Name: Key

Practice - 20.4 Electric Power and Energy

1. Why do incandescent lightbulbs grow dim late in their lives, particularly just before their filaments break?

The filaments thin, increasing the resistance and, hence, reducing the current.

2. What is the power of a 1.00×10^2 MV lightning bolt having a current of 2.00×10^4 A?

$$P = IV = (2.00 \times 10^4 A)(1.00 \times 10^2 \times 10^6 V) = \boxed{2.00 \times 10^{12} W}$$

3. What power is supplied to the starter motor of a large truck that draws 250 A of current from a 24.0-V battery hookup?

$$P = IV = (250A)(24.0V) = \boxed{6.00 \times 10^3 W} = 6.00 kW$$

4. A charge of 4.00 C of charge passes through a pocket calculator's solar cells in 4.00 h. What is the power output, given the calculator's voltage output is 3.00 V?

$$P = IV = \frac{Q}{t}V = \frac{4.00C}{4.00h\left(\frac{3600s}{1h}\right)}(3.00V) = \boxed{8.33 \times 10^{-4} W}$$

5. Verify the energy unit equivalence that 1 kW·h = 3.60×10^6 J.

$$1 kWh = 1 \times 10^3 \frac{J}{s}(3600s) = \boxed{3.60 \times 10^6 J}$$

6. An electric water heater consumes 5.00 kW for 2.00 h per day. What is the cost of running it for one year if electricity costs 12.0 cents/kW·h?

$$Cost = (5.00\,kW)\left(\frac{2\,h}{day}\right)\left(\frac{365\,d}{1\,y}\right)\left(\frac{\$0.12}{kWh}\right) = \boxed{\$438/y}$$

7. When operating, a typical toaster consumes 1200 W of power.
   A. How much electrical energy is needed to make a slice of toast (cooking time = 1 minute)?

$$E = Pt = (1200\,W)(1\,min)\left(\frac{60\,s}{1\,min}\right) = \boxed{7.20 \times 10^4\,J}$$

   B. At 12 cents/kW·h, how much does this cost?

$$Cost = (7.20 \times 10^4\,J)\left(\frac{1\,kWh}{3.60 \times 10^6\,J}\right)\left(\frac{\$0.12}{1\,kWh}\right) = \boxed{\$0.00240}$$

$$= 0.240¢$$

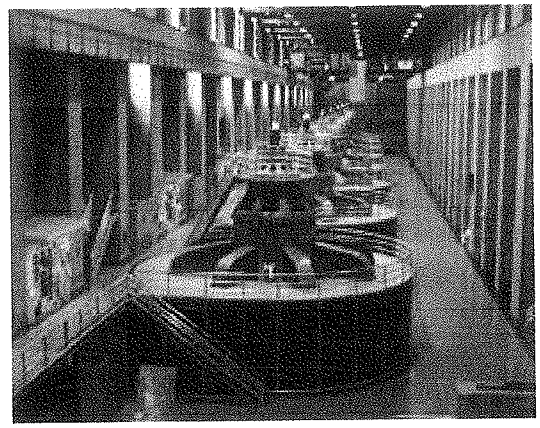
8. The average television is said to be on 6 hours per day.
   A. Estimate the yearly cost of electricity to operate 1 TV, assuming its power consumption averages 150 W and the cost of electricity averages 12.0 cents/kW·h.

$$Cost = (150\,W)\left(\frac{1\,kW}{1000\,W}\right)\left(\frac{6\,h}{1\,d}\right)\left(\frac{365\,d}{1\,y}\right)\left(\frac{\$0.12}{1\,kWh}\right) = \boxed{\$39.4/y}$$

   B. Estimate the yearly cost of 100 million TVs with the same assumptions.

$$\frac{\$39.4}{1\,y} \times 100 \times 10^6 = \boxed{\$3.94 \times 10^9}$$

9. Hydroelectric generators at Hoover Dam produce a maximum current of 8.00×10^3 A at 250 kV.



A. What is the power output?

$$P = IV = (8.00\times10^3 A)(250\times10^3 V)$$
$$= \boxed{2.00\times10^9 W}$$

B. The water that powers the generators enters and leaves the system at low speed (thus its kinetic energy does not change) but loses 160 m in altitude. How many cubic meters per second are needed, assuming 85.0% efficiency? [Note: 1 m^3 of water = 1000 kg]

$$\Delta U = mg\Delta h$$

$$0.85\frac{\Delta U}{s} = 2.00\times10^9\frac{J}{s}$$

$$0.85\frac{mg\Delta h}{s} = 2.00\times10^9\frac{J}{s}$$

$$m = \frac{2.00\times10^9 J}{(0.85)(9.80\frac{m}{s^2})(160m)} = 1.50\times10^6 kg\left(\frac{1m^3}{1000kg}\right) = \boxed{1.50\times10^3\frac{m^3}{s}}$$

10. Assuming 95.0% efficiency for the conversion of electrical power by the motor, what current must the 12.0-V batteries of a 750-kg electric car be able to supply to accelerate from rest to 25.0 m/s in 1.00 min?

$$0.95P = 0.95IV = \frac{\Delta E}{t} = \frac{\Delta K}{t} = \frac{\frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2}{t}$$

$$\Rightarrow I = \frac{mv_f^2}{2(0.95)(V)(t)} = \frac{(750kg)(25.0\frac{m}{s})^2}{2(0.95)(12.0V)(60.0s)} = \boxed{343A}$$