PHYSICS

NCERT - NCERT PHYSICS(GUJRATI)

UNITS AND MEASUREMENT

Example

1. Calculate the angle of (a) $1°$ (degree) (b) 1' (minute of arc or arcmin) and (c) 1" (second of arc or arc second) in radians. Use $360° = 2\pi$ rad, $1° = 60'$ and 1'=60".

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2. 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 distant object O in line with AC. He then walks perpendicular to AC up to B, a distance of 100 m, 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 $\theta = 40°$ (θ is known as 'Parallax') estimate the distance of the tower C from his original position A.

3. The moon is observed from two diametrically opposite points A and B on Earth. The angle θ subtended at the moon by the two directions of observation is $1°54'$. Given the diameter of the Earth to be about 1.276×10^7 , compute the distance of the moon from the Earth.

4. The Sun's angular diameter is measured to be 1920". The distance D of the Sun from the Earth is 1.496×109^{11} m. What is the diameter of the Sun ?

5. If the size of a nucleus (in the range of 10^{-15} to 10^{-14}) is scaled up to the tip of a sharp pin, what roughly is the size of an atom ? Assume tip of the pin to be in the range 10^{-5} m to $10^{-4}m$.

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6. Two clocks are being tested against a standard clock located in a national laboratory . At 12:00:00 noon by the standard clock, the regarding of the two clocks are :

If you are doing an experiment that requires precision time interval measurements, which of the two clocks will you prefer ?
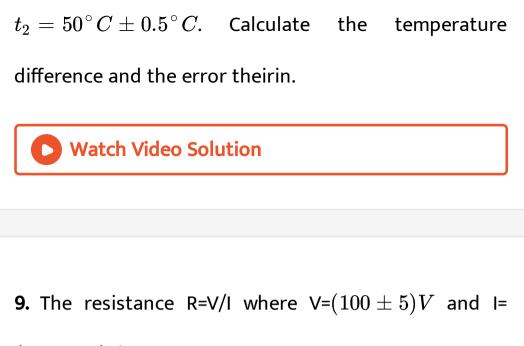
7. We measure the period of oscillation of a simple pendulum. In successive measurements, the readings turn out to be 2.63s, 2.56s, 2.42s , 2.71s and 2.80s. Calculate the absolute errors, relative error or percentage error.

8. The temperature of two bodies measured by a thermometer are $t_1 = 20°C \pm 0.5°C$ and

$t_2 = 50°C \pm 0.5°C.$ Calculate the temperature difference and the error theirin.

9. The resistance R=V/I where V=$(100 \pm 5)V$ and I= $(10 \pm 0.2)A.$ Find the percentage error in R.

10. Two resistors of resistances $R_1 = 100 \pm 3$ ohm and $R_2 = 200 \pm 4$ ohm are connected (a) series , (b) in parallel. Find the equivalent resistance of the (a) series combination, (b) parallel combination. Use for (a) the

relation $R = R_1 + R_2$ and for (b) $\dfrac{1}{R'} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$ and $\dfrac{\Delta R'}{R'^2} = \dfrac{\Delta R_1}{R_1^2} + \dfrac{\Delta R_2}{R_2}$

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11. Find the relative error in Z, if Z = $A^4 \dfrac{B^{\frac{1}{3}}}{C} D^{\frac{3}{2}}$.

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12. The period of oscillation of a simple pendulum is T = $2\pi\sqrt{\dfrac{L}{g}}$. Measuted value of L is 20.0 cm known to 1mm accuracy and time for 100 oscillations of the pendulum

is found to be 90s using a wrist watch of 1 s resolution. What is the accuracy in the determination of g ?

13. Each side of a cube is measured to be 7.203m. What are the total surface area and the volume of the cube to appropriate significant figures ?

14. 5.74 g of a substance occupies $1.2cm^3$. Express its density by keeping the significant figures in view.

15. Let us consider an equation $\frac{1}{2}mv^2 = mgh$

Where m is the mass of the body. V its velocity , g is the acceleration due to gravity and h is the height . Check whether this equation is dimensionally correct.

16. The SI unit of energy is $J = kgm^2s^{-2}$, that of speed v is ms^{-1} and of acceleration a is ms^{-2}. What of the formulae for kinetic energy (k) given below can you rule out on the basis of dimensional arguments (m stands for the mass of the body) :

(a) $K = m^2v^2$

(b) $K = \left(\dfrac{1}{2}\right) mv^2$

(c) $K = ma$

(d) $K = \left(\dfrac{3}{16}\right) mv^2$

(e) $K = \left(\dfrac{1}{2}\right) mv^2 + ma$

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17. Consider a simple pendulum, having a bob attached to a string, that oscillates under the action of the force of gravity. Suppose that the period of oscillation of the simple pendulum depends on its length (l), mass of the bob (m) and acceleration due to gravity (g). Derive the expression for its time period using method of dimensions.

Exercise Fill In The Blanks

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

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

3. A vehicle moving with a speed of $18 kmh^{-1}$ covers..........m in 1 s.

4. The relative density of lead is 11.3. Its density is ....gcm^{-3} or ....kgm^{-3}.

5. $1 kgm^2 s^{-2} = \ldots\ldots\ldots gcm^2 s^{-2}$

6. 1 m ....ly

7. $3.0 ms^{-2} = \ldots\ldots\ldots Kmh^{-2}$

8.

$G = 6.67 \times 10^{-11} Nm^2 (kg)^{-2} = \ldots\ldots\ldots (cm)^3 s^{-2} g^{-1}$

.

1. 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 βm, the unit of time is γs. Show that a calorie has a magnitude 4.2 $\alpha^{-1}\beta^{-2}\gamma^2$ in terms of the new units.

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2. 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.

3. 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 ?

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4. 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 ?

5. 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 hair ?

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

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7. A screw gauge has a pitch of 1.0mm 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 ?

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8. 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 ?

9. The photograph of a house occupies an area of $1.75 cm^2$ on a 35 mm side. 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.

10. State the number of significant

$$0.007m^2$$

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11. State the number of significant

$$2.64 \times 10^{24}kg$$

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12. State the number of significant

$$0.2370gcm^{-3}$$

13. 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.

14. 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 ?

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

$$P = a^3 \frac{b^2}{\sqrt{cd}}$$

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 ?

16. A book with many printing errors contains four different formulas for the displacement y of a particle undergoing a certain peroidic motion :

(a) $y = a \sin 2\pi t / T$

(b) y=asinvt

(c) $y = (a/T)\sin t/a$

(d) $y = (a/\sqrt{2})(\sin 2\pi t / T + \cos 2\pi t / T)$

(a = maximum displacement of the particle, v=speed of the particle. T=time-period of motion). Rule out the wrong formulas on dimensional grounds)

17. A famous relation in physics relates 'moving mass' m to the 'rest mass' m_0 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.

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18. The unit of length convenient on the atomic scale is known as an angstrom and is denoted by Å: 1Å

$= 10^{10} m$. The size of a hydrogen atom is about 0.5Å. What is the total atomic volume in m^{-3} of a mole of hydrogen atoms ?

19. 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 1Å). Why is this ratio so large ?

20. 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 (hills tops, the Moons, 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.)

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21. The principle of 'parallax' in section 2.3.1 is used in the determination of distances of very distant starts. 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 $=3 \times 10^{11} m$. 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 conventent 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 ?

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22. The nearest star to our solar system is 4.29 light years away. How much is this distance in terms of

paesecs ? 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 ?

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23. Precise measurements of physical quantities are a need of 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 you can, give a quantitative idea of the precision needed.

24. Just as precise measurements are necessary in science, it is equally important to be able to make rough estimates of quantities using rudimentary ideas and common estimate is difficult to obtain, try to get an upper bound on the quantity):

(a) the total mass of rain-bearing clouds over India during the Monsoon

(b) the mass of an elephant

(c) the wind speed during a strom

(d) the number of strands of hair on your head

(e) the number of air molecules in your classroom.

25. The Sun is a hot plasma (ionized matter) with its inner core at a temperature exceeding $10^7 Kg$, and its outer surface at a temperature of about 6000K. 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: mass of the Sun $= 2.0 \times 10^{30} Kg$, radius of the Sun $= 7.0 \times 10^8 m$.

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

Exercise Additional Exercise

1. 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 $v \rightarrow o$, $\theta \rightarrow 0$, 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 you, guess the correct relation.

2. It is claimed that two cesium clocks, it allowed to run for 100 years, free from any distrubance, 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 1s ?

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

4. The unit of length convent on the nuclear scale is a fermi : $1f = 10^{-15}m$. Nuclear sized 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 sodium nucleus. Compare it with the average mass density of a sodium atom obtained in Exercise . 2.27.

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5. A LASER is a source of very intense, monochromatic, and unidirectional beam of light.These properties of a laser light can be exploited to measure long distance. 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 ?

6. A SONAR (sound navigation and ranging) uses ultrasonic waves to detect and locate objects under water. 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 77.0s. What is the distance of

the enemy submarine ? (Speed of sound in water = $1450ms^{-1}$).

7. 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 puzzing 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 ?

8. It is a well known fact that during a toal solar eclipse the disk of the moon almost completely covers the disk of the Sun. From this fact and from the information you can gather fro examples 2.3 and 2.4, determine the approximate diameter of the moon.

9. A great physicist of this century (P.A.M. Dirac) loved playing with numerical values of Fundamental constants of nature. This led him to an interesting observation. Dirac found that from the basic constants of atomic physics(c,e, mass of electron, mass of proton) and the gravitational constant G, he could arrive at a

number with the dimension of time. Further, it was a very large number, its magnitude being close to the present estimate on the age of the universe (~ 15 billion years). From the table of fundamental constants in this book, try to see if you too can construct this number (or any other interesting number you can think of). If its coincidence with the age of the universe were significant , what would this imply for the constancy of fundamental constants ?

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