Homework 1 Solutions

1) i) They are a finite resource, and not able to be renewed within a reasonable amount of time.

ii) Combustion of fossil fuels causes environmental problems such as air pollution and global warming.

✯ 3) $F = 10\text{ lbs}$ $D = 10\text{ ft}$ $W = ?$ or "FP"

$$W = F \cdot D \qquad W = (10\text{ lbs})(10\text{ ft}) = \boxed{100\text{ ft}\cdot\text{lbs}}$$

In Joules: $W = 100\,\cancel{\text{ft}\cdot\text{lbs}}\left(\frac{1.36\text{ J}}{1\,\cancel{\text{ft}\cdot\text{lb}}}\right) = \boxed{136\text{ J}}$

8) 80 Watts is a unit of Power, which is $\frac{\text{Energy}}{\text{Time}}$ $\quad P = \frac{E}{T}$

A Watt is defined as $\frac{1\text{ Joule}}{\text{second}}$, so we can write:

$$80\text{ Watts} = \frac{80\text{ J}}{\text{s}} = P$$

We want to know the Energy, $E = P \cdot T$, in calories:

$$E = \underbrace{\left(\frac{80\text{ J}}{\cancel{\text{s}}}\right)}_{P} \cdot \underbrace{5\,\cancel{\text{min}}\left(\frac{60\,\cancel{\text{s}}}{1\,\cancel{\text{min}}}\right)}_{T} \cdot \left(\frac{1\text{ calorie}}{4.184\,\cancel{\text{J}}}\right) = \frac{80 \cdot 5 \cdot 60}{4.184}\text{ calories}$$

$\boxed{E = 5736\text{ calories}}$ or 5.74 Calories

(kilo-calories!)

✯: The energy goes primarily into 2 places. Depending on how much friction there is, the cart will have sped up to a certain degree. The velocity of the cart represents how much Kinetic Energy it has (the energy of motion). Friction will cause the energy to dissipate and be converted to Heat Energy, which raises the temperature of the cart and the floor, or whatever other mechanical components exist (wheels).

Intensity = $\frac{\text{Power}}{\text{Area}}$ $\boxed{I = \frac{P}{A}}$

10) $I = 1000 \frac{W}{m^2}$ Efficiency = .9 $\Rightarrow$ only $900 W/m^2$ absorbed the rest is reflected in various forms of radiation.

$$900 \frac{W}{m^2} = \frac{900 J}{m^2 \cancel{s}} \left(\frac{1 Btu}{1055 J}\right) \cdot \left(\frac{60 s}{1 min}\right)\left(\frac{60 min}{1 Hr}\right) = \frac{900 \cdot 60 \cdot 60}{1055} \frac{Btu}{Hr\ m^2}$$

$$= \boxed{3071 \frac{Btu}{Hr \cdot m^2}}$$

Remember, $P = \frac{E}{T}$, $W = \frac{J}{s}$

* Note: This solution converts Energy and Time separately, but you can also use appropriate conversions to go straight from Watts to Btu/Hr in terms of Power.

11) $P = 1400 W$ Efficiency = .8 $\Rightarrow$ Effective Power : $P = 1120 W$

$\boxed{P = \frac{E}{T} \Rightarrow E = P \cdot T}$ $E = 1120 W \cdot 24$ Hours

$$E = \left(\frac{1120 J}{\cancel{s}}\right) \cdot 24 \cancel{Hours} \cdot \left(\frac{60 \cancel{min}}{1 \cancel{Hour}}\right)\left(\frac{60 \cancel{s}}{1 \cancel{min}}\right) = 1120 \cdot 24 \cdot 60 \cdot 60 J = \boxed{9.68 \times 10^7 J}$$

or $\simeq 97 MJ$

$$9.68 \times 10^7 \cancel{J} \left(\frac{1 Btu}{1055 \cancel{J}}\right) = \boxed{9.17 \times 10^4 Btu}$$

12) Assume the current population is 290 million $= 2.9 \times 10^8$ persons

(This figure is taken from the lecture notes)

A 1% increase over a year is $(.01) \cdot 2.9 \times 10^8$ persons $= 2.9 \times 10^6$ persons

According to the lecture notes, the average person in the US uses about 60.4 Barrels of Oil worth of energy per year.

$$2.9\times10^6 \cancel{\text{persons}} \cdot \left(\frac{60.4 \text{ Barrels}}{\cancel{\text{person}}}\right) \approx \boxed{1.75\times10^8 \text{ Barrels of Oil}}$$

In Btu: $1.75\times10^8 \text{ Barrels of Oil} \cdot \left(\frac{5.8\times10^6 \text{ Btu}}{1 \text{ Barrel}}\right) = \boxed{1.02\times10^{15} \text{ Btu}}$

In Tons of Coal: $1.02\times10^{15} \text{ Btu} \left(\frac{1 \text{ Ton of Coal}}{2.66\times10^7 \text{ Btu}}\right) = \boxed{3.82\times10^7 \text{ Tons of Coal}}$

✲ Note: Depending on which information is used, this problem may turn out slightly differently. Be clear about which figure you use for such things as population and average energy consumption per year, as these numbers will vary from source to source.

Multiple Choice

1) $(5\times10^5)\times(6\times10^6)\times(7\times10^7)$

$$= (5\times6\times7)\times10^{5+6+7} = 210\times10^{18} = \boxed{2.1\times10^{20}} \Rightarrow \boxed{f}$$

2) $\boxed{KE = \frac{1}{2}mv^2} = \frac{1}{2}(2000\text{kg})(30\text{ m/s})^2 = 9\times10^5 \text{ kg}\frac{m^2}{s^2} = \boxed{9\times10^5 \text{ J}}$

$$\Rightarrow \boxed{g}$$

Leap Year!

4) $\frac{3.3\times10^8 \text{ Btu}}{\cancel{\text{year}}}\left(\frac{1055\text{J}}{1\text{ Btu}}\right)\left(\frac{\cancel{1\text{year}}}{365.24\cancel{\text{days}}}\right)\left(\frac{1\cancel{\text{day}}}{24\cancel{\text{Hours}}}\right)\left(\frac{1\cancel{\text{Hour}}}{3600\text{Sec}}\right) = \frac{(3.3\times10^8)(1055)}{(365.24)(24)(3600)}\frac{\text{J}}{\text{s}}$

$$= 1.1\times10^4 \frac{\text{J}}{\text{s}} = 1.1\times10^4\text{W} = 11\times10^3\text{W} = \boxed{11\text{kW}} \Rightarrow \boxed{d}$$

5) According to Figure 1.3 on page 5 of the text, India consumes approximately 2.5 Barrels of Oil per capita. America consumes approximately 60 Barrels of Oil per capita.

This gives us $\frac{60}{2.5} = 24$

The closest answer is $\boxed{d}$, 25 times as much energy.

7) Remember, a "food calorie" is a Calorie, which is equivalent to 1000 standard calories.

$$3000\ \frac{\text{Calories}}{\text{day}} = 3\,000\,000\ \frac{\text{calories}}{\text{day}} = 3\times10^6\ \frac{\text{calories}}{\text{day}}$$

$$\frac{3\times10^6\ \text{calories}}{\cancel{\text{day}}}\cdot\left(\frac{4.184\text{J}}{1\text{calorie}}\right)\cdot\left(\frac{1\cancel{\text{day}}}{24\cancel{\text{Hrs}}}\right)\left(\frac{1\cancel{\text{Hr}}}{3600\text{sec}}\right) = \frac{(3\times10^6)(4.184)}{24\cdot3600}\ \frac{\text{J}}{\text{s}}$$

$$= 145.3\ \frac{\text{J}}{\text{s}} \approx \boxed{145\ \text{Watts}} \Rightarrow \boxed{b}$$

See inside front cover

11) Mass Energy $= E_m = mc^2$ On Earth, 1 pound $\approx .454$ kg of mass

$$E_m = (.454\,\text{kg})(3\times10^8\,\text{m/s})^2 = 4\times10^{16}\ \text{kg}\,\frac{\text{m}^2}{\text{s}^2} = \boxed{4\times10^{16}\,\text{J}} \Rightarrow \boxed{b}$$

* Note: A pound is a unit of force (weight is a type of force), not mass. Equating 1 pound to .454kg of mass is taking advantage of the relatively uniform pull of gravity, which for most purposes is constant at $g = -9.8\,\text{m/s}^2$. Since it is constant, we can relate all weights to their mass by including the gravity factor, since it simply scales linearly. Thus, a pound of weight on Earth will always contain $\approx .454$ kg of mass, though the same amount of mass will give a different weight measurem depending on the pull of gravity (i.e. it will be smaller on the moon

13) $$\frac{(4.8 \times 10^9) \times (3.6 \times 10^5)}{2.8 \times 10^{10}}$$

$$= \frac{4.8 \times 3.6}{2.8} \times 10^{9+5-10}$$

$$= \boxed{6.17 \times 10^4} \Rightarrow \boxed{C}$$