

09PHYSICS 80C – HOMEWORK 1 – ANSWERS TO NUMERICAL QUESTIONS

1. Work out how many meters there are in a light year.

(a) What is the speed of light, in meters per second? $\underline{3 \times 10^8}$

(b) How many seconds are there in a year? $\underline{3 \times 10^7}$

(c) Multiply to get the answer: $\underline{9 \times 10^{15}}$ meters

(d) Convert your answer above to miles, using $1.61 \text{ km} = 1 \text{ mile}$.

$$\underline{9 \times 10^{15}} \text{ meters} \times 10^{-3} \frac{\text{km}}{\text{meter}} \times \frac{\text{mile}}{1.61 \text{ km}} = \underline{6 \times 10^{12}} \text{ miles}$$

2. Ratios of big numbers. To find out how much bigger the cosmic horizon (10^{29} cm) is than the earth (10^7 cm), divide: $10^{29} \text{ cm} / 10^7 \text{ cm} = 10^{29-7} = 10^{22}$ times bigger.

(a) How much bigger is a galaxy (10^{23} cm) than a person (1 m)? $\underline{10^{21}}$

(b) How much bigger is a person than an atom (10^{-8} cm)? $\underline{10^{10}}$

3. (a) Multiply 5×10^{28} times 2×10^7 $\underline{10^{36}}$

(b) Divide 6×10^8 by 10^7 $\underline{6 \times 10^1 = 60}$

4. The amount of energy E in a kilogram of matter is given by Einstein's famous formula $E = mc^2$, where m is the mass in kilograms and $c = 3 \times 10^8 \text{ m/s}$ is the speed of light (in meters per second) and E is the energy in Joules.

(a) How much energy is in a kilogram of matter? $\underline{9 \times 10^{16} \text{ Joules}}$

(b) You are billed for electric power at around 10 cents per kilowatt-hour (kwh), and $1 \text{ kwh} = 3.6 \times 10^6 \text{ Joules}$. How much is the energy in a kilogram of matter worth at that rate? $\underline{\$3 \times 10^9 = 3 \text{ billion dollars}}$

In more detail, using the same approach as for problem 1,

$$1 \text{ kg} = (9 \times 10^{16} \text{ Joules}) \left(\frac{1 \text{ kwh}}{3.6 \times 10^6 \text{ Joules}} \right) (\$0.10) = \$2.5 \times 10^9$$

and I rounded up 2.5 to 3.