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## PHYSICS

## NCERT - NCERT PHYSICS(HINGLISH)

## UNITS AND MEASUREMENT

## Solved Example

1. Calculate the angle of (a) $1^{\circ}$ (degree) (b) $1^{\prime}$
(minute of arc of are min) and (c ) 1"(secondof
arc of arc sec) in radian. Use $360^{\circ}=2 \pi \mathrm{rad} ., 1^{\circ}=60^{\prime}$ and $1^{\prime}=60^{\prime \prime}$.

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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 $A C$. He then walks perpendicualr to $A C$ upto $B$, a distaance of 100 m and looks at $O$ and $C$ again. Since $O$ is very distant, the direction of 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 $\theta=40^{\circ}(\theta$ is known as parallax $)$.

Estimate the distance fo the tower C from his original position A .

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3. The moon is observed from two diametrically
opposite points $A$ and $B$ on earth. The angle $\theta$
substended at the moon by the two directions
of observation is $1^{\circ} 54^{\prime}$. Given the diameter of
earth to be about $1.276 \times 10^{7} \mathrm{~m}$, calculate the distance of moon from earth.

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4. The sun's angular diameter is measured to be 1920". The distance of the sun from the earth is $1.496 \times 10^{11} \mathrm{~m}$. What is the diameter of the sun?

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5. If the size of a nucleus $\left(\approx 10^{-15} \mathrm{~m}\right)$ is scaled up to the tip of a sharp pin $\left(\approx 10^{-5} \mathrm{~m}\right)$, what roughly is the size of an atom?

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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 readings of the two clocks are :

## Clock $1 \quad$ Clock 2

Monday 12:00:05 10:15:06
Tuesday 12:01:15 10:14:59
Wednesday 11:59:08 10:15:18
Thursday 12:01:50 10:15:07
Friday 11:59:15 10:14:53
Saturday 12:01:30 10:15:24
Sunday 12:01:19 10:15:11
If you are doing an experiment that requires
precision time interval measurements, which of the two clocks will you prefer?

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7. In successive measurement, the reading of the period of oscillation of a simple pendulum
were found to be $2.63 \mathrm{~s}, 2.56 \mathrm{~s}, 2.71 \mathrm{~s}$ and 2.80 s in an experiment. Calculate (i) mean value of the period oscillation (ii) absolute errer in each measurement (iii) mean absolute error (iv) releative error (v) percentage error and (vi) express the result in proper form.

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8. The temperature of two bodies measured by
a thermometer are $(20 \pm 0.5)^{\circ} C$ and
$(50 \pm 0.5)^{\circ} C . \quad$ Calculate the temperature difference with error limits.

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9. The resistance $\quad R=\frac{V}{I}, \quad$ where
$V=(100 \pm 5.0) V$ and $I=(10 \pm 0.2) A$. Find
the percentage error in $R$.
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10. Two resistors of resistances $R_{1}=100 \pm 3$ ohm and $R_{2}=200 \pm 4$ ohm are connected (a) in 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) $\frac{1}{R^{\prime}}=\frac{1}{R_{1}}+\frac{1}{R_{2}}$ and $\frac{\Delta R^{\prime}}{R}{ }^{\prime 2}=\frac{\Delta R_{1}}{R_{1}^{2}}+\frac{\Delta R_{2}}{R_{2}^{2}}$

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

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12. The period of oscillation of a simple pendulum is $T=2 \pi \sqrt{L / g}$. Measured value of

L is 20.0 cm known to 1 mm accuracy and time
for 100 oscillations of the pendulum is found to be 90 s 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 7.203
m . What is (i) the total surface area and (ii) the
volume of the cube to appropriate significant figures ?

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14. A substance weight 5.74 g occupies a volume of $1.2 \mathrm{~cm}^{3}$. Caluclate its density with due regard to significant digits.
15. Let us consider an equaiton
$\frac{1}{2} m v^{2}=m g h$,
Where m is the mass of the body, $v$ its velocity,
$g$ is acceleration due to gravity and $h$ is the height. Cheak whether this equation is dimensionally correct.

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16. The SI unit of energy is $J=k g m^{2} s^{-2}$, that of speed $v$ is $m s^{-1}$ and of acceleration a is $m s^{-2}$ which 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) $K=m^{2} v^{3}$ (b) $K=\frac{1}{2} m v^{2}$ (c) $K=m a$
(d) $K=\frac{3}{16} m v^{2}$ (e) $K=\frac{1}{2} m v^{2}+m a$

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

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Exercise

1. Fill in the blanks
(a) The volume of a cube of side 1 cm isk equal
to..... $m^{3}$
(b) the surface area fo a solid cylinder of radius
2.0 cm and height 10.0 cm is equal to .... $(\mathrm{mm})^{2}$
(c) A vehical moving with a speed of $18 \mathrm{kmh}^{-1}$ covers ....m in 1 s .
(d) The relative density of lead is 11.3. its density is ......g $\mathrm{cm}^{-3}$ or $\ldots . \mathrm{kgm}^{-3}$

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2. Fill in the blanks by suitable conversion of units :
(a) $1 \mathrm{kgm}^{2} \mathrm{~s}^{-2}=g \mathrm{~cm}{ }^{2} \mathrm{~s}^{-2}$
(b) $1 \mathrm{~m}=\ldots . .$. . Light
year (c) $3 m s^{-2}=\ldots . . K m h^{-2}$
(d)
$G=6.67 \times 10^{-11} \mathrm{Nm}^{2} \mathrm{~kg}^{-2}=\ldots \ldots . \mathrm{cm}^{3} \mathrm{~s}^{-2} g^{-1}$

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3. A calorie is a unit of heat or energy and it equals about $4.2 J, w h e r e 1 J=1 \mathrm{kgm}^{2} \mathrm{~s}^{-2}$.

Suppose we employ a system of units in which the unit of mass equals $\alpha k g$, the unit of length equals is $\beta m$, the unit of time is $\gamma s$. Show
tthat a calorie has a magnitude $4.2 \alpha^{-1} \beta^{-1} \gamma^{2}$ in terms of the new units.

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4. 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 statement 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.

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5. A new unit of length is chosen such that the speed of light in vecuum 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 sec. to cover the distance ?

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6. (A) Vernier callipers with 20 divisions on sliding scale, coinciding with 19 main scale divisions
(B) A screw gauge of pitch 1 mm and 100 divisons on the circular scale
(C) An optical instrument that can measure
length to within a wavelength of light Out of $A$ , $B$ and $C$ the most precise devide for measuring length is

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

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8. Answer the following :
(a) You are given a tread 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 arbitratily 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 measurement only?

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9. The photograph fo a house occupies an area of $1.7 \mathrm{~cm}^{2}$ on a 35 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 liner magnification of the projector screen arrangement?

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10. State the number of significant figures in the following : (a) $0.007 \mathrm{~m}^{2}$ (b) $2.64 \times 10^{24} \mathrm{~kg}$ (c
) $0.2370 \mathrm{gcm}^{-3}$ (d) 6.320 J (e ) $6.032 \mathrm{Nm}^{-2}$
$0.0006032 m^{2}$
11. The length, breadth, and thickness of a metal sheet are $4.234 \mathrm{~m}, 1.005 \mathrm{~m}$, and 2.01 cm , respectively. Give the area and volume of the sheet to the correct number of significant figures.

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12. The mass of a box measured by a grocer's balance is 2.300 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?

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13. A physical quantity $P$ is related to four observables $\mathrm{a}, \mathrm{b}, \mathrm{c}$ and d as $P=a^{3} b^{2} / \sqrt{c} d$.

The percentage errors in the measurements of
$\mathrm{a}, \mathrm{b}, \mathrm{c}$ 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 this formula turns out to be 3.763 , to what value should you round off the result?

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14. A book with many printing errors contains
four different forumlae for the displacement $y$
of a particle undergoing a certain periodic
motion : (i) $y=a \frac{\sin (2 \pi t)}{T}$
(ii) $\quad y=a \sin v t$
(iii) $y=\frac{a}{T} \frac{\sin (t)}{a}$
$y=\frac{a}{\sqrt{2}}\left[\frac{\sin (2 \pi t)}{T}+\frac{\cos (2 \pi t)}{T}\right]$ Here, a is
maximum displacement of particle, $v$ is speed
of particle, T is time period of motion. Rule out the wrong forumlae on dimensinal grounds.

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15. A famous relation in phyics relates the 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 the special theory of relativity due to Albert Einstein). A body recalls the relation almost correctly but forgets where to
put the constant $c$. He writes $m=\frac{m_{0}}{\left(1-V^{2}\right)^{1 / 2}}$. Guess where to put the missing $c$.

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16. The unit of length convenint on the atomic
scales is known as an angstrom and is denoted by $\AA: 1 \AA=10^{-10} m$. The size of a hydrogen atom is about $0.5 \AA$ What is the totall atomic volume in $m^{3}$ of a mole of hydrogen atoms?
17. One mole of an ideal gas at NTP occupies
22.4 liters (molar volume). What is the ratio of molar volume to atomic volume to atomic volume of a mole of hydrogen ? Take size of hydrogen molecule to be $1 \AA$. Why is this ratio so large?

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18. Explain this common observation clearly: If
you look out of the window of a fast moving
train, the nearby tress, houses etc. seem to move rapidly in a direction opposite to the train's motion, but the distant objects (hill yops, the Moon, the starts 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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19. The principle of 'parallax' in Art. 1(c ).4. is used in the determination of distacne of very
distant stars. The baseline $A B$ in 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 $\approx 3 \times 10^{11} \mathrm{~m}$. However, even the nearest
stars are so distnat the 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
shown a parallax of 1 " (second) of arc fame oppsoite ends of a beasline equal to the
distance from the Earth to the sun. How much
is a parsec in terms of metres ?

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20. The nearest star to our solar system is 4.29
light years away. How mcuh is this distance in terms of par sec ? How mcuh parallax would this star show when viewed from two locations of the earth six months apart in its orbit around the sun?
21. Precise measurements of physical quantities
are a need of science. For example to escertain
the speed of an aircraft, one must have an
accurate methi=od 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, arc needed. Also,
whereever you can, give a quantitative idea of the precision needed.
22. 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 observations.

Think of ways by which you can estimate the following (where an estimate is difficult to obtain. try to get upper bound on the quantity)
(a) the total mass of rain-bearing clouds over India during the Monosoon
(b) the mass of an elephant
(c) the wind speed during a storm
(d) the number of strands of hair on your head
(e) the number of air molecules in your classroom.

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23. The sun is a hot plasma (ionised matter)
with its linner core at a temperature excedding
$10^{7} \mathrm{~K}$, and its outer surface at a temperature of about 6000K. At such high temps, 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, liquieds or gases ? Check if your guess is correct from the following data : mass of sun $=2.0 \times 10^{30} \mathrm{~kg} \quad, \quad$ radius of the sun $=7.0 \times 10^{8} \mathrm{~m}$

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24. When planet Jupiter is at a distance of 824.7 million km from earth, its angular diameter is
measured to be $35.72^{\prime \prime}$ of arc. Calculate the diameter of Jupiter.

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

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26. It is claimed that two cesium clocks, if allowed to run for 100 years, free from any disturbance, may differ by only about 0.02s.

What does this imply for the accuracy of the
standard cesium clock in measuring a time interval of 1s ?

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27. Estimate the averaage atomic mass density of a sodium atom, assuming its size ot be $2.5 \AA$.

Compare it with density of sodium in its crystalline phase $\left(970 \mathrm{kgm}^{-3}\right)$. Are the two denities of the same order of magnitude? If so, why?
28. The unit of length convenient on nuclear
scale is a fermi, $\left.1 f=10^{9}-15\right) \mathrm{m}$. Nuclear sizes obey rougholy the following empricial relation : $r=r_{0} A^{1 / 3}$, where r is radius of the nucleus and $r_{0}$ is a constant equal to 1.2 f . show that the rule implies that nuclear mass density in nearly constant for different neclei.

Estimate the mass density of sodium nucleus.
Compare it with avarge mass density of sodium atom is $\mathrm{Q} .27\left(4.67 \times 10^{3} \mathrm{~kg} / \mathrm{m}^{3}\right)$.
29. A LASER is 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 determine very precisly at the moon's surface. How much is the radius of the lunar orbit around the Earth?
30. A SONAR (sound navigation and ranging)
uses ultrasonic waves to detect and locate object under water. In a submarine equaipped with as SONAR, the time delay between genration of a probe wave and the recption of its echo after refection from an enemy submarine is found to be 77.0 s . What is the distance of the enemy submarine? (speed of sound in water $=1450 \mathrm{~ms}^{-1}$
31. The farthest objects in out universe discovered by modern astronomeres are so distant that light emitted by them takes billions of year to reach the earth. These object
(known as quasers) have may puzzling features, which have yet not been satisfactorily explained. What is the distance in km of a quasar form which light takes 3.0 billion years to reach us?
32. It is a well known fact that during a total
solar eclipes the disc of the moon almost completely covers the disc of the sun. From
this fact and from the information you can gather from Solved Examples 3 and 4 on page $1 / / 44$, determine the approximate diameter of the moon.

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33. A great physicist of this century (P. A. M.

Dirac) loved playing with numerical values of
fundamental constant of nature. This led him
to an instreasing observaion. Dirac found that
form the basic constant of atomin physice (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 ( $\approx 15$ billionyears $)$. Form the table of fundamental constants in this book, try to
see if you too can construct this number (or any other instresting number you can think of).
if its coincidence with the age of the universe
ware significant, what would this imply for the constancy of fundamental constants ?

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## Question

1. A satellite is launched to a circular orbit of
radius $R$ and speed $v$. An accident causes it to
be given a velocity component perpendicular to its orbital velocity(and away from the

Earth).The ratio of this perpendicular velocity
component to the original orbital velocity is x .

The satellite is lost i.e. it escape from the earth
. As it travels far away, the perpendicular distance of its line of motion from the earth is given by
$y=\frac{R}{\sqrt{x^{2}-1}}$
If R is reported with a $1 \%$ error , $x=3 \pm 0.08$
. find the fractional error only

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