PHYSICS

BOOKS - HC VERMA

INTRODUCTION TO PHYSICS

Example

1. Calculate the dimensional formula of energy from the equation $E = \frac{1}{2}mv^2$.

2. Test dimensionally if the formula $t = 2\pi\sqrt{\frac{m}{\frac{F}{x}}}$ may be corect where t is time period, F is force and x is distance.

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3. Find the dimensional formulae of the following quantities:

a. the universal constant of gravitation G,

b. the surface tension S,

c. the thermal conductivity k and

d. the coeficient of viscosity η.

Some equation involving these quantities are

$F = \frac{Gm_1m_2}{r^2}, S = \frac{\rho grh}{2},$

$$Q = k\frac{A(\theta_2 - \theta_1)t}{d} \text{ and } F = -\eta A\frac{v_2 - v_1}{x_2 - x_1}$$

where the symbols have their usual meanings.

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4. Find the dimensional formulae of

a the charge Q.

the potential V,

c. the capacitance C and

d the resistance R.

Some of the equations containing these quantities are Q=It, U=VIt, Q=CV and V=RI,`

where I denotes the electric current, t is time and U is energy.

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5. The SI and CGS units of energy are joule and erg respectivel. How many ergs are equal to one joule.

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6. Young's modulus of steel is $19 \times 10^{10} \frac{N}{m^2}$. Expres it indyne/cm^2. Here dyne is the CGS unit of force.

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7. Taking velocity, time and force as the fundamental quantities, find the dimensions of mass.

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8. Test dimensionally if the $v^2 = u^2 + 2ax$ may be correct.

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9. The distance covered by a particle in time t is given by $x = a + bt + ct^2 + dt^3$, find the dimensions of a,b,c and d.

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10. If the centripetal force is of the form $m^a v^b r^c$, find the valus of a,b, and c.

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11. When a solid moves through a liquid, the liquid opposes the motion with a force F. The magnitude of F depends on the coefficient of viscosity η of the liquid, the radius r of the sphere and the speed v of the sphere. Assuming that F is proportional to different powers of these quantities, guess a formula for F using the method of dimension.

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12. The heat produced in a wire carrying an electric current depends on the current, the resistance and the time. Assuming that the dependance is of the product of powers type, guess an eqn. between these quantities using dimensional analysis. The dimensional formula of resistance is $ML^2A^{-2}T^{-3}$ and heat is a form of energy.

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Question For Short Answer

1. The metre is defined as the distance travelled by ligh in $\frac{1}{299, 792, 458}$ second. Why didn't people choose some easier number such as $\frac{1}{300.000.000}$ second?

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2. What are the dimensions of :

a. volume of a cube of edge a,

b. volume of a sphere of radius a,

c. the ratio of the volume of a cube of edge a to the volume of a sphere of radius a ?

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3. Suppose you are told that the linear size of everything in the universe has been doubled overnight. Can you test this statement by measuring sizes with a meter stick? Can you test it by using the fact that the speed of light is a universal constant and has not changed? What will happen if all the clocks in the universe also start running at half the speed?

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4. If all terms in an equatioin have same units, is it necessary that they have same dimesnions ? If all the terms in an equations have same dimensions, is it necessary that they have same units ?

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5. If two quantities have same dimensions, do they represent same physical content?

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6. It is desirable that the standards of units be easily available, invariable, indestructible and easily reproducible.

If we use foot of a person as a standard unit of length, which of theabove features are present and which are not?

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7. Suggest a way to measure:

a. the thickness of a sheet of paper,

b. the distance between the sun and the moon.

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Objective 1

1. Which one of the following sets $\underline{\text{cannot}}$ enter into the list of fundamental quantities?

A. length, mass and velocity,

B. length, time and velocity,

C. mass, time and velocity

D. length, time and mass

Answer: B

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2. A physical quantity is measured and the result is expressed as nu where u is the unit used and n is the numberical value. If the result is expressed in various units then

A. $n \propto sizeofu$

B. $n \propto u^2$

C. $n \propto \sqrt{u}$

D. $n \propto \frac{1}{u}$.

Answer: D

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3. The dimension of magnetic field in M, L, T and C (coulomb) is given as

A. can always be dimensionally represented in terms of L, T and x

B. can never be dimensionally represented in terms of L, T and x.

C. May be represented in terms of L, T and x if $a \neq 0$

D. does not exist

Answer: D

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4. A dimesnsionless quantity

A. never has a unit

B. always has a unit

C. may have a unit

D. does not exist

Answer: C

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5. A unitless quantity

A. never has a nonzero dimension

B. always has a nonzero dimension

C. may have a nonzero dimension.

D. does not exist

Answer: A

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6. Evaluate $\int \frac{1}{\sqrt{2x - x^2}} dx.$

A. 0

B. -1

C. 1

D. none of these

Answer: A

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Objective 2

1. The dimensions $ML^{-1}T^{-2}$ may correspond to

A. work done by a force

B. linear momentum

C. pressure

D. energy per unit volume

Answer: C::D

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2. Choose the correct statement(s) about tenuinucellate ovule

A. A dimensionally correct equation may be correct

B. A dimensionally correct equation may be incorrect

C. A dimensionally incorrect equation may be correct

D. A dimensionally incorrect equation may be incorrect.

Answer: A::B::D

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3. Choose the correct statement(s) about tenuinucellate ovule

A. All quantities may be represented dimensionally in terms of the base quantities

B. A base quantity cannot be represented dimensionally in terms of the rest of the base quantities

C. The dimension of a base quantity in other base quantities is always zero.

D. The dimension of a derived quantity is never zero in any base quantity.

Answer: A::B::C

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Exercises

1. Find the dimensions of

a. linear momentum

b. frequency and

c. pressure

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2. Find the dimensions of

a. angular speed ω

angular acceleration α

torque τ and

d. moment of interia I.

. Some of the equations involving these quantities are $\omega = \frac{\theta_2 - \theta_1}{t_2 - t_1}, \alpha = \frac{\omega_2 - \omega_1}{t_2 - t_1}, \tau = F.r \text{ and } I = mr^2$

The symbols have standard meanings.

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3. Find the dimensions of

a. electric field E,

magnetic field B and

magnetic permeability μ_0

. The relavant equations are

$$F = qE, FqvB, \text{ and } B = \frac{\mu_0 I}{2\pi\alpha},$$

where F is force q is charge, ν is speed I is current, and α is distance.

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4. Find the dimensions of

a. electric dipole moment p and

b. magnetic dipole moment M.

The defining equations are $p = q.\, d \text{ and } M = IA,$

whre d is distance, A is area, q is charge and I is current.

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5. The dimensions of Planck's constant are same as

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6. Find the dimensions of

a. the specific heat capacity c,

b. the coeficient of linear expansion α and

c. the gas constant R

Some of the equations involving these quantities are

$Q = mc(T_2 - T_1), l_t = l_0[1 + \alpha(T_2 - T_1)]$ and $PV = nRT$.

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7. Taking foce, length and time to be the fundamental quantities find the dimension of

a. density, b. pressure,

c. momentum and d. energy

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8. Suppose the acceleration due to gravity at a place is $10\frac{m}{s^2}$. Find its value in $cm/(\min)^2$

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9. The average speed of a snails is 0.020 miles/ hour and that of a leopard is 70 miles/hours. Coinvert these speeds is

SI units.

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10. The height of mercury column in a barometer in a Calcutta laboratory was recorded to be 75 cm. Calculate this pressure in SI and CGS units the following data, Specific gravity of mercury = 13.6, Density of $water = 10^3 k\frac{g}{m^3}, g = 9.8\frac{m}{s^2}$ at Calcutta. Pressure $= h\rho g$ in usual symbols.

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11. Express the power of a 100 wtt bulb in CGS unit.

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12. The normal duratioin of I.Sc. Physics practical period in Indian colleges is 100 minute. Express this perod in microcenturies. 1 microcentruy $= 10^{-6} \times 100$ years. How many microcenturies did you sleep yesterday?

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13. The surface tension of water is 72 dyne/cm. convert it in SI unit.

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14. The kinetic energy K of a rotating body depends on its moment of inertia I and its angular speed ω. Assuming the relation to be $K = kI^{\alpha}\omega^{b}$ where k is a dimensionless constatnt, find a and b. Moment of inertia of a spere about its diameter is $\frac{2}{5}Mr^2$.

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15. Theory of relativity reveals that mass can be converted into energy. The energy E so obtained is proportional to certain powers of mass m and the speed c of light. Guess a relation among the quantities using the method of dimensions.

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16. Let I= current through a conductor, R= its resistance and V= potential difference across its ends. According to Ohm's law, product of two of these quantities equals the third. Obtain Ohm's law from dimensional analysis. Dimensonal formulae for R andV are $ML^2I^{-2}T^{-3}$ and $ML^2T^{-3}I^{-1}$ respectively.

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17. The frequency of vibration of string depends on the length L between the nodes, the tension F in the string and its mass per unit length m. Guess the expression for its frequency from dimensional analysis.

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18. Test if the following equations are dimensionally correct:

(a) $h = \frac{2S\cos\theta}{\rho r g}$

(b). $\nu = \sqrt{\frac{P}{\rho}}$,

(c). $V = \frac{\pi P r^4 t}{8\eta l}$,

(d). $v = \frac{1}{2\pi}\sqrt{\frac{mgl}{I}}$

where h height, S= surface tension, ρ= density, P= pressure, V=volume, η = coefficient of viscosity, v= frequency and I = moment of inertia.

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19. Let x and a stand of distance is $\int \frac{dx}{\sqrt{a^2 - x^2}} = \frac{1}{\alpha}\frac{\sin^{-1}(\alpha)}{x}$ dimensionally correcy ?

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