5 Work, energy and power – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	**中文**	**Write it 3 times** (English)		
Energy	能量			
Work	功			
component	分量			
Kinetic energy	动能			
Gravitational potential energy	重力势能			
conservation of energy	能量守恒			
Power	功率			
Efficiency	效率			

Recall

At IGCSE you met energy and its types. Bring this with you:

- **Energy** 能量 is measured in joules (J) and can change from one form to another.
- Energy is never made or destroyed —the total always stays the same.
- You used kinetic energy and gravitational potential energy.

At AS we define work and power precisely, and use energy conservation to solve problems.

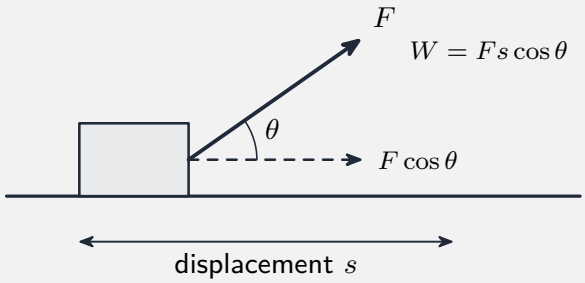
New ideas

■

Work 功 is energy transferred when a force moves something:

$$W = F \times (\text{distance moved in the force's direction}).$$

If the force acts at an angle θ to the motion, use the **component** 分量 along the motion: $W = Fs\cos\theta$. Work is measured in joules.



Worked example. A rope pulls a box 4.0 m with a force of 50 N at 30° above the ground:

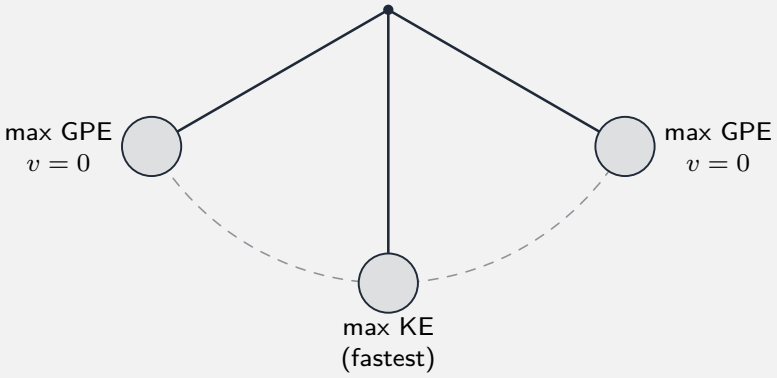
$$W = Fs\cos\theta = 50 \times 4.0 \times \cos 30^\circ = 173 \text{ J}.$$

Watch out: a force does *no* work if it acts at right angles to the motion ($\cos 90^\circ = 0$) —carrying a bag along a flat floor does no work against gravity.

■ 2 Kinetic and potential energy

Kinetic energy 动能 (energy of motion): $E_k = \frac{1}{2}mv^2$. **Gravitational potential energy** 重力势能 (energy of height): $E_p = mgh$.

By **conservation of energy** 能量守恒, the total stays constant —so as something falls, E_p turns into E_k.



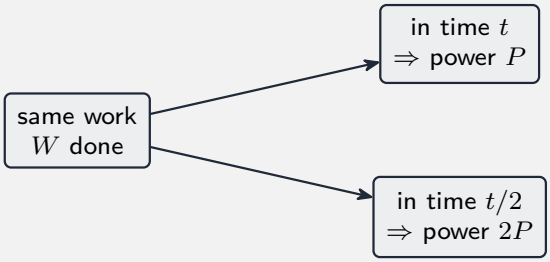
Worked example. A ball falls from rest through $h = 1.8$ m. All E_p becomes E_k:

$$mgh = \tfrac{1}{2}mv^2 \;\Rightarrow\; v = \sqrt{2gh} = \sqrt{2(9.8)(1.8)} = 5.9 \text{ m s}^{-1}.$$

(The mass cancels, so every object reaches the same speed.)

3 Power and efficiency

Power 功率 is work done per second: $P = \dfrac{W}{t}$, measured in watts (W).



$P = \dfrac{W}{t}$ — less time, more power

Efficiency 效率 is how much of the input energy is usefully transferred:

$$\text{efficiency} = \frac{\text{useful energy out}}{\text{total energy in}}.$$

Worked example. A motor lifts a 200 N load 3.0 m in 5.0 s: $W = 200 \times 3.0 = 600$ J, so $P = \dfrac{600}{5.0} = 120$ W.

Practice

5.1 A trolley is pushed 6.0 m by a steady 30 N force in the same direction. Find the work done. [2]

5.2 A rope pulls a sledge 10 m with 40 N at 60° to the ground. Find the work done. [2]

5.3 Find the kinetic energy of a 1200 kg car moving at 15 m s^{-1}. [2]

5.4 A stone falls from rest through 5.0 m. Using $\frac{1}{2}mv^2 = mgh$, find its speed ($g = 9.8$ m s^{-2}). [2]

5.5 A pump does 4500 J of work in 30 s. Find its power. [1]

5.6 A lamp takes in 60 J of electrical energy and gives out 9 J of light. Find its efficiency. [2]

5.7 Challenge. A car's kinetic energy is $\frac{1}{2}mv^2$. If its speed doubles, explain what happens to its braking distance (for the same braking force). [2]
