Phys 201A

Homework 1 Solutions

2. The metric prefixes (micro (μ), pico, nano, …) are given for ready reference on the inside front cover of the textbook (also, Table 1–2).

$$1\ \mu\text{century} = \left(10^{-6}\ \text{century}\right)\left(\frac{100\ \text{y}}{1\ \text{century}}\right)\left(\frac{365\ \text{day}}{1\ \text{y}}\right)\left(\frac{24\ \text{h}}{1\ \text{day}}\right)\left(\frac{60\ \text{min}}{1\ \text{h}}\right)$$
$$= 52.6\ \text{min}.$$

The percent difference is therefore

$$\frac{52.6\ \text{min} - 50\ \text{min}}{52.6\ \text{min}} = 4.9\%.$$

6. The time on any of these clocks is a straight-line function ($y = mx + b$) of that on another, with slopes $\neq$ 1 and y-intercepts $\neq$ 0. From the data in the figure we see that clock B goes from 25.0 s to 200 s (a change of 175 s) while clock C goes from 92.0 s to 142 s (a change of 50 s) which would give us a slope of (50 s)/(175 s) or 2/7. Substituting in simultaneous readings for clocks B and C gives us a "b" value of (594/7) s. We can similarly determine the relationship between clocks B and A:

$$t_C = \frac{2}{7}t_B + \frac{594}{7}\text{s}$$
$$t_B = \frac{33}{40}t_A - \frac{662}{5}\text{s}.$$

These are used in obtaining the following results.

(a) We find

$$t'_B - t_B = \frac{33}{40}\left(t'_A - t_A\right) = 495\ \text{s}$$

when $t'_A - t_A = 600$ s.

(b) We obtain $t'_C - t_C = \frac{2}{7}\left(t'_B - t_B\right) = \frac{2}{7}\left(495\ \text{s}\right) = 141\ \text{s}.$

(c) Clock B reads $t_B = (33/40)(400\ \text{s}) - (662/5)\text{s} \approx 198$ s when clock A reads $t_A = 400$ s.

(d) From $t_C = 15.0\text{s} = (2/7)t_B + (594/7)\text{s}$, we get $t_B \approx -245$ s.

15. The volume of ice is given by the product of the semicircular surface area and the thickness. The semicircle area is $A = \pi r^2/2$, where r is the radius. Therefore, the volume is

$$V = \frac{\pi r^2}{2}\ z$$

where z is the ice thickness. Since there are 10^3 m in 1 km and 10^2 cm in 1 m, we have

$$r = \left(2000\ \text{km}\right)\left(\frac{10^3\ \text{m}}{1\ \text{km}}\right)\left(\frac{10^2\ \text{cm}}{1\ \text{m}}\right) = 2000 \times 10^5\ \text{cm}.$$

In these units, the thickness becomes

$$z = (3000\ \text{m})\left(\frac{10^2\ \text{cm}}{1\ \text{m}}\right) = 3000 \times 10^2\ \text{cm}.$$

Therefore,

$$V = \frac{\pi}{2}\left(2000 \times 10^5\ \text{cm}\right)^2\left(3000 \times 10^2\ \text{cm}\right) = 1.9 \times 10^{22}\ \text{cm}^3.$$

17. We use the conversion factors found in Appendix D.

$$1\ \text{acre} \cdot \text{ft} = (43\ 560\ \text{ft}^2)\ (1\ \text{ft}) = 43\ 560\ \text{ft}^3.$$

The volume of water that fell during the storm is

$$V = (26\ \text{km}^2)(2\ \text{in})\left(\frac{1\ \text{ft}}{12\ \text{in}}\right)\left(\frac{3281\ \text{ft}}{1\ \text{km}}\right)^2 = 4.66 \times 10^7\ \text{ft}^3$$

Thus,

$$V = 4.66 \times 10^7\ \text{ft}^3\left(\frac{1\ \text{acre} \cdot \text{ft.}}{4.3560 \times 10^4\ \text{ft}^3}\right) = 1.1 \times 10^3\ \text{acre} \cdot \text{ft.}$$

18. The total volume V of the real house is that of a triangular prism (of height h = 3.0 m and base area A = 20 m × 12 m = 240 m^2) in addition to a rectangular box (height h' = 6.0 m and same base). Therefore,

$$V = \frac{1}{2}hA + h'A = \left(\frac{h}{2} + h'\right)A = 1800\ \text{m}^3.$$

(a) Each dimension is reduced by a factor of 1/12, and we find

$$V_{\text{doll}} = \left(1800\ \text{m}^3\right)\left(\frac{1}{12}\right)^3 \approx 1.0\ \text{m}^3.$$

(b) In this case, each dimension (relative to the real house) is reduced by a factor of 1/144. Therefore,

$$V_{\text{miniature}} = \left(1800\ \text{m}^3\right)\left(\frac{1}{144}\right)^3 \approx 6.0 \times 10^{-4}\ \text{m}^3.$$

21. We introduce the concept of density as:

$$\rho = \frac{m}{V}$$

and convert to SI units.

(a) The density in kg/m^3 is: $1\ \text{g/cm}^3 = \left(\frac{1\ \text{g}}{\text{cm}^3}\right)\left(\frac{1\ \text{kg}}{1000\ \text{g}}\right)\left(\frac{100\ \text{cm}}{1\ \text{m}}\right)^3 = 1 \times 10^3\ \text{kg/m}^3.$

Thus, the mass of a cubic meter of water is 1000 kg.

(b) We divide the mass of the water by the time taken to drain it. The mass is found from M = ρV (the product of the volume of water and its density):

$$M = (5700\ \text{m}^3)(1 \times 10^3\ \text{kg/m}^3) = 5.70 \times 10^6\ \text{kg}.$$

The time is t = (10 h)(3600 s/h) = 3.6×10^4 s, so the mass flow rate R is

$$R = \frac{M}{t} = \frac{5.70 \times 10^6\ \text{kg}}{3.6 \times 10^4\ \text{s}} = 158\ \text{kg/s}.$$

22. The volume of the water that fell is

$$\begin{aligned} V &= (26\ \text{km}^2)(2.0\ \text{in.}) \\ &= (26\ \text{km}^2)\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)^2 (2.0\ \text{in.})\left(\frac{2.54\,\text{cm}}{1\ \text{in.}}\right)\left(\frac{1\ \text{m}}{100\,\text{cm}}\right) \\ &= (26 \times 10^6\ \text{m}^2)(0.0508\ \text{m}) \\ &= 1.3 \times 10^6\ \text{m}^3. \end{aligned}$$

We write the mass-per-unit-volume (density) of the water as:

$$\rho = \frac{m}{V} = 1 \times 10^3\ \text{kg/m}^3.$$

The mass of the water that fell is therefore given by $m = \rho V$:

$$\begin{aligned} m &= (1 \times 10^3\ \text{kg/m}^3)(1.3 \times 10^6\ \text{m}^3) \\ &= 1.3 \times 10^9\ \text{kg}. \end{aligned}$$

27. The volume of one unit is 1 cm^3 = 1 x 10^{-6} m^3, so the volume of a mole of them is 6.02 x 10^{23} cm^3 = 6.02 x 10^{17} m^3. The cube root of this number gives the edge length: 8.4 x 10^5 m^3. This is equivalent to roughly 840 kilometers.

29. $$\text{Number of atoms} = 1.0\ \text{kg}\left(\frac{1\ \text{atom}}{1\ \text{u}}\right)\left(\frac{1\ \text{u}}{1.66 \times 10^{-27}\ \text{kg}}\right) = 6.0 \times 10^{26}\ \text{atoms}$$