Maths skills

1 Measurements

Practice questions

1

Physical quantity	Equation used to derive unit	Unit	Symbol and name (if there is one)
frequency	period^{-1}	s^{-1}	Hz, hertz
volume	length^3	m^3	–
density	mass ÷ volume	kg m^{-3}	–
acceleration	velocity ÷ time	m s^{-2}	–
force	mass × acceleration	kg m s^{-2}	N newton
work and energy	force × distance	N m (or kg m^2 s^{-2})	J joule

2 **a** 19 m **b** 21 s
c 1.7×10^{-27} kg **d** 5.0 s

3 Resistance $= \frac{12\text{ V}}{1.8\text{ mA}} = \frac{12\text{ V}}{0.0018\text{ A}} = 6666.666...\Omega = 6.66666...\text{k}\Omega = 6.67\Omega$

4 **a** 5.7 cm ± 2% **b** 450 kg ± 0.4%
c 10.6 s ± 0.5% **d** 366 000 J ± 0.3%

5 **a** 1200 ± 120 W **b** 330 000 ± 1650 Ω

6 **D** 1400 ± 5 mm (Did you calculate them all? The same absolute error means the percentage error will be smallest in the largest measurement, so no need to calculate.)

2 Standard form and prefixes

Practice questions

1 **a** 1.35×10^3 W (or 1.350×10^3 W to 4 s.f.) **b** 1.3×10^5 Pa
c 6.96×10^8 s **d** 1.76×10^{11} C kg^{-1}

2 **a** 2 260 000 J in 1 kg, so there will be 1000 times fewer J in 1 g: $\frac{2\,260\,000}{1000} = 2260$ J/g

b 1 kJ = 1000 J, $2\,260\,000\text{ J/kg} = \frac{2\,260\,000}{1000}\text{kJ/kg} = 2260\text{ kJ/kg}$

c 1 MJ = 1000 kJ, so $2260\text{ kJ/kg} = \frac{2260}{1000}\text{MJ/kg} = 2.26\text{ MJ/kg}$

3 **a** 2.5×10^{-3} m **b** 1.60×10^{-15} m
c 1×10^{-8} J **d** 5×10^3 m
e 6.2×10^{-1} N

4 **a** 2.5 μm **b** 1.60 f m
c 10 nJ **or** 0.01 μJ **d** 5 km

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e 0.62 N **or** 62 cN

5 **a** 0.009 m = 9×10^{-3} m = 9 mm

b 1×10^{-5} m = $1 \times 10 \times 10^{-6}$ m = 10×10^{-6} m = 10 μm

c 4.7×10^{-7} m = $4.7 \times 100 \times 10^{-9}$ m = 470×10^{-9} m = 470 nm

6 **a** 64000000 **or** 6.4×10^{7} **b** 99.99

c 800 **d** 10^{3}

7 **a** 3.0×10^{8} m s^{-1} ÷ 3.03×10^{-7} m = 1.0×10^{15} Hz

b 3.0×10^{8} m s^{-1} ÷ 1000 m = 3.0×10^{5} Hz

c 3.0×10^{8} m s^{-1} ÷ 1.0×10^{-10} m = 3.0×10^{18} Hz

3 Resolving vectors

Practice questions

1 **Scalars:** density, electric charge, electrical resistance, energy, frequency, mass, power, temperature, voltage, volume, work done

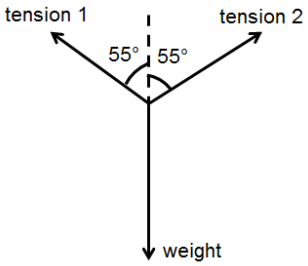
Vectors: field strength, force, friction, momentum, weight

2 **Scalars:** 3 ms^{-1}, 50 km, 273 °C, 50 kg, 3 A

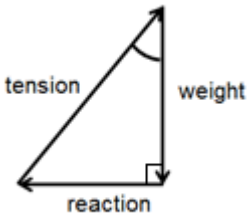
Vectors: +20 ms^{-1}, 100 m NE, −5 cm, 10 km S 30°W, 3×10^{8} m/s upwards

3 13 kN

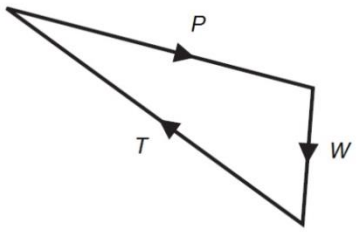
4 **Free body force diagram:**



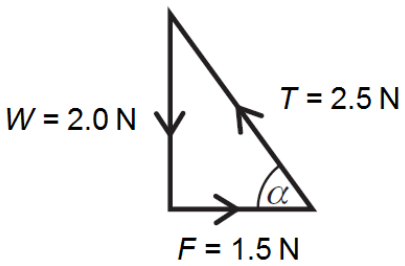
Triangle of forces:



5



6



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7 **a** 5.0 N at 37° to the 4.0 N force **b** 13 N at 23° to the 12.0 N force

4 Rearranging equations

Practice questions

1 $V = 12$ V and $I = 0.25$ A

$V = I R$ so $12 = 0.25 \times R$

$R = \frac{V}{I} = \frac{12}{0.25} = 48\ \Omega$

2 $\lambda = 650$ nm $= 650\times10^{-9}$ m and $v = 3.0\times10^{8}$ m/s

$v = f \lambda$ so $3.0\times10^{8} = f \times 650\times10^{-9}$

$f = \frac{v}{\lambda} = \frac{3.0\times10^{8}}{650\times10^{-9}} = 0.00462\times10^{17} = 4.62\times10^{14}$ Hz

3 $E = 4.01\times10^{4}$ J and $m = 0.120$ g $= 0.120$ kg

$E = mL$ so $4.01\times10^{4} = 0.120 \times L$

$L = \frac{E}{m} = \frac{4.01\times10^{4}}{0.120} = 334\,166$ J/kg $= 3.34\times10^{5}$ J/kg in standard form

5 Work done, power, and efficiency

Practice questions

1 22×10^{3} N $\times$ 2×10^{3} m $= 44\,000\,000$ J $= 44$ MJ

2 $\frac{62.5\times10^{3}\ \text{J}}{500\ \text{N}} = 125$ m

3 $\frac{260\,000\ \text{N}\times25\ \text{m}}{48\ \text{s}} = 13\,541.6$ W $= 14\,000$ W or 14 kW (2 s.f.)

4 $\frac{2500\ \text{N}\times15\ \text{m}}{5\ \text{s}} = 7500$ W $= 7.5$ kW

5 $\frac{8400}{11200} \times 100 = 75\%$

6 $\frac{850}{1.2\times10^{3}} \times 100 = 71\%$

7 $\frac{7.5}{8.0} \times 100 = 94\%$

8 0.74 s

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