November 25, 2022

1 Unit and Dimension

1. a) Write the dimensional formula of universal gravitational constant, mass and density taking force , length and time as fundamental quantity.
b) The density of gold is 19.3 gm/cc. Express its value in SI unit by using dimension method.
c) Convert 50 joule into erg by using dimensional method.
d) In Vander waals equation,$(P+\frac{a}{V^2})(V-b)$ where P be the pressure, V be the volume, T be the temperature and R be the universal gas constant. What are the dimensions of the constants a and b?

2. a) An important milestone in the evolution of the universe just after the Big Bang is the Planck time t_p , the value of which depends on three fundamental constants: (1) the speed of light c (2) Newton's gravitational constant G and (3) Planck's constant h. Based on a dimensional analysis, find the expression of the Planck time.
b) Test the correctness of expression $v^2 = u^2 + 2as$.
c) A wire has a length 6 $\pm$ 0.06 cm and radius 0.5 $\pm$ 0.005 cm and mass 0.6 $\pm$ 0.006 gm. Calculate the maximum percentage error in the calculation of density of the wire.

3. a) A sphere of radius 'a' moving through a fluid of density ρ with high velocity v experience a retarding force F given by F = $ka^x\rho^y v^z$, where k is a non-dimension constant. Use the method of dimension to find the values of x, y and z.
b) Convert a speed of 90 km/hour into m/s dimensional method.
c) What do you mean by random error and systematic error? How are these error minimized?

4. a) What do you mean by principle of homogeneity? b) The expression of force is given by F = $A\sqrt{X} + \frac{B}{t^3} + \frac{C}{\sqrt{t}}$ where X and t are the displacement and time respectively. By using principle of homogeneity of dimension , find the dimensions of A , B and C.
c) The length of the square shaped room is 10 $\pm$ 0.2 m. i) What does it mean? ii)Calculate absolute error in area and percentage error in area.
d) Distinguish between precision and accuracy.

5. a) A student writes $\sqrt{\frac{3v^2}{8\pi G R^2}}$ for critical density of the universe. Check the given equation is dimensionally correct or incorrect.
b) Find the dimension of power, angular momentum, Planck's constant and coefficient of viscosity.
c) The time period of the simple pendulum depends on length (l) and acceleration due to gravity (g). Using this information, derive an expression of time period of the simple pendulum.
d) If percentage error in length and time period of simple pendulum are 2 % and 4% respectively, calculate the percentage error in acceleration due to gravity(g).

2 Elasticity

1. a) What is breaking stress? Does it depend on cross sectional area ?
b) Why is steel more elastic than rubber?
c) Why does spring balance show wrong reading after long use?

2. a) What do you mean by elastic fatigue? Why are bridges declared unsafe after a long use?
b) A steel wire of density 8000 kg/m^3 weighs 24 gm and is 250 cm long. It lengthens 1.2 mm when stretched by a force of 80 N. Calculate the Young's modulus for the steel energy stored in the wire. (Ans: 1.4 $\times 10^{11}$ N/m^2 and 0.024 J)

3. a) What happens in young's modulus of elasticity of a material when the load hanging on it is doubled?
b) What is the percentage increase in the length of a wire of diameter 2.5 mm stretched by a force of 100 kg wt? (Young's modulus of elasticity of the wire is 12.5 $\times 10^{11} dyne/cm^2$)) (Ans : 0.16 %)
c) Two circular rods, one steel and the other copper, are joined end to end. Each rod is 0.750 m long and 1.50 cm in diameter. The combination is subjected to a tensile force with magnitude 4000 N. For each rod, what are (a) the strain and (b) the elongation? (Y for steel =2 $\times 10^{11}$ N/m^2 and Y for copper = 1.2 $\times 10^{11} N/m^2$) (Ans: 1.13 $\times 10^{-3}$, 1.88 $\times 10^{-4}$, 8.3 $\times 10^{-5}$ m and 1.41 $\times 10^{-4}$ m)

4. a) Two wires have equal lengths and are made up of same material. If the diameter of one wire is twice another wire, which one has greater extension for a given load?

b) The rubber catapult has a cross sectional area 1 mm^2 and total unstretched length 10 cm. It is stretched to 12 cm and then released to project a missile of mass 5 gm. Calculate the velocity of projection. (young's modulus of elasticity of rubber Y = 5 $\times 10^8 N/m^2$) (Ans: 20 m/s)

c) The radii and Young's modulus of two uniform wires A and B are in the ratio 2 : 1 and 1 : 2 respectively. Both the wires are subjected to the same longitudinal force. If increase in the length of wire A is 1 % . Find the the percentage increase in length of wire B. (Ans: 2 %)

d) What do you mean by Poisson's ratio? Explain.

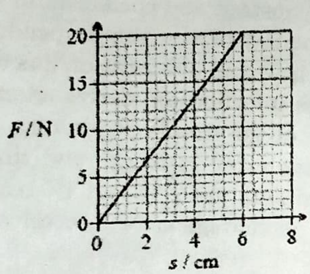

Figure 1: QN 5 (Fe curve)

5. On the basis of Force and extension curve, answer the following questions: a) What does area of the given curve give? b) In the given diagram, s represents elongation in cm and F represents force in N. Calculate force constant of the given material. c) If the length of the wire is 12 cm and area of cross section be $2\times10^{-7} m^2$, then find the value of young's modulus of given material. d) How much energy is stored at s = 0 and s = 6 ? e) Calculate work done by molecules at s = 4 cm.

6. a) What do you mean by elastic after effect and elastic hysteresis?

b) Car tyre is made of synthetic rubber, why?

c)A circular steel wire 1.98 m long must stretch no more than 0.24 cm when a tensile force of 440 N is applied to each end of the wire. What minimum diameter is required for the wire? (Y =2 $\times$ 10^{11} N/m^2) (Ans: 1.5 mm)

7. The stress-strain graphs for materials A and B are shown in Fig. The graphs are drawn to the same scale. (a) Which of the materials has the greater Young's modulus ? (b) Which of the two is the stronger material ?

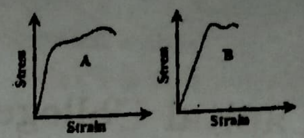

Figure 2: Stress strain curve

8. a) What is strain energy? Show that energy density is half of product of stress and strain of an elastic body.

b) A uniform steel of wire of density 7800 kg/m^3 is 2.5 m long and weighs 15.6 g. It exceeds by 1.25 mm when loaded by 8 kg. Calculate the value of young's modulus of elasticity of steel and energy stored in the wire. (Ans : 2 $\times 10^{11}$ N/m^2 and 0.05 J)

c) A steel wire with cross section 3 cm^2 has elastic limit 2.4 $\times$ 10^8 Pa. Find the maximum upward acceleration that can be given to a 1200 kg elevator supported by this cable if the stress is not to exceed $\frac{1}{3}$ rd of the elastic limit. (Ans: 10 m/s^2)

9. a) State and explain Hooke's law.

b) What force is required to stretch a steel of wire of cross section 1 cm^2 to double its length?(Y =2 $\times$ 10^{11} N/m^2) (Ans : 2 $\times 10^4$ N)

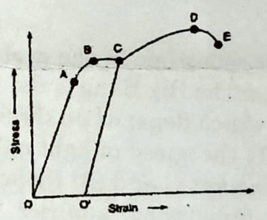

Figure 3: QN 10 Stress strain curve

10. (a) Up to which point of curve, is Hooke's law obeyed ? (b) Which point on the curve corresponds to elastic limit and yield point of the wire ? (c) Indicate the elastic and plastic regions of the stress-strain curve. (d) What change happens when the wire is loaded upto a stress corresponding to point C on curve, and then unloaded gradually ?

e) What do you mean by elastic limit? How do you distinguish ductile and brittle material on the basis of the strain stress curve? Explain.

11. a) What do you mean by bulk stress and bulk modulus? How is bulk modulus related to compressible capacity ?

b) How much should be pressure the a litre of water be changed to compress it by 0.10 %? (Bulk modulus of elasticity of water = 2.2 $\times$ $10^9 Nm^{-2}$).

c) What is force constant? Write its dimension.