

Energy stores, Sankey diagrams and efficiency

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

Each answer gives the equation, the substitution and the result with its unit in bold. Use them to check your method as well as your numbers. Where g is needed, the value 9.8 N/kg is used, and efficiency is shown as a percentage.

Level: Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** GCSE P1, HS-PS3-4

Problem 1 Name the store

1. **Elastic potential.**
2. **Thermal.**
3. **Chemical.**
4. **Gravitational potential.**
5. **Kinetic.**

Problem 2 Hydroelectric chain

1. Gravitational potential (lake) → kinetic (falling water) → kinetic (turbine) → electrical (lamps).
2. Thermal energy (from friction and electrical resistance) and sound are **wasted** in the pipes, turbine and generator.

Problem 3 Fan motor

1. $400 - 300 = \mathbf{100 \text{ J}}$.
2. $300 \div 400 \times 100 = \mathbf{75 \%}$.

Problem 4 Laptop charger

1. $60 - 9 = \mathbf{51 \text{ J}}$.
2. $51 \div 60 = 0.85$, so **85 %**.

Problem 5 Percentages and decimals

1. **40 %**.
2. **0.85**.
3. It would mean more energy comes out than goes in, which breaks the conservation of energy. Some input is always wasted.

Problem 6 Pendulum swing

1. The energy is proportional to height: $7.0 \div 8.0 = \mathbf{0.875}$ (87.5 %).
2. **12.5 %** goes to the thermal store of the air and string (friction at the pivot and air resistance), plus a little sound.

Problem 7 Workshop machine

1. $500 - 350 - 100 = \mathbf{50 \text{ J}}$.
2. $350 \div 500 \times 100 = \mathbf{70 \%}$.
3. The sound arrow carries 50 J and the thermal arrow 100 J, so it is **half as wide**.

Problem 8 Gas boiler

1. $0.85 \times 40 = \mathbf{34 \text{ MJ}}$.
2. $40 - 34 = \mathbf{6 \text{ MJ}}$.

Problem 9 Finding the input

1. Input = useful output $\div$ efficiency.
2. $1800 \div 0.60 = \mathbf{3000 \text{ J}}$.

Problem 10 Which charger is better?

1. A: $9.6 \div 12.0 = \mathbf{80 \%}$. B: $12.3 \div 15.0 = \mathbf{82 \%}$.
2. A: $12.0 - 9.6 = \mathbf{2.4 \text{ J}}$. B: $15.0 - 12.3 = \mathbf{2.7 \text{ J}}$.
3. **B** is more efficient, even though it wastes slightly more energy in total, because it takes in more energy. Efficiency compares the useful part with the input.

Problem 11 Scooter motor power

1. $480 \div 600 \times 100 = \mathbf{80 \%}$.
2. $600 - 480 = \mathbf{120 \text{ W}}$.
3. $E = P t = 120 \times 900 = \mathbf{108\,000 \text{ J}}$ (108 kJ).

Problem 12 Lift motor

1. $GPE = m g h = 600 \times 9.8 \times 20 = \mathbf{117\,600 \text{ J}}$.
2. $117\,600 \div 168\,000 = 0.70$, so **70 %**.

Problem 13 Comparing converters

1. Wasted = 75 % of 1000 = **750 J**.
2. Input = $500 \div 0.35 = \mathbf{1430 \text{ J}}$ (1428.6 J).
3. The **hydroelectric station**, at 90 %.

Problem 14 Insulating a room

1. $1500 \times 0.60 = \mathbf{900\ W}$.
2. $E = 1500 \times 3600 = \mathbf{5\ 400\ 000\ J}$ (5.4 MJ).
3. After: $900 \times 3600 = 3\ 240\ 000\ J$; saving = $\mathbf{2\ 160\ 000\ J}$ (2.16 MJ).

Problem 15 Chain oil

1. Oil reduces friction between the links, so less of the input energy is transferred to the thermal store and sound, and more goes to the kinetic energy of the bicycle.
2. Before: more thermal energy in the chain and air. After: **less thermal energy and sound** in the surroundings; the energy is still conserved.

Problem 16 Two-stage power station

1. $0.90 \times 2.0 = \mathbf{1.8\ MJ}$.
2. $0.95 \times 1.8 = \mathbf{1.71\ MJ}$.
3. $0.90 \times 0.95 = \mathbf{85.5\ \%}$ ($1.71 \div 2.0$).
4. $0.94 \times 1.71 = 1.6074$, so $\mathbf{1.61\ MJ}$; overall = $1.6074 \div 2.0 = \mathbf{80.4\ \%}$.

Problem 17 Diesel generator

1. $5000 - 1500 - 3000 = \mathbf{500\ kJ}$.
2. $1500 \div 5000 \times 100 = \mathbf{30\ \%}$.
3. $t = E \div P = 1\ 500\ 000 \div 5000 = \mathbf{300\ s}$.
4. Any two: lubricate moving parts, use the hot exhaust to heat water (recover thermal energy), insulate the engine, service the engine regularly, fit a more efficient engine.

Problem 18 Replacing a bulb

1. 5 % of 60 = $\mathbf{3.0\ W}$.
2. Input = $3.0 \div 0.30 = \mathbf{10\ W}$.
3. Time = 150 h. Saving = $(60 - 10)\ W \times 150\ h = 7500\ Wh = \mathbf{7.5\ kWh}$.
4. $7.5 \times 3.6 = \mathbf{27\ MJ}$.

Problem 19 Spot the errors

1. Impossible: output cannot exceed input. Either 120 J is wrong or the input is larger. **Efficiency is at most 100 %.**
2. Energy is not used up. It is transferred to the thermal store of the water and surroundings: **energy is conserved.**
3. In a heater the useful output is thermal energy, so almost all the input becomes useful. A very high efficiency (**nearly 100 %**) is good, not terrible.

Problem 20 Motor and load data

1. $GPE = m \times 9.8 \times 0.80$: **1.568 J, 3.136 J, 4.704 J, 6.272 J**.
2. $1.568 \div 5.2 = \mathbf{30\%}$; $3.136 \div 8.9 = \mathbf{35\%}$; $4.704 \div 12.4 = \mathbf{38\%}$; $6.272 \div 15.7 = \mathbf{40\%}$.
3. Efficiency **increases with load**. The motor wastes a roughly fixed amount of energy on friction and warming the coils, so a larger useful output makes up a bigger share of the input.