Lesson content

C1 Thermal physics in domestic and industrial applications

1. Be able to use the following quantities and units - power, watt (W), kilowatt (kW), megawatt (MW), gigawatt (GW), convert °C to K, pressure (Pascals (Pa), Newton per metre squared (Nm^{-2})).
2. Know the following definitions:
   - work done as energy transferred
   - work done as force × distance moved in direction of force ($W = F \times \Delta x$)
3. Be able to calculate efficiency using the relationships - efficiency = useful energy output / total energy input o for heat engines

Understanding units

A base unit is a fundamental unit in a system of measurement that is based on an established standard and from which other units may be derived. For example, metre is a unit of distance and is the basis for measuring length.

Let's complete the table to show the symbols and means of the following units.

name	symbol	meaning	ratio to base unit
giga			
mega			
kilo			

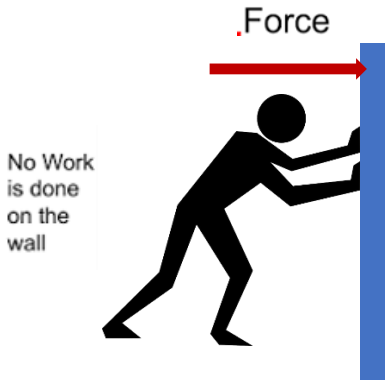
Practice questions

Power is measured in watt (W), kilowatt (kW), megawatt (MW), gigawatt (GW)

1. 5kW = _____W
2. 2.5MW = ___2500000_____W
3. 3.8kJ = ___3800_____J
4. 0.5kJ = _500_____J
5. 72GW = __72000000000_____W

1. Work

When a force causes a body to move, work is being done on the object by the force.



Can you give any other examples?

Work is the measure of energy transfer when a force (*F*) moves an object through a distance (*d*). So:

energy transferred = work done

Energy transferred and work done are both measured in joules (J). The equation used to calculate the work done is:

work done = force × distance

$$W = F \times d$$

Work done is measure in joules (J)

Force in measure in Newtons (N)

Distances is measured in metres (m)

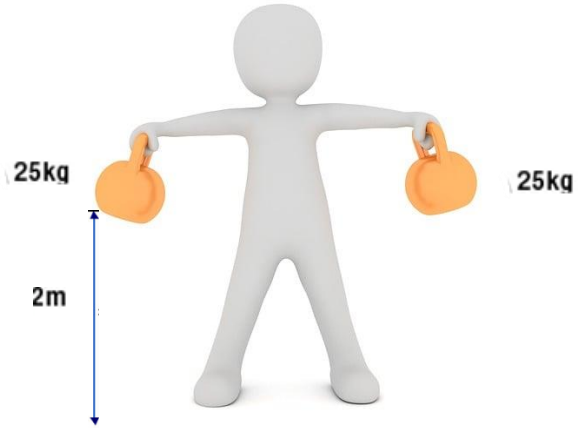
Example 1

A force of 10 N causes the box to move a horizontal distance of 2 m

Calculate the work done:

Example 2

A weight lifter lifts a total of 50kg over 2m. Calculate the work done.



Practice questions

Question 1

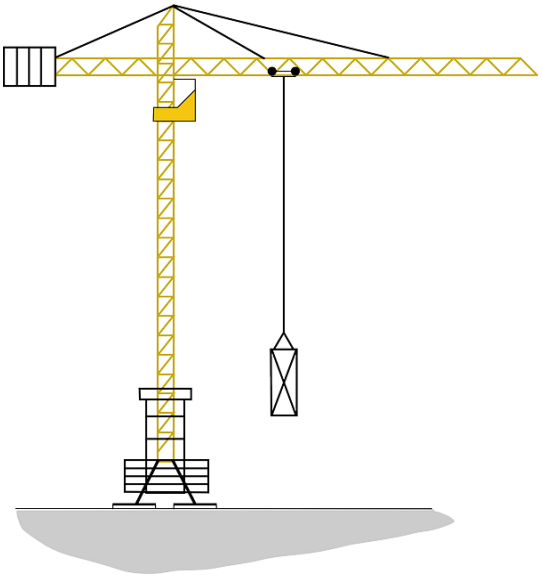
A horizontal force of 50 N causes a trolley to move a horizontal distance of 30 m. How much work is done on the trolley by the force?

Question 2

12,000 J of energy is supplied to move a small truck a distance of 80 m. What is the size of the force applied?

Exam practice

1. The following image shows a crane lift



(a) The motor for the crane has a power of 45kW. Give the value of 45kW in Watts

_____(W) (1)

(b) The crane lifts a weight through a height of 0.5 km. The weight is 12 500N. Calculate the work done lifting the weight.

Use the equation: $W = F\Delta x$

(3)

Show your working.

work output of the motor = ... J

2. Power

When work is done on an object, energy is transferred. The rate at which this energy is transferred is called power. So the more powerful a device is, the more energy it will transfer each second. The equation used to calculate power is:

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

Or

$$power = \frac{W}{t}$$

Draw an equation triangle to represent this equation. What are the units?

Practice questions

Example 1

Two electric motors are used to lift a 2 N weight through a vertical height of 10 m.

Motor one does this in 5 seconds. Motor two does this in 10 seconds. For the 2 motors, calculate which is more powerful?

Example 2

A hair dryer transfers 48,000 J of energy in one minute. What is the power rating of the hairdryer?

Example 3

If the work took 5 minutes, calculate the power required to do the work

More practice questions

1 How much power does it take to lift 30.0 N 10.0 m high in 5.00 s?

2 How much power does it take to lift 30.0 kg 10.0 m high in 5.00 s?

3 You move a 25 N object 5.0 meters. How much work did you do?

4 You carry a 20. N bag of dog food up a 6.0 m flight of stairs. How much work was done?

5 You push down on a 3.0 N box for 10. minutes. How much work was done?

6 You use 35 J of energy to move a 7.0 N object. How far did you move it?

7 You do 45 J of work in 3.0 seconds. How much power do you use?

8 A car uses 2,500 Joules in 25 seconds. Find power.

9 A 60. watt light bulb runs for 5.0 seconds. How much energy does it use?

3. Efficiency

The efficiency of a device refers to its ability to convert energy input into useful energy output. A highly efficient device minimizes energy wastage, whereas a poorly efficient device loses most of its input energy. Efficiency represents the fraction of supplied energy that is effectively utilized, and it can be expressed as either a decimal or a percentage, using the following equation:

$$efficiency = \frac{useful\ energy\ transferred}{total\ energy\ supplied}$$

You can also use

$$percentage\ efficiency = efficiency \times 100$$

Practice questions

Example 1

A transformer usefully transfers 190,000 W of the 200,000 W of energy supplied to it. How efficient is the transformer?

Example 2

How much work can a 22 kW car engine do in 60. s if it is 100% efficient?

Exam practice

5(a). Look at the information about different electric motors.

Electric motor	Energy input per hour (J)	Useful energy output per hour (J)	Energy 'wasted' per hour (J)
A	72 000	60 000	
B	54 000	36 000	
C	18 000		3 000
D		48 000	12 000
E	54 000	48 000	

Calculate the % efficiency of electric motor **E**.

Use the equation: Efficiency = Useful output energy transfer / Input energy transfer

Give your answer to **2** significant figures.

Answer = _____ % **[2]**

(b).

i. Calculate the energy input per hour in J for electric motor **D**.

Answer = _____ J **[2]**

ii. Which electric motor has the **lowest** 'wasted' energy in one hour?

_____ **[1]**

iii. Which electric motor has the **highest** 'wasted' energy in one hour?

_____ **[1]**

iv. Describe how energy is 'wasted' in an electric motor.

_____

_____ **[1]**

v. Suggest how this 'wasted' energy can be reduced in an electric motor.

_____

_____ **[1]**

7. A boiler has an input energy of 720 kJ from the gas it burns.

It transfers 540 kJ of useful energy to the home.

What is the efficiency of the boiler?

Use the equation: efficiency = useful output energy transfer ÷ total input energy transfer

A 0.12

B 0.75

C 0.90

D 1.33

Your answer ☐ **[1]**