CLASS – 11

WORKSHEET- Units and Measurement

(1 mark questions)

1. Which of the following system of units is not based on unit of mass, length and time?

   (a) CGS (b) FPS (c) MKS (d) SI

   _____

2. Which of the following measurements is most precise?

   (a) 5.00km (b) 5.00 m (c) 5.00 cm (d) 5.00 mm

   _____

3. Name any three physical quantities having the same dimensions and also give their dimensions.

   _____

   _____

4. How many light years are there in one metre?

   _____

5. Name the physical quantities whose dimensional formulae are as follows: (mark each)

   (i) $ML^2 T^{-2}$

   _____

   (ii) $ML^2 T^{-3}$

   _____

   (iii) MT^{-2}

   _____

   (iv) $ML^{-1} T^{-1}$

   _____

   (v) $ML^{-1} T^{-2}$

6. Deduce the dimensional formulae for the following physical quantities: (1 mark each)

(i) Gravitational constant

(ii) Power

(iii) Young's modulus

(iv) Coefficient of viscosity

(v) Surface tension

(vi) Planck's constant

7. Solve the following and express the result to an appropriate number of significant figures: (mark each)

(i) Add 6.2g, 4.33g and 17.456 g

(ii) Subtract 63.54kg from 187.2 kg

(iii) 75.5×125.5×0.51

(iv) 2.13×24.78/458.2

(v) $2.51\times10^{-4}\times1.81\times10^{7}/0.4463$

8. State the number of significant figures in the following measurements: (1 mark each)

(a) $0.009m^2$

(b) $5.049Nm^{-2}$

(c) $0.1890g\ cm^{-3}$

(d) $1.90\times10^{11}kg$

(e) 0.20800m

(f) 5.308J

9. The equation of state for real gas is given by $(P+a/V^2)(V - b) = RT$. The dimensions of the constant a are:

(a) $[ML^5T^{-2}]$ (b) $[M^{-1}\ L^5T^2]$ (c) $[ML^{-5}T^{-1}]$ (d) $[ML^5T^{-1}]$

10. A cube has a side of length 1.2×10^{-2}m. Calculate its volume.

(a) $1.7\times10^{-6}m^3$ (b) $1.73\times10^{-6}m^3$ (c) $1.0\times10^{-6}m^3$ (d) $1.732\times10^{-6}m^3$

11. Which of the following has the dimensions of pressure?

(a)) $[MLT^{-2}]$ (b)) $[ML^{-1}T^{-2}]$ (c)) $[ML^{-2}T^{-2}]$ (d)) $[M^{-1}\ L^{-1}]$

12. Fill in the blanks (1 mark each)

(a) The volume of a cube of side 1 cm is equal to …..m^3

(b) The surface area of a solid cylinder of radius 2.0 cm and height 10.0 cm is equal to…$(mm)^2$

(c) A vehicle moving with a speed of 18 km h^{-1} covers….m in 1 s

(d) The relative density of lead is 11.3. Its density is ….g cm^{-3} or ….kg m^{-3}

13. Fill in the blanks by suitable conversion of units

(a) 1 kg m^2 s^{-2} = ….g cm^2 s^{-2}

(b) 1 m = ….. ly

(c) 3.0 m s^{-2} = …. km h^{-2}

(d) G = 6.67×10^{-11} N m^2 $(kg)^{-2}$ = …. $(cm)^3 s^{-2}$ g^{-1}

14. Answer the following : (1 mark each)

(a)You are given a thread and a metre scale. How will you estimate the diameter of the thread?

(b)A screw gauge has a pitch of 1.0 mm and 200 divisions on the circular scale. Do you think it is possible to increase the accuracy of the screw gauge arbitrarily by increasing the number of divisions on the circular scale?

(c) The mean diameter of a thin brass rod is to be measured by vernier callipers. Why is a set of 100 measurements of the diameter expected to yield a more reliable estimate than a set of 5 measurements only?

15. State the number of significant figures in the following : (1 mark each)

(a)0.007 m^2

(b) 2.64×10^{24} kg

(c) 0.2370 g cm^{-3}

(d) 6.320 J

(e) 6.032 N m^{-2}

(f) 0.0006032 m^2

(2 marks questions)

16. Express the average distance of the earth from the sun in (i) light year and (ii) parsec.

17. Convert 1 dyne into newton.

18. If the value of universal gravitational constant in SI is 6.6×10^{-11} Nm^2 kg^{-2}, then find its value in CGS system.

19. Name any three physical quantities having the same dimensions and also give their dimensions.

20. Mention the various sources of occurrence of errors, while taking measurements.

21. Describe the parallax method to find the distance of an inferior planet from earth.

22. A calorie is a unit of heat (energy in transit) and it equals about 4.2 J where 1J =1 kg m^2 s^{-2}. Suppose we employ a system of units in which the unit of mass equals α kg, the unit of length equals β m, the unit of time is γ s. Show that a calorie has a magnitude of 4.2 α^{-1} β^{-2} γ^2 in terms of the new units.

23. A new unit of length is chosen such that the speed of light in vacuum is unity. What is the distance between the Sun and the Earth in terms of the new unit if light takes 8 min and 20 s to cover this distance?

24. The photograph of a house occupies an area of 1.75 cm^2 on a 35 mm slide. The slide is projected on to a screen, and the area of the house on the screen is 1.55 m^2. What is the linear magnification of the projector-screen arrangement?

25. The length, breadth and thickness of a rectangular sheet of metal are 4.234 m, 1.005 m, and 2.01 cm respectively. Give the area and volume of the sheet to correct significant figures.

26. The mass of a box measured by a grocer's balance is 2.30 kg. Two gold pieces of masses 20.15 g and 20.17 g are added to the box. What is

(a) the total mass of the box,

(b) the difference in the masses of the pieces to correct significant figures?

27. The unit of length convenient on the atomic scale is known as an angstrom and is denoted by Å: 1 Å = 10^{-10} m. The size of a hydrogen atom is about 0.5 Å. What is the total atomic volume in m^3 of a mole of hydrogen atoms?

28. One mole of an ideal gas at standard temperature and pressure occupies 22.4 L (molar volume). What is the ratio of molar volume to the atomic volume of a mole of hydrogen? (Take the size of hydrogen molecule to be about 1 Å). Why is this ratio so large?

29. Explain this common observation clearly: If you look out of the window of a fast-moving train, the nearby trees, houses etc. seem to move rapidly in a direction opposite to the train's motion, but the distant objects (hilltops, the Moon, the stars etc.) seem to be stationary. (In fact, since you are aware that you are moving, these distant objects seem to move with you).

30. The principle of 'parallax' is used in the determination of distances of very distant stars. The baseline AB is the line joining the Earth's two locations six months apart in its orbit around the Sun. That is, the baseline is about the diameter of the Earth's orbit $\approx 3 \times 10^{11}$m. However, even the nearest stars are so distant that with such a long baseline, they show parallax only of the order of 1" (second) of arc or so. A parsec is a convenient unit

of length on the astronomical scale. It is the distance of an object that will show a parallax of 1" (second of arc) from opposite ends of a baseline equal to the distance from the Earth to the Sun. How much is a parsec in terms of metres?

31. When the planet Jupiter is at a distance of 824.7 million kilometres from the Earth, its angular diameter is measured to be 35.72″ of arc. Calculate the diameter of Jupiter.

32. It is claimed that two cesium clocks, if allowed to run for 100 years, free from any disturbance, may differ by only about 0.02 s. What does this imply for the accuracy of the standard cesium clock in measuring a time-interval of 1 s?

(3marks questions)

33. Explain the method of measuring the size of oleic acid molecule.

34. Distinguish between 'accuracy' and 'precision' of a measurement.

35. (a) Explain the principle of homogeneity of dimensions.

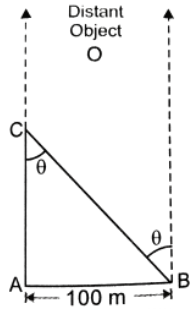
(b) Pressure is defined as momentum per unit volume. Is it true?

36. The frequency depends upon (a) tension of the string. (b) length of the string. (c) linear mass density. Using dimensional analysis, derive an expression of frequency.

37. The shadow of tower standing on a level plane is found to be 50m longer when sun's altitude is 30° than when it is 60°, Find the height of the tower.

38. A man wishes to estimate the distance of a nearby tower from him. He stands at a point A in front of the tower C and spots a very distance object O in line with AC. He then walks perpendicular to AC upto B, a distance of 100m, and looks at O and C again. Since O is very distant, the direction BO is practically the same as AO; but he finds the line of sight

of C shifted from the original line of sight by an angle $\theta = 40°$ (a is known as parallax). Estimate the distance of the tower C from his original position A.



39. The radius of a muonic hydrogen atom is 2.5×10^{-13}m. What is the total atomic volume in m^3 of a mole of such hydrogen atoms?

40. A drop of olive oil of radius 0.25mm spreads into a circular film of radius 10cm on the water surface. Estimate the molecular size of olive oil.

41. The velocity 'v' of water waves depends on the wavelength 'λ', density of water 'ρ' and the acceleration due to gravity 'g'. Deduce by the method of dimensions the relationship between these quantities.

42. If two resistors of resistances $R_1 = (4 \pm 0.5)\Omega$ and $R_2 = (16 \pm 0.5)\,\Omega$ are connected in series and (ii) in parallel; find the equivalent resistance in each case with limits of percentage error.

43. The length and breadth of a rectangle are (5.7±0.1)cm and (3.4±0.2)cm. Calculate area of the rectangle with error limits.

44. The measure of the diameter of a cylinder is (1.60±0.01)cm and its length is (5.0±0.1)cm. Calculate the percentage error in its volume.

45. If nth division of main scale coincides with (n+1)th divisions of vernier scale, find the least count of the vernier. Given one main scale division is equal to 'a' units.

46. Derive dimensionally the relation: $S = ut + \frac{1}{2} at^2$.

47. Define the following: (a) Light year (b) Parsecond (c) Astronomical unit.

48. Define dimensional formula. Give uses of dimensional analysis. Write down the limitations of dimensional analysis.

49. Show that the maximum error in the sum of two quantities is equal to the sum of the absolute errors in the two individual quantities.

50. Show that the maximum error in the quotient of two quantities is equal to the sum of their individual fractional errors.

51. State the principle of homogeneity of dimensions. Test the dimensional homogeneity of the following equation: $h = h_0 + v_0t + \frac{1}{2} gt^2$.

52. Which of the following is the most precise device for measuring length :
(a) a vernier callipers with 20 divisions on the sliding scale
(b) a screw gauge of pitch 1 mm and 100 divisions on the circular scale

(c) an optical instrument that can measure length to within a wavelength of light?

53. A student measures the thickness of a human hair by looking at it through a microscope of magnification 100. He makes 20 observations and finds that the average width of the hair in the field of view of the microscope is 3.5 mm. What is the estimate on the thickness of the hair?

54. A physical quantity P is related to four observables a, b, c and d as follows:

$$P = a^3 b^2 / \sqrt{c}\, d$$

The percentage errors of measurement in a, b, c and d are 1%, 3%, 4% and 2%, respectively. What is the percentage error in the quantity P? If the value of P calculated using the above relation turns out to be 3.763, to what value should you round off the result?

55. A famous relation in physics relates 'moving mass' m to the 'rest mass' mo of a particle in terms of its speed v and the speed of light, c. (This relation first arose as a consequence of special relativity due to Albert Einstein). A boy recalls the relation almost correctly but forgets where to put the constant c. He writes :

$$m = \frac{m_0}{(1 - v^2)^{1/2}}$$

Guess where to put the missing c.

56. The nearest star to our solar system is 4.29 light-years away. How much is this distance in terms of parsecs? How much parallax would this star (named Alpha Centauri) show when viewed from two locations of the Earth six months apart in its orbit around the Sun?

57. Precise measurements of physical quantities are a need for science. For example, to ascertain the speed of an aircraft, one must have an accurate method to find its positions at closely separated instants of time. This was the actual motivation behind the discovery of radar in World War II. Think of different examples in modern science where precise measurements of length, time, mass etc. are needed. Also, wherever you can, give a quantitative idea of the precision needed.

58. The Sun is a hot plasma (ionized matter) with its inner core at a temperature exceeding 107 K, and its outer surface at a temperature of about 6000 K. At these high temperatures, no substance remains in a solid or liquid phase. In what range do you

expect the mass density of the Sun to be, in the range of densities of solids and liquids or gases? Check if your guess is correct from the following data: a mass of the Sun = 2.0×10^{30} kg, radius of the Sun = 7.0×10^{8} m.

59. A man walking briskly in rain with speed v must slant his umbrella forward making an angle θ with the vertical. A student derives the following relation between θ and v: $\tan \theta = v$ and checks that the relation has a correct limit: as $v \to 0$, $\theta \to 0$, as expected. (We are assuming there is no strong wind and that the rain falls vertically for a stationary man). Do you think this relation can be correct? If not, guess the correct relation.

60. Estimate the average mass density of a sodium atom assuming its size to be about 2.5 Å. (Use the known values of Avogadro's number and the atomic mass of sodium). Compare it with the mass density of sodium in its crystalline phase: 970 kg m^{-3}. Are the two densities of the same order of magnitude? If so, why?

61. The unit of length convenient on the nuclear scale is a fermi: 1 f = 10–15 m. Nuclear sizes obey roughly the following empirical relation :

$r = r_0 A^{1/3}$

where r is the radius of the nucleus, A its mass number, and r_0 is a constant equal to about, 1.2 f. Show that the rule implies that nuclear mass density is nearly constant for different nuclei. Estimate the mass density of the sodium nucleus. Compare it with the average mass density of a sodium atom obtained in previous Qs.

62. A LASER is a source of very intense, monochromatic, and the unidirectional beam of light. These properties of a laser light can be exploited to measure long distances. The distance of the Moon from the Earth has been already determined very precisely using a laser as a source of light. A laser light beamed at the Moon takes 2.56 s to return after reflection at the Moon's surface. How much is the radius of the lunar orbit around the Earth ?

63. A SONAR (sound navigation and ranging) uses ultrasonic waves to detect and locate objects underwater. In a submarine equipped with a SONAR, the time delay between generation of a probe wave and the reception of its echo after reflection from an enemy submarine is found to be 77.0 s. What is the distance of the enemy submarine? (Speed of sound in water = 1450 m s^{-1}).

64. The farthest objects in our Universe discovered by modern astronomers are so distant that light emitted by them takes billions of years to reach the Earth. These objects (known as

quasars) have many puzzling features, which have not yet been satisfactorily explained. What is the distance in km of a quasar from which light takes 3.0 billion years to reach us?

65. In van der Waal's equation $(P + a/V^2)(V - b) = RT$. Determine the dimensions of a and b?

66. Write the dimension of a in the relation $F = a\sqrt{x} + bt^2$, where F is force, x is distance and t is time.

(5 marks questions)

67. The diameter of a wire as measured by a screw gauge was found to be 0.026cm, 0.028cm, 0.029cm, 0.027cm, 0.024cm, 0.027cm. Calculate (i) mean value of the diameter (ii) mean absolute error (iii) relative error (iv) percentage error. Also express the result in terms of absolute error and percentage error.

68. The period of oscillation of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$. Measured value of L is 20.0cm known to 1mm accuracy and time for 100 oscillations of the pendulum is found to be 90s using a wrist watch of 1s resolution. What is the accuracy in the determination of g?

69. If the velocity of light c, the constant of gravitation G and Planck's constant h be chosen as fundamental units, find the dimensions of mass, length and time in terms of c, G and h.

70. Explain this statement clearly :
"To call a dimensional quantity 'large' or 'small' is meaningless without specifying a standard for comparison". In view of this, reframe the following statements wherever necessary :
(a) atoms are very small objects
(b) a jet plane moves with great speed
(c) the mass of Jupiter is very large
(d) the air inside this room contains a large number of molecules
(e) a proton is much more massive than an electron
(f) the speed of sound is much smaller than the speed of light.