First homework ANSWERS

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1 SI units

1. Find out the names of the seven base units used in the SI system of units.

Quantity	Unit
mass	kilogram (kg)
length	metre (m)
time	second (s)
electric current	ampere (A)
temperature	kelvin (K)
amount of substance	mole (mol)
luminous intensity	candela (cd)

2. Find out the definitions of the two base units which interest you the most.

Unit	Definition
kg	The distance travelled by light in vacuum in $\frac{1}{299\,792\,458}$ second.
m	The mass of the International Prototype Kilogram.
s	The duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom.
A	The constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 m apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newtons per metre of length.
K	The fraction $\frac{1}{273.16}$ of the thermodynamic temperature of the triple point of water.
mol	The amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12.
cd	The luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of $\frac{1}{683}$ watt per steradian.

3. Find out the prefixes used in the SI system of units e.g. m, milli-, 10^{-3}. (You might want to lay these out in a table)

Prefix	Factor	Name
Y	10^{24}	yotta-
Z	10^{21}	zetta-
E	10^{18}	exa-
P	10^{15}	peta-
T	10^{12}	tera-
G	10^{9}	giga-
M	10^{6}	mega-
k	10^{3}	kilo-
h	10^{2}	hecto-
da	10^{1}	deca-
d	10^{-1}	deci-
c	10^{-2}	centi-
m	10^{-3}	milli-
µ	10^{-6}	micro-
n	10^{-9}	nano-
p	10^{-12}	pico-
f	10^{-15}	femto-
a	10^{-18}	atto-
z	10^{-21}	zepto-
y	10^{-24}	yocto-

2 Calculations / standard notation

1. How long does it take light to travel across a room of 6.0 m wide if the speed of light is $3.0 \times 10^8\,\mathrm{m\ s^{-1}}$

$$\begin{aligned}\text{speed} &= \frac{\text{distance}}{\text{time}}\\ \text{time} &= \frac{\text{distance}}{\text{speed}}\\ &= \frac{6.0\,\cancel{\mathrm{m}}}{3\times 10^8\,\cancel{\mathrm{m}}\,\mathrm{s^{-1}}}\\ &= 2\times 10^{-8}\,\mathrm{s}.\end{aligned}$$

2. Find the volume of a small rectangular chip of dimension $0.50 \times 1.00 \times 0.25$ mm. Give answers in $\mathrm{mm^3}$, $\mathrm{cm^3}$ and $\mathrm{m^3}$.

$$\begin{aligned}\text{Volume} &= \text{length} \times \text{width} \times \text{depth}\\ &= 0.50\,\mathrm{mm} \times 1.00\,\mathrm{mm} \times 0.25\,\mathrm{mm} = 0.125\,\mathrm{mm^3}\\ &= 0.05\,\mathrm{cm} \times 0.1\,\mathrm{cm} \times 0.025\,\mathrm{cm} = 1.25\times 10^{-4}\,\mathrm{cm^3}\\ &= 0.5\times 10^{-3}\,\mathrm{m} \times 1\times 10^{-3}\,\mathrm{m} \times 0.25\times 10^{-3}\,\mathrm{m} = 1.25\times 10^{-10}\,\mathrm{m^3}.\end{aligned}$$

3. The radius of the Earth is approximately 6.4×10^6 m. Find its surface area and its volume.

$$\begin{aligned}\text{Surface Area (sphere)} &= 4\pi r^2\\ &= 4\times\pi\times(6.4\times 10^6\,\mathrm{m})^2\\ &= 5.1\times 10^{14}\,\mathrm{m^2}.\end{aligned}$$

$$\begin{aligned}\text{Volume (sphere)} &= \frac{4}{3}\pi r^3 \\ &= \frac{4}{3} \times \pi \times (6.4 \times 10^6\,\text{m})^3 \\ &= 1.1 \times 10^{21}\,\text{m}^3.\end{aligned}$$

4. A fine wire has a diameter of 0.14 mm. Find its area of cross section in mm^2 and in m^2.

$$\begin{aligned}\text{Area (circle)} &= \pi r^2 \\ &= \pi \times (0.07\,\text{mm})^2 = 0.015\,\text{mm}^2 \\ &= \pi \times (0.07 \times 10^{-3}\,\text{m})^2 = 1.5 \times 10^{-8}\,\text{m}^2.\end{aligned}$$

5. One light year is the distance travelled by light in one year. The speed of light is $3.0 \times 10^8\,\text{m s}^{-1}$. If a star is 12 light years away, find the distance to it in metres.

$$\begin{aligned}\text{Distance} &= \text{speed} \times \text{time} \\ &= 3 \times 10^8\,\text{m/s} \times 12\,\text{year} \times 365\,\text{day/year} \times 24\,\text{hour/day} \times 60\,\text{min/hour} \times 60\,\text{s/min} \\ &= 1.1 \times 10^{17}\,\text{m}.\end{aligned}$$

6. The planet Venus is approximately 110 000 000 km from the Sun.

   (a) What is this distance in metres, written in standard form?

$$\begin{aligned}110\,000\,000\,\text{km} &= 110\,000\,000 \times 10^3\,\text{m} \\ &= 1.1 \times 10^{11}\,\text{m}.\end{aligned}$$

   (b) If its orbit were circular, how many metres would it travel to complete one orbit?

$$\begin{aligned}\text{Circumference} &= 2\pi r \\ &= 2 \times \pi \times 1.1 \times 10^{11}\,\text{m} \\ &= 6.9 \times 10^{11}\,\text{m}.\end{aligned}$$

7. The planet Mars is approximately 2.3×10^{11} m from the Sun. It takes about 690 days to travel once around the Sun. If its orbit were circular, find its average speed in m s^{-1}.

$$\begin{aligned}\text{speed} &= \frac{\text{distance}}{\text{time}} \\ &= \frac{2 \times \pi \times 2.3 \times 10^{11}\,\text{m}}{690\,\text{day} \times 24\,\text{hour/day} \times 60\,\text{min/hour} \times 60\,\text{s/min}} \\ &= 2.4 \times 10^3\,\text{m s}^{-1}.\end{aligned}$$