Multiple Choice Questions

Chapter 1

1. $(5\times10^5)\times(6\times10^6)\times(7\times10^7) = (5\times6\times7)\times(10^5\times10^6\times10^7) = 210\times10^{18} = 2.1\times10^{20} \Rightarrow$ **f)**

2. Kinetic energy goes as $\frac{1}{2}mv^2$ where m is the mass, and v is the velocity.
   Thus, $KE = \frac{1}{2}(2000\,kg)(30\,m/s)^2 = 900\,000\,kg\cdot\frac{m^2}{s^2} = 9\times10^5\,J \Rightarrow$ **g)**

5. Looking at the graph on page 5, we see the horizontal axis has precisely the data we need. Taking the ratio of US consumption to India consumption, we get about $\approx 20 \Rightarrow$ **d)**

6. Gravitational potential energy is proportional to an object's mass m, gravitational field strength g, and the object's height h in the field.
   Thus $PE_G = (1000\,kg)(9.8\,m/s^2)(1000\,m) = 9.8\times10^6\,J \Rightarrow$ **f)**

   Note! An object's mass is not the same as an object's weight in physics. Weight is a force (say, measured in newtons), while mass is a measure of inertia: $W = mg$, in mathematical terms.

Chapter 2

1. There is a simple trick to solving this problem. Since the colony doubles every minute, and we know that the jar is full at 12:00 $\Rightarrow$
   12:00 → full
   11:59 → 1/2
   11:58 → 1/4
   11:57 → 1/8 $\Rightarrow$ **g)**

   More generally, for exponential growth: $N = N_0(1+r)^n$; where N_0 is the starting value, r is the growth rate, n is the # of iterations (time), N is the value at time n.
   For this problem $r = 100\%$ (doubling), and $N = 1$ at $n = 60$ (60 iterations in this hour)
   $\Rightarrow N_0 = 2^{-60}$. We want to know when $N = \frac{1}{8} = 2^{-3} \Rightarrow 2^{-3} = 2^{-60}(1+1)^n \Rightarrow 2^{57} = 2^n \Rightarrow$ at the 57th iteration we're at 1/8 capacity.

Questions and Problems

Chapter 1

1. Simply put; 1) Fossil fuels are a nonrenewable source of energy (on a human time scale)
   2) The environmental effects caused by burning these hydrocarbons (particulates, impurities, CO_2, etc.) will be extremely harmful in the long run (and on the scale we burn them at).

2. Almost anything you can think of involves work (i.e. exerting a force over a distance).

3. Work = Force × Distance. The cart weighs 10 lbs, and we've moved it by 10 feet. $\Rightarrow W = 100$ ft·lbs
   Let's do a unit conversion to have some fun: $1\,ft = 12\,in\cdot 2.54\frac{cm}{in}\cdot 0.01\frac{m}{cm} = 0.3048\,m$
   $1\,lb = 1\,slug\,\frac{ft}{s^2}\left(14.5939\frac{kg}{slug}\right)\left(0.3048\frac{m}{ft}\right) = 4.448221\,N \Rightarrow 1\,ft\cdot lb = 1.3558\,J \approx 1.36\,J \Rightarrow W = 136\,J$

Questions and Problems (continued)

Chapter 1

4. The energy has gone into the motion of the cart (kinetic energy), friction between parts and the wheels and the ground (thermal energy), moving air molecules to make sound (acoustic energy), etc. The energy came from your body, which ~~obtained~~ in turn, came from the food you ate (chemical energy).

5. Any object in a gravitational field will always have gravitational potential energy. When the ball is thrown, you impart kinetic energy to the ball. At the top of its path, the ball's velocity is zero (acceleration is not!) so it has no kinetic energy. As it falls back down, it will pick up more and more kinetic energy until you catch it. Many people mentioned thermal energy (the ball heating up as it travels through the air), mass energy, acoustic energy, etc. and these were all valid as long as they were well-explained.

6. As you saw from the data in lecture, solar energy is the way to go. Other alternatives include hydroelectric, wind, geothermal, tidal, etc., but most pale in comparison to the amount of possible extractable energy from sunlight.

12. This question was worded a little oddly, in that all the data is provided for 2003. However, the question asks for the increase this year. You all interpreted this to mean 3 different things, so I didn't penalize for not noticing this detail. For future homework, though, be warned! You must know your data!

1) Assume the question asked for 2003 → 2004. To maintain the same ratio, the total energy expenditure must also increase by 1%.

In one year, we must multiply the total energy E and total population N by 1.01.

From the book, $E = 98.3$ QBtu, and $N = 291$ million people. $\Rightarrow E = 99.283$ QBtu in 2004

So this year $\Delta E = 0.983$ QBtu must be added. Now to convert: 1 barrel = 42 gallons

$1 \text{ bbl petroleum} = 5.80 \times 10^6 \text{ Btu} \Rightarrow 1.381 \times 10^5 \text{ Btu/gallon} \Rightarrow \Delta E = \frac{0.983 \times 10^{15} \text{ Btu}}{1.381 \times 10^5 \text{ Btu/gallon}} = 7.12 \times 10^9$ gallons oil

$1 \text{ ton of coal} = 2.66 \times 10^7 \text{ Btu} \Rightarrow \Delta E \approx 3.69 \times 10^7$ tons coal

2) Assume the question asked for 2003 → 2011 $\quad E$ in 2011 $= (98.3 \text{ QBtu})(1.01)^8 = 106.44$ QBtu

$\Delta E = 8.145 \text{ QBtu} = 5.898 \times 10^{10}$ gallons oil $= 3.062 \times 10^8$ tons of coal.

3) Assume the question asked for 2010 → 2011 $\quad E$ in 2010 $= (98.3 \text{ QBtu})(1.01)^7 = 105.39$ QBtu

$\Delta E = 1.05 \text{ QBtu} = 7.60 \times 10^9$ gallons of oil $= 3.94 \times 10^7$ tons of coal

Online Questions

1. $250 \frac{\text{bills}}{\text{stack}}$; $1 \frac{\text{inch}}{\text{stack}}$ If we use \$1000 bills, $1 \text{ stack} = 250 \frac{\text{bills}}{\text{stack}} \frac{\$1000}{\text{bill}} \frac{1 \text{ stack}}{\text{inch}} = \frac{\$250000}{\text{inch}}$

$\Rightarrow \$1 \text{ trillion} = \$10^{12} \Rightarrow \frac{\$10^{12}}{\$250000/\text{inch}} = 4 \times 10^6 \text{ inches} \approx 101.6 \text{ km}!$

With \$100 bills the stack should be 10 times higher $\Rightarrow 4 \times 10^7$ inches ≈ 1016 km! →

Online Questions

2. So we have an initial investment of \$500,000 with an annual return of 20%.

a. Unless money can reproduce like biological beings, this is simply not possible to continue forever given economic and fiscal constraints. Also, as the answers to parts b and c show, this would lead to severe devaluation of currency, creating hyperinflation which would counter the value obtained from the growth.

b. $2008 - 1965 = 43 \Rightarrow N = (\$500000)(1+0.2)^{43} \approx \$1.27 \times 10^9 = \$1$ billion!

c. $2065 - 1965 = 100 \Rightarrow N = (\$500000)(1.2)^{100} = \$4.14 \times 10^{13} \approx \$41$ trillion! Or in units of the previous problem, 1.656×10^8 inches of \$1000! ($\approx$ 4200 km stack!)