1.1-1.2 THE REALM OF PHYSICS AND MEASUREMENT *HOMEWORK KEY*

1. Express the following numbers in scientific notation, to two significant figures:

a) 0.00342 3.4×10^{-3}
b) 0.005291 5.3×10^{-3}
c) 0.145 1.5×10^{-1}
d) 153.2 1.5×10^{2}
e) 674 6.7×10^{2}

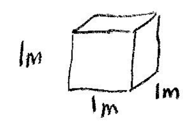
2. Without (and with) a calculator, find the value of:

a) $10^3 \times 10^6$ — $10^{(3+6)} = 10^9$
b) $1 \times 10^2 \times 1 \times 10^4$ — $(1\times1)(10^{2+4}) = 10^6$
c) $3 \times 10^6 \times 2 \times 10^3$ — $(3\times2)(10^{6+3}) = 6\times10^9$
d) $10^{-3} \times 10^{-6}$ — $10^{(-3+-6)} = 10^{-9}$
e) $10^6 / 10^3$ — $10^{(6-3)} = 10^3$
f) $1/1 \times 10^3$ — $= \frac{10^0}{10^3} = 10^{(0-3)} = 10^{-3}$
g) $15 \times 10^6 / 5 \times 10^{-3}$ — $\left(\frac{15}{5}\right)(10^{6--3}) = 3\times10^9$

3. Express the following quantities in the appropriate base unit in scientific notation.

a) 6.34 cm — 6.34×10^{-2} m
b) 12 mm — 12×10^{-3} m $= 1.2\times10^{-2}$ m
c) 832 km — 832×10^{3} m $= 8.32\times10^{5}$ m
d) 546 nm — 546×10^{-9} m $= 5.46\times10^{-7}$ m
e) 53.4 g — 53.4×10^{-3} kg $= 5.34\times10^{-2}$ kg
f) 500 tonnes — Use: 1 tonne = 1000 kg — 500,000 kg $= 5\times10^{5}$ kg
g) 123 mg — 123×10^{-6} kg $= 1.23\times10^{-4}$ kg
h) 2.3 μg — 2.3×10^{-9} kg
i) 30 minutes — 1800 s $= 1.8\times10^{3}$ s
j) 23 ms — 23×10^{-3} s $= 2.3\times10^{-2}$ s
k) 24 hours — 86,400 s $= 8.6\times10^{4}$ s

4. Express the following volumes in m^3 and scientific notation in two sig figs.

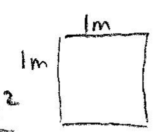


$1\,m^3 = 10^6\,cm^3 = 10^9\,mm^3 = 10^{-9}\,km^3$

a) $7.8\,cm^3$ — $\frac{7.8\,cm^3}{1}\times\frac{1\,m^3}{10^6\,cm^3} = 7.8\times10^{-6}\,m^3$
b) $34\,mm^3$ — $\frac{34\,mm^3}{1}\times\frac{1\,m^3}{10^9\,mm^3} = 3.4\times10^{-8}\,m^3$
c) $9.8\,km^3$ — $\frac{9.8\,km^3}{1}\times\frac{1\,m^3}{10^{-9}\,km^3} = 9.8\times10^{9}\,m^3$
d) 47 litres — $\frac{47\,L}{1}\times\frac{1\,m^3}{1000\,L} = 4.7\times10^{-2}\,m^3$

1000 L = $1\,m^3$

5. Express the following areas in m^2



$1\,m^2 = 10^4\,cm^2 = 10^6\,mm^2$

a) $1.6\,cm^2$ — $\frac{1.6\,cm^2}{1}\times\frac{1\,m^2}{10^4\,cm^2} = 1.6\times10^{-4}\,m^2$
b) $5.3\,mm^2$ — $\frac{5.3\,mm^2}{1}\times\frac{1\,m^2}{10^6\,mm^2} = 5.3\times10^{-6}\,m^2$
c) $0.0017\,cm^2$ — $\frac{0.0017\,cm^2}{1}\times\frac{1\,m^2}{10^4\,cm^2} = 1.7\times10^{-7}\,m^2$

6. Write down the following quantities as numbers in scientific notation together with the appropriate unit without any prefix:

a) 470 pm — 470×10^{-12} m $= 4.7\times10^{-10}$ m
b) 1.5 kV — 1.5×10^{3} V
c) 50 MW — 50×10^{6} W $= 5\times10^{7}$ W
d) 40 ns — 40×10^{-9} s $= 4\times10^{-8}$ s

$1\ hr = (60 \times 60)s = 3600s.$

7. A car travels at 75 kmh^{-1}. How many ms^{-1} is this?

$$\frac{75\ km}{1\ hr} \times \frac{1000m}{1km} \times \frac{1\ hr}{3600s} = \frac{75 \times 1000}{3600}\ \frac{m}{s} = \boxed{21\ m/s}$$

8. Using *1 mile = 1.609 km*, find the number of miles in 1 km.

$$\frac{1\ km}{1} \times \frac{1\ mile}{1.609\ km} = \frac{1}{1.609}\ miles = \boxed{0.6215\ miles.}$$

9. Use the above to convert 30.0 miles/hour to km/hour.

$$\frac{30.0\ mi}{1\ hr} \times \frac{1.609\ km}{1\ mi} = \frac{30.0 \times 1.609}{1}\ \frac{km}{hr} = \boxed{48.3\ \frac{km}{hr}}$$

10. The mileage rating of my car is 8.0 kmL^{-1}.(L = liters) How many miles per gallon is this? $1\ gal = 3.78541\ L$

$$\frac{8.0\ km}{1\ L} \times \frac{1\ mi}{1.609\ km} \times \frac{3.79\ L}{1\ gal} = \frac{8.0 \times 3.79}{1.609}\ \frac{mi}{gal} = \boxed{19\ \frac{mi}{gal}}$$

11. How many baseballs can be carried in 5 carts? *Given: 1 cart = 12 sacks*
3 sacks = 1 basket
1 basket = 25 baseballs

$$\frac{5\ carts}{1} \times \frac{12\ sacks}{1\ cart} \times \frac{1\ basket}{3\ sacks} \times \frac{25\ baseballs}{1\ basket}$$

$$= \frac{5 \times 12 \times 1 \times 25}{3}\ baseballs = \boxed{500\ baseballs.}$$

12. A spacecraft travels at a speed of 8/10 of a mile per second. How many days does it take it to travel from the Earth to the Moon, a distance of 240,000 miles?

convert $\frac{mi}{s}$ to $\frac{mi}{days}$; $\frac{.80\ mi}{1\ s} \times \frac{3600\ s}{1\ hr} \times \frac{24\ hr}{day} = \frac{.80 \times 3600 \times 24}{1}\ \frac{mi}{day}$

OR $69{,}000\ \frac{mi}{day}$. So, $\frac{1\ day}{69{,}000\ mi} \times \frac{240{,}000\ mi}{1} = \boxed{3.5\ days.}$

13. What is the weight of 6.50 gallons of water? How many cubic feet of water is this?
Given: 1 gallon of water weighs 8.34 pounds, 1 cubic foot of water weighs 62.4 pounds

$$\frac{6.50\ gal}{1} \times \frac{8.34\ lbs.}{1\ gal} = \frac{6.50 \times 8.34}{1}\ lbs = \boxed{54.2\ lbs.}$$

$$\frac{54.2\ lbs}{1} \times \frac{1\ ft^3}{62.4\ lbs} = \frac{54.2}{62.4}\ ft^3 = \boxed{0.869\ ft^3}$$

14. Perform the operation as indicated and state the answer with the correct number of significant figures. Don't forget the proper units!

a) 16.2 m + 5.008 m + 13.48 m = 34.688 m = **34.7 m**

b) 78.05 cm² - 32.046 cm² = 46.004 cm² = **46.00 cm²**

c) 15.07 kg - 12.0 kg = 3.07 kg = **3.1 kg**

d) 5.006 m + 12.0077 m + 8.0084 m = 25.0221 m = **25.022 m**

e) 27.807 mm x 4.2 mm = 116.7894 mm² = **120 mm²**

f) 20.008 m - 7.0 s × NOT POSSIBLE !!

g) 245 cm x 5.8 cm = 1421 cm² = **1400 cm² OR 1.4×10^3 cm²**

h) (5.6×10^3 m) - (2.8×10^{12} m) = $-2.7\bar{9}\bar{9}\times10^{12}$ = **-2.8×10^{12} m**

i) 3.28 cm - 12.47826 cm = -9.19826 cm = **-9.20 cm**

15. Rearrange the following formulae to make the letter in brackets the subject (solve for the letter in brackets).

$v = u + at$ (u)

$u = v - at$

$F = ma$ (a)

$a = \frac{F}{m}$

$P = \frac{F}{A}$ (A)

$A = \frac{F}{P}$

$v^2 = u^2 + 2as$ (a)

$2as = v^2 - u^2$

$a = \frac{v^2 - u^2}{2s}$

$E = mc^2$ (c)

$c^2 = \frac{E}{m}$

$c = \left(\frac{E}{m}\right)^{1/2}$

$P = \frac{V^2}{R}$ (V)

$V^2 = RP$

$V = (RP)^{1/2}$

$F = mv^2r$ (v)

$v^2 = \frac{F}{mr}$

$v = \left(\frac{F}{mr}\right)^{1/2}$

$E = \frac{4Mgl}{\pi ed^2}$ (d)

$\frac{\pi ed^2}{4Mgl} = \frac{1}{E}$

$d = \left(\frac{4mgl}{E\pi e}\right)^{1/2}$

$C = \frac{2F}{\rho v^2 A}$ (v)

$\frac{\rho v^2 A}{2F} = \frac{1}{C}$

$v = \left(\frac{2F}{C\rho A}\right)^{1/2}$

$F = k\rho v^2 r^2$ (r)

$r^2 = \frac{F}{k\rho v^2}$

$r = \frac{1}{v}\left(\frac{F}{k\rho}\right)^{1/2}$

$T = \sqrt{\frac{p}{d}}$ (d)

$\frac{p}{d} = T^2$

$\frac{d}{p} = \frac{1}{T^2}$

$\Rightarrow d = \frac{p}{T^2}$

$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$ (r)

$\frac{4\pi\varepsilon_0 r^2}{q_1 q_2} = \frac{1}{F}$

$r = \left(\frac{q_1 q_2}{4\pi\varepsilon_0 F}\right)^{1/2}$

W = F.d   J =

16. As a sphere of radius r moves with a constant velocity v through a liquid of density ρ, the force F on it is given by the equation:

$$F = k\rho r^2 v^2$$

Show that k is a dimensionless constant.

Units of r: [m]
Units of v: $\left[\frac{m}{s}\right]$
Units of ρ: $\left[\frac{kg}{m^3}\right]$
Units of F: $\left[\frac{kg \cdot m}{s^2}\right]$

$$k = \frac{F}{\rho r^2 v^2}$$

$$\Rightarrow \left[\frac{kg \cdot m}{s^2}\right]\left[\frac{m^3}{kg}\right]\cdot\left[\frac{1}{m^2}\right]\left[\frac{s^2}{m^2}\right] = \left[\frac{kg \cdot m^4 s^2}{kg \cdot m^4 s^2}\right] = \text{no units!}$$

$$F \times \frac{1}{\rho} \times \frac{1}{r^2} \times \frac{1}{v^2}$$

✓

17. The drag coefficient of a car C_D moving with a speed v through air of density ρ is given by

$$C_D = \frac{F}{\frac{1}{2}\rho v^2 A}$$

where F is the force, and A is the maximum cross-sectional area of the car perpendicular to the direction of travel. *Show that C_D is dimensionless.*

Units of F: $\left[\frac{kg \cdot m}{s^2}\right]$
Units of v: $\left[\frac{m}{s}\right]$
Units of ρ: $\left[\frac{kg}{m^3}\right]$
Units of A: $[m^2]$

$$\Rightarrow \left[\frac{kg \cdot m}{s^2}\right]\cdot\left[\frac{m^3}{kg}\right]\left[\frac{s^2}{m^2}\right]\left[\frac{1}{m^2}\right]$$

$$F \times \frac{1}{\rho} \times \frac{1}{v^2} \times \frac{1}{A}$$

$$= \left[\frac{kg\, m^4 s^2}{s^2\, kg\, m^4}\right] = \text{no units!}$$ ✓

18. Check to see if the following equations are dimensionally correct:

a) $F = mv^2 r$, where F = Force, m = mass, v = velocity and r = radius.

$\left[\frac{kg \cdot m}{s^2}\right]$ [kg] $\left[\frac{m}{s}\right]$ [m]

$$\text{So, } \left[\frac{kg \cdot m}{s^2}\right] \overset{?}{=} \left[\frac{kg}{1}\right]\left[\frac{m^2}{s^2}\right]\left[\frac{m}{1}\right] = \left[\frac{kg\, m^3}{s^2}\right]$$

∴ NOT CORRECT!

b) $E = mv^2$, where E = energy, m = mass and v = velocity.

$\left[\frac{kg\, m^2}{s^2}\right]$ [kg] $\left[\frac{m}{s}\right]$

$$\text{So, } \left[\frac{kg \cdot m^2}{s^2}\right] \overset{?}{=} \left[\frac{kg}{1}\right]\left[\frac{m^2}{s^2}\right] = \left[\frac{kg \cdot m^2}{s^2}\right]$$ ✓

∴ YES, CORRECT!

c) $c = \sqrt{\frac{p}{d}}$, where c = velocity, p = pressure and d = density.

$\left[\frac{m}{s}\right]$ $\left[\frac{kg}{m s^2}\right]$ $\left[\frac{kg}{m^3}\right]$

$$p = \frac{F}{A} = \left[\frac{kg\, m}{s^2}\right]\left[\frac{1}{m^2}\right]$$

$$\text{So, } \left[\frac{m}{s}\right] \overset{?}{=} \left[\frac{kg}{m s^2}\right]^{1/2} \cdot \left[\frac{m^3}{kg}\right]^{1/2} = \left[\frac{kg^{1/2}}{kg^{1/2}}\right]\left[\frac{1}{s}\right]\cdot\left[\frac{m}{1}\right] = \left[\frac{m}{s}\right]$$ ✓

∴ YES, CORRECT!