5 Work, energy and power – Part 2

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)		
velocity	速度			
power	功率			
drag	阻力			
compression	压缩			
elastic potential energy	弹性势能			
spring constant	劲度系数			

Recall

In **Part 1** you used work ($W = Fs\cos\theta$), kinetic and gravitational potential energy, conservation of energy, and power as energy per second ($P = W/t$). Part 2 adds a faster way to find power, efficiency in real machines, and using energy ideas to solve problems.

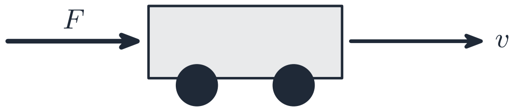
New ideas

■ 1 Power, force and velocity

For a force F that moves an object along at **velocity** 速度 v, the **power** 功率 is

$$P = Fv.$$

Worked example. A car drives at a steady 25 m s^{-1} against a total resistive force of 600 N. At constant speed the driving force equals the resistance, so $P = Fv = 600 \times 25 = 1.5 \times 10^4$ W $= 15$ kW. (At higher speed the **drag** 阻力 is larger, so more power is needed.)



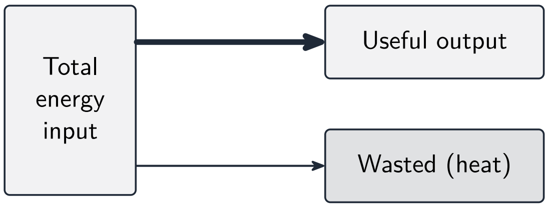
$P = Fv$

Watch out: $P = Fv$ uses the force *along* the motion. At a steady speed the driving force equals the total resistance, so use that value for F.

■ 2 Efficiency of a machine

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

It is always below 100% — some input energy is wasted, usually as heat.



$\text{efficiency} = \dfrac{\text{useful output}}{\text{total input}}$

Worked example. A motor lifts a 50 kg load at a steady 0.40 m s^{-1} using 250 W of electrical power. Useful output $= mgv = 50 \times 9.8 \times 0.40 = 196$ W, so efficiency $= \frac{196}{250} \times 100\% \approx 78\%$.

■ 3 Solving problems with energy

Energy is conserved: *start energy + work put in = end energy + energy lost.* A handy case — a moving block runs into a spring on a smooth surface; at greatest **compression** 压缩 x all its kinetic energy has become **elastic potential energy** 弹性势能 $\frac{1}{2}kx^2$ (where k is the **spring constant** 劲度系数).

Worked example. A block with 2.0 J of kinetic energy compresses a spring of $k = 100$ N m^{-1}. At greatest compression $\frac{1}{2}(100)x^2 = 2.0$, so $x^2 = 0.040$ and $x = 0.20$ m.

Practice

5.1 A locomotive pulls with a force of 800 N at a steady 15 m s^{-1}. Find its output power. [2]

5.2 A crane lifts a load of weight 200 N straight up at a steady 0.50 m s^{-1}. Find the useful power output. [2]

5.3 A device gives 150 W of useful power for 200 W of input power. Find its efficiency. [1]

5.4 A spring of spring constant 40 N m^{-1} is compressed by 0.30 m. Find the elastic potential energy stored. [2]

5.5 A block with 4.5 J of kinetic energy slides into a spring ($k = 100$ N m^{-1}) on a smooth surface. Find the greatest compression. [2]

5.6 Challenge. Explain *why* a car needs much more engine power to drive at 30 m s^{-1} than at 15 m s^{-1}, even on a flat road. [2]