

Exercise walk-through

3.5

Power

AP Physics 1

Power

Power is how **fast** energy is transferred:

Two forms

$$P = \frac{W}{\Delta t} \quad P = Fv$$

Measured in **watts** (joules per second).

Same work, more power = done **sooner**.

Worked example

Lift 50 kg up 10 m in 5 s:

$$W = mgh = 4900 \text{ J}$$

$$P = \frac{4900}{5} = 980 \text{ W}$$

In 2 s instead: 2450 W – same work, more power.

The general potential energy, and efficiency

near a surface

$U_g = mgh$ – valid only where g is roughly constant

in general

for two spherical masses a distance r apart, $U_g = -\frac{Gm_1 m_2}{r}$, taking zero at infinity

why negative

the system is **bound**: energy must be added to separate the masses

elastic potential energy

$U_s = \frac{1}{2}kx^2$, from natural length

total mechanical energy

$E = K + U$; conserved when only conservative forces act

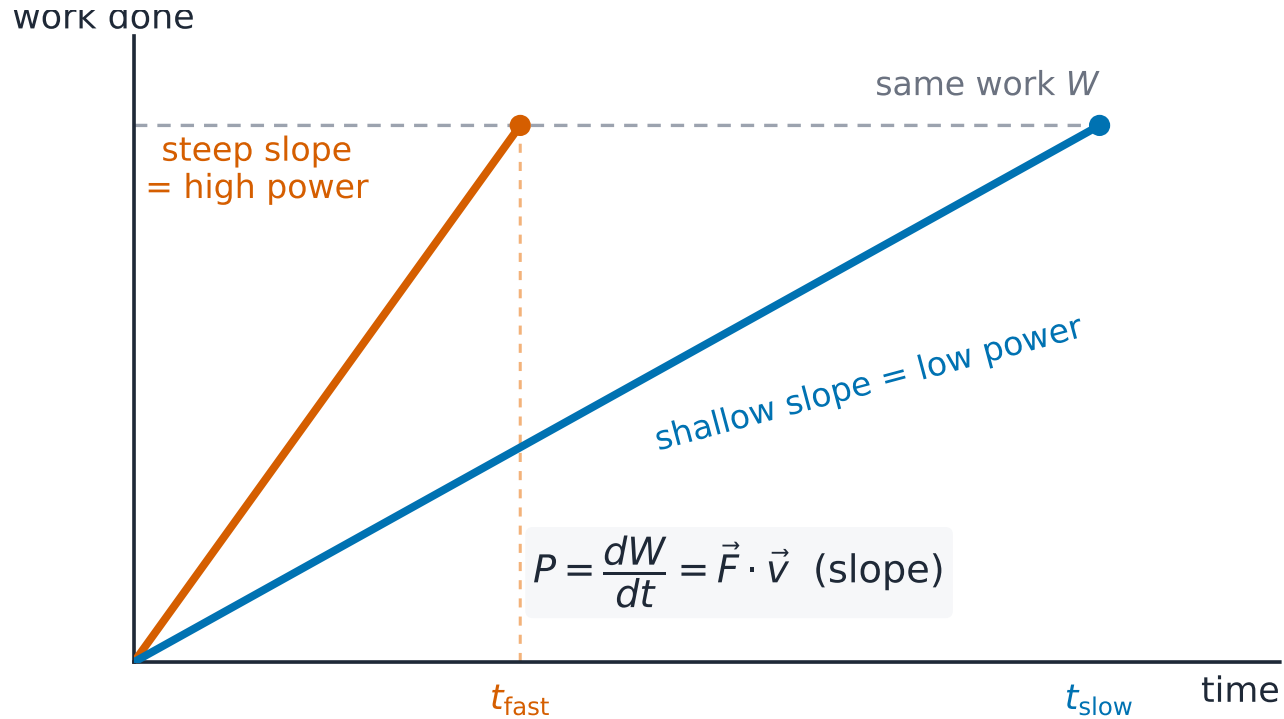
efficiency

useful output power divided by total input power – real machines always waste some

The **work–energy theorem**

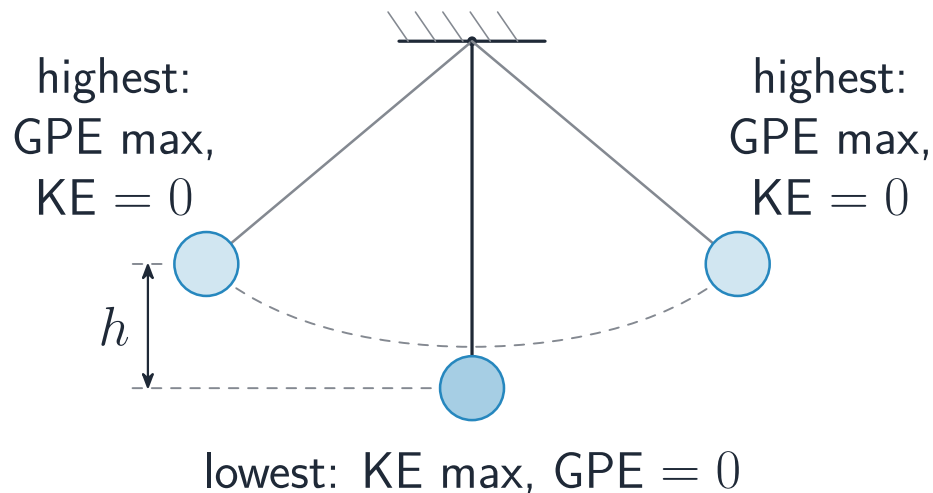
$W_{\text{net}} = \Delta K$ is the bridge between the two halves of this unit. Quote it when a question gives a force and asks for a speed.

Power is the slope of the work-time graph



Power is the slope of the work-time graph: the same work in less time means more power

Conservation of Energy, continued



A swinging pendulum trades gravitational potential energy for kinetic energy and back

Exam tips

- Use $W = Fd \cos \theta$: work is zero when the force is perpendicular to the motion, and negative when it opposes it.
- Reach for the **work–energy theorem** ($W_{\text{net}} = \Delta K$) or **energy conservation** ($K_1 + U_1 = K_2 + U_2$) instead of forces whenever the path is complicated.
- When friction acts, mechanical energy is **not** conserved – subtract the energy lost to heat.
- Remember $K \propto v^2$: doubling the speed **quadruples** the kinetic energy (and the stopping distance).
- Use $P = Fv$ for power at a steady speed; at constant velocity the net force is zero but the power is **not**.

Exercises 2.1-2.3

2.1 A crane does 9000 J of work in 6.0 s. Find its power. [1]

2.2 A car engine pushes with 800 N at a steady 20 m s^{-1} . Find the power delivered. [2]

2.3 A 60 W device runs for 120 s. Find the energy it uses. [1]

Exercises 2.1·2.3

2.1 A crane does 9000 J of work in 6.0 s. Find its power. [1]

2.1

- $P = \frac{W}{\Delta t} = \frac{9000}{6.0} = 1500 \text{ W}$

2.2 A car engine pushes with 800 N at a steady 20 m s⁻¹. Find the power delivered. [2]

2.2

- $P = Fv = 800 \times 20 = 16\,000 \text{ W}$

2.3 A 60 W device runs for 120 s. Find the energy it uses. [1]

2.3

- $W = P \Delta t = 60 \times 120 = 7200 \text{ J}$

Exercises 3.1-3.2

3.1 One watt is equal to

[1]

☐

A 1 J

B 1 J s⁻¹

C 1 N

D 1 J s

3.2 A motor lifts a 200 N weight at a constant 0.50 m s⁻¹. Its power output is

[1]

☐

A 100 W

B 200 W

C 400 W

D zero

Exercises 3.1-3.2

3.1 One watt is equal to

[1]

☐

A 1 J

B 1 J s⁻¹

C 1 N

D 1 J s

3.1 B

- 1 J s⁻¹.

3.2 A motor lifts a 200 N weight at a constant 0.50 m s⁻¹. Its power output is

[1]

☐

A 100 W

B 200 W

C 400 W

D zero

3.2 A

- $P = Fv = 200 \times 0.50 = 100 \text{ W}$

Exercise 3.3 (a)

3.3 A 500 kg lift rises 20 m at constant speed in 10 s (take $g = 10 \text{ m s}^{-2}$).

(a) Find the work done against gravity.

[2]

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(a) Find the work done against gravity.

[2]

(a)

- $W = mgh = 500 \times 10 \times 20 = 1.0 \times 10^5 \text{ J}$

Exercise 3.3 (b)

3.3 A 500 kg lift rises 20 m at constant speed in 10 s (take $g = 10 \text{ m s}^{-2}$).

(b) Find the power output of the motor.

[1]

Exercise 3.3 (b)

3.3 A 500 kg lift rises 20 m at constant speed in 10 s (take $g = 10 \text{ m s}^{-2}$).

(b) Find the power output of the motor.

[1]

(b)

- $$P = \frac{1.0 \times 10^5}{10} = 1.0 \times 10^4 \text{ W}$$