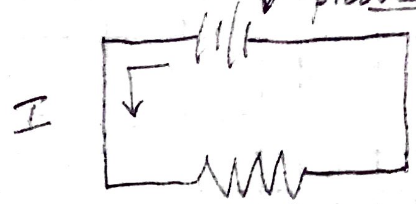
9.55

$\Delta V = 20.0 \text{ Volts}$
$R = 10{,}000\,\Omega$

V produces Power, delivers Energy



R dissipates Power, uses Energy

a) $I = \frac{V}{R} = \frac{20\text{ V}}{10000\,\Omega} = 0.00200\text{A}$
$= 2.00e^{-3}\text{A}$
$= 2.00 \text{ mA}$

b) Power dissipated by resistor $= I^2 R$
$= (2e{-3})^2 (10000)$
$= \boxed{0.040\text{ W}}$

c) Power delivered $= IV$
$= (0.002)(20\text{ V}) = \boxed{0.040\text{ W}}$

Coincidence?
No!

d) Energy dissipated by the resistor is converted to thermal energy: heating the air, heating water (if it's a convection coil, perhaps), causing a wire to emit visible radiation, etc.

9.56

V_{max} for a $10\,k\Omega$ resistor rated at $1/4\,W$ = ?

$R = 10{,}000\,\Omega$
$P = 0.25\,W$
$V = ?$

$$P = IV = I^2R = \frac{V^2}{R}$$

$$P = \frac{V^2}{R} \rightarrow V = \sqrt{P \cdot R}$$
$$= \sqrt{(0.25)(10000)}$$
$$= \boxed{50\,V}$$

More voltage than this will be more Power than the resistor can dissipate. It will fail/melt/burn.

9.58

Power of LED bulb = 16 Watts
Cost of energy = \$0.10 per kiloWatt-hour.
How much to run the bulb for 4 hours a day, for one year?

The SI-unit of energy is the Joule, where

Energy (Work) = Power · time
or Joules = Watts · seconds

& Another unit of energy is:

$$\begin{aligned} \text{kiloWatt-hour} &= \text{Power} \cdot \text{time} \\ &= \text{kilowatt} \cdot \text{hour} \\ &= 1000\,\text{Watts} \cdot 3600\,\text{s} \\ 1\ \text{kW} \cdot \text{hr} &= \underline{3.6e6\ \text{J}} \end{aligned}$$

Solve this problem as a unit-dimensional analysis problem:

$$P \cdot t = (16\ \cancel{\text{Watts}})\left(\frac{4\ \cancel{\text{hrs}}}{\cancel{\text{day}}}\right)\left(\frac{365\ \cancel{\text{days}}}{\text{yr}}\right)\left(\frac{1\ \cancel{\text{kW}}}{1000\ \cancel{\text{W}}}\right)\left(\frac{\$0.10}{\cancel{\text{kW}}\ \cancel{\text{hr}}}\right) =$$

$$\frac{16 \cdot 4 \cdot 365 \cdot 0.10}{1000} = \boxed{2.34\ \$/\text{yr}}$$

9.60

The car's 12-Volt battery is "rated at 100 Amp·hours". What kind of measurement is an Amp·hour?

Current I time t

Current & time are related to charge: $I = \frac{Q}{t}$, so $Q = I \cdot t$. That's how much charge can be delivered by the battery, but we can solve ~~this~~ without needing to know Q.

There are 2 12-Volt headlights, each at 40 W.

$2 \times 40\,W = 80\,W$ Power being dissipated.

$P = IV \rightarrow I = \frac{P}{V} = \frac{80\,W}{12\,V} = 6.67\,A$ of current coming from battery.

$100 \text{ Amp·hrs} \times \frac{1 \text{ hr}}{6.67\,A} = \boxed{15.0 \text{ hours}}$

Unless it's a very quick round-trip, the battery will be dead by the time the driver returns.

9.61 Refrigerator runs with current $I = 3.00A$
& $V = 110V$ $(P = IV = (3)(110) = 330W)$;
a lamp (100-W), an overhead light (60-W),
& 3.00 W at other devices.

$P_{total} = 330 + 100 + 60 + 3 = \underline{493\ W}$ total

a) Assuming plant supplies this Power at 110V from 10000 m away via aluminum cables using wire w/ radius $\frac{8.252e-3}{2}$ m, estimate Power lost in transmission.

What?!?

Current in wire: $P = IV$, so $I = \frac{P}{V}$
$= \frac{493\ W}{110V}$
$= \underline{4.48A}$

What is the resistance of that wire?

$$R = \rho \frac{L}{A} = \underbrace{(2.65e-8)}_{\text{in book}} \frac{(\overset{\text{2 wires}}{2})(10{,}000m)}{(\pi)\left(\frac{8.252e-3}{2}\right)^2}$$

$= \underline{9.91\,\Omega}$

P lost to this resistance $= I^2R = (4.48A)^2(9.91\Omega)$
$= \underline{199W}$

$$\% \text{ loss} = \frac{199W}{(493+199)} = \boxed{28.7\% \text{ loss}}$$

b) If Power delivered at 110,000 V? This is 1000x the voltage, so the current $I = \frac{P}{V}$ will be 1000 times smaller. According to $P = I^2R$, the Power lost will be $(1000x)^2 = 1$ million times less $= \underline{1.99e-4\ W}$

$$\frac{1.99e-4}{493 + 1.99e-4} = 4.0e-5\% \text{ loss (negligible)}$$