New Syllabus

CONCEPT

Chapter wise Objective Question

JHARKHAND POLYTECHNIC

Question Bank

1st Semester

All Branch

ACCORDING TO JHARKHAND UNIVERSITY OF TECHNOLOGY RANCHI 2021-22

SUBJECT

- Engineering physic-I
- Engineering chemistry-I
- Engineering Maths-I
- Communication skill-I
- Computer Fundamental
- Engineering Graphics

SPECIAL FEATURES

- 2019 Question With Answer
- Chapter Wise Previous Year Question With Lutid Explanation
- Answer according to marks.
- Solved by experience faculties.
- Errorless and easy langauage.

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EDUCATION JHARKHAND

JHARKHAND POLYTECHNIC

(According to Latest Syllabus)

Chapter wise

QUESTION BANK

With

ANSWER

Solved by

Ritesh Srivastava

B. Tech

OEC, Bhubaneswar

- Engineering Physic-I
- Engineering Chemistry-I
- Engineering Maths-I
- Communication Skill -I
- Computer Fundamental
- Engineering Graphics

For All Branch

CONTENTS

SUBJECT	PAGE No.

Engineering Physics-I

SYLLABUS

Course Name : All Branches of diploma in Engineering
Semester : First
Subject Title : Engineering Physics I
Subject Code : *103/107*
Teaching and Examination Scheme :

Teaching Scheme			Examination Scheme					
L	T	P	Full Marks	External Exam marks	Internal Exam Marks	External Pass Marks	Total Pass Marks	Duration of External
03	1	–	100	80	20	26	40	3 Hrs
Practical		2	50	40	10	13	20	4 Hrs

CH.	CONTENT	Hr.	Mr.
1	**Unit And Measurements** 1.1 Need of measurement and unit in engineering and science, definition of unit, requirements of standard unit, systems of units-CGS, MKS and ST, fundamental and derived quantities and their units 1.2 Definition of dimensions with examples, principle of homogeneity of dimensions, limitations of dimensions. 1.3 Definition of accuracy, precision and error, estimation of errors-absolute error, relative error and percentage error, rules and identification of significant figures. **(Numericals on percentage error and significant figures)**	04	06
2	**MECHANICS** **2.1 Motion along a straight line and Force** Concept of scalar and vector quantities, Equations of motion with constant accelerations (derivation not required), Equations of motion of falling body under gravity, Newton's laws of motion, Force, inertia, Action and reaction, tension, momentum, impulse and impulsive force with practical examples (basic Idea), Conservations of linear momentum. **(Simple problems on linear motion)**	05	10
	2.2 Angular Motion Definition of angular displacement, angular velocity and angular acceleration, relation between linear velocity and angular velocity, definition of simple harmonic motion (SHM), SHM as a projection of uniform circular motion on any diameter, equation of SHM, derivation of displacement, velocity and acceleration of a body executing SHM.	05	08
3	**GRAVITATION** Newton's laws of gravitation Newton's gravitational constant (G) and its SI unit, Acceleration due to gravity (g) and its latitude (deduction not required) **(Simple problems)**	03	06
4.	**WORK, ENERGY & POWER** Definition of work, energy and power, equations for P.E. & K.E., Work-Energy principle, (Representation of work by using graph, work done by a torque (no derivation) **Numericals on work, potential and Kinetic energy**	02	06
5.	**GENERAL PROPERTIES OF MATTER** **5.1 ELASTICITY** Deformating force, restoring foprce, elastic and plastic body, stress and strain with their types, elastic limit, Hooke's law Young's modulus, bulk modulus of rigidity and relation between them (no derivation). **(Numerical on stress, strain and Young's modulus)**	04	08
	5.2 Surface Tension. Molecular force, cohesive and adhesive force, Molecular range, sphere of influence, Laplace's molecular theory, Definition of surface tension and its S.I. unit, angle of constact, capillary action with examples, shape of meniscus for water and mercury, relation between surface tension, capillary rise and radius of capillary (no derivation), effect of impurity and temperature on surface tension **Numerical on relation between surface tension, capillary rise and radius**	04	08
	5.3 Viscosity Definition of viscosity, viscous force, velocity gradient, Newton's law of viscosity, coefficient of viscosity and its S.I. unit, streamline and turbulent flow with examples, critical velocity, Reynolds's number and its significance, derivation of viscous force for free fall of spherical body through viscous medium, upthrust, terminal velocity, Stoke's law (statement and formula). **(Numerical on coefficient of viscocity, Reynods number and Stoke's formula)**	04	08
6.	**Heat** **Transmission of heat and expansion of solids :** Three modes of transmission of heat-conduction, convection and radiation, good and bad conductor of heat with examples, law of thermal conductivity, coefficient of thermal conductivity and its S.I. unit, Definition of linear, aerial and cubical expansion and relation between them (no derivation) (Numericals on law of thermal conoductivity, and coefficients of expansions)	04	08
7.	**ACCOUSTICS** **7.1 Sound** Definition of wave motion, amplitude, period, frequency, and wavelength, relation between velocity, frequency and wavelength, longitudinal and transverse wave, definition of stationary wave, node and antinode, forced and free vibrations, definition of resonance with examples. Derivation of formula for velocity of sound with end correction (Numericals on relation v = n and resonance	04	06
	7.2 Accoustics of Building Acoustics-concept and definition, Intensity and loudness of sound, echo, Reverberation standard reverberation time, Sabine's formula, Conditions for good acoustics, Factors affecting Acoustical planning of auditorium **(Numericals on Sabine's formula)**	04	06
	Total	42	80

Chapter 1.
Units And Measurements

Multiple Choice Question

1. One Newton meter is the unit of
(a) Momentum (b) Power
(c) Torque (d) None of these
Ans. (c)

2. What is the significant figure in 6.0023
(a) 2 (b) 3 (c) 6 (d) None
Ans.(d)

3. Light year is the unit of
(a) Time (b) Distance (c) Speed (d) None
Ans.(b)

4. The number of basic units required to cover all physical quantities in science and Engineering is.
(a) 7 (b) 5 (c) 6 (d) 3
Ans.(a)

5. The unit of coefficient of thermal conductivity is.
(a) Watt per Kelvin - m (b) Watt 1 m-k
(c) J/s (d) Joule
Ans.(a)

6. The unit of luminous intensity is.
(a) Candela (b) Watt (c) lumen (d) ampere
Ans.(a)

7. S.I. unit of coefficient of thermal conductivity is
(a) wkm (b) $wk^{-1}m^{-1}$ (c) $Jg^{-1}s^{-1}$ (d) $JKg^{-1}k^{-1}$
Ans.(b)

8. Unit of heat in S.I system is :
(a) Calorie (b) Joule (c) Kelvin (d) None
Ans. (b)

9. S.I unit of electronic capacitance is.
(a) Volt (b) Coulomb (c) Farad (d) None
Ans.(c)

10. Light year is the unit of :
(a) Time (b) Distance (c) Speed (d) None
Ans.(b)

11. The S.I unit of energy is joule and is equivalent to.
(a) 10^6 ergs (b) 10^{-7} ergs (c) 10^7 ergs (d) 10^5 ergs
Ans.(c)

12. Newton meter is the unit of -
(a) momentum (b) Torque (c) Force (d) None
Ans.(b)

13. Which of the following has not been expressed in proper unit.
(a) (Stress/Strain) = N/m^2 (b) Surface tension = N/m
(c) **enegy = kg × m/s** (d) Pressure = N/m^2.
Ans.(c)

14. Percentage error for a quantity A is
(a) $\frac{A}{\Delta A}\times 100$ (b) $\frac{\Delta A}{A}\times 100$
(c) (d) $A\Delta A$
Ans: (b)

15. Which of the following is not a unit of time ?
(a) Second (b) month
(c) year (d) light year
Ans.(d)

16. According to SI units, mass of substanceis measured in
(a) moles (b) kilograms (c) meters (d) candelas
Ans.(b)

17. The unit of luminance is
(a) lumen (b) candela per square meter
(c) lux (d) lumen per square meter
Ans.(b)

18. Another name for fundamental units is
(a) base units (b) atoms
(c) the metric system (d) letter symbols
Ans.(a)

19. Which of the following metric prefixes could replace 10^{-9}?
(a) nano (b) mega (c) kilo (d) micro
Ans.(a)

20. The SI unit for amount of substance is
(a) mole (b) mole fraction (c) kilogram (d) gram
Ans.(a)

21. Farad is the unit of
(a) charge (b) illumination (c) potential (d) capacitance
Ans.(d)

22. The metric system is also called as
(a) CGS (b) MKS system (c) SI (d) None of these
Ans.(b)

23. What is the name of physical quantities which are independent of each other?
(a) fundamental quantity (b) derived quantity
(c) numerical quantity (d) None of these
Ans.(a)

24. Which of the quantity consists of unit as kg.m/sec?
(a) speed (b) momentum (c) acceleration (d) impulse
Ans.(b)

25. Which of the quantity consists of unit as newton second?
(a) impulse (b) acceleration (c) speed (d) velocity
Ans.(a)

26. Which of the quantity consists of unit as Pascal?
(a) temperature (b) pressure (c) force (d) impulse
Ans.(b)

27. Which of the following quantities consists of SI unit as Hertz?
(a) charge (b) force (c) frequency (d) power
Ans.(c)

28. What is the formulas for momentum?
(a) force × displacement (b) mass × velocity
(c) mass × acceleration (d) change of velocity/time
Ans.(b)

29. What is the SI unit of angle?
(a) steradian (b) candela (c) radian (d) degreee
Ans.(c)

30. The fundamental unit which is common in FPS and MKS systems is
(a) foot (b) sec (c) kilo gram (d) pound
Ans.(b)

31. Which of the following system is a British system?
(a) CGS system (b) FPS system
(c) MKS system (d) None of these
Ans.(b)

32. The dimensional formula for Kinetic Energy/Potential Energy is :
(a) M^2L^2T (b) ML^2T^{-2} (c) M^0L^{-1} (d) ML^2T
Ans.(b)

33. Dimensions of gravitational constant are :
(a) ML^2T^2 (b) $M^1L^3T^{-2}$ (c) $M^0L^3T^2$ (d) $M^{-1}L^3T^{-2}$
Ans.(d)

34. Dimensional formula for angular momentum is :
(a) T^{-1} (b) MLT^{-1} (c) ML^2T^{-1} (d) $M^0L^0T^0$
Ans.(c)

35. Dimensions os Stefan's constant are :
(a) ML^2T^{-2} (b) $ML^2T^{-2}\theta^{-4}$ (c) $MT^{-3}\theta^{-4}$ (d) $MT^{-2}L^0$
Ans.(c)

One pascals is equal to
(a) One dyne/cm^2 (b) 1 Newton/m^2
(c) 1 Newton/metre (d) 1 Newton metre
Ans.(b)

36. $ML^{-1}T^{-2}$ stands for the dimensional formula of
(a) surface tension (b) gravitational constant
(c) viscosity (d) stress
Ans.(d)

37. The dimensions of Boltzmann constant are :
(a) $ML^2T^{-2}\theta^{-1}$ $mole^{-1}$ (b) $ML^2T^{-2}\theta$
(c) $M^2LT^{-2}\theta^{-1}$ (d) $ML^0T^{-2}\theta^{-1}$
Ans.(a)

38. The dimensional formula for the modulus of rigidity is :
(a) ML^2T^{-2} (b) $ML^{-1}T^{-3}$ (c) $ML^{-2}T^{-2}$ (d) $ML^{-1}T^{-2}$
Ans.(d)

39. The dimensional formula of angular velocity is :
(a) $M^0L^0T^{-1}$ (b) MLT^{-1} (c) $M^0L^0T^1$ (d) ML^0T^{-2}
Ans.(a)

40. The dimensions of calories are :
(a) ML^2T^{-2} (b) MLT^{-2} (c) $ML^{-2}T^{-1}$ (d) ML^2T^{-1}
Ans.(a)

41. Given $F = at^{-1}+bt^2$, where F denotes force and t time, the dimensions of a and b are repectively.
(a) LT^{-2} and T^{-2} (b) T and T^{-2}
(c) LT^{-1} and T^{-2} (d) MLT^{-1} and MLT^{-4}
Ans.(d)

42. The dimensions of self inductance are :
(a) $MLT^{-2}A^{-2}$ (b) $ML^2T^{-1}A^{-2}$ (c) $ML^2T^{-2}A^{-2}$ (d) $ML^2T^{-2}A^{-1}$
Ans.(c)

43. The dimensional formula for latent heat is :
(a) $M^0L^2T^{-2}$ (b) MLT^{-2} (c) ML^2T^{-2} (d) ML^2T^{-1}
Ans.(a)

44. The dimensions of solar constant are :
(a) MLT^{-2} (b) ML^0T^{-3} (c) ML^2T^{-2} (d) $M^0L^0T^0$
Ans.(b)

45. $M^1L^1T^{-1}$ are the dimension of :
(a) Power (b) Momentum (c) Force (d) Couple
Ans.(b)

46. Dimension of power are :
(a) $M^1L^2T^{-3}$ (b) $M^2L^1T^{-2}$ (c) $M^1L^2T^{-1}$ (d) $M^1L^1T^{-2}$
Ans.(a)

47. The dimensional formula for the coefficient of viscosity :
(a) $ML^{-1}T^{-1}$ (b) $ML^{-1}T^{-3}$ (c) $ML^{-2}T^{-2}$ (d) ML^2T^{-2}
Ans.(a)

48. Dimensions of electrical conductivity are :
(a) $M^{-1}L^{-3}T^3A^2$ (b) $ML^3T^3A^2$
(c) $M^2L^3T^{-3}A^2$ (d) $ML^3T^{-3}A^{-2}$
Ans.(a)

49. Dimension of electric current is :
(a) $[M^0L^0T^{-1}Q]$ (b) $[ML^2T^{-1}Q]$
(c) $[M^2LT^{-1}Q]$ (d) $[M^2L^2T^{-2}Q]$
Ans.(a)

50. Dimensional formula for torque is :
(a) MLT^{-2} (b) MLT^{-2} (c) $ML^{-1}T^{-2}$ (d) $ML^{-2}T^{-2}$
Ans.(b)

51. Dimensional formula for luminous flux is :
(a) ML^2T^{-2} (b) ML^2T^{-3}
(c) ML^2T^{-1} (d) None of the above
Ans.(b)

52. The dimensions of Farad are :
(a) $M^{-1}L^{-2}T^2Q^2$ (b) $M^{-1}L^{-2}TQ$
(c) $M^{-1}L^{-1}T^{-2}Q$ (d) $M^{-1}L^{-2}TQ^2$
Ans.(a)

53. The equation of a wave is given by $y = A\sin\omega\left(\frac{x}{v}-k\right)$ where ω is angular velocity and v is the linear velocity. The dimension of k is :
(a) LT (b) T (c) T^{-1} (d) T^2
Ans.(b)

54. Dimensional formula of capacitance is :
(a) $M^{-1}L^{-2}T^4A^2$ (b) $ML^2T^4A^{-2}$
(c) $MLT^{-4}A^2$ (d) $M^{-1}L^{-2}T^{-4}A^{-2}$
Ans.(a)

55. The physical quantity that has no dimensions :
(a) Angular velocity (b) Linear momentum
(c) Angular momentum (d) Strain
Ans.(d)

56. The dimensions of pressure are :
(a) MLT^{-2} (b) $ML^{-1}T^{-2}$ (c) ML^2T^{-2} (d) MLT^{-1}
Ans.(b)

57. Dimensional formula of Bulk Modulus of Elasticity K is
(a) $ML^{-1}T^{-2}$ (b) MLT^{-2} (c) $M^0L^0T^0$ (d) $ML^{-2}T^{-2}$
Ans.(a)

58. The dimensional formula of relative density is :
(a) ML^{-3} (b) MLT^{-2} (c) MLT^{-2} (d) Dimensionless
Ans.(d)

59. The closeness of values indicated by an instrument to the actual value is defined as
(a) repeatability (b) reliability
(c) uncertainty (d) accuracy
Ans.(d)

60. Precision is defined as

(a) repeatability (b) reliability
(c) uncertainty (d) accuracy

Ans.(a)

61. The ratio of change in output to the change in the input is called
(a) precision (b) resolution
(c) sensitivity (d) repeatability

Ans.(c)

62. The deviation of the measured value to the desired value is defined as
(a) error (b) repeatability (c) hystersis (d) resolution

Ans.(a)

63. Accuracy is expressed as
(a) relative accuracy (b) % accuracy
(c) error (d) % error

Ans.(b)

64. Error is expressed as
(a) absolute error (b) relative error
(c) % error (d) % accuracy

Ans.(c)

65. The number of significant figures in 0.06900 is
(a) 5 (b) 4 (c) 2 (d) 3

Ans.(b)

66. The sum 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

Ans.(c)

67. 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

Ans.(d)

68. The number of significant figures in 5418000 are
(a) 4 (b) 5 (c) 6 (d) 7

Ans.(a)

69. 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

Ans.(a)

70. The number of seconds in 1 day is 86400. With due regards to significant figures, it should be written in terms of power of 10 as.
(a) 8.6×10^4 (b) 8.64×10^4
(c) 8.640×10^4 (d) 8.6400×10^4

Ans.(d)

71. A cube has a side of length 1.2×10^{-2} m. Its volume in appropriate significant figures will be
(a) 1.7×10^{-6} m^3 (b) 1.70×10^{-6} m^3
(c) 1.73×10^{-6} m^3 (d) 1.732×10^{-6} m^3

Ans.(a)

Answer the following questions

Q1. What is units ? What are the requirement of standard unit.

Ans.Unit : The reference standard used for measurement of a physical quantity is called unit of physical quantity.

For Example : Length of rod is 5m.

Here, $5m = 5 \times 1\,m$

$\therefore$ 1 m is the standard (unit) used for measurement of length and 5 is magnitude of length.

Requirements of standard unit :

Requirements of good or standard unit are as follows :

i) It should be well defined.
ii) It should be easily reproducible at all places.
iii) It should not change with space and time.
iv) It should be easily comparable and readily avail able.
v) It should be universally accepted.
vi) It should be such that the quantity measured with it should not be too large or too small.

Q2. Write down different system of units. Explain S.I. system of units.

Ans.A measuring system is based on few fundamental units e.g. length, mass, time, temperature etc. All the physical quantities is being expressed in terms of these fundamental units.

(a) F. P. S. System :- Here, the length is measured in yard, mass, weight or force in pound, time in seconds and temperature is degree farenheit.

(b) Metric System :- Here, the length is measured in meter mass in kilogram force in kilogram force, time in seconds and temperature in degree centigrade.

(c) S.I System :- This system is extension and refinement of the metre system. Here, the length is expressed in meter, mass in kg, force in newton, time in seconds etc. It is based on decimal arithmatic.

(d) C.G. S. System :- In this system, the units of length of length, mass and time are centimetre, Gram and Second.

(e) M.K.S. System :- In this system, the units of length, mass and time are metre, Kilogram and Second.
This system is extension and refinement of the metre system. Here, the length is expressed in meter, mass in kg, force in newton, time in seconds etc. It is based on decimal arithmatic

S. No.	Physical Quantity	Unit	Symbol
1.	Length	Metre	M
2.	Mass	Kilogram	Kg
3.	Time	Second	S
4.	Temperature	Kelvin	K
5.	Electric current	Ampere	A
6.	Luminous intensity	Candela	Cd
7.	Quantity of substance	Mole	Mole

Q3. What do you know about fundamental and derived quantities ? Give examples.

Ans. Fundamental Quantities :

The physical quantities which does not depend on any other quantity are called fundamental physical quantities.

The unit of fundamental quantity is called fundamental unit.

It does not depend on any other unit.

These are the basic (fundamental) quantities (units) with the help of which unit of any quantity in engineering and science can be derived. The following are fundamental physical quantities along with their units.

Fundamental physical quantity	Fundamental unit
1 Length	metre
2 Mass	kilogram
3 Time	second
4 Electric current	ampere
5. Temperature	kelvin
6 Luminous intensity	candela
7. Amount of substance	mole

Derived Quantities :

The physical quantities which are derived using two or more fundamental quantities are called derived quantities.

The units of derived quantities are called derived units. These units depend on two or more fundamental units.

As we have seen there are seven fundamental quantities. The remaining all quantities are derived quantities.

e.g.
$$Density = \frac{Mass}{Volume}$$
$$= \frac{Mass}{l \times b \times h}$$

It is derived using two fundamental quantities i.e. mass and length. Following are few derived quantities along with their units.

Derived physical quantity	Derived unit
Area	square metre
Volume	cubic metre
Velocity	metre/sec
Acceleration	metre/sec^2
Force	newton
Pressure	newton/metre^2

Q4. State Dimensional formula (equation) ? What are the uses and limitation of Dimension equation.

Ans. Dimensional formula (equation) - Dimensional formula (equation) (Definition) : An equation, which gives the relation between fundamental units and derived units in terms of dimensions is called dimensional formula (equation) In me chanics the length, mass and time are taken as three base di mensions and are represented by letters L,M,T respectively.

Uses of Dimensional Equations

The method of dimensional analysis is used for following purposes.

1. To check the dimensional correctness of given physical equation.
2. To convert a physical quantity from one system of units to another system.
3. To establish relation among various physical quantities.

Limitations of Dimensional analysis

Although dimensional analysis is useful, it has the following limitations:

1. Dimensionless quantities cannot be determined by this method. Also constant of proportionality cannot be determined by this method.
2. This method is not applicable to trigonometric, logarithmic and exponential functions.
3. If a physical quantity depends upon more than three factors, then relation among them cannot be established.
4. This method cannot be used to derive equation involving addition and subtraction of physical quantities.
5. If dimensions are given, physical quantity may not be unique as many physical quantities have same dimensions. For example, if the dimensional formula of a physical quantity $[L^2MT^{-2}]$ then the quantity may be work or energy or torque.

Q5. State the principle of homogeneity of dimension.

Ans. According to this principle, **"For an equation to be dimensionally correct, the dimensions of each term on LHS must be equal to the dimensions of each term on RHS".** The reason this is simple, that only similar quantities can be added or subtracted or equated. e.g. two masses can be equal to each other, two velocities can be equal to each other, but mass cannot be equal to velocity. Similarly, two masses or two velocities can be added or subtracted, but mass and velocity cannot be added to each other or subtracted from each other. On this basis we can check whether the given physical equation is correct or not. For this we find out the dimensions of all the term on LHS and RHS of the equation. If dimensions of all the terms are equal, then the equation is correct otherwise not.

For example, Check the correctness of the equation v = u + at, where 'u' is initial velocity of a particle, 'a' is constant acceleration and 'v' is final velocity after time 't'.

Solution : We have equation $v = u + at$

The dimensional formulae of the quantities in given equation are :

Final velocity, $v = [L^1M^0T^{-1}]$
Initial velocity, $u = [L^1M^0T^{-1}]$
Acceleration, $a = [L^1M^0T^{-2}]$
Time, $t = [L^0M^0T^1]$

$\therefore$ L.H.S $\Rightarrow$ Dimensions of $v = [L^1M^0T^{-1}]$
R.H.S $\Rightarrow$ Dimensions of $u = [L^1M^0T^{-1}]$
and dimensions of 'at' = [Acceleration × Time] = $[L^1M^0T^{-2}] \times [L^0M^0T^1] = [L^1M^0T^{-1}]$.

Thus dimensions of each term on RHS are the same as those

(a) repeatability (b) reliability
(c) uncertainty (d) accuracy

Ans.(a)

61. The ratio of change in output to the change in the input is called
(a) precision (b) resolution
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Ans.(c)

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(a) 5 (b) 4 (c) 2 (d) 3

Ans.(b)

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ii) It should be easily reproducible at all places.
iii) It should not change with space and time.
iv) It should be easily comparable and readily avail able.
v) It should be universally accepted.
vi) It should be such that the quantity measured with it should not be too large or too small.

Q2. Write down different system of units. Explain S.I. system of units.

Ans.A measuring system is based on few fundamental units e.g. length, mass, time, temperature etc. All the physical quantities is being expressed in terms of these fundamental units.

(a) F. P. S. System :- Here, the length is measured in yard, mass, weight or force in pound, time in seconds and temperature is degree farenheit.

(b) Metric System :- Here, the length is measured in meter mass in kilogram force in kilogram force, time in seconds and temperature in degree centigrade.

(c) S.I System :- This system is extension and refinement of the metre system. Here, the length is expressed in meter, mass in kg, force in newton, time in seconds etc. It is based on decimal arithmatic.

(d) C.G. S. System :- In this system, the units of length of iength, mass and time are centimetre, Gram and Second.

(e) M.K.S. System :- In this system, the units of length, mass and time are metre, Kilogram and Second.
This system is extension and refinement of the metre system. Here, the length is expressed in meter, mass in kg, force in newton, time in seconds etc. It is based on decimal arithmatic

S. No. Physical Quantity	Unit	Symbol
1. Length	Metre	M
2. Mass	Kilogram	Kg
3. Time	Second	S
4. Temperature	Kelvin	K
5. Electric current	Ampere	A
6. Luminous intensity	Candela	Cd
7. Quantity of substance	Mole	Mole

Q3. What do you know about fundamental and derived quantities ? Give examples.

Ans. Fundamental Quantities :

The physical quantities which does not depend on any other quantity are called fundamental physical quantities.

The unit of fundamental quantity is called fundamental unit.

It does not depend on any other unit.

These are the basic (fundamental) quantities (units) with the help of which unit of any quantity in engineering and science can be derived. The following are fundamental physical quantities along with their units.

Fundamental physical quantity	Fundamental unit
1 Length	metre
2 Mass	kilogram
3. Time	second
4 Electric current	ampere
5. Temperature	kelvin
6. Luminous intensity	candela
7. Amount of substance	mole

Derived Quantities :

The physical quantities which are derived using two or more fundamental quantities are called derived quantities.

The units of derived quantities are called derived units. These units depend on two or more fundamental units.

As we have seen there are seven fundamental quantities. The remaining all quantities are derived quantities.

e.g. $$Density = \frac{Mass}{Volume}$$

$$= \frac{Mass}{l \times b \times h}$$

It is derived using two fundamental quantities i.e. mass and length. Following are few derived quantities along with their units.

Derived physical quantity	Derived unit
Area	square metre
Volume	cubic metre
Velocity	metre/sec
Acceleration	metre/sec^2
Force	newton
Pressure	newton/metre^2

Q4. State Dimensional formula (equation) ? What are the uses and limitation of Dimension equation.

Ans. Dimensional formula (equation) - Dimensional formula (equation) (Definition) : An equation, which gives the relation between fundamental units and derived units in terms of dimensions is called dimensional formula (equation) In me chanics the length, mass and time are taken as three base di mensions and are represented by letters L,M,T respectively.

Uses of Dimensional Equations

The method of dimensional analysis is used for following purposes.

1. To check the dimensional correctness of given physical equation.
2. To convert a physical quantity from one system of units to another system.
3. To establish relation among various physical quantities.

Limitations of Dimensional analysis

Although dimensional analysis is useful, it has the following limitations:

1. Dimensionless quantities cannot be determined by this method. Also constant of proportionality cannot be determined by this method.
2. This method is not applicable to trigonometric, logarithmic and exponential functions.
3. If a physical quantity depends upon more than three factors, then relation among them cannot be established.
4. This method cannot be used to derive equation involving addition and subtraction of physical quantities.
5. If dimensions are given, physical quantity may not be unique as many physical quantities have same dimensions. For example, if the dimensional formula of a physical quantity $[L^2 MT^{-2}]$ then the quantity may be work or energy or torque.

Q5. State the principle of homogeneity of dimension.

Ans. According to this principle, **"For an equation to be dimensionally correct, the dimensions of each term on LHS must be equal to the dimensions of each term on RHS".** The reason this is simple, that only similar quantities can be added or subtracted or equated. e.g. two masses can be equal to each other, two velocities can be equal to each other, but mass cannot be equal to velocity. Similarly, two masses or two velocities can be added or subtracted, but mass and velocity cannot be added to each other or subtracted from each other. On this basis we can check whether the given physical equation is correct or not. For this we find out the dimensions of all the term on LHS and RHS of the equation. If dimensions of all the terms are equal, then the equation is correct otherwise not.

For example, Check the correctness of the equation v = u + at, where 'u' is initial velocity of a particle, 'a' is constant acceleration and 'v' is final velocity after time 't'.

Solution : We have equation $v = u + at$

The dimensional formulae of the quantities in given equation are :

Final velocity, $v = [L^1M^0T^{-1}]$
Initial velocity, $u = [L^1M^0T^{-1}]$
Acceleration, $a = [L^1M^0T^{-2}]$
Time, $t = [L^0M^0T^{-1}]$

$\therefore$ L.H.S $\Rightarrow$ Dimensions of $v = [L^1M^0T^{-1}]$
R.H.S $\Rightarrow$ Dimensions of $u = [L\,M^0T^{-1}]$
and dimensions of 'at' = [Acceleration×Time] = $[L^1M^0T^{-2}] \times [L^0M^0T^1] = [L^1M^0T^{-2}]$.

Thus dimensions of each term on RHS are the same as those of the term on LHS. Hence the given equation is dimensionally correct.

Q6. Write the Physical Quantities with Formula and dimensions.

Ans.

Physical quantity	Formula or Relation	Dimensional formula (equation)	S.I unit symbol
Length	Length	$[L^1M^0T^0]$	l
Mass	mass	$[L^0M^1T^0]$	kg
Time	Time	$[L^0M^0T^1]$	s
Area	Length × breadth = length × length	$[L^2M^0T^0]$	m^2
Volume	Length × breadth× height =length× length× length	$[L^3M^0T^0]$	m^3
Density	$\frac{mass}{volume}=\frac{mass}{length\times breadth\times height}$ $=\frac{mass}{length\times length\times length}$	$[L^{-3}M^1T^0]$	kg/m^3
Speed (Velocity)	$\frac{distance}{time}=\frac{length}{time}$	$[L^1M^0T^{-1}]$	m/s
Acceleration	$\frac{velocity}{time}=\frac{\frac{distance}{time}}{time}$	$[L^1M^0T^{-2}]$	m/s^2
Force	$mass\times acceleration=mass\times\frac{velocity}{time}$ $=mass\times\left(\frac{\frac{distance}{time}}{time}\right)$	$[L^1M^1T^{-2}]$	N
Pressure	$\frac{force}{area}=\frac{mass\times acceleration}{area}$ $=\frac{mass\times velocity}{area\times time}$ $=\frac{mass\times\frac{distance}{time}}{length\times breadth\times time}$ $=\frac{mass\times length/time}{length\times length\times time}$	$[L^{-1}M^1T^{-2}]$	N/m^2 kg/ms^2
Impulse	Force × time = mass × acceleration × time $=mass\times\frac{velocity}{time}\times time$ $=mass\times velocity=mass\times\frac{distance}{time}$	$[L^1M^1T^{-1}]$	Ns Kg-m/s
Work	(force)× displacement =(mass×acceleration) ×distance $=(mass\times\frac{velocity}{time})\times distance$ $=\left(mass\times\frac{\frac{distance}{time}}{time}\right)\times distance$	$[L^2M^1T^{-2}]$	J ($kg\text{-}m^2/s^2$)
K.E.	$\frac{1}{2}mv^2=\frac{1}{2}\times mass\times\left(\frac{distance}{time}\right)^2$	$[L^2M^1T^{-2}]$	J ($kg\text{-}m^2/s^2$)
P.E.	$mgh=mass\times\frac{velocity}{time}\times length$ $=\left(mass\times\frac{\frac{distance}{time}}{time}\times length\right)$ $=\left(mass\times\frac{\frac{length}{time}}{time}\times length\right)$	$[L^2M^1T^{-2}]$	J ($kg\text{-}m^2/s^2$)
Power	$\frac{work}{time}$ $=\frac{force\times displacement}{time}$ $=\frac{(mass\times acceleration)\times distance}{time}$ $=\frac{\left(mass\times\frac{velocity}{time}\right)\times distance}{time}$ $=\frac{mass\times\frac{distance}{time^2}\times distance}{time}$	$[L^2M^1T^{-3}]$	W or J/s
Momentum	Mass×(velocity) $=mass\times\frac{distance}{time}$	$[L^1M^1T^{-1}]$	Kg.m/s
Stress (Note dimensions of stress and pressure are same)	$\frac{Force}{Area}=\frac{(mass\times acceleration)}{(length\times breadth)}$ $=\frac{\left(mass\times\frac{velocity}{time}\right)}{(length\times length)}$ $\frac{Force}{Area}=\frac{\left(mass\times\frac{distance}{time^2}\right)}{(length\times length)}$	$[L^{-1}M^1T^{-2}]$	N/m^2
Strain	$\frac{change\ in\ dimensions}{original\ dimension}$	$[L^0M^0T^0]$	No unit
Frequency	$\frac{1}{time\ period}$	$[L^0M^0T^{-1}]$	Hz or /s
Wavelength	Length of one wave	$[L^1M^0T^0]$	m

Q7. Define the terms accuracy and precision.

Ans. Accuracy : In any measurement, the possibility of error is bound to arise. No measurement is exact. Hence, accuracy of measurement is most important aspect.

Definition : Accuracy is the agreement of the result of a measurement with the true value of the measured quantity.

The accuracy of the instrument is its ability to give correct results.

The accuracy of measurement depends upon quality of instrument and selection of proper instrument e.g. diameter of ball bearing can be measured more accurately by micrometer than that of vernier.

Accuracy of measurement depends on human limitations i.e. sense of hearing, sense of touch, sense of sight and systematicness.

Accuracy also depends on conditions of surroundings like temperature, pressure, humidity etc.

Precision : The degree to which an instrument will repeat the same vaule of measurement (reading) is called as precision.

OR

Precision is the repeatability of a measurement process, when number of measurements are called out for a single quantity in identical conditions.

Q8. Distinguish between accuracy and precision .

Ans.

Accuracy	Precision
1. Accuracy is the agreement of the result of measurement with the true value of the measured quantity.	1. Precision is the repeatability of measuring process.
2 Accuracy depends on least count, range of instrument, human limitations and conditions of surroundings.	2 Precision depends on quality of instrument, human limitations and conditions of surroundings.
3 Accurate measurement may not be precise.	3. Precise measurement may not be accurate.
4. Less is the percentage error then more is the accuracy in measurement.	4. Less is the percentage error then more is the precision in measurement.
5 It can be determined by calibration against standard.	5. It can be determined by comparative test measurement.

Q9. What is an error ? Explain the types of error and the types of estimation of error.

Ans. Error : "The difference between the measured value and actual value of a physical quantity", is called error.

Explanation : If two persons use the same instrument for measurement for finding the same measurement, it is not essential that they may get the same results. There may arises a difference between their measurements. This difference is referred to as an "ERROR"

There are three types of errors :

(i) **Personal Error :** In taking observation of a particular quantity, the reading changes from person. It is called personal error. Personal error comes into existence due to making an error in reading a scale. It is due to faulty procedure adopted by the person making measurement.

(ii) **Instrumental Error :** There are some errors in construction of the apparatus and in the measuring instrument itself.

OR

The error arises due to use of faulty instrument.

(iii) **Systematic Error :** There is a error in measurement due to improper setting of the instrument such type of error is called as systematic error.

(iv) **Random Error :** Even after using faultless instrument & taking every care in measurement some error occurs. This error may occur due to sudden change in experimental conditions is called "RANDOM ERROR". It is beyond the control of person who is doing measurements.

For example :

Sudden change in temperature, change in humidity, fluctuatioon in potential difference (voltage).

Types of estimation of error :

(i) **Absolute error :** The difference between the average values and each measured value gives the absolute error in that measurement.

$\therefore$ Absolute error = average value - measured value

(ii) **Relative error :** The ratio of average absolute error to average value, is called the relative error in the measurement.

$$\therefore\ Relative\ error=\frac{Average\ \ absolute\ \ error}{Average\ \ value}$$

(iii) **Percentage error :** It is the relative error expressed in percentage.

$$\%\ error\ =relative\ \ error\ \times 100$$

$$=\frac{Average\ \ absolute\ \ error}{Average\ \ value}$$

Q10. What are significant figures ? Write the rules to identify significant figures in a given measurement.

Ans. Significant figures : The number of digits which is used to express the value of physical quantity with the accuracy in the measurement is called significant figure.

It is reasonably trustworthy. It depends upon the accuracy of measuring instrument.

Rules for significant figure are as follows:

(i) All non - zero digits are significant figures

Ex :

$$\left.\begin{array}{l}19\ \rightarrow 2\\198\ \rightarrow 3\\1982\ \rightarrow 4\end{array}\right\}significant\ figure$$

(ii) All zeros occuritng between non - zero digits are significant figures

Ex:

$$\left.\begin{array}{l}201\ \rightarrow 3\\2102\ \rightarrow 4\\21304\ \rightarrow 5\end{array}\right\}significant\ figure$$

(iii) All zeros to the right of the last non - zero digit are not significant figure

Ex:

$$= \frac{12400}{50 \times 10^{3}} \times 10^{-10}\ m$$

$$= 248 \times 10^{-13}\ m\ \upsilon\theta = 180^{0}$$

$$= \frac{stress}{strain}$$

(iv) All zero to the right of a decimal point and to the left of a non - zero digit are not signifiacant figure.

Ex:

$$\left.\begin{array}{l} 0.04 \rightarrow 1 \\ 0.005 \rightarrow 1 \end{array}\right\} significant\ figure$$

(v) All zero to the right of c decimal point and to the right of a non - zero digit are significant figure

Ex:

$$\left.\begin{array}{l} 0.20 \rightarrow 2 \\ 0.230 \rightarrow 3 \\ 0.2370 \rightarrow 4 \end{array}\right\} significant\ figure$$

Q1. Calculate percentage error in measurement of area of land. The length and breath are given by $l = 27.37 \pm 0.01$ km, $b = 18.45 \pm 0.01$ km.

Sol. We have, Area = A = $l \times b$

$$\%\,error\ in\ area = \frac{\delta A}{A} \times 100 = \left(\frac{\delta l}{l} \times 100\right) \times \left(\frac{\delta b}{b} \times 100\right)$$

$$= \left(\frac{0.01}{27.37} \times 100\right) + \left(\frac{0.01}{18.45} \times 100\right)$$

$$= 0.365 + 0.0542$$

Q2. Find in significant figures, the surface area and volume of a sphere whose diameter is measured by micrometer as 3.456 cm.

Sol. Given : Diameter = 3.456 cm $\therefore$ r = 1.728cm

We have, Area of sphere = $4\pi r^2$

$$= 4 \times 3.124 \times (1.728)^2$$

$$= 37.5278469$$

(We have to consider only 3 digits after decimal point)

$\therefore$ Area = 37.528 cm^2

We have, Volume of sphere $= \frac{4}{3} \times \pi r^2$

$$= \frac{4}{3} \times 3.142 \times (1.728)^3$$

$$= 21.616039$$

Volume = 21.616 cm^3

Q3. State the number of significant figures in the following (i) 3.730×10^5, (ii) 1.23×10^4, (iii) 1234 (iv) 3200, (v) 3.0045 (vi) 0.00345, (vii) 200.034 (viii) 244.000, (ix) 2.34×10^{-3}, (x) 0.020

Sol.

Gives	Number of significant figures
(i) 3.730×10^5	4
(ii) 1.23×10^4	3
(iii) 1234	4
(iv) 3200	2
(v) 3.0045	5
(vi) 0.0045	3
(vii) 200.034	6
(viii) 244.000	6
(ix) 2.34×10^{-3}	3
(x) 0.020	2

Q4. The mass of object is 37.6 $\pm$ 0.02 gm. Estimate the percentage error in this measurement.

Sol.Given : $A_m = 37.6$, $\delta A_m = 0.02$

To find : Percentage error = ?

$$Percentage\ error = \frac{Average\ absolute\ error}{Average\ Reading} \times 100$$

$$\%\ error = \frac{\delta A_m}{A_m} \times 100$$

$$\%\ error = \frac{0.02}{37.6} \times 100$$

$$\%\ error = 0.053\ \%$$

Q5. Determine the number of significant figure in each of the following measurements.

(i) 0.023 cm (ii) 3.4×10^7 N/m^2 (iii) 5.40 km

Sol.

Numbers	Significant Figure
0.023 cm	2
$3.4 \times 10^7\ N/m^2$	2
5.40 km	3

Q6. Find the number of significant figures in followinjg measurement.

(i) 0.0025 (ii) 0.0250 (iii) 0.002500 (iv) 5.98×10^{24}

Sol.(i) 0.0025

Significant Number = 2

(ii) 0.0250

Significant Number = 3

(iii) 0.0025000

Significant Number = 4

(iv) 5.98×10^{24}

Significant Number = 3

Chapter 2.

Mechanics

2.1 (Motion Along a Straight Line and Force)

Multiple Choice Question

1. **The appearent weight of the body falling freely under gravity is :**
   (a) 0 (b) Indefinite (c) 9.8gm (d) None of these

Ans.(c)

2. **Which law of Newtons law of motion is called law of inertia :**
   (a) Newton first law of motion
   (b) Newton second law of motion
   (c) Newton third law of motion.
   (d) None of these

Ans.(a)

3. **Which of the following is equal to the change in momentum of the body :**
   (a) Energy (b) Impulse
   (c) Displacement (d) None

Ans. (b)

4. **The unit of measuring momentum of a moving body is :**
   (a)Ms^{-1} (b)Kg ms^{-1} (c)Kg ms^{-2} (d)None of these

Ans.Kg ms^{-1}.

5. **Newton's second law of motion connects**
   (a) Amplitude of vibrating body
   (b) Change of momentum and velocity
   (c) Rate of change of momentum and force
   (d) Rate of change of force and momentum

Ans.(c)

6. **Netwton's first law of motion gives the concept of**
   (a) Work (b) Momentum (c) Inertia (d) energy

Ans. (c)

7. **Newtons second law of motion gives the measure of :**
   (a) Force (b) work (c) Power (d) None of these

Ans. (a)

8. **A man pushes a wall and fails to displace it.He does**
   (a) Negative work
   (b) Positive work but not maximum work
   (c) No work at all
   (d) Maximum positive work

Ans.(c)

9. **The velocity of a body starting form rest is directly proportional to time, Which is uniform?**
   (a) Volocity only (b) Acceleration only
   (c) both velocity and acceleration
   (d) neither velocity nor acceleration

Ans. (b)

10. **When a body is falling freely under gravity then its ....is uniform.**
    (a) Momentum (b)Acceleration
    (c) Velocity (d) Speed

Ans.(b)

11. **When motion takes place along a straight line, speed and velocity are**
    (a) same (b) not same (c) zero (d) infinity

Ans.(a)

12. **When a body moves with uniform velocity, its acceleration is**
    (a) maximum (b) minimum (c) zero (d) infinity

Ans.(a)

13. **If the rate of change of velocity is constant, then acceleration is**
    (a) uniform (b) variable (c) zero (d) infinity

Ans.(a)

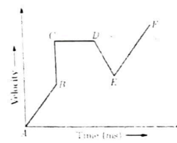
14. **The area under acceleration-time (a-t) graph gives**
    (a) acceleration (b) displacement
    (c) velocity (d) change in velocity

Ans.(d)

15. **The area under time-velocity denotes**
    (a) acceleration (b) force (c) momentum (d) distance

Ans.(d)

16. **The velocity-time graph of an object is shown below. The part of the graph showing zero acceleration is**



(a) AB (B) BC (c) CD (d) DE

Ans.(c)

17. **In case of a moving body**
    (a) displacement>distance (b) displacement<distance
    (c) displacement≥distance (d) displacement≤distance

Ans.(d)

18. **The slope of velocity-time graph for uniform motion of an object is**
    (a) unity (b) zero
    (c) infinite (d) more than unity but has some finite value

Ans.(b)

19. **If the displacement of a particle is zero, then distance covered by it**
    (a) must be zero (b) must not be zero
    (c) may or may not be zero (d) may be unity

Ans.(c)

20. **A scalar quantity has_____.**
    (a) magnitude (b) direction
    (c) both (a) and (b) (d) none of these

Ans.(a)

21. **Which of the following is/are scalar quantity (s)?**
    (a) distance (b) density (c) temperature (d) all of these

Ans.(d)

22. **A vector quantity has ______.**
(a) magnitude (b) direction
(c) both (a) and (b) (d) none of these

Ans.(c)

23. **Which of the following is/are vector quantity (s)?**
(a) force (b) electric field intensity
(c) acceleration (d) all of these

Ans.(d)

24. **The basic cause of motion is**
(a) velocity (b) acceleration (c) force (d) energy

Ans.(c)

25. **A man on a horizontal plane. How can he get off if no horizontal force is exerted by pushing against the surface**
(a) by jumping (b) by spitting or sneezing
(c) by rolling on the surface (d) by running on the plane

Ans.(b)

26. **The inertia is**
(a) an intrinsic characteristic of a body
(b) an extrinsic characteristic of a body
(c) a tensor quantity (d) None of the above

Ans.(a)

27. **The inertia of a body is measured in terms of**
(a) force applied on it (b) its mass
(c) its acceleration (d) None of the above

Ans.(b)

28. **A 10 g bullet moving at 200 m/s stops after penetrating 5 cm of wooden plank. The average force exerted by the bullet will be**
(a) 2000 N (b) - 2000 N (c) 4000 N (d) - 4000 N

29. **A man in a lift weighs more, when the lift**
(a) begins to go up (b) is going up streaky
(c) is slowing down (d) is descending freely

Ans.(a)

30. **The momentum of a body depends**
(a) only on its velocity (b) only on its mass
(c) both mass and velocity (d) None of the above

Ans.(c)

31. **The CGS unit of force is dyne therefore 1 dyne force is equivalent to**
(a) 10^{6} N (b) 10^{5} N (c) 10^{7} N (d) 10^{-5} N

Ans.(d)

32. **An athlete does not come to rest immediately after crossing the winning line due to the**
(a) inertia of rest (b) inertia of motion
(c) inertia of direction (d) none of these

Ans.(b)

33. **Swimming is possible by**
(a) Newton's law of gravitation
(b) Newton's first law of motion
(c) Newton's second law of motion
(d) Newton's third law of motion

Ans.(d)

34. **A man is at rest in the middle of a pond on perfectly smooth ice. He can get himself to the shore by making use of Newton's**
(a) first law (b) second law
(c) third law (d) all the law

Ans.(c)

35. **A body whose momentum is constant, must have constant**
(a) acceleration (b) velocity
(c) force (d) none of these

Ans.(b)

36. **Which of the followings is known as law of inertia?**
(a) Newton's first law of motion
(b) Newton's second law of motion
(c) Newton's third law of motion
(d) Law of conservation of mass

Ans.(a)

37. **Ram jumps from his school bus while it is running state, then Ram falls in**
(a) forward direction (b) backward direction
(c) remain in straight direction (d) None of the above

Ans.(a)

38. **A rider on a horse back falls forward, when the horse suddenly stops. This is due to**
(a) the inertia of horse (b) the inertia of rider
(c) large weight of the horse (d) losing the balance

Ans.(b)

39. **The units of impulse are same as that of**
(a) energy (b) linear momentum (c) velocity (d) power

Ans.(b)

40. **If two bodies collide, then impulsive force between them can change**
(a) speech of each (b) kinetic energy of each
(c) momentum of each (d) all of these

Ans.(d)

41. **The masses of two bodies are in the ratio 1 : 6 and their velocities are in the ratio 3 : 2. Then the momentum will be in the ratio**
(a) 2 : 3 (b) 2 : 1 (c) 4 : 1 (d) 1 : 4

Ans.(d)

42. **If rope of lift brakes suddenly. The tension exerted by the surface of lift is**
(a) mg (b) m (g + a) (c) m (g - a) (d) 0

Ans.(d)

43. **The working of a rocket is based on**
(a) Newton's first law of motion
(b) Newton's second law of motion
(c) Newton's third law of motion
(d) None of the above

Ans.(c)

44. **A machine gun fires n bullets per second, each of mass m. If the speed of each bullet is v, then the force of recoil is**
(a) mvn (b) mg (c) mnvg (d) mnv/g

Ans.(a)

45. **A bullet of mass 200 g is fired with a velocity 30 ms^{-1} from a gun of mass 100 kg. The recoil velocity of the gun is**
(a) 5 ms^{-1} (b) 10 ms^{-1} (c) 0.06 ms^{-1} (d) None of the above

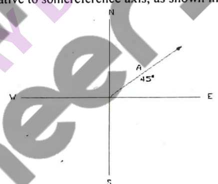
Ans.(c)

Answer the following questions

Q1. What are the concept of scalar and vector quantity?

Ans.Scalar Quantity: A scalar quantity is defined as a quantity that has magnitude only. Typical examples of scalarquantities are time, speed, temperature, and volume. A scalar quantity or parameter has nodirectional component, only magnitude. For example, the units for time (minutes, days, hours,etc.) represent an amount of time only and tell nothing of direction. Additional examples ofscalar quantities are density, mass, and energy.

Vector Qusntity: A vector quantity is defined as a quantity that has both magnitude and direction. To work withvector quantities, one must know the method for representing these quantities.Magnitude, or "size" of a vector, is alsoreferred to as the vector's "displacement." Itcan be thought of as the scalar portion of thevector and is represented by the length of thevector. By definition, a vector has bothmagnitude and direction. Direction indicateshow the vector is oriented relative to somereference axis, as shown in Figure below



Using north/south and east/west referenceaxes, vector "A" is oriented in the NEquadrant with a direction of 45 north of theoEW axis. G iving direction to scalar "A"makes it a vector. The length of "A" isrepresentative of its magnitude ordisplacement.

Q2. Difference between scalar quantity and vector quantity ?

Ans.

Scalar quantity	Vector quantity
Definition : "A physical quantity having only magnitude but no direction is known as a scalar quantity."	Definition : "A physical quantity having both magnitude and direction is known as a vector quantity."
Scalar quantities can be added or subtracted by usual arithmetical operations.	Vector quantities can be added or subtracted vectorially and not arithmetically.
Examples : Mass, area, volume, density, time, speed, temperature, work, power, energy etc.	Examples : Displacement, velocity, force, weight, moment, momentum, acceleration, etc.

Q3. State the three equation of rectilinear motion along with meaning of each symbol.

Ans. Three equations of rectilinear motions are :

(i) $v = u + at$

(ii) $s = ut + \frac{1}{2}at^2$

(iii) $v^2 = u^2 + 2as$

Here u =Initial velocity
v =Final velocity
t =Time taken by a particle to change velocity from u to v.
s =Distance travelled in time t.
a =Uniform Acceleration

Q4. Explain the motion of a body falling freely under gravity with equation of motion.

Ans.Equation of motion for motion under gravity :

* There is a force of attraction between earth and any body. This force of attraction causes an acceleration called gravitational acceleration(g).
* A freely falling body is always subjected to the constant gravitational acceleration 'g'.
* Thus,in the above equation (1),(2), and (3),substituting a=g for downward motion and a =-g for upward motion.

Case 1: when a body is **Freely falling** under gravity i.e.,when a body moves vertically downwards towards the earth,then **a=g.**

$$\therefore \quad v = u + gt \quad \text{............ (1)}$$

$$s = ut + \frac{1}{2}at^2 \quad \text{............ (2)}$$

$$v^2 = u^2 + 2as \quad \text{............ (3)}$$

Here g- Acceleration due to gravity(9.81 m/s^2)

Case 2 : when a body moves vertically upwards away from the earth i.e,when motion takes place against the force of gravity,its velocity goes on decreasing by 'g'.The corresponding equations for upward motion will be as under.

$$v = u - gt$$

$$s = ut - \frac{1}{2}gt^2$$

$$v^2 = u^2 - 2gs$$

a = −g. (against gravity).

Q4. Write the Newtons law of motion and explain with one example.

Ans.Netwon's First law of motion

Statement : "Every body continues in its state of rest or of uniform motion in a straight line, unless, it is acted upon by some external unbalanced force." This means in the absence of unbalanced force, every object has a tendency to resist any change in its state of rest or motion. This tendency is inertia. So this law is also known as law of inertia.

For Example: A person falls forward while getting down from a moving bus or train. This is because as his feet touch on the ground,the lower part of his body come to rest.On the other hand, the upper part remains in motion due to inertia of motion and hence he fall forward.

Netwon's Second law of motion

Statement : " Rate of change of momentum of a body is proportional to the applied force and takes place in the direction of force."

$$Thus,\ \frac{mv - mu}{time} \alpha F$$

$$\frac{m(v-u)}{time} \alpha F \quad or \quad \frac{m(v-u)}{t} = cons\tan t \times F$$

$$ma = F$$

Where, F= force,

mv = Final momentum

mu = Initial momentum

t = time

m = mass

a = acceleration

u = initial velocity

v = final velocity.

For Example : Aperon falling on a cemented floor gets injured but a person falling on a heap of sand is not injured.because the change in momentum of the person takes place in a longer period of time .Hence, the average force exerted on the body of of the person by the heap of sand in small.

Netwon's Third law of motion

Statement : " For every action there is equal and opposite reaction." This implies that for every force there is a reaction force that is equal in size, but opposite in direction. That is whenever an object pushes another object it gets pushed back in the opposite direction equally.

For Example :

(i) Action : While swimming, our body push the water backwards

Reaction : The water pushes our body forward.

(ii) Action : A rocket pushes out exhaust...

Reaction : The exhaust pushes the rocket forward.

Q5. What is inertia ? Explain inertia of rest and inertia of motion with examples.

Ans. Inertia : Inertia is defined as the tendency of an object to resist changes in its state of rest or motion.

(i) Inertia of rest : It is inability of a body by virtue of which it cannot moves by itself. In other words, the resistance or opposition offered by a body to change its state of rest is called inertia of rest.

Example :

When a bus suddenly starts moving forward the passengers of the bus fall backward. This is because the lower part of the bodies of the passenger being in contact with the floor of the bus come in motion along with bus, whereas the upper parts of the bodies remain at rest due to inertia of rest.

(ii) Inertia of motion : It is the inability of a body in motion to stop by itself. In other words, the resistance or opposition offered by a body to change its uniform motion is called inertia of motion.

Example :

A person falls forward while getting down from a moving bus or train. This is because as his feet touch on the ground, the lower part of his body comes to rest. On the other hand, the upper remains in motion due to inertia of motion and hence he falls forward.

Q6. Define Impulse and Impulsive force with suitable example?.

Ans.Impulse. Impulse is defined as the change in momentum.

Impulse = change in momentum

$= mv - mu$

= m (v - u)

= m (at) (since v- u = at)

= Fxt (force, F = ma)

Thus an impulse is equal to the net force on the object times the time period over which this force is applied. Its S.I unit is kg m /s or Ns.

It is a vector quantity.

Example

Impulse : Impulse is defined as the dhange in momentum. It is measured as the product of the average force and time for which the force acts it is a vector quantity directed along the direction of force.

Thus, Impulse = force × time

Since, $\vec{F} = m\vec{a}$

$$= m\left(\frac{\vec{v_2} - \vec{v_1}}{t_2 - t_1}\right) = \frac{m\vec{v_2} - m\vec{v_1}}{t_2 - t_1}$$

$$= \frac{\vec{p_2} - \vec{p_1}}{t_2 - t_1}$$

$$\vec{F}(t_2 - t_1) = \vec{p_2} - \vec{P1}$$

$\vec{F}(t_2 - t_1)$ is called the impulse of force F in time interval

$t_2 - t_1$ put $t_2 - t_1 = t$.

Then impulse, $\vec{I} = \vec{Ft}$

Its SI unit N - s.

Impulsive Force :- Impulsive force is the which acts for a short time and produces considerable change in the momentum of a body. Impulsive force is the rate of impulse with respect to time.

i.e; Impulsive force $= \frac{Im\ pulse}{Time}$

For example :

(i) A football hit by a player. Here the kick applice by a foot ball player is impulsive force.

(ii) A ball rebounding from marble floor remains in contact with the floor for a very short time.A large force is exerted on the ball by the floor . Such a force is called an impulsive force.

Q7. Explain is recoil of gun ?

Ans.(i) When a bullet is fired form a gun, the gasses produced exerts a tremendous force on the bullet (action force).

(ii) As a result the bullet moves forward with a great velocity called the muzzle velocity. The bullet at the same time exerts an equal force on the gun in the opposite direction (reaction force)

(iii) Due to this the gun moves backward. This backward motion of the gun is cslled the recoil of the gun and the velocity eith which the gun moves backwards is called the recoil velocity.;

(iv) Let, 'M_g' be the mass of the gun and M_b that of the bullet, After firing let V_g be the velocity of the gun and V_b that of the bullet.

By law of conservation of linear momentum.

Initial momentum of gun and bullet = F Final momentum of gun and bullet.

But initial momentum of the gun and the bullet is equal to zero because they are initially at rest.

Therefore, Final momentum after firing = $M_b V_b + M_g (V-_g)$= 0

The negative sign indicates that the gun moves in the backward direction.

$$\therefore M_b V_b = M_g V_g$$

This is the equation of recoil velocity $\therefore V_g = \frac{M_b V_b}{V_g}$

Q8. Explain the motion of lift ?

Ans: Consider a person standing on a surface of lift then the two forces acting on that person are :

(i) The weight of the person. (W = mg) acting in downward direction.

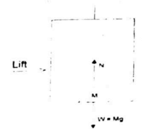
(ii) Normal force N acted by lift floor in the upward direction (Tension).

Case I : When lift is stationary or moving with constant velocity is unaccelerated.

So, the net force acting on that person (N-W) is zero. Thus the upward force exerted by the floor must exactly balance the downward force of gravity (weight). i.e. N = W.

Therefore N = W = mg

Thus, apparent weight is equal to actual weight.



Case II : When lift moves upward.

Since the lift is moving upward, the magnitude of normal force N acted by lift floor in the upward direction is greater than the weight of the person (N>W) and the net force acting = N - W

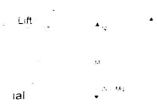
According to Newton's second law

N - W = ma

N- mg = ma (Since W = mg)

N = mg + ma

N = m(g + a)



Thus, apparent weight is greater than actual weight.

Case III : When lift moves downward

Since the lift is moving downward, the magnitude of normal force N acted by lift floor in the upward direction is smaller than the weight of the person (N<W) and the net force acting = W - N.

According to Newton's second law

W - N = ma

mg - N = ma (Since W = mg)

N = mg - ma = m (g - a)

Thus, apparent weight is less than actual weight.

Q9.Define momentum and state law of conservation of momentum ?

Ans. Momentum of a body is the amount of motion that a body or a particle has. Mathematically momentum is the product of mass and velocity it is a represented by p.

Momentum = Mass x velicity

$p = m \times v$

Its S.I unit is kg m/s It is a vector quanitity.

Law of conservation of momentum: When two bodies collide with each other their total momentum before collision is equal to their total momentum after collision

Total momentum before collision = Total momentum after collision . When a first body of mass m_1, moving with a velocity of u_1 along a straight line collides with second body of mass m_2 moving with u_2. After collision suppose the velocities of first body becomes V_1 and that of second body becomes V_2 Then according to law of conservation of momentum, $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$.

SOLVED EXAMPLE

Q1. A stone is allowed to fall from terrace of building 20m high. After what time it will reach the ground ? What will be its velocity at that time ?

Ans. Given : Initial velocity u = 0

Displacement s = 20 m

Time, t = ?

Final velocity, V = ?

Using 2[nd] equation of motion ,

$S = ut + \frac{1}{2}at^2$

$20 = 0 + \frac{1}{2}(9.8)t^2$

(there a = g = 9.8 m/s²)

$t^2 \frac{20}{4.9} = 4.08$

∴ t = 2.02 sec. Putting t = 2.02 sec in 1[st] equ[n] of motio

we get ∴ = V = 0 + (9.8 × 2.02) = 19.796 m/s

∴ Time, t = 2. 02 sec and Final velocity, V = 19.79 m/s.

Q2. A ball is thrown vertically upward with an initial velocity of 25 m/s. Find the maximum height reached by the ball

Ans. Given : initial velocity, u = 25 m/s.

Final Velocity, V = 0 (After attaining Max. height, its velocity becomes 0)

Max. height reached = Displacement

Maximum Height reached, S = ?

According to 3[rd] equation of motion. $V^2 = u^2 + 2gs$

As the ball is thrown vertically upward

put a = - g in above equation.

$v^2 - u^2 = -2gs$

$0^2 - (25)^2 = -2 \times 9.8 \times s.$

s = 31.88 m.

∴ The max, height reached by ball is 31.88m.

Q3. A car man driving the car at 75 km/hr applies the breaks. If the retardation is 6 m/s². Find the distance covered in bringing the car to rest after applying brakes.

Ans. Given :

Initial velocity, u = 75 km / hr

$= \frac{75 \times 1000}{60 \times 60} m/s = 20.83\, m/s$

Retardation, negative acceleration a = - 6 m/s²

Final Velocity V = 0 (After applying breaks, its velocity becomes 0)

Distnce covered, s = ?

According to 3rd equation of motion,

$V^2 - u^2 = 2as$

$O^2 - (20.83)^2 = 2 \times (-6) \times s$

∴ - 433.88 = -12 × s

∴ The distance covered in bringing the car to rest after applying brakes is 36. 15 m.

Q4. A motorcycle has initial velocity 15 m/s. It accelerates for 10 seconds at the rate of 4 m/s². Determine the final velocity and distance travelled during this time.

Ans.Given : Initial velocity u = 15 m/s.

Acceleration a = 4 m/s²

time, t = 10 sec,

Final velocity, v = ?

Distance covered, S = ?

According to 1st equation of motion

v = u + at

v = 15 + (4) (10)

= 55 m/s.

∴ Final velocity, V= 55 m/s.

According to 2[nd] equation of motion.

$S = ut + \frac{1}{2}at^2$

$= (15)(10) + \frac{1}{2}(4)(10)^2$

= 150 + 200

= 350m.

∴ Fnal velocity = 55 m/s and Distance covered, s = 350 m.

Q5. If the weight of the car is 500 KN and moving at 150 km/hr. Find the momentum of the car ?

Ans.Given :

Weight of the car, W = 500 K N

$= 500 \times 10^3$ N

Velocity of car, V = 150 km/hr

$= \frac{150 \times 1000}{3600} = 41.66\, m/s$

∴ Momentum of the car = ?

We know that,

Weight = mass×acceleration due

to gravity

= m × g

∴ Mass $m = \frac{Weight}{g}$

$= \frac{500 \times 10^3}{9.8}$

$= 51.02 \times 10^3$ kg

Now momentum = mass × velocity

P = m ×v

$P = 51.02 \times 10^3 \times 41.66$

$= 2125.49 \times 10^3$ kg m/s or N sec.

∴ Momentum of car = 2125.49×10^3 kg m/s.

Q6. A force of 980 N acts on a body for 0.1 sec. Calculate the change in momentum of the body.

Ans. Given :

Force, F = 980 N

Time for which the force acts.

t = 0.1sec.

Change in momentum = ?

We know that,

Change in momentum = Impulse

and Impulse = Force × time

= F × t

Therefore, Change in momentum F × t

= 980 × 0.1

= 98 N sec

∴ Change in momentum = 98 N sec.

Q7. Calculate the momentum of a toy car of 200 g moving with a speed of 15 m/s.

Ans.Given

Mass of a toy car m , = 200g

= 0.2 kg.

Speed of a toy car, V = 15 m/s.

Momentum of a toy car, P = ?

Momentum of a toy car,

P = mass × velocity

∴ P = mv

= 0.2× 15

= 3 kg m/s or N sec.

∴ Momentum = 3kg m/s

Q8. Calculate the change in momentum of a body weighing 10kg when its velocity decreases form 20 m/s to 5 m/s.

Ans. Given :

Mass of body m = 10 kg.

Initial velocity u = 20 m/s.

Final velocity v = 5 m/s

Change in momentum = ?

We know that,

Momentum = mass × velocity

∴ Initial Momentum = m u.

and Final Momentum = m v.

∴ Change in momentum

= Final momentum - Initial momentum

= mv - mu

= m (v-u)

= 10 (5-20)

= 10 (-15)

= -150 N sec

∴ Change in momentum = - 150 N sec

Q9. A body of mass 25 kg has a momentum of 300 kg m/s. Calculate the velocity of the body.

Sol.Given :

Mass of body, m = 25 kg.

Momentum of body, p = 300 kg m/s.

Velocity of body, V = ?

We know that,

Momentum = mass × velocity.

P = mv

∴ velocity $= \frac{Momentum}{mass}$

$= \frac{p}{m} = \frac{300}{25}$

= 12 m/s

∴ **Velocity of body = 12 m/s**

Q10. A nail of mass 0.02 kg is driven into a fixed wooden block. Its initial speed is 40 m/s and it is brought to rest in 4ms, find the impulse and impulse and impulsive force.

Sol. Given:

Mass of nail, m = 0.02kg

Initial velocity, u = 40 m/s.

Final velocity, v = 0

Time, t = 4ms = 4×10^{-3} sec impulsive = ?

Impulsive force = ?

We know that,

Impulse = mv - mu

= m (v-v)

= 0.02(0-40)

= - 08 N sec

Negative sing indicates that impulse is in the opposite direction of motion of nail Also.

$$\text{Impulsive force} = \frac{impulse}{time}$$

$$= \frac{0.8}{4\times10^{-3}}$$

$$= 200\ N$$

$\therefore$ Impulse = 0.8 N sec, and Impulsive force = 200 N

Q11. A body of mass 10 kg moving with a velocity of 20 m/s along a straight line collides with anody body of mass 8 kg moving in the same direction with a velocity of 5 m/s After collision the velocity of the heavier body is 10 m/s. Calculate final velocity of other.

Ans:- Given :

Mass of first body m_1 = 10 kg
Initial velocity of first body u_1 = 20 m/s.
Final velocity of first body v_1 = 10 m/s.
Mass of second body m_2 = 8 kg
Initial velocity of second body u_2 = 8 kg
Initial velocity of second body u_2 = 5 m/s
Final velocity of Second body v_2 = ?
According to law of conservation of momentum.

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$(10\times20) + (8\times5) = (10\times10) + 8v_2$$

$$200 + 40 = 100 + 8v_2$$

$$8v_2 = 240 - 100$$

$$= 140$$

$$\therefore v_2 = \frac{140}{8}$$

$$= 17.5 m/s$$

Final velocity of another body = 17.5 m/s.

Q12. A bullet of mass 40 gm is fired with a muzzle velocity of 500 m/s from a gun of mass 4 kg. Calculate the recoil velocity of a gun.

Sol.Given :

Mass of bullet, M_b = 40 gm
= 0.04kg
Velocity of bullet V_b = 500 m/s
Mass of gun M_g = 4 kg
Recoil velocity of gun Vg = ?

We know that,
Recoil velocity of gun,

$$Vg = \frac{M_bV_b}{M_g}$$

$$= \frac{0.04\times500}{4}$$

$$= 5\ m/s$$

$\therefore$ Recoil velocity of gun = 5 m/s

2.2 Angular Motion

Multiple Choice Question

1. **The S.I Unit of angular velocity is.........**
(a) rad/s. (b) degree/s (c)m/s (d)None
Ans.(a)

2. **In simple harmonic motion, the acceleration is**
(a) Directly proportional to the displacement form central position.
(b) Constant.
(c) Invesely proportionl to the square of displacement form central position.
(d) Inversely proportional to the displacement form central position.
Ans.(a)

3. **For a particle executing uniform circular motion**
(a) velocity is transverse , acceleration is radial
(b) velocity is transverese acceleration is transverse
(c) velocity is radial, acceleration is transverse
(d) velocity is radial, acceleration is radial
Ans.(c)

4. **If a particle moves in a circle, describing equal angles in equal interval, the velocity vector**
(a) remains constant (b) changes in magnitude
(c) changes in direction
(d) changes both in magnitude & direction
Ans.(c)

5. **The Linear velocity of a particle of mass 'm' describing horizonatal circle of radius 'r' with angular 'w' is**
(a) rw (b) 0 (c) rw^2 (d) r^2w
Ans.(a)

6. **When a body executing S.H.M passes through its equilibrium position it has.**
(a) Maximum potential energy (b) Maximum kinetic energy
(c) Minimum kinetic energy (d) Minimum acceleration
Ans.(d)

7. **Period of a body executing S.H.M. of frequency 20Hz is**
(a) 20 sec. (b) 20π sec. (c) $\frac{\pi}{2}$ sec. (d) $\frac{1}{20}$ sec.
Ans.(d)

8. **In SHM acceleration is proportional to:**
(a)Frequency (b)Displacement
(c)Veilocity (d)Time period
Ans.(b)

9. **In a body executing SHM,acceleration is maximum at :**
(a)Both ends (b)Mean position
(c)Both (a) & (b) (d)None
Ans:-Both ends.

10. **In SI system, angular velocity is measured in**

(a) degree per second (b) rotation per second
(c) radians per second (d) revolution per second
Ans.(c)

11. **When axis of rotation is fixed, angular velocity is considered as**
(a) scalar quantity (b) vector quantity
(c) physical quantity (d) both a and b
Ans.(a)

12. **In a circular motion, direction of motion**
(a) changes continuously (b) changes after time
(c) never changes (d) remains constant
Ans.(a)

13. **Angular displacement is measured in**
(a) metre (b) time (c) radian (d) steradians
Ans.(c)

14. **If the frequency of an object in uniform circular motion is doubled, its acceleration becomes**
(a) two times (b) four time
(c) half (d) one fourth
Ans.(b)

15. **The angular displacement in circular motion is**
(a) dimensional quantity (b) dimensionless quantity
(c) unitless and dimensionless (d) unitless quantity
Ans.(b)

16. **Direction of $\vec{\alpha} \times \vec{r}$ is**
(a) tangent to path (b) perpendicular to path
(c) parallel to the path (d) along the path
Ans.(a)

17. **In SI system, angular acceleration is measured in**
(a) degree per second (b) degree per second square
(c) radians per second (d) radians per second square
Ans.(d)

18. **An object moving in a circular path at constant speed has constant**
(a) energy (b) velocity (c) acceleration (d) displacement
Ans.(a)

19. **A body moves with constant angular velocity on a circle. Magnitude of angular acceleration is**
(a) rw^2 (b) constant (c) zero (d) rw
Ans.(c)

20. **What is the angular speed of the seconds hand of a watch?**
(a) 60 rad/s (b) π rad/s (c) $\frac{\pi}{30}$ rad/s (d) 2 rad/s
Ans.(c)

21. **The relation between linear speed v, angular speed w and angular acceleration α in circular motion is**
(a) $\alpha = \frac{dw}{v}$ (b) $\alpha = \frac{dv}{w}$ (c) $\alpha = \frac{vw}{a}$ (d) $\alpha = \frac{w}{av}$
Ans.(a)

22. **In simple harmonic motion, the acceleration is**
(a) directly proportional to the displacement from central position
(b) constant
(c) inversely proportional to the displacement from central position
(d) inversely proportional to the square of displacement from central position
Ans.(a)

23. **The total energy of a particle executing SHM is proportional to**
(a) displacement from equilibrium position
(b) frequency of oscillation
(c) velocity in equilibrium position
(d) square of amplitude of motion
Ans.(d)

24. **A particle executes simple harmonic motion along a straight line with an amplitude a, the potential energy is maximum when the displacement is**
(a) $\pm a$ (b) 0 (c) $\pm\frac{a}{2}$ (d) $\pm\frac{a}{\sqrt{2}}$
Ans.(a)

25. **In SHM, which of the following quantities does not very as per nature of the sine curve?**
(a) displacement (b) velocity
(c) acceleration (d) time period
Ans.(d)

26. **A particle is moving on a circle with uniform speed. its motion is**
(a) periodic and SHM (b) periodic but not SHM
(c) a periodic but not SHM (d) None of the above
Ans.(b)

27. **In extreme positions of a particle executing simple harmonic motion**
(a) both velocity and acceleration are zero
(b) both velocity and acceleration are maximum
(c) velocity is maximum but acceleration is zero
(d) velocity is zero but acceleration is maximum
Ans.(d)

28. **A body executes SHM with an amplitude a. The energy of the vibrating body is half kinetic and half potential when the displacement is**
(a) $\frac{a}{3}$ (b) $\frac{a}{2}$ (c) $\frac{a}{\sqrt{2}}$ (d) $\frac{a}{2\sqrt{2}}$
Ans.(c)

29. **The acceleration of a particle executing SHM in the position of maximum displacement is**
(a) maximum (b) minimum
(c) zero (d) neither maximum nor minimum
Ans.(a)

30. **The SHM of a particle is given by the equation $y = 3\sin\omega t + 4\cos\omega t$. Ifs amplitude is**
(a) 7 (b) 1 (c) 5 (d) 12
Ans.(c)

31. **The phase angle between the projections of uniform circular motion on two mutually perpendicular diameters is**
(a) zero (b) $\frac{\pi}{2}$ (c) $\frac{3\pi}{4}$ (d) π
Ans.(b)

32. The amplitude of a SHM is a and the time-period is T. The maximum instantaneous velocity will be

(a) $\frac{4a}{T}$ (b) $\frac{2a}{T}$ (c) $\frac{2\pi a}{T}$ (d) $2\pi\sqrt{\frac{a}{T}}$

Ans.(c)

Answer the following questions

Q1. Define the terms : Angular displement, angular velocity and angular acceleration.

Ans.Angular displacement (θ) The angle subtended at the centre of a circle by the path tavelled .The S.I unit of angular displacement is radian (rad)

(ii) Angular velocity (ω): The rate of change of angular displacement with respect to time is called angular velocity (ω) of a particle. S.I unit of angular velocity is rad/s.

$$\left[\omega = \frac{d\theta}{dt}\right]$$

(iii) Angular acceleration (α): The rate of change of angular velocity with respect to time is called angular acceleration.

$$\left[\alpha = \frac{d\omega}{dt}\right] or \left[\alpha = \frac{(\omega_2 - \omega_1)}{dt}\right]$$

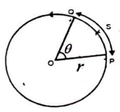
S.I unit of angular acceleration is rad/s^2.

Q2. Deduce the relation between linear velocity and angular velocity.

Ans. Suppose that a particle executing circular motion covers a linear distance Δs on the circumference of the circle in time interval Δt and during the same time interval its angular displacement is $\Delta\theta$. Let r be the radius of the circular path.

Since, $Angle = \frac{Arc}{Radius}$

$$\Delta\theta = \frac{\Delta r}{r}$$



On dividing both sides by Δt . We have,

$$\frac{\Delta\theta}{\Delta r} = \frac{1}{r}\left(\frac{\Delta s}{\Delta t}\right)$$

If the time interval Δt is infinitesimally small i.e. $\Delta t \to 0$ then,

$$\lim_{\Delta t\to 0}\left(\frac{\Delta\theta}{\Delta t}\right) = \frac{1}{r}\left[\lim_{\Delta t\to 0}\left(\frac{\Delta s}{\Delta t}\right)\right]$$

But $\lim_{\Delta t\to 0}\left(\frac{\Delta\theta}{\Delta t}\right) = \omega$ (Instantaneous angular velocity)

and $\lim_{\Delta t\to 0}\left(\frac{\Delta s}{\Delta t}\right) = \upsilon$ (Instantaneous linear velocity)

$$\omega = \frac{\upsilon}{r} \text{ or } \upsilon = r\omega$$

i.e. Linear Velocity = Radius × angular velocity

Thus, linear velocity is radius times the angular velocity.

Q3. Define simple harmonic motion (SHM)? describe how S.H.M could be realised in actual practice as far projection of a uniform circular motion on any diameter of the circle.

Ans. Simple Harmonic Motion (S.H.M.).

Simple Harmonic Motion is a periodic motion in which restoring force is directly proportional to displacement of body from the quilibrium position and is always directed towards the equilibrium position.

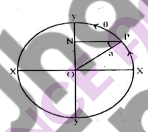
F = -k x

The force is called a restoring force and k is the force constant or spring constant. The negative sign indicates that the direction of force is always opposite to the direction of the displacement.

Ex.: Simple pendulum, motion of spring. Vibration of prong of tunning fork.

Simple harmonic motion can considered to be the one-dimensional projection of uniform circular motion.

(i) Consider a particle moving along the circumference of a radius a and center O as shown in fig. below



(ii) Let XX' and YY' be two diameters of the circle.

(iii) Suppose the particle in initially at point P after time t and ω is the angular velocity. Then the angular displacement θ in time t is given by $\theta = \omega t$.

(iv) Draw a perpendicular (projection) from P to YY' at point N.

(v) If the particle moves from X to Y then its projection also moves from O to Y.

(vi) The particle completes one revolution along the circumference when it moves from Y to X', then from X' to Y' and back again to X. Then its projection also completes one vibration (moves up and down) about mean position O.

(vii)The motion of projection of a particle along YY' is nothing but Simple Harmonic Motion.

(viii) Thus, the projection of Uniform Circular Motion performs

SHM on a diameter.

Q4. Find the expression for velocity and accelearation of a body executing SHM?

Ans.Equations of Angular Motion

Consider a particle, rotating about its axis.

Let, ω_0 =Initial angular velocity

ω =Final angular velocity

t = Time (in seconds) taken by the particle to change its velocity from ω_0 to ω .

α =Constant angular acceleration in rad/s^2

and θ = Total angular displacement in radians

Since in t seconds, the angular velocity of the particle has increased steadily from ω_0 to ω at the rate of α rad/s^2.

Therefore,

$$\omega = \omega_0 + \alpha t \quad \text{(Formula-1)}$$

and average angular velocity

$$= \frac{\omega_0 + \omega}{2}$$

We know that the total angular displacement

$$\theta = Average\ velocity \times Time$$

$$\theta = \left(\frac{\omega_0 + \omega}{2}\right) \times t \quad \text{(Formula-2)}$$

Substituting the value of ω from eqn. (1),

$$\theta = \frac{\omega_0 + (\omega_0 + \alpha t)}{2} \times t = \frac{2\omega_0 + \alpha t}{2} \times t$$

$$= \omega_0 t + \frac{1}{2}\alpha t^2$$

and from eqn. (1), we find that

$$t = \frac{\omega - \omega_0}{\alpha}$$

Substituting this value of t in Eq. (2),

$$\theta = \left(\frac{\omega_0 + \omega}{2}\right) \times \left(\frac{\omega - \omega_0}{\alpha}\right) = \frac{\omega^2 - \omega^2{}_0}{2\alpha}$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta \quad \text{(Formula -3)}$$

Q5. Derive the equation of S.H.M and represent the displacement, velocity and acceleration of a particle. executing S.H.M graphically.

Ans. The equation for the displacement of a particle executing SHM:

The distance traveled by the vibrating particle at any instant of time t from its mean position is known as displacement of particle.

(i) Consider the particle performing uniforom circular motion along the circumference of a circle of radius a, with angular velocity ω .

(ii) Initially when the particle is at P, its projection on the diameter Y'is at point N.

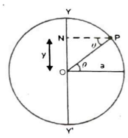
(iii) As SHM is considered as projection of uniform circular motion.Then its displacement along Y axis is ON i.e.y.

(iv) Consider tringle OPN,

$$\text{Sin}\,\theta = \frac{ON}{Op}$$

$$ON = OP \sin\theta$$

$$y = OP\ \text{Sin}\,\omega t \quad (\text{Since}\,\omega = \frac{\theta}{t})$$



(v) As the amplitude of the vibrating particle is its maximum displacement from the mean position and OP = a, the radius of the circle. Therefore the displacement of the vibrating particle is

$$y = a \sin \omega t$$

This is the equation of displacement of a particle executing S.H.M is it the particle starts with initial phase angle ϕ_0 then equation of SHM is $y = a\sin(\omega t + \phi_o)$

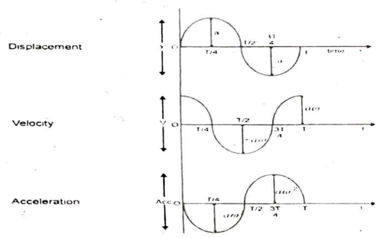
Graphical reresentation of displacement, velocity acceleration of a particle in SHM .

Case I: When the particle is starting from mean position

Equation of displacement $y = a\sin\omega t$

Equation of velocity $v = a\omega\cos\omega t$

Equation of acceleration $acc. = -a\omega^2 \sin\omega t$

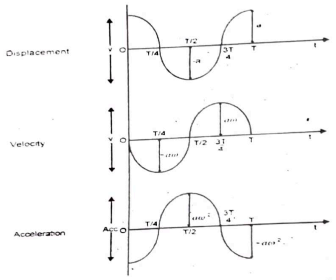


Case II: When the particle is starting form extreme position

Equation of displacement $y = a\cos\omega t$

Equation of velocity $v = -a\omega\sin\omega t$

Equation of acceleration $acc = -a\omega^2\cos\omega t$



Chapter 3. Gravitation

Multiple Choice Question

1. SI unit of gravitational constant is ________.
(a)N m²kg² (b)N m²kg⁻² (c) N m²s⁻² (d).N mkg⁻²

Ans.(b)

2. What is the value of gravitational constant?
(a)6.6734×10^{-11}N m²/kg² (b) 6.6734×10^{-10}N m²/kg²
(c)6.6734×10^{-11}N m/kg² (d) 6.6734×10^{-11}N m²/kg

Ans.(a)

3. If the distance between two bodies is doubled, the force of attraction F between them will be ______
(a)1/4 F (b) 2 F (c) 1/2 F (d) F

Ans.(a)

4. The force of gravitation between two bodies in the universe does not depend on
(a)The distance between them (b) The product of their masses
(c) The sum of their masses (d) The gravitational constant

Ans.(c)

5. When an object is thrown up, the force of gravity
(a)is opposite to the direction of motion
(b)is in the same direction as the direction of motion
(c)becomes zero at the highest point
(d)increases as it rises up

Ans.(a)

6. What is the final velocity of a body moving against gravity when it attains the maximum height?
(a) Zero (b)$u^2/2g$ (c) h/t (d)2gh

Ans.(a)

7. The acceleration due to gravity is zero at ______.
(a) The equator (b) Poles
(c)Sea level (d)the centre of the earth

Ans.(d)

8. The acceleration due to gravity of a body moving against gravity is
(a) 9.8 m/s² (b) -9.8 m/s²
(c) ± 9.8 m/s² (d) 9.6 m/s

Ans.(b)

9. The value of acceleration due to gravity on the surface of the earth at sea level is
(a) 4.9 m/s² (b) 6 m/s² (c) 8 m/s² (d) 9.8 m/s²

Ans.(d)

10. When an object is thrown vertically upward, on reaching the highest point, the value of acceleration due to gravity will be
(a) 4.9 m/s² (b) 9.8 m/s² upwards
(c) 9.8 m/s² towards the ground (d) 0 m/s²

Ans.(c)

11. Weight of an object on the surface of the moon is

(a) 1/2th of the weight of object on the surface of the earth
(b) 1/4th of the weight of object on the surface of the earth
(c) 1/6th of the weigth of object on the surface of the earth
(d) 1/8th of the weight of object on the surface of the earth

Ans.(c)

12. The force which keeps the body to move in circular motion when acceleration is
(a) Centripetal force (b) Magnetic force
(c) Electrostatic force (d) Force of gravitation

Ans.(a)

13. The expression for finding the gravitational force of attraction between any two bodies is
(a) $F= Gm_1m_2/r$ (b) $F= Gm_1m_2/r^2$
(c) $F = Gm_1/r^2$ (d) $F=Gm_1m_2/r^3$

Ans.(b)

14. The mass of an object
(a) varies at different locations (b) remains constant
(c) can be measured using spring balance
(d) is in the direction of gravitational force

Ans.(b)

15. The value of acceleration due to gravity at the poles
(a) is more than at the equator (b) Same as at the equator
(c) is less than at the equator (d) zero

Ans.(a)

16. The value of g
(a) Increases as we go above the earth's surface
(b) Decreases as we go to the centre of the earth
(c) Remains constant
(d) Is more at equator and less at poles

Ans.(b)

17. The distance between two bodies becomes 6 times more than the usual distance. The F becomes
(a) 36 times (b) 6 times (c) 12 times (d) 1/36 times

Ans.(d)

18. If the distance between two bodies is doubled, the force of attraction F between them will be
(a) 1/4 F (b) 2F (c) 1/2F (d) F

Ans.(a)

19. The acceleration due to gravity is zero at
(a) the equator (b) poles
(c) sea level (d) the centre of the earth

Ans.(d)

20. In the relation $F = GMm/d^2$, the quantity G
(a) depends on the value of g at the place of observation
(b) is used only when the earth is one of the two masses
(c) is greatest at the surface of the earth
(d) is universal constant of nature

Ans.(d)

21. Law of gravitation gives the gravitational force between
(a) the earth and a point mass only
(b) the earth and sun only
(c) any two bodies having some mass
(d) two charged bodies only

Ans.(c)

22. The value of G depends upon :
(a) the masses of bodies
(b) the medium between the bodies
(c) the temperature of bodies
(d) none of the above

Ans.(d)

23. If the earth suddenly stops rotating, the weight of body on earth's surface would become
(a) zero (b) smaller (c) greater (d) remain unaffected

Ans.(c)

24. g_e and g_p acceleration due to gravity on earth and another planet respectively. If the mass and radius of the planet are twice that of earth, them :
(a) $g_p = g_e$ (b) $g_p = \left(\frac{1}{2}\right) g_e$
(c) $g_p = 2g_e$ (d) $g_p = \left(\frac{1}{\sqrt{2}}\right) g_e$

Ans.(b)

Answer the following questions

Q1. State Newton's law of gravitation with its S.I unit ?

Ans. Newton's law of gravitation states that every particle in the universe attracts every other particle with a force directly proportional to the product of their masses and inversely proportional to the square of the distance between them. The direction of the force is along the line joining the particles.

$$F \propto m_1 m_2 \text{ and } F \propto \frac{1}{r^2}$$

$$\therefore \quad F = G\frac{m_1 m_2}{r^2}$$

Where G is constant , called as the universal constant of gravitation.

The vale of G has been experimentally determined i.e. $G=6.67\times10^{-11}$ Nm²/Kg².

Dimensional formula of G is $[M^{-1}L^3T^{-2}]$

Q2. Define the gravitation constant (G). What is its SI unit.

Ans. The universal gravitational constant may be defined as the force of attaraction between two bodies of unit mass each and placed unit distance apart.

In SI, the gravitational constant is equal to the force of attraction between two bodies of 1 kg each and placed 1 m apart.

Dimensions of G

As $F = G\dfrac{m_1 m_2}{r^2}$

Thus $G = \dfrac{Fr^2}{m_1 m_2}$

Dimensions of G is $[M^{-1}L^{3}T^{-2}]$

Units of G

As $G = \dfrac{Fr^2}{m_1 m_2}$

Thus SI unit of G $= \dfrac{Nm^2}{kg \times kg} = Nm^2 kg^{-2}$

Similarly, cgs unit of G = dyn cm^2 g^{-2}

Q3. What are the important characteristics of gravitation force.

Ans. The important characteristics of gravitation force are as follows:

(i) Gravitational force between two bodies is a central force i.e., it acts along the line joining the centres of the two interacting bodies.

(ii) Gravitational force between two bodies is independent of the nature of the intervening medium.

(iii) Gravitational force between two bodies does not depend upon the presence of other bodies.

(iv) It is valid for point objects and spherically symmetrical objects.

(v) Magnitude of force is extremely small.

Q3. State acceleration due to gravity ?Explain the variation of acceleration due to gravity.

Ans. Acceleration Due to Gravity:The acceleration produced in a body on account of the force of gravity is known as acceleration due to gravity.

It is usually denoted by 'g'. It is always towards the centre of Earth.

If a body of mass 'm' lying on the surface of the earth, the gravitational force acting on the body is given by

$$F = G\frac{Mm}{R^2}$$

Where , M =Mass of earth

R =Radius of earth

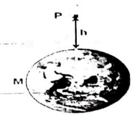
Acceleration due to gravity, $g = G\dfrac{M}{R^2}$

Variation of Acceleration Due to Gravity: The value of acceleration due to gravity changes with height (i.e.,altitude), depth, shape of the earth and rotation of earth about its own axis.

(a) Effect of Altitude: As one goes above the surface of Earth, value of acceleration due to gravity gradually goes on decreasing. If g be the value of acceleration due to gravity at a height h from the surface of Earth,

Then,

$$g_h = \frac{g}{\left(1+\frac{h}{R}\right)^2}$$

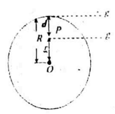


If $h << R$, then

$$g_h = g\left(1-\frac{2h}{R}\right)$$

(b) Effect of Depth: The value of acceleration due to gravity decrease with depth.It is given as

$$g_h = g\left(1-\frac{d}{R}\right) \text{ Where d=depth}$$



At the centre of the earth , the acceleration due to gravity becomes zero.

(c) Effect due to rotation of earth: The acceleration due to gravity (i) decreases due to rotation of the earth (ii) increase with the increase in lattitude.It is given by

$$g_\theta = g\left(1-\frac{R\varpi^2}{g}\cos^2\theta\right)$$

Where, θ = latittude of the earth

(d) Effect due to shape: The equitorial radius of earth is longer than its polar radius.

The value of g increases from equator to pole.It is given as

$$g_{pole} > g_{equator}$$

Q4. Why is the weight of an object on the moon 1/6th its weight on the earth?

Ans. The mass of moon is 1/100 times and its radius 1/4 times that of earth. As a result, the gravitional attraction on the moon is about one sixth when compared to earth. Hence, the the weight of an object on the moon 1/6th its weight on the earth.

Q5. What happens to the force between two objects, if
(i) the mass of one object is doubled?
(ii) the distance between the objects is doubled and tripled?
(iii) the masses of both objects are doubled?

Ans. From Universal law of gravitation , force exerted on an object of mass m by earth is given by

$$F = G\frac{m_1 m_2}{R^2} \text{ --------(i)}$$

(i) When the mass of the object say 'm' is double then

$$F = G\frac{M.2m}{R^2} = 2F$$

So as the mass of any one of the object is doubled the force is also doubled

(ii) The force F is inversely proportional to the distancebetween the objects. So if the distance between two objects isdoubled then the gravitational force of attraction between them is reduced to one fourth of its original value. Similarly f is the distance between two objects is tripled , then the gravitational force of attraction becomes one ninth of its original value.

(iii) Again fron Universal law of attraction from equation (i) force F is directly proportional to the product of both the masses. So if both the masses are doubled then the gravitational force of attraction becomes four times the original value.

Solved Example

Q1. The gravitational force of attraction between two masses is 50 N. The mass of one object is doubled ther distance then is halved. What is the new force of attraction between the two masses ?

Sol. Let F be the old force and FN be the new force of attraction between the masses.

Then,

According to force of Gravitation

$$F = \frac{G\, m_1 m_2}{r^2}$$

$$F_N = \frac{G(2m_1)(m_2)}{(r/2)^2} = 8F$$

Substituting F = 50, we get $F_N = 8 \times 50 = 400$ N.

Q2. If mass of earth (M_E) ***= 6×10^{24} kg and mass of moon M_m = 7.4 × 10^{22} kg and distance between them is 3.84×10^5 km. Find gravitational force between earth and moon. Take G = 6.7×10^{-11} Nm^2/kg^2.***

Sol. Given,

Mass of Earth (M_E) = 6×10^{24} kg.

Mass of moon (M_m) = 7.4 × 10^{22} kg

Then, $d = 3.84 \times 10^5$ km $= 3.84 \times 10^8$ m.

$$F_N = \frac{G m_E m_m}{d^2}$$

$$= \frac{(6.67\times10^{-11})(6\times10^{24})(7.4\times10^{22})}{(3.8\times10^{8})^2}$$

$$= 2.01 \times 10^{20}\ N$$

Q3. A 65 kg person and a 80 kg person are sitting in their physics class room 1.5 m appart. From each other. Calculate the gravitational force between them.

Sol. According the force of Gravitation:

$$F_G = \frac{Gm_1 m_2}{r^2}$$

$$F_G = 6.67\times10^{-11}\frac{Nm^2}{kg} = \frac{(60\,kg)(80\,kg)}{(1.5m)^2}$$

$$F_G = 1.5\times10^{-7}\ N$$

Q4. The acceleration due to gravity near the earth's surface is 9.8 m/s^2. and the earth radius is 6400 km. From this data calculate the mass of the earth. Use any universal constant if required.

Sol. Acceleration due to gravity (g) = 9.8 m/s^2

Radius of the earth (r = 6400 km

Let mass of the earth be ' m'

We know that

$$g = \frac{Gm}{r^2}$$

$$9.8 = 6.67\times10^{-11}\times\frac{m}{(6400\times10^3)^2}$$

$$\text{Mass of the earth (M)} = \frac{9.8\times(6400\times10^3)^2}{6.67\times10^{-11}}$$

$$= 6.02\times10^{24}\ kg$$

Q5. The mass of earth is 6 × 10^{24} kg, the radius of earth is 6.4 × 10^6 m and mass of the man is 60 kg. Assume earth to be a uniform solid sphere.
(a) Find the force with which earth attracts man
(b) Does man also attract the earth? If yes, then find this force.
(c) Find the acceleration of man.
(d) Find the acceleration of earth.
(e) What is the weight of man?

Sol. (a) The force with which earth attracts the mass

$$F = \frac{GMm}{r^2}$$

Here, r = 6.4 × 10^6 m, because the man can be considered as a point mass on the surface of earth. This is because the height of the man is negligible as compared to the radius of the earth.

Thus $F = \dfrac{6.67\times10^{-11}\times6\times10^{24}\times60}{(6.4\times10^6)^2}$

$$= \left(\frac{6.67\times6\times60}{6.4\times6.4}\right)\times\left(\frac{10^{-11}\times10^{24}}{10^6\times10^6}\right)N$$

$$= 58.62 \times 10^1 = 586.2\ N$$

(b) Yes, the man also attracts the earth. To each and every action, there is equal and opposite reaction. Therefore, the man also attracts the earth with the same force (586.2 N).

(c) We know that,

F = ma If F is constant,

$$\alpha \propto \frac{1}{m}$$

The acceleration of man

$$a_m = \frac{F}{mass\ of\ man} = \frac{586.2}{60} = 9.8\ ms^{-2}$$

(d) The acceleration of earth

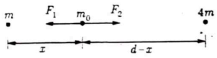
(e) The weight of man is equal to the gravitational pull of earth.

Weight of man = 586.2 N

$$a_e = \frac{F}{mass\ of\ earth} = \frac{586.2}{6\times10^{24}} = 9.8\times10^{-23}\ ms^{-2}$$

Q6. A mass of m kg and another mass of 4 m kg are placed at a distance d from each other. Where should a mass m_o be placed on the line joining these masses, so that the net force acting on m_o is zero?

Sol. Let us assume that the required point is distant x from the mass m. Let the force on m_0 due to the m kg mass be F_1 and that due to 4 m kg mass be F_2. The mass m_0 is being acted on by to equal and opposite forces.



Now, $F_1 = \frac{Gmm_o}{x^2}$

and $F_2 = \frac{G(4m)m_o}{(d-x)^2}$

If the net force on m_0 is zero, these forces must be equal and opposite. Hence

$$F_1 = F_2$$

or $\frac{Gmm_o}{x^2} = \frac{G(4m)m_o}{(d-x)}$

or $\left(\frac{d-x}{x}\right)^2 = 4$

or $\frac{d-x}{x} = 2$ or $x = \frac{d}{3}$

Q7. A particle weights 120N on the surface of the earth . At what height above the earth's surface will its weight be 30 N? Radius of the earth = 6400 km.

Sol. Mass of the particle remains same i.e. m

Only the acceleration due to gravitation varies because of increase in distance.

Let the weight be h

Thus on surface of earth, $F = 120\ N = G\frac{mm}{R^2}$ ...(i)

Then, at height h,

$$F' = 30\ N = G\frac{mm}{(R+h)^2} \quad .....(ii)$$

Dividing equation (i) by (ii) we get

$$4 = \frac{(R+h)^2}{R^2}$$

$\Rightarrow \quad 2 = \frac{R+h}{R} \quad \Rightarrow \quad V = R$

Thus at a weight of 6400 km.

Chapter 4.
Work, Energy & Power

Multiple Choice Question

1. The mass of the body in halved and its velocity is double the kinetic energy of the body will:
(a) Doubled (b) Four time
(c) Eight time (d) None
Ans. (c)

2. A car is running at speed of 15 km /h-1 while another similar car is moving at speed of 30 km /h-1. Their kinetic energies are in the ratio :
(a) 1:2 (b) 2:1 (c) 1:4 (d) 4:1
Ans.(c)

3. A man pushes a wall and fails to displace it.He does
(a) Negative work
(b)Positive work but not maximum work
(c) No work at all
(d) Maximum positive work
Ans.(c)

4.The work done by a force on a body will positive if
(a) The body does not moves
(b) The body moves perpendicular to the direction of applied force
(c) The body moves along the direction of applied force
(d) The body moves opposite to the direction of applied force
Ans.(c)

5. When the velocity of a body is doubled its kinetic energy
(a) Becomes four time (b) is doubled
(c) Become half (d) Remains the same
Ans.(a)

6.When force is applied on an object but object does not move it means that
(a)no power is used (b)no work is done
(c)work is done (d)power is used
Ans.(b)

7.Power is defined as
(a)p = W/t, where W is work and t is time
(b)p = t/W, where t is time and W is work
(c)p = W/d, where W is work and d is distance
(d)p = d/W, where d is distance and W is work
Ans.(a)

8.Work in relevance to time is related to
(a)Efficiency (b)Work (c)Power`` (d)Force
Ans.(c)

9.When spring or rubber band is released it converts potential energy into
(a)Mechanical Energy (b)Electrical Energy
(c)Thermal energy (d)Kinetic energy

Ans.(d)

10. 1 joule = 1 ______
(a)N m^2 (b) Kgm/s^2 (c)N m (d)$N^2 m^2$
Ans.(c)

11.Power is a measure of the ______
(a)rate of change of momentum
(b)force which produces motion
(c)change of energy
(d)rate of change of energy
Ans.(d)

12.If the speed of an object is doubled then its kinetic energy is ______
(a)doubled (b)quadrupled (c)halved (d)tripled
Ans.(b)

13. A man of mass 50 kg jumps to a height of 1 m. His potential energy at the highest point is (g = 10 m/s2)
(a)50 J (b)60 J (c)500 J (d)600 J
Ans.(c)

14. The law of conservation of energy is a statement that
(a)energy must be conserved and you are breaking a law if you waste energy.
(b)the supply of energy is limited so we must conserve.
(c)the total amount of energy is constant.
(d)energy cannot be used faster than it is created.
Ans.(c)

15. Energy is
(a)the ability to do work.
(b)the work needed to create potential or kinetic energy.
(c)the work that can be done by an object with PE or KE.
(d)all of the above.
Ans:(d)all of the above.

16. If the K.E. of a particle is doubled, then its momentum will
(a) remain unchanged (b) be doubled
(c) be quadrapled (d) increase $\sqrt{2}$ times
Ans.(d)

17. The unit of power in SI system is
(a) hp (b) joule/s (c) watt (d) both b and c
Ans.(c)

18. The kinetic energy of a particle of mass m and velocity v is quantified by
(a) mv (b) mv^2 (c) 1/2 mv^2 (d) $2mv^2$
Ans.(c)

19. If a momentum of a body be tripled then its K.E. will become
(a) three times (b) six times
(c) nine times (d) eighteen times
Ans.(c)

20. In which of the following case (s), work done is zero?
(a) displacement = 0 (b) the body displaces by 90°
(c) the body displaces by 270°
(d) In all these cases
Ans.(d)

21. In which of the following cases, work done is negative? (θ being the angle by which the object deflects from the line of action of force)
(a) $\theta = 180^\circ$ (b) $\theta = 270^\circ$
(c) both a and b (d) None of the above
Ans.(a)

22. A man pushes a wall and fails to displace it. He does
(a) negative work (b) positive but not maximum work
(c) no work at all (d) maximum work
Ans.(c)

23. In which of the following situations, negative work is done?
(a) a player kicks a ball
(b) a moving object stops due to friction
(c) a weight-lifter raises a barbell
(d) None of the above
Ans.(b)

24. When a coolie carries a load on his head and walks in the horizontal direction, he does
(a) positive work (b) negative work
(c) no work (d) None of the above
Ans.(c)

25. The energy stored in wound watch spring is
(a) kinetic energy (b) potential energy
(c) heat energy (d) chemical energy
Ans.(b)

26. The work done does not depend upon
(a) applied force (b) displacement
(c) angle at which force in inclined to the displacement
(d) initial velocity of the object
Ans.(d)

27. A particle of mass m has momentum p. Its kinetic energy will be
(a) mp (b) $\frac{2p^2}{m}$ (c) $\frac{p^2}{2m}$ (d) $\frac{p^2}{m}$
Ans.(c)

28. A boy pushes a wall and falls to displace it. Therefore, he does
(a) positive work (b) negative work
(c) positive but not maximum work (d) no work at all
Ans.(d)

29. In which case work is done
(a) a green plant carrying out photosynthesis
(b) a porter standing at a place and carrying a heavy load on his head
(c) drying of food grains in sum
(d) a trolley rolling down a slope
Ans.(d)

30. A man carries a suitcase in his hand climbs up the stairs. The work done by the man is

(a) positive (b) negative (c) zero (d) None of the above

Ans.(a)

31. **Area under force-displacement graph is equal to**

(a) impulse (b) momentum
(c) work done (d) None of the above

Ans.(c)

32. **Two bodies of masses m_1 and m_2 have same momentum. The ratio of their KE is**

(a) $\sqrt{\frac{m_2}{m_1}}$ (b) $\sqrt{\frac{m_1}{m_2}}$ (c) $\frac{m_1}{m_2}$ (d) $\frac{m_2}{m_1}$

Ans.(d)

33. **A bus and car have the same momentum. If kinetic energy of the bus k_1 and kinetic energy of the car is k_2, then**

(a) $k_1 = k_2$ (b) $k_1 < k_2$ (c) $k_1 > k_2$ (d) $k_1 \geq k_2$

Ans.(b)

Answer the following questions

Q1. Define work A person holding a suitcase on his head is at rest is heading any work ? Explain.

Ans. Work : Work refers to an activity involving a force and movement in the directon of the force. Ex : - A force of 20 newtons pushing an object 5 meters in the direction of the force does 100 joules of work. It's S.I. unit of work is Nm.

From the mathematical expression of work.

$$w = F.S\cos\theta$$

But in this case person holding

Suitcase on his head and does not move than

$$S = 0$$

$$\therefore \quad w = 0$$

Hence, work done by him is zero.

Q2. Define energy . A body of mass 8kg is moving with a velocity of 5 m/s at a hight of 10 m calculate the total energy. g = 9.8 m/s².

Ans: Energy of a body is defined as the capacity of donig work .It is measured by the total amount of work that a body can do.It is a scalar quantity.The unit and dimension of energy are the same as that of the work.

SI unit of energy is joule (J).

Dimensional formula for energy $=\{ML^2T^{-2}\}$.

Given:Mass (m)=8kg

Velocity(v)=5m/s

Height (h)=10m

Acceleration due to gravity

(g)=9.8m/s²

Total Energy=k.E + P.E

$$= \frac{1}{2} = mv^2 + mgh$$

$$= \frac{1}{2} x 8 x 5^2 + 8 x 9.8 x 10$$

=884 J

Q3. Define kinetic energy ?A block of mass 2kg is lying on the frictionless table. A force of 8N is applied on it for 10 sec Calculate its kinetic energy.

Ans. kinetic Energy : The energy possessed by a body by virtue of its motion is called kinetic energy. In general, all moving bodies posses kinetic energy.

The kinetic energy possessed by a moving body can be measured by the amount of work which the moving body can perform before coming to rest.

Examples of kinetic energy :

(i) moving vehicles posses kinetic energy.

(ii) A bullet fired from the gun has kinetic energy and due to their energy the bullet penetrates into a targed.

(iii) Moving water possesses kinetic energy which is used to run the water mills. The kinetic energy of a body of mass 'M' moving with velocity is given by the relation $K.E. = \frac{1}{2}mv^2$

SI unit of kinetic energy is N - m or joule.

Numerical :

Solution : Given, m = 2kg, F = 8N

$$\therefore \text{Acceleration, } a = \frac{F}{m} = \frac{8}{2} = 4m/s^2.$$

Velocity attained by body after 10 second.

$$v = u + at$$

$$\Rightarrow \quad v = 0 + 4 \times 10 = 40 \text{ m/s}$$

$$\therefore \text{K.E.of the body } = \frac{1}{2}mv^2 = \frac{1}{2} \times 2 \times 40 \times 40 = 1600j$$

Q4. Explain potential energy with examples. A man weighing 50 kg climbs 10m high. Calculate the work done by gravity or potential energy.

Ans. Potential energy: The energy posseseced by a virtue of its position or configuration (shape) is called potential energy potential energy is a stored energy in an object or a body.

It may be noted that position refers to the height above the surface of earth and configuration refers to arrangement of the body. It is usually dented by the symbol U.

$$U = mgh$$

Example of potential energy :

(i) Water stored in the reservoir of of a dam possesses potential energy.

(ii) An apple or a mango hanging form the branch of a tree has a potential energy.

(iii) An object lifted to a certain from the surface of earth has potential energy at the position.

(iv) A comperssed spring possesses potential energy.

Unit of potential energy :

SI unit of P.E. is joule (j) and CGS unit is erg dimension of P.E. = $[ML^2T^{-2}]$

Numerical : m = 50 kg

h = 10 m

g = 9.8 m/s²

P.E. (U) = mgh

= 50×9.8×10 = 49001

Q5. Define power . A 60 kg man runs up a flight of stairs 3 m high in 2 seconds. calculate power.

Ans. Power is defined as the rate of doing work. It is measured by the ratio of work done to the time taken.

$$Power = \frac{Work\ done}{Time\ taken}$$

$$P = \frac{dw}{dt}.$$

It is scalar quantity.

Units of Power : In SI. the unit of power is watt (w)

$$1 \text{ watt (W)} = = \frac{1J}{1\sec} = 1J\sec^{-1}$$

Power is said to be one watt if one joule work is done in one second by any agent.

Bigger units of power are :

1 Kilowatt (KW) = 10^3 W

1 Megawatt (MW) = 10^6 W.

The pratctical unit of power of the horse power (HP)

1 HP = 746 watt.

Dimension of power, $P = \frac{W}{t} = \frac{[ML^2T^{-2}]}{[T]} = [ML^2T^{-3}]$

Numerical

Solution : Given , m = 60 kg, h = 3m, t = 2 sec.

Work done = P.E = mgh = 60 ×9.8 × 3

= 1764j.

Power = $882J/s = 882W$

Q6. State and explain work energy principle ? A praticle of mass 0.5 kg travels in a straight line with a velocity $v = 5x^{5/2}$ ms^{-1}. How much work is done by the net force during the displacement from x = 0 to x = 2m?

Ans. Work - Energy principle : According to this principle, the work done by a system of force acting on a body between any two points is equal to the change in kinetic energy of a body between these same two points i.e. work done on the body is equal to the change in kinetic energy.

Let us consider a body of mass 'm' moving with initial velocity 'u' When a force F is applied on the body along its direction of motion, it produces an acceleration 'a' and the velocity of the body changes from u to v in moving a distance s. Then

Work done by the force = force × displacement

$$w = F \times S$$

$$w = ma \times S \quad ..... (i)$$

From equation of motion,

$$v^2 = u^2 + 2as$$

$$\Rightarrow \quad \frac{v^2 - u^2}{2} = as$$

putting the value of as in equation (i),

$$W = m \times \frac{(v^2 - u^2)}{2}$$

$$\Rightarrow \quad W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$\therefore \quad W = K_f - K_i$$

Where K_i and K_f is the initial and final kinetic energy.

W = change in K.E. of a body = Δ (K.E)

This is know as work energy principle of theorem.

Numerical:

Solution : Given : m = 05kg

$v = (5x^{5/2})$ m/s

When, x = 0 v_i = 0 and

When x = 2m, $v_f = 5\ (2)^{5/2}$ m/s.

using work energy theorem,

W = change in K.E

$$W = \frac{1}{2}mv_f^2 - \frac{1}{2}mu_i^2$$

$$= \frac{1}{2}m(v^2_f - v^2_i)$$

$$W = \frac{1}{2} \times 0.5 \times [\{5(2)^{5/2}\} - 01]$$

$$= \frac{1}{2} \times (0.5 \times 25 \times 2)^5 = 200J$$

Q7. Differentiate between potential energy and kinetic energy.

Ans.

Potential Energy (P.E.)	Kinetic Energy (K.E.)
Potential energy is the energy possessed by a body on account of its position	Kinetic energy of a body is the energy possessed by it on account of its motion.
It is given by the formula, P.E. = mgh	It is given by the formula, K.E. = ½ mv^2
Potential energy of a body can be negative	Kinetic energy of a body is never negative
Potential energy cannot be directly put into work	Kinetic energy can be directly put to work
e.g., A wound spring of a watch, a stretched arrow etc.	e.g., Running car, stream of water etc.

Q8. Give difference among work, power and energy.

Ans.

Work	Power	Energy
When force acting on a body displaces it then work is said to be done and is given by the product of force and the displacement produced.	Power is defined as the rate of doing work	Energy of a body is defined as its capacity of doing work
Its SI unit is joule	Its SI unit is watt	Its SI unit is joule
Work done by a force may be negative	Power is never negative	Energy of a body is never negative
Work is a specific type of energy transfer in the direction of applied force	Power is a measure of how fast the work is done	Energy is an invisible agent and is a measure of amount of work done

Chapter 5.
General Properties of Matter

5.1 ELASTICITY

Multiple Choice Question

1. Hooke's law essentially defines.
(a) Stress (b) Strain
(c) Yield point (d) Elastic limit
Ans.(d)

2. The maximum value of stress for which Hooke's law holds good is called.
(a) Elasticity (b) Strain
(c) Elastic limit (d) Young's modulus
Ans.(c) Elastic limit

3. Young's modulus for a perfectly plastic body's.
(a) zero (b) Infinity (c) one (d) Finite
Ans.(a)

4. Steel is more elastic than rubber because for a given stress, strain produced in steel is,
(a) equal to that in rubber (b) greater than in rubber
(c) less than in rubber (d) None of these
Ans.(c)

5. Young's modulus (Y), Bulk modulus (K) and modulus of rigidity (n) are related as.
(a) $\frac{1}{k} = \frac{1}{3n} + \frac{9}{9y}$ (b) $\frac{1}{Y} = \frac{1}{3n} + \frac{1}{9k}$
(c) $\frac{Y}{3} = \frac{1}{n} + \frac{1}{9k}$ (d) $\frac{1}{n} = \frac{1}{3y} + \frac{1}{9k}$
Ans.(b)

6. Which one of the followings substances possesses the highest elasticity ?
(a) Rubber (b) Glass (c) Steel (d) Copper
Ans.(c)

7. If a wire is stretched to doubled its length its strains is
(a) 2 (b) 1/2 (c) 1 (d) 4
Ans.(c)

8. The Young's modulus of a wire is numerically equal to the stress which will :
(a) Not change the length of the wire
(b) Double the length of the wire
(c) Increase the length by 50%
(d) Change the area of cross-section of the wire to half.
Ans.(b)

9. A wire can be broken by applying a load of 20 kg wt. The force required to break the wire of twice the diameter is:

(a) 20 kg wt (b) 5 kg wt (c) 80 kg wt (d) 160 kg wt.
Ans.(d)

10. Energy stored per unit volume in a streched wire is :
(a) $\frac{1}{2}$ Load × strain (b) Load × strain
(c) stress × strain (d) $\frac{1}{2}$ × stress × strain
Ans.

11. Steel is preferred for making springs over copper. Why?
(a) Steel is cheaper
(b) Young's modulus of steel is more than that of copper
(c) Young's modulus of copper is more than that of steel
(d) Steel is less likely to be oxidised
Ans.(b)

12. Stress is defined as
(a) Resioring force/ area (b) External force / area
(c) Deforming force (d) All the above.
Ans. (d)

13. The ratio of stress and strain is called
(a) Surface tension (b) Coefficient of fnction
(c) Modulus of elasticity (d) Co - efficient of viscosity
Ans.(c)

14. The minimum value of stress at which a body acquires its original shape is called.
(a) Elastic limit (b) Limit of proportionallty
(c) Yield point (d) Breaking point
Ans.(a)

15. Hooke's law holds good upto
(a) proportional limit (b) yield point
(c) elastic point (d) plastic limit
Ans.(a)

16. Elastic limit is the property of a .... whereas elasticity is the property of ....
(a) body and material (b) material and body
(c) body and body (d) material and material
Ans.(a)

17. The modulus of elasticity for mild steel is approximately equal to
(a) 0.1×10^6 kg/cm² (b) 0.8×10^6 kg/cm²
(c) 1.0×10^6 kg/cm² (d) 2.1×10^6 kg/cm²
Ans.(d)

18. Young's modulus of substance depends on
(a) its strength (b) its area
(c) acceleration due to gravity (d) None of these
Ans.(d)

19. Young's modulus of elasticity for a perfectly rigid body is
(a) zero (b) unity
(c) infinity (d) None of these
Ans.(c)

20. There are .... moduli of elasticity.
(a) one (b) two (c) three (d) four
Ans.(c)

21. Which of the following relation hold good in relation with bulk modulus?
(a) $K_{solid} > K_{liquid} > K_{gas}$ (b) $K_{solid} < K_{liquid} < K_{gas}$
(c) $K_{solid} = K_{liquid} = K_{gas}$ (d) $K_{solid} > K_{liquid} = K_{gas}$
Ans.(a)

22. The value of K for a perfectly rigid body is
(a) infinity (b) zero (c) one (d) ± 1

23. The reciprocal of bulk modulus is called
(a) Young's modulus (b) shear modulus
(c) compressibility (d) poisson's ratio
Ans.(c)

24. Theoretical value of Poisson's ratio lies between
(a) -1 and zero (b) -1 and -1/2
(c) -1 and +1/2 (d) -1 and +1
Ans.(c)

25. Practical value of Poisson's ratio lies between
(a) zero and +1/2 (b) - 1 and -1/2
(c) -1 and +1/2 (d) -1 and +1
Ans.(a)

26. Poisson's ratio for most of the materials is close to
(a) 0.5 (b) 0.33 (c) 0.25 (d) 0.2
Ans.(b)

27. Which material has the highest value of Poisson's ratio?
(a) rubber (b) wood (c) copper (d) steel
Ans.(a)

28. If the value of Poisson's ratio is zero, then it means that
(a) the material is rigid
(b) the material is perfectly plastic
(c) there is no longitudinal strain in the material
(d) the longitudinal strain in the material is infinite
Ans.(a)

29. A ductile material is able to regain its original length upto
(a) elastic limit (b) proportional limit
(c) yield limit (d) ultimate limit
Ans.(a)

Answer the following questions

Q1. Define the following terms
(i) Deforming force ***(ii) Restoring force***
(iii) Elasticity ***(iv) Elasticity body***
(v) Plasticity ***(vi) Plastic body***

Ans:(i) Deforming force : When an external force is applied to a body, its shape and size changes. This change in shape and size of the body is called as deformation and the applied force is called as deforming force.

Thus the force which is responsible for the change in shape and size of the body is called as deforming force.

(ii) Restoring force :
Under the deformed condition, body tries to restore its original dimension due to the internal restoring force developed inside the body. This internal force which helps to regain original size & shape of the deformed body is called as internal

restoring force.

(iii)Elasticity : It is defined as the property on account of which, body opposes the deforming forces and regains its original shape and size on the removal of the deforming forces.

(iv)Elasticity body : The body which, opposes the deforming forces and regains its original shape and size on the removal of the deforming forces is called as Elastic body.

For ex. Rubber, Steel.

(v)Plasticity : The property possessed by a material body due to which it does not regain its original shape and size and remains in the deformed state even after removal of the deforming forces is called Plasticity.

(vi)Plastic body : The body which can easily be deformed even when very small deforming force is applied to it. On removal of deforming force, the body does not regain its original shape and size, such body, is called as plastic body.

For ex. Plastic, mud, clay, dough, etc.

Q2. Define stress, strain and elastic limit. Also state Hook's law.

Ans. Stress: The force of resistance per unit area, offered by a body against deformation is known as stress.

Mathematically stress is written as,

$$P = \frac{F}{A}$$

Where, P = Stress (also called intensity of stress)

F = External force or load

A = Cross - Sectional area.

MKS or S.I unit of stress is N/m^2 and C.G.S unit is $dyne/cm^2$.

Dimensions of stress are $[M^1L^{-1}T^{-2}]$

Strain: When a body is subjected to some external force, there is some change of dimension of the body. The ratio of change of dimension of the body to the original dimension is known as strain.

$$\text{Strain} = \frac{\text{Change in dimensions}}{\text{Original dimensions}}$$

Strain is the ratio of two similar quantities. Hence, strain has no unit. Strain is a pure number.

Elastic limit and Hooke's law :

Elastic limit : "The stress corresponding to the limiting value of the load, which when applied and subsequently released, does not produce permanent deformation is called as elastic limit".

If this limit is crossed, the proportionality is lost and the stress is found to be less than what is expected.

Hooke's law : It states that, "within elastic limit, stress is directly proportional to the strain."

$$\therefore \quad Stress \propto Strain$$

$$\therefore \quad Stress = Constant \times Strain$$

$$\therefore \quad \frac{Stress}{Strain} = Constant$$

The constant of proportionality is called as modulus of elasticity.

$$\therefore \quad Modulus\ of\ elasticity = \frac{Stress}{Strain}$$

S.I. unit of modulus of elasticity is N/m^2. CGS unit is $dyne/cm^2$ and dimensions of modulus of elasticity are $[M^1L^{-1}T^{-2}]$.

Q3. *State the type of stress.*

Ans. The different types of stesses are as follow:

(i)Tensile (Longitudinal) stress : The deforming force acting per unit cross-sectional area normal to the surface of the body is called tensile stress.

Such type of stress produces change in length of body.

$$Tensile\ stress = \frac{Applied\ force}{Cross-sectional\ area} = \frac{F}{A}$$

It's SI unit is N/m^2 and CGS unit $dyne/cm^2$.

(ii)Volume Stress : The deforming force acting per unit area which produces change in volume of the body is called as volume stress.

$$Volume\ stress = \frac{Applied\ force}{Area} = \frac{F}{A} = P \left\{\because \frac{F}{A} = P\right\}$$

Where, P means pressure on the body.

It's SI unit is N/m^2 and CGS unit $dyne/cm^2$.

(iii)Tangential (shearing stress) : The deforming force acting per unit area tangential to the surface of the body is called tangential (shearing) stress.

Such type of stress produces change in shape of the body.

$$Tangential\ stress\ (shearing\ stress) = \frac{Tangential\ force}{Area} = \frac{F}{A}$$

It's SI unit is N/m^2 and CGS unit is $dyne/cm^2$.

Q4. State the types of strain.

Ans. The different types of strain are as follow:

(a)Longitudinal Strain: When deforming force is applied along the length of a body, there is a change in its length. The strain so produced in the body is called longitudinal strain. It is defined as the change in length per unit original length, when deformed by the external force within the eleastic limit.

Suppose a wire of length l is stretched by applying a force and Δl is the change in length produced in the wire then

$$\text{Longitudinal Strain} = \frac{Change\ in\ length(\Delta l)}{Original\ length(l)}$$

If the length of the solid wire increases ($\Delta l > 0$), then it is called tensile strain but if the length decreases ($\Delta l < 0$), then it is called compressional strain.

(b)Volumetric Strain: When deforming force is applied normal to the surface of the body, then change occur in volume of the body. Strain resulting from a change in volume is called volumetric strain.

It is defined as change in volume per unit original volume, within the eleastic limit. Thus,

$$\text{Volumetric strain} = \frac{Change\ in\ volume(\Delta V)}{Original\ volume(V)}$$

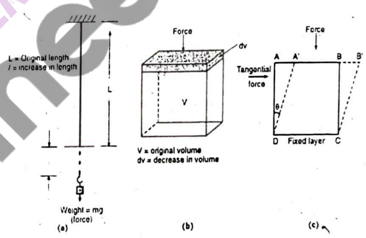
(c)Shear Strain: When one face of a body is kept fixed and a deforming force is applied tangentially at the opposite face, it produces a change in the shape of the body without changing its volume. Strain resulting due to the change of shape is called shear strain.

It is defined as the angle (in radian) through which a plane perpendicular to the fixed face of the cubical body turned on applying tangential deforming force.

$$\text{Shear Strain} = \tan\theta$$

$$= \frac{Relative\ Dsplacement\ between\ two\ parallel\ faces}{Distance\ between\ parallel\ faces}$$

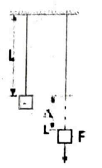
$$= \frac{\Delta l}{l}$$



(a) (b) (c)

Q5. Explain young's modulus, Bulk modulus and modulus of rigidity. Also write the relation between them ?

Ans. Young's Modulus of Elasticity (Y) :



It is the ratio of longiurdinal stress to longitudinal strain, within elastic limit. It is denoted by 'Y'.

$$\therefore \quad Y = \frac{\text{Longitudinal stress}}{\text{Longitudinal strain}}$$

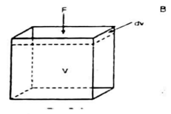
Consider a wire of length l and cross sectional area A streched by a force F through a distance Δl.

Then, $Y = \frac{F/A}{\Delta l/l} = \frac{Fl}{A\Delta l}$ If $A = 1$, $l = 1$ and $\Delta l = 1$

Then, $Y = F$

So, Young's modulus of elasticity is equal to the force required to extend a wire of unit length and unit cross sectional area through unity. The S.I unit of Young's modulus of elasticity is Nm^{-2} or Pa.

Bulk Modulus (B or K) : When a solid or fluid (liquid or gas) is subjected to change in pressure its volume changes, but the shape remains unchanged. The force per unit area, applied normally and uniformly to the surface of body, i.e., pressure, gives the stress and change in volume per unit volume gives strain. Now within the limits of proportionality, the ratio of uniform and normal stress on the surface of the body to volume stain is called bulk modulus of material of body. It is denoted by letter B or K.



i.e., $B = \frac{\text{Volume stress}}{\text{Volume strain}}$

Thus, if the volume V of a body diminishes by an amount ΔV when the pressure on its surface is increased uniformly by ΔP, then in equilibrium

Volume stress = ΔP

$$\text{Volume strain} = \frac{-\Delta V}{V}$$

$$\therefore \quad B = \frac{\Delta P}{-\Delta V/V} = -V\frac{\Delta P}{\Delta V}$$

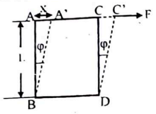
The negative sign shows that with increase in pressure by ΔP, the volume decreases by ΔV, i.e., ΔP is +ve ΔV is –ve. So Bulk modulus is a positive quantity.

Modulus of Rigidity : Within limits of proportionality, the ratio of tangential stress to the shearing strain is called modulus of rigidity of material of the body and is denoted by η, i.e.,

$$\eta = \frac{\text{Shearing stress}}{\text{Shearing strain}}$$

In this case the shape of body changes but its volume remains unchanged.

Consider a cube of material fixed at its lower face and acted upon by a tangential force at its surface having area A. The shearing stress then will be.



Shearing stress = F/A

This shearing force causes the consecutive horizontal layers of the cube to be slightly displaced or sheared relative to one another each line such as AB or CD in the cube is rotated through an angle φ by this shear. The shearing strain is defined as the angle φ in radians through which a line normal to a fixed surface has turned. For small values of angle.

$$\text{Shearing strain} = \varphi = \frac{AA'}{AB} = \frac{x}{L}$$

$$\text{So, } \eta = \frac{\text{Shear stress}}{\text{Shear strain}} \Rightarrow \eta = \frac{F/A}{\varphi} \Rightarrow \eta = \frac{F}{A\varphi}$$

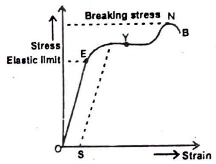
Relation between y, k and η

$$\left[y = \frac{9\eta k}{3k+\eta} \right].$$

Q6. Explain the behaviour of a wire under continuosly increasing load using stress diagram.

Ans. Behaviour of wire under continuously increasing load or stress against strain diagram.

A wire is subjected to increasing load step by step. The extension during each step is measured and a graph of stress - strain is plotted as shown in figure.



(i) The initial part OE of graph is a straight line which indicates that stress is directly proportional to the strain upto point E and Hooke's law is obeyed for OE path.

(ii) The stress corresponding to point E, is called elastic limit.

(iii) Beyond the point E, the strain increases rapidly for small increase in stress and hence Hooke's law is not obeyed.

(iv) Between point E and Y, if all load is removed, then wire does not regain original dimension and some permanent strain OS is produced in it. This wire also obeys Hooke' law, along dotted straight line.

(v) After point Y, the strain goes on increasing without any increase in stress. In this case, the wire is said to flow. The point Y, is called yield point.

(vi) The point N, at which the wire can bear maximum stress, is called breaking stress.

(vii) At this state, the wire stretches suddenly and neck is formed at weakest part of wire. Then wire goes on stretching until the breaking point B is reached and the wire breaks into pieces.

Yield point : It is defined as the point at which deformation in a wire begins to increase without any increase in the load (or stress).

Breaking stress : The maximum stress upto which wire can be loaded or wire can bear is called as breaking stress. The corresponding point in the graph is breaking point B.

Ultimate Stress : It is the maximum stress (force per unit area) that the material can with stand before it breaks or fractures.

$$\text{Ultimate stress} = \frac{\text{maximum load the system can withstand}}{\text{Original cross sectional area}}$$

Working stress : It is the actual practical stress on the system. Working stress is defined as the ratio of actual load to the original cross-sectional area.

$$\text{Working stress} = \frac{\text{Actual load on the specimen (system)}}{\text{Original cross - sectional area}}$$

Factor of safety : Working stress is the maximum allowed (permitted) stress on the system. For the safety of structure, this working stess should be less than elastic limit of the material. Working stress is determined by dividing the ultimate stress by a number called factor of safety.

Factor of safety is defined as the ratio of ultimate stress to working stress.

$$\text{Factor of safety} = \frac{\text{Ultimate stress (load)}}{\text{Working stress (load)}}$$

or factor of safety is defined as the ratio of maximum load that the structure can bear to the actual load on the structure.

Q7. Why steel is more elastic than rubber.

Ans. (i) Elasticity means the ability of a material to retain its original form immediately after releasing a force from it.

(ii) In the case of steel it retains its original state after releasing force.

(iii) But in the case of rubber, It takes some time to retain its original form.

(iv) In the case of rubber, some energy is stored in the material and after time passes the energy comes down and it gets its original shape.

(v) Also Young's Modulus of steel is more than youn's modulus of rubber.

(vi) So steel is more elastic than rubber.

Solved Example

Q1. A wire of length 3 m extends by 3 mm when a force 2 N is applied to it. Calculate (i) stress produced in it, if $Y=2\times10^{11} N/m^2$ (ii) Area of wire.

Sol. Given : L = 3 m, $l = 3\text{ mm} = 3\times10^{-3}\,m$, F = 2N

$$Y = \frac{stress}{strain}$$

$$\therefore \quad Stress = Y \times Strain = Y \times (l/L) = 2\times10^{11}\times\left(\frac{3\times10^{-3}}{3}\right)$$

$$\therefore \quad Stress = 2\times10^{8}\ N/m^2$$

Now, $$Stress = \frac{Force}{Area}$$

$$\therefore \quad Area = \frac{Force}{Stress} = \frac{2}{2\times10^{8}}$$

$$\therefore \quad Area = 1\times10^{-8}\ m^2$$

Q2. A weight exerts force of 100 N on a steel wire of cross-sectional area 0.02 cm². Find extension produced if the length of wire is 5 m. ($Y=2\times10^{11}N/m^2$)

Sol. Given : F = 100 N

$A = 0.02\ cm^2 = 0.02\times10^{-4} m^2$

l = ?

L = 5 m

$Y = 2\times10^{11} N/m^2$

We have, $$Y = \frac{F/A}{l/L}$$

$$Y = \frac{FL}{Al}$$

$$\therefore \quad l = \frac{FL}{YA} = \frac{100\times5}{2\times10^{11}\times0.02\times10^{-4}}$$

$$l = 1.25\times10^{-3}\ m$$

Q3. A wire of diameter 3 mm and length 4 m extends by 2.5 mm when a force of 10 N is applied. Find the Young's modulus of material of wire.

Sol. Given : dia = 3 mm

$\therefore$ $r = 1.5\text{ mm} = 1.5\times10^{-3}m$

L = 4 m

$l = 2.5\text{ mm} = 2.5\times10^{-3}m$

F = 10 N

Y = ?

We have $$Y = \frac{F/A}{l/L} = \frac{FL}{(A)l} = \frac{FL}{(\pi r^2)l}$$

$$= \frac{(10)(4)}{(3.142)(1.5\times10^{-3})^2(2.5\times10^{-3})}$$

$$Y = 2.26\times10^{9}\ N/m^2$$

Q4. A wire of length 1 m extends by 1 mm when stretched by a load of 1 kg. Find the area of cross section of the wire. (Given $Y=2\times10^{11}N/m^2$ and $g = 9.81\ m/s^2$)

Sol. L = 1 m, $l = 1\text{ mm} = 1\times10^{-3}m$, M = 1 kg, A = ?

$$Y = \frac{Mgl}{Al}$$

$$\therefore \quad Y = \frac{Mgl}{Yl} = \frac{(1)\times(9.8)\times(1)}{((2\times10^{11})\times(1\times10^{3}))}$$

$$A = 4.9\times10^{-8}\,m^2$$

Q5. A copper wire is stretched by 5% of its length. Determine the stress produced in the wire. Given Y for copper $=1.2\times10^{11}N/m^2$.

Sol. Given : Since wire is stretched 5%, take $l = 5$ and L = 100, Stress = ?

$$Y = \frac{Stress}{Strain}$$

$$Stress = Y\times Strain = Y\times\left(\frac{l}{L}\right) = 1.2\times10^{11}\times\left(\frac{5}{100}\right)$$

$$Stress = 6\times10^{9}\ N/m^2$$

Q6. Find the maximum weight that can be attached to a copper wire of area of cross-section 2.4 mm² if breaking stress for copper is $5\times10^8 N/m^2$.

Sol. Given, $A = 2.4\ mm^2 = 2.4\times10^{-6}\ m^2$

Breaking stress $= 5\times10^8\ N/m^2$

We know that,

$$Stress = \frac{F}{A}$$

F = Stress × A

$= 5\times10^8\times2.4\times10^{-6}$

Hence, F = 1200 N

The maximum weight that can be attached to the wire is 1200 N.

Q7. A force of 14 N is applied to a metal wire of diameter 3.6 m. Determine the stress in the wire?

Sol. Given, Force, F = 14 N, Diameter, d = 3.6 m

$$\text{Area, } A = \frac{\pi d^2}{4} = \frac{\pi(3.6)^2}{4} = 10.179\ m^2$$

We know that,

$$Stress,\ \sigma = \frac{F}{A}$$

Hence, $\sigma = \frac{14}{10.179} = 1.375\ N/m^2$ or Pascals

Q8. *A stepped bar is subjected to an axially compressive load of 35 kN. Find maximum and minimum stressses produced.*

Sol. Given, F = 35 kN

Area of the upper bar,

$$A_1 = \frac{\pi}{4}(2)^2 = 3.1415\ cm^2$$

Area of the lower bar,

$$A_2 = \frac{\pi}{4}(3)^2 = 7.0685\ cm^2$$

Now, $\sigma_{max} = \frac{F}{A_1} = \frac{35}{3.1415} = 11.1411\ kN/cm^2$

and $\sigma_{min} = \frac{F}{A_2} = \frac{35}{7.0685} = 4.9515\ kN/cm^2$

Q9. *Find the minimum diameter of a steel wire, which is used to raise a load of 4000 N if the stress in wire is not to exceed 95 N/mm².*

Sol. Load, F = 4000 N

Stress, $\sigma = 95\ N/mm^2$

We know that,

$$Stress,\ \sigma = \frac{F}{A}$$

Hence, $A = \frac{F}{\sigma} = \frac{4000}{95} = 42.10\ mm^2$

$$A = \frac{\pi}{4}d^2$$

Thus, $42.10 = \frac{\pi}{4} \times d^2$

or $d^2 = \frac{42.10 \times 4}{\pi} = 53.60$

Hence, d = 7.32 mm

Q10. *A cylindrical bar of length 0.2 m deforms to 2 mm. What will be the strain developed in the bar?*

Sol. Given,

Change in length,

$$\Delta l = 4\%\ of\ l = \frac{4}{100}l$$

We know that,

$$\text{Tensile strain} = \frac{\Delta l}{l}$$

Hence, Tensile strain $= \frac{\frac{4l}{100}}{l} = \frac{4}{100} = 0.04$

Q11. *Calculate the magnitude of volume strain if volume changes by 2% of original volume.*

Sol. Given,

Change in volume,

$$(\Delta V) = 2\%\ of\ V = \frac{2}{100}V$$

We know that,

$$\text{Volume strain} = \frac{\Delta V}{V}$$

Hence, Volume strain $= \frac{\frac{2}{100}V}{V} = 0.02$

Q12. *For a cube each of side 8 cm, the upper face is displaced by 1.2 cm due to a force of 1 N. Calculate shearing stress and shearing strain.*

Sol. Given,

F = 1 N, l = 8 cm = 8 × 10^{-2} m

A = h² = 64 × 10^{-4} m²,

$\Delta l = 1.2\ cm = 12 \times 10^{-3}\ cm$

1. Shearing stress $= \frac{F}{A} = \frac{1}{64 \times 10^{-4}} = 156.25\ N/m$
2. Shearing strain $= \frac{\Delta l}{l} = \frac{12 \times 10^{-3}}{8 \times 10^{-2}} = 0.15$

Q13. *A prismatic bar has cross section 12.5 cm² and a length 2 m. The measured elongation of the bar 0.15 cm under an axial load 90 kN. Compute the tensile stress and strain in the bar.*

Sol. Given,

A = 12.5 cm²

l = 2 × 100 cm

F = 90 kN

Δl = 0.15 cm

Tensile stress, $\sigma = \frac{F}{A} = \frac{90 \times 1000}{12.5} = 7200\ N/cm^2$

Tensile strain, $\varepsilon = \frac{\Delta l}{l} = \frac{0.15}{2 \times 100} = 7.5 \times 10^{-4}$

Q14. *A copper wire of length 5 m and cross section 5 × 10⁻⁵ m² stretches by the same amount as a steel wire of length 6 m and cross-section 4 × 10⁻⁵ m² under given load. Find the ratio of Young's modulus of copper to steel.*

Sol. For copper, l_1 = 5 m, A_1 = 5 × 10^{-5} m²

For steel, l_2 = 6 m, A_2 = 4 × 10^{-5} m²

Let load be Mg and extension produced be l.

Then, Young's modulus for copper,

$$Y_{Cu} = \frac{Mgl_1}{A_1\Delta l}$$

Young's modulus for steel,

$$Y_{St} = \frac{Mgl_2}{A_2\Delta l}$$

Taking ratios, $\frac{Y_{Cu}}{Y_{St}} = \frac{Mgl_1/A_1\Delta l}{Mgl_2/A_2\Delta l}$

$$= \frac{l_1A_2}{l_2A_1} = \frac{5 \times 4 \times 10^{-5}}{6 \times 5 \times 10^{-5}}$$

$$= \frac{4}{6} = \frac{2}{3} = 0.667$$

Q15. *When a load of 5 kg is attached to the free end of a suspended wire of length 4 m and diameter 2 mm, the elongation produced is 0.5 mm. Calculate the longitudinal stress, longitudinal strain and Young's modulus of the material of wire.*

Sol. Given, M = 5 kg, l = 4 m, D = 2 mm

r = 1 mm = 1 × 10^{-3} m

$\Delta l = 0.5\ mm = 0.5 \times 10^{-3}\ m$

1. Longitudinal stress

$$= \frac{F}{A} = \frac{Mg}{\pi r^2} = \frac{5 \times 9.8}{3.14 \times (10^{-3})^2}$$

= 1.56 × 10^7 N/m²

2. Longitudinal strain $= \frac{\Delta l}{l}$

$$= \frac{0.5 \times 10^{-3}}{4} = 1.25 \times 10^{-4}$$

3. Young's modulus,

$$Y = \frac{\text{longitudinal stress}}{\text{longitudinal strain}}$$

$$= \frac{1.56 \times 10^7}{1.25 \times 10^{-4}} = 1.248 \times 10^{11}\ N/m^2$$

Q16. *An aluminium wire 3 mm in diameter and 4 m long is used to support a mass of 50 kg. What is the elongation of the wire? Young's modulus of aluminium is 7 × 10¹⁰ N/m².*

Sol. Given, D = 3 mm

r = 1.5 mm = 1.5 × 10^{-3} m

M = 50 kg, Y = 7 × 10^{10} N/m²

l = 4 m

We know that,

$$Y = \frac{Mgl}{(\pi r^2)\Delta l}$$

Hence, $\Delta l = \frac{Mgl}{\pi r^2 Y}$

$$= \frac{50 \times 9.8 \times 4}{3.142 \times (1.5 \times 10^{-3})^2 \times 7 \times 10^{10}}$$

= 3.96 × 10^{-3} m = 3.96 mm

Q17. *If the shear modulus and bulk modulus of a material are 0.42 × 10¹¹ N/m² and 0.21 × 10¹¹ N/m² respectively, find Young's modulus of that material.*

Sol. Given, $\eta = 0.42 \times 10^{11}\ N/m^2$

K = 0.21 × 10^{11} N/m²

We know that,

Young's modulus, $Y = \frac{9K\eta}{3K + \eta}$

Hence, $Y = \frac{9 \times 0.21 \times 10^{11} \times 0.42 \times 10^{11}}{3 \times 0.21 \times 10^{11} + 0.42 \times 10^{11}}$

$$= \frac{0.7938 \times 10^{22}}{1.05 \times 10^{11}} = 0.756 \times 10^{11} = 7.56 \times 10^{10}\ N/m^2$$

5.2 Surface Tension

Multiple Choice Question

1. The surface tension does not depend upon
(a) nature of the liquid (b) temperature
(c) Presence of impurities (d) atmospheric pressure
Ans.(d)

2. Cause of origin of surface tension is
(a) Cohasive force (b) Adhesive force
(c) Frictional force (d) None of these
Ans:(a)

3. A liquid does not wet a solid surface if the angle of contact for the given pair of liquid and solid surfaces is
(a) 0° (b) 90° (c) 60° (d) 120°
Ans.(d)

4. The drying of hands by a towel is due to
(a) Surface tension (b) Capillarity
(c) Viscosity (d) Evaporation
Ans.(b)

5. Soap helps in better cleaning of cloths because
(a) it reduces the surface tension of solution
(b) it gives strength to the solution
(c) it absorbs the dirt
(d) chemicals of soap change
Ans.(a)

6. When some detergent is added to water, its surface tension
(a) Increases (b) Decreases
(c) Remains unchanged (d) Ist decreases, then increases
Ans.(b)

7. On increasing temperature of a liquid generally it's surface tension
(a) decreases (b) increases
(c) remains same (d) increases than decreases
Ans. (a)

8. If the diameter of the capillary tube is doubled the rise of water in it becomes
(a) Doubled (b) Halved
(c) four times (d) Remain same

9. The surface tension is pure water as compared to that of soap solution is
(a) less (b) more
(c) same (d) depends upon the nature of soap
Ans.(a)

10. Tiny insects can float and walk on the surface of water due to
(a) Upthrust force (b) surface tension alone
(c) Both upthrust & surface tension
(d) Neither upthrust nor surface tension
Ans.(b)

11. As iron needle slowly placed on the surface of water floats

on it because
(a) when inside the water it will displace water more than its weight
(b) the density of the material of needle is less than that of water
(c) its surface tension
(d) of its shape

Ans.(c)

12. Soap helps in better cleaning of clothes because
(a) it reduces the surface tension of solution
(b) it gives strength to solution
(c) it absorbs the dirt
(d) chemical of soaps change

Ans.(a)

13. Which of the following examples can be explained as a result of surface tension?
(a) a child sips milk through a straw
(b) spilled mercury forms into small drops
(c) table salt is in the forms of cubic crystal
(d) the smell of trying fish coming out of the house

Ans.(b)

14. A liquid does not wet the surface of a solid if the angle of contact is
(a) zero (b) an acute one
(c) 45° (d) an obtuse one

Ans.(d)

15. With a rise in temperature, the surface tension of a liquid
(a) increases (b) decreases
(c) does not change (d) changes erratically

Ans.(b)

16. Tip of the nib of a pen is split. It is because
(a) the ink may come in contact with the air of atmosphere
(b) the ink may rise by capillary action
(c) neither a nor b
(d) of gravitational pull

Ans.(b)

17. Which one of the following represents correctly the variations of surface tension σ with temperature θ ?
(a) $\sigma \propto \theta$ (b) $\sigma \propto \theta^{-1}$ (c) $\sigma \propto \theta^{0}$ (d) $\sigma \propto \theta^{-2}$

Ans.(b)

18. Meniscus of mercury in capillary is
(a) concave (b) convex (c) plane (d) cylindrical

Ans.(b)

19. We find that water sticks to a glass rod, it is because
(a) the force of cohesion is > force of adhesion
(b) the force of adhesion is > force of cohesion
(c) force of adhesion = force of cohesion
(d) None of the above

Ans.(b)

20. Hair of shaving brush cling together when it is removed from water, due to
(a) surface tension (b) viscosity
(c) friction (d) elasticity

Ans.(a)

21. Addition of detergent to water
(a) increases the surface tension
(b) decreases the surface tension
(c) does not alter the surface tension
(d) increases the angle of contact

Ans.(b)

22. What is the shape of meniscus when a non-wetting liqui is placed in a capillary tube?
(a) concave upward (b) convex upward
(c) concave downward (d) convex downward

Ans.(b)

23. A liquid does not wet a solid surface if the angle of conta may be
(a) zero (b) 60° (c) 135° (d) 30°

Ans.(c)

24. Angle of contact depends on
(a) a force between the liquid and solid surface
(b) surface tension
(c) viscosity (d) None of the above

Ans.(a)

25. A liquid wets a solid surface, the angle of contact may b
(a) 180° (b) 120° (c) 120° (d) 30°

Ans.(d)

26. The angle of contact for glass-mercury interface is
(a) less than 90° (b) 90°
(c) greater than 90° (d) zero

Ans.(c)

27. A liquid, which wets a solid surface, the angle of conta θ is given by
(a) $\theta = 135^\circ$ (b) $0 < \theta < 90^\circ$
(c) $90^\circ < \theta < 180^\circ$ (d) $180^\circ < \theta < 360^\circ$

Ans.(b)

28. A liquid, which does not wet a solid surface, the angle contact θ is given by
(a) $0 < \theta < 90^\circ$ (b) $90^\circ < \theta < 180^\circ$
(c) $180^\circ < \theta < 360^\circ$ (d) $\theta = 60^\circ$

Ans.(b)

29. For tap water and clean glass, the angle of contact is
(a) 0° (b) 90° (c) 140° (d) 8°

Ans.(d)

Answer the following questions

Q1. Define the following terms:(i)Molecular force (ii)Adhesi force(iii)Cohesive force.(iv)Molecular range (v)Sphere influence.

Ans.(i)Molecular force: Every molecule attracts anoth molecules. This force of attraction is called molecular forc

(ii)Adhesive force : The molecular force of attraction betwe molecules of the different substances is called adhesive forc

Example : If we dip a pencil in water, it becomes wet becau the molecules of water are attracted by pencil molecules.

(iii)Cohesive force : The molecular force of attraction between molecules of same substance is called cohesive force.

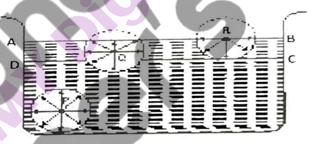
Example :- If we dip a glass rod in mercury and take it out, mercury does not stick to the glass rod because the cohesive force of mercury is very large as compared to other.

(iv)Molecular Range: The maximum distance upto which cohesive force can act is called as molecular range.

(v)Sphere of influence: The imaginary sphere ,surrounding a molecules in which force of attraction is present is called the sphere of influence of that molecules.

Q2. Explain Laplace's molecular theory.

Ans. The theory is based on cohesive force between molecules of liquid.Consider three molecules of liquid A,B and C of water in a beaker.The sphere influences are shown in figure below



Consider a molecule : A whose sphere of influence lies totally inside the water. The neighbouring molecules of water exert cohesive forces on it in all directions. so the resultant force acting on molecule - A is zero. [F = 0]

Now consider the molecule - B_2 whose small part of sphere of influence lies outside the water. The cohesive forces acting on molecule -B are shown in figure. The forces having upward direction are small in magnitude. So the resultant force acting on it, is in downward direction and having small magnitude.

Similarly consider the molecule - C, on surface of water whose half sphere of influence lies outside the water. The forces acting on molecule -C in half sphere of water and absense of forces [negligible adhesive force] in half sphere of air, so there exist maximum downward force (F max) on molecule - C From above explanation, it is seen that if the molecule lies fully in water, then resultant force on it,is zero. But if we consider the molecules from bottom to top of water, the resultant force acting on molecules of surface goes on increasing and it is maximum on point on surface of water. In this way, the surface area pulls - down due to downward force acting on each molecule of surface. This tendency to minimise the area gives rise the phenomenon of Surface Tension (T))

Q3. Define surface tension and write its S.I. unit. What is the effect of impurity and temperature on surface tension ?

Ans.Surface tension is a property of a liquid surface tends to occupy a minimum surface area behaves like a stretched membrance.

Surface tension as the force acting per unit length of the line drawn on the surface of the liquid the direction being at right angles to this line and tangential to the surface of the liquid.

i.e. surface tension

$$= \frac{\text{Total force on eitherside of the imaginary line}}{\text{length of the line}}$$

or, $$T = \frac{F}{l}$$

S.I unit of surface tension is N/m or Nm^{-1}

Dimensional formula of surface tension $T = [ML^0T^{-2}]$.

Effect of impurity and temperature on surface tension are :

(i) The surface tension of a liquid decreases with the rise in temperature and vice-versa.

Ex- hot soup tastes better than the cold soup. While machinery parts get jammed in winter.

(ii) The surface tension of a liquid changes appreciably with addition of impurities.

Ex- Surface tension of water increases with addition of highly soluble substances like NaCl, Zn, SO_4 etc. while surface tension of water gets reduced with the addition of freely soluble substances like phenol, soap etc

Q4.Define angle of contact ? Explain the significant of Angle of contact.

Ans.Angle of contact: The angle made by the tangent to the curved part of liquid surface at the point of contact with wall of a container measured through the liquid is called angle of contact θ.Its unit is radian.

Significance of Angle of contact :

(i) In case of water in the glass container, θ is acute because force of adhesion is stronger than cohesion i.e. water can stick to glass and therefore liquid creeps up at the wall of a container.

If θ is acute i.e. ($\theta < 90^\circ$), then
(a) The liquid wets the solid surface in contact.
(b) Meniscus of liquid is concave.
(c) Liquid rise in capillary.
(d) Cohesive forces are smaller than adhesive forces.

For example : West and glass.

(ii) In case of mercury in glass container, θ is obtuse because force of cohesion is stronger i.e. mercury does not stick to glass container and therefore liquid de presses down at the wall of a container.

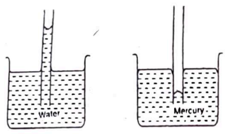
If θ is obtuse i.e. ($\theta > 90^\circ$), then
(a) The liquid does not wet the solid surface in contact.
(b) Meniscus of liquid in convex.
(c) Liquid get depressed in capillary.

(d) Cohesive forces are greater than adhesive forces.

For example : Mercury and glass.

Q5.Explain capillary action with examples. What is the shape of meniscus for water and mercury in a capillary tube ? Also write a relation between surface tension, capillary rise and radius of capillary tube.

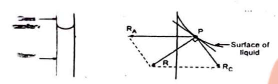
Ans.Capillarity or capillary Action with Example :-Consider a capillary tube (i.e. a glass tube with narrow bore) dipped in a liquid. It is observed that the liquid rises in the capillary above the general level of liquid in the breaker if the angle of contact is acute e.g. water rises up inside the capillary; and it is depressed down the general level of liquid if the angle of contact is obtuse e.g. mercury depresses down inside the capillary. **This rise or fall of liquid inside the capillary is called as capillarity.** [Refer Fig. below] e.g. Rise of oil wick end of oil lamp, i.e. the rise of oil in oil lamp upto the tip of wick is due to capillary action.



Shape of Meniscus for water : It is observed that shape of liquid surface in a capillarytube may be plane or concave or convex dependingupon the nature of liquid and container.

(i) Shape of water surface in a glass capillary tube is concave as shown in Fig. 1.2 (a).

R_A = Resultant adhesive force
R_C = Resultant cohesive force
R = Resultant of R_A and R_C.



(a) Shape of water surface in glass capillary is concave (b) Diagram explaining why water surface is concave in glass capillary

Explanation : P' is a water molecule near the glass wall.Molecule 'P' experiences two forces at a time.

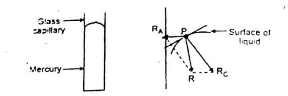
(a)Force of adhesion i.e. force of attraction between water molecule 'P' and glass molecule.

(b)Force of cohesion i.e. force of attraction between water molecule 'P' and other water molecules near to it.

In order to balance this resultant force, the surface of liquid should be perpendicular to 'R'. Hence, the surface of water gets concave shape as shown.

(ii) Shape of mercury in a glass capillary tube is convex as shown in Fig. (a).

R_A = Resultant adhesive force
R_C = Resultant cohesive force
R = Resultant of R_A and R_C.



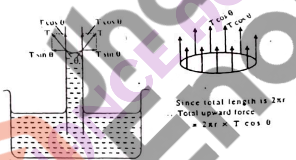
(a) Shape of mercury surface in glass capillary is convex (b) Diagram explaining why mercury surface is convex in glass capillary

Explanation : 'P' is a mercury molecule near the glass wall. Molecule 'P' experience two forces at a time.

(1) Force of adhesion i.e. force of attraction between mercury molecule 'P' and glass molecules.

(2) Force of cohesion i.e. force of attraction between mercury molecule 'P' and other mercury molecules near to it. In case mercury in glass container, force $R_C > R_A$ (mercury does not stick to glass). R is the resultant of R_A and R_C as shown in Fig. (b) In order to balance this resultant force, the surface of liquid should be perpendicular to 'R'. Hence, the surface mercury gets convex shape as shown in Fig. (b).

Relation between Surface Tension (T), Capillary Rise (b) and Radius of capillary (r) :



Where T = Force of surface tension
$T\cos\theta$ = Vertical component of T
$T\sin\theta$ = Horizontal component of T

$$T = \frac{rhdg}{2\cos\theta}$$

Where , r - radius of capillary tube
h - level difference or rise of liquid
d - density of liquid
g - gravitational acceleration
θ - angle of contact

Q6. How does chalk obsorb water or ink ? Explain.

Ans. The fine bores or holes in a chalk form capilaries and when the chalk is brough near the water or ink, chalk is able to absorb water or ink.

When chalk dip into ink or water we find that some of the liquid absorbed by the chalk. This phenomenon if absorbing such types of water or ink due to surface tension of the liquid.

Solved Example

Q1.A glass tube of diameter 1mm is introduced in water. If surface tension of water is 0.07 N/m, density of water 1000 kg/m³. Calculate the rise in level of water.

Sol. We know that,

$$T = \frac{rhdg}{2\cos\theta}$$

$$\therefore h = \frac{2T\cos\theta}{rdg}$$

Here, g = 9.8 m/s² and for water, $\theta = 0^0$.

$$\therefore h = \frac{2\times0.07\cos\theta}{0.5\times10^{-3}\times10^3\times9.8} = \frac{0.14}{4.9} \quad (\because \cos 0 = 1)$$

$= 0.0285$ m

$\therefore$ Rise in water level = 0.0285 m.

Q2.Water rises to a height of 2.5 cm in capillary tube of diameter 1 mm. Find surface tension if d = 1000 kg/m³.

Sol. We know that,

$$T = \frac{rhdg}{2\cos\theta}$$

Here, g = 9.8 m/s² & for water. $\theta = 0^0$

$$\therefore T = \frac{0.5\times10^{-3}\times2.5\times10^{-2}\times10^{-3}\times9.8}{2\cos\theta}$$

$$= \frac{12.25\times10^{-2}}{2} \quad (\because \cos 0 = 1)$$

$= 6.125\times10^{-2}$
$= 0.061$ N/m.

$\therefore$ Surface Tension = 0.061 N/m.

Q3.A capillary tube of radius 0.06 cm is dipped in pure water. How far will it rise in tube ? Surface tension of water is 7 × 10⁻²N/m.

Sol. We know that

$$T = \frac{rhdg}{2\cos\theta}$$

$$\therefore h = \frac{2T\cos\theta}{rhg}$$

Here, g = 9.8 m/s² and

For water, density, d = 1000 kg/m³, Angle of contact, $\theta = 0^0$

$$\therefore h = \frac{2\times7\times10^{-2}}{0.06\times10^{-2}\times10^3\times9.8} (\because \cos 0 = 1)$$

$$= \frac{14\times10^{-2}}{0.588\times10}$$

$= 23.80\times10^{-3}\ m = 0.0238\ m$

$\therefore$ Rise in water level = 0.0238 m.

Q4.A liquid rise through a height of 4 cm in a capillary tube of radius 0.4 mm. How far will it rise in a capillary tube of radius 0.8 mm.

Sol. Both tubes are immersed in the same liquid

$$\therefore T = \frac{r_1 h_1 dg}{2\cos\theta}$$

Also, $$\therefore T = \frac{r_1 h_2 dg}{2\cos\theta}$$

Equating both the equations

$$\frac{r_1 h_1 dg}{2\cos\theta} = \frac{r_2 h_2 dg}{2\cos\theta}$$

$$\therefore r_1 h_1 = r_2 h_2$$

$$h_2 = \frac{r_1 h_1}{r_2}$$

$$= \frac{0.4\times10^{-3}\times4\times10^{-2}}{0.8\times10^{-3}} = 2\times10^{-2}\ m = 0.02\ m = 2\ cm$$

$\therefore$ Rise of liquid in 2nd tube = 2 cm

Q5. A capillary tube of radius 0.5 mm is dipped in water. How far will the water rise in the tube if surface tension of water is 7.2 × 10⁻²N/m ? Density of water = 1 × 10³Kg/m³.

Sol. We know that,

$$T = \frac{rhdg}{2\cos\theta} \quad \therefore h = \frac{2T\cos\theta}{rdg}$$

But for water, $\theta = 0^\circ$ & $g = 9.8\ m/s^2$

$$h = \frac{2\times7\times10^{-2}}{0.5\times10^{-3}\times10^3\times9.8} = 0.0285\ m\ (\because \cos 0 = 1)$$

Rise of water in tube = 0.0285 m

Q6.In a capillary tube of diamerter 0.1 cm the level of mercury is depressed by 1.25 cm. Find the surface tension of mercury [Given - density of mercury = 1.36 × 10³Kg/m³ and angle of contact = 128° 42'].

Sol. We know that,

$$T = \frac{rhdg}{2\cos\theta}$$

$$= \frac{0.05\times10^{-2}\times-1.25\times10^{-2}\times13.6\times10^3\times9.8}{2\cos 128^0 42'}$$

$= 6.65\times10^{-1}$ N/m $= 0.665$ N/m.

$\therefore$ Surface Tension = 0.665 N/m.

Q7.Two tubes are immerssed in a liquid when the rise of liquid is 2.8 cm in one tube of diameter of 0.12 cm. If the diameter

of other is 0.4 mm, calculate the rise in it. Assume liquid is same.

Sol. As both the tubes are immersed in same liquid.

$$T = \frac{r_1 h_1 dg}{2\cos\theta}$$

Also, $T = \dfrac{r_2 h_2 dg}{2\cos\theta}$

Thus, equating both equations,

$$\frac{r_1 h_1 dg}{2\cos\theta} = \frac{r_2 h_2 dg}{2\cos\theta}$$

$$r_1 h_1 = r_2 h_2 \qquad \therefore h_2 = \frac{r_1 h_1}{r_2}$$

$$= \frac{0.06\times10^{-2}\times2.8\times10^{-2}}{0.2 10^{-3}} = 0.84\times10^{-1}\ m$$

$=0.084m=8.4cm$

$\therefore$ Rise in 2nd tube = 8.4 cm.

Q8. Two Capillary tube diameter 2.4 mm and 1.6 mm are dipped in liquid. If liquid rises to 6.4 cm in a narrower tube. Calculate the rise in other.

Sol. We know that,

$$h_1 r_1 = h_2 r_2$$

$$h_1 \times 1.2\times10^{-3} = 6.4\times10^{-2}\times0.8\times10^{-3}$$

$$h_1 = \frac{6.4\times0.8\times10^{-5}}{1.2\times10^{-3}} = \frac{5.12\times10^{-2}\,m}{1.2}$$

$h_1 = 4.26\ cm$

$\therefore$ The rise in other [wide] tube = 4.26 cm

Q9. A liquid density 1.1×10^{3} kg/m³ and surface tension 31.5×10^{-3} N/m rises to a height of 0.15 cm in a tube of diameter 0.82 mm. Find the angle of contact of the liquid.

Sol. We know,

$$T = \frac{r h dg}{2\cos\theta}$$

$$\therefore \cos\theta = \frac{r h dg}{2T}$$

$$= \frac{(0.41\times10^{-3})\times(0.15\times10^{-2})(1.1\times10^{3})\times9.8}{2\times31.5\times10^{-3}}$$

$$= \frac{0.41\times0.15\times1.1\times9.8\times10^{1}}{63}$$

$$\cos\theta = \frac{0.663\times10}{63} = \frac{6.63}{63} = 0.1052$$

$\therefore \theta = \cos^{-1}[0.1052]$

$\therefore \theta = 83.96^{0}$

$\therefore$ Angle of contact = 83.96^{0}

Q10. A capillary tube of diameter 1mm is dipped in water. How far will water rise in the tube if surface tension of water is 7×10^{-2} N/m ?

Sol. Given : d = 1mm = 0.001 m = 0.0005 = 5×10^{-4}

$T = 7\times10^{-2}$ N/m;

$\rho = 1000\ kg/m^3$; Take $\theta = 0^0$

$$h = \frac{2T\cos\theta}{r\rho g} = \frac{2\times7\times10^{-2}\times1}{5\times10^{-4}\times1000\times9.8} \cong 2.86\ cm$$

Q11. What rises in a capillary tube upto a height of 6cm. What will be the rise of water column of radius of the tube is doubled.

Sol. There are two cases,

Case 1 : When the h = 0.6 m

$$\text{Now, } T = \frac{\left(h+\frac{r}{3}\right)\times d\times g\times r}{2\cos\theta} \quad \text{...(i)}$$

where, r = radius of capillary;
h = height of water column
T = surface tension of water

Contact angle of water $=\theta = 0^0 \Rightarrow g = 9.8\,m/s^2$

Case 2 : When radius is doubled, then new height of water is h'

$$T = \frac{\left(h+\frac{2r}{3}\right)\times d\times g\times 2r}{2\cos\theta}$$

...(ii)

Dividing (ii) by (i)

$$\frac{T}{T} = \frac{\left(h+\frac{2r}{3}\right)\times d\times g\times 2r/2\cos\theta}{\left(h+\frac{r}{3}\right)\times d\times g\times r/2\cos\theta}$$

$$\Rightarrow h+\frac{r}{3} = h'+\frac{2r}{3} \quad h' = h+\frac{r}{3}-\frac{2r}{3}$$

$$= 0.6-\frac{r}{3} \Rightarrow h = 0.6-\frac{r}{3}$$

The rise of water column i.e.,

$$h' = 0.6-\frac{r}{3}$$

5.3 Viscosity

Multiple Choice Question

1. Viscosity is exhibited by
(a) solids, liquids and gases (b) only solids & liquids
(c) only liquids & gases (d) only gases & solids
Ans.(b)

2. The maximum velocity at which nature of flow of liquid remains streamline is called
(a) Terminal velocity (b) critical velocity
(c) Renyolds number (d) None of these
Ans.(b)

3. When increasing the temperature the coefficient of viscosity of liquid is
(a) Increasing (b) Decreasing
(c) Remains same (d) None of these
Ans.(b)

4. According to Newtons the viscous force F is
(a) $\dfrac{na}{dvdx}$ (b) $\dfrac{n}{a}dv\,dx$
(c) na dv/dx (d) - na dv/dx
Ans.

5. The flow of liquid in which particle of the liquid at any point varies continuously with time in magnitude and direction is called.
(a) Streamline flow (b) Turbulent flow
(c) both (a) and (b) (d) None
Ans.

6. The flow of liquid is laminar or stream lined is determined by
(a) rate of flow of liquid (b) density of liquid
(c) radius of tube (d) co-efficient of viscosity of liquid
Ans.(a)

7. For a liquid of density ρ and co-efficient of viscosity η, flowing through a pipe of diameter d, Reynold's number is given by
(a) $\dfrac{\rho V_c d}{\eta}$ (b) $\dfrac{\rho\eta d}{V_c}$
(c) $\dfrac{\rho V_c \eta}{d}$ (d) $\dfrac{\rho V_c d}{\rho}$
Ans.(a)

8. If the temperature remains constant, the pressure of the gas will
(a) Increase with the increase in volume
(b) Decrease with the increase in volume
(c) Not change with volume
(d) None of these
Ans.

9. The viscous force between two liquid layers is
(a) radial
(b) normal to the liquid surface
(c) tangential to the liquid surface
(d) neither purgly tangential nor purely normal
Ans.(c)

10. The spherical shape of rain drops is due to
(a) density of water (b) atmospheric pressure
(c) gravity (d) surface tension
Ans.(d)

11. On increasing temperature, the co-efficient of viscosity of a liquid
(a) increase (b) decreases
(c) first increases then decreases (d) remains constant
Ans.(b)

12. The critical velocity Vc of a fluid is related to its density ρ, co-efficient of viscosity λ and radius r of the tube by
(a) $Vc = \dfrac{kr}{\lambda\rho}$ (b) $Vc = \dfrac{k\rho}{\lambda r}$
(c) $Vc = \dfrac{k\lambda}{\rho r}$ (d) $Vc = \dfrac{nr}{k\rho}$
Ans.(c)

13. Streamline flow is more likely for liquids with
(a) high density and low viscosity
(b) low density and high viscosity
(c) high density and high viscosity
(d) low density and low viscosity
Ans. (b)

14. With the rise in temperature, the coefficient of viscosity of a gas
(a) increases (b) decreases
(c) does not change
(d) may increase or decrease depending upon the range of temperature
Ans.(a)

15. The viscous force between two liquid layers is
(a) radial (b) normal to the liquid surface
(c) tangential to the liquid surface
(d) neither purely tangential nor purely normal
Ans.(c)

16. With rise of temperature, the viscosity of liquid
(a) increases (b) decreases
(c) remain unchanged
(d) may decrease or increase depending on nature of liquid
Ans.(b)

17. Which of the following substance has greatest viscosity
(a) mercury (b) water (c) oxygen (d) glycerine
Ans.(d)

18. The velocity of a falling rain drop attains limited value because of
(a) upthrust force of air (b) viscous force exerted by air
(c) surface tension effect (d) air current in atmosphere
Ans.(b)

19. **Reynold's number is low for**
   (a) low velocity (b) low density
   (c) high viscosity (d) All of these

Ans.(c)

20. **In Millikan's oil drop experiment a small spherical oil drop of radius r is moving in a medium of density ρ with an instantaneous speed υ. The viscous force F is**
   (a) $6\pi\eta / r\upsilon$ (b) $\eta r\upsilon$
   (c) $6\eta / r\upsilon$ (d) $6\eta n\upsilon / n$

Ans.(a)

21. **The Reynold's number for fluid flow in a pipe depends on**
   (a) viscosity of the fluid (b) velocity of the fluid
   (c) diameter of the pipe (d) All of these

Ans.(d)

22. **Which of the following substances has the greatest viscosity?**
   (a) air (b) hydrogen (c) water (d) mercury

Ans.(d)

23. **According to newton's law of viscosity, coefficient of viscosity of the liquid is**
   (a) $\eta = \dfrac{F}{A\left(\dfrac{dV}{dx}\right)}$ (b) $\eta = FA\left(\dfrac{dV}{dx}\right)$
   (c) $\eta = \dfrac{F}{\left(\dfrac{d\upsilon}{dx}\right)}$ (d) $\eta = F.A$

Sol. (a)

Answer the following questions

Q1. What is viscosity ? Define co-efficient of viscosity and write its S.I. unit.

Ans. Viscosity : A measure of the resistance to flow that a fluid offers when it is subjected to shear stress.

Viscosity is the property of liquid on account of which liquid tries to oppose the relative motion between its different layers. For a newtonian fluid the force F, needed to maintain a velocity gradient $\frac{dv}{dx}$, between adjacent planes of a fluid of area A is given by

$$F = \eta A \frac{dv}{dx} \qquad \text{.............. (i)}$$

where, η = co-efficient of viscosity.

Coefficient of viscosity :

If A = 1 and $\frac{dv}{dx} = 1$ Then from equation (i)

$\eta = F$

Thus, coefficient of viscosity of a liquid is defined as the viscous force or drag acting per unit area of the layer having unit velocity gradient perpendicular to the direction of the flow liquid. S.I. unit of (η) is Ns/m^2 or poise in CGs unit.

Q2. What do you mean by Reynold's number ? write its significant.

Ans. Reynold's Number (R_e) : A dimensionless number used in fluid dynamics to determine the type of flow of a fluid through a pipe, to design prototypes from small scale models, etc. It is the ratio

$$\frac{v\rho l}{\eta}$$

Where v = is the flow velocity.
ρ = is the fluid density.
l = is a characteristic linear dimension such as the diameter of a pipe.
η = is the fluid viscosity.

In a pipe, laminar flow usually occurs if $(R_e) < 2000$ and turbulent flow is established if $(R_e) > 3000$.

Significance of Reynold's number

(i) When R <2000, the flow of liquid is streamline.
(ii) When R >3000, the flow of liquid is turbulent.
(iii) When R = 2000-3000, the flow of liquid is unstable.

Q3. State and explain velocity gradient.

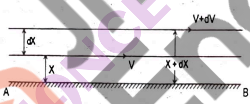
Ans. (i) The liquid column consists of different horizontal layers. The velocity of layers goes on increasing as the distance of the layer from the solid surface is increased.

(ii) Let V and (V+dV) are the velocities of the layers at distance X and (X+dX) from the solid surface AB.

(iii) The velocity changes by dV over a distance dX. This ratio of dV/dX is called Velocity Gradient.

(iv) Thus, Velocity Gradient is defined as the ratio of change in velocity to the corresponding change of dis tance.

(v) It's unit is 1/S or S^{-1}.



Q4. State and explain Newton's law of viscosity.

Ans. Newton's law of viscosity : Newton's law of viscosity states that for a streamline flow of a liquid, the viscous force F acting on a layer of liquid is directly proportional to :

(i) the surface area (A) of the layer in contact i.e. $F \propto A$ and

(ii) the velocity gradient $\left(\frac{dv}{dx}\right)$ between the layers, i.e. $F \propto \frac{dv}{dx}$

$\therefore$ From (i) and (ii)

$$F \propto A\frac{dv}{dx}$$

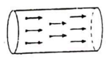
$$\therefore F = -\eta A \frac{dv}{dx}$$

Where, the constant η is called the coefficient of viscosity of the liquid.

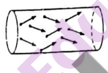
[**Note :** -ve sign shows that the direction of F is opposite to the direction of motion of the liquid].

Q5. Explain the terms- Streamline flow, turbulent flow and critical velocity.

Ans.



Streamline or laminar flow



Turbulent flow

Streamline or Laminar flow : Streamline flow is the flow of the liquid in which every particle of liquid moves in the same direction (i.e. parallel or inline) of flow of liquid. When liquid flows steadily, each particle follows its earlier particle. In streamline flow, the velocity at every point within the liquid remains constant. The flowremains streamline so long as the velocity is below certain velocity called velocity. e.g. Flow of river wa ter in summer season is slow and steady i.e.streamline.

Critical Velocity : The value of velocity of flow of liquid upto which flow is streamline is called critical velocity 'v_c'.

If velocity of flow of liquid increases and crosses critical velocity, then particle starts moving in random direction i.e. flow becomes turbulent.

Thus, critical velocity is defined as the velocity of flow of liquid at which streamline flow changes into turbulent flow.

Turbulent flow :

The flow of liquid in which every particle is not moving in line and they move in random direction is called turbulent flow.

This happens when speed of flow of water is more than certain value (i.e. more than critical velocity).

e.g. Flow of river water after very heavy rain i.e. during flood.

Velocity is given by the relation

$$v = \frac{\eta R}{pr}$$

where V - Velocity of flow of liquid
η - Coefficient of viscosity of liquid
R - Reynold's number
p - Density of liquid
r - Radius of the tube

Q6. Define Upthrust Force and how the temperature and adulteration effects viscocity of liquid.

Ans: Buoyant (Upthrust) Force : When a body falls in liquid col umn, liquid gets displaced and displaced liquid lifts the body in upward direction. The force with which the liquid lifts the body in upward direction dipped in it is called upthrust force. When a body is placed in water the upthrust or buoyant force acting on it depends upon the following factors.

(i) Volume of the object immersed in the liquid (v)
(ii) Density of a liquid (d)
(iii) Acceleration due to gravity (g)
i.e. upthrust $= v \times d \times g$

Effect of Temperature & Adulteration on viscosity of liquid :

(i) It is observed that as temperature of liquid increases, its viscosity decreases i.e.

$$Vis\cos ity \propto \frac{1}{temperatur\ e}$$

(ii) And when adulteration such as soluble substance is added to liquid, its viscosity goes on increasing.

i.e. $Vis\cos ity \propto adulterati\ on$.

Q7. Explain why rain drops are spherical.

Ans. (i) The resulting force acting on the molecules lying inside the liquid is zero.

(ii) But for the molecules present on the surface of the liquid, there are no more molecules present on other side. So the resultant force acting on those molecules is directed towards the interior of the liquid.

(iii) Because of this, the surface molecules cause the surface to contract and occupy minimum surface area.

(iv) The geometrical shape having small surface area is nothing but a spherical shape.

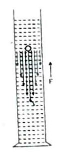
(v) So, the shape of the liquid drop is spherical.

Q8. Explain stokes law and terminal velocity. On what factors does the terminal velocity of a small particle depend ?

Ans. Stokes law : When a body falls under gravitation, through a column of liquid, different liquid layers move with different speeds. Liqiuid layers which are in contact with body has maximum velocity and liquid layer in contact with wall of container has zero velocity. Because of different speeds of different layers, a viscous force which opposes the relative motion is developed.

Practically, it is observed that after covering certain distance the body, which is freely falling, attains constant velocity called as terminal velocity 'v'.

Terminal velocity : The constant velocity with which a body falls through liquid column is called terminal velocity.



Stoke's law : Stoke's law states that the force of viscosity experienced by a small metal sphere falling freely through a viscous medium, with terminal velocity is directly proportional to

(i) radius of metal sphere 'r'

(ii) terminal velocity 'v'

(iii) coefficient of viscosity of liquid 'η'

ie. $F = \eta r v$

$F = 6\pi \eta r v$ ....Stoke's law formula

Q9. Differentiate between Streamline and turbulent flow?

Ans.

Streamline Flow	Turbulent Flow
The path of every particle is same.	Path of every particles is different.
Velocity of particle is constant in magnitude and direction.	Velocity of particle at each point is not constant.
Flow is regular or steady	Flow is irregular or speedy.
No circular currents or eddies are developed.	Random circular current called vorticose are developed.
The liquid flows steadily	The flow becomes turbulent after critical velocity.
The velocity of flow of liquid is less than critical velocity $V<V_c$	The velocity of flow of liquid is more than critical velocity $V>V_c$
e.g. Flow of liquid through pipes. flow of water in a canal.	e.g. Water fall, Flow of water in a river during floods.

Q10. Define buoyant force or upthrust force?

Ans. When an object is immersed in a liquid, it experences an upward force. This upward force is called buoyant force.

Thus, the upward force acting on a object immersed in a liquid is called buoyant force. It is due to the upward buoyant force exerted by a liquid that the weight of an objects appears to be less in the liquid than its actual weight in air. The upward force exerted by a liquid is also known as upthrust force. It is due to the upward force exerted by water that we are able to swim in water and ships float in water.

Q11. State and explain Archimedes principle?

Ans. Archimedes' principle states that the upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaces and acts in the upward direction at the center of mass of the displaced fluid. Archimedes' principle is a law of physics fundamental to fluid mechanics. It was formulated by Archimedes of Syracuse.

Applications of Archimedes' Principle:

The important applications of Archimedes' principle are given below:

(i) Archimedes' principle is used in determining the relative density of a substance.

(ii) The hydrometers used for determining the density of liquids are based on Archimedes' principle.

(iii) The lactometers used for determining the purity of milk are based on Archimedes' principle.

(iv) Archimedes' principle is used in designing ships and submarines.

Q12. Why an objects float or sink in a liquids?

Ans. An object will oaton the surface of water when it has density less than that of water because it always displaces more weight of water than its own weight, and as the buoyant force is more than its own weight, therefore it oats. on the other hand, an object sinks in water when it has density more than that of water because it always displaces less weight of water than its own weight.

Solved Example

Q1. A spherical ball of radius 0.15 cm takes 6 seconds to travel a distance of 80 cm through a viscous liquid. If the density of ball is 8×10^3 and that of liquid is $1.2\times 103 kg/m^3$, find the viscosity of the liquid.

Sol. Given : r = 0.15 cm = 0.15×10^{-2}m

$$v = \frac{dis\tan ce}{time} = \frac{80\ cm}{6\ sec}$$

$$= (13.33)cm/s = (0.133)m/s$$

$d = 8\times 10^3\ kg/m^3$

$p = 1.2\times 10^3\ kg/m^3$

$\eta = ?$

$$\eta = \frac{2}{9}\frac{r^2 g(d-p)}{v}$$

$$= \frac{2}{9}\frac{(0.15\times 10^{-2})^2(9.8)(8\times 10^3 - 1.2\times 10^3)}{0.133}$$

$$\eta = 0.25\ Ns/m^2$$

Q2. A spherical ball of radius 2.2 mm and density $8\times 10^3 kg/m^3$ falls through aliquid of density $1.3\times 10^3 kg/m^3$. Find terminal velocity. (Given : η for liquid = 0.45 Ns/m²).

Sol. : Given : r = 2.2 mm = $2.2\times 10^3\ m$

$d = 8\times 10^3\ kg/m^3$

$p = 1.3\times 10^3\ kg/m^3$

$\eta = 0.4\ Ns/m^2$

v = ?

We have, $\eta = \frac{2}{9}\frac{r^2 g(d-p)}{v}$

$$v = \frac{2}{9}\frac{r^2 g(d-p)}{\eta}$$

$$v = \frac{2}{9}\frac{(2.2\times 10^{-3})^2(9.8)(8\times 10^3 - 1.3\times 10^3)}{0.45}$$

$\therefore$ v = 0.157 m/s

Q3. A metal plate of area 0.25 m² rests on a layer of oil 0.003 m thick with coefficient of viscosity 1.56 Ns/m². If the plate is moved with a velocity of o.05 m/s. Calculate the horizontal force acting on the plate.

Sol. Given : A = 0.25 m²

dx = 0.003 m

$\eta = 1.56\ Ns/m^2$

dv = 0.05 m/s

F = ?

We have, $F = \eta A\frac{dv}{dx}$

$$= (0.05)(0.25)\left(\frac{0.05}{0.003}\right)$$

F = 6.5 N

Q4. A plate of metal having 100 sq. cm. area rests on a layer of paraffin oil 2 mm thick. If the horizontal force required to move the plate with velocity 3 cm/s is 0.24 newton, find the coefficient of viscosity.

Sol. A = 100 cm² = $100\times 10^{-4}\ m^2$

dx = 2 mm = $2\times 10^{-3}\ m$

dv = 3 cm/s = $3\times 10^{-2}\ m/s$

F = 0.24 N

$\eta = ?$

By Newton's law of viscosity,

$$F = \eta A\times\frac{dv}{dx}$$

$$\therefore \eta = \frac{F}{A\times\frac{dv}{dx}}$$

$$\eta = \frac{(0.24)}{(100\times 10^{-4})\times\frac{(3\times 10^{-2})}{(2\times 10^{-3})}}$$

$$\eta = 1.6\ Ns/m^2$$

Q5. Find the velocity of flow of a liquid of viscosity 0.02 Ns/m² and density 1.2 gm/cm³ through a pipe of radius 0.05 m; Reynold's number = 2000.

Sol. Given : $\eta = 0.02\ Ns/m^2$

$p = 1.2\ gm/cm^3 = 1.2\times 10^3 kg/m^3$

r = 0.05 m

R = 2000

v = ?

$$V = \frac{\eta R}{pr}$$

$$= \frac{(0.02)(2000)}{(1.2\times 10^3)(0.05)}$$

v = 0.667 m/s

Q6. A liquid flows through a pipe of diameter 10 cm with a speed of 0.5 m/s. The density of liquid is0.8 $\times 10^3 kg/m^3$ and the coefficient of viscosity is 0.4 Ns/m². Determine Reyoind's number and state whether the flow is turbulent or streamline.

Sol. Given : diameter = 10 cm

radius r = 5 cm = 0.05 m

v = 0.5 m/s

$p = 0.8\times 10^3\ kg/m^3$

$\eta = 0.4\ Ns/m^2$

R = ?

$$V = \frac{\eta R}{pr}$$

$$R = \frac{vpr}{\eta} = \frac{(0.5)\times(0.8\times 10^3)\times(0.05)}{0.4}$$

R = 50

$\because$ R < 2000, the liquid flow is streamlined.

Q7. A steel ball of density 8 $\times 10^3 kg/m^3$ falls vertically in a tall jar containing an oil of density $1.5\times 10^3 kg/m^3$ and acquires a terminal velocity 0.2 m/s. If radius of the ball is 2 mm, find coefficient of viscosity of oil. (g = 9.81 m/s²)

Sol. Given : $d = 8\times 10^3\ kg/m^3$

$p = 1.5\times 10^3\ kg/m^3$

v = 0.2 m/s

r = 2 mm = 0.002 m

$\eta = ?$

$$\eta = \frac{2}{9}\frac{r^2 g(d-p)}{v}$$

$$= \frac{2}{9}\times\frac{(0.002)^2(9.81)(8\times 10^3 - 1.5\times 10^3)}{0.2}$$

$$\eta = 0.28\ Ns/m^2$$

Q8. Calculate the viscous force on a steel ball of radius 2 mm, falling freely in a tall jar containing oil with a terminal velocity 0.2 m/s, coefficient of viscosity of oil is 0.28 Ns/m².

Sol. F = ?

r = 2 mm = $2\times 10^{-3}\ m$

v = 0.2 m/s

$\eta = 0.28\ Ns/m^2$

We have Stoke's formula for viscous force.

$F = 6\pi\eta r v$

$= 6\times 3.142\times(0.28)(2\times 10^{-3})(0.2)$

$F = 2.11\times 10^{-3}\ N$

Q9. Assuming the Reynold's nmber to be 1000, calculate the critical velocity for glycerine in the pipe of diameter 2 cm. Density and viscosity of glycerine are $1.36\times10^3 kg/m^3$ and $0.85\ Ns/m^2$ respectively.

Sol.Given : $R = 1000$

diameter = 2 cm

$r = 1\ cm = 1\times10^{-2}\ m$

density, $\rho = 1.36\times10^3\ kg/m^3$

$\eta = 0.85\ Ns/m^2$

$v = v_c = ?$

$v = v_c$

$$= \frac{R\eta}{\rho r} = \frac{(1000)\times(0.85)}{(1.36\times10^3)\times(1\times10^{-2})}$$

$\therefore\ v_c = 62.5\ m/s$

Q10. An air bubble of radius 1 cm rises steadily through solution of density $1.75\times10^3 kg/m^3$ at the steady velocity of 0.25 m/s. Calculate coefficient of viscosity of the solution neglecting density of air.

Sol. Given : $r = 1\ cm = 1\times10^{-2}\ m$

density of liquid, $d = 1.75\times10^3\ kg/m^3$

$v = 0.35\ m/s$

$$\eta = \frac{2}{9}\frac{r^2 g(d-p)}{v}$$

$$= \frac{2}{9}\frac{(1\times10^{-2})^2\times(9.8)\times(1.75\times10^3-0)}{0.35}$$

$\eta = 1.08\ Ns/m^2$

Q11. The terminal velocity of raindrop is 30cm/s. Taking the viscosity of air as $1.8\times10^{-5}\ Nm^{-2}s$. What is the radius of the rain drop. (density of air = $1.29\ kg/m^3$)

Ans.Given : $\rho = 10^3 kg/m^3; \sigma = 1.29 kg/m^3$

$\eta = 1.8\times10^{-5} Nm^{-2}s$; $v = 30\ cm/s = 0.3\ m/s$

$$v = \frac{2r^2(\rho-\sigma)g}{9\eta} \Rightarrow r^2 = \frac{v9\eta}{2\times(\rho-\sigma)g}$$

Now,

$$\therefore r = \sqrt{\frac{v9\eta}{2\times(\rho-\sigma)g}} \Rightarrow \sqrt{\frac{0.3\times9\times1.8\times10^{-5}}{2\times(10^3-1.29)\times9.8}}$$

$r = 4.98\times10^{-5} m$

$\therefore$ radius of the rain drop = 4.98×10^{-5}m.

Chapter 6.
Transmission of heat and Expansion of Solids

Multiple Choice Question

1. Thrmal conductivity of a material depends upon

(a) temperature difference (b) area
(c) thickness (d) None of the above

Ans.(a)

2. The transformer of heat from one place to another without the help fo any medium is called.

(a) conduction (b) convention
(c) Radiation (d) None of these

Ans.(c)

3. The process in which metal rod is heated at one end, the heat is transfered to another end is called

(a) Conduction (b) Convention
(c) Radiation (d) None

Ans.(b)

4. The relation between ∞, β and γ is

(a) $\alpha:\beta:\gamma = 1:1:1$ (b) $\alpha:\beta:\gamma = 1:2:3$
(c) $\alpha:\beta:\gamma = 3:2:1$ (d) None of these

Ans.(b)

5. The S.I. unit of co-efficient of thermal conductivity is

(a) walt-kelvin metre (b) joule
(c) watt/m-k (d) joule/second

Ans.(c) watt/m-k

6. Which of the following is a unit of specific heat ?

(a) Jkg^0C^{-1} (b) J/kg^0C
(c) kg^0C/J (d) J/kg^0C^{-2}

Ans.(b) J/kg^0C

7. Sun's heat reaches us by

(a) Conduction (b) Radiation
(c) Convection (d) Scattering

Ans.: (b) Radiation

8. The ratio of co-efficients of cubical expansion and linear expansion is

(a) 1 : 1 (b) 3 : 1 (c) 2 : 1 (d) None

Ans.(b)

9. When a solid metallic sphere is heated, the largest percentage increase occurs in its

(a) Daimeter (b) Surface area
(c) Volume (d) Density

Ans.(b)

10. The fastest mode of transmission of heat is

(a) Conduction (b) Convection
(c) Radiation (d) All the above

Ans.(b)

12. The S.I. unit of co-officient of thermal conductivity is

(a) joule (b) watt/m-K
(c) watt-Kelvin-metre (d) joule/second

Ans.(b)

13. Which one is the correct relation between the three co-efficients of expansion.

(a) $\frac{\alpha}{3} = \frac{\beta}{2} = \gamma$ (b) $\frac{\alpha}{2} = \frac{\beta}{3} = \gamma$

(c) $\frac{\alpha}{1} = \frac{\beta}{2} = \frac{\gamma}{3}$ (d) $\frac{\alpha}{2} = \frac{\beta}{6} = \frac{\gamma}{9}$

Ans.(c)

14. The transmission of heat by conduction is possible in case of

(a) solids (b) liquids (c) gases (d) All of these

Ans.(a)

15. Amount of heat energy flowing in one second between the opposite faces of a unit cube, in the direction perpendicular to the faces, when difference in temperature is 1^0C is called

(a) heat capacity (b) heat flow
(c) thermal conductivity (d) None of these

Ans.(c)

16. The metal with highest thermal conductivity is

(a) copper (b) silver (c) iron (d) gold

Ans.(b)

17. Which is a good conductor in the following liquids?

(a) alcohol (b) water (c) mercury (d) benzene

Ans.(c)

18. The ultimate insulator of heat is

(a) asbestos (b) air (c) wood (d) vacuum

Ans.(d)

19. The water gets heated by the process of

(a) conduction (b) convection
(c) radiation (d) None of these

Ans.(b)

20. The state of matter which is heated by convection is

(a) solids (b) gases (c) liquids (d) both b and c

Ans.(d)

21. Convection is not possible in solids because the molecules of solids

(a) do not interchange their positions
(b) are held firmly by molecular forces
(c) reflect heat energy (d) both a and b

Ans.(d)

22. Heat transfer takes place as per

(a) zeroth law of thermodynamics
(b) first law of thermodynamics
(c) second law of thermodynamics
(d) All of these

Ans.(c)

23. Heat flows from one body to other when they have

(a) different heat contents (b) different specific heat
(c) different atomic structure (d) different temperature

Ans.(d)

24. An iron bar is heated from 10^0C to 100^0C

(a) its volume increases and its density decreases
(b) its volume increases and its density is unchanged
(c) its volume increases and its density increases
(d) its volume is unchanged and its density increases

Ans.(a)

25. In severe winters, water pipes burst because

(a) water expands on freezing (b) lead pipes contract
(c) because of high atmospheric pressure
(d) None of the above

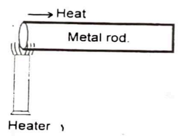
Ans.(a)

Answer the following questions

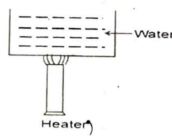
Q.1 Describe the various modes of transfer of heat by giving one example of each.

Ans.: Energy always flows from higher energy level to lower energy level. Heat is a form of energy which flows from a body at higher temperature to a body at lower temperature. There are three modes of transfer of heat.

1. Conduction : It is a process of transfer of heat from a part of body at higher temperature to a part of body at lower temperature *without bodily* (actual) *movement of* particles. It takes place through solids. Example :- Heating of a rod.

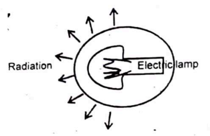


2. Convection : It is a process of transfer of heat from a part of body at higher temperature to part of body at lower temperature with bodily (actual) movement of particles. It takes place in case of liquids. Example : Boiling of water.



3. Radiation : It is the process of transfer of heat in which heat is transferred from one place to other directly without the necessity of intervening medium e.g. we get heat from sun without affecting the intervening medium. Heat radiations can pass through vacuum.

Example :Heat radiations from sun or electric bulb.



Q2.State good conductor and bad conductor with example.

Ans.Good conductor : The material through which heat conducts easily and speedily is called good conductor of heat. e.g. copper, iron, aluminium.

Applications:

(i) Good conducting material is used as heat sink in electronic circuits which absorbs heat and protects the components from overheating.

(ii)Spiral tube of good conductor is used in electric heater for speedy conduction of heat.

(iii)MICA is good conductor of heat, but bad conductor of electricity, hence used in electric iron.

Bad conductor : The material through which heat does not conduct (flow) is called bad conductor of heat. e.g. wood, wool, plastic.

Applications:

(i) Bad conducting material like thermocole is used in ice box in which ice melts slowly.

(ii)Handle of cooker is mae up of bad conducting material like plastics.

(iii)Use of double walled flask or thermosflask:Flasks having double layers and air gap in between avoid thermal loss.hence warm food or liquid inside the flask remains warm for longer time.

Q.3Write the laws of thermal conductivity and define co-efficient of thermal conductivity ?

Ans.Law of Thermal Conductivity :- Suppose AB is a bar of metal, of cross sectional area A as shown in figure.

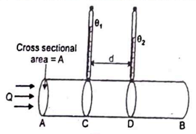


Fig.

Consider the bar to be in steady state.

No amount of heat is lost to the surroundings by means of radiation.

Consider two places C and D in the bar.

Let, Q = the amount of heat flowing from C to D

d = distance between C and D or distance two thermometers.

θ_1 = temperature of plane C.

θ_2 = temperature of plane D.

$\theta_1 > \theta_2$

Then, amount of heat flowing (Q) from C to D at steady state is directly proportional to

1. Cross sectional area 'A' of rod,
2. Temperature difference between two planes i.e., $(\theta_1 - \theta_2)$,
3. Time 't' for which heat flows,

and inversely proportional to

1. Distance 'd',between two planes or distance between two thermometers.

Thus, $Q \propto A$

$Q \propto (\theta_1 - \theta_2)$

$Q \propto t$

$Q \propto \frac{1}{d}$

$\therefore$ Combining,

$$Q \propto \frac{A \times (\theta_1 - \theta_2) t}{d}$$

$$Q = \text{Constant} \times \frac{A \times (\theta_1 - \theta_2) t}{d}$$

$$\boxed{Q = K \times \frac{A \times (\theta_1 - \theta_2) \times t}{d}} \quad ...(i)$$

where K is the constant of proportionality which is called coefficient of thermal conductivity. 'K' depends on material of a bar.

Coefficient of Thermal Conductivity (K) :

We have, $Q = K \frac{A(\theta_1 - \theta_2)t}{d}$ ..from eqn(i)

If $A = 1$

$(\theta_1 - \theta_2) = 1$

$t = 1$

$d = 1$

then $Q = \frac{K \times 1 \times 1 \times 1}{1}$

$Q = K$

Thus, coefficient of thermal conductivity is defined as amount of heat conducted in one second, in steady state of temperature through unit cross sectional area of an element of material of unit thickness with unit temperature difference between its opposite faces.

Unit of 'K' :

$$K = \frac{Q \times d}{A(\theta_1 - \theta_2)t} = \frac{\text{cal} \times \text{m}}{\text{m}^2 (^0\text{C}) \sec}$$

$$= \frac{\text{cal}}{\text{m}\ ^0\text{C} \sec}$$

$$= \frac{\text{cal}}{\text{cm}\ ^0\text{C} \sec} \quad ...\text{CGS unit}$$

$$= \frac{\text{kcal}}{\text{m}\ ^0\text{C} \sec} \quad ...\text{MKS unit}$$

$$= \frac{\text{watt}}{\text{m}\ ^0\text{K}} \quad ...\text{S.I. unit.}$$

Q4. What is the expansion in solids ? Why in a railway line small gap is always left between the iron rails ?

Ans.Expansion in solids :- Almost all solids, liquid & gases expand when their temperature increases. Solid can change in length, area or volume, When heated. The increase in size of a body due to increase in the temperature is called thermal expansion. Three type of expansion can take place in solid

(i) Linear expansion

(ii) Superficial expansion

(iii) Cubical expansion.

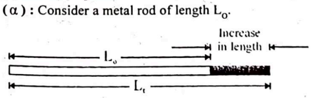
Reasons: Substances like steel expand when heated and very large forces may be set up if there is no space (an obstruction) for the free movement of the expanding or contracting bodies. In the summer season the rail lines get expanded ; the possibillity of bending the rail lines increases if the gap between the two lines is not kept which may result into derailment of railway. Hence, while laying railway lines, small spaces are left between consecutive rails

Q5. Define the co-efficients of linear expansion $(\propto)$, superficial expansion (β) and cubical expansion (γ).

Ans. Whenever solid is heated, it expands. If solid is in thin rod form, then after heating, its length increases. If it is in thin sheet form, then its area increases and if it is incube form, then after heating, its volume increases.

Accordingly, there are three types of coefficient of expansion.

(a) Linear expansion or coefficient of linear expansion (α) : Consider a metal rod of length L_o.



Let, L_o = Original length of rod at 0ºC.

L_t = New length at tºC

$(L_t - L_o)$ = Increase in length (shaded portion)

$(t - 0)$ = increase in temperature

Then, coefficient of linear expansion is given by

$$\alpha = \frac{(L_t - L_o)}{L_o \times t}$$

Definitation of coefficient of linear expansion : The coefficient of linear expansion of the material of a rod is defined as the change in length per unit in length per unit in temperature. In other words it is defined as fractional increases in length per ºC rise in temperature.

$$\alpha = \frac{\Delta L}{L_o \Delta T}$$

$$\therefore \alpha = \frac{\text{Change in length}}{\text{Original length} \times \text{Change in temperature}}$$

(b) Coefficient of superficial expansion : The Coefficient of superficial expansions of the material body is defined as the change in surface area per unit surface area per unit change in temperature.

In other words it is defined as fractional increase in area per ºC rise in temperature.

Mathematically, it is given by

$$\beta = \frac{\Delta A}{A \Delta T}$$

$$\beta = \frac{\text{Change in area}}{\text{Original area} \times \text{Change in temperature}}$$

(c)Coefficient of cubical expansion : The coefficient of cubical expansion of the material body is defined as change in volume per unit volume per unit change in temperature. It can also be defined as fractional change in volume per ºC rise in temperature.

Mathematically, it is given by

$$\gamma = \frac{\Delta V}{V \Delta T}$$

$$\Rightarrow \gamma = \frac{\text{Change in volume}}{\text{Original volume} \times \text{Change in temperature}}$$

Relation between α, β and γ : We have seen α, β and γ. For a given material, coefficient of linear expansion 'α' is always constant. Similarly, for a given material, 'β' and 'γ' are constant. Also it is observed that for a given material, α, β and γ are interrelated with each other.For a given material (e.g., aluminium),

β is twice of $\alpha \rightarrow (\beta = 2\alpha)$ and γ is thrice of $\alpha \rightarrow (\gamma = 3\alpha)$

Thus for a given material, relation between α, β and γ is as under

Radio $\alpha : \beta : \gamma$; 1 : 2 : 3

Solved Example

Q1.The length of a copper rod at 0ºC is 90cm. When it is heated to 100ºC, Its length increases by 0.14cm. Find the co-efficients of linear expansion (α) and superficial expansion (β) of copper.

Ans. $\Delta T = (100-0) = 100^0C$, $L_0 = 90cm$,

$\Delta L = 0.14cm$

Co-efficient of linear expansion,

$$\propto = \frac{\Delta L}{L_0 \Delta T} = \frac{0.14}{90 \times 100} = 2\times10^{-5}/^0C$$

Co-efficient of superficial expansion, β

$\propto : \beta = 1:2$

$$\frac{\propto}{\beta} = \frac{1}{2}$$

$\Rightarrow \beta = 2\propto = 2\times2\times10^{-5}/^0C$

$= 4\times10^{-5}/^0C$ **Ans.**

Q2.A thin square metallic sheet at 0°C has each side 1m. When heated to 100°C, each side of the metallic sheet becomes 1.01 m. Calculate the coefficients of linear and superficial expansion.

Sol. $\Delta L = 0.01$ m ; $L_0 = 1$m

$\Delta T = (100-0)^0C = 100^0C$

Linear expansion

(i) $\alpha = \frac{\Delta L}{L_0 \Delta T} = \frac{0.01}{1\times100} = 1\times10^{-4}/^0C$

(ii) Superficial expansion,

$\beta = 2\times10^{-4}/^0C$

Q3. *When a bar of iron 50 cm long at 15°C in heated in a furnance, it becomes 50.4 cm. If the co-efficient of linear expansion of iron is 0.000011°C-1, find the temperature of the furnance.*

Sol. We know that,

$$\alpha = \frac{L_1 = L_0}{L_0(t_2 - t_1)} \Rightarrow 0.000011 = \frac{50.4 - 50}{50\times(t_2 - 15)}$$

$$\Rightarrow t_2 - 15 = \frac{0.4}{50\times0.000011} = 727.3$$

$\therefore t_2 = 742.3^0C$.

Q4.When a metallic bar is heated from 0°C to 1000°C, its length increases by 0.05%. What is the co-efficient of linear expansion of the metal ?

Sol. Given :

$t_1 = 0^0c$, $t_2 = 1000^0c$, $\frac{\Delta l}{l} = 0.05\%$

$\alpha = ?$

$$\alpha = \frac{\Delta l}{l}\times\frac{1}{(t_2 - t_1)} = \frac{0.0005}{1000} = 5\times10^{-7}c^{-1}$$

Q5. Find the quantity of heat conducted inj 5 minutes across a silver sheet of size $40\,cm\times30\,cm$ of thickness 3 mm. If its two faces are at temperatures of 40°C and 25°C, K for silver = 0.1 kcal/m °Cs.

Sol: Given : $Q = ?$

$t = 5$ min $= (5\times60)$sec

$A = 40\,cm \times 30\,cm$

$= 1200$ cm²

$= 0.12$ m²

d = 3mm

$= 3\times10^{-3}\,m$

$(\theta_1 - \theta_2) = (40-25) = 15^0C$

We have, $$Q = \frac{KA(\theta_1 - \theta_2)t}{d}$$

$$= \frac{(0.1)(0.12)(15)(5\times60)}{(3\times10^{-3})}$$

Q = 18000 kcal

Q6. A nickel plate of thickness 4 mm has temperature difference of 32°C between its faces. It transmits 200 kcal per hour through an area of 5 cm². Calculate the conductivity of nickel.

Sol. Given : d = 4 mm

$= 4\times10^{-3}\,m$

$(\theta_1 - \theta_2) = 32^0C$

Q = 200 kcal

A = 5 cm²

$= 5\times10^{-4}\,m^2$

K = ?

t = 1 hr

$= (60\times60)$sec

We have, $$Q = \frac{KA(\theta_1 - \theta_2)t}{d}$$

$$\therefore \quad K = \frac{Q\times d}{A(\theta_1 - \theta_2)t}$$

$$K = \frac{200(4\times10^{-3})}{(5\times10^{-4})(32)(60\times60)}$$

K = 0.0139 kcal/m °C sec

Q7.A copper rod 19 cm long and area of cross-section 0.79 cm², which i thermally insulated, is heated at one end to a temperature of 100°C while the other end is kept at 30°C. Calculate the amount of heat which will will flow in 5 min. along the rod if K for copper is 380 W/m °K.

Sol. Given : d = 19 cm (length of rod or distance between two thermometers)

= 0.19 m

A = 0.79 cm² $= 0.79\times10^{-4}\,m^2$

$\theta_1 = 100^0C$

$\theta_2 = 30^0C$

Q = ?

t = 5 min = 5 × 60 = 300 sec

K = 380 W/m °K

We have,

$$Q = \frac{KA(\theta_1 - \theta_2)t}{d} = \frac{380\times0.79\times10^{-4}\times(100-30)300}{0.19}$$

Q = 3318 J

OR $$Q = \frac{3318}{4.2}$$

Q = 790 cal.

Q8. The inside and outside temperature of a glass window pan are 24° C and 18°C resectively. The window is 3 mm thick. Find its area if 50 kcal of heat escapes in minute.

Sol. **Given :** $(\theta_1 - \theta_2) = (24\text{-}18)\,^0C$

d = 3 mm

A = ?

Q = 50 kcal

t = 1 minute = 60 sec.

Note : There is a discrepency in the question paper, value of 'K' is not given

K for glass is note given. $$Q = \frac{KA(\theta_1 - \theta_2)t}{d}$$

$$\therefore \quad A = \frac{Q\times d}{K(\theta_1 - \theta_2)t}$$

$$\therefore \quad A = \frac{(50)(3\div10^{-3})}{K(24-18)(60)}$$

$$\therefore \quad A = \frac{4.16\times10^{-4}}{K}m^2$$

Q9.A thin rod of iron has coefficient of linear expansion α =0.12× 10-4/°C. Calculate the coefficient of superficial expansion of thin sheet of iron.

Sol. Given : $\alpha = 0.12\times10^{-4}/^0C$

$\beta = ?$

We have, $\beta = 2\alpha = 2\times0.12\times10^{-4}/C$

$\beta = 0.24\times10^{-4}/^0C$

Q10.The length of metal rod at 15°C is 50 cm and at 90°C is 50.15 cm. Calculate the coefficient of linear expansion.

Sol. $L_1 = 50$ cm, $t_1 = 15$°C, $L_2 = 50.15$ cm, $t_2 = 90$° C

$(L_2 - L_1) = (50.15 - 50) = 0.15\,cm$

$(t_2 - t_1) = 90 - 15 = 75^0C$

We have, $(L_2 - L_1) \propto L_1$

and $(L_2 - L_1) \propto (t_2 - t_1)$

$\therefore \quad (L_2 - L_1) \propto L_1(t_2 - t_1)$

$\therefore \quad (L_2 - L_1) = \alpha\, L_1(t_2 - t_1)$

$$\therefore \quad \alpha = \frac{(L_2 - L_1)}{L_1(t_2 - t_1)} = \frac{(0.15)}{50(75)}$$

Coefficient of linear expansion, $\alpha = 4\times10^{-5}/^0C$

Q11. The length of copper rod at 0°C is 90 cm. When heated to 100°C, it increases by 0.14 cm. Find the coefficient of linear expansion.

Sol. Given : $L_0 = 90$ cm at 0°C

$(L_t - L_0) = 0.14$ cm

$\therefore \quad L_1 = 90.14$ cm at t = 100°C

$\alpha = ?$

$$\alpha = \frac{(L_t - L_0)}{L_0 t}$$

$$= \frac{0.14}{90\times100}$$

$$= \frac{0.14}{90\,00}$$

$\alpha = 1.56\times10^{-5}/^0C$

Q12.A sheet of copper has area 80 cm² at 50°C. What will be its area when heated to 90°C ? The coefficient of linear expansion of copper is 16 × 10⁻⁶/°K.

Sol. $A_1 = 80\,cm^2$ ... at $t_1 = 50^0C$

$A_2 = ?$ .... at $t_2 = 90$°C

Coefficient of linear expansion,

$\alpha = 16\times10^{-6}/^0K$

$\therefore$ Coefficient of aerial expansion,

$\beta = 2\alpha = 2\times16\times10^{-6}/^0K$

$$\beta = \frac{(A_2 - A_1)}{A_1(t_2 - t_1)}$$

$$2\times16\times10^{-6} = \frac{(A_2 - 80)}{80(90-50)}$$

$0.1024 = (A_2 - 80)$

$\therefore \quad A_2 = 80 + 0.1024$

$\therefore \quad A_2 = 80.1024$ cm²

Q13.The length of an aluminium rod is 2 m at room temperature. When the rod is heated to 120°C, its length increases by 0.5 cm. Find the room temperature.

Sol. Given : $L_2 = 2$m = 200 cm ... at t_1 = ? (room temperature)

$L_2 = 2$m + 0.5 cm ... at $t_1 = 120$°C

= 200.5 cm

$\alpha = 25\times10^{-6}/^0C$

$$\alpha = \frac{L_2 - L_1}{L_1(t_2 - t_1)}$$

$$20\times10^{-6} = \frac{200.5 - 200}{200(120 - t_1)}$$

$$(120 \times t_1) = \frac{200.5 - 200}{200\,(25 \times 10^{-6})}$$

$(120 - t_1) = 100$

$\therefore (120 - 100) = t_1$

$\therefore t_1 = 20^{\circ}C$

Q14. The coefficient of cubical expansion of a metal is 46×10^{-6}/ $^{\circ}C$. Find the coefficient of aerial expansion.

Sol. Given : $\gamma = 46 \times 10^{-6} /^{\circ}C$, $\beta = ?$

We have $\beta : \gamma$ is 2 : 3

i.e. $$\frac{\beta}{\gamma} = \frac{2}{3}$$

$\therefore$ $$\beta = \frac{2}{3} \times \gamma = \frac{2}{3} \times (46 \times 10^{-6})$$

$\therefore \beta = 30.66 \times 10^{-6} /^{\circ}C$

Q15. An iron rod has length of 90 cm at 20°C temperature. What would be its length at 80°C ? Coefficient of linear expansion, $\alpha = 0.000012^{\circ}C$.

Sol. Given : $l_{t_1} = 90\ cm$, $t_1 = 20^{\circ}C$

$l_{t_2} = ?$, $t_2 = 80^{\circ}C$

We have, $$\alpha = \frac{l_{t_2} - t_1}{l_{t_1} \times (t_2 - t_1)}$$

$$1.2 \times 10^{-5} = \frac{l_{t_2} - 90}{90 \times (80 - 20)}$$

$\therefore l_{t_2} = (1.2 \times 10^{-5} \times 90 \times 60) + 90$

$l_{t_2} = 90.0648\ cm$

Chapter 7. Acoustics

7.1 Sound

Multiple Choice Question

1. When a stone is dropped on the surface of the still water the wave produce are
(a) transverse (b) longitudinal
(c) stationary
(d) partly transverse and partly longitudinal right sign
Ans.(d)

2. The velocity of sound in vacuum is
(a) 0 m/s (b) 330 m/s
(c) 156 m/s (d) 1000 m/s
Ans.(a)

3. What type of waves carry sound should in air ?
(a) Transverse waves (b) Longitudinal waves
(c) Electromagnetic waves (d) Transverse and longitudinal waves
Ans.(b)

4. In a stationary wave, the distance between two consecutive nodes or antinodes is
(a) λ (b) $\frac{\lambda}{2}$ (c) $\frac{\lambda}{3}$ (d) $\frac{3\lambda}{4}$
Ans.(b)

5. Resonance is an example of
(a) tuning form (b) forced vibrations
(c) free vibrations (d) damped vibrations
Ans.(d)

6. Sound in air propagates in the form of
(a) Longitudinal Waves (b) Transverse Waves
(c) Both longitudinal and transverse Waves
(d) Neither longitudinal nor transverse Waves
Ans.(b)

7. Which is the case of forced vibrations ?
(a) sound produced in organ pipe
(b) sound produced in flute
(c) vibrations produced in piano string
(d) vibrations produced in telephone transmitter during conversion
Ans.(a)

8. In a wave motion, the maximum displacement is called
(a) amplitude (b) wavelength
(c) frequency (d) intensity
Ans.(a)

9. In a progressive wave, which of the following physical quantity is transmitted?
(a) amplitude (b) velocity
(c) momentum (d) energy
Ans.(d)

10. For a mechanical wave, the required material medium must possess
(a) inertia and surface tension (b) inertia and elasticity
(c) surface tension and viscosity
(d) rigidity and conductivity
Ans.(b)

11. Which type of waves carry sound in air?
(a) transverse wave (b) longitudinal wave
(c) electromagnetic wave
(d) transverse and longitudinal wave
Ans.(b)

12. The relation between frequency V, wavelength λ and velocity of propagation υ of a wave is
(a) $V = \upsilon\lambda$ (b) $V = \frac{\lambda}{\upsilon}$ (c) $V = \frac{\upsilon}{\lambda}$ (d) $\lambda\upsilon V = 1$
Ans.(c)

13. Two sound waves are $y = a\sin(\omega t - kx)$, $y = a\cos(\omega t - kx)$, the phase difference between the two waves is
(a) $\frac{\pi}{2}$ (b) $\frac{\pi}{4}$ (c) π (d) zero
Ans.(a)

14. Water waves are
(a) longitudinal (b) transverse
(c) both (d) none of the above
Ans.(c)

15. The equation of progesive wave is
(a) $y = A\sin\omega t$ (b) $y = A\cos(\omega t + \phi)$
(c) $y = A\cos(\omega t - kx)$ (d) $y = A\sin\frac{2\pi t}{T}\cos\frac{2\pi x}{\lambda}$
Ans.(c)

16. Range of audible sound waves is
(a) 20 to 20000 Hz (b) 10^6 to 10^8 Hz
(c) 10 to 20 Hz (d) None of these
Ans.(a)

17. A sound wave have frequency 500 Hz and velocity 360 m/sec. What is the distance between the two particles having phase difference of 60°?
(a) 0.7 cm (b) 12 cm (c) 70 cm (d) 120 cm
Ans.(b)

18. A transverse wave is represented by $x = A\sin(kx - \omega t)$. The velocity of the wave is given by
(a) kx (b) $\frac{k}{x}$ (c) ωt (d) $\frac{\omega}{k}$
Ans.(d)

19. The speed of sound in air is
(a) proportional to the pressure of air
(b) proportional to square root of the pressure of air
(c) proportional to square of the pressure of air
(d) independent of pressure of air
Ans.(b)

20. Which of the following is transmitted by a wave?
(a) Amplitude (b) Velocity
(c) Energy (d) None of these
Ans.(c)

21. Which of the following properties of sound is affected by change in air temperature
(a) Amplitude (b) Frequency
(c) Wavelength (d) Intensity
Ans.(c)

22. The velocity of sound is largest in
(a) Water (b) Air (c) Steel (d) Vacuum
Ans.(c)

23. Which property of wave does not change on changing the medium
(a) Amplitude (b) Wavelength
(c) Frequency (d) None of these
Ans.(c)

24. Resonance is a special case of
(a) Forced oscillations (b) Damped oscillations
(c) Free oscillations (d) Natural oscillations
Ans.(a)

25. the vibrations taking place in diaphragm of microphone will be
(a) Free vibrations (b) Damped vibrations
(c) Forced vibrations (d) Electrically maintained vibrations
Ans.(c)

26. Which of the following is not a transverse wave?
(a) X-rays (b) Sound wave in a gas
(c) Visible light wave (d) γ-rays
Ans.(b)

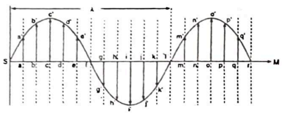
Answer the following questions

Q1. Define the terms wave motion, amplitude, frequency and wavelength, Time period.

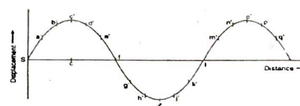
Ans. Wave motion : Wave motion is a form of disturbance which travels through the medium due to repeated periodic motion of the medium particle about its mean position.

It is one of the methods of transfer of energy.

A wave motion can be explained on the basis of SHM.



Amplitude (a) : The maximum displacement of the oscillation in the wave is called amplitude. In figure cc' is the amplitude.



Frequency (n) : The number of oscillations completed in one second is called frequency n, its unit is hertz (Hz).

1 Hz = 1 osc/sec

$$\boxed{n = \frac{1}{T}}$$

Wavelength(λ): The distance between two consecutive points in the wave, which are in same phase, is called wavelength and denoted by symbol λ (lambada).

Its unit is meter or Angstrom unit, denoted by A^0 or A.U

Time Period: The time period of a wave is the time in which a particle of medium completes one vibration to and fro about its mean position. It is denoted by T.

Q2. ***Establish a relation between wave velocity, frequency and wavelength.***

Ans. Relation between Velocity, Frequency and Wavelength :

We have, $\text{Velocity} = \frac{\text{Distance cover}}{\text{Time taken}}$

When disturbance travels through one full wave, then,
Distance covered = Wavelength
Time taken = Period

$\therefore \quad \text{Velocity} = \frac{\text{Wavelength}}{\text{Period}}$

$$\boxed{v = \frac{\lambda}{T}} \qquad \text{But } \frac{1}{T} = n$$

$$\therefore \quad \boxed{v = n\lambda}$$

This is the relation between velocity, frequency and wavelength.

Q.3 ***Define the terms : longitudinal wave, transverse wave, stationary wave, node and antinode ?***

Ans.: Longitudinal wave : A wave motion in which the particles of the medium vibrate about their mean position along the same line as that of propagation of the wave.

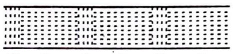


Fig. Logitudinal wave

$C \rightarrow$ compression ; $R \rightarrow$ rare fraction

In this wave, the particle of material medium are vibrating to and from and the wave is travelling in horizontal direction (right).

Transverse wave : A wave motion in which the particle of the medium vibrate about their mean position at right angles to the direction of propagation.

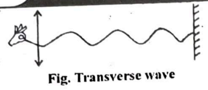


Fig. Transverse wave

In this wave, the particles of material medium are vibrating up and down but (disturbance) wave travels in horizontal (right) direction.

Stationary wave : When two identical progressive waves travel through a medium along the same line in opposite direction with equal velocities they superimpose over each other and produce a new type of wave which is called a stationary wave or standing wave.

Node : Since there is no flow of energy along the waves. There are certain points, half a wavelength apart which are permanently at rest called nodes.

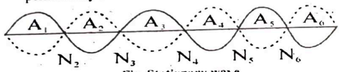


Fig. Stationary wave

Antinode : There are some other points midway between the nodes where the displacement is maximum known as antinodes.

Q4. ***Write the equation of progressive wave.***

Ans. The equation of progressive wave :-

$$y = a\sin 2\pi\left(nt - \frac{x}{\lambda}\right)$$

or, since, $n = \frac{1}{T}$ (T = Time period of SHM)

$$y = a\sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$$

Since $\quad n = \frac{v}{\lambda}$

$$y = a\sin\frac{2\pi}{\lambda}(vt - x)$$

Where, λ = Wavelength
y = displacement; a = amplitude

Q5. Explain Forced vibration and Resonance with example.

Ans. Force vibrations: When a body is maintained in a state of oscillation by a strong periodic force of frequency other than the natural frequency of the body, the oscillation are called force vibrations.

The frequency of forced oscillation is different from the natural frequency of the body. It is equal to the frequency of applied force.

Let an external periodic force of frequency V be applied to a body A of natural frequency V_0. The body a will start oscillating with frequency V and not V_0. The external force is called driver while the body A is called 'driven oscillator'.

Examples :

(i) Press the stem of a vibrating tuning fork against the top of a tabla. The tabla will suffer forced oscillations.

(ii) Hold the bob of a simple pendulum and give it any number of oscillation in unit time.

(iii) The sound board of stringed musical instrument suffer forced oscillations.

Resonance : If a frequency is forced upon a body and if the forced frequency matches (is equal to) the natural frequency of the body, the body vibrates with a large amplitude. The phenomenon is called "Resonance".

Explanation: When a pendulum or a block at the end of a spring is set into motion by a periodic force, the system moves with largest amplitude or with maximum energy when the frequency of force equals the frequency of natural vibrations of the free system. Let us consider a simple example to explain resonance. If we push a child or a swing periodically then the oscillations of swing becomes stronger if the pushing frequency is equal to the frequency of natural oscillation of the swing. Thus the concept of resonance is that the oscillation of a free system are most strong when frequency of driving force is equal to the frequency of the systems free vibrations.

Examples :

(i) If two exactly tuned 'Tanpuras' are kept side by side and if a wire of one is plucked, then the corresponding wire of the other Tanpura also starts vibrating even though it is not actually plucked.

(ii) When we tune a radio receiver set, the frequency of radio waves received in the set is adjusted equal to the natural frequency of the set or frequency of radio receiver becomes equal to frequency of transmitted wave of transmitting station, then we get clear and loud sound.

Q6. Differentiate between free vibration and forced vibration.

Ans. Free vibration : It can defined as the vibration in which the body vibrates with its own natural frequency when free to itself.

If no resistance is offered to motion of the vibrating body by any source such as air friction or internal forces, the body will keep on vibrating indefinitely and such vibration is called free vibration.

$$\left[\text{Natural vibration } (n) = \frac{1}{2\pi}\sqrt{\left(\frac{k}{m}\right)}\right]$$

Forced vibration : It can be defined as the vibration in which the body vibrates with a frequency other than its natural frequency under the action of an external periodic force.

e.g.- The vibrations of a bridge under the influence of marching soldier or vibrations of atuning fork when exposed to the periodic force of sound waves.

In both cases the body vibrates because it is subjected to an external periodic force.

Q7. What is end correction in resonance tube experiment?

Ans. In resonance tube experiment, fordetermination of velocity of the sound, the anti node is not formed exactly at the mouth of the resonance tube but at some distance above it. This additional distance is taken as 0.3d, where, d is the internal diameter of the resonance tube. This correction is known as end correction and the corrected length is taken as, L = l + e
L = (f + 0.3d.)

where, l = length of vibrating air column and the formula for the velocity of sound

$V = 4n(l + 0.3d)$ n

Q8. State the formula for velocity of sound with end correction.

Ans. The velocity of sound with end correction is given by

$V = n\lambda = 4n(l + 0.3d)$

Where, V = velocity of sound wave
n - frequency of the tuning fork
λ = wavelength .
l- resonating length of air column
d - inner diameter of tube.

Q9. Distinguish between longitudinal and transverse wave?

Ans.

Sl. no	Transverse waves	Longitudinal waves
1	Particle of the medium vibrate perpendicular to the direction of propagation of the wave.	Particles of the medium vibrate parallel to the direction of propagation of the wave.
2	The medium gets divided into crests and troughs when the wave propagates through it .	The medium gets divided into compression and rarefactions when the wave propagates through it .

Sl. no	Transverse waves	Longitudinal waves
3	One wavelength gets one trough and one rarefraction.	One wavelength contains one compression crest.
4	There is no change in the density of the medium when transverse wave travels through it..	There is a change in the density of medium which is higher in compression region than that in rarefraction region,when longitudinal wave travels through it.
5.	Transverse waves can be polarised.	Longitudinal waves cannot be polarised.

Q10.Distinguish between progressive waves and stationary waves?

Ans.

Sl. no	Progressive waves	Stationary waves
1	The distribution travels forward with a definite velocity.	The distribution remains confined to the region where it is produced.
2	Each particle of the medium executes SHM about its mean position with the same amplitude .	Except nodes, all particles of the medium executes SHM with varying amplitude.
3.	There is a continuous change of phase from one particle to the next.	All the particles between two successive nodes vibrates in the same phase ,but the phase reverses for particles between next pair of nodes.
4.	No particle of the medium is permanently at rest.	The particles of the medium at nodes are permanently at rest.
5.	There is a no instant when all the particles are at the mean positions together.	Twice during each cycle,all particles pass through their mean positions simultaneously.

Solved Example

Q1.A tuning fork of frequency 384 Hz produces sound wave of wavelength 86 cm. Find the velocity of sound.

Sol. Given :

$n = 384 Hz$

$\lambda = 86cm = 0.86m$

$v = ?$

We have, $v = n\lambda = (384)(0.86)$

$\therefore \quad v = 330.24 m/s$

Q2.The velocity of wave is 300 m/s. If the frequency of vibration of wave is 300 Hz, calculate the wavelength.

Sol. Given:

$v = 300 m/s$

$n = 300 Hz$

$\lambda = ?$

We have, $v = n\lambda$

$\therefore \quad \lambda = \frac{v}{n} = \frac{300}{300}$

$\therefore \quad \lambda = 1m$

Q3. A body produces waves of wavelength 33cm. What is the vibration if velocity of propagation is 330 m/s ?

Sol.Given:

$\lambda = 33cm = 0.33m$

$n = ?$

$v = 330 m/s$

We have, $v = n\lambda$

$\therefore \quad n = \frac{v}{\lambda} = \frac{330}{0.33}$

$n = 1000 Hz$

Q4. An air column of length 17cm in a resononce tube resonates when fork of 500 Hz is used calculate the velocity of sound.

Sol. Given :

$l = 17cm = 0.17m$

$n = 500 Hz$

$v = ?$

$v = 4nl = 4 \times (500) \times (0.17)$

$V = 340 m/s$

Q5. Find the corrected length of air column in a resonance tube of diameter 4.cm if the length of the resonationg air column, for the first resonance is 18.8 cm.

Sol. Given:

$l = 18.8cm$, diameter = D = 4cm,

corrected resonating length = ?

Corrected resonating length, L = (l + 0.30 D) [18.8+(0.3×4)]

L = 20 cm

Q6. A vibrating body sends waves of 110 cm wavelength in air and 480 cm wavelength in water. If velocity of sound in air is 330 m/s find velocity of sound in water.

Sol. Given :

$\lambda air = 110cm = 1.1m$

$\lambda water = 480cm = 4.8m$

$v = n\lambda$

$\therefore \quad V_{air} \propto \lambda_{air}$

and $\quad V_{water} \propto \lambda_{water}$

Divding equation (2) by equation (1),

$$\frac{V_{water}}{V_{air}} = \frac{\lambda_{water}}{\lambda_{air}}$$

$$\therefore \quad V_{water} = \frac{\lambda_{water}}{\lambda_{air}} \times V_{air} = \frac{4.8}{1.1} \times 330$$

$$\therefore \quad V_{water} = 1440 \ m/s$$

Q7.If the broad casting frequency of wave is 20× 10⁶Hz, Calculate its wavelength?

Ans.Given:n=20×10^6Hz

Here, the velocity of a radiowave is equal to the velocity of light, that is

v= 3×10^8m/s

we know that,

$v = n\lambda$

$\lambda = \frac{v}{n}$

$= \frac{20 \times 10^6}{3 \times 10^8}$

$= 6.67 \times 10^{-2} m$

7.2 Acostiecs of Building

Multiple Choice Question

1. Intensity of loudness depends on
(a) Amplitude of vibrating body
(b) Change of momentum and force
(c) Distance form the vibrating body
(d) All the factors mentioned above
Ans.(d)

2. The persistence of sound in a hall is called
(a) reverberation (b) articulation
(c) acoustics (d) resonatce
Ans.(a)

3. Pitch of sound:
(a) Depend upon on its frequency
(b) Do not depend on its frequency
(c) Depend on its amplitude
(d) None of these
Ans. (a)

4. For a good acoustic quality hall it is necessary that :
(a) Reverberation time is more
(b) Reverberation time is less
(c) Reverberation time is zero
(d) None of these
Ans. (d) None of these

5. Reverberation time can be controlled by:
(a) Adjusting the volume of hall
(b) By increasing the sound absorption
(c) By adjusting effective area of absorption
(d) None of the above
Ans. (a)

6.Loudness of sound is measured by
(a)Joule (b)Candela (c)Decible (d) meter
Ans.(c)

7. The time of reverberation of a hall can be reduced by using
(a) reflectors (b) absorbers (c) domes (d) archs
Ans.(b)

8. The reverberation time for good music sound be
(a) 0.5 to 1.50 sec (b) 1.50 to 2 sec
(c) 2 to 3 sec (d) 3 to 4 sec
Ans.(b)

9. The walls of hall built for music concerns shouls
(a) amplify sound (b) reflect sound
(c) transmit sound (d) absorb sound
Ans.(d)

10. The frequency of audible sound is
(a) 20 Hz to 20000 Hz (b) 20 Hz to 10000 Hz
(c) 20 Hz to 2000 Hz (d) 20 kHz to 2000 kHz
Ans.(a)

11. For good audibility, the reverberation time is nearly
(a) 0.1 sec (b) 1.50 sec (c) 10 sec (d) 100 sec
Ans.(b)

12. The Sabine is the unit of
(a) energy (b) reverberation time
(c) absorption in a wall (d) reflection by a wall
Ans.(c)

13. Which of the following material has lowest absorbing power at medium frequency?
(a) stone (b) asbestos (c) plaster (d) glass
Ans.(a)

14. The quality of musical note is termed as
(a) echo (b) reverberation (c) pitch (d) timbre
Ans.(d)

15. Reverberation time is time during which the intensity of sound falls
(a) to one-millionth of its maximum intensity
(b) by one-millionth of its maximum intensity
(c) to 60 dB
(d) None of the above
Ans.(a)

16. Loudness of sound in measured by
(a) joule (b) candela (c) decibel (d) nanometer
Ans.(c)

17. Reverberation time (in second) of a broadcasting room sould be
(a) 0 (b) 1 (c) ∞ (d) None of the above

Ans.(a)

18. **Reverberation time (in second) of a concert hall should be**
(a) 0 (b) 1 (c) 1.5 (d) 2

Ans.(d)

19. **Human heaving are sensitive to sound around**
(a) 1-2 kHz (b) 2-4 kHz (c) 4-8 kHz (d) 5-10 kHz

Ans.(b)

20. **Reverberation time (in second) of an opera house should be**
(a) 0 (b) 1.0 (c) 1.5 (d) 2.0

Ans.(c)

21. **Reverberation time (in second) of a dead room is**
(a) 0 (b) 1 (c) 2 (d) ∞

Ans.(a)

22. **Reverberation time (in second) of open air space is**
(a) 0 (b) 1 (c) 2 (d) ∞

Ans.(a)

23. **Reverberation time (in second) of a lecture room should be**
(a) 0 (b) 1.0 (c) 1.5 (d) 2.0

Ans.(b)

24. **Intensity level or relative intensity is**
(a) $I_I = K$ (b) $I_L = K \log I_0$
(c) $I_L = K \log I_{10}\left(\frac{I}{I_0}\right)$ (d) $I_L = K \log\left(\frac{I_0}{I}\right)$

Ans.(c)

25. **Reverberation time for a hall is the time required for the intensity to drop by**
(a) 30 dB (b) 40 dB (c) 60 dB (d) 80 dB

Ans.(c)

Answer the following questions

Q1. What do you mean by acoustics of building.

Ans. Acoustics which deals with the design and construction or planning of various buildings or hall such that sound produced inside the building (hall) is clearly heard (clear sound) at all places in the hall without any confusion.

Q2. Define the following terms - Intersity and loudness of sound, Echo, Pitch of a sound.

Ans. Intensity of sound : The intensity of sound at a point through the unit area of the medium in unit time. It sound energy spreads uniformly in all directions, then the intensity of sound at a point is inversely proportional to the square Of the distance from the source.

$$I = \frac{1}{d^2}$$; S.I unit of intensity is watt /m²

Loudness of Sound: Loudness is a subjective measurement of sound power. Loudness can also be defined as an observer's auditory impression of the strength of second. For ex:- In case of a young person and old person sitting on the same bench away from a speaker. the intensity is same but loudness for the younger person is more than that of the older person.

Echo: It is defined as the same sound heard again after on interval of $\frac{I}{10}th$ Sound from a surface which is at a distance greater than 16.5 meter from the source of sound.

Pitch of a Sound: Pitch is a perceptual property of sounds that allows their ordering on a frequency-related scale, or more commonly, pitch is the quality that makes it possible to judge sounds as "higher" and "lower" in the sense associated with musical melodies. Pitch can be determined only in sounds that have a frequency that is clear and stable enough to distinguish from noise. Pitch is a major auditory attribute of musical tones, along with duration, loudness, and timbre.

Q3. What is meant by reverberation and reverberation time? State the conditions for good acoustics of a building.

Ans. Reverberation : It is defined as the peersistance of sound due to multiple reflection in a hall even after the source of sound is cut-off. However, the sound goes on becoming weaker after every reflection as part of the sound energy is absorbed by the reflecting surface.

Reverberation time : The time for which the sound persists in a hall even after the source is cut-off is called reverberation time.

Standard reverbration time is the value of reverbration time which is suitable for certain volume of a hall.

Some important condition for good acoustics given below :

(i) The sound produced should be uniformly distributed through out the hall and should clearly heard at all parts of the hall.
(ii) The sound should bee heard at all parts of hall sufficiently loudly.
(iii) The consecutive musical notes or spoken words should be districtly heard and there should be no overlapping on them.
(iv) The reverberation time of a hall should have a proper value depending upon the types of sound produced.
(v) The echelon effect should be absent.
(vi) There should not be any concentration of sound at a particular points in the hall as in case of whispering galleries, because in such case, the sound is clearly hard at some points only, but not heard at all other points in the hall which is most undersirable.
(vii) The external sound should not be allowed to enter the hall as these sound & from the outside will produce udesirable confusion in the sound which is produced in the hall.

Q4. What are the factors affecting acoustical planning of auditorium?

Ans. The factor which effect the accoustical planning of auditorium are given below:

(i) Echo (ii) Reverberation (iii) Reverberation time
(iv) Creep (v) noise

(i) Echo : The reflection of sound is known as echo. It can controlled by the reducing the distance between the source of sound and reflecting surface blow 16.5 meter. Due to this original and reflected sound mixed partically.

(ii) Reverbration : When the reflected sound heared no. of times, then it is called reverberation. Due to this original sound cannot heared clearly. It can be controlled by the installing sound absorbing elements in the walls and ceiling of the hall.

(iii) Reverberation time : The time for which the sound persists in a hall even after the source is cut-off is called reverbration time. It can be controlled by the increasing

(iv) Creep : Creep occurs because of reflection of sound along curved surface most of the time in architecture point of view, the ceilings of auditorium are in dome shape. If the source of sound is close to dome then sound can be heard at other side. It can be controlled by placing the source of sound far below the dome.

(v) Noise : The external sound sources produces noise in the auditorium. So it can controlled by the making the auditorium sound proof.

Q5. Give sbine's equation to find reverberation time.

Ans. Sabine's formula to find reverberation time

$$t = \frac{0.166V}{\sum Sa}$$

Where t = reverberation time
V= volume of hall
S= surface area
a=coefficient of absorption.

Q6. Define bel and decibel?

Ans. Decibel: The decibel (dB) is used to measure sound level, but it is also widely used in electronics, signals and communication. The dB is a logarithmic way of dscribing a ratio. The ratio may be power, sound pressure, voltage or intensity or several other things.

Bel: In electronics and communications, the Bel expresses the logarithmic ratio between two levels of signal power, voltage, or current.

Q7. Distinguish between loudness and intensity?

Ans.

Sl. no	Loudness	Intensity
1.	It is a degree of sensation produced on the ear.	It is the quantity of sound energy flowing across unit area in unit time.
2.	It varies from listener to listener.	It is independent of listener.
3.	It is a physiological quantity.	It is a physical quantity.
4.	It unit is sone.	Its unit is W/m²

Solved Example

Q1. An auditorium of volume 6550 m has reverberation time of 2 seconds. If the total absorbing surface in the hall is 4990 m² find the coefficient of absorption.

Sol. Given ,
$V = 6550\ m^3$, $T = 2$ sec., $S = 4990\ m^2$, α =?

Since, $T = \frac{0.165v}{\alpha s}$

$\therefore \alpha = \frac{0.165v}{T.s}$

$= \frac{0.165 \times 6550}{2 \times 4990} = 0.10829 O.W.U$

Q2. A lecture hall has a total surface absorption of 180 O.W.U. The reverberation time so calculate is 3.50 sec. Find the volume of the hall.

Sol. Given : $\sum \alpha s$ = 180 O.W.U. T = 3.50 sec, v = ?

$$T = \frac{0.165v}{\sum \alpha s}$$

$$\Rightarrow \frac{T \times \sum \alpha s}{0.165} = v$$

$$\therefore v = \frac{3.50 \times 180}{0.165} = 3818.18 m^3$$

Q3. The intensity of sound in a street during heavy traffic is 10^{-6} Wm^{-2}. Calculate the intensity level in dB.

Sol. Given, $I = 10^{-6}\ Wm^{-2}$

We know $I_0 = 10^{-12}\ Wm^{-2}$

Hence
$$I_L = 10 \log_{10}\left(\frac{I}{I_0}\right)$$
$$= 10 \log_{10}\left(\frac{10^{-6}}{10^{-12}}\right)$$
$$= 10 \log_{10} 10^6 = 10 \times 6\ dB$$
$$= 60\ dB$$

Q4. Calculate the intensity level in dB at a distance of 15 m from a source which radiates energy at the rate of 3.56 W. The reference intensity is 100 Wm^{-2}.

Sol. Given, $Q = 3.56$ W

$r = 15$ m

$I_0 = 100\ Wm^{-2}$

We know that,
$$I = \frac{Q}{A} = \frac{3.56}{4\pi r^2}$$
$$= \frac{3.56}{4 \times 3.14 \times (15)^2} = \frac{3.56}{2826}$$
$$= 1.2597 \times 10^{-3}\ Wm^{-2}$$

We also know that,
$$I_l = 10\log_{10}\left(\frac{I}{I_0}\right) = 10\log_{10}\left(\frac{1.2597 \times 10^{-3}}{100}\right)$$
$$= 10\log_{10}(1.2597 \times 10^{-5})$$
$$= 10 \times (-4.8997)$$

Hence $I_L = -48.997$ dB

Q5. What is the resultant sound level when a 70 dB sound is added to a 80 dB sound?

Sol. Given, $I_L = 70$ dB

$I_{l_2} = 80\ dB$

We know that, $I_{l_2} = 10\log_{10}\left(\frac{I_1}{I_0}\right)$

Hence,
$$70 = 10\log_{10}\left(\frac{I_1}{I_0}\right)$$
$$\frac{I_1}{I_0} = 10^7$$

or $I_1 = 10^7 I_0$

Similarly, $80 = 10\log_{10}\left(\frac{I_2}{I_0}\right)$

Hence,
$$\frac{I_2}{I_0} = 10^8$$
$$I_2 = 10 \times 10^7 I_0$$

Now $I = I_1 + I_2$
$$= 10^7 I_0 + 10 \times 10^7 I_0 + 11 \times 10^7 I_0$$

Now,
$$I_l = 10\log_{10}\left(\frac{I}{I_0}\right)$$
$$= 10\log_{10}(11 \times 10^7)$$
$$= 10 \times 8.0413 = 80.41 \text{ dB}$$

Therefore, the resultant intensity is 80.41 dB

Q5. A concrete hall of volume 2500 m³ has a total surface absorption of 205. Find the reverberation time.

Sol. Given, $V = 2500\ m^3$

$\Sigma\alpha S = 205$

Now
$$T = \frac{0.167V}{\Sigma\alpha S}$$
$$= \frac{0.167 \times 2500}{205} = 2.036 \text{ sec}$$

Q6. A hall of volume 5000 m³ has reverberation time of 2 seconds. If the absorbing surface in the hall amounts to 3[illegible] m², determine the coefficient of absorption.

Sol. Given, $V = 5000\ m^3$

$T = 2$ sec

$\Sigma S = 3320\ m^2$

Now
$$T = \frac{0.167V}{\Sigma\alpha S}$$

Hence,
$$\alpha = \frac{0.167V}{T\Sigma S}$$
$$= \frac{0.167 \times 5000}{2 \times 3320} = 0.125\ O.W.U.$$

Q7. A hall of volume 6000 m³ has a reverberation time of [illegible] The surface area of the sound absorbing surface is 25[illegible] m². Calculate the average coefficient of absorption.

Sol. Given, $V = 6000\ m^3$

$T = 4s$

$S = 2500\ m^2$

We know that,

Now,
$$T = \frac{0.167 \times V}{\Sigma\alpha S}$$

Hence,
$$4 = \frac{0.167 \times 6000}{\alpha \times S}$$

or
$$\alpha = \frac{0.167 \times 6000}{4 \times 2500} = 0.1002\ OWU \text{ or sabin}$$

Q8. The volume of a hall is 475 m³. The area of wall is 200 m², area of floor and ceiling each is 100 m². If absorption coefficient of the wall, ceiling and floor are 0.025, 0.02 and 0.55, repectively. Calculate the reverberation time for the hall.

Ans.Given, $V = 475\ m^3$; $S_1 = 200\ m^2$; $S_2 = 100\ m^2$; $S_3 = 100\ m^2$

$$\alpha_1 = 0.025\ O.W.U.; \alpha_2 = 0.02\ O.W.U.; \alpha_3 = 0.55\ O.W.U.$$

Now
$$T = \frac{0.167V}{\Sigma\alpha S}$$
$$= \frac{0.167 \times 475}{0.025 \times 200 + 0.02 \times 100 + 0.55 \times 100}$$
$$= \frac{79.325}{5 + 2 + 55} = \frac{79.325}{62} = 1.2794 \text{ sec}$$

2019

Engineering Physics-I

Q.1. Choose the correct answer of the following questions:

(i) Which is a fundamental quantity?

(a) Length (b) Velocity

(c) Acceleration (d) Force

Ans.(a)

(ii) Which is a vector quantity?

(a) Force (b) Work

(c) Speed (d) Distance

Ans.(a)

(iii) Dimension of work is-

(a) ML^2T^{-2} (b) ML^4T^{-2}

(c) M^2LT (d) MLT

Ans.(a)

(iv) A liquid does not wet a solid surface if the angle of contact for pair of liquid and solid is -

(a) 0^0 (b) 90^0 (c) 60^0 (d) 120^0

Ans.(d)

(v) Ratio among the coefficients of linear expansion, superficial expansion and cubical expansion is -

(a) 3 : 5 : 4 (b) 1 : 2 : 3

(c) 4 : 3 : 5 (d) 5 : 3 : 4

Ans.(b)

(vi) What type of wave carry sound in air?

(a) Transverse wave (b) Longitudinal wave

(c) Electromagnetic wave (d) None of the above

Ans.(b)

(vii) Equation for kinetic energy is-

(a) $\frac{1}{2}mv^2$ (b) mv^2

(c) $\frac{1}{2}mv^2v^2$ (d) m^2v^2

Ans.(a)

(viii) The gravitational force between two bodies is-

(a) attractive (b) repulsive

(c) both (a) & (b) (d) none of these

Ans.(c)

Q.2(a) State and explain Newton's laws of motion.

Ans. *Refers to chapter 2 Q.no. 4*

Q.2(b) Find the significant figures in the following numbers:

(i) 1.080 (ii) 0.0018 (iii) 108 (iv) 5.98 × 10¹¹

Ans. (i) 4 (ii) 3 (iii) 3 (iv) 3

Q.3(a) Define angular displacement, angular velocity and angular acceleration. Establish the relation between linear velocity and angular velocity.

Ans. *Refers to chapter 2.2 Q.no. 1 & 2.*

Q3.(b) State and explain Newton's law of gravitation.

Ans. *Refers to chapter 3 Q.no. 1.*

OR

Q3.Define gravitational constant and write the S.I. unit of it.

Ans. *Refers to chapter 3 Q.no. 2.*

Q4.(a)State Hook's law. Define young's modulus; bulk modulus and modulus of rigidity.

Ans. *Refers to chapter 5 Q.no. 2 & 5.*

Q4.(b) Define surface tension. Write its S.I. unit. What is the effect of impurities and tempereature on the surface tension?

Ans. *Refers to chapter 5.2 Q.no. 3.*

Q5.(a) Write Newton's laws of viscosity and define coefficient of viscosity. Write its dimension formula.

Ans. *Refers to chapter 5.3 Q.no. 1.*

Q5.(b) Explain linear expansion, superficial or serial expansion and cubical expansion.

Ans. *Refers to chapter 6 Q.no. 5.*

Q6.(a) Define Amplitude, Time period, frequency and wavelength.

Ans. *Refers to chapter 7 Q.no. 1.*

Q6.(b) Define reverberation time. Write the conditions for good acoustics of building.

Ans. *Refers to chapter 7.2 Q.no. 3*

Q7. A block of wood of mass 3kg is lying on the frictionless table. A force of 9N is applied on it for 10 seconds. Calculate the kinetic energy.

Ans. Given: $m = 3kg, F = 9N$

$\therefore$ Acceleration, $a = \frac{F}{m} = \frac{9}{3} = 3m/s^2$

Velocity attained by body after 10 second.
$$V = 4 + at$$
$$\Rightarrow V = 0 + 3 \times 10$$
$$= 30\ m/s$$

$\therefore$ K.E of the body $= \frac{1}{2}mv^2$

$= \frac{1}{2} \times 3 \times 30 \times 30$

$= 1350$ J

2018

Engineering Physics-I

Q1.Choose the correct answer:

(i) How many significant degits are in 0.04058?

(a) 4 (b) 5 (c) 6 (d) 3

Ans.(a)

(ii) When we kick a stone, we get hurt this is due to

(a)Reaction (b)Velocity (c)momentum (d)inertia

Ans.(c)

(iii) The mass of the body is halved and its speed is doubled. What happen to the K.E of the body

(a) double (b)4 times (c) 8 times (d) remains unchanged

Ans.(b)

(iv) Viscosity is a property of

(a)liquid only (b)Solid only

(c)solid and liquid only (d)liquid and gases only

Ans.(d)

(v) The spherical shape of rain drop is due to

a)density of water (b)atmospheric pressure

c)gravity (d)surface tension

ns.(d)

i) Which one of the following substances possess the highest elasticity?

)rubber (b)glass (c)steel (d)copper

ns.(c)

i) As we go from equator to poles, the value of g

remains the same (b)increases

lecreases (d)decreses upto a latitude of 45°

.(b)

) A thin circular disk has a concentric hole in it. The disc is heated, the volume of the cavity will

ncrease (b) decrease

main unchanged (d)none of these

Ans.(b)

(ix) Echo is

(a)ghost talking (b)double vibration of air

(c)reflection of sound (d)none of these

Ans.(c)

(x) In a stationary wave, node is a point having

(a)maximum density (b)maximum displacement

(c)minimum amplitude (d)maximum stress

Ans.(c)

Q2.(a)State and explain Newtons law of gravitation? define gravitational constant(G). What is its S.I units?

Ans. Refers to chapter 3 Q. no. 1 & 2

Q2.(b)What is simple harmonic motion ? Find the expressi for velocity and acceleration of a body executing SH

Ans. Refers to chapter 2.2 Q. no. 3 & 4

Q3.(a)Define the term:accuracy, precision, absolute error a percentage error.

Ans. Refers to chapter 1 Q. no. 7 & 9

Q3.(b)Define surface tension and write its S.I unit. How you explain pheonomenon on the basis of molecul theory?

Ans. Refers to chapter 5.2 Q. no. 2 & 3

Q4.(a) State and explain Newton's laws of motion.

Ans. Refers to chapter 2.1 Q. no. 4

Q4.(b)What are the concept of scalar and vector quantities

Ans. Refers to chapter 2.1 Q. no. 1

Q5.(a)Defines Acoustics . What are the condition for go acoustics ?

Ans. Refers to chapter 7.2 Q. no.1 & 3

Q5.(b)Explain the differents modes of transmission of heat w examples.

Ans. Refers to chapter 6 Q. no. 1

Q6.Define work, energy and power. What is work- ener principle ?

Ans. Refers to chapter 4 Q. no. 6 & 8

Q7.(a)Define stress and strain with there types . Also write the unit?

Ans. Refers to chapter 5.1 Q. no. 2 , 3 & 4

Q7.(b)Calculate the strain produced in a material if the stress the 2000kg/m² and $Y = 2 \times 10^6$ kg/m².

Ans. Refers to chapter 5.1 (Solved Example)

Q8.What is viscosity ? State Newtons law of viscocity and derive the expression for coefficient of viscocity .

Ans. Refers to chapter 5.3 Q. no. 1 & 4

Q9.Define amplitude, period, frequency and wavelength.

Ans. Refers to chapter 7.1 Q. no. 1

OR

Q. If the broad casting frequency of wave is 20×10^6Hz, Calculate its wavelength?

Ans. Refers to chapter 7.1 Q. no. 7

2017

Engineering Physics-I

Q1. Choose the correct answer in the following questions :

(i) Which of the following is not a unit of time ?

(a) Second (b) month

(c) year (d) light year

Ans. (d)

(ii) Steel is preferred for making springs over copper. Why?

(a) Steel is cheaper

(b) Young's modulus of steel is more than that of copper

(c) Young's modulus of copper is more than that of steel

(d) Steel is less likely to be oxidised

Ans. (b)

(iii) The surface tension does not depend upon

(a) nature of the liquid (b) temperature

(c) Presence of impurities (d) atmospheric pressure

Ans. (c)

(iv) Viscosity is exhibited by

(a) solids, liquids and gases (b) only solids & liquids

(c) only liquids & gases (d) only gases & solids

Ans. (b)

(v) The equation for the adiabatic change in a gas is PV^r = a constant, where r stands for { where Cp and Cv represent the principal specific heats of the gas }

(a) Cv/ Cp (b) Cp - Cv (c) Cp . Cv (d) Cp/Cv

Ans. Out of syllabus

(vi) Thrmal conductivity of a material depends upon

(a) temperature difference (b) area

(c) thickness (d) None of the above

Ans. (a)

(vii) When light travels from air to glass, which of the following properties does not change ?

(a) Frequency (b) velocity

(c) Amplitude (d) Wavelength

Ans. out of syllabus

(viii) When a stone is dropped on the surface of the still water the wave produce are

(a) transverse (b) longitudinal

(c) stationary (d) None of the above

Ans. (d)

(ix) Laser light is produced by

(a) Spontaneous emission (b) stimulated emission

(c) Stimulated absorption (d) spontaneous absorption

Ans. out of syllabus

(x) Who discovered X - rays ?

(a) Lave (b) Moseley

(c) Compton (d) Roentgen

Ans. Out of syllabus

Q2. (a) Define the terms - accuracy, precision and error. Explain absolute error, relative error & percentage error. What are significant figure ?

Ans. Refers to chapter 1 Q. no. 7, 9 & 10

Q2.(b) What do you understand by Modulus of Elasticity ? Explain young's Modulus, Bulk Modulus & Modulus of rigidity. Also write the relation between them.

Ans. Refers to chapter 5.1 Q.no. 5

Q3. (a) Define surface tension. Explain the phenomenon of surface tension on the basis of molecular theory. What is the effect of impurity on surface tension ?

Ans. Refers to chapter 5.2 Q.no. 3 & 2

Q3.(b) What do you mean by viscosity ? Define coefficient of viscosity and give its S.I. unit. Also explain the terms streamline flow, turbulent flow & critial velocity.

Ans. Refers to chapter 5.3 Q.no. 1 & 5 .

Q4. Explain dispersion and diffraction of light along with ray diagram. What is polarization ?

Ans. Out of syllabus.

Q5. What do you understand by fundamental and derived quantities ? Give examples.

Ans. Refers to chapter 1 Q.no. 3

Q6. Explain the modes of transmission of heat .

Ans. Refers to chapter 6 Q.no. 1

OR

A gas at 30°C is heated at constant pressure till its volume is doubled. Calculate the final temperature of the gas.

Ans. Out of syllabus

Q7. state Einstein photoelectric equation and write the properties of photon. Find maximum kinetic energy of photoelectrons ejected from surface of metal when light of frequency 1×10^{15} Hz (given threshold wave - length for metal = 4500 A) is incident on it.

Ans. Out of syllabus.

Q8. What is the difference between free vibration forced vibration and resonance ? Give one example of each case.

Ans. Refers to chapter 7.1 Q.no. 5 & 6

Q9. A tunning fork of frequency 480 Hz resonates with air columm of length 16 cm, the end correction is 5mm. calculate the velocity of sound in air.

Ans. Refers to chapter 7.1 (Solved Example - 1)

Q10. Give the full form of LASER. Describe spontaneous emission, stimulated emission and population inversion in case of laser.

Ans. Out of syllabus.

OR

What are X- rays ? Explain the production fo X- Rays using Coolidge tube ?

Ans. Out of syllabus.

2016

Engineering Physics-I

Q.1.Choose the correct answer in the following question:

(i) Hooke's law essentially defines.

(a) stress (b) strain
(c) yield point (d) elastic limit

Ans.(d)

(ii) The surface tension is pure water as compared to that of soap solution is

(a) less (b) more
(c) same (d) depends upon the nature of soap

Ans.(a)

(iii) The flow of liquid is laminar or stream lined is determined by

(a) rate of flow of liquid (b) density of liquid
(c) radius of tube (d) co-efficient of viscosity

Ans.(a)

(iv) The S.I. unit of co-efficient of thermal conductivity is

(a) walt-kelvin metre (b) joule
(c) watt/m-k (d) joule/second

Ans.(c)

(v) The gas law pv = constant holds good for

(a) isothermal changes (b) adiabatic changes
(c) both isothermal and adiabatic changes
(d) None of the above

Ans.(b)

(vi) The refractive index of glass is 1.5. The velocity of light in glass is.

(a) 0.67 m/s (b) 4.5 m/s
(c) 2 m/s (d) 1.986×10^8 m/s

Ans.(d)

(vii) The velocity of sound in vacuum is

(a) 0 m/s (b) 330 m/s
(c) 156 m/s (d) 1000 m/s

Ans.(a)

(viii) Work function is the energy required

(a) for acceleration the atom
(b) for producing x-rays
(c) for taking out the election just on the metal surface
(d) for charging the atom

Ans.(a)

(ix) X-ray exposure is most dangerous for

(a) bones (b) skin
(c) lungs (d) white blood carpuscles

Ans.(d)

Q.2 What is an error ? Explain the terms :

(i) Absolute error (ii) Relative error

Ans. Refers to Chapter 1 Q.no. 9

Q.3 Explain young's modulus, Bulk modulus and modulus of rigidity. Also write the relation between them ?

Ans. Refers to Chapter 5.1 Q.no. 5

Q.4 Define surface tension and write its S.I. unit. What is the effect of impurity and temperature on surface tension ?

Ans. Refers to Chapter 5.2 Q.no. 3

Q.5 What is viscosity ? Define co-efficient of viscosity and write its S.I. unit. What is Reynold's number ?

Ans. Refers to Chapter 5.3 Q.no. 1 & 2

Q.6 Write the laws of thermal conductivity and define co-efficient of thermal conductivity ?

Ans. Refers to Chapter 6 Q.no. 3

OR

Q . Describe the various modes of transfer of heat by giving one example of each.

Ans. Refers to Chapter 6 Q.no. 1

Q.7 State and explain Boyle's law and charle's law ?

Ans. Out of Syllabus

Q.8 Explain reflaction of light with a neat ray diagram. What is snell's law ? Also give the physical significance of refractive index ?

Ans. Out of Syllabus

Q.9 Describe the construction and working of He-Ne laser?

Ans. Out of Syllabus

Q.10 Define the terms : longitudinal wave, transverse wave, stationary wave, node and antinode ?

Ans. Refers to Chapter 7.1 Q.no. 3

Q.11 What is the concept of photon ? State plank's hypothesis and write the properties of photon ?

Ans. Out of Syllabus

Q.12Describe in brief the production of X-rays using coolidge tube ?

Ans. Out of Syllabus

2015

Engineering Physics-I

Q.1 Choose the correct answer in the following question :

(i) The maximum value of stress for which Hooke's law holds good is called

(a) elasticity (b) strain
(c) elastic limit (d) young's modulus

Ans. (c)

(ii) A liquid does not wet a solid surface if the angle of contact for the given pair of liquid and solid surfaces is

(a) 0^0 (b) 90^0 (c) 60^0 (d) 120^0

Ans.(d)

(iii) For a liquid of density ρ and co-efficient of viscosity η, flowing through a pipe of diameter d, Reynold's number is given by

(a) $\frac{\rho V_c d}{\eta}$ (b) $\frac{\rho \eta d}{V_c}$

(c) $\frac{\rho V_c \eta}{d}$ (d) $\frac{\rho V_c d}{\rho}$

Ans.(a)

(iv) Ratio among the co-efficients of linear expansion (α), superficial expansion (β) and cubical expansion (γ) is :

(a) 3 : 2 : 1 (b) 1 : 2 : 3
(c) 4 : 3 : 2 (d) all of the above

Ans.(b)

(vi) Which of the following is a unit of specific heat ?

(a) Jkg^0C^{-1} (b) J/kg^0C
(c) kg^0C/J (d) J/kg^0C^{-2}

Ans.(b)

(vii) Photons of frequency f are incident on a metal surface of threshold frequency f_o. The maximum kinetic energy of emitted photo electrons is

(a) $h(f - f_0)$ (b) hf
(c) $h f_0$ (d) $h(f + f_0)$

Ans.(a)

(viii) The splitting of a beam of white light into different colours is known as

(a) refraction (b) reflection
(c) interference (d) dispersion

Ans.(d)

(ix) What type of waves carry should in air ?

(a) Transverse waves (b) Longitudinal waves
(c) Electromagnetic waves
(d) Transverse and longitudinal waves

Ans.(b)

(x) What happens when fast moving electrons strike a metallic target in an evacuated glass bulb ?

(a) γ -rays are produced (b) X-rays are produced
(c) β -particles are produced (d) Reflected back

Ans.(b)

Q.2(a) Define stress, strain and elastic limit. Also state Hook's law.

Ans. Refers to Chapter 5.1 Q.no. 2

Q.2(b) Define the terms - Viscosity, velocity gradient and co-efficient of viscosity. What is Reynold's number ?

Ans. Refers to Chapter 5.3 Q.no. 1, 2 & 3

Q.3(a) Define surface tension and write its S.I. unit. What is angle of contact ?

Ans. Refers to Chapter 5.2 Q.no. 3 & 4

Q.3(b) State the principle of superposition of waves. Also explain the phenomenon of interference of light.

Ans.: Out of Syllabus

OR

Q.3(a)Explain capillary action with examples. What is the shape of meniscus for water and mercury in a capillary tube ? Also write a relation between surface tension, capillary rise and radius of capillary tube.

Ans. Refers to Chapter 5.2 Q.no. 5

Q.3(b)What do you know about reflection and refraction of light ? State Snell's law.

Ans. Out of Syllabus

Q.4.(a) Define wave motion, frequency and wavelength of a wave. Also establish a relation between wave velocity frequency and wavelength.

Ans.Refers to Chapter 7.1 Q.no. 1 & 2

Q.4(b) What is photo electric effect and what are its characteristics ?

Ans. Out of Syllabus

OR

Q.4(a) Describe the construction and working of a photoelectric cell in brief.

Ans.Out of Syllabus.

Q.4(b) What are longitudinal waves, transverse waves and stationary wave ? Also define node and antinode.

Ans. Refers to Chapter 7.1 Q.no. 3

Q.5 What are significant figures ? Write the rules to identify significant figures in a given measurement.

Ans. Refers to Chapter 1 Q.no. 10

Q.6 Define the co-efficients of linear expansion ($\propto$), superficial expansion (β) and cubical expansion (γ).

Ans. Refers to Chapter 6 Q.no. 5

OR

Q. The length of a copper rod at 0^0C is 90cm. When it is heated to 100^0C, Its length increases by 0.14cm. Find the co-efficients of linear expansion (α) and superficial expansion (β) of copper.

Ans. Refers to Chapter 6 (Solved Example- 1)

Q.7 Define the specific heat capacities of a gas at constant volume (C_v) and at constant pressure (C_p).

Ans.: Out of Syllabus

Q.8 What are X-rays ? Write four properties of X-rays.

Ans.Out of Syllabus

OR

Q. Find the minimum wavelength of X-rays produced by ar X-rays tube operated at 20KV.

Ans.Out of Syllabus

Q9.Describe the construction and working of He-Ne Laser.

Ans.Out of Syllabus

OR

Q. Write the full form of Laser. Also explain population inversion and optical pumping.

Ans.Out of Syllabus

2014

Engineering Physics-I

Q.1 Choose the correct answer in the following question :

(i) How many basic units are included in S.I ?

(a) 3 (b) 4 (c) 5 (d) 7

Ans.(d)

(ii) Steel is more elastic than rubber because for a given stress, strain produced in steel is

(a) equal to that in rubber (b) greater than in rubber
(c) less than in rubber (d) none of these

Ans. (c)

(iii) Soap helps in better cleaning of cloths because

(a) it reduces the surface tension of solution
(b) it gives strength to the solution
(c) it absorbs the dirt
(d) chemicals of soap change

Ans. (a)

(iv) The viscous force between two liquid layers is

(a) radial
(b) normal to the liquid surface
(c) tangential to the liquid surface
(d) neither purgly tangential nor purely normal

Ans.(c)

(v) The ratio of co-efficients of cubical expansion and linear expansion is

(a) 1 : 1 (b) 3 : 1 (c) 2 : 1 (d) none

Ans.(b)

(vi) When a ray of light enters a denser medium, it

(a) bends away from the normal
(b) bends towards the normal
(c) goes undeviated (d) is reflected back

Ans.(b)

(vii) LASER is based on the principle of :

(a) total internal reflection (b) refraction
(c) population inversion (d) spontaneous emission

Ans.(d)

(viii) Resonance is an example of

(a) tuning form (b) forced vibrations
(c) free vibrations (d) damped vibrations

Ans.(d)

(ix) In photo-electric effect, the incident photon is

(a) completely absorbed
(b) scattered elasticity
(c) sctteredin elasticity
(d) absorbed and emitted at a greater frequency

Ans. (d)

(x) Specific heats of a gas at constant volume (C_v) and at constant pressure (C_p) are related as

(a) $\frac{C_p}{C_v} = 1 - \frac{R}{J}$ (b) $C_p - C_v = \frac{R}{J}$
(c) $C_p - C_v = \frac{J}{R}$ (d) $C_p + C_v = \frac{R}{J}$

Ans.(b)

Q2.(a) Explain the behaviour of a wire under continuosly increasing load using stress diagram.

Ans.Refers to Chapter 5.1 Q.No. 6 Page No. 25,26

Q2.(b) Define surface tension and write its S.I. unit. What is angle is contact ?

Ans.Refers to Chapter 5.2 Q.No. 3,4 Page No. 28,29

OR

Q2.(a) Explain Young's modulus and Bulk modulus of elasticity and write their S.I. unit.

Ans.Refers to Chapter 5.1 Q.no. 5

Q2.(b) What is effect of impurity and temperature on surface tension.

Ans.Refers to Chapter 5.2 Q.no. 3

Q3.(a) What do you mean by viscosity ? Define co-efficient of viscosity and write its S.I. unit.

Ans.Refers to Chapter 5.3 Q.no. 1

Q3.(b) What is photo-electric effect ? Define work function and write Einstein's photo-electric equation.

Ans.Out of Syllabus

Q4.(a) Define dispersion and diffraction of light along with ray diagram.

Ans.Out of Syllabus

Q4.(b) Define wave motion, amplitude, frequency and wavelength.

Ans.Refers to Chapter 7.1 Q.no. 1

OR

Q4.(a) Define stationary wave, node and antinode.

Ans.Refers to Chapter 7.1 Q.no. 3

Q4.(b) Explain the phenomenon of refraction of light. Also write Snell's law.

Ans. Out of Syllabus

Q.5. Write the fundamental quantities in S.I. with their units.

Ans.Refers to Chapter 1 Q.no. 3

Q.6 State Boyle's law and Charle's law.

Ans.Out of Syllabus

Q.7 Define the co-efficient of thermal conductivity and write its S.I. unit.

Ans. Refers to Chapter 6 Q.no. 3

OR

Q. A thin square metallic sheet at 0^0C has each side 1m. When heated to 100^0C, each side of the metallic sheet becomes 1.01 m. Calculate the coefficients of linear and superficial expansion.

Ans.Refers to Chapter 6 (Solved .Example-2)

Q.8 What is meant by population inversion and optical pumping ?

Ans.Out of Syllabus

Q.9 Write four properties of X-rays.

Ans.Out of Syllabus

OR

Q. A coolidge tube operates at 50 KV. Find the minimum wavelength of X-rays generated.

Ans. Out of Syllabus

2013

Engineering Physics-I

Q.1 Choose the correct answer in the following question :

(i) The S.I. unit of luminous intensity is

(a) lumen (b) watt
(c) candela (d) ampere

Ans. (c)

(ii) Which one of the followings substances possesses the highest elasticity ?

(a) Rubber (b) Glass
(c) Steel (d) Copper

Ans.: (c)

(iii) The drying of hands by towel is due to

(a) evaporation (b) surface tension
(c) capillarity (d) viscosity

Ans.(a)

(iv) The spherical shape of rain drops is due to

(a) density of water (b) atmospheric pressure
(c) gravity (d) surface tension

Ans.(d)

(v) On increasing temperature, the co-efficient of viscosity of a liquid

(a) increase (b) decreases
(c) first increases then decreases (d) remains constant

Ans.(b)

(vi) The pitch of a screw is equal to

(a) the area of its head (b) the thickness of the screw
(c) the length of threading of on it

(d) the distance moved ahead by it in one rotation

Ans.(d)

(vii) Which one of the following statements is true about a gas undergoing an isothermal change ?

(a) The temperature of the gas remains constant
(b) The pressure of the gas remains constant
(c) The volume of the gas remains constant
(d) The gas is completely insulated from the surroundings

Ans.(d)

(viii) The S.I. unit of co-officient of thermal conductivity is

(a) joule (b) watt/m-K
(c) watt-Kelvin-metre (d) joule/second

Ans.(b)

(ix) The specific heat capacities of a gas at constant volume (Cv) and at constant pressure (Cp) are related as

(a) $Cp - Cv = \frac{J}{R}$ (b) $Cp + Cv = \frac{R}{J}$
(c) $\frac{Cp}{Cv} = 1 - \frac{R}{J}$ (d) $Cp - Cv = \frac{R}{J}$

Ans. (a)

(x) A monochromatic beam of light passes from a denser medium to a rarer medium, As a result

(a) its velocity increases (b) its velocity decreases
(c) its frequency decreases (d) its wavelength decreases

Ans. (a)

(xi) The phenomenon of interfererce is used to prove that light is

(a) longitudinal (b) transverse
(c) stationary wave (d) quantized

Ans.(b)

(xii) The main characteristics of LASER radiations are

(a) coherence (b) monochromaticity
(c) high directionality and extreme brightness
(d) all the above

Ans.(d)

(xiii) Which is the case of forced vibrations ?

(a) sound produced in organ pipe
(b) sound produced in flute
(c) vibrations produced in piano string
(d) vibrations produced in telephone transmitter during conversion

Ans.(a)

(xiv) X-ays are emitted due to

(a) the breaking of nucleus
(b) the decay of neutrons
(c) electronic transitions taking place in inner most orbits of target atoms
(d) electronic transitions taking place in valence band of target atoms

Ans.(c)

(xv) The work function of a photo-metal is rerated to

(a) frequency of incident radiation
(b) intensity of incident radiation
(c) the threshold frequency for the metal
(d) shape of the photo-cathode

Ans.(c)

(xvi) X-ray exposure is most dangerous for

(a) bones (b) skin
(c) white blood corpuscles (d) lungs

Ans.(c)

(xvii) Photo-electric cell is a device which converts

(a) light energy into electric energy
(b) chemical energy into electrical energy
(c) electric energy into light energy
(d) magnetic energy into electrical energy

Ans.(a)

(xviii) In a wave motion, the maximum displacement is called

(a) amplitude (b) wavelength
(c) frequency (d) intensity

Ans.(a)

(xix) Electron volt is the unit of

(a) charge (b) potential difference
(c) current (d) energy

Ans.(d)

Q3. Define surface tension and state its S.I. unit. How will you explain this phenomenon on the basis of molecular theory ? What is the effect of impurity on surface tension ?

Ans. Refers to Chapter 5.2 Q.no. 2 & 3

Q.4 What do you understand by isothermal and adiabatic expansion of a gas ? Define the two specific heat capacities of gas and explain why gases have two specific heat capacities while solids and liquids have only one ?

Ans.: Out of Syllabus

Q.5 What do you understand by reflection and refraction of light ? State Snell's law of refraction. What is refractive index and what is its physical significance ?

Ans. Out of Syllabus

Q.6 What are X-rays ? Describe the production of X-rays using Coolidge tube with a neat diagram.

Ans. Out of Syllabus

Q.7 Define stress, strain and elastic limit.

Ans. Refers to Chapter 5.1 Q.no. 2

Q.8 Explain viscosity and co-efficient of viscosity.

Ans. Refers to Chapter 5.3 Q.no. 1

Q.9 Explain the different modes of transmission of heat with examples.

Ans. Refers to Chapter 6 Q.no. 1

Q.10m What are longitudinal and transverse waves? Define stationary wave.

Ans.: Refers to Chapter 7.1 Q.no. 3

Q.11 What is absolute zero temperature and what is its value in centigrade scale ?

Ans. Out of Syllabus

Q.12 Define photo-electric effect and explain Einstein's photo-electric equation.

Ans. Out of Syllabus

Q.13 What is the full form of LASER ? Mention some of the important properties of laser.

Ans. Out of Syllabus

Q.14 A load of 2kg produces an extension of 1mm in a wire of 3 metres in length and 1mm in diameter. Calculate the Young's modulus of the wire.

Ans. Refers to Chapter 5.1 (Solved Example)

Q.15 When a metallic bar is heated from 0^0C to 1000^0C, its length increases by 0.05%. What is the co-efficient of linear expansion of the metal ?

Ans. Refers to Chapter 6 (Solved Example- 4)

Q.16 Find the minimum wavelength of X-rays produced by an X-ray tube operated at 1000 KV. (Given, $h = 6.63 \times 10^{-34}$ joule-sec, $e = 1.6 \times 10^{-19}$ C and $C = 3 \times 10^8$ m/s).

Ans. Out of Syllabus

2012(A)

Engineering Physics-I

Q.1 Choose the correct answer in the following question :

(i) S.I. unit of co-efficient of thermal conductivity is

(a) Wkm (b) $Wk^{-1}m^{-1}$
(c) $Jkg^{-1}s^{-1}$ (d) $Jkg^{-1}k^{-1}$

Ans.(b)

(ii) If a wire is stretched to doubled its length, it's strain is

(a) 2 (b) 1/2
(c) 1 (d) 4

Ans.(c)

(iii) On increasing temperature of a liquid generally it's surface tension

(a) decreases (b) increases
(c) remains same (d) increases than decreases

Ans.(a)

(iv) Which of the following is correct relation for critical velocity.

(a) $V_C = \frac{kr}{\eta \rho}$ (b) $V_C = \frac{k\rho}{\eta r}$
(c) $V_C = \frac{\eta r}{k \rho}$ (d) $V_C = \frac{k\eta}{r\rho}$

Ans.(c)

(v) Which one is the correct relation between the three co-efficients of expansion.

(a) $\frac{\alpha}{3} = \frac{\beta}{2} = \gamma$ (b) $\frac{\alpha}{2} = \frac{\beta}{3} = \gamma$
(c) $\frac{\alpha}{1} = \frac{\beta}{2} = \frac{\gamma}{3}$ (d) $\frac{\alpha}{2} = \frac{\beta}{6} = \frac{\gamma}{9}$

Ans.(c)

(vi) In adiabatic process, which among the following remains constant.

(a) Heat (b) Temperature
(c) Volume (d) Pressure

Ans.(d)

(vii) If refractive index (R.I) of water with respect to air is 4/3 and R.I of glass with respect to air is 3/2 then R.I of glass with respect to water is

(a) $\frac{8}{9}$ (b) $\left(\frac{4}{3} + \frac{3}{2}\right)$
(c) $\frac{9}{8}$ (d) None

Ans. (c)

(viii) Emission of LASER is

(a) Spontaneous (b) Regular
(c) In packets (d) Stimulated

Ans.(d)

(ix) Nature of light waves in air is

(a) Transverse (b) Longitudinal
(c) Transverse & Longitudinal both
(d) None of the above

Ans.(c)

(x) The number of photo electrons from a metal depends upon

(a) Frequency of incident radiation
(b) Wavelength of incident radiation
(c) Velocity of incident radiation
(d) Intensity of incident radiation

Ans.(d)

Q2. What do you mean by accuracy and precision ? Explain error and its various types?

Ans. Refers to Chapter 1 Q.no. 7 & 9

Q3. ***State and explain Hooke's law & various modulus of elasticity ? Also, draw a stress strain diagram and label the various points.***

Ans. Refers to Chapter 5.1 Q.no.2,5 & 6

Q4. ***Explain optical pumping ? Also, explain with neat diagram, the construction and the working of He-Ne Laser.***

Ans.: Out of Syllabus

Q5. ***Explain isothermal and adiabatic expansion of gas ? Also, explain why have gases two specific heat capacity while solids and liquids have only one ?***

Ans.Out of Syllabus

Q6. ***How is X-ray's produced using coolidge tube explain with diagram. What are the application of X-rays ?***

Ans. Out of Syllabus

Q7. ***Explain stress and its types (at least two types).***

Ans. Refers to Chapter 5.1 Q.no. 2.3

Q8. ***How does chalk absorb water or ink ? Explain.***

Ans.: Refers to Chapter 5.2 Q.no. 6

Q9. ***What are streamline and turbulent motion ? What are the characterisrics of a stream line motion.***

Ans.: Refers to Chapter 5.3 Q.no. 5

Q10. ***What do you mean by conduction mode of transmission of heat ? Also explain Co-fficient of thermal conductivity.***

Ans. Refers to Chapter 6 Q.no. 1 & 3

Q11. ***Explain how specific heat capacity of a gas at constant pressure is greater than that at constant volume.***

Ans.: **Out of Syllabus**

Q12. ***Differentiate between free vibration and forced vibration.***

Ans.: Refers to Chapter 7.1 Q.no. 6

Q13. ***Explain construction and working of a photocell?***

Ans.Out of Syllabus

Q14. ***The terminal velocity of raindrop is 30cm/s. Taking the viscosity of air as 1.8×10^{-5} $Nm^{-2}s$. What is the radius of the rain drop. (density of air = 1.29 kg/m^3)***

Ans. Refers to Chapter 5.3 (Solved Example- 11)

Q15. ***What rises in a capillary tube upto a height of 6cm. What will be the rise of water column of radius of the tube is doubled.***

Ans. Refers to Chapter 5.2 (Solved Example- 11)

Q16. ***What amount of heat will flow out per second the throu a wooden window of size 3m × 2m and thickness 8cm, temperature of outside room is 30^0C more than that of insi and thermal conductivity of wood is 1.68 w m^{-1} k^{-1}..***

Ans. Same as 2013, Q. no : 11

Q17. ***Pressure of 1.5 mole of a gas at 27^0C is $10 Nm^{-2}$, then fi out its volume ?***

Ans.Out of Syllabus

Q18. ***Radiation of 6000^0A, wavelength fall on a metal pl of work function 1.8 eV. Calculate the maxim kinetic energy of the emitted electrons 1 eV = 1.6 10^{-19} J, $h = 6.62 \times 10^{-34}$Js. 1 $A^0 = 10^{-10}$m, $C = 3 \times 1$ m/s.***

Ans.: Out of Syllabus