Energy

OxfordAQA International GCSE Physics 9203, topic 3.2: work, energy stores, power, efficiency, resources

The accountant of physics

> Energy is never destroyed: it moves between stores, and some is dissipated.

- OxfordAQA International GCSE Physics 9203, topic 3.2.
- **Work**, power, three store equations, efficiency, resources.

Work done

$W = F \times d$: force times distance moved along the force.

- **Work** transfers energy: 1 J = 1 N m.
- Work against friction heats: brakes, re-entry, meteorites.

Three energy stores

Store	Equation	Example
elastic	$E_e = \frac{1}{2}ke^2$	a stretched spring
gravitational	$E_p = mgh$	a raised mass
kinetic	$E_k = \frac{1}{2}mv^2$	a moving car

Double the speed, four times the energy

E_k $= \frac{1}{2}mv^2$: the speed is squared.

- Doubling mass doubles kinetic energy.
- Doubling speed quadruples it: the road-safety link.

Worked: the catapult

1. **Elastic store** $E_e = \frac{1}{2} \times 100 \times 0.20^2 = 2.0$ J
2. **All to the stone** $\frac{1}{2} \times 0.050 \times v^2 = 2.0$, so $v^2 = 80$
3. **Speed** $v = \sqrt{80} = 8.9$ m/s

Decision

The 0.050 kg stone leaves at 8.9 m/s.

A falling ball

From 5.0 m: $v = \sqrt{(2 \times 10 \times 5.0)} = 10$ m/s, whatever the mass.

- $mgh = \frac{1}{2}mv^2$, so $v = \sqrt{(2gh)}$.
- The mass cancels; air resistance is ignored.

Worked: the crane's power

1. **Energy** $E = mgh = 500 \times 10 \times 12 = 60\,000$ J
2. **Time** $t = 20$ s
3. **Power** $P = 60\,000 \div 20 = 3000$ W

Decision

3.0 kW.

(P) The pendulum

All GPE at the top, all KE at the bottom.

- Energy swaps between the GPE and KE stores.
- Air resistance slowly dissipates it: the swings shrink.

Efficiency

A 60 W lamp giving 6 W of light: $6/60 \times 100 = 10\%$.

- Efficiency = useful energy out $\div$ total energy in $\times$ 100%.
- The same with powers. Never above 100%.

A Sankey diagram to scale

800 W in: 600 W useful (75%), 200 W wasted.

- Arrow width is proportional to energy.
- The outputs add up to the input.

Choosing fuels and resources

> A country trades renewability against cost and reliability.

- Fuels: ease of storage, energy content, safety.
- Cost of extraction, use and disposal counts too.

Four renewables

Resource	Advantage	Drawback
wind	no fuel, no emissions	unreliable; visual impact
solar	no fuel; small or large	only in daylight
hydroelectric	reliable, starts fast	floods a valley
tidal	predictable	few sites; harms habitats

Common mistakes

Mistake	**Fix**
forgetting the square in $\frac{1}{2}mv^2$	square v first, then multiply
mass as the force in $W = Fd$	the force is the weight, mg
efficiency above 100%	useful out $\leq$ total in
spring length, in cm	extension, in metres

Check yourself

Question	**Answer**
50 N moves 4 m: **work** done?	200 J
$k = 200$ N/m, $e = 0.15$ m: elastic energy?	2.25 J
800 J in 20 s: power?	40 W
12 J of light per 100 J in: efficiency?	12%