1. a) Electrical energy is converted into radiant energy (light) and internal energy

   b) Input (E): Electrical energy, output (E_{useful}): radiant energy, «waste»: internal energy

   c) $P_{extracted}$ = 3.0 W

   d) $\eta = \frac{P_{extracted}}{P_{supplied}} = \frac{3.0\text{ W}}{10.0\text{ W}} = 0.30 = \underline{\underline{30\ \%}}$

   e) $\eta = \frac{P_{extracted}}{P_{supplied}} = \frac{3.0\text{ W}}{60.0\text{ W}} = 0.050 = \underline{\underline{5.0\ \%}}$

2. a) $E = \frac{E_{useful}}{\eta} = \frac{460.0\text{ kJ}}{0.700} = \underline{\underline{657\text{ kJ}}}$

   b) $P_{extracted} = P_{supplied} \cdot \eta = 50.0\text{ kW} \cdot 0.700 = \underline{\underline{35.0\text{ kW}}}$

3. a) Electrical energy is converted into gravitational potential energy and internal energy

   b) Input (E): Electrical energy, output (E_{useful}): gravitational potential energy, «waste»: internal energy

   c) $W = m \cdot g \cdot h = 400.0\text{ kg} \cdot 9.81\ \frac{\text{m}}{\text{s}^2} \cdot 15.0\text{ m} = \underline{\underline{58'860\text{ J}}} = \underline{\underline{58.9\text{ kJ}}}$

   d) $E_{useful} = W = \underline{\underline{58.9\text{ kJ}}}$

   e) $E = \frac{E_{useful}}{\eta} = \frac{58'860\text{ J}}{0.75} = 78'480\text{ J} = \underline{\underline{78\text{ kJ}}}$

4. a) Gravitational potential energy is converted into kinetic energy (and internal energy) which is then converted into electric energy (and more internal energy).

   b) Input (E): Gravitational potential energy, output (E_{useful}): electrical energy, «waste»: internal energy

   c) $P_{supplied} = \frac{P_{extractedl}}{\eta} = \frac{13.00\text{ MW}}{0.9000} = \underline{\underline{14.44\text{ MW}}}$

   d) $E(\text{input}) = P_{supplied} \cdot t = 14.44\text{ MW} \cdot 1.000\text{ s} = \underline{\underline{14.44\text{ MJ}}}$

   $E_p = E\ (\text{input}) = 14.44\text{ MJ}$ $\qquad m = \frac{E_p}{g \cdot h} = \frac{14'444'444\text{ J}}{9.81\ \frac{\text{m}}{\text{s}^2} \cdot 200.0\text{ m}} = \underline{\underline{7'362\text{ kg}}}$

5. a) $P = \frac{W}{t} = \frac{m \cdot g \cdot h}{t} = \frac{60.0\text{ kg} \cdot 9.81\,\frac{\text{m}}{\text{s}^2} \cdot 400.0\text{ m}}{3'600\text{ s}} = \underline{\underline{65.4\text{ W}}}$

b) $W = m \cdot g \cdot h = 160.0\text{ kg} \cdot 9.81\,\frac{\text{m}}{\text{s}^2} \cdot 400.0\text{ m} = = \underline{\underline{627'840\text{ J}}} = \underline{\underline{628\text{ kJ}}}$

c) $E_{\text{useful}} = W = \underline{\underline{628\text{ kJ}}}$

d) $P_{\text{extracted}} = \frac{W}{t} = \frac{m \cdot g \cdot h}{t} = \frac{160.0\text{ kg} \cdot 9.81\,\frac{\text{m}}{\text{s}^2} \cdot 400.0\text{ m}}{300\text{ s}} = 2092.8\text{ W} = \underline{\underline{2.09\text{ kW}}}$

e) $E = \frac{E_{\text{useful}}}{\eta} = \frac{627'840\text{ J}}{0.720} = 872'000\text{ J} = \underline{\underline{872\text{ kJ}}}$

f) $E = \frac{E_{\text{useful}}}{\eta} = \frac{W}{\eta} = \frac{m \cdot g \cdot h}{t} = \frac{60.0\text{ kg} \cdot 9.81\,\frac{\text{m}}{\text{s}^2} \cdot 400.0\text{ m}}{0.35} = 672'685.7\text{ J} = = 673\text{ kJ}$

$\frac{673\text{ kJ}}{21.8\,\frac{\text{kJ}}{\text{g}}} = \underline{\underline{30.9\text{ g}}}$

6. a) $E_{\text{useful(electrical)}} = E_{\text{input(sun)}} \cdot \eta_1 = 4'900'000\text{ J} \cdot 0.15 = 735'000\text{ J} = \underline{\underline{7.4 \cdot 10^5\text{ J}}}$
$= \underline{\underline{0.74\text{ MJ}}}$ (electrical energy)

b) $E_{\text{useful(light)}} = E_{\text{input(electrical)}} \cdot \eta_2 = 735'000 \cdot 0.300 = 220'500\text{ J} = \underline{\underline{2.2 \cdot 10^5\text{ J}}}$
$= \underline{\underline{0.22\text{ MJ}}}$ (light/radiant energy)

c) $\eta_{\text{total}} = \frac{E_{\text{useful(light)}}}{E_{\text{input(sun)}}} = \frac{220'500\text{ J}}{735'000\text{ J}} = 0.045 = \underline{\underline{4.5\ \%}}$ or
$\eta_{\text{total}} = \eta_1 \cdot \eta_2 = 0.15 \cdot 0.300 = 0.045 = \underline{\underline{4.5\ \%}}$

7. a) Chemical energy is transformed into internal energy (overcoming friction and air resistance) and more internal energy (warming the engine, exhaust etc.)

b) Input (E): Chemical energy, output (E_{useful}): internal energy overcoming friction and air resistance, «waste»: internal energy warming the engine, exhaust, etc

c) $F_{\text{f(rolling resistance)}} = C_{\text{rr}} \cdot F_{\text{n}} = C_{\text{rr}} \cdot m \cdot g = 0.022 \cdot 1'200\text{ kg} \cdot 9.81\,\frac{\text{m}}{\text{s}^2} = 258.984\text{ N} = 259\text{ N}$
$F = F_{\text{air-resistance}} + F_{\text{f(rolling resistance)}} = 516\text{ N} + 259\text{ N} = 775\text{ N} = 7.8 \cdot 10^2\text{ N} = \underline{\underline{0.78\text{ kN}}}$

d) $W = F \cdot s = 775\text{ N} \cdot 21'000\text{ m} = 16'275'000\text{ J} = \underline{\underline{16\text{ MJ}}}$

e) $\underline{\underline{16\text{ MJ}}}$ (E_{useful} is the work done by the engine overcoming friction)

f) For 16 MJ of useful energy the engine consumes 1.52 liters of fuel, that is 16 MJ per 1.52 ℓ.
The useful energy per liter is: $E_{\text{useful}(1\ \ell)} = \frac{16.275\text{ MJ}}{1.52} = 10.707\text{ MJ} = \underline{\underline{11\text{ MJ}}}$

g) E (input) = $\underline{\underline{35\text{ MJ}}}$ (see problem)

h) $\eta = \frac{E_{\text{useful}(1\ \ell)}}{E_{\text{input}}} = \frac{10.707\text{ MJ}}{35.0\text{ MJ}} = 0.306 = \underline{\underline{31\ \%}}$