



Attempt questions first; check the separate key afterward. Show units, dimensions, significant figures and uncertainty steps where relevant.

### A. Very short answers - 1 mark each

1. What is a fundamental quantity? Give two examples with their SI units.
2. State the principle of dimensional homogeneity.
3. How many significant figures occur in 0.005070 and  $2.00 \times 10^3$ ?
4. Can a dimensionless quantity have a unit? Give one example.
5. Distinguish between accuracy and precision in measurement.

### B. Short answers / practice - 2 marks each

6. Express the SI units of force and energy in terms of base units.
7. Round 8.7462 to three significant figures. Evaluate  $12.11 + 0.3 + 1.024$  to appropriate precision.
8. Obtain the dimensional formulae of pressure and impulse.
9. A density is  $160 \text{ kg/m}^3$ . Express its numerical value in a system with mass unit 20 g and length unit 10 cm.
10. Find the dimensions of a and b in  $x = at^2 + bt^3$ , where x is displacement and t is time.
11. Convert 72 km/h to SI speed.
12. Find dimensions of angular momentum.
13. How many significant figures are in 0.0200?
14. Convert  $5 \text{ cm}^2$  to  $\text{m}^2$ .
15. Can a dimensionally incorrect equation be physically correct?
16. Find dimensions of power.
17. Find dimensions of surface tension.
18. Express  $3 \mu\text{m}$  in metres.
19. Find percentage error in  $x^2$  if x has 1% error.
20. Explain why measured results should not contain unjustified significant digits.

### C. Application / reasoning - 3 marks each

21. Check the dimensional validity of  $v^2 = u^2 + 2as$ . Explain why this check cannot prove the equation physically correct.

22. A length is  $(12.4 \pm 0.1) \text{ cm}$  and a breadth is  $(5.0 \pm 0.1) \text{ cm}$ . Find their area and maximum percentage uncertainty.

23. The radius of a sphere has 2% uncertainty and its mass 3%. Determine the maximum percentage uncertainty in its density.

24. Find the dimensions of a and b in  $(P + a/V^2)(V - b) = RT$  for one mole, with V denoting volume.

25. A force depends on velocity as  $F = av + bv^2$ . Find the dimensions and SI units of a and b.

26. For readings 2.41, 2.43, 2.42 and 2.44 cm, calculate the mean, mean absolute error and relative error.

### D. Extended practice - 5 marks each

27. Assume a pendulum's period depends on length l, mass m and gravitational acceleration g. Use dimensional analysis to obtain its form. State two limitations of this method.
28. A cylinder has  $r = (1.00 \pm 0.01) \text{ cm}$  and  $h = (10.0 \pm 0.1) \text{ cm}$ . Find its volume, maximum percentage error and absolute error. Use  $\pi = 3.14$ .
29. Using dimensions, obtain the dependence of a stretched string's wave speed on tension F and linear mass density  $\mu$ . Explain why dimensions cannot determine a numerical constant.
30. Derive the rule for changing the numerical value of a quantity of dimensions  $M^a L^b T^c$  between unit systems. Hence convert 1 J into erg.

### ANSWER KEY - Numerical / closed questions

- 3) 4 and 3. 4) Yes; plane angle has unit radian. 6) Force  $\text{kg m s}^{-2}$ ; energy  $\text{kg m}^2 \text{s}^{-2}$ . 7) 8.75; 13.4. 8) Pressure  $\text{ML}^{-1}\text{T}^{-2}$ ; impulse  $\text{MLT}^{-1}$ . 9) 8. 10) a:  $\text{LT}^{-2}$ ; b:  $\text{LT}^{-3}$ . 11) 20 m/s. 12)  $\text{ML}^2\text{T}^{-1}$ . 13) 3. 14)  $5 \times 10^{-4} \text{ m}^2$ . 15) No. 16)  $\text{ML}^2\text{T}^{-3}$ . 17)  $\text{MT}^{-2}$ . 18)  $3 \times 10^{-6} \text{ m}$ . 19) 2% maximum. 21) Dimensionally valid; numerical constants cannot be checked. 22)  $62 \text{ cm}^2$ ; maximum uncertainty 2.81% (about  $1.74 \text{ cm}^2$ ). 23) 9%. 24) a:  $\text{ML}^5\text{T}^{-2}$ ; b:  $\text{L}^3$ . 25) a:  $\text{MT}^{-1}$ , kg/s; b:  $\text{ML}^{-1}$ , kg/m. 26) 2.425 cm; 0.010 cm; 0.00412. 27)  $T = C\sqrt{l/g}$ , independent of m. 28)  $31.4 \text{ cm}^3$ ; 3%; 0.942  $\text{cm}^3$ . 29)  $v = C\sqrt{F/\mu}$ . 30) 1 J =  $10^7$  erg.