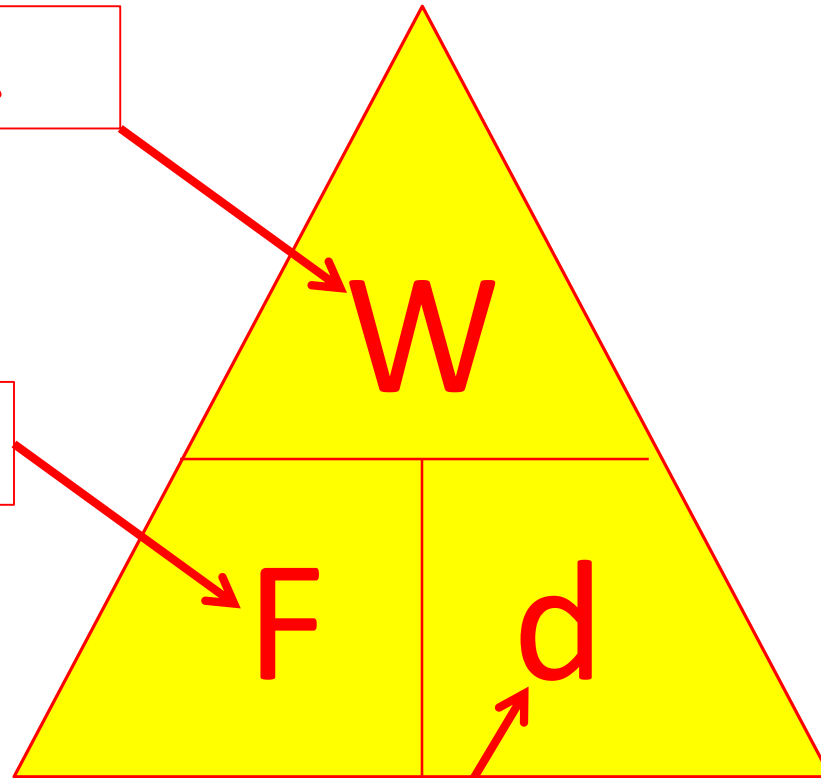
Work

$$W = F \times d$$

Force

$$F = \frac{W}{d}$$

Distance



Work

Work

$$W = F \times d$$

W

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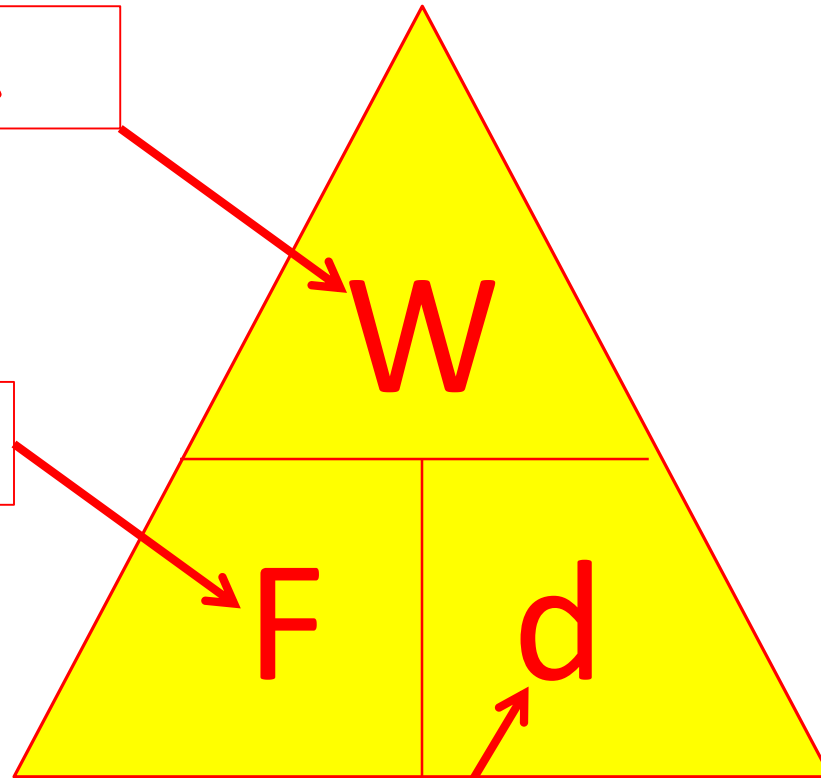
Force

F

$$d = \frac{W}{F}$$

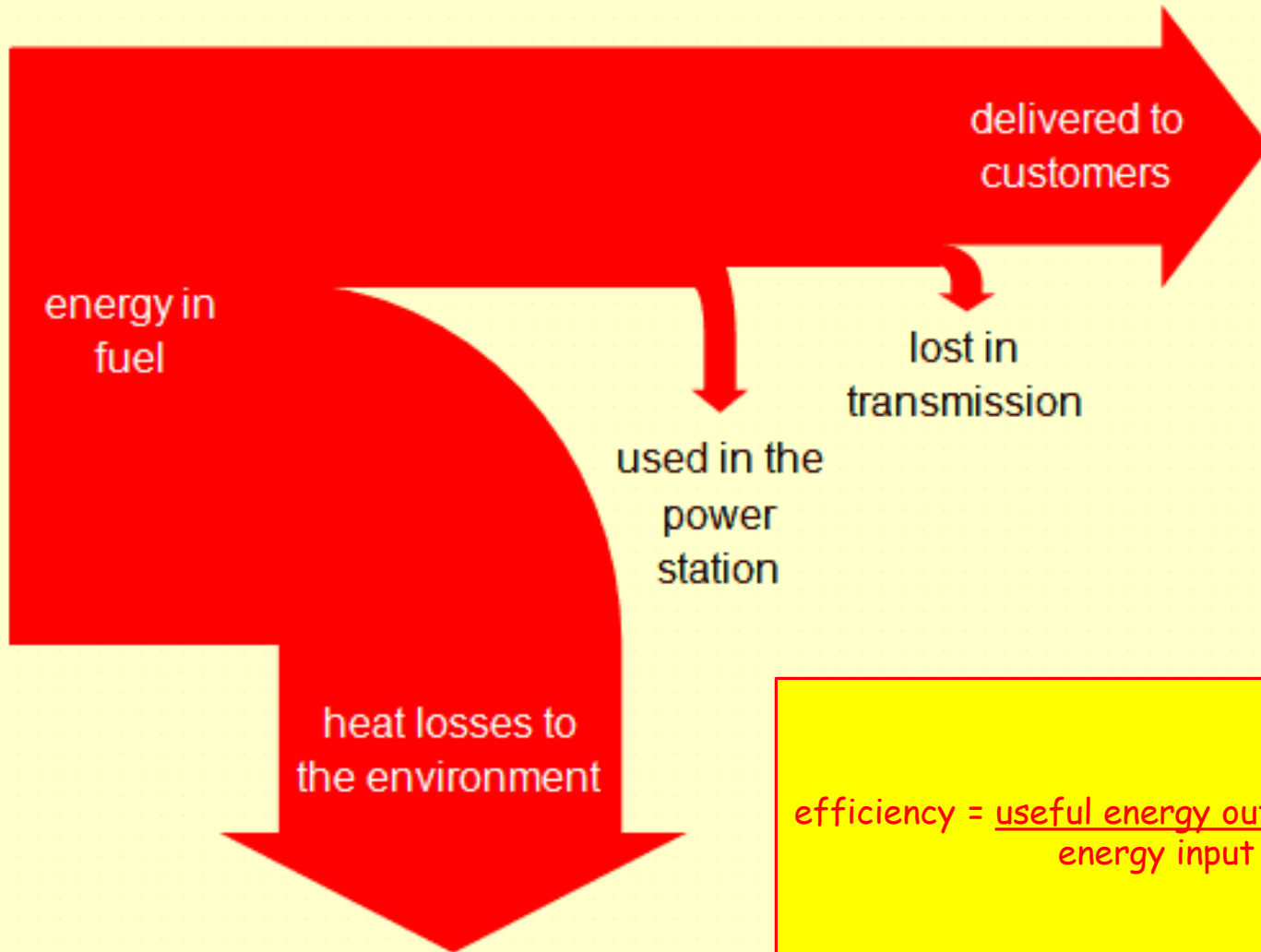
d

Distance



Power and Efficiency





Power and Efficiency



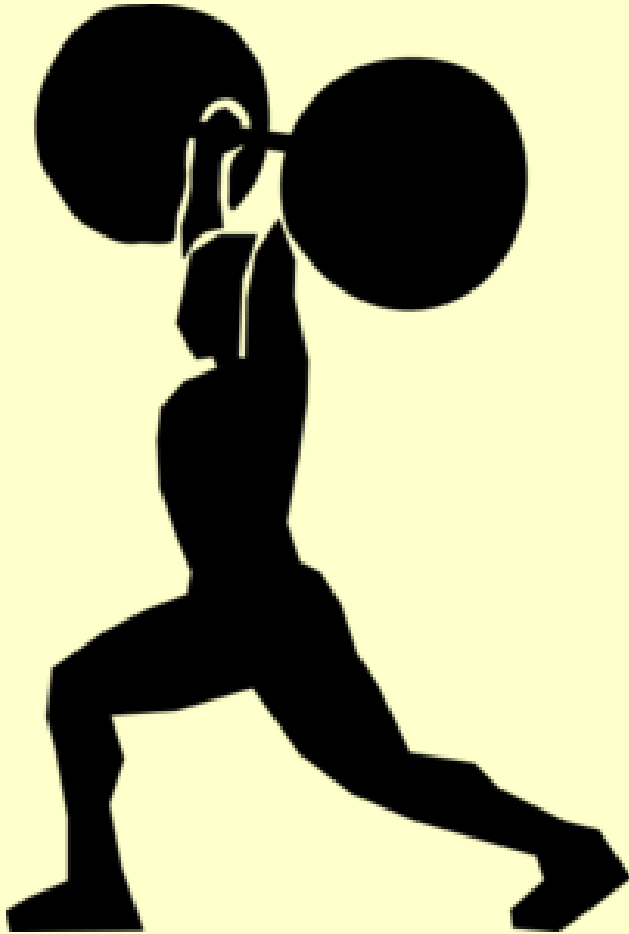
$$\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$$

Power and Efficiency

Examples

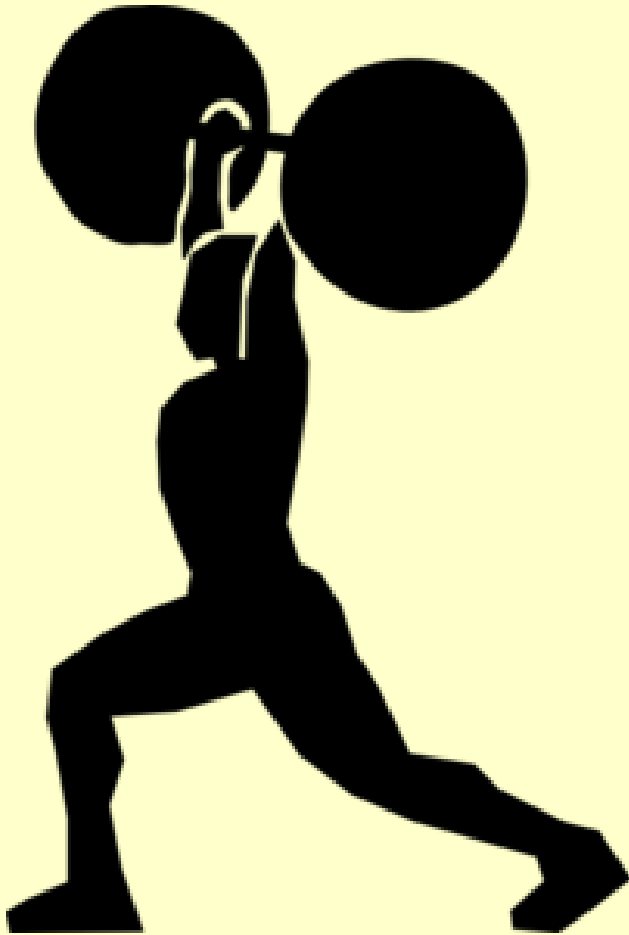
Total energy input (J)	Engine / motor	Useful work done (J)	Efficiency (%)
100	 Petrol engine	25	25
100	 Diesel engine	35	35
100	 Electric motor	80	80
100	 Human body	15	15

Power and Efficiency



Power is the rate at which work is done.

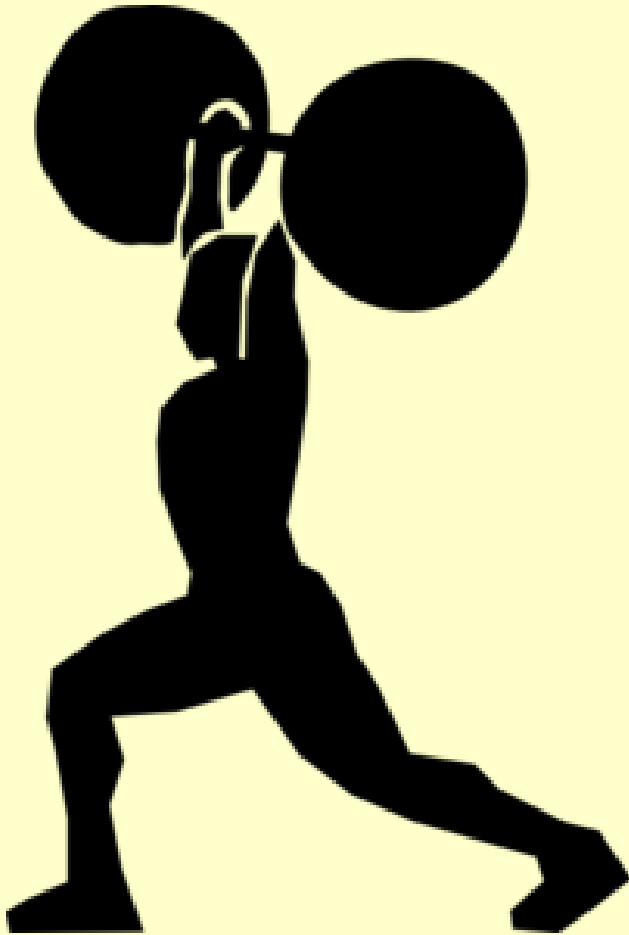
Power and Efficiency



Power is the rate at which work is done.

The unit of power is the watt (w).

Power and Efficiency

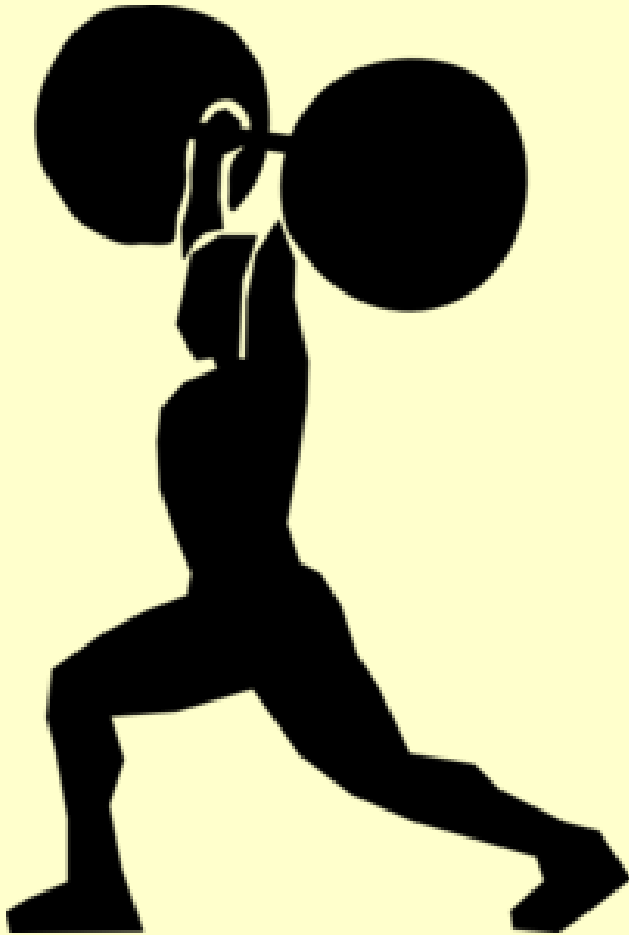


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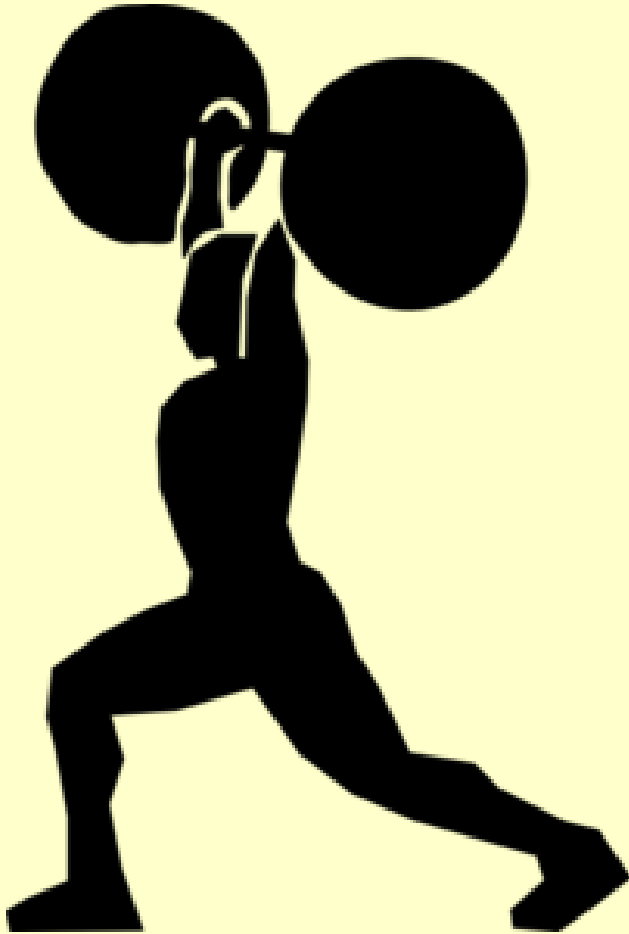
One watt is energy transferred at the rate of one joule per second.

Power and Efficiency



$$\text{power} = \frac{\text{work done}}{\text{time taken}}$$

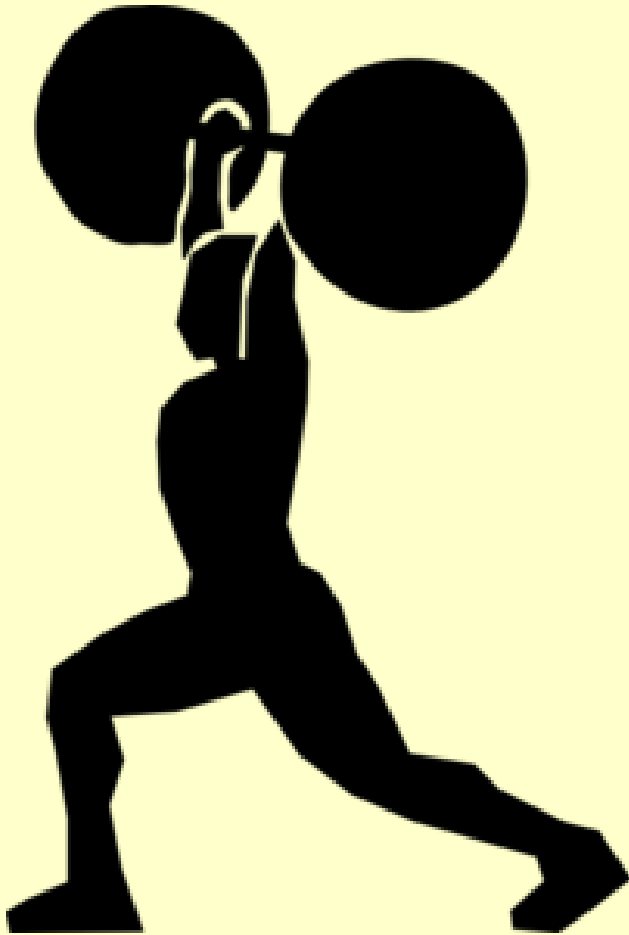
Power and Efficiency



$$\text{power} = \frac{\text{work done}}{\text{time taken}}$$

$$1000 \text{ W} = 1 \text{ kilowatt (kW)}$$

Power and Efficiency



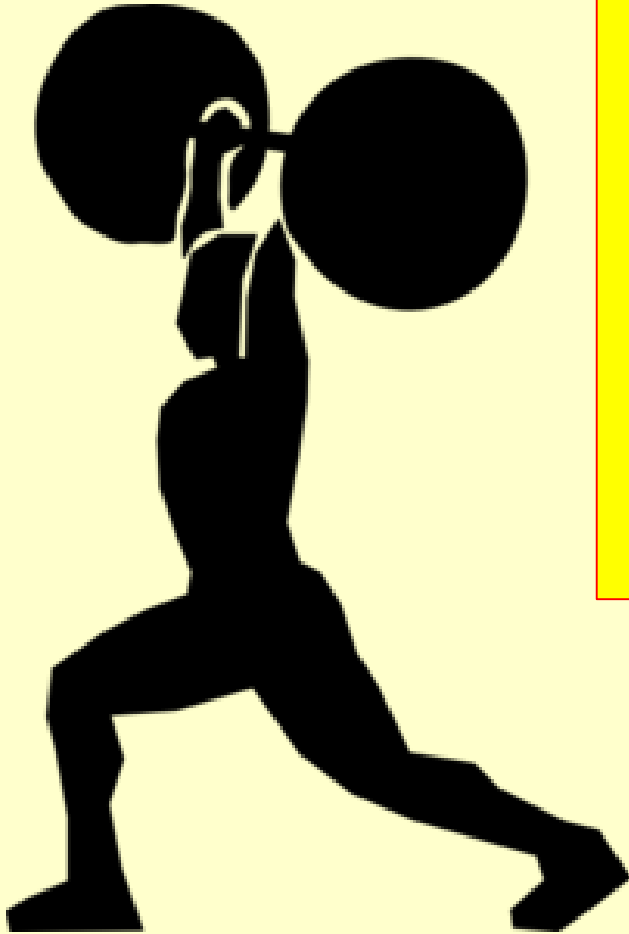
$$\text{power} = \frac{\text{work done}}{\text{time taken}}$$

1000 W = 1 kilowatt (kW)

Typical power outputs:

Washing machine motor	250 W
Athlete	400 W
Small car engine	35 000 W
Large car engine	150 000 W
Large jet engine	75 000 000 W

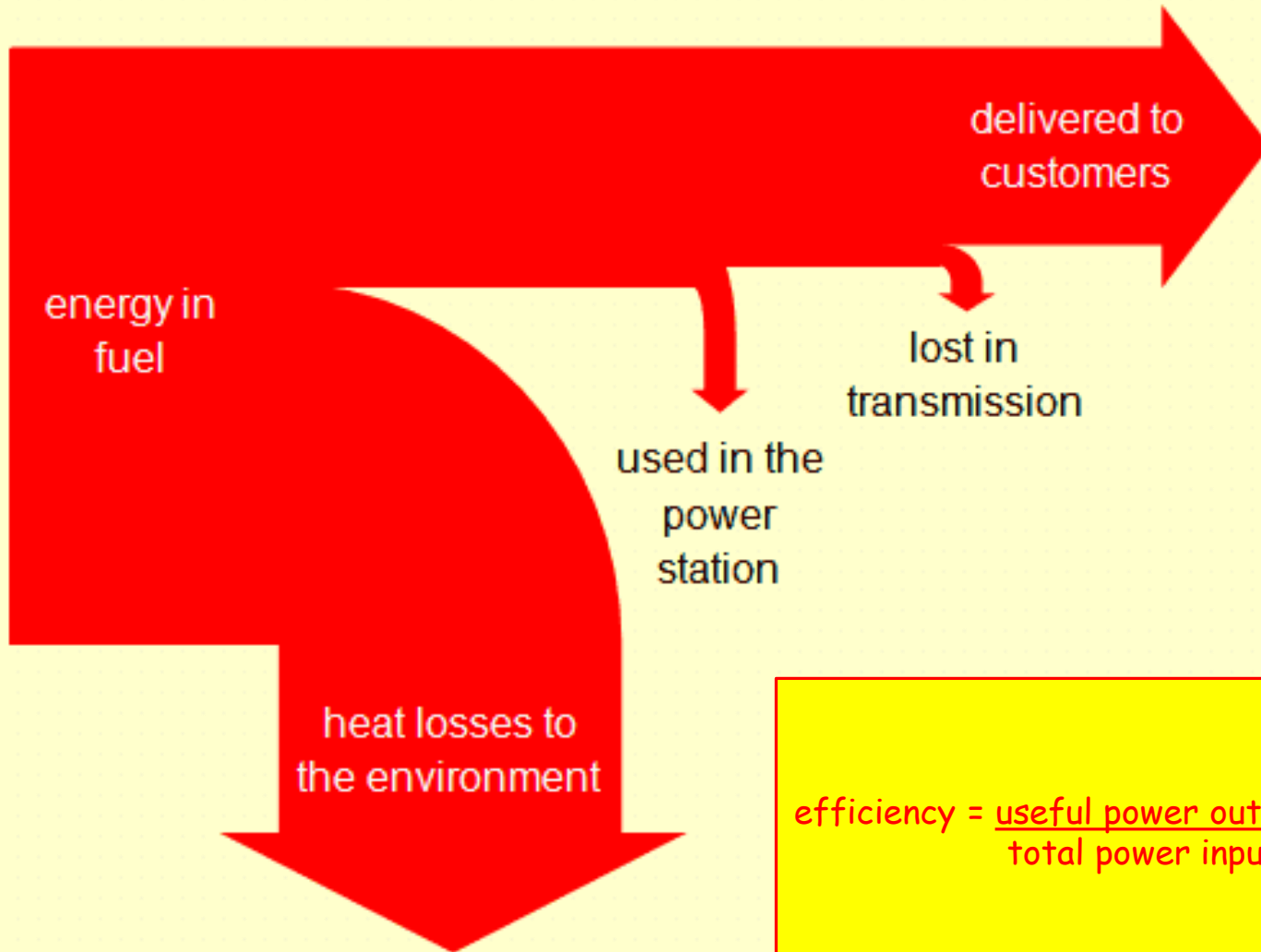
Power and Efficiency



power = energy transformed
time taken

$$\text{power} = \frac{\Delta E}{t}$$

Power and Efficiency



$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100\%$$

Power and Efficiency



Calculation examples

$$\text{power} = \frac{\text{work done}}{\text{time taken}}$$

The weightlifter in the picture is pressing the weight above his head 50cm each time.

a) The weightlifter spends 3 minutes doing 60 lifts of 45 kg. Work out his power output.

convert the time to seconds, = $3 \times 60 = 180\text{s}$

work done = force x distance = $60 \times 45 \times 10 \times 0.5 = 13\,500\text{ J}$

power = work done / time taken = $13\,500 / 180 = 75\text{ W}$

Power and Efficiency



Calculation examples

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The weightlifter in the picture is pressing the weight above his head 50cm each time.

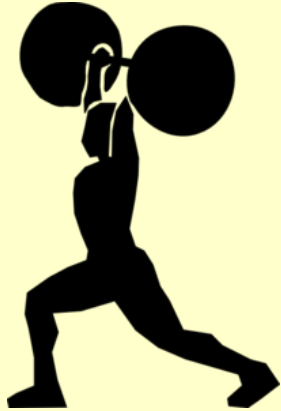
- b) Work out the weightlifter's total power output if he does 3 sets of 10 lifts with 70kg in 5 minutes.

convert the time to seconds, = $5 \times 60 = 300\text{s}$

work done = force x distance = $(3 \times 10) \times 70 \times 10 \times 0.5 = 10\,500\text{ J}$

power = work done / time taken = $10\,500 / 300 = 35\text{ W}$

Power and Efficiency



Calculation examples

$$\text{power} = \frac{\text{work done}}{\text{time taken}}$$

The weightlifter in the picture is pressing the weight above his head 50cm each time.

- c) Over the next 10 minutes, he does 50 lifts of 40kg, 3 sets of 10 lifts with 75kg and 2 sets of 15 lifts with 60 kg. Work out his total power output to the nearest whole number.

convert the time to seconds, = $10 \times 60 = 600\text{s}$

$$\text{total force} = (50 \times 40 \times 10) + (30 \times 75 \times 10) + (30 \times 60 \times 10)$$

$$= 20\,000 + 22\,500 + 18\,000 = 60\,500$$

$$\text{work done} = 60\,500 \times 0.5 = 30\,250$$

$$\text{power} = 30\,250 / 600 = 50\text{ W}$$

Power and Efficiency



Calculation examples

$$\text{power} = \frac{\text{work done}}{\text{time taken}}$$

The weightlifter in the picture is pressing the weight above his head 50cm each time.

- d) The weightlifter's maximum power output is 100 W. At maximum power, how many times can he lift 80kg in 4 minutes?

convert the time to seconds, = $4 \times 60 = 240\text{s}$

$$\text{power} = \text{work done} / \text{time taken} \quad 100 = (n \times 80 \times 10 \times 0.5) / 240$$

$$100 = (n \times 400) / 240$$

$$100 \times 240 = n \times 400$$

$$(100 \times 240) / 400 = n$$

$$n = 24\,000 / 400 = 60 \text{ reps}$$