PHYSICS

BOOKS - S CHAND PHYSICS (ENGLISH)

DIMENSIONS

Additional Solved Problems

1. Check the correctness of the following equation by the method of dimensions

(i) $v^2 = u^2 + 2gs$ (ii) $s = ut + \frac{1}{2}\mathrm{gt}^2$ (iii) $v = u + \mathrm{gt}$

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2. Check the correctness of the equation $\frac{1}{2}mv^2 = mgh$, using dimensions.

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3. Derive an expression using the method of dimensions, the distance travelled by a body during an interval of time t, if its initial velocity is u and uniform acceleration is a.

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4. The critical velocity v for a liquid depends upon (a) coefficient of viscosity η (b) density of the liquid ρ and © radius of the pipe r. Using dimensions derive an expression for the critical velocity.

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5. A freely body acquires a velocity of $g^x h^y$ after falling through a height h. Using dimensions find the values fo x and y.

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6. It is given that the mass m of the largest stone that can be moved by the folowing river depends upon the velocity v, density ρ and acceleration due gravity g. Using dimensions show that $m = \frac{kv^6\rho}{g^3}$.

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7. Convert an energy of 1 joule into ergs.

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8. If the velocity of light is taken as the unit of velocity and year as the unit of time find the unit of length?

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9. A gas bubble from an explosion under water oscillates with a period T proportional to $p^a d^b E^c$ where p is the static pressure d is the density of water and E is the total energy of explosion. Find the value of a,b and c.

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10. Check the correctness of the formula using dimensions: $x = a \sin(\omega t + \phi), x -$

displacement, α - amplitude, ω angular velocity

ϕ is an angle and it has no dimensions.

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11. The displacement y(t) of a particle depends on time according in equation $y(t) = a_1 t - a_2 t^2$. What is the dimensions of a_1 and a_2?

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12. The frequency v of the stretched string may depend on (i) the length of the vibrating segment 1 (ii) the tension in the string and (iii) the mass per unit length m. Show that $v \propto \frac{1}{l}\sqrt{\frac{F}{m}}$.

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13. Using dimensions method show that the speed of sound in a material medium of modulus of elasticity E and density ρ is

$$v \propto \sqrt{\frac{E}{\rho}}$$

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14. Using dimensions show that the viscous force acting on a glass sphere falling through a highly viscous liquid of coefficient of viscosity η is $F \propto \eta$ av where a is the radius of the sphere and v its terminal velocity.

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15. Find the dimensions of (i) force (ii) surface tension and (iii) momentum in terms of frequency, velocity and density as fundamental units.

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16. If area (A), density (D) and force (F) are taken as fundamental quantities, find the dimensional formula for young's modulus.

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17. Given the unit of power as 1 million erg/min, the unit of force as 1000 dynes, unit of time as 1/10 s, what is the unit of mass and length.

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18. The period of revolution of a satellite depends upon the radius of the orbit, the mass of the planet and the gravitational constant. Prove that the square of the period varies as the cube of the radius.

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19. In van der Waal's equations $\left(P + \frac{a}{V^2}\right)(V - b) = RT$, what are the dimensions of the constants a and b?

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20. The rotational kinetic energy of a body is given by $E = \frac{1}{2} I\omega^2$. Use this equation to get the dimensional formula of I?

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Short Answer Questions With Answers

1. By knowing dimensions what idea do you get about a physical quantity?

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2. What is the difference between a dimensional constant and a dimensionless constant?

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3. Match the physical quantities given in column I with dimensions expressed interms of mass (M), length (L), time (T) and charge (Q) given in column II and wire the correct answer against the match quantity in labourar form.

I	II
Angular momentum	ML^2T^{-2}
Latent heat	ML^2Q^{-2}
Torque	ML^2T^{-1}
Capacitance	$ML^3T^{-1}Q^{-2}$
Inductance	$M^{-1}L^{-2}T^2Q^2$
Resistivity	L^2T^{-2}

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4. Which physical quantities have the same dimensions of $ML^{-1}T^{-2}$?

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5. The calorie is a unit of heat or energy and it equals about 4.2 J where $1J = 1kgm^2s^{-2}$. Suppose we employ a system of units in which the unit of mass equals α kg, the unit of length equals β m and the unit of time is γ s. Show that the calorie has a magnitude of $4.2\alpha^{-1}\beta^{-2}\gamma^2$ in terms of the new units.

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6. Show dimensionally that the pressure is given by (i) energy per unit volume (ii) force per unit area.

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7. What is the dimensional formula of angular velocity?

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8. Name three physical quantities without dimensions.

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9. Name three physical quantities having the same dimensions.

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10. Obtain the dimensions of (1) coefficient of thermal conductivity (2) Gas constant (3) Boltzmann constant (4) Planck's constant.

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Long Answer Questions

1. Explain the uses of dimensional analysis with one example for each.

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2. What are (i) dimensional constant, (ii) dimensionless constants, (iii) dimensional variables and (iv) dimensionless variables.

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3. Give the limitations of dimensional analysis.

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Short Answer Questions

1. What are dimensions of a physical quantity?

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2. What is the difference between a dimensional formula and a dimensional equation?

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3. What are dimensional variables ?Give examples.

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4. What are dimensionless variables? Why are they called so?

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5. g is dimensional constant where as π is the dimensionless constant. Why?

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6. Give the dimensional formula of (i) gravitational constnat (ii) coefficient of viscosity η.

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7. Angle and strain have no dimensions. Why?

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8. Mention the uses of dimensional equations.

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9. What is meant by the principle of homogeneity of dimensions?

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10. Check the correctness of the equations (i) $s = ut + \frac{1}{2}at^2$ (ii) $v^2 = u^2 + 2as$ using dimensions.

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11. Using dimension convert one dyne into newton.

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12. Mention the limitation of dimensional analysis.

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Very Short Answer Questions

1. What are the dimensions of angular displacement?

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2. What is B the name of dimensional constant whose dimensions are the same as that of angular momentum.

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3. Give three examples for a quantity which has unit, but still dimensionless.

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4. Do we have quantity which has dimensions but no unit?

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5. What is the principle behind the principle of homogeneity of dimensions?

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Selected Problems From Checking The Correctness Of An Equation

1. Check the correctness of the equation $y = a\sin\frac{2\pi}{\lambda}(vt - x)$ using dimensional analysis where y is the displacement of a particle at a distance x from the origin at time t, λ- wavelength v-wave velocity, a- amplitude.

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2. Check the correctness of the equation $v = \frac{K\eta}{r\rho}$ using dimensional analysis, where v is the critical velocity η is the coefficient of viscosity, r is the radius and ρ is the density?

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3. The displacement of a particle is related to time by the expression $s = kt^3$, what is the dimension of the constant k?

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4. Using dimensional analysis check the correctness of the equation $T = 2\pi\sqrt{\frac{l}{g}}$, where T is the period of the simple pendulum of length l and g is the acceleration due to gravity.

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5. Check the correctness of the equation $W = \frac{1}{2}mv^2 - \frac{1}{2}\text{mu}^2$ using the dimensional analysis, where W is the work done, m is the mass of body,u-its initial velocity and v its final velocity.

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6. A student writes the equation for the capillary rise of a liquid in a tube as $h = \frac{\rho g}{2T \cos \theta}$, where r is the radius of the capillary tube, ρ is the density of liquid, T is the surface tension and θ is the angle of contact. Check the correctness of the equation using dimensional analysis?

7. Find the which of the following are correct using dimensional analysis.

(i) $t^2 = 4\pi^2 a^3$ (ii) $t^2 = \frac{4\pi^2 a^3}{G}$ (iii) $t^2 = \frac{4\pi^2 a^3}{GM}$

where t is the time period, a is the radius of the orbit of a planet and M is the mass of sun.

8. Give the quantities for which the following are the dimensions:

$M^{0}L^{0}T^{-2}$

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9. Give the quantities for which the following are the dimensions:

$M^{1}L^{-1}T^{-2}$

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10. Give the quantities for which the following are the dimensions:

M^1T^{-2}

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11. Give the quantities for which the following are the dimensions:

M^1L^2

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12. Give the quantities for which the following are the dimensions:

$M^{-1}L^{3}T^{-2}$

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13. Give the quantities for which the following are the dimensions:

$M^{0}L^{0}T^{0}$

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Selected Problems From Finding The Dimension Of A Physical Quantity

1. The density of the earth is given by $\rho = Kg^{x}r^{y}G^{z}$. Obtain the values of x,y and z

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2. The rotaitonal kinetic energy $E = \frac{1}{2}I\omega^{2}$. Use this equation to get the dimensional formula for ω, where I is the moment of inertia and ω is the angular velocity.

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3. The velocity of a particle change with time according to the relation $v = xt + yt^2 + z$. Give the dimensions of x,y and z if v is in ms^{-1} and t is in s.

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Selected Problems From Derivation Of Formulae Using Dimensions

1. The acceleration due to gravity at a piece depends on the mass of the earth M, radius of the earth R and the gravitational constant G. Derive an expression for g?

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2. The time period of oscillation T of a small drop of liquid under surface tension depends upon the density ρ, the radius r and surface tension σ. Using dimensional analysis show that $T \propto \sqrt{\frac{\rho r^3}{\sigma}}$

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3. The escape velocity of a body from the surface of the earth depends upon (i) the mass of the earth M, (ii) The radius of the eath R, and (iii) the gravitational constnat G. Show that $v = k\sqrt{\frac{GM}{R}}$, using the dimensional analysis.

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4. The rate of a flow V a of liquid through a capillary under a constant pressure depends upon (i) the pressure gradient (P/l) (ii) coefficient of viscosity of the liquid η (iii) the radius of the capillary tube r. Show dimesionally that the rate of volume of liquid flowing per sec V∝ Pr^4 /ηl

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5. Derive an experession for the period of oscillation of a mass attached to a spring executing simple harmonic motion. Given that the period of oscillation depends on the mass m and the force constant k, where k is the force required to stretch the spring by unit length?

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Selected Problems From Conversions Of One Systems Of Units Into Another

1. Using dimensional analysis show that $1N/m^2 = 10\text{dyne}/cm^2$.

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2. The value of atmosphere pressure is 10^6 dynes/cm^2. Find the value in S.I. using dimensional analysis?

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3. Find the value 15 joule in a system which has 10 cm, 100 gm and 20sec as a fundamental units?

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4. Using dimensional analysis obtain the value of density of water in S.I. In C.G.S system density of water is $1 gm / cm^3$.

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5. Using dimensional analysis show that if the units of length and force are each doubled, the units of energy is increased four times?

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6. Obtain the dimensions of linear momentum and surface tension in terms of velocity (v), density (ρ) and frequency(ν) as fundamental units.

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7. 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 as tan $\theta = v$ and checks that the relation has a correct limit when $v \to 0, \theta \to 0$ as expected. Do you think the relation can be correct? If not guess out the correct relation.

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8. If velocity of light, acceleration due to gravity and normal atmospheric pressure are taken as the fundamental units, what will be the units of mass, length and time, given velocity of light as $3 \times 10^8\ ms^{-1}$ acceleration due to gravity $10ms^{-2}$ and normal pressure $= 10^5 Nm^{-2}$

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9. If acceleration due to gravity g, the speed of light c and pressure p are taken as the fundamental quantities then find the dimensions of length.

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