Contents

Chapter 1

Physical quantities and units

1.1 Physical quantities

1. 9702_m20_qp_12 Q: 1

The table shows some measurable quantities.

Which row gives the correct order of magnitude of the measurable quantity in the stated unit?

	measurable quantity	order of magnitude	unit
A	mass of a coin	10^{-4}	kg
B	thickness of a sheet of paper	10^{-2}	m
C	weight of an apple	10^{0}	N
D	temperature of a person's body	10^{1}	K

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2. 9702_s20_qp_11 Q: 1

What is a reasonable estimate of the kinetic energy of a car travelling at a speed of $30\,m\,s^{-1}$?

A $10^{2}\,J$ **B** $10^{4}\,J$ **C** $10^{6}\,J$ **D** $10^{8}\,J$

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3. 9702_s20_qp_12 Q: 1

What is a reasonable estimate of the mass of a raindrop?

A $10^{1}\,kg$ **B** $10^{-1}\,kg$ **C** $10^{-3}\,kg$ **D** $10^{-5}\,kg$

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4. 9702_s20_qp_13 Q: 1

A man is running a race in a straight line.

What is an approximate value of his kinetic energy?

A 10 J **B** 100 J **C** 1000 J **D** 10 000 J

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5. 9702_s19_qp_13 Q: 4

What is the approximate kinetic energy of an Olympic athlete when running at maximum speed during a 100 m race?

A 400 J **B** 4000 J **C** 40 000 J **D** 400 000 J

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6. 9702_w19_qp_11 Q: 1

For which quantity is the magnitude a reasonable estimate?

A frequency of a radio wave 500 pHz

B mass of an atom 500 μg

C the Young modulus of a metal 500 kPa

D wavelength of green light 500 nm

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7. 9702_w19_qp_12 Q: 1

A cyclist has a speed of 5 m s^{-1} and a small car has a speed of 12 m s^{-1}.

Which statement does **not** give a reasonable estimate?

A The kinetic energy of the cyclist is 1×10^3 J.

B The kinetic energy of the car is 7×10^4 J.

C The momentum of the cyclist is 4×10^2 kg m s^{-1}.

D The momentum of the car is 2×10^5 kg m s^{-1}.

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8. 9702_s18_qp_11 Q: 1

What is a unit for stress?

A kg m^{-1} s^{-2} **B** kg m^{-2} s^{-2} **C** N m^{-1} **D** N m

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9. 9702_s18_qp_12 Q: 1

A sheet of gold leaf has a thickness of 0.125 μm. A gold atom has a radius of 174 pm.

Approximately how many layers of atoms are there in the sheet?

A 4 **B** 7 **C** 400 **D** 700

---

10. 9702_s18_qp_13 Q: 1

What is the best way of describing a physical quantity?

A a quantity with a magnitude and a direction but no unit

B a quantity with a magnitude and a unit

C a quantity with a magnitude but no direction

D a quantity with a unit but no magnitude

---

11. 9702_w18_qp_11 Q: 1

The radius of the Earth is approximately 6.4×10^6 m, and the radius of the Moon is approximately 1.7×10^6 m. A student wishes to build a scale model of the Solar System in the classroom, using a football of radius 0.12 m to represent the Earth.

Which object would best represent the Moon?

A basketball

B cherry

C golf ball

D tennis ball

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12. 9702_w18_qp_12 Q: 1

A car is travelling at a speed of 20 m s^{-1}. The table contains values for the kinetic energy and the momentum of the car.

Which values are reasonable estimates?

	kinetic energy / J	momentum / kg m s^{-1}
A	3×10^5	3×10^4
B	3×10^5	5×10^6
C	2×10^7	3×10^4
D	2×10^7	5×10^6

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13. 9702_w18_qp_13 Q: 1

Which statement is **not** a reasonable estimate?

A Atmospheric pressure at sea level is about 1×10^5 Pa.

B Light takes 5×10^2 s to reach us from the Sun.

C The frequency of ultraviolet light is 3×10^{12} Hz.

D The lifespan of a man is about 2×10^9 s.

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14. 9702_m17_qp_12 Q: 2

What is an approximate value for the speed of sound in air?

A $30\,m\,s^{-1}$ **B** $300\,m\,s^{-1}$ **C** $30\,000\,m\,s^{-1}$ **D** $300\,000\,000\,m\,s^{-1}$

---

15. 9702_s17_qp_11 Q: 1

A student creates a table to show reasonable estimates of some physical quantities.

Which row is **not** a reasonable estimate?

	quantity	value
A	current in a fan heater	12 A
B	mass of an adult person	70 kg
C	speed of an Olympic sprint runner	$10\,m\,s^{-1}$
D	water pressure at the bottom of a garden pond	10^6 Pa

---

16. 9702_s17_qp_12 Q: 1

What is the approximate average speed of a winning female Olympic athlete running a 100 m race?

A $6\,m\,s^{-1}$ **B** $9\,m\,s^{-1}$ **C** $12\,m\,s^{-1}$ **D** $15\,m\,s^{-1}$

---

17. 9702_s17_qp_13 Q: 1

What is the best estimate of the kinetic energy of a family car travelling at $50\,km\,h^{-1}$?

A 1.5×10^3 J **B** 1.5×10^5 J **C** 1.5×10^7 J **D** 1.5×10^9 J

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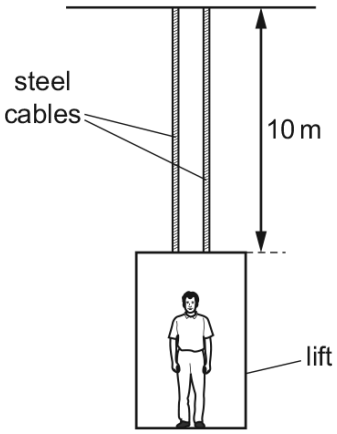
18. 9702_s16_qp_11 Q: 3

A lift is supported by two steel cables, each of length 10 m and diameter 0.5 cm.



NOT TO SCALE

The cables extend by 1 mm when a man of mass 80 kg steps into the lift.

What is the best estimate of the value of the Young modulus of the steel?

A $2 \times 10^{10}\,\text{N m}^{-2}$

B $4 \times 10^{10}\,\text{N m}^{-2}$

C $2 \times 10^{11}\,\text{N m}^{-2}$

D $4 \times 10^{11}\,\text{N m}^{-2}$

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19. 9702_s16_qp_12 Q: 1

Which quantity with its unit is correct?

A acceleration of a bicycle = $1.4\,\text{m s}^{-1}$

B electric current in a lamp = $0.25\,\text{A s}^{-1}$

C electric potential difference across a battery = $8.0\,\text{J C}^{-1}$

D kinetic energy of a car = $4500\,\text{N m}^{-1}$

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20. 9702_w16_qp_11 Q: 1

What is the order of magnitude of the Young modulus for a metal such as copper?

A $10^{-11}\,\text{Pa}$ **B** $10^{-4}\,\text{Pa}$ **C** $10^{4}\,\text{Pa}$ **D** $10^{11}\,\text{Pa}$

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21. 9702_w16_qp_13 Q: 1

What is the order of magnitude of the Young modulus for a metal such as copper?

A $10^{-11}\,\text{Pa}$ **B** $10^{-4}\,\text{Pa}$ **C** $10^{4}\,\text{Pa}$ **D** $10^{11}\,\text{Pa}$

1.2 SI units

22. 9702_m20_qp_12 Q: 2

A byte (b) comprises 8 bits.

How many bits are there in 1 terabyte (1Tb)?

A 1×10^{9} **B** 8×10^{9} **C** 1×10^{12} **D** 8×10^{12}

---

23. 9702_s20_qp_11 Q: 2

The frequency f of vibration of a mass m supported by a spring with spring constant k is given by the equation

$$f = Cm^{p}k^{q}$$

where C is a constant with no units.

What are the values of p and q?

	p	q
A	$-\frac{1}{2}$	$-\frac{1}{2}$
B	$-\frac{1}{2}$	$\frac{1}{2}$
C	$\frac{1}{2}$	$-\frac{1}{2}$
D	$\frac{1}{2}$	$\frac{1}{2}$

---

24. 9702_s20_qp_13 Q: 2

A sample of gas has a mass of 4.8 μg and occupies a volume of 1.2 dm^3.

What is the density of the sample of gas?

A $4.0 \times 10^{-3}\,kg\,m^{-3}$

B $4.0 \times 10^{-5}\,kg\,m^{-3}$

C $4.0 \times 10^{-6}\,kg\,m^{-3}$

D $4.0 \times 10^{-8}\,kg\,m^{-3}$

---

25. 9702_m19_qp_12 Q: 2

At temperatures close to 0 K, the specific heat capacity c of a particular solid is given by $c = bT^3$, where T is the temperature and b is a constant, characteristic of the solid.
The SI unit of specific heat capacity is $J\,kg^{-1}\,K^{-1}$.

What is the unit of constant b, expressed in SI base units?

A $m^2\,s^{-2}\,K^{-3}$

B $m^2\,s^{-2}\,K^{-4}$

C $kg\,m^2\,s^{-2}\,K^{-3}$

D $kg\,m^2\,s^{-2}\,K^{-4}$

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26. 9702_s19_qp_11 Q: 1

Which unit can be expressed in base units as $kg\,m^2\,s^{-2}$?

A joule

B newton

C pascal

D watt

---

27. 9702_s19_qp_11 Q: 2

The luminosity L of a star is given by

$$L = 4\pi r^2 \sigma T^4$$

where

r is the radius of the star,

T is the temperature of the star and

σ is a constant with units $W\,m^{-2}\,K^{-4}$.

What are the SI base units of L?

A $kg\,m^2\,s^{-1}$ **B** $kg\,m^2\,s^{-2}$ **C** $kg\,m^2\,s^{-3}$ **D** $kg\,m^2\,s^{-4}$

---

28. 9702_s19_qp_12 Q: 1

What is equivalent to 2000 microvolts?

A $2\,\mu J\,C^{-1}$ **B** 2 mV **C** 2 pV **D** 2000 mV

---

29. 9702_s19_qp_12 Q: 2

What is the number of SI base units required to express electric field strength and power?

	electric field strength	power
A	3	3
B	3	2
C	4	2
D	4	3

---

30. 9702_s19_qp_12 Q: 3

The Planck constant h has SI units J s.

Which equation could be used to calculate the Planck constant?

A $h = \frac{DE}{v}$ where D is distance, E is energy and v is velocity

B $h = \frac{v}{D}$ where v is velocity and D is distance

C $h = \frac{1}{4\pi E}$ where E is electric field strength

D $h = \frac{Fr^2}{m}$ where F is force, r is radius and m is mass

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31. 9702_s19_qp_13 Q: 1

Which is an SI base unit?

A current

B gram

C kelvin

D volt

---

32. 9702_s19_qp_13 Q: 2

Osmium, a naturally occurring element, has a density of 23 000 kg m^{-3}.

What is also a value of the density of osmium?

A $2.3 \times 10^4\,\mu g\,cm^{-3}$

B $2.3 \times 10^4\,g\,cm^{-3}$

C $2.3\,kg\,cm^{-3}$

D $2.3 \times 10^{-2}\,kg\,cm^{-3}$

---

33. 9702_w19_qp_11 Q: 2

The speed of a wave in deep water depends on its wavelength L and the acceleration of free fall g.

What is a possible equation for the speed v of the wave?

A $v = \sqrt{\left(\frac{gL}{2\pi}\right)}$ **B** $v = \frac{gL}{4\pi^2}$ **C** $v = 2\pi\sqrt{\left(\frac{g}{L}\right)}$ **D** $v = \frac{2\pi g}{L}$

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34. 9702_w19_qp_12 Q: 2

Which expression gives an SI base quantity?

A charge per unit time

B force per unit area

C mass per unit volume

D work done per unit distance

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35. 9702_w19_qp_13 Q: 1

Which quantity with its unit is correct?

A acceleration of a bicycle = 1.4 m s^{-1}

B electric current in a lamp = 0.25 A s^{-1}

C electric potential difference across a battery = 8.0 J C^{-1}

D kinetic energy of a car = 4500 N m^{-1}

---

36. 9702_w19_qp_13 Q: 2

Which two units are **not** equivalent to each other?

A N m and $kg\,m^2\,s^{-2}$

B N s and $kg\,m\,s^{-1}$

C $J\,s^{-1}$ and $kg\,m^2\,s^{-3}$

D Pa and $kg\,m\,s^{-2}$

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37. 9702_m18_qp_12 Q: 1

Which unit is equivalent to the coulomb?

A ampere per second

B joule per volt

C watt per ampere

D watt per volt

---

38. 9702_m18_qp_12 Q: 2

Which row shows a quantity and an **incorrect** unit?

	quantity	unit
A	efficiency	no unit
B	moment of force	$N\,m^{-1}$
C	momentum	N s
D	work done	J

---

39. 9702_s18_qp_12 Q: 2

The drag coefficient C_d is a number with no units. It is used to compare the drag on different cars at different speeds. C_d is given by the equation

$$C_d = \frac{2F}{v^n \rho A}$$

where F is the drag force on the car, ρ is the density of the air, A is the cross-sectional area of the car and v is the speed of the car.

What is the value of n?

A 1 **B** 2 **C** 3 **D** 4

---

40. 9702_w18_qp_11 Q: 2

When a beam of light is incident on a surface, it delivers energy to the surface. The intensity of the beam is defined as the energy delivered per unit area per unit time.

What is the unit of intensity, expressed in SI base units?

A $\mathrm{kg\,m^{-2}\,s^{-1}}$ **B** $\mathrm{kg\,m^{2}\,s^{-3}}$ **C** $\mathrm{kg\,s^{-2}}$ **D** $\mathrm{kg\,s^{-3}}$

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41. 9702_w18_qp_12 Q: 2

What is the unit of resistance when expressed in SI base units?

A $\mathrm{kg\,m^{2}\,s^{-2}\,A^{-1}}$

B $\mathrm{kg\,m^{2}\,s^{-3}\,A^{-2}}$

C $\mathrm{kg\,m\,s^{-2}\,A^{-1}}$

D $\mathrm{kg\,m\,s^{-3}\,A^{-1}}$

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42. 9702_w18_qp_13 Q: 2

Three of these quantities have the same unit.

Which quantity has a different unit?

A $\dfrac{\text{energy}}{\text{distance}}$

B force

C power $\times$ time

D rate of change of momentum

---

43. 9702_m17_qp_12 Q: 1

Which expression has the same SI base units as pressure?

A $\dfrac{\text{force}}{\text{length} \times \text{speed}}$

B $\dfrac{\text{force}}{\text{length} \times \text{time}}$

C $\dfrac{\text{mass}}{\text{length} \times (\text{time})^2}$

D $\dfrac{\text{mass} \times (\text{time})^2}{\text{length}}$

---

44. 9702_s17_qp_12 Q: 3

What correctly expresses the volt in terms of SI base units?

A $A\,\Omega$

B $W\,A^{-1}$

C $kg\,m^2\,s^{-1}\,A^{-1}$

D $kg\,m^2\,s^{-3}\,A^{-1}$

---

45. 9702_s17_qp_13 Q: 3

Which expression using SI base units is equivalent to the volt?

A $kg\,m^2\,s^{-1}\,A^{-1}$

B $kg\,m\,s^{-2}\,A$

C $kg\,m^2\,s^{-1}\,A$

D $kg\,m^2\,s^{-3}\,A^{-1}$

---

46. 9702_w17_qp_11 Q: 1

Which SI unit, expressed in base units, is **not** correct?

A unit of force, $kg\,m\,s^{-2}$

B unit of momentum, $kg\,m\,s^{-1}$

C unit of pressure, $kg\,m^{-2}\,s^{-2}$

D unit of work, $kg\,m^2\,s^{-2}$

---

47. 9702_w17_qp_12 Q: 1

Which pair of units are **not** the same when expressed in SI base units?

A $m\,s^{-2}$ and $N\,kg^{-1}$

B $N\,s$ and $kg\,m\,s^{-1}$

C Pa and $N\,m^{-2}$

D $V\,m^{-2}$ and $N\,C^{-1}$

---

48. 9702_w17_qp_12 Q: 3

The units of specific heat capacity are $J\,kg^{-1}\,K^{-1}$.

What are the SI base units of specific heat capacity?

A $m\,s^{-2}\,K^{-1}$ **B** $m\,s^{-1}\,K^{-1}$ **C** $m^2\,s^{-2}\,K^{-1}$ **D** $m^2\,s^{-1}\,K^{-1}$

---

49. 9702_w17_qp_13 Q: 1

How many cubic nanometres, nm^3, are in a cubic micrometre, μm^3?

A 10^3 **B** 10^6 **C** 10^9 **D** 10^{12}

---

50. 9702_w17_qp_13 Q: 2

The maximum theoretical power P of a wind turbine is given by the equation

$$P = k\rho A v^n$$

where ρ is the density of air, A is the area swept by the turbine blades, v is the speed of the air and k is a constant with no units.

What is the value of n?

A 1 **B** 2 **C** 3 **D** 4

---

51. 9702_m16_qp_12 Q: 1

The prefixes nano (n), micro (μ) and pico (p) are often used with units.

Which row shows their correct values?

	n	μ	p
A	10^{-6}	10^{-9}	10^{-12}
B	10^{-6}	10^{-12}	10^{-9}
C	10^{-9}	10^{-6}	10^{-12}
D	10^{-12}	10^{-9}	10^{-6}

---

52. 9702_m16_qp_12 Q: 3

The SI unit of specific heat capacity is $J\,kg^{-1}\,K^{-1}$.

What is the unit of specific heat capacity expressed in SI base units?

A $m\,s^{-2}\,K^{-1}$ **B** $kg\,m\,s^{-1}\,K^{-1}$ **C** $m^2\,s^{-2}\,K^{-1}$ **D** $kg\,m^2\,s^{-1}\,K^{-1}$

Appendix A

Answers

SN	Paper	Q. No.	Answer
1	9702_m20_qp_12	1	C
2	9702_s20_qp_11	1	C
3	9702_s20_qp_12	1	D
4	9702_s20_qp_13	1	C
5	9702_s19_qp_13	4	B
6	9702_w19_qp_11	1	D
7	9702_w19_qp_12	1	D
8	9702_s18_qp_11	1	A
9	9702_s18_qp_12	1	C
10	9702_s18_qp_13	1	B
11	9702_w18_qp_11	1	D
12	9702_w18_qp_12	1	A
13	9702_w18_qp_13	1	C
14	9702_m17_qp_12	2	B
15	9702_s17_qp_11	1	D
16	9702_s17_qp_12	1	B
17	9702_s17_qp_13	1	B
18	9702_s16_qp_11	3	C
19	9702_s16_qp_12	1	C
20	9702_w16_qp_11	1	D
21	9702_w16_qp_13	1	D
22	9702_m20_qp_12	2	D
23	9702_s20_qp_11	2	B
24	9702_s20_qp_13	2	C
25	9702_m19_qp_12	2	B
26	9702_s19_qp_11	1	A
27	9702_s19_qp_11	2	C
28	9702_s19_qp_12	1	B
29	9702_s19_qp_12	2	D
30	9702_s19_qp_12	3	A
31	9702_s19_qp_13	1	C
32	9702_s19_qp_13	2	D
33	9702_w19_qp_11	2	A
34	9702_w19_qp_12	2	A
35	9702_w19_qp_13	1	C
36	9702_w19_qp_13	2	D
37	9702_m18_qp_12	1	B
38	9702_m18_qp_12	2	B
39	9702_s18_qp_12	2	B
40	9702_w18_qp_11	2	D
41	9702_w18_qp_12	2	B

SN	Paper	Q. No.	Answer
42	9702_w18_qp_13	2	C
43	9702_m17_qp_12	1	C
44	9702_s17_qp_12	3	D
45	9702_s17_qp_13	3	D
46	9702_w17_qp_11	1	C
47	9702_w17_qp_12	1	D
48	9702_w17_qp_12	3	C
49	9702_w17_qp_13	1	C
50	9702_w17_qp_13	2	C
51	9702_m16_qp_12	1	C
52	9702_m16_qp_12	3	C
53	9702_s16_qp_11	2	C
54	9702_s16_qp_12	2	C
55	9702_s16_qp_13	1	D
56	9702_s16_qp_13	2	B
57	9702_w16_qp_11	2	B
58	9702_w16_qp_12	1	B
59	9702_w16_qp_12	2	D
60	9702_w16_qp_13	2	B
61	9702_s15_qp_11	1	C
62	9702_s15_qp_11	3	A
63	9702_s15_qp_12	1	C
64	9702_s15_qp_12	2	D
65	9702_s15_qp_13	1	C
66	9702_s15_qp_13	2	D
67	9702_m20_qp_12	3	D
68	9702_s20_qp_11	3	B
69	9702_s20_qp_12	2	C
70	9702_s20_qp_13	3	A
71	9702_s19_qp_12	4	C
72	9702_s19_qp_13	3	C
73	9702_w19_qp_11	3	A
74	9702_w19_qp_12	3	B
75	9702_w19_qp_13	3	C
76	9702_m18_qp_12	3	D
77	9702_m18_qp_12	5	B
78	9702_s18_qp_11	2	C
79	9702_s18_qp_11	3	C
80	9702_s18_qp_13	2	B
81	9702_s18_qp_13	3	A
82	9702_w18_qp_11	3	B
83	9702_w18_qp_12	3	B