

PHYSICS 1030

Homework #1

(Due Sept. 13, 2011)

1. (Serway 1-2) The standard kilogram is a platinum-iridium cylinder 39.0 mm in height and 39.0 mm in diameter. What is the density of the material?
2. (Serway 1-3) A major motor company displays a die-cast model of its first automobile, made from 9.35 kg of iron. To celebrate its hundredth year in business, a worker will recast the model in gold from the original dies. What mass of gold is needed to make the new model?
3. Which of the following equations are dimensionally correct?
 - (a) $v_f = v_i + ax$
 - (b) $y = (2 \text{ m}) \cos(kx)$, where $k = 2 \text{ m}^{-1}$.
4. (Serway 1-18) A pyramid has a height of 481 ft, and its base covers an area of 13.0 acres (Fig. P1.18 in text). The volume of a pyramid is given by the expression $V = \frac{1}{3}Bh$, where B is the area of the base and h is the height. Find the volume of this pyramid in cubic meters. (1 acre = 43,560 ft².)
5. Find the density of the nucleus of an iron atom, and compare with a typical neutron star density of $\sim 10^{14} \text{ g/cm}^3$. (The nucleus of an iron atom has a radius of 3.555 fm, and an atomic mass of 56.)
6. (Serway 1-20) Assume that it takes 7.00 minutes to fill a 30.0-gal gasoline tank.
 - (a) Calculate the rate at which the tank is filled in gallons per second.
 - (b) Calculate the rate at which the tank is filled in cubic meters per second.
 - (c) Determine the time interval, in hours, required to fill a 1-m³ volume at the same rate. (1 U.S. gal = 231 in³.)
7. (“Back of the envelope” problem) If the iron in the Earth’s core were made into a wire as long as the radius of the visible universe, what would be the diameter of the wire?

THE BACK OF THE ENVELOPE

Edward M. Purcell, *Editor*

Department of Physics, Harvard University, Cambridge, Massachusetts 02138

ROUND-NUMBER HANDBOOK OF PHYSICS

CONSTANTS

$$\begin{aligned}c &= 3 \times 10^{10} \text{ cm s}^{-1} \\ \hbar &= 10^{-27} \text{ erg s} \\ N_0 &= 6 \times 10^{23} \text{ mole}^{-1} \\ n_0 &= 3 \times 10^{19} \text{ cm}^{-3} \\ g &= 10^3 \text{ cm s}^{-2} \\ e &= 4.8 \times 10^{-10} \text{ esu} \\ &= 1.6 \times 10^{-19} \text{ C} \\ k &= 1.4 \times 10^{-16} \text{ erg deg}^{-1} \\ \alpha &= e^2/\hbar c = 1/137 \\ (\mu_0/\epsilon_0)^{1/2} &= 377 \Omega \\ G &= 7 \times 10^{-8} \text{ g cm}^{-4} \text{ s}^{-2} \\ \mu_0 &= 4\pi \times 10^{-7} \text{ N A}^{-2} \\ \epsilon_0 &= 8.8 \times 10^{-12} \text{ N}^{-1} \text{ A}^2 \text{ m}^{-2} \text{ s}^2 \\ R &= 2 \text{ cal/mole deg}\end{aligned}$$

CONVERSIONS

$$\begin{aligned}1 \text{ cal} &= 4 \text{ J} = 4 \times 10^7 \text{ erg} \\ 1 \text{ N} &= 10^5 \text{ dyn} \\ 680 \text{ lumens} &= 1 \text{ W} (5550 \text{ \AA}) \\ 1 \text{ ft} &= 30 \text{ cm} \\ 1 \text{ lb} &= 4.4 \text{ N} \\ 1 \text{ ci} &= 4 \times 10^{10} \text{ disint/s} \\ 1 \text{ eV} &= 1.6 \times 10^{-12} \text{ erg} \\ 1 \Omega^{-1} &= 9 \times 10^{11} \text{ cm/s} \\ \text{pc(eV)} &= 300 \text{ Br(G cm)}\end{aligned}$$

MASSES

$$\begin{aligned}m_e &= 10^{-27} \text{ g} \\ m_{\text{pion}} &= 270m_e \\ m_{\text{kaon}} &= 1000m_e \\ m_{\text{nucleon}} &= 2000m_e \\ m_e c^2 &= 0.5 \text{ MeV} \\ m_{\text{muon}} &= 200m_e\end{aligned}$$

USEFUL NUMBERS

$$\begin{aligned}\text{classical electron radius} &= r_0 = e^2/m_e c^2 = 3 \times 10^{-13} \text{ cm} \\ \text{Bohr radius} &= a_0 = \hbar^2/m_e e^2 = 5 \times 10^{-9} \text{ cm} \\ \text{Rydberg wavelength} &= \lambda_R = \hbar^3 c/m_e e^4 = 7 \times 10^{-7} \text{ cm} \\ \text{Compton wavelength} &= \lambda_c = \hbar/m_e c = 4 \times 10^{-11} \text{ cm} \\ \text{Bohr magneton} &= e\hbar/2mc = 10^{-26} \text{ erg/G} \\ \text{Stefan-Boltzman const} &= 6 \times 10^{-12} \text{ W/deg}^4 \text{ cm}^2 \\ \text{Min. ionization loss} &= 2 \text{ MeV/g cm}^2 \\ kT_{\text{room}} &= 0.025 \text{ eV} \\ R_{\text{nuclear}} &= A^{1/3} \times 10^{-13} \text{ cm} \\ e^2/a_0 &= 26 \text{ eV}\end{aligned}$$

$$\begin{aligned}h\nu(\text{visible}) &= 2 \text{ eV} \\ \text{Band gaps: Si} &= 1.1 \text{ eV; Ge} = 0.7 \text{ eV} \\ \text{Spin precession: } e &: 3 \text{ MHz/G; } p: 4 \text{ kHz/G}\end{aligned}$$

MATERIALS

$$\begin{aligned}\text{Resistivities in } \Omega \text{ cm: Cu} &: 2 \times 10^{-6} \text{ (room temp.)} \\ \text{H}_2\text{O(pure)} &: 2 \times 10^7; \text{ seawater: } 25 \Omega \text{ cm} \\ \text{Specific heat (solid or liquid)} &= 0.5 \text{ cal/cm}^3 \text{ deg} \\ \text{Linear expansion (solid or liquid)} &= 2 \times 10^{-5}/\text{deg} \\ \text{Heat conduction (insulator)} &= 10^{-2} \text{ cal/s cm deg} \\ &(\text{metal}) = 1.0(\rho_{\text{Cu}}/\rho_{\text{metal}}) \text{ cal/s cm deg} \\ \text{Heat of combustion (food or fuel)} &= 10^4 \text{ cal/g} \\ \text{Heat of vaporization} &= 10^4 \text{ cal/mole} \\ \text{Elastic moduli (solids)} &= 10^{11}\text{--}10^{12} \text{ dyn/cm}^2 \\ \text{Tensile strength (solids)} &= 10^8\text{--}10^{10} \text{ dyn/cm}^2 \\ \text{Surface tension: H}_2\text{O} &= 50 \text{ dyn/cm} \\ \text{Diffusion: H}_2\text{O} &10^{-5}, \text{ air: } 0.2 \text{ cm}^2/\text{s} \\ \text{Viscosity: H}_2\text{O} &10^{-2}, \text{ air: } 2 \times 10^{-4} \text{ dyn s/cm}^2\end{aligned}$$

ASTRONOMICAL

$$\begin{aligned}1 \text{ pc} &= 3 \times 10^{18} \text{ cm} \\ 1 \text{ mag} &= -4 \text{ dB} \\ m_{\text{abs}} &= m \text{ at } 10 \text{ pc} \\ m_{\text{abs}}(\text{sun}) &= +5 \\ B_{\text{Earth}}(\text{pole}) &= 0.5 \text{ G} \\ M_{\text{Earth}} &= 6 \times 10^{27} \text{ g} \\ R_{\text{Earth}} &= 6 \times 10^8 \text{ cm} \\ M_{\odot} &= 2 \times 10^{33} \text{ g} \\ R_{\odot} &= 8 \times 10^{10} \text{ cm} \\ L_{\odot} &= 2 \times 10^{33} \text{ erg/s} = 1 \text{ kW/m}^2 \text{ at Earth} \\ r_{\text{moon}} &= 4 \times 10^{10} \text{ cm} \\ r_{\text{sun}} &= 1 \text{ AU} = 1.5 \times 10^{13} \text{ cm} \\ M_{\text{Galaxy}} &= 2 \times 10^{44} \text{ g} \\ \text{Distance to center of galaxy} &= 3 \times 10^{22} \text{ cm} \\ \text{Distance between galaxies} &= 10^{25} \text{ cm} \\ \text{Energy density: starlight} &= 10^{-12} \text{ erg/cm}^3 \\ \text{Primary cosmic rays} &: 1/\text{cm}^2 \text{ s} \\ R_{\text{Universe}} &= 3000 \text{ Mpc}\end{aligned}$$

ATMOSPHERE (STP)

$$\begin{aligned}P_{\text{atm}} &= 10^6 \text{ dyn/cm}^2 = 15 \text{ psi} \\ V_{\text{sound}} = V_{\text{molec}} &= 4 \times 10^4 \text{ cm/s} \\ \text{Radiation length} &= 36 \text{ g/cm}^2 \\ \text{Density} &= 10^{-3} \text{ g/cm}^3 \\ \text{Mean free path} &= 7 \times 10^{-6} \text{ cm} \\ \text{Scale height} &= 8 \text{ km}\end{aligned}$$