F1

(a) $293.45 = 2.934\,5 \times 10^2$, (b) $1\,380 = 1.380 \times 10^3$, (c) $-2\,804 = -2.804 \times 10^3$, (d) $0.005\,67 = 5.67 \times 10^{-3}$.

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F2

(a) 1.23×10^6, 727 and 0.043 2 all have three significant figures. (In some contexts 727 may be intended to represent an *exactly* known quantity.)

(b) 8.5×10^6 and 1.148×10^7 both have the same order of magnitude (i.e. the *nearest* 'power of ten' to each is 10^7), none of the others have matching orders of magnitude.

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F3

In the SI system, the unit of frequency f is hertz (Hz), which is equivalent to s^{-1}, X is dimensionless and therefore has no units, and the unit of speed c is $m\,s^{-1}$. Appropriate units for R are therefore $\dfrac{s^{-1}}{m\,s^{-1}} = \dfrac{1}{m} = m^{-1}$. Any quantity expressed in these units must have the dimensions of length^{-1}.

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R1

(a) $x^3 \times x^4 = x^7$,

(b) $x^5 \times x^{-2} = x^3$,

(c) $1/x^2 = x^{-2}$,

(d) $1/x^{-6} = x^6$,

(e) $x^8/x^3 = x^5$,

(f) $(x^4)^{-6} = x^{-24}$,

(g) $\sqrt{x^3}\sqrt{1/x^5} = \sqrt{x^3/x^5} = \pm x^{-1}$, where the symbol $\pm$ is a reminder that the square root of a positive quantity may be positive or negative.

(If you feel unsure about the use of *powers,* you should consult the relevant entry in the *Glossary* which will tell you where in *FLAP* the topic is more fully developed.)

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R2

Dividing both sides of the equation by $6\pi rv$ gives $F/(6\pi rv) = \eta$. (Consult *rearrangement* in the *Glossary* if you need further information about this process.)

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T1

The complete table is shown in Table 5.

Table 5 See Answer T1.

Number written in full		Number written using a product of 10		Number written as a power of 10
100 000		$10 \times 10 \times 10 \times 10 \times 10$		10^5
10 000		$10 \times 10 \times 10 \times 10$		10^4
1 000		$10 \times 10 \times 10$		10^3
100		10×10		10^2
10		10		10^1
1		1		10^0
0.1	1/10	1/10	$1/10^1$	10^{-1}
0.01	1/100	$1/(10 \times 10)$	$1/10^2$	10^{-2}
0.001	1/1000	$1/(10 \times 10 \times 10)$	$1/10^3$	10^{-3}

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T2

(a) The number of zeros after the 1, the number of tens multiplied together and the power of ten are all the same.

(b) The (negative) power of ten gives the position of the 1 after the decimal point, for example $10^{-2} = 0.01$ and the 1 is in the second place after the point. (Note that in part (b) the number of zeros after the decimal point is *not* the same as the (negative) power of 10.)

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T3

(a) $3.2 \times 10^6 = 3.2 \times 1\,000\,000 = 3\,200\,000$ (You will see later that such numbers may be misleading, hence the need for scientific notation.)

(b) $8.76 \times 10^{-4} = 8.76 \times 0.000\,1 = 0.000\,876$.

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T4

(a) $98\,765 = 9.876\,5 \times 10\,000 = 9.876\,5 \times 10^4$.

(b) $0.004\,32 = 4.32 \times 0.001 = 4.32 \times 10^{-3}$.

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T5

(a) $1.40 \times 10^4 \times 5.50 \times 10^{13} \times 6.20 \times 10^{-15}$

$= 1.40 \times 5.50 \times 6.20 \times 10^2$.

(b) $2 \times 10^6 \times 3 \times 10^5/(8 \times 10^7) = (2 \times 3 \times 1/8) \times 10^4$.

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T6

(a) $1.40 \times 10^4 \times 5.50 \times 10^{13} \times 6.20 \times 10^{-15}$

$= 4.774 \times 10^3$.

In evaluating this you should have collected together terms before punching any keys on your calculator.

(b) $2 \times 10^6 \times 3 \times 10^5/(8 \times 10^7) = 7.5 \times 10^3$.

(You will see later when *significant figures* are discussed that these answers may not be reliable.)

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T7

(a) $|2.3| = 2.3$

(b) $|-3.1| = 3.1$

(c) $|(4-7)/2| = |-3/2| = 3/2$

(d) $|(4-5)(7-9)| = |(-1)(-2)| = |2| = 2$

(e) $|2|/|4| = 1/2$

(f) $|-6||3| = 18.$

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T8

(a) 65.43 has four significant figures, two decimal places;

(b) 0.003 56 has three significant figures, five decimal places;

(c) 2 278 has four significant figures, no decimal place;

(d) 3.04×10^{-5} has three significant figures, seven decimal places. It should be noted that this last answer needs careful interpretation since the decimal part of the number (3.04) is only specified to two decimal places.

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T9

(a) Only two figures are significant since one of the dimensions (0.23 m) is only known to two significant figures. The volume is therefore $4.1 \times 10^{-3}\ \mathrm{m}^3$.

(b) Since the volume has only two significant figures, the density will have only two significant figures.

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T10

(a) Mass of the Sun ~ 10^{30} kg;

(b) radius of the Sun ~ 10^{9} m;

(c) mass of a proton ~ 10^{-27} kg;

(d) mass of an electron ~ 10^{-30} kg.

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T11

$z \approx 7 \times 9 \times 10^3 \times 10^2/(2 \times 4 \times 10^4 \times 10^5) \approx 7 \times 10^{-4}$, so $z \sim 10^{-3}$.

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T12

(a) True, the set of integers is a subset of the set of real numbers.

(b) True, since $\sqrt{8} = 2\sqrt{2}$ and $\sqrt{2}$ is irrational.

(c) False, all natural numbers are positive.

(d) The use of three significant figures indicates that 2.00 is a real number in the range 1.995 000 ... to 2.004 999 ..., so the statement is false. However, in practice you will meet many cases where the intended meaning is unclear, so you should be prepared to use all available information to arrive at the most reasonable interpretation in any given situation.

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T13

(a) 2 is an integer and π is an irrational number.

(b) The value of 2 is exact, so does not affect the precision of the answer. The value of π can be expressed to at least as many figures as l and g so will not adversely affect the precision of the answer.

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T14

If the equation is rearranged

$$\varepsilon_0 = q_1 q_2/(4\pi F_{el} r^2) = \text{(numerical factor)} \times \mathrm{C}^2/\mathrm{N\ m}^2$$

The SI units of ε_0 are therefore $\mathrm{C}^2\ \mathrm{N}^{-1}\ \mathrm{m}^{-2}$.

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T15

(a) [density] = [mass/volume] = [mass/length^3]

$= \mathrm{M\,L^{-3}}$

(b) $[G] = [F_{\mathrm{grav}} r^2/(m_1 m_2)]$ = [force × length^2/mass^2]

$= \mathrm{M\,L\,T^{-2}} \times \mathrm{L^2\,M^{-2}} = \mathrm{M^{-1}\,L^3\,T^{-2}}$ (The dimensions of force were worked out earlier in the text.)

(c) [speed] = [length/time] = $\mathrm{L\,T^{-1}}$.

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T16

The dimensions of energy can be determined by examining the definition of the SI unit of energy (the joule) in Table 4; [energy] = $\mathrm{M\,L^2\,T^{-2}}$. Therefore the implausible expressions are (c) because $[mv/4] = \mathrm{M\,L\,T^{-1}}$, (d) because $[mh/2] = \mathrm{M\,L}$, and (g) because the second term has dimensions
$[F^2h/(mv^2)] = \mathrm{M^2\,L^2\,T^{-4}\,L/(M\,L^2\,T^{-2})} = \mathrm{M\,L\,T^{-2}}$.

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