PHYSICS-2

Elementary Physics of Energy

Homework 1 Solutions

Problems on page 28:

3. Work equals force times distance, so: W = 10 lbs × 10 ft = 100 ft·lb. Convert to joules: 100 ft·lb $\times \frac{1.36 joules}{1 ft \cdot lb}$ = 136 joules.

4. If the cart moves at constant speed, the energy you've expended has turned into heat, because you've done work to overcome friction. If the cart speeds up at all, some of the energy you've generated has gone into kinetic energy. The energy is generated by chemical energy sources in your body.

7. The average person in the United States uses the equivalent of 61 barrels of oil per year. Using the data from the Energy Equivalents table on the inside cover of the text, this amount can be converted to an equivalent amount of coal:

$$61\ bbl\ oil \times \frac{1\ ton\ coal}{2.8 \times 10^{10} J} \times \frac{6.12 \times 10^9 J}{1\ bbl\ oil} = 13.3\ ton\ coal.$$

8. Five minutes equals 300 seconds, so the total amout of energy expended is: 80 W × 300 sec $\times \frac{1\ cal}{4.184\ J}$ = 5736 cal = 5.74 kcal.

Note: In nutritional contexts the 'food calorie' is used. This is not the same as the calorie above. It is a kilocalorie = 1000 calories (i.e. 4184 joules), and sometimes written Calorie (with a capital C). To avoid confusion just be mindful of the context.

9. Energy radiated by the sun continues unabated into space, unless it is absorbed or scattered by particulate matter including atoms, molecules and dust. Its path may be deflected somewhat by massive bodies (this is a consequence of relativity, discovered by Einstein).

10. The total intensity absorbed is $1000 \frac{W}{m^2} \times 0.90 = 900 \frac{W}{m^2}$, or 900 joules per second per square meter. Using the conversion that 1055 J = 1 Btu,

$$\frac{900\ J}{m^2\ s} \times \frac{3600\ s}{hr} = 3071 \frac{Btu}{m^2\ hr}$$

The other 10% gets reflected.

11. The weight of water in pounds is

$$40\ gal \times \frac{0.1337\ ft^3}{1\ gal} \times \frac{62.4\ lbs}{1\ ft^3} = 333.7\ lbs$$

so the required energy, in Btu, is: 333.7 lbs $\times$ 50 °F $= 1.67 \times 10^4$ Btu. Using the conversion rate 1 W = 3.41 Btu/hr, we calculate that the windmill is generating 1400 times this rate, or 4774 Btu/hr. Dividing these quantities gives:

$$\frac{1.67 \times 10^4\ Btu}{4774\ Btu/hr} = 3.5\ hours$$

Multiple choice questions on pg. 29-30:

3. c. All the potential energy has been converted to kinetic energy, so KE $= 5\ kg \times 9.81\ m/s^2 \times 2\ m = 98\ J$.

5. d. From Figure 1.3, India's per capita use is around 2.5 bbl oil, compared to the U.S. per capita use of around 60 bbl.

8. d.

14.

a. calorie	E
b. horsepower	P
c. joules/sec	P
d. joule·sec	N
e. kilowatt/hour	N
f. watt	P
g. Btu/hr	P
h. killowatt·hour	E
i. Btu	E
j. horsepower/day	N