Multiple Choice Questions I

2.1. The number of significant figures in 0.06900 is:
a) 5
b) 4
c) 2
d) 3
Answer:
The correct answer is b) 4
The number of zeroes on the left of the non-zero number are not considered as significant figures but the zeroes that are on the right of the non-zero number are significant figures.

2.2. The sun of the numbers 436.32, 227.2, and 0.301 in appropriate significant figures is:
a) 663.821
b) 664
c) 663.8
d) 663.82
Answer:
The correct answer is c) 663.8

2.3. The mass and volume of a body are 4.237 g and 2.5 cm^3 respectively. The density of the material of the body in correct significant figures is:
a) 1.6048 g/cm^3
b) 1.69 g/cm^3
c) 1.7 g/cm^3
d) 1.695 g/cm^3
Answer:
The correct answer is c) 1.7 g/cm^3

2.4. The numbers 2.745 and 2.735 on rounding off to 3 significant figures will give:
a) 2.75 and 2.74
b) 2.74 and 2.73
c) 2.75 and 2.73
d) 2.74 and 2.74
Answer:
The correct answer is d) 2.74 and 2.74

2.5. The length and breadth of a rectangular sheet are 16.2 cm and 10.1 cm respectively. The area of the sheet in appropriate significant figures and error is:
a) 164 ± 3 cm^2
b) 163.62 ± 2.6 cm^2
c) 163.6 ± 2.6 cm^2
d) 163.62 ± 3 cm^2
Answer:
The correct answer is a) 164 ± 3 cm^2

2.6. Which of the following pairs of physical quantities does not have same dimensional formula?
a) work and torque
b) angular momentum and Planck's constant
c) tension and surface tension

d) impulse and linear momentum
Answer:
The correct answer is a) work and torque

2.7. Measure of two quantities along with the precision of respective measuring instrument is:
A = 2.5 m/s ± 0.5 m/s
B = 0.10 s ± 0.01 s
The value of AB will be
a) (0.25 ± 0.08) m
b) (0.25 ± 0.5) m
c) (0.25 ± 0.05) m
d) (0.25 ± 0.135) m
Answer:
The correct answer is a) (0.25 ± 0.08) m

2.8. You measure two quantities as A = 1.0 m ± 0.2 m, B = 2.0 m ± 0.2 m. We should report correct value for $\sqrt{AB}$ as:
a) 1.4 m ± 0.4 m
b) 1.41 m ± 0.15 m
c) 1.4 m ± 0.3 m
d) 1.4 m ± 0.2 m
Answer:
The correct answer is d) 1.4 m ± 0.2 m

2.9. Which of the following measurements is most precise?
a) 5.00 mm
b) 5.00 cm
c) 5.00 m
d) 5.00 km
Answer:
The correct answer is a) 5.00 mm

2.10. The mean length of an object is 5 cm. Which of the following measurements is most accurate?
a) 4.9 cm
b) 4.805 cm
c) 5.25 cm
d) 5.4 cm
Answer:
The correct answer is a) 4.9 cm

2.11. Young's modulus of steel is 1.9×10^{11} N/m^2. When expressed in CGS units of dynes/cm^2, it will be equal to:
a) 1.9×10^{10}
b) 1.9×10^{11}
c) 1.9×10^{12}
d) 1.9×10^{13}
Answer:
The correct answer is c) 1.9×10^{12}

2.12. If momentum (P), area (A), and time (T) are taken to be fundamental quantities, then energy has the

dimensional formula
a) $(P^1A^{-1}T^1)$
b) $(P^2A^1T^1)$
c) $(P^1A^{-1/2}T^1)$
d) $(P^1A^{1/2}T^{-1})$
Answer:
The correct answer is d) $(P^1A^{1/2}T^{-1})$

Multiple Choice Questions II

2.13. On the basis of dimensions, decide which of the following relations for the displacement of a particle undergoing simple harmonic motion is not correct:
a) $y = a \sin 2\pi t/T$
b) $y = a \sin vt$
c) $y = a/T \sin (t/a)$
d) $y = a\sqrt{2}\,[\sin (2\pi t/T) - \cos (2\pi t/T)]$
Answer:
The correct answer is b) $y = a \sin vt$ and c) $y = a/T \sin (t/a)$

2.14. If P, Q, R are physical quantities, having different dimensions, which of the following combinations can never be a meaningful quantity?
a) $(P - Q)/R$
b) $PQ - R$
c) PQ/R
d) $(PR - Q^2)/R$
e) $(R + Q)/P$
Answer:
The correct answer is d) $(PR - Q^2)/R$ and e) $(R + Q)/P$

2.15. Photon is quantum of radiation with energy E = hv where v is frequency and h is Planck's constant. The dimensions of h are the same as that of:
a) linear impulse
b) angular impulse
c) linear momentum
d) angular momentum
Answer:
The correct option is b) angular impulse and d) angular momentum

2.16. If Planck's constant (h) and speed of light in vacuum (c) are taken as two fundamental quantities, which of the following can in addition be taken to express length, mass, and time in terms of the three chosen fundamental quantities?
a) mass of electron (m_e)
b) universal gravitational constant (G)
c) charge of electron (e)
d) mass of proton (m_p)
Answer:
The correct answer ia a) mass of electron b) universal gravitational constant and d) mass of proton

2.17. Which of the following ratios express pressure?
a) Force/area

b) Energy/volume
c) Energy/area
d) Force/volume
Answer:
The correct answer is a) force/area and b) energy/volume

2.18. Which of the following are not a unit of time?
a) second
b) parsec
c) year
d) light year
Answer:
The correct answer is b) parsec and d) light year

Very Short Answers

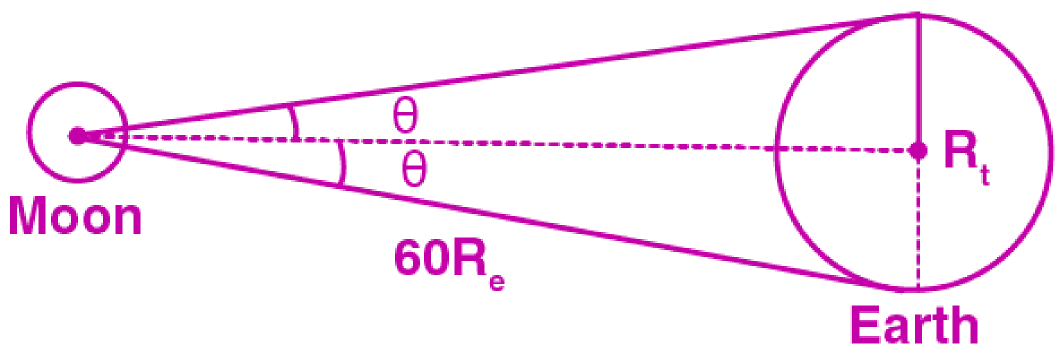
2.19 Why do we have different units for the same physical quantity?
Answer:
We have different units for the same physical quantity because they differ from place to place.

2.20 The radius of atom is of the order of 1 Å and radius of nucleus is of the order of fermi. How many magnitudes higher is the volume of atom as compared to the volume of nucleus?
Answer:
Radius of atom = 1 Å = 10^{-10} m
Radius of nucleus = 1 fermi = 10^{-15} m
Volume of atom = $4/3\pi Ra^3$
Volume of nucleus = $4/3\pi Rn^3$
Vatom/Vnucleus = 10^{15}
Mass of one mole of carbon atom = 12 g = 1.67×10^{-27} kg

2.21 Name the device used for measuring the mass of atoms and molecules.
Answer:
Mass spectrograph is the device that is used for measuring the mass of atoms and molecules.

Short Answers

2.25 (a) The earth-moon distance is about 60 earth radius. What will be the diameter of the earth (approximately in degrees) as seen from the moon?
(b) Moon is seen to be of (½)° diameter from the earth. What must be the relative size compared to the earth?
(c) From parallax measurement, the sun is found to be at a distance of about 400 times the earth-moon distance. Estimate the ratio of sun-earth diameters.
Answer:
a)



The radius of the earth is treated as an arc as the distance between the moon and the earth is greater than the radius of the earth.
Let Re be the length of the arc
Distance between the moon and the earth = 60Re
Angle subtended by the diameter of the earth = 2^o

b) The relative size of the moon when compared to the earth is = diameter of the earth/diameter of the moon = 4

c) The ratio of sun-earth diameter = Dsun/Dearth = 100

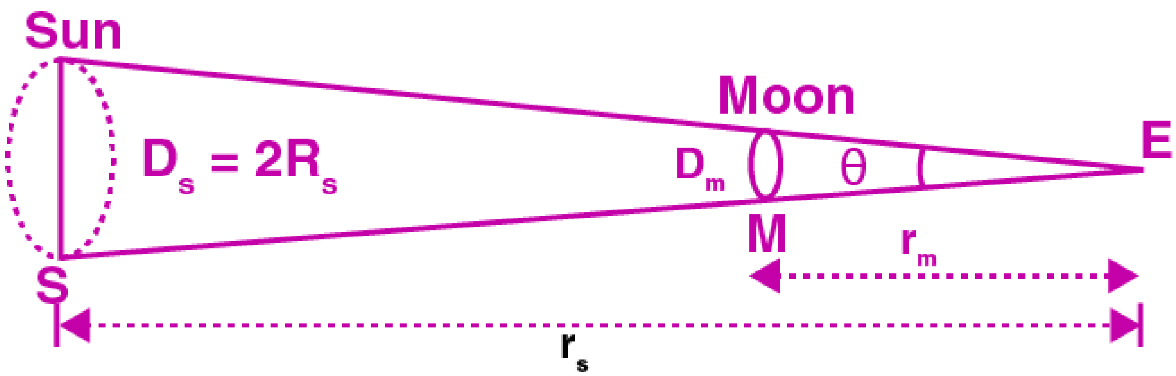
2.26 Which of the following time measuring devices is most precise?
(a) A wall clock.
(b) A stop watch.
(c) A digital watch.
(d) An atomic clock.
Give reason for your answer.
Answer:
The correct option is d) an atomic clock as it measures up to one second.

2.27 The distance of a galaxy is of the order of 1025 m. Calculate the order of magnitude of time taken by light to reach us from the galaxy.
Answer:
Distance of the galaxy = 10^{25}m
Speed of light = 3×10^8 m/s
Time taken, t is
t = distance/speed = 3.33×10^{16} s

2.28 The vernier scale of a travelling microscope has 50 divisions which coincide with 49 main scale divisions. If each main scale division is 0.5 mm, calculate the minimum inaccuracy in the measurement of distance.

Answer:
The minimum inaccuracy in the measurement of distance = (1/50)(0/5)mm = 0.01 mm

2.29 During a total solar eclipse the moon almost entirely covers the sphere of the sun. Write the relation between the distances and sizes of the sun and moon.
Answer:



Rme is the distance of the moon from the earth
Rse is the distance of the sun from the moon
Asun is the area of the sun
Amoon is the area of the moon
Rs/Rm = Rse/Rme

2.30 If the unit of force is 100 N, unit of length is 10 m and unit of time is 100 s, what is the unit of mass in this system of units?
Answer:
Force [F] = 100 N
Length [L] = 10 m
Time [t] = 100 s
[F] = $[MLT^2]$
Substituting the values, we get M = 10^5 kg

Long Answers

2.36. A new system of units is proposed in which unit of mass is α kg, unit of length β m and unit of time γ s. How much will 5 J measure in this new system?
Answer:
Let Q be the physical quantity = n1u1 = n2u2
Let M1, L1, T1 and M2,L2,T2 be the units of mass, length, and time for the given two systems.
n2 = n1

$[U] = [ML^2T^2]$
M1 = 1 kg
L1 = 1 m
T1 = 1 s
M2 = α kg
L2 = β m
T1 = γ s
Substituting the values we get, $n2 = 5\gamma^2/\alpha\beta^2$ J

2.37 The volume of a liquid flowing out per second of a pipe of length l and radius r is written by a student as $$v = \frac{\pi}{8}\frac{Pr^4}{\eta l}$$ **where P is the pressure difference between the two ends of the pipe and η is coefficient of viscosity of the liquid having dimensional formula $ML^{-1}T^{-1}$. Check whether the equation is dimensionally correct.**
Answer:
Dimension of the given physical quantity is
[V] = dimension of volume/dimension of time = $[L^3]/[T]=[ML^{-1}T^{-2}]$
LHS = $[L^3T^{-1}]$
RHS = $[L^3T^{-1}]$
LHS = RHS
Therefore, the equation is correct.

2.38 A physical quantity X is related to four measurable quantities a, b, c and d as follows: $X = a^2 b^3 c^{5/2} d^{-2}$. The percentage error in the measurement of a, b, c and d are 1%, 2%, 3% and 4%, respectively. What is the percentage error in quantity X ? If the value of X calculated on the basis of the above relation is 2.763, to what value should you round off the result.
Answer:
The given physical quantity, $X = a^2 b^3 c^{5/2} d^{-2}$
Percentage error in X = (Δx/x)(100)
Percentage error in a = (Δa/a)(100) = 1%
Percentage error in b = (Δb/b)(100) = 2%
Percentage error in c = (Δc/c)(100) = 3%
Percentage error in d = (Δd/d)(100) = 4%
Maximum percentage error in X = ±23.5%
X should have two significant values, therefore, X = 2.8

2.39 In the expression $P = E l^2 m^{-5} G^{-2}$, E, m, l and G denote energy, mass, angular momentum and gravitational constant, respectively. Show that P is a dimensionless quantity.
Answer:
From the problem, $P = E l^2 m^{-5} G^{-2}$
E is the energy = $[ML^2T^{-2}]$
m is the mass = [M]
L is the angular momentum = $[ML^2T^1]$
G is the gravitational constant = $[M^{-1}L^2T^2]$
Substituting the values we get, $[P] = [M^0L^0T^0]$

2.40 If velocity of light c, Planck's constant h and gravitational constant G are taken as fundamental

quantities then express mass, length and time in terms of dimensions of these quantities.

Answer:

Principle of homogeneity is used for solving this problem.

$[h] = [ML^2T^1]$

$[c] = [LT^{-1}]$

$[G] = [M^{-1}L^3T^{-2}]$

Let $m = kc^a h^b G^c$

Solving the above we get,

$m = kc^{1/2}h^{1/2}G^{-1/2} = k\sqrt{ch/G}$

Let $L = kc^a h^b G^c$

Solving the above we get,

$L = kc^{-3/2}h^{1/2}G^{1/2} = k\sqrt{hG/c^3}$

Let $T = c^a h^b G^c$

Solving the above we get,

$L = kc^{-5/2}h^{1/2}G^{1/2} = k\sqrt{hG/c^5}$

2.41. An artificial satellite is revolving around a planet of mass M and radius R, in a circular orbit of radius r. From Kepler's third law about the period of a satellite around a common central body, square of the period of revolution T is proportional to the cube of the radius of the orbit r. Show using dimensional analysis, that T = k/R √r3/g where k is a dimensionless constant and g is acceleration due to gravity.

Answer:

From Kepler's third law, we know that

T2 a3 where T2 is the square of time period of the satellite revolving around a planet and is proportional to the cube of the radius of the orbit r3.

T2 r3

T r3/2

T depends on R and g

T r3/2gaRb

2.42. In an experiment to estimate the size of a molecule of oleic acid, 1mL of oleic acid is dissolved in 19mL of alcohol. Then 1mL of this solution is diluted to 20mL by adding alcohol. Now, 1 drop of this diluted solution is placed on water in a shallow trough. The solution spreads over the surface of water forming one molecule thick layer. Now, lycopodium powder is sprinkled evenly over the film we can calculate the thickness of the film which will give us the size of oleic acid molecule.

Read the passage carefully and answer the following questions:

a) Why do we dissolve oleic acid in alcohol?

b) What is the role of lycopodium powder?

c) What would be the volume of oleic acid in each mL of solution prepared?

d) How will you calculate the volume of n drops of this solution of oleic.

e) What will be the volume of oleic acid in one drop of this solution?

Answer:

a) Oleic is dissolved in the alcohol because it does not get dissolved in water.

b) With the help of lycopodium powder one can measure the area over which the oleic acid spreads as lycopodium powder clears the circular area when oleic acid is added.

c) 20mL of oleic acid contains 1mL of oleic acid.

This means that each mL of solution contains 1/20 mL of oleic acid.
1mL of this solution is diluted to 20mL by adding alcohol.
Therefore, each mL of solution prepared, volume of oleic acid = (1/20)(1/20) = 1/400mL

d) To calculate the volume of n drops of this solution of oleic, burette and measuring cylinder can be used.

e) The volume of oleic acid in one drop = 1/400mL

2.43. a) How many astronomical units (AU) make 1 parsec?
b) Consider the sun like a star at a distance of 2 parsec. When it is seen through a telescope with 100 magnification, what should be the angular size of the star? Sun appears to be (1/2) degree from the earth. Due to atmospheric fluctuations, eye cannot resolve objects smaller than 1 arc minute.
c) Mars has approximately half of the earth's diameter. When it is closer to the earth it is at about ½ AU from the earth. Calculate at what size it will disappear when seen through the same telescope.
Answer:
a) From the definition, 1 parsec is equal to the distance at which 1 AU long arc subtends an angle of 1s.
Using the definition, we can say that
1 parsec = (3600)(180)/π AU
= 206265 AU
= 2×10^5 AU

b) Given that the sun's angular diameter from the earth is 1/2 degree at 1 AU.
Angular diameter of the sun like star at a distance of 2 parsec
= [(1/2)/(2)(2)(105)] degree
= $1/8 \times 10^{-5}$ degree
= 7.5×10^{-5} arcmin

When the sun appears like a start through the telescope that has a magnification of 100, the angular diameter of the star is
= $(100)(7.5 \times 10^{-5})$
= 7.5×10^{-3} arcmin
But the angular size of the sun appears as 1 arcmin to the eyes as the eyes cannot resolve smaller than 1 arcmin because of atmospheric fluctuations.

c) Given that,
Dmars/Dearth = 1/2
We also know that Dearth/Dsun = 1/100
Therefore, Dmars/Dsun = 1/2 × 1/100
At 1AU, the sun's diameter = (1/2) degree
Therefore, diameter of mars = (1/400) degree
At 1/2 AU, mars diameter = (1/400)(2) = (1/200) degree
With 100 magnification, mars diameter = (1/2) degree = 30'
Therefore, it can be said that the value is larger than the resolution limit because of atmospheric fluctuations and hence it looks magnified.

2.44. Einstein's mass-energy relation emerging out of his famous theory of relativity relates mass (m) to energy (E) as $E = mc^2$, where c is speed of light in vacuum. At the nuclear level, the magnitudes of energy are very small. The energy at nuclear level is usually measured in MeV where 1 MeV = 1.6×10^{-13}J, the masses are measured in unified equivalent of 1u is 931.5 MeV.
a) Show that the energy equivalent of 1 u is 931.5 MeV.

b) A student writes the relation as 1 u = 931.5 MeV. The teacher points out that the relation is dimensionally incorrect. Write the correct relation.

Answer:

a) Using Einstein's mass-energy relation, the energy that is equivalent to the given mass can be calculated

1 amu = 1 u = 1.67×10^{-27} kg

Applying $E = mc^2$

E = 931.5 MeV

b) As $E = mc^2$

$m = E/c^2$

Which means that 1u = 931.5 MeV/c^2

The dimensionally correct relation of 1 amu = 931.5 MeV