Chapter 1

1. We use the conversion factors given in Appendix D (many are also listed on the inside back cover of the textbook) and the definitions of the SI prefixes given in Table 1–2 (also listed on the inside front cover of the textbook). Here, "ns" represents the nanosecond unit, "ps" represents the picosecond unit, and so on.

(a) 1 m = 3.281 ft and 1 s = 10^9 ns. Thus,

$$3.0 \times 10^8 \text{ m/s} = \left(\frac{3.0 \times 10^8 \text{ m}}{\text{s}}\right)\left(\frac{3.281 \text{ ft}}{1 \text{ m}}\right)\left(\frac{1 \text{ s}}{10^9 \text{ ns}}\right) = 0.98 \text{ ft/ns}.$$

(b) Using 1 m = 10^3 mm and 1 s = 10^{12} ps, we find

$$\begin{aligned} 3.0 \times 10^8 \text{ m/s} &= \left(\frac{3.0 \times 10^8 \text{ m}}{\text{s}}\right)\left(\frac{10^3 \text{ mm}}{1 \text{ m}}\right)\left(\frac{1 \text{ s}}{10^{12} \text{ ps}}\right) \\ &= 0.30 \text{ mm/ps}. \end{aligned}$$

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).

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

The percent difference is therefore

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

3. None of the clocks advance by exactly 24 h in a 24-h period but this is not the most important criterion for judging their quality for measuring time intervals. What is important is that the clock advance by the same amount in each 24-h period. The clock reading can then easily be adjusted to give the correct interval. If the clock reading jumps around from one 24-h period to another, it cannot be corrected since it would be impossible to tell what the correction should be. The following gives the corrections (in seconds) that must be applied to the reading on each clock for each 24-h period. The entries were determined by subtracting the clock reading at the end of the interval from the clock reading at the beginning.

CLOCK	Sun. -Mon.	Mon. -Tues.	Tues. -Wed.	Wed. -Thurs.	Thurs. -Fri.	Fri. -Sat.
A	−16	−16	−15	−17	−15	−15
B	−3	+5	−10	+5	+6	−7
C	−58	−58	−58	−58	−58	−58
D	+67	+67	+67	+67	+67	+67
E	+70	+55	+2	+20	+10	+10

Clocks C and D are both good timekeepers in the sense that each is consistent in its daily drift (relative to WWF time); thus, C and D are easily made "perfect" with simple and predictable corrections. The correction for clock C is less than the correction for clock D, so we judge clock C to be the best and clock D to be the next best. The correction that must be applied to clock A is in the range from 15 s to 17s. For clock B it is the range from –5 s to +10 s, for clock E it is in the range from –70 s to –2 s. After C and D, A has the smallest range of correction, B has the next smallest range, and E has the greatest range. From best to worst, the ranking of the clocks is C, D, A, B, E.

4. The number of seconds in a year is 3.156×10^7. This is listed in Appendix D and inside the back cover and results from the product

$$(365.25 \text{ day/y})\ (24 \text{ h/day})\ (60 \text{ min/h})\ (60 \text{ s/min}).$$

(a) The number of shakes in a second is 10^8; therefore, there are indeed more shakes per second than there are seconds per year.

(b) Denoting the age of the universe as 1 u-day (or 86400 u-sec), then the time during which humans have existed is given by

$$(10^6 \text{ y})\left(\frac{1 \text{ u-day}}{10^{10} \text{ y}}\right) = 10^{-4} \text{ u-day},$$

which we may also express as

$$\left(10^{-4} \text{ u-day}\right)\left(\frac{86400 \text{ u-sec}}{1 \text{ u-day}}\right) = 8.6 \text{ u-sec}.$$

5. We convert meters to astronomical units, and seconds to minutes, using

$$\begin{aligned} 1000 \text{ m} &= 1 \text{ km} \\ 1 \text{ AU} &= 1.50 \times 10^8 \text{ km} \\ 60 \text{ s} &= 1 \text{ min}. \end{aligned}$$

Thus, 3.0×10^8 m/s becomes

$$\left(\frac{3.0 \times 10^8 \text{ m}}{\text{s}}\right)\left(\frac{1 \text{ km}}{1000 \text{ m}}\right)\left(\frac{1 \text{ AU}}{1.50 \times 10^8 \text{ km}}\right)\left(\frac{60 \text{ s}}{1 \text{ min}}\right) = 0.12 \text{ AU/min}.$$

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:

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

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.

7. The last day of the 20 centuries is longer than the first day by

$$\left(20 \text{ century}\right)\left(0.0010 \text{ s/century}\right) = 0.02 \text{ s}.$$

The average day during the 20 centuries is (0 s + 0.02 s)/2 = 0.01 s longer than the first day. Since the increase occurs uniformly, the cumulative effect T is

$$\begin{aligned} T &= \left(\text{average increase in length of a day}\right)\left(\text{number of days}\right) \\ &= \left(\frac{0.01 \text{ s}}{\text{day}}\right)\left(\frac{365.25 \text{ day}}{\text{y}}\right)\left(2000 \text{ y}\right) \\ &= (7305 \text{ s})\left(\frac{1 \text{ min}}{60 \text{ s}}\right)\left(\frac{1 \text{ hr}}{60 \text{ min}}\right) = 2.03 \text{ hr}. \end{aligned}$$

8. Since a change of longitude equal to 360° corresponds to a 24 hour change, then one expects to change longitude by 360°/(24 hr) or 15° before resetting one's watch by 1.0 h.

9. A week is 7 days, each of which has 24 hours, and an hour is equivalent to 3600 seconds. Thus, two weeks (a fortnight) is 1 209 600 s. By definition of the micro prefix, this is roughly 1.21×10^{12} μs.

10. We denote the pulsar rotation rate f (for frequency). $f = \dfrac{1 \text{ rotation}}{1.55780644887275 \times 10^{-3} \text{ s}}$

(a) Multiplying f by the time-interval t = 7.00 days (which is equivalent to 604 800 s, if we ignore *significant figure* considerations for a moment), we obtain the number of rotations:

$$N = \left(\frac{1 \text{ rotation}}{1.55780644887275 \times 10^{-3} \text{ s}}\right)\left(604800 \text{ s}\right) = 388238218.4 \text{ rotations}$$

which should now be rounded to 3.88×10^8 rotations since the time-interval was specified in the problem to three significant figures.

(b) We note that the problem specifies the *exact* number of pulsar revolutions (one million). In this case, our unknown is t, and an equation similar to the one we set up in part (a) takes the form

$$N = ft$$
$$1 \times 10^6 \text{ rotations} = \left(\frac{1 \text{ rotation}}{1.55780644887275 \times 10^{-3} \text{ s}}\right) t$$

which yields the result t = 1557.80644887275 s (though students who do this calculation on their calculator might not obtain those last several digits).

(c) Careful reading of the problem shows that the time-uncertainty *per revolution* is $\pm 3 \times 10^{-17}$ s. We therefore expect that as a result of one million revolutions, the uncertainty should be $(\pm 3 \times 10^{-17} \text{ s/rev})(1 \times 10^6 \text{ rev}) = \pm 3 \times 10^{-11}$ s.

11. Using the given conversion factors, we find

(a) the distance *d in rods* to be

$$d = 4.0 \text{ furlongs} = (4.0 \text{ furlongs})\left(\frac{201.168 \text{ m}}{1 \text{ furlong}}\right)\left(\frac{1 \text{ rod}}{5.0292 \text{ m}}\right) = 160 \text{ rods},$$

(b) and that distance *in chains* to be

$$d = 4.0 \text{ furlongs} = (4.0 \text{ furlongs})\left(\frac{201.168 \text{ m}}{1 \text{ furlong}}\right)\left(\frac{1 \text{ chain}}{20.117 \text{ m}}\right) = 40 \text{ chains}.$$

12. The customer expects $20 \times 7056 \text{ in}^3$ and receives $20 \times 5826 \text{ in}^3$, the difference being 24600 cubic inches, or

$$\left(24600 \text{ in}^3\right)\left(\frac{2.54 \text{cm}}{1 \text{ inch}}\right)^3\left(\frac{1 \text{ L}}{1000 \text{ cm}^3}\right) = 403 \text{ L}$$

where Appendix D or the table inside the back cover has been used.

13. Various geometric formulas are given in Appendix E.

(a) Substituting

$$R = \left(6.37 \times 10^6 \text{ m}\right)\left(\frac{1 \text{ km}}{1000 \text{ m}}\right) = 6.37 \times 10^3 \text{ km}$$

into *circumference* $= 2\pi R$, we obtain 4.00×10^4 km.

(b) The surface area of Earth is

$$4\pi R^2 = 4\pi\left(6.37 \times 10^3 \text{ km}\right)^2 = 5.10 \times 10^8 \text{ km}^2.$$

(c) The volume of Earth is

$$\frac{4}{3}\pi R^3 = \frac{4\pi}{3}\left(6.37\times10^3\ \text{km}\right)^3 = 1.08\times10^{12}\ \text{km}^3.$$

14. (a) From Appendix D or the table inside the back cover we obtain

$$\left(0.80\ \text{cm}\right)\left(\frac{1\ \text{inch}}{2.54\ \text{cm}}\right)\left(\frac{6\ \text{picas}}{1\ \text{inch}}\right)\left(\frac{12\ \text{points}}{1\ \text{pica}}\right)\approx 23\ \text{points},$$

(b) and

$$\left(0.80\ \text{cm}\right)\left(\frac{1\ \text{inch}}{2.54\ \text{cm}}\right)\left(\frac{6\ \text{picas}}{1\ \text{inch}}\right)\approx 1.9\ \text{picas}.$$

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

$$r = \left(2000\,\text{km}\right)\left(\frac{10^3\ \text{m}}{1\ \text{km}}\right)\left(\frac{10^2\ \text{cm}}{1\ \text{m}}\right) = 2000\times10^5\ \text{cm}.$$

In these units, the thickness becomes

$$z = \left(3000\ \text{m}\right)\left(\frac{10^2\,\text{cm}}{1\ \text{m}}\right) = 3000\times10^2\ \text{cm}.$$

Therefore,

$$V = \frac{\pi}{2}\left(2000\times10^5\ \text{cm}\right)^2\left(3000\times10^2\,\text{cm}\right) = 1.9\times10^{22}\ \text{cm}^3.$$

16. (a) Using the fact that the area A of a rectangle is width $\times$ length, we find

$$\begin{aligned} A^{\text{total}} &= \left(3.00\,\text{acre}\right) + \left(25.0\,\text{perch}\right)\left(4.00\,\text{perch}\right)\\ &= \left(3.00\ \text{acre}\right)\left(\frac{\left(40\ \text{perch}\right)\left(4\ \text{perch}\right)}{1\,\text{acre}}\right) + 100\,\text{perch}^2\\ &= 580\ \text{perch}^2. \end{aligned}$$

We multiply this by the perch^2 $\rightarrow$ rood conversion factor (1 rood/40 perch^2) to obtain the answer: $A^{\text{total}} = 14.5$ roods.

(b) We convert our intermediate result in part (a):

$$A^{\text{total}} = \left(580\ \text{perch}^2\right)\left(\frac{16.5\ \text{ft}}{1\ \text{perch}}\right)^2 = 1.58\times10^5\ \text{ft}^2.$$

Now, we use the feet → meters conversion given in Appendix D or inside the back cover to obtain

$$A_{\text{total}} = \left(1.58 \times 10^5 \text{ ft}^2\right)\left(\frac{1 \text{ m}}{3.281 \text{ ft}}\right)^2 = 1.47 \times 10^4 \text{ m}^2.$$

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,

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

19. If M_E is the mass of Earth, m is the average mass of an atom in Earth, and N is the number of atoms, then $M_E = Nm$ or $N = M_E/m$. We convert mass m to kilograms using Appendix D (1 u = 1.661 × 10^{-27} kg). Thus,

$$N = \frac{M_E}{m} = (5.98 \times 10^{24} \text{ kg})\left(\frac{1 \text{ atom}}{40 \text{ u}}\right)\left(\frac{1 \text{ u}}{1.661 \times 10^{-27} \text{ kg}}\right) = 9.0 \times 10^{49} \text{ atoms.}$$

20. To organize the calculation, we introduce the notion of density (which the students have probably seen in other courses):

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

(a) We take the volume of the leaf to be its area A multiplied by its thickness z. With density $\rho = 19.32$ g/cm^3 and mass $m = 27.63$ g, the volume of the leaf is found to be

$$V = \frac{m}{\rho} = \left(\frac{27.63 \text{ g}}{19.32 \text{ g/cm}^3}\right) = 1.430 \text{ cm}^3.$$

We convert the volume to SI units:

$$\left(1.430 \text{ cm}^3\right)\left(\frac{1 \text{ m}}{100 \text{ cm}}\right)^3 = 1.430 \times 10^{-6} \text{ m}^3.$$

And since $V = Az$ where $z = 1 \times 10^{-6}$ m (metric prefixes can be found in Table 1–2 or inside the front cover), we obtain

$$A = \frac{1.430 \times 10^{-6} \text{ m}^3}{1 \times 10^{-6} \text{ m}} = 1.430 \text{ m}^2.$$

(b) The volume of a cylinder of length ℓ is $V = A\ell$ where the cross-section area is that of a circle: $A = \pi r^2$. Therefore, with $r = 2.500 \times 10^{-6}$ m and $V = 1.430 \times 10^{-6}$ m^3, we obtain

$$\ell = \frac{V}{\pi r^2} = 7.284 \times 10^4 \text{ m}.$$

21. We introduce the notion of density (which the students have probably seen in other courses):

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

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):

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

The time is $t = (10 \text{ h})(3600 \text{ s/h}) = 3.6 \times 10^4$ 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

$$\begin{aligned} V &= (26\ \text{km}^2)(2.0\ \text{in.}) \\ &= (26\ \text{km}^2)\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)^2(2.0\ \text{in.})\left(\frac{2.54\,\text{cm}}{1\ \text{in.}}\right)\left(\frac{1\ \text{m}}{100\,\text{cm}}\right) \\ &= (26\times10^6\ \text{m}^2)(0.0508\ \text{m}) \\ &= 1.3\times10^6\ \text{m}^3. \end{aligned}$$

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

$$\rho = \frac{m}{V} = 1\times10^3\ \text{kg/m}^3.$$

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

$$\begin{aligned} m &= (1\times10^3\ \text{kg/m}^3)(1.3\times10^6\ \text{m}^3) \\ &= 1.3\times10^9\ \text{kg}. \end{aligned}$$

23. From the information given, we can find the number of atoms per cubic meter.

(a) $$\left(\frac{7.87\ \text{g}}{1\ \text{cm}^3}\right)\left(\frac{100\ \text{cm}}{1\ \text{m}}\right)^3\left(\frac{1\ \text{kg}}{1000\ \text{g}}\right)\left(\frac{1\ \text{atom}}{9.27\ \times\ 10^{-26}\ \text{kg}}\right) = 8.49\ \times\ 10^{28}\text{atom/m}^3$$

If we take the reciprocal of this value, we will get the volume of an individual atom in cubic meters.

$$\left(\frac{1}{8.49\ \times\ 10^{28}\text{atom/m}^3}\right) = 1.18\times10^{-29}\,\text{m}^3/\text{atom}$$

(b) We set $V = 4\pi R^3/3$, where R is the radius of an atom (Appendix E contains several geometry formulas). Solving for R, we find

$$R = \left(\frac{3V}{4\pi}\right)^{1/3} = \left(\frac{3(1.18\times10^{-29}\ \text{m}^3)}{4\pi}\right)^{1/3} = 1.41\times10^{-10}\ \text{m}.$$

The center-to-center distance between atoms is twice the radius, or 2.82×10^{-10} m.

24. The metric prefixes (micro (μ), pico, nano, …) are given for ready reference on the inside front cover of the textbook (see also Table 1–2) and Appendix E contains a variety of geometry formulas. The surface area A of each grain of sand of radius $r = 50\ \mu\text{m} = 50\times10^{-6}$ m is given by $A = 4\pi(50\times10^{-6}\,\text{m})^2 = 3.14\times10^{-8}\ \text{m}^2$. A cube has six equal faces so the indicated surface area is 6 m^2. The number of spheres (the grains of sand) N which have a total surface area of 6 m^2 is given by

$$N = \frac{6\ \text{m}^2}{3.14 \times 10^{-8}\ \text{m}^2} = 1.91 \times 10^8.$$

We introduce the notion of density (which the students have probably seen in other courses):

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

so that the mass can be found from $m = \rho V$, where $\rho = 2600\ \text{kg/m}^3$. Thus, using $V = 4\pi r^3/3$, the mass of each grain is

$$m = \left(\frac{4\pi\left(50 \times 10^{-6}\ \text{m}\right)^3}{3}\right)\left(2600\ \frac{\text{kg}}{\text{m}^3}\right) = 1.36 \times 10^{-9}\ \text{kg}.$$

Therefore, the total mass M is given by

$$M = Nm = \left(1.91 \times 10^8\right)\left(1.36 \times 10^{-9}\ \text{kg}\right) = 0.260\ \text{kg}.$$

25. $$\frac{2.3\ \text{kg}}{1\ \text{week}} = \left(\frac{2.3\ \text{kg}}{1\ \text{week}}\right)\left(\frac{1 \times 10^3\ \text{g}}{1\ \text{kg}}\right)\left(\frac{1 \times 10^3\ \text{mg}}{1\ \text{g}}\right)\left(\frac{1\ \text{week}}{7\ \text{days}}\right)\left(\frac{1\ \text{day}}{86,400\ \text{s}}\right) = 3.8\ \ \text{mg/s}.$$

26. If we estimate the "typical" large domestic cat mass as 10 kg, and the "typical" atom (in the cat) as 10 u ≈ 2 x 10^{-26} kg, then there are very roughly (10 kg)/(2 x 10^{-26} kg) ≈ 5 x 10^{26} atoms. This is close to being a factor of a thousand greater than Avogradro's number. Thus there are roughly 10^3 moles (a kilomole) of atoms in the cat.

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.

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

(a) $$1.0\ \text{km} = 1.0\ \text{km}\left(\frac{1 \times 10^3\ \text{m}}{1\ \text{km}}\right)\left(\frac{1 \times 10^6\ \mu\text{m}}{1\ \text{m}}\right) = 1.0 \times 10^9\ \mu\text{m}.$$

The given measurement is 1.0 km (two significant figures), which implies our result should be written as 1.0×10^9 μm.

(b) $$1.0\ \mu\text{m} = 1.0\ \mu\text{m}\left(\frac{1\ \text{m}}{1 \times 10^6\ \mu\text{m}}\right)\left(\frac{100\ \text{cm}}{1\ \text{m}}\right) = 1 \times 10^{-4}\ \text{cm}.$$

We conclude that the fraction of one centimeter equal to 1.0 μm is 1/10000.

(c) $$1.0\ \text{yd} = 1.0\ \text{yd}\left(\frac{3\ \text{ft}}{1\ \text{yd}}\right)\left(\frac{1\ \text{m}}{3.28\ \text{ft}}\right)\left(\frac{1\times 10^{6}\ \mu\text{m}}{1\ \text{m}}\right) = 9.1\times 10^{5}\ \mu\text{m}.$$

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

30. One *gry* is equivalent to $1\ \text{gry}\left(\frac{(1/10)\ \text{line}}{1\ \text{gry}}\right)\left(\frac{(1/12)\ \text{in}}{1\ \text{line}}\right)\left(\frac{1\ \text{point}}{(1/72)\ \text{in}}\right) = 0.60\ \text{point}.$

Thus, 1 gry^2 = (0.60 point)^2 = 0.36 point^2. Therefore, $\frac{1}{2}gry^2$ = 0.18 point^2.