BRILLIANT PUBLIC SCHOOL , SITAMARHI

(Affiliated up to +2 level to C.B.S.E., New Delhi)

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XI - Physics Chapterwise Worksheets with Solution

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CBSE TEST PAPER-01

CLASS - XI PHYSICS (Physical World & Measurement)
Topic: - Physical World & Measurement

1. If x = at + bt^2 where x is in meters and t is in seconds. What are the units of a and b? [1]

2. Fill ups. [1]
 (i) 3.0m/s^2 = --------------------- km/hr^2
 (ii) 6.67 10^{-11}Nm^2/kg^2 = ------------------------- g^{-1}cm^{3}s^{-2}

3. Write S.I unit of luminous intensity and temperature? [1]

4. Calculate the time taken by the light to pass through a nucleus of diameter 1.56 $\times 10^{-16}$ m. (speed of light is 3×10^8 m/s) [2]

5. If force (F) acceleration (A) and time (T) are taken as fundamental units, then find the dimension of energy. [2]

6. Two resistances R$_1$ = $100 \pm 3\Omega$ and R$_2$ = $200 \pm 4\Omega$ are connected in series. Then what is the equivalent resistance? [2]

7. If velocity, time and force were chosen the basic quantities, find the dimensions of mass? [2]

8. Young's modulus of steel is 19×10^{10} N/m^2. Express it in dynes cm^2. Here dynes are the C.G.S unit of force. [3]

9. The velocity υ of water waves may depend on their wavelength λ density of water ρ and the acceleration due to gravity g. Find relation between these quantities by the method of dimension? [3]

10. The force acting on an object of mass m traveling at velocity υ in a circle of radius r is giving by $F = \dfrac{m\upsilon^2}{r}$ [3]

 The measurements recorded as m $m = 3.5kg \pm 0.1kg$

 $\upsilon = 20m/s \pm 1m/s$ $\quad r = 12.5m \pm 0.5m$

 Find the maximum possible (1) fractional error (2) % error in the measurement of force. How will you record the reading?

CBSE TEST PAPER-01

CLASS - XI PHYSICS (Physical World & Measurement)

Topic: - Physical World & Measurement [ANSWERS]

Ans1: $a = \frac{x}{t} = m/s$

$b = \frac{x}{t} = m/s^2$

Ans2: (i) 3.0m/s^2 = $\frac{3\times10^{-3}}{\left(\frac{1}{3600}h\right)^2}$ km/hr^2 = 3.9×10^4 km/hr^2

(ii) 6.67 10^{-11}Nm^2/kg^2 = g^{-1}cm^{3}s^{-2}

$= 6.67\times10^{-11} kg^{-1}m^3s^{-2}$

$= 6.67\times10^{-11}\times10^3\times(10^2 cm)^3$

$= 6.67\times10^{-8} g^{-1}cm^3s^{-2}$

Ans3: S.I unit of luminous intensity is candela (cd) and of temperature is Kelvin (k).

Ans4: $\text{time} = \frac{\text{distance}}{\text{velocity}}$

$\text{time} = \frac{1.56\times10^{-16}}{3\times10^{8}}$

$\boxed{t = 5.2\times10^{-25}\text{ seconds}}$

Ans5: $F = MLT^{-2}$; $A = LT^{-2}$ ---------(1)

F=MA ⇒ M=FA^{-1} → (2)

From equation 1) L = AT^2

∴ Dimensions of energy = ML^2 T^{-2}

$\left[FA^{-1}\ A^2\ T^4\ T^{-2}\right]$

$=\left[FAT^2\right]$

Ans6: Here $R_1 = 100\pm3\Omega$

$R_2 = 200\pm4\Omega$

In series $R_{net} = R_1 + R_2$

$$R_{net} = (100 \pm 3\Omega) + (200 \pm 4\Omega)$$

$$R_{net} = (300 \pm 7)\, ohms.$$

Ans7: force = mass $\times$ acceleration

$$\text{force = mass } \times \frac{\text{velocity}}{\text{time}}$$

$$\frac{\text{time} \times \text{force}}{\text{velocity}} = \text{mass}$$

$$mass = \frac{FT}{V}$$

$$mass = \left[FTV^{-1}\right]$$

Ans8: $$y = \frac{[F]}{\left[L^2\right]} = \frac{MLT^{-2}}{\left[L^2\right]} = \left[ML^{-1}T^{-2}\right]$$

Comparing with $M^a L^b T^c$

$$a = 1, \quad b = -1, \quad c = -2$$

$$n_2 = n_1 \left[\frac{M^1}{M_2}\right]^a \left[\frac{L^1}{L_2}\right]^b \left[\frac{T^1}{T_2}\right]^c$$

$$n_2 = 19 \times 10^{10} \left[\frac{1kg}{1g}\right]^1 \left[\frac{1m}{1cm}\right]^{-1} \left[\frac{1S}{1S}\right]^{-2}$$

$$n_2 = 19 \times 10^{10} \left[\frac{1000g}{1g}\right]\left[\frac{100cm}{1cm}\right]^{-1} [1]^{-2}$$

$$n_2 = 19 \times 10^{10} \left[1000 \times \frac{1}{100} \times 1\right]$$

$$\boxed{n_2 = 19 \times 10^{11}}$$

Ans9: $$\upsilon \alpha \lambda^a p^b g^c$$

$$\upsilon = R\lambda^a p^b g^c \text{ ----------- } (1)$$

Where K is dimensionless constant

$$\left[LT^{-1}\right] = [L]^a \left[ML^{-3}\right]^b \left[LT^{-2}\right]^c$$

$$\left[M^o LT^{-1}\right] = [L]^{a-3b+c} [M]^b [T]^{-2c}$$

$$a - 3b + c = 1$$

$b = 0 \quad \Rightarrow a = \frac{1}{2}$

$-2c = -1$

$c = \frac{1}{2}$ Put these values in equation (1)

$\upsilon = k\lambda^{1/2} P^{o} g^{1/2}$

$\upsilon = k\lambda^{1/2} g^{1/2}$

$$\boxed{\upsilon = k\sqrt{\lambda g}}$$

Ans10: (i) $F = \frac{m\upsilon^2}{r}$

$$\frac{\Delta F}{F} = \frac{\Delta m}{m} + 2\frac{\Delta v}{\vartheta} + \frac{\Delta r}{r}$$

$$\frac{\Delta F}{F} = \frac{0.1}{3.5} + 2\times\frac{1}{20} + \frac{0.5}{12.5}$$

$$\frac{\Delta F}{F} = 0.17$$

(ii) % error in F = 0.17×100 = 17%

(iii) $F = \frac{m\upsilon^2}{r} = \frac{(3.5)\times(20)^2}{12.5}$

$$\boxed{F = 112N}$$

$$\boxed{\Delta F = 19N}$$

$\Delta F = 0.17 \times 112$

Measurement of force $\boxed{F = 112 \pm 19N}$

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Physical World & Measurement)

Topic: - Physical World & Measurement

1. What is the difference between A^{o} and A.U.? [1]

2. Define S.I. unit of solid angle? [1]

3. Name physical quantities whose units are electron volt and pascal? [1]

4. When a planet X is at a distance of 824.7 million kilometers from earth its angular diameter is measured to be 35.72^{11} of arc. Calculate the diameter of 'X'. [2]

5. A radar signal is beamed towards a planet from the earth and its echo is received seven minutes later. Calculate the velocity of the signal, if the distance between the planet and the earth is $6.3x10^{10}$m? [2]

6. Give two methods for measuring time intervals? [2]

7. Find the dimensions of latent heat and specific heat? [2]

8. in Vander Waal's equation $\left(\frac{P+a}{V^2}\right)(V-b)=RT$ [2]

9. E, m, l and G denote energy, mass, angular momentum and gravitational constant respectively. Determine the dimensions of EL^2/m^5G^2 [2]

10. (a) State which of the following are dimensionally current [3]

    (i) Pressure = Energy per unit volume

    (ii) Pressure = Momentum $\times$volume $\times$time

    (b) The density of cylindrical rod was measured by the formula:- $P=\frac{4m}{\pi D^2 l}$

    The percentage in m, D and l are 1%, 1.5% and 0.5%. Calculate the % error in the calculated value of density?

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Physical World & Measurement)
Topic: - Physical World & Measurement [ANSWERS]

Ans1: A° and A.U. both are the units of distances but 1A° = 10^{-10}m and 1A.U. = 1.496×10^{11}m.

Ans2: One steradian is defined as the angle made by a spherical plane of area 1 square meter at the centre of a sphere of radius 1m.

Ans3: Energy and pressure.

Ans4: $r = 824.7\times10^{6} km$

$$\theta = 35.72^{4}$$

$$\theta = \frac{35.72}{60\times60}\times\frac{\pi}{180}\text{ radian}$$

Diameter $l = ?$

$$l = r\theta$$

$$l = 824.7\times10^{6}\times\frac{35.72}{60\times60}\times\frac{\pi}{180}$$

$$\boxed{l = 1.429\times10^{5} km}$$

Ans5: $x = c\times {t}/{2}$

$$\Rightarrow c = {2x}/{t} = \frac{2\times6.3\times10^{10}}{7\times60} = 3\times10^{8} m/s$$

Ans6: (1) Radioactive dating – to know age of fossil fuels, rocks etc.

(2) Atomic clocks – used to note periodic vibrations taking place within two atoms.

Ans7: (1) Latent Heat $= \dfrac{Q(Heat\ Energy)}{m(mass)}$

$$\text{Latent Heat} = \frac{ML^2T^{-2}}{M} = \left[M^oL^2T^{-2}\right]$$

$$\text{(2) Specific heat} = (S) = \frac{Q}{m\times Q}\frac{ML^2T^{-2}}{M\times K}$$

$$(S) = \left[M^oL^2T^{-2}K^{-1}\right]$$

Ans8: $P = {}^{a}\!/\!{}_{V^2} \Rightarrow a = PV^2$

$$a = \frac{F}{A}\times V^2$$

$$a = \frac{MLT^{-2}}{L^2}\times\left[L^3\right]^2$$

$$a = \frac{MLT^{-2}L^6}{L^2}$$

$$a = \left[ML^5T^{-2}\right]$$

$$Also\quad b = V$$

$$V = \left[M^oL^3T^o\right]$$

Ans9: $E = \left[ML^2T^{-2}\right]$

$$L = \left[ML^2T^{-1}\right]$$

$$m = [M]$$

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

$$\therefore \text{Dimensions of } {}^{EL^2}\!/\!{}_{m^5G^2} = \frac{\left[ML^2T^{-2}\right]\left[ML^2T^{-1}\right]^2}{[M]^5\left[M^{-1}L^3T^{-2}\right]^2}$$

$$= \frac{M^3L^6T^{-4}}{M^3L^6T^{-4}} = 1$$

Thus, it is dimension less

Ans10: (a) (i) Pressure $= F/A = \frac{MLT^{-2}}{L^2} = \left[ML^{-1}T^{-2}\right]$

$$\left[ML^{-1}T^{-2}\right] = \frac{ML^2T^{-2}}{L^3}$$

$$\left[ML^{-1}T^{-2}\right] = \left[ML^{-1}T^{-2}\right]$$

Hence it is dimensionally correct

(ii) Pressure = Momentum $\times$ volume $\times$ time

$$\left[ML^{-1}T^{-2}\right] = [M]\left[LT^{-1}\right]\times\left[L^3\right]\times[T]$$

$$\left[ML^{-1}T^{-2}\right] = \left[ML^4T^o\right]$$

Hence, it is not correct

(b) $\rho = \frac{4m}{\pi D^2 l}$

$$\frac{\Delta\rho}{P} = \frac{\Delta m}{m} + 2\frac{\Delta D}{D} + \frac{\Delta l}{l}$$

$$\frac{\Delta P}{P}\% = 1\% + 2\times(1.5)\% + 0.5\%$$

$\boxed{\%\frac{\Delta l}{l} = 4.5\%}$ $\times \Rightarrow \frac{\Delta P}{P}\% = 4.5\%$

CBSE TEST PAPER-01

CLASS - XI PHYSICS (Kinematics)

Topic: - Motion in Straight Line

1. Under what condition is the relation $s = \upsilon t$ correct? [1]

2. Two balls of different masses are thrown vertically upward with same initial speed. Which one will rise to a greater height? [1]

3. What is the relative velocity of two bodies having equal velocities? [1]

4. Write the characteristics of displacement? [2]

5. Draw displacement time graph for uniformly accelerated motion. What is its shape? [2]

6. Sameer went on his bike from Delhi to Gurgaon at a speed of 60km/hr and came back at a speed of 40km/hr. what is his average speed for entire journey. [2]

7. Define $\vartheta = v + at$ from velocity time graph. [3]

8. A particle is moving along a straight line and its position is given by the relation [3]

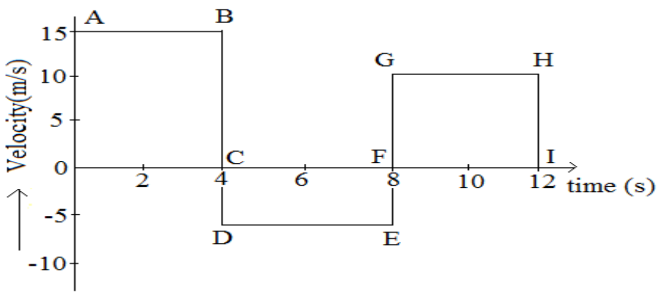
   $x = \left(t^3 - 6t^2 - 15t + 40\right)m$

   Find (a) The time at which velocity is zero.

   (b) Position and displacement of the particle at that point.

   (c) Acceleration for the particle at that line.

9. Velocity time graph of a moving particle is shown. Find the displacement (1) 0 – 4 s (2) 0 – 8 (3) 0 12 s from the graph. Also write the differences between distance and displacement. [5]



CBSE TEST PAPER-01

CLASS - XI PHYSICS (Kinematics)
Topic: - Motion in Straight Line [ANSWERS]

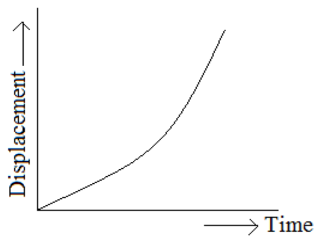
Ans1: When the particle moves with uniform velocity and along a straight line.

Ans2: Both the balls will rise to a greater height.

Ans3: If $Va = Vb = V(say)$
Then $\overrightarrow{Vab} = V\vec{a} - V\vec{b} = \vec{V} - \vec{V} = 0$

Ans4: (1) It is a vector quantity having both magnitude and direction.
(2) Displacement of a given body can be positive, negative or zero.

Ans5: The graph is parabolic in shape



Ans6: $\upsilon av = \dfrac{2\upsilon_1\upsilon_2}{\upsilon_1 + \upsilon_2} = \dfrac{2\times 60\times 40}{60+40} = 48 km/hr.$

Ans7: Slope of $\upsilon - t$ graph

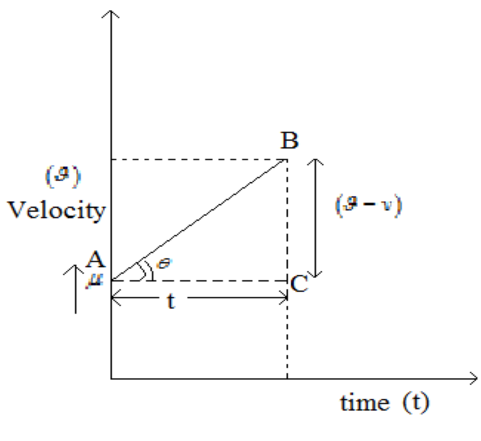
$\tan\theta = \dfrac{\upsilon - v}{t}$

$But \tan\theta = \text{acceleration(a)}$

$\Rightarrow a = \dfrac{\upsilon - v}{t}$

$\upsilon - v = at$

$\boxed{\upsilon = v + at}$



Ans8: $x = t^3 - 6t^2 - 15t + 40$

$\upsilon = \dfrac{dx}{dt} = \left(3t^2 - 12t - 15\right) m/s$

$a = \dfrac{dv}{dt} = (6t - 12) m/s^2$

(a) $3t^2-12t-15=0$

$3t^2-15t+3t-15=0$

$3t(t-5)+3(t-5)=0$

$(3t+3)(t-5)=0$

Either $t=-1$ or $t=5$

Time cannot be negative

$\therefore$ t = 5 seconds.

(b) Position at t = 5 s At t = 0 s

$x=(5)^3-6(5)^2-15(5)+40$ $x=40m$

$x=-60m$

Displacement at t = 5 s and t = 0s

$s=x_5-x_0$

$x_5=-60m$

$x_0=40m$

$s=-60-40$

$\boxed{s=-100m}$

(c) Acceleration at t = 5s

$a=6(5)-12$

$a=(30-12)$ $\boxed{a=18m/s^2}$

Ans9: (1) Displacement

Diving (0 – 4) s

S_1 = area of OAB s

$S_1 = 15 \times 4 = 60$ m

(2) Displacement (0 – 8s)

$S_2 = S_1$ + area (CDEF)

$S_2 = 60 + (-5) \times 4 = 60 - 20 = 40$m

(3) Displacement (0 – 12s)

$S_3 = S_1$ + area (CDEF) + area (FGHI)

$S_3 = 60 - 20 + 40 = 80$m

Distance	**Displacement**
1. Distance is a scalar quantity	1. Displacement is a vector quantity.
2. Distance is always positive	2. Displacement can be positive negative or zero.

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Kinematics)
Topic: - Motion in Straight Line

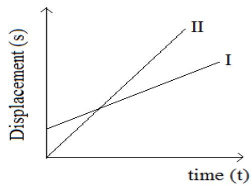
1. A railway train 400m long is going from New Delhi railway station to Kanpur. Can we consider railway train as a point object [1]

2. Shipra went from her home to school 2.5km away. On finding her home closed she returned to her home immediately. What is her net displacement? What is the total distance covered by her? [1]

3. Can speed of an object be negative? Justify [1]

4. What causes variation in velocity of a particle? [2]

5. Figure. Shows displacement – time curves I and II. What conclusions do you draw from these graphs? [2]



6. Displacement of a particle is given by the expression $x = 3t^2 + 7t - 9$, where x is in meter and t is in seconds. What is acceleration? [2]

7. A particle is thrown upwards. It attains a height (h) after 5 seconds and again after 9s comes back. What is the speed of the particle at a height h? [2]

8. A police jeep on a petrol duty on national highway was moving with a speed of 54km/hr. in the same direction. It finds a thief rushing up in a car at a rate of 126km/hr in the same direction. Police sub – inspector fired at the car of the thief with his service revolver with a muzzle speed of 100m/s. with what speed will the bullet hit the car of thief? [3]

9. Establish the relation $Snth = u + a/2\,(2n-1)$ where the letters have their usual meanings. [3]

10. A stone is dropped from the top of a cliff and is found to ravel 44.1m diving the last second before it reaches the ground. What is the height of the cliff? $g = 9.8m/s^2$ [3]

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Kinematics)

Topic: - Motion in Straight Line [ANSWERS]

Ans1: Yes, because length of the train is smaller as compared to the distance between New Delhi and Kanpur.

Ans2: Displacement = 0
Distance = 2.5km + 2.5km = 5.0km.

Ans3: No speed of an object can never be negative because distance is also always positive.

Ans4: Velocity of a particle changes
(1) If magnitude of velocity changes
(2) If direction of motion changes.

Ans5: (1) Both the curves are representing uniform linear motion.
(2) Uniform velocity of II is more than the velocity of I because slope of curve (II) is greater.

Ans6: $x = 3t^2 + 7t - 9$

$$\upsilon = \frac{dx}{dt} = 6t + 7 \text{ m/s}$$

$$a = \frac{d\vartheta}{dt} = 6m/s^2$$

Ans7: $s = ut + \frac{1}{2}at^2$

As the particle comes to the same point as 9s where it was at 5s. The net displacement at 4s is zero.

$$0 = \upsilon \times 4 - \frac{1}{2}(g) \times (4)^2$$

$$4\upsilon = \frac{1}{2} \times 9.8 \times 16$$

$$\upsilon = 2 \times 9.8$$

$$\boxed{\upsilon = 19.6m/s}$$

Ans8: V_{PJ} = 54km/hr = 15m/s V_{TC} = 126km/hr = 35m/s
Muzzle speed of the bullet $\upsilon_b = 100m/s.$

V_{CP} = 35 – 15 = 20m/s. V_{CP} = Velocity of car w.r.t. police

V_{BC}= 100 – 20 = 80 m/s V_{BC} = Velocity of bullet w.r.t car

Thus bullet will hit the car with a velocity 80m/s.

Ans9: $Snth = Sn - Sn_{-1}$

$$S_n = un + \frac{1}{2}an^2$$

$$S_{n-1} = u(n-1) + \frac{1}{2}a(n-1)^2$$

$$Snth = un + \frac{1}{2}an^2 - u(n-1) - \frac{1}{2}a(n-1)^2$$

$$\cancel{un} + \frac{\cancel{1}}{\cancel{2}}\cancel{an}^2 - \cancel{un} + u - \frac{\cancel{1}}{\cancel{2}}\cancel{an}^2 - \frac{1}{2}a + na$$

Snth = u-$\frac{1}{2}a + na$

= u+$\frac{a}{2}(2n-1)$

Hence proved.

Ans10: Let h be the height of the cliff

n be the total time taken by the stone while falling

u = 0

A = g = 9.8m/s^2

$$Snth = u + {}^{a}\!/_{2}(2n-1)$$

$$44.1 = 0 + \frac{9.8}{2}(2n-1)$$

$$n = {}^{10}\!/_{2} = 55$$

Height of the cliff

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

$$h = un + \frac{1}{2}gn^2$$

$$h = 0\times 5 + \frac{1}{2}\times 9.8\times(5)^2$$

$$h = 4.9\times 25$$

$$\boxed{h = 122.5\text{m}}$$

CBSE TEST PAPER-03

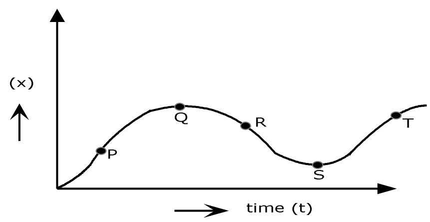
CLASS - XI PHYSICS (Kinematics)

Topic: - Motion in Straight Line

1. Under what condition the displacement and the distance of a moving object will have the same magnitude? [1]

2. What is the shape of the displacement time graph for uniform linear motion? [1]

3. Figure shows a displacements time graph. Comment on the sign of velocities at point P, Q, R, S and T. [1]



4. Draw displacement time graph for a uniformly accelerated motion? What is its shape? [2]

5. The displacement x of a particle moving in one dimension under the action of constant force is related to the time by the equation where x is in meters and t is in seconds. Find the velocity of the particle at (1) t = 3s (2) t = 6s. [2]

6. A balloon is ascending at the rate of 4.9m/s. A pocket is dropped from the balloon when situated at a height of 245m. How long does it take the packet to reach the ground? What is its final velocity? [2]

7. A car moving on a straight highway with speed of 126km/hr. is brought to stop within a distance of 200m. What is the retardation of the car (assumed uniform) and how long does it take for the car to stop? [2]

8. Establish $s = ut + \frac{1}{2}at^2$ from velocity time graph for a uniform accelerated motion? [3]

9. (a) Define the term relative velocity? [3]

   (b) Write the expression for relative velocity of one moving with respect to another body when objects are moving in same direction and are moving in opposite directions?

   (c) A Jet airplane traveling at the speed of 500km/hr ejects its products of combustion at the speed of 1500km/h relative to the Jet plane. What is the speed of the latter with respect to an observer on the ground?

10. Define (i) v = u + at (ii) $V^2 - u^2 = 2as$ by calculus method [3]

CBSE TEST PAPER-03

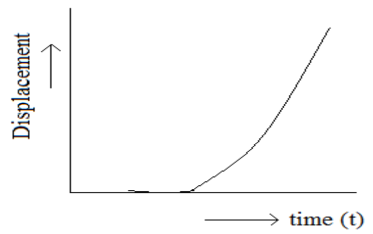
CLASS - XI PHYSICS (Kinematics)
Topic: - Motion in Straight Line [ANSWERS]

Ans1: Distance and displacement have the same magnitude when the object moves in a straight line.

Ans2: A straight line inclined to time axis (x – axis)

Ans3: Velocity at P and T is positive
Velocity at Q and S is zero
Velocity at R is negative

Ans4: Graph is parabolic in shape



Ans5: $t = \sqrt{x} - 3$

$\sqrt{x} = t + 3$

$x = (t+3)^2$

(i) $\upsilon = \dfrac{dx}{dt} = 2(t+3)$

For $t = 3$ sec $\upsilon = 2(3+3) = 12 m/s$

(ii) For $t = 6$ sec $\upsilon = 2(6+3) = 18 m/s$

Ans6: $u = 4.9 m/s$ $(upward)$

$h = 245m$

For packet (care of free fall) a = g = 9.8m/s^2 (downwards)

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

$245 = -4.9 \times t + \frac{1}{2}(9.8) \times t^2$

$4.9t^2 - 4.9t = 245$

$t = 7.6s$ $or -5.6s$ Since time cannot be negative

$\therefore$ $\boxed{t = 7.6s}$

Now $\upsilon = u + at$

$\upsilon = -4.9 + (9.8)(76)$ $\boxed{\upsilon = 69.6 m/s}$

Ans7: $u = 126 km/hr = 35 m/s$

$\upsilon = 0 \; s = 200m$

$\upsilon^2 - v^2 = 29s$

$$a = \frac{\upsilon^2 - v^2}{2s}$$

$$a = \frac{(0)^2 - (126)^2}{2\times 200} = \frac{(0)^2 - (35)^2}{2\times 200}$$

a = -3.06m/s² (Retardation)

Now V = u + at

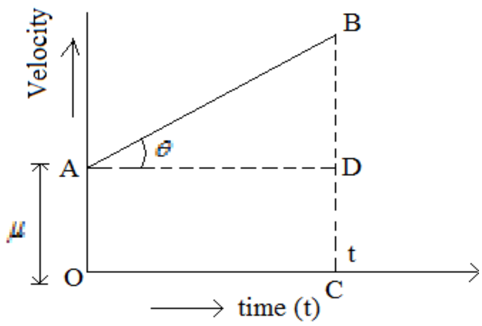
$$t = \frac{V - v}{a} = \frac{0-35}{-3.06} \qquad \boxed{t = 11.4s}$$

Ans8: Displacement of the particle in time (t)

S = area under $\upsilon - t$ graph

S = area OABC

S = area of rectangle AODC + area of Δ ADB



$$S = OA\times OC + \frac{1}{2}AD\times BD$$

$$S = ut + \frac{1}{2}(AD)\times\left(\frac{AD\times DB}{AD}\right)$$

$$S = ut + \frac{1}{2}(AD)^2\times\left(\frac{DB}{AD}\right)$$

$$S = ut + \frac{1}{2}(t)^2\times\left(\frac{DB}{AD}\right)$$

$$S = ut + \frac{1}{2}(t)^2\times(a) \qquad \left[\because a = \tan\theta = \frac{BD}{AD}\right] \qquad \boxed{S = ut + \frac{1}{2}at^2}$$

Ans9: (a) Relative velocity $V\vec{AB}$ of body A with respect to body B is defined as the time rate of change of position of A wrt. B.

(b) (i) When two objects move in the same direction

$$V\vec{AB} = V\vec{A} - V\vec{B} \qquad A \to V\vec{A}$$

$$B \to V\vec{B}$$

$$\to V\vec{AB}$$

(ii) When two objects move in the opposite direction

$$V\vec{AB} = \vec{VA} - (-V\vec{B}) \qquad A \to \vec{\upsilon_A}$$

$$V\vec{AB} = \vec{VA} + \vec{VB} \qquad \leftarrow \upsilon\vec{B}$$

$$\to V\vec{AB}$$

(c) Velocity of the Jet plane V_J = 500km/hr velocity of gases wrt. Jet plane V_{gJ} = -1500km/hr (direction is opposite)

$$V_{gJ} = V_g - V_J$$

$$V_g = V_{gJ} + V_J$$

Velocity of the Vg = -1500 + 500 = -1000km/hr

(As hot gases also comes out in opposite direction of the Jet plane)

Ans10: We know

(i) $a = \frac{dv}{dt}$

$dv = adt$

Integrating $\int dv = \int adt$

$V = at + k ----(1)$

Where K is constant of integration

$when\ t = 0\ \vartheta = u$

$\Rightarrow K = u$

$\Rightarrow \boxed{V = at + u}$

(ii) $\upsilon^2 - v^2 = 2as$

We know $a = \frac{dv}{dt}$

Multiply and Divide by dx

$a = \frac{dv}{dt} \times \frac{dx}{dx}$

$a = \frac{dv}{dx} \times \vartheta$

$adx = vdv$

$\left(\because \frac{dx}{dt} = v\right)$

Integrating within the limits

$a\int_{\lambda o}^{x} dx = \int_{v}^{\vartheta} \upsilon dv$

$a(x - x_o) = \frac{\upsilon^2}{2} - \frac{v^2}{2}$

$as = \frac{\upsilon^2 - v^2}{2} \left(\because (x - x_o) = \text{s} = \text{displacement}\right)$

$\boxed{\upsilon^2 - v^2 = 2as}$

CBSE TEST PAPER-04

CLASS - XI PHYSICS (Kinematics)
Topic: - Motion in Plane

1. What is "Trajectory of a projectile? [1]

2. A projectile is fired at an angle of 30^o with the horizontal with velocity 10m/s. At what angle with the vertical should it be fired to get maximum range? [1]

3. What is the value of angular speed for 1 revolution? [1]

4. What is the angle between two forces of 2N and 3N having resultant as 4N? [2]

5. What is the angle of projection at which horizontal range and maximum height are equal? [2]

6. Prove that for elevations which exceed or fall short of 45^o by equal amounts the ranges are equal? [2]

7. At what range will a radar set show a fighter plane flying at 3 km above its centre and at distance of 4 km from it? [2]

8. Derive expressions for velocity and acceleration for uniform circular motion. [3]

   OR Derive expression for linear acceleration in uniform circular motion.

9. Derive an equation for the path of a projectile fired parallel to horizontal. [3]

10. (a) Define time of flight and horizontal range? [3]

    (b) From a certain height above the ground a stone A is dropped gently. Simultaneously another stone B is fired horizontally. Which of the two stones will arrive on the ground earlier?

CBSE TEST PAPER-04

CLASS - XI PHYSICS (Kinematics)

Topic: - Motion in Plane [ANSWERS]

Ans1: The path followed by a projectile is called trajectory of projectile e.g. parabola.

Ans2: Maximum range is obtained at an angle of 45^o.

Ans3: For one complete revolution, $\theta = 2\pi$ in time period t = T , $W = 2\pi/T$

Ans4: Using $R=(A^2+B^2+2AB\cos\theta)^{1/2}$ we get

$$4 = (2^2 + 3^2 + 2\times 2\times 3\cos\theta)^{1/2}$$

$$16 = 4+9+12\cos\theta$$

$$\cos\theta = \frac{3}{12} = \cos^{-1} 0.25$$

$$\theta = 75^o 32'$$

Ans5: Equating, $\frac{\mu^2 \sin 2\theta}{g} = \frac{u^2 \sin^2\theta}{2g}$ $\quad \because \frac{u^2 Sin2\theta}{g} = R(\text{Horizontal Range})$

$\sin 2\theta = 1/2 \sin^2\theta$ $\quad \because \frac{u^2 Sin^2\theta}{2g} = hm(\text{Maximum Height})$

$2\sin\theta\cos\theta = 1/2\sin^2\theta \quad ie \tan\theta = 4 \Rightarrow \theta = 75.96^o$

Ans6: We know $R = \frac{u^2 \sin 2\theta}{g}$

$$\theta_1 = 45+\alpha \;;\; \theta_2 = 45-\alpha$$

$$R_1 = \frac{u^2 \sin 2\theta_1}{g} = \frac{u^2 \sin 2(45+\alpha)}{g}$$

$$R_1 = \frac{u^2 \sin(90+2\alpha)}{g}$$

$$R_1 = \frac{u^2 Cos2\alpha}{g} \rightarrow (1)$$

$$R_2 = \frac{u^2 Sin2\theta_2}{g} = \frac{u^2 Sin2(45-\alpha)}{g}$$

$$= \frac{u^2 Sin(90-2\alpha)}{g}$$

$$R_2 = \frac{u^2 Cos2\alpha}{g}$$ So, $\boxed{R_1 = R_2}$

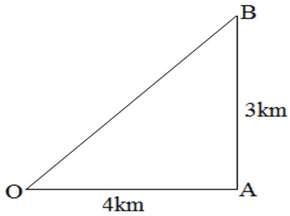
Ans7: Here straight distance of the object form the radar = OB

$OB = \sqrt{4^2 + 3^2}$

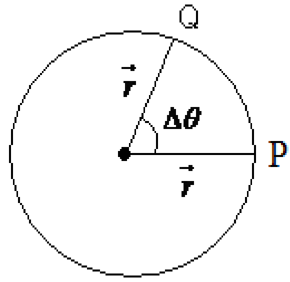
$OB = \sqrt{16 + 9}$

$OB = \sqrt{25} = 5$

$\Rightarrow Range = 5km$



Ans8: (1) IF $PQ = \Delta l$ then $v = \frac{\quad}{\Delta t} ------(1)$



And angular velocity $W = \frac{\Delta\theta}{\Delta l}$

Using $\theta = l/r \Rightarrow \Delta\theta = \Delta l / r$ -------(2)

$\Delta l = V \Delta t$ and $\Delta\theta = W \Delta t$

Substituting in (1) $W \cancel{\Delta t} = V \cancel{\Delta t} / r \Rightarrow v = rw$

(2) Since $a = dv/dt = r\, dw/dt = w\, dr/dt = wv = \frac{v}{r} \times v = v^2/r \Rightarrow \boxed{a = v^2/r}$

Ans9: Let a projectile having initial uniform horizontal velocity u be under the influence of gravity, then at any instant t at position P the horizontal and vertical.

For horizontal motion

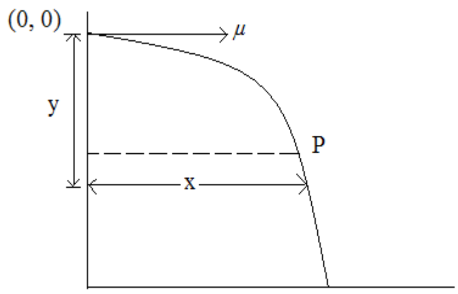
$S = ut + \frac{1}{2}at^2$

$s = x,\ u = u,\ t = t$

$and\ \ a = 0$

$x = ut$

$t = x/u$ ----(1)



For vertical motion

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

$s = -y,\ u = 0,\ t = t,\ a = -g$

We get $-y = -\frac{1}{2}gt^2$

Or $y = 1/2\, gt^2$ -----(2)

Using equation (1) and (2)

$y = \frac{1}{2} g \left(x/u\right)^2 = \frac{1}{2} g \frac{x^2}{u^2}$

Ans10: (a) **<u>Time of flight</u>** – The time taken by the projectile to complete its trajectory is called time of flight.

<u>Horizontal Range</u> – The maximum horizontal distance covered by the projectile form the foot of the tower to the point where projectile hits the ground is called horizontal range.

(b) Both the stones will reach the ground simultaneously because the initial vertical velocity in both cases is zero and both are falling with same acceleration equal to acceleration due to gravity.

CBSE TEST PAPER-05

CLASS - XI PHYSICS (Kinematics)

Topic: - Motion in Plane

1. Give an example of a body moving with uniform speed but having a variable velocity and an acceleration which remains constant in magnitude but changes in direction [1]

2. What is the direction of centripetal force when particle is following a circular path? [1]

3. Two vectors $\vec{A}$ *and* $\vec{B}$ are perpendicular to each other. What is the value of $\vec{A}.\vec{B}$? [1]

4. Two forces 5 and 10 kg wt are acting with an inclination of 120^{o} between them. What is the angle which the resultant makes with 10kg wt? [2]

5. A stone is thrown vertically upwards and then it returns to the thrower. Is it a projectile? Explain? [2]

6. Which is greater the angular velocity of the hour hand of a watch or angular velocity of earth around its own axis? [2]

7. Why does the direction of motion of a projectile become horizontal at the highest point of its trajectory? [2]

8. A vector $\vec{A}$ has magnitude 2 and another vector $\vec{B}$ have magnitude 3 and is perpendicular to each other. By vector diagram find the magnitude of $2\vec{A}+\vec{B}$ and show its direction in the diagram. [2]

9. Find a unit vector parallel to the resultant of the vectors [2]

$$\vec{A}=2\hat{i}+3\hat{J}+4\hat{k} \text{ and } \vec{B}=3\hat{i}-5\hat{J}+\hat{k}$$

10. (a) What is the angle between $\vec{A}$ *and* $\vec{B}$ if $\vec{A}$ *and* $\vec{B}$ denote the adjacent sides of a parallelogram drawn form a point and the area of the parallelogram is $\frac{1}{2}AB$? [5]

(b) State and prove triangular law of vector addition?

CBSE TEST PAPER-05

CLASS - XI PHYSICS (Kinematics)
Topic: - Motion in Plane [ANSWERS]

Ans1: A body moving in a circular path.

Ans2: The direction of the centripetal force is towards the centre of the circle.

Ans3: Since $\theta = 90^o$

$$\vec{A}.\vec{B} = AB\cos\theta$$
$$\vec{A}.\vec{B} = 0$$

Ans4: $F_1 = 5kgwt$

$$F_2 = 10kgwt$$
$$\theta = 120^o$$
$$\Rightarrow F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$
$$and\ \tan\beta = \frac{F_2\sin\theta}{F_1 + F_2\cos\theta}$$
$$\tan\beta = \frac{5\sin 120^o}{10 + 5\cos 120^o}$$
$$\tan\beta = \frac{5\times\sqrt{3}/2}{10 - 5\times 1/2}$$
$$\tan\beta = 1/\sqrt{3}$$
$$\Rightarrow \beta = \tan^{-1}\left(1/\sqrt{3}\right) = 30^o$$

Ans5: A stone cannot be considered as a projectile because a projectile must have two perpendicular components of velocities but in this case a stone has velocity in one direction while going up or coming downwards.

Ans6: In hour hand of a watch (T) =1 2h

$$W_H = \frac{2\pi}{12}$$

For rotation of earth T = 24h

$$We = \frac{2\pi}{24}$$
$$\Rightarrow W_H : We = 24/12 = 2$$
$$\Rightarrow \quad \boxed{W_H = 2We}$$

Ans7: At the highest point vertical component of velocity becomes zero thus direction of motion of projectile becomes horizontal.

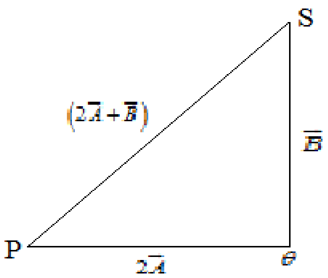
Ans8: Here $\left(P\vec{Q}\right) = 2\vec{A} = 4cm$

$Q\vec{S} = \vec{B} = 3cm$

$\left|P\vec{S}\right| = \sqrt{PQ^2 + QS^2}$

$\left|P\vec{S}\right| = \sqrt{4^2 + 3^2}$

$\left|P\vec{S}\right| = 5cm$



Ans9: We know $\hat{R} = \dfrac{\vec{R}}{\left|\vec{R}\right|}$

$\vec{R} = \vec{A} + \vec{B} = \left(2\hat{i} + 3\hat{J} + 4\hat{k}\right) + \left(3\hat{i} - 5\hat{J} + \hat{k}\right)$

$\vec{R} = 5\hat{i} - 2\hat{J} + 5\hat{k}$

$\left|\vec{R}\right| = \sqrt{(5)^2 + (-2)^2 + (5)^2}$

$\left|\vec{R}\right| = \sqrt{25 + 4 + 25}$

$\left|\vec{R}\right| = \sqrt{54}$

$\Rightarrow \hat{R} = \dfrac{5\hat{i} - 2\hat{j} + 5\hat{k}}{\sqrt{54}}$

Ans10: (a) Area of a parallelogram = $\left|\vec{A} \times \vec{B}\right|$

Area of parallelogram = A B Sin θ (∵ Applying cross product)

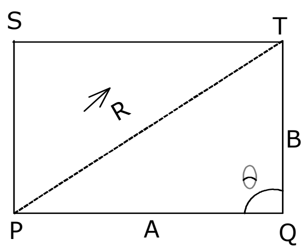
Given, area of parallelogram = $\dfrac{1}{2}AB$

So, $\dfrac{1}{2} = AB = AB\ Sin\theta$

$\dfrac{1}{2} = Sin\theta$

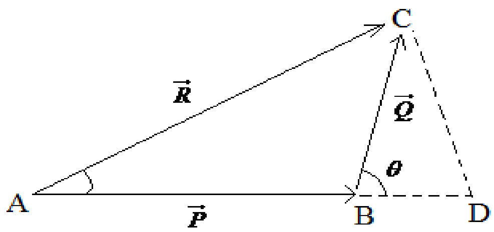
$\theta = Sin^{-1}\left(\dfrac{1}{2}\right)$

$\boxed{\theta = 30^0}$



(b) Triangular law of vector addition states that if two vectors can be represented both in magnitude and direction by the sides of a triangle taken in order then their resultant is given by the third side of the triangle taken in opposite order.

Proof → in Δ ADC



$$(AC)^2 = (AD)^2 + (DC)^2$$

$$(AC)^2 = (AB + BD)^2 + (DC)^2$$

$$(AC)^2 = (AB)^2 + (BD)^2 + 2(AB)(BD) + (DC)^2$$

$$(AC)^2 = (P^2) + (Q\cos\theta)2 + 2(P)(Q\cos\theta) + (Q\sin\theta)^2$$

$$(AC)^2 = P^2 + Q^2(\sin^2\theta + \cos^2\theta)\left(\because \frac{BD}{BC} = \cos\theta\right)$$

$$+2PQ\cos\theta\left(\because \frac{CD}{BC} = \sin\theta\right)$$

$$(R)^2 = P^2 + Q + 2PQ\cos\theta\left(\because \sin^2\theta + \cos^2 Q\right)$$

$$R = \sqrt{P^2 + Q + 2P\theta\cos\theta}$$

CBSE TEST PAPER-06

CLASS - XI PHYSICS (Kinematics)
Topic: - Motion in Plane

1. What will be the effect on horizontal range of a projectile when its initial velocity is doubled, keeping the angle of projection same? [1]

2. What will be the effect on maximum height of a projectile when its angle of projection is changed from 30^o to 60^o, keeping the same initial velocity of projection? [1]

3. What is the angular velocity of the hour hand of a clock? [1]

4. A body is moving on a curved path with a constant speed. What is the nature of its acceleration? [2]

5. A stone tied at the end of string is whirled in a circle. If the string breaks, the stone flies away tangentially. Why? [2]

6. What are the two angles of projection of a projectile projected with velocity 30m/s, so that the horizontal range is 45m. Take, g = $10m/s^2$. [2]

7. The blades of an aeroplane propeller are rotating at the rate of 600 revolutions per minute. Calculate its angular velocity. [2]

8. What is a uniform circular motion? Explain the terms time period, frequency and angular velocity. Establish relation between them. [3]

9. A body of mass m is thrown with velocity 'υ' at angle of 30^o to the horizontal and another body B of the same mass is thrown with velocity υ at an angle of 60^o to the horizontal. Find the ratio of the horizontal range and maximum height of A and B? [3]

10. At what point of projectile motion (i) potential energy maximum (ii) Kinetic energy maximum (iii) total mechanical energy is maximum [3]

CBSE TEST PAPER-06

CLASS - XI PHYSICS (Kinematics)
Topic: - Motion in Plane [ANSWERS]

Ans1: Four times the initial horizontal range.

Ans2: Three times the initial vertical height.

Ans3: $\pi/6$ radian per hour.

Ans4: Acceleration must be perpendicular to the direction of motion and is called centripetal acceleration.

Ans5: When a stone is moving around a circular path, its velocity acts tangent to the circle. When the string breaks, the centripetal force will not act. Due to inertia, the stone continues to move along the tangent to circular path, and flies off tangentially to the circular path.

Ans6: $$R = \frac{u^2 \sin 2\theta}{g} = \frac{(30)^2 \sin 2\theta}{10} = 45$$

$$\Rightarrow \sin 2\theta = \frac{450}{(30)^2}$$

$$\sin 2\theta = 1/2$$

$$2\theta = 30^o \ or \ 150^o \Rightarrow \theta = 15^o \ or \ 75^o$$

Ans7: $v = 600$ revolutions/min

$v = \frac{600}{60}$ revolutions/sec.

$$w = 2\pi v = 2 \times \pi \times \frac{600}{60}$$

$$w = 20\pi \ rad / s$$

Ans8: When an object moves in a circular path with constant speed then the motion is called uniform circular motion

Time period – The time taken by the object to complete one revolution

Frequency – The total number of revolutions in one second is called the frequency.

Angular velocity – It is defined as the time rate of change of angular displacement.

$$W = \frac{2\pi}{T} = 2\pi v \qquad \left(\because \frac{1}{T} = v \right)$$

Ans9: (1) When $\theta = 30^o\, R_A = \frac{\mu^2}{g}\sin 2\left(30^o\right)$

$$R_A = \frac{\mu^2}{g}\times\frac{\sqrt{3}}{2}$$

When $\theta = 60^o\, R_B = \frac{\mu^2}{g}\sin 2\left(60^o\right)$

$$R_B = \frac{\mu^2}{g}\times\frac{\sqrt{3}}{2}$$

$$R_A : R_B = 1:1$$

(2) When $\theta = 30^o\, H_A = \frac{\mu^2}{g}\sin^2 30^o$

$$H_A = \frac{\mu^2}{2g}\left(\frac{1}{4}\right)$$

When $\theta = 60^o\, H_B = \frac{\mu^2}{2g}\sin^2 60^o$

$$H_B = \frac{\mu^2}{g}\left(3/4\right)$$

$$H_A : H_B = 1:3$$

Ans10: (1) P.E. Will be maximum at the highest point

(P.E.) highest point = mgH

$$\left(P.E\right)_H = mg\left(\frac{\mu^2\sin^2\theta}{2g}\right)$$

$$\left(P.E\right)_H = \frac{1}{2}m\mu^2\sin^2\theta$$

(2) K.E will be minimum at the highest point

$$\left(K.E.\right)_H = \frac{1}{2}m\left(v_H\right)^2$$

(Vertical component of velocity is zero)

$$\left(K.E.\right)_H = \frac{1}{2}m\vartheta^2\cos^2\theta$$

(3) Total mechanical energy

$$\left(K.E.\right)_H + \left(P.E.\right)_H$$

$$\frac{1}{2}mu^2\cos^2\theta + \frac{1}{2}mu^2\sin^2\theta$$

$$\frac{1}{2}mu^2\left(\cos^2\theta + \sin^2\theta\right)$$

$$\boxed{\frac{1}{2}m\,u^2}$$

CBSE TEST PAPER-01

CLASS - XI PHYSICS (Laws of Motion)

Topic: - Laws of Motion

1. If force is acting on a moving body perpendicular to the direction of motion, then what will be its effect on the speed and direction of the body? [1]

2. The two ends of spring – balance are pulled each by a force of 10kg.wt. What will be the reading of the balance? [1]

3. A lift is accelerated upward. Will the apparent weight of a person inside the lift increase, decrease or remain the same relative to its real weight? If the lift is going with uniform speed, then? [1]

4. A soda water bottle is falling freely. Will the bubbles of the gas rise in the water of the bottle? [2]

5. Two billiard balls each of mass 0.05kg moving in opposite directions with speed 6m/s collide and rebound with the same speed. What is the impulse imparted to each ball due to other. [2]

6. A nucleus is at rest in the laboratory frame of reference. Show that if it disintegrates into two smaller nuclei, the products must be emitted in opposite directions. [2]

7. Explain why passengers are thrown forward form their seats when a speeding bus stops suddenly. [2]

8. A man weighs 70kg. He stands on a weighting machine in a lift, which is moving [3]
 (a) Upwards with a uniform speed of 10m/s.
 (b) Downwards with a uniform acceleration of $5m/s^2$.
 (c) Upwards with a uniform acceleration of $5m/s^2$. Take $g = 9.8m/s^2$.
 What would be the readings on the scales in each case what would be the reading if the lift mechanism failed and it came down freely under gravity?

9. (a) State impulse – momentum theorem? [3]
 (b) A ball of mass 0.1kg is thrown against a wall. It strikes the wall normally with a velocity of 30m/s and rebounds with a velocity of 20m/s. calculate the impulse of the force exerted by the ball on the wall.

10. Ten one rupee coins are put on top of one another on a table. Each coin has a mass *m* kg. Give the magnitude and direction of [3]
 (a) The force on the 7^{th} coin (counted from the bottom) due to all coins above it.
 (b) The force on the 7^{th} coin by the eighth coin and
 (c) The reaction of the sixth coin on the seventh coin.

CBSE TEST PAPER-01

CLASS - XI PHYSICS (Laws of Motion)
Topic: - Laws of Motion [ANSWERS]

Ans1: No change in speed, but there can be change in the direction of motion.

Ans2: The reading of the balance will be 10kgwt.

Ans3: The apparent weight will increase. If the lift is going with uniform speed, then the apparent weight will remain the same as the real weight.

Ans4: bubbles will not rise in water because water in freely falling bottle is in the state of weight – lessens hence no up thrust force acts on the bubbles.

Ans5: Initial momentum to the ball A = 0.05(6) = 0.3 kg m/s
As the speed is reversed on collision,
final momentum of ball A = 0.05(-6) = -0.3 kg m/s
Impulse imparted to ball A = change in momentum of ball A = final momentum – initial momentum = -0.3 -0.3 = -0.6 kg m/s.

Ans6: According to the principle of conservation of linear momentum, total momentum remains constant.
Before disintegration linear momentum = zero
After disintegration linear momentum = $m_1\overrightarrow{\upsilon_1} + m_2\overrightarrow{\upsilon_2}$

$$\Rightarrow m_1\upsilon_1 + m_2\upsilon_2 = 0 \Rightarrow \upsilon_2 = -\frac{m_1\upsilon_1}{m_2}$$

Ans7: When the speeding bus stops suddenly, lower part of the body in contact with the seat comes to rest but the upper part of the body of the passengers tends to maintain its uniform motion. Hence the passengers are thrown forward.

Ans8: Here, m = 70kg, g = 9.8m/s^2
(a) When the lift moves upwards with a uniform speed, its acceleration is zero.
R = mg = 70 $\times$9.8 = 686 N

(b) When the lift moves downwards with

$a = 5 m/s^2$

$R = m (g - a) = 70(9.8 + 5) = 336N$

(c) $a = 5 m/s^2$

$R = m (g + a) = 70 (9.8 + 5) = 1036N$

If the lift falls freely under gravity, a = g

$R = m (g - a) = m (g - g) = 0$

Ans9: (a) It states that impulse is measured by the total change in linear momentum is

Impulse = $m(\upsilon - v)\ \overrightarrow{P_2} - \overrightarrow{P_1}$

(b) m = 0.1kg v = 30m/s $\upsilon = -20 m/s$

Impulse = $\overrightarrow{P_2} - \overrightarrow{P_1} = m\upsilon - mv$

Impulse = $m(\upsilon - v)$ s

Impulse = m (-20 – 30) = -5Ns

Ans10: (a) The force on 7th coin is due to weight of the three coins lying above it.

Therefore, F = (3 m) kgf = (3 mg) N

Where g is acceleration due to gravity. This force acts vertically downwards.

(b) The eighth coin is already under the weight of two coins above it and it has its own weight too. Hence force on 7th coin due to 8th coin is sum of the two forces i.e.

F = 2m + m = (3m) kg f = (3 mg) N

The force acts vertically downwards.

(c) The sixth coins is under the weight of four coins above it

Reaction, R = -F = -4 m (kgf) = - (4 mg) N

-ve sign indicates that reaction acts vertically upwards.

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Laws of Motion)
Topic: - Laws of Motion

1. A thief jumps from the roof of a house with a box of weight W on his head. What will be the weight of the box as experienced by the thief during jump? [1]

2. Which of the following is scalar quantity? Inertia, force and linear momentum. [1]

3. Action and reaction forces do not balance each other. Why? [1]

4. A bird is sitting on the floor of a wire cage and the cage is in the hand of a boy. The bird starts flying in the cage. Will the boy experience any change in the weight of the cage? [2]

5. Why does a cyclist lean to one side, while going along curve? In what direction does he lean? [2]

6. How does banking of roads reduce wear and tear of the tyres? [2]

7. A monkey of mass 40 kg climbs on a rope which can stand a maximum tension 600 N. In which of the following cases will the rope break? The monkey (a) climbs up with an acceleration of $6m/s^2$ (b) climbs down with an acceleration of $4m/s^2$ (c) climbs up with a uniform seed of 5m/s (d) falls down the rope freely under gravity. Take $g = 10m/s^2$ and ignore the mass of the rope. [2]

8. What is meant by coefficient of friction and angel of friction? Establish the relation between the two? **OR** [3]

   A block of mass 10kg is sliding on a surface inclined at a angle of 30^o with the horizontal. Calculate the acceleration of the block. The coefficient of kinetic friction between the block and the surface is 0.5

9. State and prove the principle of law of conservation of linear momentum? [3]

10. A particle of mass 0.40 kg moving initially with constant speed of 10m/s to the north is subject to a constant force of 8.0 N directed towards south for 30s. Take at that instant, the force is applied to be t = 0, and the position of the particle at that time to be x = 0, predict its position at t = -5s, 25s, 30s? [3]

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Laws of Motion)
Topic: - Laws of Motion [ANSWERS]

Ans1: Weight of the box $W = m(g - a) = m(g - g) = 0$.

Ans2: Inertia and linear momentum is measured by mass of the body and is a vector quantity and mass is a scalar quantity.

Ans3: Action and reaction do not balance each other because a force of action and reaction acts always on two different bodies.

Ans4: When the bird starts flying inside the cage the weight of bird is no more experienced as air inside is in free contact with atmospheric air hence the cage will appear lighter.

Ans5: A cyclist leans while going along curve because a component of normal reaction of the ground provides him the centripetal force he requires for turning.
He has to lean inwards from his vertical position i.e. towards the centre of the circular path.

Ans6: When a curved road is unbanked force of friction between the tyres and the road provides the necessary centripetal force. Friction has to be increased which will cause wear and tear. But when the curved road is banked, a component of normal reaction of the ground provides the necessary centripetal force which reduces the wear and tear of the tyres

Ans7: $m = 40kg$, $T = 600N$ (max tension rope can hold)
Rope will break if reaction (R) exceeds Tension (T)

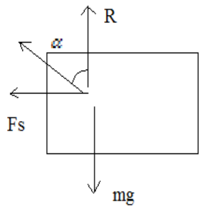
(a) $a = 6m/s^2$
$R = m(g + a) = 40(10 + 6) = 640$ N (Rope will break)

(b) $a = 4m/s^2$
$R = m(g - a) = 40(10 - 6) = 240$ N (Rope will not break)

(c) $\upsilon = 5m/s$ (constant) $a = 0$
$R = mg = 40 \times 10 = 400$ N (Rope will not break)

(d) $a = g$; $R = m(g - a) = m(g - g)$
R = zero (Rope will not break)

Ans8: Angle of friction is the contact between the resultant of limiting friction and normal reaction with the normal reaction $\boxed{\tan\alpha = \frac{Fs}{R}}$ ---------- (1)



Coefficient of static friction

The limiting value of static frictional force is proportion to the normal reaction is $Fs \alpha R \Rightarrow Fs = \mu s R$

Or $\mu s = {}^{Fs}\!/_{R} ----(2)$

From (1) & (2) $\boxed{\mu s = \tan\alpha = {}^{Fs}\!/_{R}}$

OR

A block of mass 10kg is sliding on a surface inclined at a angle of 30o with the horizontal. Calculate the acceleration of the block. The coefficient of kinetic friction between the block and the surface is 0.5

$m = 10kg \;\; \theta = 30^o \;\; \mu k = 0.5$

$a = g(\sin\theta - \mu k\cos\theta)$

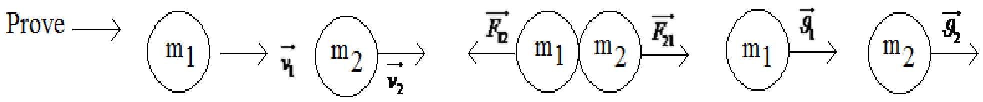
$a = 9.8(\sin 30^o - 0.5\cos 30^o)$

$a = 9.8(-.5 - 0.5 \times 0.866)$

$\boxed{a = 0.657 m/s^2}$

Ans9: The law of conservation of linear momentum states that if no external force acts on the system. The total momentum of the system remains unchanged.

i.e. if $\vec{F}ext = 0 \; then \; \vec{P} = \text{constant}$



Before collision during collision after collision

Impulse experienced by $m_1 = \vec{F_{12}}\,\Delta t = m_1\vec{\upsilon_1} - m_1\vec{v_1}$

Impulse experienced by $m_2 = \vec{F_{21}}\,\Delta t = m_2\vec{\upsilon_2} - m_2\vec{v_2}$

According to Newton's third law

$\vec{F_{12}} = -\vec{F_{21}}$

$\Rightarrow m_1\vec{\upsilon_1} - m_1\vec{v_1} = -\left(m_2\vec{\upsilon_2} - m_2\vec{v_2}\right)$

$m_1\vec{v_1} + m_2\vec{v_2} = m_1\vec{\upsilon_1} + m_2\vec{\upsilon_2}$

Thus momentum gained by one ball is lost by the other ball. Hence linear momentum remains conserved.

Ans10: m = 0.40kg

u = l0m/s due North

F = - 8.0N

$a = F/m = \frac{-8.0}{0.40} \Rightarrow$ $\boxed{a = -20 m/s^2}$

(1) At t = -5s

$x = ut = 10 \times (-5)$

$\boxed{x = -50m}$

(2) At t = 25s

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

$x = 10 \times 25 + (-20)(25)^2$

$\boxed{x = -6000m}$

(3) At t = 30s

$x_1 = ut + \frac{1}{2}at^2$

$x_1 = 10 \times 30 + \frac{1}{2}(-20)(30)^2$

$\boxed{x_1 = -8700m}$

(4) At t = 30s

$\upsilon = u + at$

$\upsilon = 10 + (-20)(30)$

$\upsilon = -590 m/s.$

$\therefore$ Motion from 30s to 100s

$x_2 = ut = -590 \times 70$

$\boxed{x_2 = -41300m}$

$\therefore$ Total distance x = $x_1 + x_2$

$\boxed{x = -50000m}$

CBSE TEST PAPER-03

CLASS - XI PHYSICS (Laws of Motion)

Topic: - Laws of Motion

1. Why is it desired to hold a gun tight to one's shoulder when it is being fired? [1]

2. Why does a swimmer push the water backwards? [1]

3. Friction is a self adjusting force. Justify. [1]

4. A force is being applied on a body but it causes no acceleration. What possibilities may be considered to explain the observation? [2]

5. Force of 16N and 12N are acting on a mass of 200kg in mutually perpendicular directions. Find the magnitude of the acceleration produced? [2]

6. An elevator weighs 3000kg. What is its acceleration when the in the tension supporting cable is 33000N. Given that g = 9.8m/s^2. [2]

7. Write two consequences of Newton's second law of motion? [2]

8. How is centripetal force provided in case of the following? [3]
   (i) Motion of planet around the sun,
   (ii) Motion of moon around the earth.
   (iii) Motion of an electron around the nucleus in an atom.

9. State Newton's second, law of motion. Express it mathematically and hence obtain a relation between force and acceleration. [3]

10. A railway car of mass 20 tonnes moves with an initial speed of 54km/hr. On applying brakes, a constant negative acceleration of 0.3m/s^2 is produced. [3]
    (i) What is the breaking force acting on the car?
    (ii) In what time it will stop?
    (iii) What distance will be covered by the car before if finally stops?

CBSE TEST PAPER-03

CLASS - XI PHYSICS (Laws of Motion)
Topic: - Laws of Motion [ANSWERS]

Ans1: Since the gun recoils after firing so it must be held lightly against the shoulder because gun and the shoulder constitute one system of greater mass so the back kick will be less.

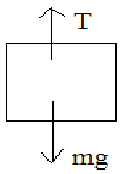
Ans2: A swimmer pushes the water backwards because due to reaction of water he is able to swim in the forward direction

Ans3: Friction is a self adjusting force as its value varies from zero to the maximum value to limiting friction.

Ans4: (1) If the force is deforming force then it does not produce acceleration.
(2) The force is internal force which cannot cause acceleration.

Ans5:
$$F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$
$$F = \sqrt{F_1^2 + F_2^2} \qquad \left(\theta = 90^o\right)$$
$$F = (\sqrt{16)^2 + (12)^2}$$
$$F = 20N$$
$$a = F/m = 20/200$$
$$\boxed{a = 0.1 m/s^2}$$

Ans6: Net upward force on the
Elevator F = T – mg $\left(\because F = ma\right)$



$$ma = T - mg$$
$$T = m(a+g)$$
$$T = 33000N = 3000(a+9.8)$$
$$a = \frac{33000 - 3000\times 9.8}{3000}$$
$$\boxed{a = 1.2\, m/s^2}$$

Ans7: (1) It shows that the motion is accelerated only when force is applied.
(2) It gives us the concept of inertial mass of a body.

Ans8: (i) Gravitational force acting on the planet and the sun provides the necessary centripetal force.
(ii) Force of gravity due to earth on the moon provides centripetal force.

(iii) Electrostatic force attraction between the electron and the proton provides the necessary centripetal force.

Ans9: According to Newton's second law the rate of change of momentum is directly proportional to the force.

i.e. F α rate of change of momentum $\left(\frac{d\vec{p}}{dt}\right)$

$$\vec{F} = k\frac{d\vec{p}}{dt}$$

$$\left(\vec{P} = m\vec{\upsilon}\right)$$

$$\Rightarrow \vec{F} = km\frac{d\vec{\upsilon}}{dt}$$

$\vec{F} = km\vec{a}$ (In S.I. unit K = 1)

$$\boxed{\vec{F} = km\vec{a}}$$

Ans10: $m = 20 tonnes = 20 \times 1000 kg \;\; u = 54 km/hr = 15 m/s$

$a = -0.3 m/s^2 \;\; \vartheta = 0$

(a) F = ma

$$F = 20000 \times (-0.3)$$

$$\boxed{F = -6000N}$$

(b) $\upsilon = u + at$

$$\upsilon - u = at$$

$$t = \frac{\upsilon - u}{a} = \frac{0 - 15}{-0.3}$$

$$\boxed{t = 50s}$$

(c) $\upsilon^2 - v^2 = 2\,as$

$$(0)^2 - (15)^2 = 2(-0.3)s$$

$$\boxed{S = 375m}$$

CBSE TEST PAPER-04

CLASS - XI PHYSICS (Laws of Motion)

Topic: - Laws of Motion

1. What is the unit of coefficient of friction? [1]

2. Name the factor on which coefficient of friction depends? [1]

3. What provides the centripetal force to a car taking a turn on a level road? [1]

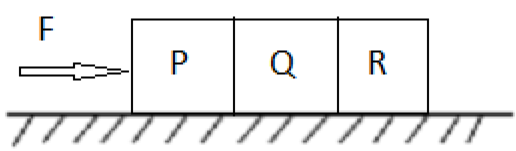
4. Give the magnitude and direction of the net force acting on [2]
   (a) A drop of rain falling down with constant speed.
   (b) A kite skillfully held stationary in the sky.

5. Two blocks of masses m_1, m_2 are connected by light spring on a smooth horizontal surface. The two masses are pulled apart and then released. Prove that the ratio of their acceleration is inversely proportional to their masses. [2]

6. A shell of mass 0.020kg is fired by a gun of mass 100kg. If the muzzle speed of the shell is 80m/s, what is the recoil speed of the gun? [2]

7. A train runs along an unbanked circular bend of radius 30m at a speed of 54km/hr. The mass of the train is 106kg. What provides the necessary centripetal force required for this purpose? The engine or the rails? What is the angle of banking required to prevent wearing out of the rail? [3]

8. Three identical blocks each having a mass m, are pushed by a force F on a frictionless table as shown in figure [3]



   What is the acceleration of the blocks? What is the net force on the block P? What force does P apply on Q. What force does Q apply on R?

9. (a) Define impulse. State its S.I. unit? [5]
   (b) State and prove impulse momentum theorem?

CBSE TEST PAPER-04

CLASS - XI PHYSICS (Laws of Motion)

Topic: - Laws of Motion [ANSWERS]

Ans1: It has no unit.

Ans2: Coefficient of friction $\mu s = F/R$ depends on the nature of surfaces in contact and nature of motion.

Ans3: Centripetal force is provided by the force of friction between the tyres and the road.

Ans4: (1) According to first law of motion F = 0 as a = 0 (particle moves with constant speed)

(2) Since kite is stationary net force on the kite is also zero.

Ans5: The forces F_1 and F_2 due to masses m_1 and m_2 acts in opposite directions

Thus $F_1 + F_2 = 0$

$m_1 a_1 + m_2 a_2 = 0$

$m_1 a_1 = -m_2 a_2$

$\frac{a_1}{a_2} = -\frac{m_1}{m_2}$ Hence proved

Ans6: Momentum before firing = 0

Momentum after firing = momentum of (bullet+gun)

Momentum after firing = $m_b \upsilon_b - m_g \upsilon_g$

According to law of conservation of linear momentum

$0 = m_b \upsilon_b - m_g \upsilon_g$

$m_b \upsilon_b = m_g \upsilon_g$

$\Rightarrow \upsilon_g = \frac{m_b \upsilon_b}{m_g}$

$\upsilon_g = \frac{m_b \upsilon_b}{m_g} = \frac{0.02 \times 80}{100}$ $\boxed{\upsilon_g = 0.016 m/s}$

Ans7: (1) The centripetal force is provided by the lateral force acting due to rails on the wheels of the train.

(2) Outer rails

(3) $\tan\theta = \frac{\upsilon^2}{rg} = \frac{(15)^2}{30 \times 9.8}$

$\tan\theta = 0.7653$ $\boxed{\theta = 37.4^\circ}$

Ans8: If a is the acceleration

Then F = (3m)a

$a = F/3m$

(1) Net force on P

$F_1 = ma = m \times \frac{F}{3m}$ $\boxed{F_1 = F/3}$

(2) Force applied on Q

$F_2 = (m + m)a$

$F_2 = 2m \times a = 2\cancel{m} \times \frac{F}{3\cancel{m}}$ $\boxed{F_2 = 2F/3}$

(3) Force applied on R by Q

$F_3 = m \times a = \cancel{m} \times \frac{F}{3\cancel{m}}$ $\boxed{F_3 = F/3}$

Ans9: (a) Force which are exerted over a short time intervals are called impulsive forces.

Impulse I=F×t

Unit – NS

Impulse is a vector quantity directed along the average force $\vec{F}av$.

(b) Impulse of a force is equal to the change in momentum of the body.

According to Newton's second law

$$\vec{F} = \frac{d\vec{p}}{dt}$$

$$or\ d\vec{p} = \vec{F}dt$$

$$At\ t = 0\ \vec{P} = \vec{P_1}\ and\ at$$

$$t = t\ \vec{P} = \vec{P_2}$$

$$\int_{\vec{P_1}}^{\vec{P_2}} dp = \int_{v}^{t} Fdt$$

$$\vec{P_2} - \vec{P_1} = Ft$$

$$\boxed{\vec{P_2} - \vec{P_1} = I} \qquad [\because Ft = I\,(\text{Impulse})]$$

CBSE TEST PAPER-01

CLASS - XI PHYSICS (Work, Energy and Power)
Topic: - Work, Energy and Power

1. A spring is cut into two equal halves. How is the spring constant of each half affected? [1]
2. The momentum of an object is doubled. How does it's. K.E. change? [1]
3. In which motion momentum changes but K.E. does not? [1]
4. A light body and a heavy body have same linear momentum. Which one has greater K.E.? [2]
5. A shot fired from cannon explodes in air. What will be the changes in the momentum and the kinetic energy? [2]
6. Can a body have momentum without energy? [2]
7. Obtain an expression for K.E. of a body moving uniformly? [2]
8. What is meant by a positive work, negative work and zero work? Illustrate your answer with example? [3]
9. A body of mass 2kg initially at rest moves under the action of an applied force of 7N on a table with coefficient of kinetic friction = 0.1. Calculate the [3]
   (1) Work done by the applied force in 10s
   (2) Work done by the friction in 10s
   (3) Work done by the net force on the body in 10s.
10. Derive the expression for the potential energy stored in a spring? [3]

CBSE TEST PAPER-01

CLASS - XI PHYSICS (Work, Energy and Power)

Topic: - Work, Energy and Power [ANSWERS]

Ans1: Spring constant of each half becomes twice the spring constant of the original spring.

Ans2: K.E. becomes four times since K.E. = $\frac{P^2}{2m}$

Ans3: In uniform circular motion.

Ans4: Given $P_1 = P_2$ ie $M_1\upsilon_1 = M_2\upsilon_2 \therefore \frac{M_1}{M_2} = \frac{\upsilon_1}{\upsilon_2}$

$$E_1 = \frac{1}{2}M_1\upsilon_1^2 \; E_2 = \frac{1}{2}M_1\upsilon_2^2$$

$$\frac{E_2}{E_1} = \frac{M_1\upsilon_2^2}{M_1\upsilon_1^2} = \frac{M_1}{M_2}\left(M_1/M_2\right)^2$$

$E_2/E_2 = M_1/M_2$ $If \; M_1 < M_2 \Rightarrow \; E_2 < E_1$ i.e. lighter body has more kinetic energy.

Ans5: The linear momentum will be conserved, because explosion occurs from within. However, KE will increase due to (chemical) potential energy of the explosives.

Ans6: Yes. When E = K + U = 0, either both are zero or K = -U. Thus K.E. may or may not be zero. As $P=\sqrt{2MK.E.}$

$If \; P = 0 \; K.E. = 0 \; and \; p \neq 0$ $\boxed{K = -U}$

Ans7: If $\vec{F}$ is the force applied to move the object through a distance $d\vec{S}$ then dw=$\left(\because \text{Let } \theta=0^0\right)$

$$dw = m\vec{a}d\vec{S} = \frac{md\vec{v}d\vec{S}}{d\vec{t}} = m\upsilon d\upsilon$$

Integrating $w = m\left|\frac{\upsilon^2}{2}\right|_o^v \Rightarrow$ $\boxed{w = 1/2\, MV^2 = K.E.}$

Ans8: (1) When a body falls under the action of gravity, $\theta = 0^o$ Work done is said to be positive.

(2) When brakes are applied on a moving vehicle work done by braking force is negative.

(3) A coolie carrying a load on his head moves on a horizontal platform, $\theta = 90^o$ work done is zero.

Ans9: Here m = 2kg U = 0, F = 8N $\mu = 0.1$ W = ? t = 10s

$a_1 = {}^{f}\!/_{m} = {}^{7}\!/_{2} = 3.5 m/s^2$

Force of friction $f = \mu R = \mu mg$

$f = 0.1 = 2 \times 9.8 = 1.96 N$

Retardation $(a_2) = {}^{-f}\!/_{m} = \frac{-1.96}{2} = -0.98 m/s^2$

Net acceleration $(a) = a_1 + a_2 = 3.5 - 0.98 = 2.52 m/s^2$

Distance moved in 10 seconds

$$\text{S=ut+}\frac{1}{2}\text{a}\times\text{t}^2$$
$$\text{S=0+}\frac{1}{2}\times 2.52(10)^2 = 126\text{m}$$

(a) $W_1 = F \times S = 7 \times 126 = 882 Joules$

(b) Work done by friction

$$W = -f \times S$$
$$W = -1.96 \times 126$$
$$W = -246.9 Joules$$

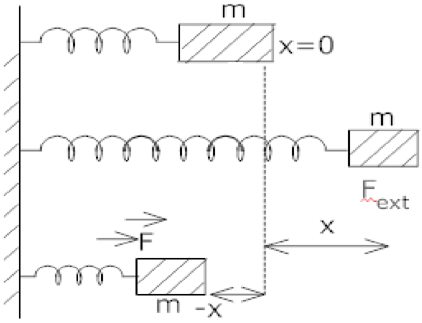
(c) Work done by the net force

$$\text{W}_3\text{=Net force} \times \text{Distance}$$
$$\text{W}_3\text{=(F-f)s=(7-1.96)}\times 126$$
$$\text{W}_3\text{=635 Joules}$$

Ans 10. Let a spring of spring constant 'k' is stretched through a distance 'x' by the application of force f_{ext}.

Let x = o is the normal posting then the restoring force $\vec{F}$ brings the spring to its normal position.

By Hooke's law:



$\vec{F} = -k\vec{x} - 1)$

Also, $\vec{F}_{ext} = -\vec{F}$

so, equation 1) is $\vec{F}_{ext} = -\vec{F}$

$\vec{F}_{ext} = +k\ x \ \rightarrow 2)$

If the spring is stretched through a distance dx) $\therefore dw = \vec{F}_{ext}.dx$

$dw = F_{ext}\ dx$ (Let $\theta = 0^0$)

dw = k x d x ($\because$ Using equation 2)

on Integrating, we get total work done

so, $\int dw = \int kx\ dx$

P.E. = w = $K\left[\frac{x^2}{2}\Big|_0^x\right] = K\left[\frac{x^2}{2} - \frac{0^2}{2}\right] = \frac{1}{2}Kx^2$

Potential energy stored in a spring

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Work, Energy and Power)
Topic: - Work, Energy and Power

1. When an air bubble rises in water, what happens to its potential energy? [1]
2. What should be the angle between the force and the displacement for maximum and minimum work? [1]
3. What is work done in holding a 15kg suitcase while waiting for a bus for 15 minutes? [1]
4. A light body and a heavy body have same kinetic energy. Which one has greater linear momentum? [2]
5. Can a body have energy without momentum? [2]
6. A particle moves along the x – axis form x = 0 t x = 5m influence of force given by $F = 7 - 2x + 3x^2$. Calculate the work done in doing so. [2]
7. A body of mass 3kg makes an elastic collision with another body at rest and continues to move in the original direction with a speed equal to one – third of its original speed. Fine the mass of the second body. [2]
8. Show that for a freely falling body the sum of its kinetic energy and potential energy remains constant at all points during its fall? [3]
9. Ball A of mass m moving with velocity U collides head on with ball B of mass m at rest. If e be the coefficient of restitution then determine the ratio of final velocities of A and B after the collision. [3]
10. If the momentum of the body increases by 20% what will be the increase in the K.E. of the body? [3]

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Work, Energy and Power)
Topic: - Work, Energy and Power [ANSWERS]

Ans1: Potential energy of air bubble decreases, because work is done by up thrust on the bubble.

Ans2: For maximum work angle must be zero degree and for minimum work force and displacement must be perpendicular to each other.

Ans3: Work done is zero, because displacement is zero.

Ans4: Given $E_1 = E_2$

$$\frac{1}{2}m_1\upsilon_1^2 = \frac{1}{2}m_2\upsilon_2^2 \qquad \frac{\upsilon_2^2}{\upsilon_1^2} = \left(\sqrt{\frac{m_1}{m_2}}\right)$$

$$As \;\; P_1 = m_1\upsilon_1 \quad P_2 = m_2\upsilon_2$$

$$\frac{P_1}{P_2} = \frac{m_2\upsilon_2}{m_1\upsilon_1} = \frac{m_2}{m_1} \times \sqrt{\frac{m_1}{m_2}}$$

$$\frac{P_1}{P_2} = \sqrt{\frac{m_2}{m_1}} \;\; \text{If } m_2 > m_1 \text{ then } P_2 > P_1$$

i.e. heavier body has greater linear momentum

Ans5: Yes, when p = 0, K = 0
But E = K + U = U (Pot. Energy), which may or may not be zero.

Ans6: Work done to displace the particle by a force F through a distance dx is given by dW = F dx.
Total work done to displace the particle from x = 0 to 5m is given by x = 5

$$W = \int_o^5 F dx = \int_o^5 \left(7 - 2x + 3x^2\right) dx$$

$$w = 7\int_o^5 dx - 2\int_o^5 x dx + \int_o^5 x^2 dx$$

$$w = 7\left|x\right|_o^5 - \cancel{2}\left|\frac{x^2}{\cancel{2}}\right|_o^5 + \cancel{3}\left|\frac{x^3}{\cancel{3}}\right|_o^5$$

$$w = 7(5-0) + 25 + 125 = 135 Joules$$

Ans7: Here $m_1 = 3kg$ $v_1 = \upsilon$ $m_2 = ?$ $v_2 = 0$

$\upsilon_1 = \upsilon/3$

$As\ \upsilon_1 = \dfrac{(m_1 - m_2)v_1 + 2m_2v_2}{m_1 + m_2}$

$\dfrac{\upsilon}{3} = \dfrac{(3 - m_2)\upsilon + 2m_2(0)}{m_2 + 3}$

$(m_2 + 3)\cancel{\upsilon} = (3 - m_2)\cancel{\upsilon} \times 3$

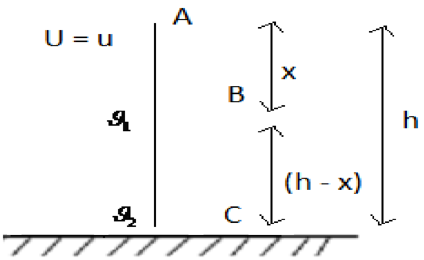
$m_2 + 3 = 9 - 3m_2$

$4m_2 = 9 - 3$

$4m_2 = 6$

$$\boxed{m_2 = 6/4}$$

Ans8: At point A



$PE = mgh$

$KE = 0$

$T.E = mgh ------(1)$

At point B

$PE = mg(h - x)$

$KE = \frac{1}{2}M\upsilon_1^1$ $\qquad (V_1^2 - (0) = 2gx)$

$KE = \frac{1}{\cancel{2}}M \times \cancel{2}gx$

$KE = mgx$

$TE = mgh - \cancel{mgx} + \cancel{mgx}$

$TE = mgh --------(2)$

At point C

$P.E. = 0$

$KE = \frac{1}{2}M\upsilon_2^2$

$(\upsilon_2^2 - (0) = 2g(h)$

$KE = \frac{1}{2}M(2hg)$

$KE = mgh$

$Thus T.E = mgh - (3)$

Concluding from equation (1), (2) and (3) energy remains conserved.

Ans9: Coefficient of restitution

$$e = \frac{\upsilon_1 - \upsilon_2}{u - 0}$$

$$\upsilon_1 - \upsilon_2 = eu -------(1)$$

According to law of conservation of linear momentum

$$mu = m\upsilon_1 + m\upsilon_2$$

$$\upsilon_1 + \upsilon_2 = u ---------(2)$$

Adding (1) and (2)

$$2\upsilon_2 = u(1+e)$$

$$\upsilon_2 = (1+e)\,u/2 ------(3)$$

Subtracting (1) from (2)

$$\upsilon_1 = (1-e)\,u/2 ------(4)$$

Dividing (4) by (3)

$$\boxed{\frac{\upsilon_1}{\upsilon_2} = \frac{(1+e)}{(1-e)}}$$

Ans10: $$K.E. = \frac{P^2}{2m}$$

$$P' = P + 20\% \text{ of } P$$

$$P' = P + \frac{20}{100}P = P + P/5 = 6P/5$$

$$\therefore K.E' = \frac{P_1^2}{2m}$$

$$K.E' = \frac{36P^2}{25 \times 2m} = \frac{36}{25}E$$

% Increase in K.E = $\frac{E' - E}{E} \times 100\%$

$$= \left(\frac{E'}{E} - 1\right) \times 100 = \left(\frac{36}{25} - 1\right) \times 100$$

$$= \frac{11}{25} \times 100 = 44\%$$

CBSE TEST PAPER-03

CLASS - XI PHYSICS (Work, Energy and Power)
Topic: - Work, Energy and Power

1. If two bodies stick together after collision will the collision be elastic or inelastic? [1]

2. When an air bubble rises in water, what happens to its potential energy? [1]

3. A spring is kept compressed by pressing its ends together lightly. It is then placed in a strong acid, and released. What happens to its stored potential energy? [1]

4. A body is moving along Z – axis of a co – ordinate system is subjected to a constant force F is given by $\hat{i}, \hat{j}, \hat{k}$ $\vec{F} = -\hat{i} + 2\hat{j} + 3\hat{k}\ N$, [2]

   Where $\hat{i}, \hat{j}, \hat{k}$ are unit vector along the x, y and z – axis of the system respectively what is the work done by this force in moving the body a distance of 4m along the Z – axis?

5. A ball is dropped from the height h_1 and if rebounces to a height h_2. Find the value of coefficient of restitution? [2]

6. State and prove work energy theorem analytically? [2]

7. An object of mass 0.4kg moving with a velocity of 4m/s collides with another object of mass 0.6kg moving in same direction with a velocity of 2m/s. If the collision is perfectly inelastic, what is the loss of K.E. due to impact? [2]

8. Prove that in an elastic collision in one dimension the relative velocity of approach before impact is equal to the relative velocity of separation after impact? [3]

9. (a) Define potential energy. Give examples. [5]

   (b) Draw a graph showing variation of potential energy, kinetic energy and the total energy of a body freely falling on earth from a height h?

CBSE TEST PAPER-03

CLASS - XI PHYSICS (Work, Energy and Power)

Topic: - Work, Energy and Power [ANSWERS]

Ans1: Inelastic collision.

Ans2: Potential energy of an air bubble decreases because work is done by upthrust on the bubble.

Ans3: The loss in potential energy appears as kinetic energy of the molecules of the cid.

Ans4: $\vec{F} = -\hat{i} + 2\hat{j} + 3\hat{k}\ N,$

$\hat{S} = 4\hat{k}$

$W = \vec{F}.\vec{S}$

$W = \left(\hat{i} + 2\hat{j} + 3\hat{k}\right).\left(4\hat{k}\right)$ $\boxed{W = 12\ J}$

Ans5: Velocity of approach $\upsilon_1 = \sqrt{2gh_1}$

(Ball drops form height h_1)

Velocity of separation $= \sqrt{2gh_2}$

(Ball rebounds to height h_2)

Coefficient of restitution

$$e = \frac{\upsilon_2}{\upsilon_1} = \sqrt{\frac{2gh_2}{2gh_1}}$$

$$\boxed{e = \sqrt{\frac{h_2}{h_1}}}$$

Ans6: It states that work done by force acting on a body is equal to the change produced in its kinetic energy.

If $\vec{F}$ force is applied to move an object through a distance dS

Then $dw = \vec{F}.\vec{dS}$

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

$$dw = m\vec{a}.d\vec{S}$$

$$dw = m\frac{d\vec{v}}{dt}.d\vec{S}$$

$$dw = m\frac{ds}{dt}d\upsilon$$

$$dw = m\upsilon d\upsilon$$

Integrating

$$\int_o^w dW = W = \int_u^\upsilon m\upsilon d\upsilon$$

$$W = m\left|\frac{V^2}{2}\right|_u^\upsilon \qquad \boxed{W = \frac{m\upsilon^2}{2} - \frac{mu^2}{2}}$$

Hence W = Kf – Ki Where Kf and Ki are final and initial kinetic energy.

Ans7: $m_1 = 0.4$kg, $u_1 = 4$m/s, $m_2 = 0.6$kg $u_2 = 2$m/s.

Total K.E. be fore collision

$$Ki = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$$

$$Ki = \frac{1}{2}(0.4)\times(4)^2 + \frac{1}{2}(0.6)\times(2)^2$$

$$Ki = 4.4J$$

Since collision is perfectly inelastic

$$\upsilon = \frac{m_1u_1 + m_2u_2}{m_1 + m_2} = 2.8m/s$$

Total K.E. after collision

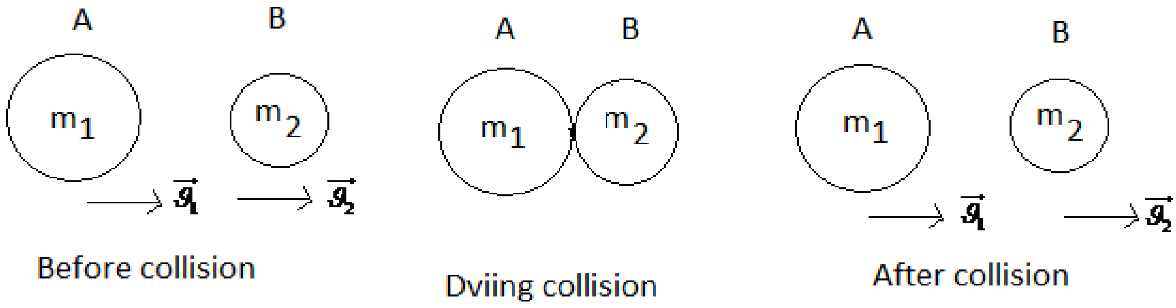
$$Kf = \frac{1}{2}(m_1 + m_2)\upsilon^2$$

$$Kf = \frac{1}{2}(0.4 + 0.6)\times(2.8)^2$$

$$Kf = 3.92J$$

Loss in K.E. (ΔK) =Ki – Kf = 4.4 – 3.92 = 0.48J

Ans8:



According to law of conservation of linear momentum

$$m_1u_1 + m_2u_2 = m_1\upsilon_1 + m_2\upsilon_2$$

$$m_1\left(u_1 - \upsilon_1\right) = m_2\left(\upsilon_2 - u_2\right) - - - - - - - - (1)$$

K.E. also remains conserved.

$$\frac{1}{2}m_1u_1^{\ 2} + \frac{1}{2}m_2u_2^{\ 2} = \frac{1}{2}m_1\upsilon_1^{\ 2} + \frac{1}{2}m_2\upsilon_2^{\ 2}$$

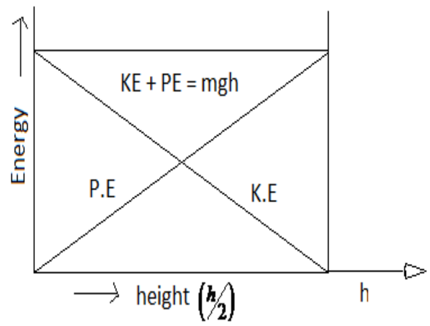
$$m_1\left(u_1^{\ 2} - \upsilon^2{}_1\right) = m_2\left(\upsilon_2^{\ 2} - u_2^{\ 2}\right) - - - - - - - (2)$$

Dividing (2) by (1)

$u_1 - \upsilon_1 = \upsilon_2 + u_2$ $\boxed{u_1 - u_2 = \upsilon_2 - \upsilon_1}$

I.e. Relative velocity of approach = Relative velocity of separation

Ans9: (a) Potential energy is the energy possessed by a body by virtue of its position in a field or due to change in its configuration example – A gas compressed in a cylinder, A wound spring of a water, water raised to the overhead tank in a house etc.



(i) Gravitational potential energy decreases as the body falls downwards and is zero at the earth

(ii) Kinetic energy increases as the body falls downwards and is maximum when the body just strikes the ground.

(iii) According to law of conservation of energy total mechanical (KE + PE) energy remains constant

CBSE TEST PAPER-01

CLASS - XI PHYSICS (System of particles and Rigid Body)
Topic: - System of particles and Rotational Motion

1. Two particles in an isolated system under go head on collision. What is the acceleration of the centre of mass of the system? [1]

2. Which component of a force does not contribute towards torque? [1]

3. What is the position of centre of mass of a rectangular lamina? [1]

4. Show that cross product of two parallel vectors is zero? [2]

5. Prove the relation $\vec{t} = \frac{d\vec{t}}{dt}$ [2]

6. Show that for an isolated system the centre of mass moves with uniform velocity along a straight line path? [2]

7. The angle θ covered by a body in rotational motion is give by the equation $\theta = 6t + 5t^2 + 2t^3$. Determine the value of instantaneous angular velocity and angular acceleration at time t = 2S. [2]

8. (a) Which physical quantities are represented by the [5]

   (i) Rate of change of angular momentum

   (ii) Product of I and $\vec{w}$

   (b) Show that angular momentum of a satellite of mass M_S revolving around the earth having mass M_e in an orbit of radius r is equal to $\left[G\ Me\ Ms^2 r\right]^{1/2}$

CBSE TEST PAPER-01

CLASS - XI PHYSICS (System of particles and Rigid Body)
Topic: - System of particles and Rotational Motion [ANSWERS]

Ans1: Acceleration is zero as force, are internal forces.

Ans2: The radial component of a force does not contribute towards torque.

Ans3: The centre of mass of a rectangular lamina is the point of intersection of diagonals.

Ans4: $\vec{A}\times\vec{B} = AB\sin\theta\hat{x}$

If $\vec{A}$ and $\vec{B}$ are parallel to each other

$\theta = 0^o$

$\Rightarrow \vec{A}\times\vec{B} = 0$

Ans5: We know $\vec{L} = I\vec{w}$

Differentiating wrt. Time

$\frac{d\vec{L}}{dt} = \frac{d}{dt}\left(I\vec{w}\right) = \frac{Id\vec{w}}{dt} = I\vec{\alpha} - - - - - (1)$ $\vec{\tau}$ = Argular Momentum

$\left(where \frac{d\vec{w}}{dt} = \alpha\right)$ $\vec{\tau} = Torque$

$\Rightarrow \vec{\tau} = I\vec{\alpha} - - - - - - - (2)$

From (1) and (2)

$$\boxed{\vec{\tau} = \frac{d\vec{L}}{dt}}$$

Ans6: Let $\vec{M}$ be the total mass concentrated at centre of mass whose position vector is $\vec{r}$

$\vec{F} = \frac{Md^2\vec{r}}{dt^2}$

$\vec{F} = \frac{Md}{dt}\left(\frac{d\vec{r}}{dt}\right) = \frac{Md}{dt}\left(V\overrightarrow{cm}\right)$

For an isolated system $\vec{F} = 0$

$\Rightarrow \frac{Md}{dt}\left(V\overrightarrow{cm}\right) = 0$

$or\ \frac{d}{dt}\left(V\overrightarrow{cm}\right) = 0\ as\ M \neq 0$

$\Rightarrow \left(V\overrightarrow{cm}\right) = \text{constant}$

Ans7: $\theta = 6t + 5t^2 + 2t^3$

Angular velocity

$$w = \frac{d\theta}{dt} = 6 + 10t + 6t^2$$

$$At\ 2S\ w = 6 + 10(2) + 6(2)^2$$

$$w = 50 rad / s$$

Again angular acceleration

$$\alpha = \frac{dw}{dt} = \frac{d^2\theta}{dt^2} = 10 + 12t$$

$$At\ t = 2S\ \alpha = 10 + 12(2)$$

$$\alpha = 34 rad / s^2$$

Ans8: (a) (1) Torque i.e. $\tau = \frac{d\vec{L}}{dt}$

(2) Angular momentum i.e. L = Iw

(b) Mass of satellite = Ms

Mass of earth = Me

Radius of satellite = r

Required centripetal force $= \frac{Msv^2}{r}$ ------(1)

Where υ is the orbital velocity with which the satellite revolves round the earth.

Gravitational force between the satellite and the earth

$$= \frac{GMeMs}{r^2} \text{------}(2)$$

Equating (1) and (2)

$$\frac{GMe\cancel{Ms}}{r^{\cancel{2}}} = \frac{\cancel{Ms}\upsilon^2}{\cancel{r}}$$

$$\Rightarrow \upsilon = \sqrt{\frac{GMe}{r}}$$

Now angular momentum of the satellite

$$L = Ms\upsilon r$$

$$L = Ms \times \sqrt{\frac{GMe}{r}} \times r$$

$$\boxed{L = \sqrt{GMeMs^2r}}$$

Hence Proved

CBSE TEST PAPER-02

CLASS - XI PHYSICS (System of particles and Rigid Body)
Topic: - System of particles and Rotational Motion

1. What is the position of the centre of mass of a uniform triangular lamina? [1]

2. What is the moment of inertia of a sphere of mass $20\,kg$ and radius $\frac{1}{4}m$ about its diameter? [1]

3. What are the factors on which moment of inertia of a body depends? [1]

4. What is the value of linear velocity if $\vec{w} = 3\hat{i} - 4\hat{j} + \hat{x}$ *and* $\vec{r} = 5\hat{i} - 6\hat{j} + 6\hat{k}$? [2]

5. Establish the third equation of rotational motion $w^2 - w_o^2 = 2\alpha\theta$ [2]

6. Find the expression for radius of gyration of a solid sphere about one of its diameter? [2]

7. Prove that the centre of mass of two particles divides the line joining the particles in the inverse ratio of their masses? [2]

8. A circular ring of diameter 40cm and mass 1kg is rotating about an axis normal to its plane and passing through the centre with a frequency of 10 rotations per second. Calculate the angular momentum about its axis of rotation? [3]

9. (a) A cat is able to land on its feet after a fall. Why? [5]
(b) If angular momentum moment of inertia is decreased, will its rotational $K.E.$ be also conserved? Explain.

CBSE TEST PAPER-03

CLASS - XI PHYSICS (System of particles and Rigid Body)
Topic: - System of particles and Rotational Motion

1. A wheel 0.5m in radius is moving with a speed of 12m/s. find its angular speed? [1]

2. State the condition for translational equilibrium of a body? [1]

3. How is angular momentum related to linear momentum? [1]

4. A planet revolves around on massive star in a highly elliptical orbit is its angular momentum constant over the entire orbit. Give reason? [2]

5. Obtain the equation $w = w_o + at$? [2]

6. What is the torque of the force $\vec{F} = 2\hat{i} - 5\hat{j} + 4\hat{k}$ acting at the point $\vec{r} = \left(3\hat{i} + 3\hat{j} + 3\hat{k}\right)m$ about the origin? [2]

7. The moment of inertia of a solid sphere about a tangent is $\frac{7}{5}MR^2$. Find the moment of inertia about a diameter? [3]

8. Four particles of mass 1kg, 2kg, 3kg and 4kg are placed at the four vertices A, B, C and D of square of side 1m. Find the position of centre of mass of the particle. [3]

9. (a) Why is moment of inertia called rotational inertia? [5]

   (b) Calculate M.I of a uniform circular disc of mass 500gm and radius 10cm about

   (i) Diameter (ii) axis tangent to the disc and parallel to diameter

   (c) Axis passing trough centre and perpendicular to its plane?

CBSE TEST PAPER-03

CLASS - XI PHYSICS (System of particles and Rigid Body)
Topic: - System of particles and Rotational Motion [ANSWERS]

Ans1: $v = rw$

$$w = \frac{v}{r} = \frac{12}{0.5}$$
$$w = 24 rad / s.$$

Ans2: For translations equilibrium of a body the vector sum of all the forces acting on the body must be zero.

Ans3: $\vec{L} = \vec{r} \times \vec{p}$

$or\ L = rp\sin\theta$

Where θ is the angle between $\vec{r}$ and $\vec{p}$

Ans4: A planet revolves around the star under the effect of gravitational force since the force is radial and does not contribute towards torque. Thus in the absence of an external torque angular momentum of the planet remains constant.

Ans5: Since $\alpha = \dfrac{dw}{dt}$

$dw = \propto dt$

Integrating within the limits

$$\int_{w_o}^{w} dw = \int_{o}^{t} \alpha dt$$

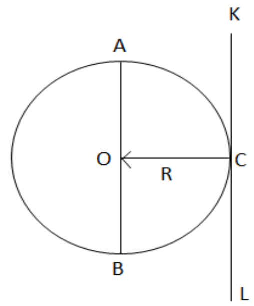
$$w - w_o = \alpha t \qquad \boxed{w = w_o + \alpha t}$$

Ans6: $\vec{\tau} = \vec{r} \times \vec{F}$

$$\vec{\tau} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -3 & 4 \\ 3 & 2 & 3 \end{vmatrix}$$

$$\vec{\tau} = \left(17\hat{i} - 6\hat{j} - 13\hat{k}\right) \text{Nm}$$

Ans7: A tangent KCl is drawn at pt. C of a solid sphere of mass M and radius R. Draw a diameter AOB || to KCl.



Then according to Theorem of parallel axis, I, = I + M (OC)^2

I_1(M.I about the tangent) = $7/5\, MR^2$

$I = I_1 - M(OC)2$

$I = \frac{7}{5} MR^2 - MR^2$

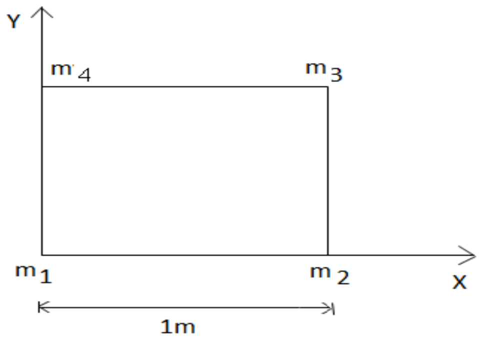
$$\boxed{I = 2/5\, MR^2}$$

Ans8: Hence $m_1 = 1kg \quad (x_1, y_1) = (0,0)$

$m_2 = 2kg \quad (x_2, y_2) = (1,0)$

$m_3 = 3kg \quad (x_3, y_3) = (1,1)$

$m_4 = 4kg \quad (x_4, y_4) = (0,1)$



$$Xcm = \frac{m_1x_1 + m_2x_2 + m_3x_3 + m_4x_4}{m_1 + m_2 + m_3 + m_4}$$

$Xcm = 0.5m$

$$Ycm = \frac{m_1y_1 + m_2y_2 + m_3y_3 + m_4y_4}{m_1 + m_2 + m_3 + m_4}$$

$Ycm = 0.7m$

Thus centre of mass (0.5m, 0.7m)

Ans9: (a) Moment of inertia is called rotational inertia because it measures moment of inertia during its rotational motion.

(b) (i) $Id = \frac{1}{4} MR^2$

$$Id = \frac{1}{4} \times 500 \times 10^2 = 12500 gmcm^2$$

(ii) $Id' = Id + MR^2$

$$Id' = \frac{1}{4} MR^2 + MR^2$$

$$Id' = \frac{5}{4} MR^2 + \frac{5}{4} \times 500 \times 10^2$$

$$Id' = 62500 gmcm^2$$

(iii) $I = 1/2\, MR^2$

$$I = \frac{1}{2} \times 500 \times (10)^2$$

$$I = 25{,}000 gmcm^2$$

CBSE TEST PAPER-01

CLASS - XI PHYSICS (Gravitation)

Topic: - Gravitation

1. On which fundamental law of physics is keplers second law is based? [1]

2. Which is greater the attraction of the earth for 1 kg of aluminum or aluminum or attraction of 1kg of aluminum for the earth? [1]

3. Distance between two bodies is increased to three times its original value. What is the effect on the gravitational force between them? [1]

4. The distance of the planet Jupiter from the sun is 5.2 times that of the earth. Find the period of the Jupiter's revolution around the sun? [2]

5. Show that for a two particle system [2]

   $\overrightarrow{F_{12}} = \overrightarrow{F_{21}}$

6. State two essential requisites of geostationary satellite? [2]

7. Show that an artificial satellite circling round the earth in an orbit of radius obeys keeper's third low? [2]

8. A 400kg satellite in a circular orbit of radius 2 Re about the earth calculate the kinetic energy potential energy and total energy of the satellite? [?]

   $R_E = 6.4 \times 10^6$m

   $M = 6 \times 10^{24}$kg

9. Two uniform solid spheres of radii R and 2R are at rest with their surfaces just touching. Find the force of gravitational attraction between them if density of spheres be P? [3]

10. Find expressions for (1) potential energy (2) kinetic energy (3) total energy for an artificial satellite. [3]

CBSE TEST PAPER-01

CLASS - XI PHYSICS (Gravitation)
Topic: - Gravitation [ANSWERS]

Ans01. Low of conservation of angular momentum.

Ans02. In accordance with the universal law of gravitation both the forces are equal and opposite.

Ans03. Since $F \propto \frac{1}{r^2}$

$r^1 \rightarrow 3r$

$\rightarrow$ Force will be decreased to 1/9 times

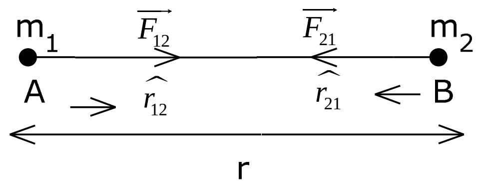
Ans04. Te = 1 year RJ = 5.2 Re

$$\left(\frac{T_J}{Te}\right)^2 = \left(\frac{R_J}{\text{Re}}\right)^3$$

T_J =(5.2) 3/2 x 1year

T_J = 11.86 year

Ans05. $\overrightarrow{F_{12}} = \frac{Gm_1m_2}{r^2}\ \widehat{r_{21}}$ (1)



$\overrightarrow{F_{21}} = \frac{Gm_1m_2}{r^2}\ \widehat{r_{12}}$ (2)

& (1) and (2) cam be written as $\left(\hat{a} = \frac{\hat{a}}{\overrightarrow{1a1}}\right)$

$\overrightarrow{F_{12}} = \frac{Gm_1m_2}{r^3}\ \overrightarrow{r_{21}}$

$$\overrightarrow{F_{21}} = \frac{Gm_1m_2}{r^3}\ \overrightarrow{r_{12}}$$

Since $\overrightarrow{r_{12}} = \overrightarrow{r_{21}}$

$$\rightarrow\ \overrightarrow{F_{21}} = \frac{-Gm_1m_2}{r^3}\ \overrightarrow{r_{21}}$$

$$\rightarrow\ \boxed{\overrightarrow{F_{21}} = -\overrightarrow{F_{12}}}$$

Hence proved

Ans06. (1) The period of revolution of a satellite around the earth should be same as that of earth about its own axis (T=24hrs)

(2) The sense of rotation of satellite should be same as that of the earth about its own axis i.e. from west to east in anti-clockwise direction

Ans07. Orbital velocity of a satellite is

$$\upsilon = \sqrt{\frac{GM}{r}}$$

Where M is the crass of earth

Time period of satellite T = $\frac{2\pi r}{\upsilon}$

$$T = \frac{2\pi r}{\sqrt{\frac{GM}{r}}}$$

$$T = 2\pi\sqrt{\frac{r^3}{GM}}$$

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

$$\frac{4\pi^2}{GM} = R\ (\text{constant})$$

Thus $\boxed{T^2 \alpha r^3}$

Hence proved

Ans08. M = $6x10^{24}$ kg M = 400 kg

$R_E = 6.4x10^6$m

Hence r = $2R_E = 12.8x10^6$m

G = $6.67x10^{-4}$ N m^2/kg^2

KE = $\frac{Gmm}{2r} = \frac{6.67\times10-11\times6\times1}{} \quad \frac{Gmm}{2r} = \frac{6.67\times10^{-11}\times6\times10^{24}\times400}{2\left(12.8\times10^{6}\right)}$

$$\boxed{KE = 6.25\times10^{9}\,Joules}$$

P. E. = $\frac{-2GMm}{2r}$ = -2K.E

PE = -2 x 6.25 x 10^9 = -12.5× 10^9 Joules

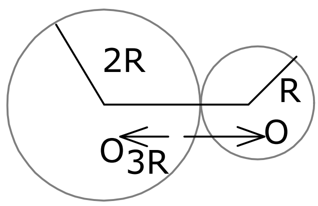
T. E. = K. E + P. E

T. E. = 6.25 ×10^9 – 12.50 × 10^9

T. E. = 6.25 × 10^9 Joules

Ans09. Two spheres of density p and radii R and 2R

s = oo^1 = 2R+R=3R



F = $\frac{Gm_1m_2}{r^2}$

F = $\frac{G\left(\frac{4}{3}\pi p\left(2R\right)^{3}\right)\left(\frac{4}{3}\pi pR^{3}\right)}{\left(3R\right)^{2}}$

$$\boxed{F = \frac{128}{27}\pi^{2}GP^{2}R^{4}}$$

Ans10. Potential energy of a satellite

$$U = \int_{\infty}^{r} F \text{ dx}$$

$$U= \int_{\infty}^{r} \frac{GMm}{x^{2}}dx$$

U = GMm $\int_{\infty}^{r} \frac{1}{x^2} dx$

U = GMm $\left| -\frac{1}{x} \right|_{\infty}^{r}$

U =GMm $\left[-\frac{1}{r} + \frac{1}{\infty} \right]$

$$\boxed{\text{U} = -\frac{GMm}{r}}$$

Kinetic energy KE = $\frac{1}{2} m\upsilon^2$

But $\upsilon = \sqrt{\frac{GM}{r}}$

K. E = $\frac{1}{2} m \left(\frac{GM}{r} \right)$

$$\boxed{\text{KE} = \frac{GMm}{2r}}$$

Total energy of satellite E = $U + \upsilon$

E = - $\frac{GMm}{r} + \frac{GMm}{2r}$

$$\boxed{\text{E} = -\frac{GMm}{2r}}$$

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Gravitation)

Topic: - Gravitation

1. The gravitational force between two blocks is F what would happen if a mass of both the blocks as well as distance between them is doubled? [1]

2. A body is weightless at the centre of earth. Why? [1]

3. Where will a body weigh more at Delhi or at Shimla? Why? [1]

4. Find an expression for the weight of a body at the centre of the earth? [2]

5. Find an expression for gravitational intensity due to earth at a point on its free surface. [2]

6. The earths mass is 80 times that of moon and their diameters are in the ratio 4:1 respectively. What is the value of g on moon? [2]

7. Determine the value of g at the bottom of an ocean 7km deep Given that radius of earth is 6370 km and g = 9.8m|s^2. [2]

8. Show that value of g at a height h is same as the value of acceleration due of gravity at a depth d = 2h [2]

9. If T be the period of satellite revolving just above the surface of a planet whose average density is p, show that PT^2 is a universal constant. [2]

10. Define Gravitational potential energy Hence deduces an expression for gravitational potential energy of a body placed at a point sear the surface of earth? [5]

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Gravitation)
Topic: - Gravitation [ANSWERS]

Ans01. We know F= $\frac{Gm_1m_2}{r^2}$

Here $m_1 = m_2$ (2m)

$r_1 = r_2 = 2r$

$\Rightarrow$ F = $\frac{G(2m)(2m)}{4r^2} = \frac{Gm^2}{r^2}$

i.e. force will remains the same.

Ans02. At the centre of the earth g = o

$\therefore w = mg = o$

Ans03. A body will weigh more at Delhi because at higher altitudes the value of g decreases.

Ans04. g d =g $(1 - d/R)$

At the centre of the earth d=R

Hence g centre = g $\left(1 - \frac{R}{R}\right)$

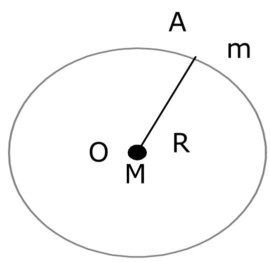
G centre = 0

Weight = mg centre

Weight = 0 i.e. weight of a body at the centre of earth is weightless.

Ans05. Gravitational force

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



Gravitational intensity of earth at point A

I = $\frac{F}{m}$ = $\frac{\frac{GMm}{R^2}}{m}$ $\boxed{I = \frac{GM}{R^2}}$

Ans06. $\frac{gm}{ge} = \left(\frac{Mm}{Me}\right) \times \left(\frac{\mathrm{Re}}{Rm}\right)^2$

$\frac{gm}{ge} = \left(\frac{1}{80}\right) \times \left(\frac{4}{1}\right)^2$ and ge = 9.8m/s^2

$\frac{gm}{ge} = \frac{16}{80}$

$gm = \frac{16}{80} \times 9.8$ $\boxed{gm = 1.96 m/s^2}$

Ans07. R = 6370km d = 7km g = 9.8m/s^2

gd = g $(1 - d/R)$ = 9.8 $\left(1 - \frac{7}{6370}\right)$

gd = 9.79m/s^2

Ans08. $g^1 = g\left(\frac{1-2h}{R}\right)$

and $g^1 = g\left(\frac{1-d}{R}\right)$

Comparing two relations

$\frac{1-2h}{R} = \frac{1-d}{R}$ or $\frac{-2h}{R} = \frac{-d}{R}$ $\boxed{d = 2h}$

Ans09. We know

T = $\sqrt{\frac{3\pi}{GP}}$

Squaring both the sides

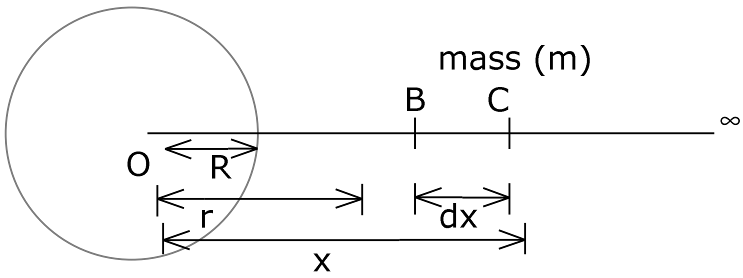
$T^2 = \frac{3\pi}{GP}$

$PT^2 = \frac{3\pi}{G}$

where $\frac{3\pi}{G}$ is a universal constant

Hence PT^2 is a universal constant

Ans10. It is defined as the work done in bringing a body from infinity to that point.



A body of mass (m) lying at a distance x from earth of mass (m)

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

If the body is displaced through a distance dx then

$$dw = Fdx = \frac{GMm}{x^2}dx$$

Total work done

$$W = \int_{\infty}^{r} \frac{GMm}{x^2}dx$$

$$w = GMm \int_{\alpha}^{r} \frac{1}{x^2}\ dx$$

$$w = GMm \left|\frac{-1}{x}\right|_{\infty}^{r}$$

$$w = -GMm \left|\frac{1}{r} - \frac{1}{\infty}\right|$$

$$w = \frac{-GMm}{r}$$

This work done is equal to the gravitational potential energy

i.e. $\boxed{w = U_g = \frac{-GMm}{r}}$

CBSE TEST PAPER-03

CLASS - XI PHYSICS (Gravitation)

Topic: - Gravitation

1. Why is gravitational potential energy always negative? [1]

2. At what height above the surface of the earth value of acceleration due to gravity is reduced to one fourth of its value on the surface of the earth? [1]

3. Name two factors which determine whether a planet has atmosphere or not? [1]

4. What is kepler's law of periods? Show it mathematically? [2]

5. With two characteristics of gravitational force? [2]

6. Assuming earth to be a uniform sphere finds an expression for density of earth in terms of g and G? [2]

7. If radius of earth is 6400km, what will be the weight of 1 quintal body if taken to the height of 1600 km above the sea level? [2]

8. A satellite is revolving is a circular path close to a planet of density P. find an expression for its period of revolution? [3]

9. How far away from the surface of earth does the value of g is reduced to 4% of its value on the surface of the earth Given radius of earth = 6400km [3]

10. Obtain on expression showing variation of acceleration due to gravity with height? [3]

CBSE TEST PAPER-03

CLASS - XI PHYSICS (Gravitation)

Topic: - Gravitation [ANSWERS]

Ans01. Gravitational potential energy is always negative because gravitational force is always attractive in nature.

Ans02. g h = g/4 = g $\left(\frac{R}{R+h}\right)^2$

$\frac{R}{R+h} = \frac{1}{\sqrt{4}} = \frac{1}{2}$

2R – R = h $\boxed{R = h}$

Ans03. (1) Acceleration due to gravity at the surface of planet

(2) Surface temperature of the planet

Ans04. It states that the square of the period of revolution of a planet around the sun is proportional of a planet to the cube of the semi-major axis of the elliptical orbit.

i.e. $T^2 \propto R^3$

$T^2 = KR^3$

where T is time period of evolution

R is the length of semi major axis

K is constant for all planets

Ans05. (1) It is a central force

(2) It is a conservation force

(3) It obeys inverse square law.

(4) It is a universal force and is always attractive in nature.

Ans06. Since g = $\frac{GM}{R^2}$

If earth is uniform sphere of mean density P

g = $\frac{G}{R^2}\left(\frac{4}{3}\pi R^3 P\right)$

g = $\frac{4}{3}\pi GRP$ $\Rightarrow$ $\boxed{P = \frac{3g}{4\pi GR}}$

Ans07. R = 6400km = 6400 x 10^3m

h = 1600km

w = mg = 1 quintal = 100 kg = 100x9.8 N

weight (w) = mgh

w = mg $\left(\frac{R}{R+h}\right)^2$

w = 100x9.8 $\left(\frac{6400}{1600+6400}\right)^2$

w = 64x9.8N = 64kg

Ans08. If satellite revolvers around the earth of radius r

T = $\frac{2\pi r}{\upsilon}$

where υ is orbital velocity

where $\upsilon = \sqrt{\frac{Gm}{r}}$

$$\boxed{T = \frac{2\pi r}{\text{v}} = \frac{2\pi r}{\sqrt{\frac{Gm}{r}}} = 2\pi\sqrt{\frac{r^3}{Gm}}}$$

If a satellite is revolving near the plant's surface then r = R radius of planet and

M $= \frac{4}{3}\pi R^3 P$

T = $2\pi\sqrt{\frac{R^3}{G.\frac{4}{3}\pi R^3 P}}$

$T = 2\pi\sqrt{\frac{3}{4\pi GP}}$ $\boxed{T = \sqrt{\frac{3\pi}{GP}}}$

Ans09. g h = g $\left(\frac{R}{R+h}\right)^2$

g h = 4% of g = $\frac{4g}{100}$

R = 6400km

$$\frac{4g}{100} g\left(\frac{R}{R+h}\right)^2$$

$$\frac{4}{100} = \left(\frac{R}{R+h}\right)^2$$

$$\frac{2}{10} = \frac{R}{R+h}$$

2R+2h = 10R

2h = 8R

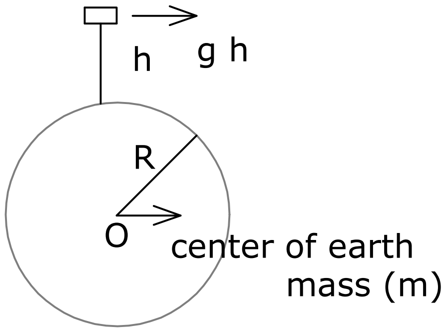
h = 4R = 4x6400 = 25,600km.

Ans10. Acceleration due to gravity at the surface of the earth

g = $\frac{GM}{R^2}$ (1)

If g h is the acceleration due to gravity at a pt situated at a height 'h' above the surface of the earth

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



Divide (2) by (1)

$$\frac{g\ h}{g} = \frac{GM}{(R+h)^2} \text{ x } \frac{R^2}{GM}$$

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

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

If h <<< R then the above relation

g h = g $\frac{R^2}{R^2(1+h/R)^2}$

g h = g $(1+h/R)^{-2}$

Expanding Binomially and neglecting **higher** power

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

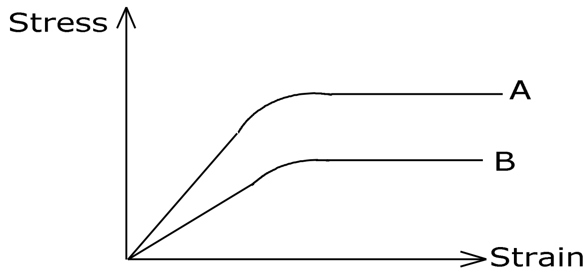
CBSE TEST PAPER-01

CLASS - XI PHYSICS (Properties of Bulk Matter)
Topic: - Elasticity

1. The stretching of a coil spring is determined by its shear modulus. Why? [1]

2. The spherical ball contracts in volume by 0.1% when subjected to a uniform normal pressure of 100 atmosphere calculate the bulk modulus of material of ball? [1]

3. In the following stress – strain curve, which has:- [2]



1) Greater young's Modulus 2) More Ductility 3) More Tensile strength.

4. A cube is subject to a pressure of $5X10^5$ $N|m^2$. Each side of cube is shortened by 1% find: - 1) the volumetric strain 2) the bulk modulus of elasticity of cube. [2]

5. If the potential energy is minimum at $r = r_o = 0.74A^0$, is the force attractive or repulsive at $r = 0.5A^0$; $1.9A^0$ and α? [2]

6. A hollow shaft is found to be stronger than a solid shaft made of same equal material? Why? [2]

7. Calculate the work done when a wire of length l and area of cross – section A is made of material of young's Modulus Y is stretched by an amount x? [2]

8. Water is more elastic than air. Why? [2]

9. Explain :- [3]
   1) Elastic Body 2) Plastic Body 3) Elasticity.

10. The length of a metal is l_1, when the tension in it is T_1 and is l_2 when tension is l_2. Find the original length of wire? [2]

Ans 01. When a coil spring is stretched, neither its length nor its volume changes, there is only the change in its shape. Therefore, stretching of coil spring is determined by shear modulus.

Ans 02. Volumetric strain = $\frac{\Delta V}{V} = 0.1\% = \frac{0.1}{100} = 10^{-3}$

Normal Stress = 100 atmosphere = 100 X 10^5 = 10^7 N|m^2

∴ Bulk Modulus of the material of the ball is :→

$$K = \frac{Normal \text{ Stress}}{Vol\text{umetric Strain}} = \frac{10^7}{10^{-3}} = 10^{10} N \,|\, m^2$$

Ans 03. 1) Since young's Modulus is given by the slope of stress – strain graph, Since slop of A is more than that of B, hence it has greater young's Modulus.

2) Ductility is the extent of plastic deformation and it is greater for A.

3) Tensile strength is the direct measure of stress required, from by graph, it is greater for A.

Ans 04. Let l = Initial length of cube.

Initial volume, V = l^3.

Change in length = 0.01% of l = $\frac{1}{100}l$

Final length of each side of cube = $l - \frac{l}{100} = \frac{99}{100}l$

Final volume = $\left(\frac{99l}{100}\right)^3$

Change in Volume, $\Delta V = \left(\frac{99l}{100}\right)^3 - l^3 = l^3\left[\left(\frac{99}{100}\right)^3 - 1\right]$

1) Volumetric Strain; $\frac{\Delta V}{V} = \frac{l^3\left[\left(\frac{99}{100}\right)^3 - 1\right]}{l^3} = \frac{-3}{100} = 0.03$

2) Bulk Modulus, K = $\frac{Normal \text{ Stress}}{\text{Volumetric Strain}} = \frac{5X10^5}{0.03} = 1.67X10^7 N|m^2$

Ans 05. Since, potential energy is minimum at $r_0 = 0.74A^0$. therefore interatomic force between two atoms is zero for $r_0 = 0.74A^0$

1) At r = 0.5 A^0 (Which is less than r_o), the force is repulsive.

2) At r = $1.9A^0$ (Which is greater than r_o), the force is attractive.

3) At r = α, the force is zero.

Ans 06. A hollow shaft is found to be stronger than a solid shaft made of equal material because the torque required to produce a given twist in hollow cylinder is greater than that required to produce in solid cylinder of same length and material through same angle.

Ans 07. Young's Modulus = $\frac{\text{Normal Stress}}{\text{Longitudinal Strain}}$

$$Y = \frac{F/A}{l/L}$$

F = Force

A = Area

l= change in length

L = original Length

x = change in Length (Given)

Average extension = $\frac{o+x}{2} = \frac{x}{2}$

Now, Work Done = Force. Average extension

$$\Rightarrow Now, y = \frac{FL}{Al}$$

$$F = \frac{YAl}{L}$$

$$\text{work Dore} = \frac{YAl}{L} \cdot \frac{x}{2}$$

$$= \frac{YAx}{L} \cdot \frac{x}{2} \quad (l = x(given))$$

$$\boxed{\text{Work Done} = \frac{YAx^2}{2L}}$$

Ans 08. Since volume elasticity is the reciprocal of compressibility and since air is more compressible than water hence water in more elastic than air.

Ans 09. 1) Elastic Body → A body which completely regains its original configuration immediately after the removal of deforming force on it is called elastic body. eg. Quartz and phosphor Bronze.

2) Plastic Body → A body which does not regain its original configuration at all on the removal of deforming force, howsoever the deforming force may be is called plastic body eg:- Paraffin wax.

3) Elasticity → The property of the body to regain its original configuration, when the deforming forces are removed is called plasticity.

Ans 10. Let l = original length of material – wire.

A = original length of metal – wire.

Change in length in the first case = (l_1-l)

Change in length is second case = (l_2-l)

Now, Young Modulus = $\frac{\text{Normal Stress}}{\text{Longitudinal Strain}}$

$$Y = \frac{T/A}{\Delta l/l}$$

Y = Young's Modulus

T = Tension

A = Area

Δl = Change in length

l = Original Length

$\therefore Y = \frac{T_1}{A} X \frac{l}{(l_1 - l)}$ for first case.

$Y = \frac{T_2}{A} X \frac{l}{(l_2 - l)}$ for second case.

Since Young's Modulus remains the same,

So,

$$\frac{T_1}{\cancel{A}} X \frac{\cancel{l}}{(l_1 - l)} = \frac{T_2}{\cancel{A}} X \frac{\cancel{l}}{(l_2 - l)}$$

$$T_1 (l_2 - l) = T_2 (l_1 - l)$$

$$T_1 l_2 - T_1 l = T_2 l1 - l\ T_2$$

$$l (T_2 - T_1) = T_2 l_1 - T_1 l_2$$

$$\boxed{l = \frac{T_2 l_1 - T_1 l_2}{T_2 - T_1}}$$

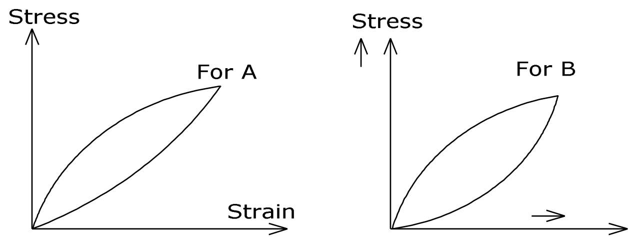
l= Original Length of wire.

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Properties of Bulk Matter)

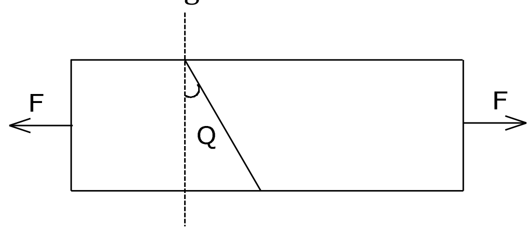
Topic: - Modulus of Elasticity

1. State Hooke's law? [1]
2. What are ductile and brittle materials? [1]
3. An elastic wire is cut to half its original length. How would it affect the maximum load that the wire can support? [2]
4. Define modulus of elasticity and write its various types [2]
5. Two different types of rubber are found to have the stress – strain curves as shown in the figure stress [2]



i) In what ways do these curves suffer from the stress- strain curve of a metal wire?
2) Which of the two rubbers A and B would you prefer to be installed in the working of a heavy machinery
3) Which of these two rubbers would you choose for a car tyre?

6. Why is the force of repulsion responsible for the formation of a solid and not the forces of attraction? [3]
7. A bar of cross section A is subjected to equal and opposite tensile force F at its ends. If there is a plane through the bar making an angle Q, with the plane at right angles to the bar in the figure [3]



a) Find the tensile stress at this plane in terms of F, A and Q
b) What is the shearing stress at the plane in terms of F, and Q.
c) For what value of Q is tensile stress a maximum.

8. Which is more elastic rubber or steel? Explain. [2]
9. The Young's modulus of steel is $2.0x10^{+11}$ w/m^2. If the interatomic spacing for the metal is $2.8x10^{-10}$m, find the increase in the interatomic spacing for a force of 10^9 N|m^2 and the force constant? [3]

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Properties of Bulk Matter)

Topic: - Modulus of Elasticity [ANSWERS]

Q1.Ans. Hooke's law states that the extension produced in the wire is directly proportional to the load applied within the elastic limit i.e. Acc to Hooke's low,

Stress α Strain

Stress = E x Strain

E = Modulus of elasticity

Q2.Ans. Ductile materials are those materials which show large plastic range beyond elastic limit. eg:- copper, Iron

Brittle materials are those materials which show very small plastic range beyond elastic limit. eg:- Cast Iron, Glass.

Q3.Ans. Since Breaking load = Breaking Stress x Area; so if cable is cut to half of its original length, there is no change in its area hence there is no effect on the maximum load that the wire can support.

Q4.Ans. Modulus of elasticity is defined as ratio of the stress to the corresponding strain produced, within the elastic limit.

E (Modulus of elasticity) = $\frac{Stress}{Strain}$

Types of Modulus of elasticity:-

1) Young's Modulus = $\frac{Normal\ Stress}{Longitudinal\ Strain}$

2) Bulk Modulus = $\frac{Normal\ Stress}{Volunetric\ Strain}$

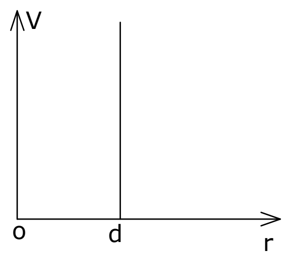
3) Modulus of Rigidity = $\frac{Tangential\ \text{Stress}}{Shearing\ \text{Strain}}$

Q5.Ans. 1) Since for the above curves, Hooke's law is not obeyed as the curve is not a straight line Hence such type of curve are called as elastic hysteresis as the materials do not retrace curve during unloading.

2) Rubber B is preferred because area of loop B is more than that of A which shows more absorption power for vibrations which is useful in machinery.

3) Since hysteresis loop is a direct measure of heat dissipation, hence rubber A is preferred over B so to minimize the heating in the car tyres.

Q6.Ans. If we study the motion of large number of spheres, it will be observed that two hard spheres do not attract each other, but rebound immediately on collision. That is they, do not come closer than their diameter 'd'. The interaction potential 'V' for a pair of hard sphere is



d = diameter

r = distance of interaction of 2 spheres

It shows that there is infinite repulsion for r = d and no potential for r>d and hence repulsive forces binds them together.

Q7.Ans. 1) Tensile stress = $\dfrac{Normal\ force}{Area}$

Normal force = F cos θ

Tensile Stress = $\dfrac{F\cos\theta}{\frac{A}{\cos\theta}} = \dfrac{F\ \cos^2\theta}{A}$

2) Shearing Stress = $\dfrac{Tangential\ \text{Stress}}{Area}$

Tangential force = F Sin θ

Area = A/cos θ

Shearing Stress = $\dfrac{F\ \sin\theta}{\frac{A}{\cos\theta}}$

$= \frac{F}{A} Sin\theta \ \cos\theta$

$= \frac{F 2 \sin\theta \cos\theta}{2A}$ (Divide & Multiply by 2)

$= \frac{F \ Sin^2\theta}{2A} \ \left(\because \ \text{Sin}^2\theta = 2\text{Sin}\theta \ \cos\theta\right)$

3) Tensile Stress = $\frac{F \ \cos^2\theta}{A}$, for A & F constant

Tensile stress $\alpha \ \cos 2\theta$

cos 2 θ = Maximum = 1

cos θ = 1

$\theta = \cos^{-1}(1)$ $\boxed{\theta = 0^0}$

i.e. when the plane is parallel to the bar.

Q8.Ans. Let length and area of rubber and stead rod = l and a respectively

Let Yr = Young's modulus of elasticity for rubber

Ys = Young's modulus of elasticity for steel when Stretching force F is applied, Let

$\Delta lr =$ Extension in rubber

Δ ls = Extension in steel

Now, Δlr will be greater that Δls.

Now Y = $\frac{Fl}{a\Delta l} = \frac{Normal \ stress}{Longitudinal \ strain}$.

So, $Y_r = \frac{Fl}{a\Delta lr}$; Ys = $\frac{Fl}{a\Delta ls}$

Since Δlr >Δls

So, Y r < Ys

Hence more the modulus of elasticity more elastic is the material, so, steel is more elastic than rubber

Q9.Ans. Y = 2.0×10^{11}N|m^2

L = 2.8×10^{-10}m

F = force

A = Area

Δl = charge in length

$\frac{F}{A} = 10^9 N|m^2$; force constant = K = $\frac{F}{\Delta l}$

Δl = ? ; $\frac{F}{\Delta l} = ?$

So, Y = Modulus of elasticity = $\frac{F \times \ell}{A \times \Delta \ell}$

Or $\Delta l = \frac{F}{A} X \frac{l}{y}$

$\Delta l = \frac{10^9 x 2.8 x 10^{-10}}{2 x 10^{11}}$

$\Delta l = \frac{2.8 x 10^{-10+9-11}}{2}$

$\Delta l = \frac{2.8 x 10^{-12}}{2}$

$\Delta l = 1.4 x 10^{-12} m$ $\boxed{\Delta \ell = 0.014 A^0}$ ($lA^0 = 10^{-10}$m)

As the distance between 2 atoms is l then area of chain of atoms = A = l x l = l^2 → (1)

Y = $\frac{F \times \ell}{A \times \Delta \ell} = \frac{F \times \ell}{\Delta \ell \times A}$

Y = $\frac{F\ x \ell}{\Delta \ell \times \ell^2}$ ($\because$ Using equation i)

Y = $\frac{F x \ell}{\Delta \ell \times \ell}$

(Force constant) = K = $\frac{F}{\Delta \ell}$; so

Y = $\frac{K}{l}$

K = Y/P

K = $2.0 x 10^{11} x 2.8 x 10^{-10}$

K = $2 x 2.8 x 10^{11-10}$

K = $5.6 x 10^4$ $\boxed{K = 56 Nm^{-1}}$

CBSE TEST PAPER-03

CLASS - XI PHYSICS (Properties of Bulk Matter)
Topic: - Liquid in Rest

1. State the law of floatation? [1]

2. The blood pressure of humans is greater at the feet than at the brain? [1]

3. Define surface tension? [1]

4. State the angle of contact and on what values do the angle of contact depends? [2]

5. Hydrostatic pressure is a scalar quantity even though pressure is force divided by area, and force is a vector. Explain? [2]

6. Find the work done in blowing a soap bubble of surface tension 0.06 N/m from 2cm radius to 5cm radius? [2]

7. Calculate the radius of new bubble formed when two bubbles of radius r_1 and r_2 coalesce? [3]

8. A liquid drop of diameter 4 mm breaks into 1000 droplets of equal size. Calculate the resultant change in the surface energy. Surface tension of the liquid is 0.07 N/m?

9. State the principle on which Hydraulic lift work and explain its working? [5]

CBSE TEST PAPER-03

CLASS - XI PHYSICS (Properties of Bulk Matter)
Topic: - Liquid in Rest [ANSWERS]

Ans01. Law of floatation states that a body will float in a liquid, if weight of the liquid displaced by the immersed part of the body is at least equal to or greater than the weight of the body.

Ans02. The height of the blood column in the human body is more at the feet than at the brain as since pressure is directly dependent on height of the column, so pressure is more at feet than at the brain.

Ans03. It is measured as the force acting on a unit length of a line imagined to be drawn tangentially anywhere on the free surface of the liquid at rest

Ans04. Angle of contact between a liquid and a solid is defined as the angle enclosed between the tangents to the liquid surface and the solid surface inside the liquid, both the tangents being drawn at the point of contact of liquid with the solid. It depends upon:-

1) Upon nature of liquid and solid in contact

2) The Medium which exists above the free surface of liquid.

Ans05. Since due to applied force on liquid, the pressure is transmitted equally in all directions, inside the liquid. Since there is no fixed direction for the pressure due to liquid. Hence it is a scalar quantity.

Ans06. Here, Surface tension = s = 0.06N/m

r_i = 2cm = 0.02m

r_2 = 5cm = 0.05m

Since bubble has two surface, initial surface area of the bubble = $2x4\pi\ r_1^2$

= $2x4\pi(0.02)^2$

$= 32\pi x10^{-4}m^2$

Find surface of the bubble $= 2x4\pi r_2^2$

$= 2x4\pi(0.05)^2$

$= 200\pi x10^{-4}m^2$

Increase in surface area $= 200\pi x10^{-4} - 32\pi x10^{-4}$

$= 168\pi x10^{-4}m^2$

∴ work done = surface tension x Increase in surface area

$= 0.06x168\pi x10^{-4}$

Work done = 0.003168J

Ans07. Consider two soap bubble of radii r_1 and r_2 and volumes as v_i and v_2. Since bubble is in the form of a sphere: →

$v_1 = \frac{4}{3}\pi r_1^3$; $v_2 = \frac{4}{3}\pi r_2^3$

Ifs = surface tension of the soap solution

p_1& p_2 = excess pressure inside the two soap bubbles

$P_1 = \frac{4S}{r_1}$; $P_2 = \frac{4S}{r_2}$

Let r be the radius of the new soap bubble formed when the two soap bubble coalesce under and excess of pressure inside this new soap bubble then

$V = \frac{4}{3}\pi r^3$

$P = \frac{4S}{r}$

As the new bubble is formed under isothermal condition, so Boyle's law holds good and hence

$P_1 v_1 + p_2 v_2 = pv$

$$\Rightarrow \frac{4S}{r_1} x \frac{4}{3}\pi r_1^3 + \frac{4S}{r_2} x \frac{4}{3}\pi r_2^3 = \frac{4S}{r} x \frac{4}{3}\pi r^3$$

$16 s\pi r_1^2 + 16S\pi r_2^2 = 16S\pi r^2$

$$\boxed{r = \sqrt{r_1^2 + r_2^2}}$$

Ans08. Since the diameter of drop = 4mm

Radius of drop = 2mm = $2x10^{-3}$m

S = Surface tension = 0.07N/m

Let r be the radius of each of the small droplets volume of big drop = 1000 x volume of the small droplets

$$\frac{4}{3}\pi r^3 = 1000x\frac{4}{3}\pi r^3$$

or $\boxed{R = 10r}$

$$\Rightarrow r = \frac{2x10^{-3}}{10} = 2x10^{-4}m$$

original surface area of the drop = $4\pi R^2$

Total surface area of $1000x4\pi r^2-4\pi R^2$

= $4\pi\,[1000r^2-R^2]$

Increase in surface or ea = 4x $\frac{22}{2}\left(\left[1000x\left(2x10^{-4}\right)^2\right]-\left[\left(2x10^{-3}\right)^2\right]\right)$

= 4x$\frac{22}{4}\left[1000x4x10^{-8}-4x10^{-6}\right]$

= 8x$\frac{22}{7}\left[10^{-5}-10^{-6}\right]$

= $\frac{3168}{7}x10^{-6}m^2$

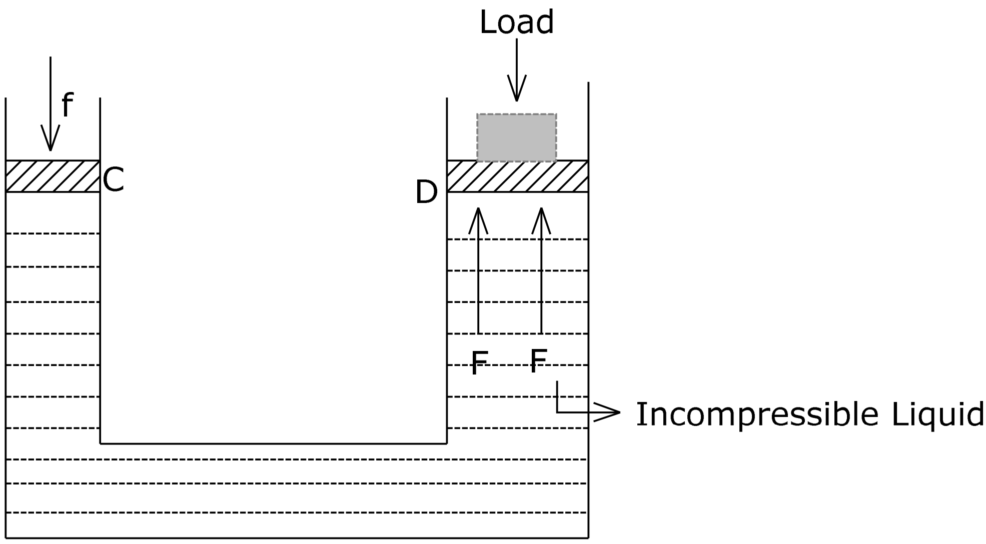
Increase in surface energy = Surface tension x Increase in surface area

= 0.07x$\frac{3168}{7}x10^{-6}$

= $3168x10^{-8}$J

Ans09. Hydraulic lift works on the principle of the Pascal's law. Acc to this law, in the absence of gravity, the pressure is same at all points inside the liquid lying at the same horizontal plane

Working of Hydraulic effect:→



a = Area of cross –section of piston at C

A = Area of cross – section of piston at D.

Let a downward force f be applied on the piston C. Then the pressure exerted on the liquid, P = $\frac{f}{a}$

Acc to Pascal's law, this pressure is transmitted equally to piston of cylinder D.

∴ Upward fore acting on the piston of cylinder D will be :→

F = PA

$= \frac{f}{a} A$

As A ≫ a, F ≫f

i.e. small fore applied on the smaller piston will be appearing as a very large force on the large piston. As a result of which heavy load placed on larger piston is easily lifted upwards.

CBSE TEST PAPER-04
CLASS - XI PHYSICS (Properties of Bulk Matter)
Topic: - Pressure in fluids

1. Does Archimedes principle hold in a vessel in a free fall? [1]

2. Why does not the pressure of atmosphere break windows? [2]

3. If a big drop of radius R is formed by 1000 small droplets of water, then find the radius of small drop? [2]

4. A boulder is thrown into a deep lake. As it sinks deeper and deeper into water, does the buoyant force changes? [2]

5. At what depth in an ocean will a tube of air have one – fourth volume it will have on reaching the surface? Given Atmospheric Pressure = 76 cm of Hg and density of Hg = 13.6g/cc? [2]

6. Why is it painful to walk barefooted on a road covered with pebbles having sharp edges? [2]

7. A liquid stands at the same level in the U – lube when at rest. If A is the area of cross section of tube and g is the acceleration due to gravity, what will be the difference in height of the liquid in the two limbs when the system is given acceleration 'a'? [2]

8. Two ballons that have same weight and volume contains equal amounts of helium. One is rigid and other is free to expand as outside pressure decreases. When released, which balloon will rise higher? [2]

9. An object floats on water with 20% of its volume above the water time. What is the density of object? Given Density of water = 1000kg|m^3. [2]

10. A cubical block of iron 5cm on each side is floating on mercury in a vessel:- [2]
    1) What is the height of the block above mercury level?
    2) Water is poured into vessel so that it just covers the iron block. What is the height of the water column?
    Given Density of mercury = 13.6g|cm^3 and Density of iron = 7.2g|cm^3

CBSE TEST PAPER-04

CLASS - XI PHYSICS (Properties of Bulk Matter)

Topic: - Pressure in fluids [ANSWERS]

Ans 01. Archimedes's Principle will not hold in a vessel in free – fall as in this case, acceleration due to gravity is zero and hence buoyant force will not exist.

Ans 02. Pressure of atmosphere does not break windows as atmospheric Pressure is exerted on both sides of a window, so no net force is exerted on the window and hence uniform pressure does not break the window.

Ans 03. Let r = Radius of small drop

R = Radius of Big drop

Now, Let P = Density of water

Mass of 1000 small droplets = 1000 × volume × Density = $1000\times\frac{4}{3}\pi r^3\times P$

Mass of Big drop = $\frac{4}{3}\pi R^3\times P$

$\because$ Volume of sphere = $\frac{4}{3}\times\pi\times(\text{radius})^3$

Now, Mass of 1000 small droplets = Mass of Big drop

$$1000\times\frac{\cancel{4}}{\cancel{3}}\cancel{\pi}r^3\times\cancel{P}=\frac{\cancel{4}}{\cancel{3}}\cancel{\pi}R^3\times\cancel{P}$$

$$1000r^3=R^3$$

$$r^3=\frac{R^3}{1000}$$

Taking cube root on both sides:→

$$\boxed{r=\frac{R}{10}}$$

Hence the radius of small drop is $\left(\frac{1}{10}\right)$ times the radius of big drop.

Ans 04. The buoyant force does not change as the boulder sinks because the boulder displaces the same volume of water at any depth and because water is practically incompressible, its density is practically the same at all depth and hence the weight of water displaced or the buoyant force is same at all depths.

Ans 05. Let volume of bubble on reaching the surface = V

Let h = height at which volume becomes $\frac{V}{4}$

Now, Initial volume = V_1= V

Final volume = V_2 = $\frac{V}{4}$

Pressure on the bubble at the surface; P_1 = 76cm of Hg

Pressure on the bubble at a depth of h cm is :→

$$P_2 = \left(76 + \frac{h}{13.6}\right) cm \text{ of Hg}$$

Acc, to Boyle's Law,

$$P_1V_1 = P_2V_2$$

$$76X\cancel{V} = \left(76 + \frac{h}{13.6}\right) X \frac{\cancel{V}}{4}$$

$$76X\,4 = 76 + \frac{h}{13.6}$$

$$304 = 76 + \frac{h}{13.6}$$

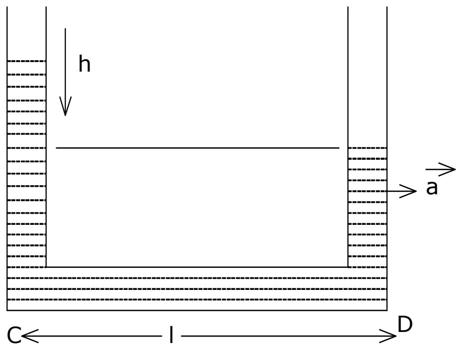
$$304 - 76 = \frac{h}{13.6}$$

$$228X13.6 = h$$

$$\boxed{h = 3100.8 \text{ cm}}$$

Ans 06. It is painful to walk bare – footed on a road covered with pebbles having sharp edges because they have small area and since: Pressure = $\frac{\text{force}}{\text{Arer}}$, Area is less i.e. pressure is more. It Means out feet exert greater pressure on pebbles and in turn pebbles exert equal reaction on the feet.

Ans 07. Let l = Length of the horizontal portion of tube.



Mass of liquid in the portion CD = Volume X Density

Let P = Density of water

Volume = Area X Length

A = Area of cross – section of tube.

= $a \times l$

So, Mass of liquid in portion CD = $(Al) \times P = AlP$

Force on the above Mass towards left = $M \times \vec{a}$ $\quad \vec{a}$ = acceleration

Force = $AlP \times \vec{a} \rightarrow$ i)

Also due to difference in height of liquid, the downward force exerted on liquid in the horizontal portion CD $\Rightarrow$

Pressure = $\dfrac{\text{force}}{\text{Area}}$

Pressure = h P g

h = height; P = Density; g = acceleration due to gravity

So, Force = Pressure X Area

Force = h P g X A $\rightarrow$2)

Equating equation 1) and equation 2) for force on C D :$\rightarrow$

$\cancel{A}l\cancel{P} \times a = h\cancel{P}g \times \cancel{A}$

$$\boxed{h = \frac{al}{g}}$$

Ans 08. The balloon that is free to expand will displace more air as it rises than the balloon is rigid and restrained from expanding. Since the balloon is free to expand will experience more buoyant force and rises higher.

Ans 09. Let volume of entire object = V

Volume of object under water $V_W = V - \dfrac{20}{100} \times V$

$$Vw = V - \frac{20V}{100}$$

$$Vw = \frac{100V - 20V}{100}$$

$$Vw = \frac{80V}{100}$$

$$Vw = 0.8V$$

Let Pw = Density of water

Buoyant force, $F_B = V_W \times P_W \times g$

g = acceleration due to gravity

$F_B = 0.8\ V \times P_W\ g \rightarrow 1)$

If P = Density of object

Weight of object = Mass × Acceleration due to gravity

Mass of object = Volume of object × Density

= V × P

Weight of object = P V g $\rightarrow$ 2)

Acc. to principle of floatation,

Buoyant force = Weight of object

From equation 1) & 2)

$$0.8\cancel{V} \times P_W \cancel{g} = P\cancel{V}\cancel{g}$$

$$P = P_W \times 0.8$$

Now, Density of water = P_W=1000

P = 1000 X 0.8

$\boxed{P = 800 Kg|m^3}$

Hence, Density of object = 800 Kg|m^3.

Ans 10. 1) Let h = height of cubical block above mercury level

Volume of cubical Iron Block = l × b × h

= 5 × 5 × 5

= 125 cm^3.

Mass of cubical Iron Block = Volume × Density of Iron

= 125 × 7.2

= 900 g → 1)

Volume of Mercury displaced = Length × Breadth × Decreased height

$= l \times b \times (5 - h)$

$= 5 \times 5 \times (5 - h)$

Mass of Mercury displaced = Volume of Mercury × Density of Mercury

$= 5 \times 5 \times (5 - h) \times 13.6 \rightarrow 2)$

From, Principle of flotation :→

Weight of Iron Block = Weight of Mercury Displaced

Mass of Iron Block × $\vec{g}$ = Mass of Mercury Displaced × $\vec{g}$

From equation 1) & 2)

$900 \times \cancel{\vec{g}} = 5 \times 5 \times (5\text{-h}) \times 13.6 \times \cancel{\vec{g}}$

$900 = 5 \times 5(5\text{-h}) \times 13.6$

$900 = 125 \times 13.6 \times (5\text{-h})$

$900 = 1700 \times (5\text{-h})$

$\frac{900}{1700} = 5 - h$

$5 - h = 2.65$

$h = 5 - 2.65$

$\boxed{h = 2.35\text{cm}}$

2) When water is poured, let x = height of block in water

∴ Depth of block in mercury = (5 – x) cm

Mass of water displaced = 5 × 5 × x × 1 = 25 x gm

1 = Density of water in g|cm^3

Mass of Mercury displaced = 5 × 5 × (5 – x) × 13.6 = 25 X 13.6 (5 – x) gm

Acc. to principle of floatation,

Weight of Iron Block = Weight of water displaced + Weight of mercury displaced.

900 = 25 x + (25 × 13.6 (5-x))

900 = 25 x + 1700 (5-x)

900 = 25 x + 8500 – 1700 x

900 – 8500 = - 1700 x + 25 x

$\cancel{-}7600 = \cancel{-}1450x$

$\frac{7600}{1450} = x$

$\boxed{2.54 \text{ cm} = x}$

CBSE TEST PAPER-05
CLASS - XI PHYSICS (Properties of Bulk Matter)
Topic: - Surface Tension

1. Oil is sprinkled on sea waves to calm them. Why? [1]

2. A drop of oil placed on the surface of water spreads out, but a drop of water placed on oil contracts. Why? [1]

3. Water rises in a capillary tube but mercury falls in the same tube. Why? [1]

4. What should be the pressure inside a small air bubble of 0.1mm radius situated just below the water surface? Surface tension of water = 7.2×10^{-2} N/m and atmospheric pressure = 1.013×10^{5} N/m^2? [2]

5. Why is a soap solution a better cleansing agent than ordinary water? [2]

6. The antiseptics used for cuts and wounds in human flesh have low surface tension. Why? [1]

7. If the radius of a soap bubble is r and surface tension of the soap solution is T. Keeping the temperature constant, what is the extra energy needed to double the radius of soap bubble? [2]

8. Find the work done in breaking a water drop of radius 1 mm into 1000 drops. Given the surface tension of water is 72×10^{-3} N/m? [2]

9. What is the energy stored in a soap babble of diameter 4 cm, given the surface tension = 0.07 N/m? [2]

10. What is the work done in splitting a drop of water of 1 mm radius into 64 droplets? Given the surface tension of water is 72×10^{-3} N/m^2? [2]

11. Why should detergents have small angles of contact? [1]

12. Show that if two soap bubbles of radii a and b coalesce to from a single bubble of radius c. If the external pressure is P, show that the surface tension T of soap solution is :→ $T = \dfrac{P\left(c^3 - a^3 - b^3\right)}{4\left(a^2 + b^2 - c^2\right)}$

CBSE TEST PAPER-05

CLASS - XI PHYSICS (Properties of Bulk Matter)

Topic: - Surface Tension [ANSWERS]

Ans 01. Since the surface tension of sea-water without oil is greater than the oily water, therefore the water without oil pulls the oily water against the direction of breeze, and sea waves calm down.

Ans 02. Since the cohesive forces between the oil molecules are less than the adhesive force between the oil molecules and the drop of oil spreads out and reverse holds for drop of water.

Ans 03. The capillary rise is given by :→

$$h = \frac{2T\cos\theta}{rPg}$$

h = height of capillary

T = Surface tension

Θ = Angle of contact

r = Radius of capillary

P = Density of liquid

g = Acceleration due to gravity

For mercury – glass surface, θ is obtuse hence Cos θ is negative, hence h is negative hence mercury will depress below the level of surrounding liquid.

Ans 04. Radius of air bubble ; R = 0.1mm

$= 0.1 \times 10^{-3}$ m (1 mm=10^{-3}m)

Surface tension of water, T = 7.2×10^{-2} N|m.

The excess pressure inside an air bubble is given by :→

$$P_2 - P_1 = \frac{2T}{R}$$

P_2 = Pressure inside air bubble

P_1 = Atmospheric pressure

$$P_2 - P_1 = \frac{2\times\left(7.2\times10^{-2}\right)}{0.1\times10^{-3}} = 1.44\times10^{3}\, N/m^{2}$$

$$\begin{aligned} Now,\ P_2 &= P_1 + 1.44\times10^{3} \text{N/m}^2 \\ &= 1.013\times10^{5} + 1.44\times10^{3} \\ &= 1.027\times10^{5} \text{N/m}^2. \end{aligned}$$

Ans 05. Since a cloth has narrow spaces in the form of fine capillaries, Capillary rise is given by:→

h = height of capillary

T = Tension surface

Θ = Angle of contact

r = Radius

P = Density

g = Acceleration due to gravity.

$$h = \frac{2TCos\theta}{rPg}$$

Now, addition of soap to water reduces the angle of contact θ, this will increase Cosθ and hence the value of h. that is, the soap water will rise more in narrow spaces in the cloth and clean fabrics better than water alone.

Ans 06. Since the surface tension of antiseptics is less, they spread more on cuts and wounds and as a result, cut or wound is healed quickly.

Ans 07. Initial radius = r

Surface Tension = T

Surface Area = $4\pi r^2$

Energy required to blow a soap babble of radius r (E_1) =

Surface Tension × 2 × Surface Area

(∵ 2 because bubble has two surfaces)

$E_1 = T \times 2 \times (4\,\pi\, r^2)$

$E_1 = 8\,\pi\, r^2\, T \rightarrow 1)$

Final Radius = 2r

Surface Tension = T

Surface Area = 4 π $(2r)^2$

= 16 π r^2

Energy required to blow a soap bubble of Radius 2 r (E_2)

= surface Tension × 2 × Surface Area

E2=T × 2 × (416 π r^2)

= 32 π r^2 T → 2)

Extra energy required : → $E_2 - E_1$

= 32 π r^2 T – 8 π r^2 T

= 24 π r^2 T

Ans 08. Initial Radius = R = 10^{-3} m (= 1 mm)

Final Radius = r

Since 1 drop breaks into 1000 small droplets, so

Initial volume = 1000 X Final Volume

$$\frac{\cancel{4}}{\cancel{3}}\cancel{\pi}R^3 = 1000 \times \frac{\cancel{4}}{\cancel{3}}\cancel{\pi}r^3$$

$$R^3 = 10^3 r^3$$

$$r^3 = \frac{R^3}{10^3}$$

On, taking cube root on both sides, $r = \frac{R}{10} \rightarrow 1)$

Initial Surface Area = 4 π R^2

$$= 4 \times \frac{22}{7} \times \left(10^{-3}\right)^2$$

$$= 4 \times \frac{22}{7} \times 10^{-6} m^2 \rightarrow 2)$$

Final Surface Area = 1000 × (4 π r^2)

$$= 1000 \times 4 \times \frac{22}{7} \times \left(\frac{10^{-3}}{10}\right)^2 \left(r = \frac{R}{10}\right) \textit{form } \text{eq}^4 \text{ 1)}$$

$$= 4\text{X}\frac{22}{7} \times 10^{-8} \times 10^3$$

$$= 4 \times \frac{22}{7} \times 10^{-5} - 3)$$

Increase in Surface Area = Final surface Area – Initial surface Area

$$= 4X\,\frac{22}{7}\times 10^{-5} - 4\times\frac{22}{7}\times 10^{-6}\,(\rightarrow 4)$$

Now, work Done = Surface Tension X Increase in surface Area

$$= 72X10^{-3}\times\left(4\times\frac{22}{7}\times 10^{-5} - 4\times\frac{22}{7}\times 10^{-6}\right)\left(\textit{from}\ \text{eq}^{4}\ 4)\right)$$

$$= 72\times 4\times\frac{22}{7}\times 10^{-3}\left(10^{-5} - 10^{-6}\right)$$

$$= 72\times 4\times\frac{22}{7}\times 10^{-3}\times 10^{-5}\left(1 - 10^{-1}\right)$$

Work Done $= 72\times 4\times\frac{22}{7}\times 10^{-8}\left(1 - \frac{1}{10}\right)$

$$= 72\times 4\times\frac{22}{7}\times 10^{-8}\times\frac{9}{10}$$

$$\boxed{\text{Work Done} = 8.14\times 10^{-6}\text{J}}$$

Ans 09. Diameter of soap bubble = 4 cm = 4×10^{-2}m

Radius of soap bubble = 2×10^{-2}m

Increase in surface Area = $2 \times 4\,\pi\,R^2$

($\because$ 2, a bubble has 2 surfaces)

Increase in Surface Area = $2 \times 4\,\pi \times (2 X 10^{-2})^2$

$$= 2\times 4\pi\times 4\times 10^{-4}$$
$$= 8\times 4\pi\times 10^{-4}\,m^2$$

Now, energy stored = Surface Tension × Increase in Surface Area

$$= T\times 8\times 4\pi\times 10^{-4}$$

$$= 0.07\times 8\times 4\times\frac{22}{7}\times 10^{-4}$$

Energy Stored $= 0.07\times 2\times 4\times\frac{22}{7}\times 4\times 10^{-4}$

$$= \frac{\cancel{7}\times 8\times 22\times 4}{\cancel{7}}\,X10^{-4}\times 10^{-2}$$
$$= 7\times 10^{-4}\,J$$

Ans 10. Let R = radius of bigger drop = 1mm = 10^{-3}m

r = radius of smaller drop

Bigger volume = 64 × smaller Volume

$$\frac{\cancel{4}}{\cancel{3}}\cancel{\pi}R^3 = 64\times\frac{\cancel{4}}{\cancel{3}}\cancel{\pi}r^3$$

$$R^3 = 64r^3$$

$$r^3 = \frac{R^3}{64}$$

Taking cube root on both sides

$$r = \frac{R}{4} = \frac{10^{-3}}{4} \quad \rightarrow 1)$$

Initial Surface Area = 4 π R^2

$$= 4\times\pi\times\left(10^{-3}\right)^2 \quad \rightarrow 2)$$

Final Surface Area = $4\pi r^2\times 64$

$$= 4\pi\times\left(\frac{R}{4}\right)^2\times 64$$

$$= 4\times\pi\times\frac{\left(10^{-3}\right)^2}{16}\times 64 \quad \rightarrow 3)$$

Increase in Surface = Final Surface Area – Initial Surface Area

$$= 64\times 4\pi\times\left(\frac{10^{-3}}{4}\right)^2 - 4\pi\times\left(10^{-3}\right)^2 \left(\because \textit{ from } \text{equation } 2\ \&3 \rightarrow\right)$$

Work Done = Surface Tension ×Increase in Surface Area

$$= 72\times 10^{-3}\times\left(64\times 4\pi\times\frac{10^{-6}}{4} - 4\pi\times 10^{-6}\right)\left(\because \textit{ from } \text{equation } \rightarrow 4\right)$$

$$= 72\times 4\pi\times 10^{-3}\times 10^{-6}\left(\frac{64}{4} - 4\right)$$

$$= 72\times 4\times\frac{22}{7}\times 10^{-9}\times\left(16-4\right)$$

$$= \frac{72\times 4\times 22\times 12\times 10^{-9}}{7}$$

$$\boxed{\text{Work Done} = 2.7\times 10^{-6}\ \text{J}}$$

Ans 11. Since, Capillary rise = h = $\frac{2TCos\theta}{rPg}$

i.e. h is directly dependent on θ (Angle of contact)

Now If θ→ Small then Cos θ is large and if detergents should have smaller angle of contact then detergent will pentrate more in the cloth and clean better.

Ans 12. Pressure inside the bubble of radius, a = P_1 =P + $\frac{4T}{a}$

Volume of bubble of radius a, $V_1 = \frac{4}{3}\pi a^3$

Pressure inside the bubble of radius, b = $P_2 = P + \frac{4T}{b}$

Volume of the bubble of radius $b, V_2 = \frac{4}{3}\pi b^3$

Pressure inside the bubble of radius C = $P_3 = P + \frac{4T}{c}$

Volume of bubble of radius C, $V_3 = \frac{4}{3}\pi c^3$.

Since, temperature remains the same during the change, from Boyle's Law:→

$$P_1V_1 + P_2V_2 = P_3V_3$$

$$\left(P + \frac{4T}{a}\right) \times \frac{4}{3}\pi a^3 + \left(P + \frac{4T}{b}\right) \times \frac{4}{3}\pi b^3 = \left(P + \frac{4T}{c}\right) \times \frac{4}{3}\pi c^3$$

$$\frac{4}{3}P\pi a^3 + \frac{16T\pi a^2}{3} + \frac{4P\pi b^3}{3} + \frac{16T\pi b^2}{3} = \frac{4}{3}P\pi c^3 + \frac{16T\pi c^2}{3}$$

$$\frac{4}{3}P\pi a^3 + \frac{16T\pi a^2}{3} + \frac{4P\pi b^3}{3} + \frac{16T\pi b^2}{3} - \frac{4}{3}P\pi c^3 - \frac{16T\pi c^2}{3} = 0$$

Taking $\frac{4\pi}{3}$ common from above equation

$$Pa^3 + 4Ta^2 + 4b^3 + 4Tb^2 - Pc^3 - 4Tc^2 = 0$$

$$P\left(a^3 + b^3 - c^3\right) + 4T\left(a^2 + b^2 - c^2\right) = 0$$

$$-P\left(a^3 + b^3 - c^3\right) = 4T\left(a^2 - b^2 - c^2\right)$$

or

$$4\text{T}\left(a^2 + b^2 - c^2\right) = P\left(c^3 - a^3 - b^3\right)$$

$$\boxed{T = \frac{P\left(c^3 - a^3 - b^3\right)}{4\left(a^2 + b^2 - c^2\right)}}$$

CBSE TEST PAPER-06

CLASS - XI PHYSICS (Properties of Bulk Matter)

Topic: - Viscosity

1. What is terminal velocity? What is the terminal velocity of a body in a freely falling system? [2]
2. The diameter of ball A is half that of ball B. What will be their ratio of their terminal velocities in water? [1]
3. Find out the dimensions of co-efficient of viscosity? [1]
4. What is the cause of viscosity in a fluid? How does the flow of fluid depend on viscosity? [2]
5. If eight rain drops each of radius 1 mm are falling through air at a terminal velocity of 5 cm | s. If they coalesce to form a bigger drop, what is the terminal velocity of bigger drop? [2]
6. Why does the cloud seem floating in the sky? [2]
7. A metal plate 5 cm × 5 cm rests on a layer of castor oil 1 mm thick whose co-efficient of viscosity is 1.55 Nsm^{-2}. What is the horizontal force required to more the plate with a speed of 2 cm | s? [2]
8. A small ball of mass 'm' and density 'd' dropped in a viscous liquid of density 'd'. After some time, the ball falls with a constant velocity. What is the viscous force on the ball? [2]
9. Two capillary tubes of length 15 cm and 5 cm and radii 0.06 cm and 0.02 cm respectively are connected in series. If the pressure difference a cross the end faces is equal to the pressure of 15 cm high water column, then find the pressure difference across the : $\rightarrow$ [3]
   1) first tube
   2) Second tube.
10. A metallic sphere of radius 1×10^{-3} m and density 1×10^{4} kg | m^3 enters a tank of water after a free fall through a high 'h' in earth's gravitational field. If its velocity remains unchanged after entering water, determine the value of h. Given :- [3]
    Co-efficient of viscosity of water = 1×10^{-3} Ns | m^2; g = 10 m | s^2; density of water = 1×10^{3} kg | m^3?

CBSE TEST PAPER-06

CLASS - XI PHYSICS (Properties of Bulk Matter)

Topic: - Viscosity [ANSWERS]

Ans 01. It is the maximum constant velocity acquired by the body while falling freely in a viscous medium. In a freely falling system, g = 0. Therefore, the terminal velocity of the body will also be zero.

Ans 02. The terminal velocity is directly proportional to the square of radius of the ball, therefore the ratio of terminal velocities will be 1:4.

Ans 03. Since

$$\mathrm{f}=\eta \mathrm{A}\frac{dv}{dx}$$

f=viscous force

A=Area

$\frac{dv}{dx}$ = velocity gradient

η=co-efficient of viscosity

$$\Rightarrow \eta = \frac{\mathrm{f}}{A\frac{dv}{dx}}$$

$$\eta = \frac{N}{[L^2]\left[\frac{1}{T}\right]}$$

$$1N = [MLT^{-2}]$$

$$\eta = \frac{\left[ML\ \mathrm{T}^{-2}\right]}{\left[L^2\right]\left[T^{-1}\right]}$$

$$\eta = \left[ML^{-1}\ \mathrm{T}^{-1}\right]$$

Ans 04. Internal friction is the cause of viscosity of fluid. The flow of fluid decreases when viscosity increases, because viscosity is a frictional force and greater the friction, lesser is the flow of liquid.

Ans 05. Let the radius of smaller drop = r

Let the radius of bigger drop = R

Volume of smaller drop = $\frac{4}{3}\pi r^3$

Volume of bigger drop = $\frac{4}{3}\pi R^3$

Now, according to the question,

Volume of bigger drop = Volume of 8 smaller drops.

$$\frac{\cancel{4}}{\cancel{3}}\cancel{\pi} R^3 = 8\times\frac{\cancel{4}}{\cancel{3}}\cancel{\pi} r^3$$

$$R^3 = 8r^3$$

Taking cube – root

$$R = 2r$$

$$= 2X1 \text{ mm} \qquad (r = 1mm \text{ (Given)})$$

$$= 2 \text{ mm}$$

$$= 0.2\text{cm} \qquad (1cm = 10mm)$$

Now, Terminal velocity of each small drop = $N_T = \frac{2}{9}\times\frac{r^2}{\eta}(P\text{-}\sigma)g \rightarrow 1)$

Terminal velocity of bigger drop = $V_T = \frac{2}{9}\times\frac{R^2}{\eta}(P-\sigma)g \rightarrow 2)$

η = Co-efficient of viscosity

P = Density of body

σ = Density of fluid

g = acceleration due to gravity

Dividing eq^n 2) by 1)

$$\frac{V_T}{N_T} = \frac{R^2}{r^2}$$

$$V_T = N_T \times \frac{R^2}{r^2}$$

Given Terminal velocity of small drop = 5 cm | s

$$V_T = 5 \times \frac{(0.2)^2}{(0.1)^2}$$

$$= 5 \times \frac{0.04}{0.01}$$

$$\boxed{V_T = 20 \text{ cm} | \text{s}}$$

Ans 06. The terminal velocity of a raindrop is directly proportional to the square of radius of drop. When falling, large drops have high terminal velocities while small drops have small terminal velocities hence the small drops falls so slowly that cloud seems floating.

Ans 07. Length of metal plate = 5 cm

Breadth of metal plate = 5 cm

A = Area of metal plate = Length X Breadth

A = 5 × 5

A = 25 cm^2

Co – efficient of viscosity = $\eta = 1.55 Ns | m^2$

d x = Small thickness of layer = 1 mm = 10^{-3}m

Small velocity = d v = 2 × 10^{-2} m | s

Now, velocity gradient =

$$\frac{\text{dv}}{\text{dx}} = \frac{2 \times 10^{-2}}{10^{-3}} = 2 \times 10^{-2+3}$$

$$= 2 \times 10^{1}$$

$$= 20 \text{ m.}$$

Now, horizontal force F= $\eta A \frac{dv}{dx}$

$$F = 1.55 \times 25 \times 10^{-4} \times \frac{2 \times 10^{-2}}{10^{-3}}$$

$$= 1.55 \times 25 \times 10^{-4} \times 20$$

$$\boxed{F = 0.0775 \text{ N}}$$

Ans 08. Now, Volume = $\frac{\text{Mass}}{\text{Density}}$

Mass of ball = m

Density of ball = d

Volume of ball = $V = \frac{m}{d}$

Density of viscous liquid = d_1

Mass of liquid displaced by the ball = $m_1 = \frac{m}{d} \times d_1 \rightarrow 1)$

When the ball falls with a constant velocity (terminal velocity), we have :→

Viscous force F = weight of ball in water →2)

Weight of ball in water = Weight of ball – Weight of liquid displaced by the ball

$$= mg - m_1 g$$

$$= mg - \frac{mgd_1}{d} \quad (\text{Using equation 1}))$$

$$= mg\left(1 - \frac{d_1}{d}\right)$$

Hence from equation 2)

Viscous force, F = $mg\left(1 - \frac{d_1}{d}\right)$

Ans 09. From, Poiseuille's formula for flow of liquid through a tube of radius 'r' :→

$$V = \frac{\pi \Pr^4}{8\eta l}$$

V = Volume of liquid

r = Radius of tube

$\frac{P}{l}$ = Pressure Gradient

η = Co – efficient of viscosity

When two tubes are connected in series, then the volume of liquid through both the tubes is equal.

Radius of first tube = 0.06 cm

Radius of second tube = 0.02 cm

Length of first tube = 15 cm

Length of second tube = 5 cm

Now, Volume of liquid through first tube = $V_1 = \frac{\pi P_1 r_1^4}{8\eta l_1}$

Volume of liquid through second tube, $V_2 = \frac{\pi P_2 r_2^4}{8\eta l_2}$

Equating above equations for tubes connected in Series

$$V_1 = V_2$$

$$\frac{\pi P_1 r_1^4}{8\eta l_1} = \frac{\pi P_2 r_2^4}{8\eta l_2}$$

Now, Pressure in first tube = $P_1 = (15-h)sg$

S = Density of liquid

Pressure in Second tube = $P_2 = hsg$

15 cm = height of water column.

Now, $\frac{\pi(15-h)sg \times r_1^4}{8\eta l_1} = \frac{\pi hsg \times r_2^4}{8\mu l_2}$

$$\frac{(15-h)r_1^4}{l_1} = \frac{hr_2^4}{l_2}$$

$$\frac{(15-h)\times(0.06)^4}{15} = \frac{h\times(0.02)^4}{5}$$

$$\frac{(15-h)}{15}\times\left(6\times10^{-2}\right)^4 = \frac{h}{5}\times\left(2\times10^{-2}\right)^4$$

$$\frac{(15-h)}{15}\times1296\times\cancel{10^{-8}} = \frac{h}{5}\times16\times\cancel{10^{-8}}$$

$$\frac{(15-h)}{15}\times1296 = \frac{h}{5}$$

$$h = 14.464cm$$

∴ Pressure difference across first tube = 15-14.464

= 0.536 cm of water column

Pressure difference across second tube = 14.464 cm of water column

Ans 10. The velocity acquired by the sphere in falling freely through a height h is $V=\sqrt{2gh}$

As per the conditions of the problem, this is the terminal velocity of sphere in water i.e.

Terminal Velocity of sphere in water is :- $V_T = \sqrt{2gh} \rightarrow 1)$

By Stoke's Law, the terminal velocity V_T of sphere in water is given by :-

$$VT = \frac{2 \times r^2 \times (P - \sigma)_g}{9\eta}$$

r = Radius of sphere = 1 X 10^{-3} m

P = Density of sphere = 1 X 10^{+4} Kg/+m^3

σ = Density of liquid = 1 X 10^3 Kg/m^3

g = Acceleration due to gravity = 10 m/s^2

η = Co-efficient of viscosity = 1 X 10^{-3} Ns/m^2

$$VT = \frac{2 \times (1 \times 10^{-3})^2 \times (1 \times 10^4 - 1 \times 10^3) \times 10}{9 \times 1 \times 10^{-3}}$$

$V_T = 20 m/s$

From equation 1) →

$$V_T = \sqrt{2gh}$$

$$V_T^2 = 2gh$$

$$h = \frac{V_T^2}{2g}$$

$$\boxed{h = \frac{(20)^2}{2 \times 10} = \frac{400}{20} = 20m}$$

CBSE TEST PAPER-07

CLASS - XI PHYSICS (Properties of Bulk Matter)
Topic: - Liquid in Motion

1. Define viscosity? [1]

2. What is the significance of Reynolds's Number? [1]

3. Give two areas where Bernoulli's theorem is applied? [1]

4. Water flows faster than honey. Why? [2]

5. What is stoke's law and what are the factors on which viscous drag depends? [2]

6. Water flows through a horizontal pipe of which the cross – section is not constant. The pressure is 1cm of mercury where the velocity is 0.35m/s. Find the pressure at a point where the velocity is 0.65m/s. [2]

7. What is terminal velocity and derive an expression for it? [3]

8. What is equation of continuity? Water plows through a horizontal pipe of radius, 1cm at a speed of 2m/s. What should be the diameter of nozzle if water is to come out at a speed of 10m/s? [3]

9. What is Bernoulli's theorem? Show that sum of pressure, potential and kinetic energy in the streamline flow is constant? [5]

CBSE TEST PAPER-07

CLASS - XI PHYSICS (Properties of Bulk Matter)
Topic: - Liquid in Motion [ANSWERS]

Ans01. Viscosity is the property of a fluid by virtue of which an internal frictional force comes into play when the fluid is in motion and opposes the relative motion of its different layers.

Ans02. Reynolds's Number (N_R) = $\frac{SDV_C}{n}$

s = Density of liquid

D = Diameter of tube

V_C = Critical velocity

n = Co-efficient of viscosity

If N_R lies b/w o to 2000, the flow of liquid is stream lined if N_R lies above 3000, the flow of liquid is turbulent.

Ans03. Bernoulli's theorem is applied in atomizer and in lift of an aero plane wing.

Ans04. Since from, Poiseuille's formula,

V = $\frac{\pi \mathrm{Pr}^4}{8\eta l}$

V = Volume of liquid plowing per second

R = Radius of narrow tube

P = Pressure difference across 2 ends of tube.

η = co-efficient of viscosity

L = height of tube.

Since, V $\alpha \frac{1}{\eta}, \eta$ for water is less than honey, so V for water is greater and hence it flows faster

Ans05. Acc. to stoke's law:-

F = 6 π η r v $\rightarrow$ The viscous drag force F depends on :-

F = Viscous drag

1) η = co-efficient of viscosity

2) r = radius of spherical body

3) V = Velocity of body

Ans06. At one point, P, = 1cmof Hg

= 0.01m of Hg

= 0.01 x ($13.6 x 10^3$) x 9.8 Pa

Velocity, V_1 = 0.35m|s

At an other point, P_2 = ?

V_2 = 0.65m|s

Density of water, s = 10^3 Kg | m^3

Acc. to Bernoulli's theorem,

$$P_1 + \frac{1}{2}sV_1^2 = P_2 + \frac{1}{2}sV_2^2$$

$$P_2 = P_1 - \frac{1}{2}s\left(V_2^2 - V_1^2\right)$$

$$= 0.01x13.6x10^3x9.8 - \frac{1}{2}x10^3\left((0.65)^2 - (0.35)^2\right)$$

$$= 13.6x10^1x9.8 - \frac{1}{2}x10^3(o.4225 - 0.1225)$$

$$= 1332.8 - \frac{1}{2}x10^3x(0.3)$$

$$= 1332.8 - 0.15x10^3$$

= 1332.8 – 150

$$= 1182.8 \text{ Pa or } \frac{1182.8}{9.8x13.6x10^3} m \text{ of Hg}$$

$$\boxed{P_2 = 0.00887 \text{ m 0f Hg}}$$

Ans07. Terminal velocity is maximum constant velocity a acquired by the body which is falling freely in a viscous medium.

When a small spherical body falls freely through viscous medium then 3 forces acts on it:-

1) Weight of body acting vertically downwards

2) Up thrust due to buoyancy = weight of liquid displaced

3) Viscous drag (F_V) acting in the direction opposite to the motion of body.

Let s = Density of material

r = Radius of spherical body

So = Density of Medium.

∴ True weight of the body = w = volume x density x g

W= $\frac{4}{3}\pi r^3 sg$

Up ward thrust F_T = Volume of Medium displaced

= $\frac{4}{3}\pi r^3 sog$

V = Terminal velocity of body

Acc. to stoke's law

F_V = $6\pi\eta rv$

When the body attains terminal velocity, thon

$F_T + F_V = W$

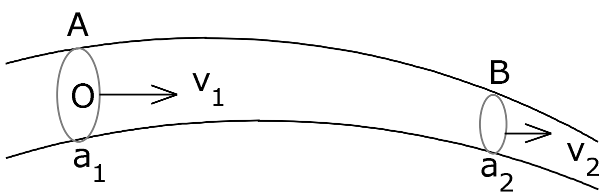
= $\frac{4}{3}\pi r^3 sog + 6\pi\eta rv = \frac{4}{3}\pi r^3 sg$

V = $\frac{2r^2\left(s - So\right)g}{9\eta}$

1) V directly depends on radius of body and difference of the pressure of material and medium.

2) V inversely depends of co-efficient of viscosity

Ans08. Consider a non-viscous liquid in streamline flow through a tube A B of varying cross-section



Let a_1, a_2 = area of cross – section at A and B

V_1, V_2 = Velocity of flow of liquid at A and B

S_1, S_2 = Density of liquid at A and B

Volume of liquid entering per second at A = a_1 v_1

Mass of liquid entering per second at A = a_1 v_1 s_1

Moss of liquid entering per second at B = a_1 v_1 s_2.

If there is no loss of liquid in tube and flow is steady, then

Mass of liquid entering per second at A = Mass of liquid leaving per second at B

$a_1 v_1 s_1 = a_2 v_2 s_2$

If the liquid is incompressible,

$s_1 = s_2 = s$

$a_1 v_1 s = a_2 v_2 s$

$a_1 v_1 = a_2 v_2$

or $\boxed{a\ v = \text{constant}}$

i. e V $\alpha \frac{1}{a}$

It means the larger the area of cross-section, the smaller will be the flow of liquid.

Here 1 $D_1 = 2r_1 = 2x1 = 2cm$

D_2 = ?

V_1 = 2m|s

V_2 = 10m|s

D_1 = Diameter

R_1 = Radius

V_1 = velocity

$a = \pi r^2$, $D=2r$

$= \pi \frac{d^2}{4}, \frac{D}{2} = r$

From equation of continuity

$a_1 v_1 = a_2 v_2$

$$\Rightarrow \left(\pi \frac{D_1^2}{4}\right)^2 x v_1 = \left(\pi \frac{D_2^2}{4}\right) v_2$$

$$D_2 = D_1\left(\frac{v_1}{v_2}\right)^{\frac{1}{2}}$$

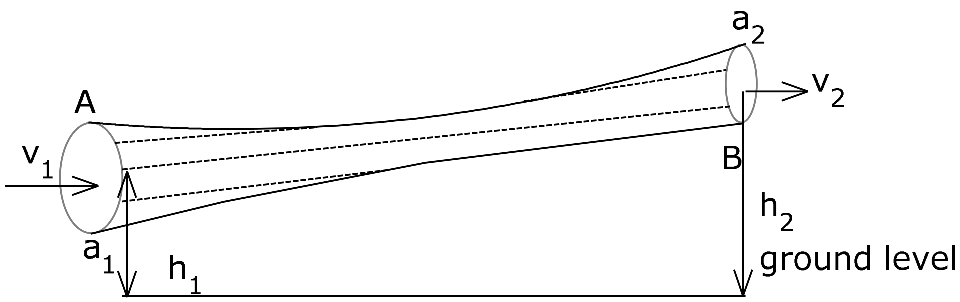
$$= 2\left(\frac{2}{10}\right)^{\frac{1}{2}}$$

$$= 2x\ \frac{1}{\sqrt{5}}$$

$$= 2x\ \frac{1}{2.236} \qquad \boxed{D_2 = 0.894cm}$$

Ans09. Acc. to this theorem, for the streamline flow of an ideal liquid, the total energy that is sum of pressure energy, potential energy and kinetic energy per unit mass remains constant at every cross-section throughout the flow.

Consider a tube A B of varying cross – section.



p_1 = Pressure applied on liquid at A

p_2 = Pressure applied on liquid at B

a_1, a_2 = Area of cross – section at A & B

h_1 h_2 = height of section A and B from the ground.

v_1, v_2 = Normal velocity of liquid at A and B

s= Density of ideal liquid

Let $P_1 > P_2$

m = Mass of liquid crossing per second through any section of tube.

$a_1 v_1 s = a_2 v_2 s = m$

or $a_1 v_1 = a_2 v_2 = \dfrac{m}{s} = v$

As $a_1 > a_2 \therefore v_2 > v_1$

Force of on liquid at A = $p_1 a_1$

Force on liquid at B = $p_2 a_2$

Work done/second on liquid at A = $p_1 a_1$` x $v_1 = p_1 V$

Work done/second on liquid at B = $p_2 V$

Net work done | second by pressure energy in moving the liquid from A to B = $p_1 v - p_2 v \rightarrow (1)$

If 'm' mass of liquid flows in one second from A to B then Increases in potential energy per second from A to B = $mgh_2 - mgh_1 \rightarrow (2)$

Increase in kinetic energy/second of liquid from A to B = $\frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2 \rightarrow (3)$

From, work energy principle:-

Work done by pressure energy = Increase in P. E. /sec + Increase in K. E/sec

From equation 1, 2, & 3

$P_1 v - p_2 v = (mgh_2 - mgh_1) + \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$

$P_1 v + mgh_1 + \frac{1}{2}mv_1^2 = p_2 v + \frac{1}{2}mv_2^2 + mgh_2$

Dividing throughout by m →

$$\frac{p_1 v}{m} + gh_1 + \frac{1}{2v}v_1^2 \pm \frac{p_2 v}{m} + \frac{1}{2}v_2^2 + gh_2$$

$$\frac{p_1}{s} + gh_1 + \frac{1}{2}v_1^2 = \frac{p_2}{s} + \frac{1}{2}v_2^2 + gh_2$$

$s1 = \frac{m}{v}$ Density

Hence, $\boxed{\frac{p}{s} + gh + \frac{1}{2}v^2 = \text{Constant}}$ →4)

$\frac{p}{s} =$ Pressure energy per unit mass

gh = potential energy per unit mass

$\frac{1}{2}v^2$ = kinetic energy per unit mass

Hence from equation), Bernoulli's theorem is proved.

CBSE TEST PAPER-08

CLASS - XI PHYSICS (Properties of Bulk Matter)

Topic: - Fluid Flow

1. What is conserved in Bernoulli's theorem? [1]

2. If the rate of flow of liquid through a horizontal pipe of length l and radius R is Q. What is rate of flow of liquid if length and radius of tube is doubled? [1]

3. Water is coming out of a hole made in the wall of tank filled with fresh water. If the size of the hole is increased, will the velocity of efflux change? [1]

4. The accumulation of snow on an aero plane wing may reduce the lift. Explain? [1]

5. Two pipes P and Q having diameters 2×10^{-2} m and 4×10^{-2} m respectively are joined in Series with the main supply line of water. What is the velocity of water flowing in pipe P? [2]

6. A horizontal pipe of diameter 20 cm has a constriction of diameter 4 cm. The velocity of water in the pipe is 2m/s and pressure is 10 N/m^2. Calculate the velocity and pressure at the constriction? [2]

7. The reading of a pressure metre attached to a closed is 2.5×10^5 N/m^2. On opening the valve of pipe, the reading of the pressure metre reduces to 2.0×10^5 N/m^2. Calculate the speed of water flowing through the pipe? [2]

8. A large bottle is fitted with a siphon made of capillary glass tubing. Compare the Co-efficient of viscosity of water and petrol if the time taken to empty the bottle in the two cases is in the ratio 2:5. Given specific gravity of petrol = 0.8 [2]

9. Under a pressure head, the rate of flow of liquid through a pipe is Q. If the length of pipe is doubled and diameter of pipe is halved, what is the new rate of flow? [2]

10. In a horizontal pipeline of uniform area of cross – section, the pressure falls by 5 N/m^2 between two points separated by a distance of 1 Km. What is the change in kinetic energy per Kg of oil flowing at these points? Given Density of oil = 800 Kg/m^3? [3]

11. 1) Water flows steadily along a horizontal pipe at a rate of 8×10^{-3}m^3/s. If the area of cross – section of the pipe is 40×10^{-4} m^2, Calculate the flow velocity of water. [3]
    2) Find the total pressure in the pipe if the static pressure in the horizontal pipe is 3×10^4 Pa. Density of water is 1000 Kg/m^3.
    3. What is the net flow velocity if the total pressure is 3.6×10^4 Pa?

CBSE TEST PAPER-08

CLASS - XI PHYSICS (Properties of Bulk Matter)

Topic: - Fluid Flow [ANSWERS]

Ans 01. According to Bernoulli's theorem, for an incompressible non – Viscous liquid (fluid) undergoing steady flow the total energy of liquid at all points is constant.

Ans 02. From Poiseuille's formula, rate of flow of liquid through a tube of radius 'R' is and length 'l' is :-

$$Q=\frac{\pi P R^4}{8\eta l} \quad \rightarrow 1)$$

If R and l are doubled then rate of flow Q_1 is

$$Q_1=\frac{\pi P(2R)^4}{8\eta(2l)}$$

$$Q_1=\frac{16\pi P R^4}{2\ 8\eta \mathrm{l}} \quad \text{(Using equation 1))}$$

$$\boxed{Q_1 = 8\ Q}$$

Ans 03. Velocity of efflux, $V=\sqrt{2gh}$, Since the velocity of efflux is independent of area of hole, it will remain the same.

Ans 04. Due to the accumulation of snow on the wings of the aero plane, the structure of wings no larger remains as that of aerofoil. As a result, the net upward force (i.e. lift) is decreased.

Ans 05. Diameter of pipe P = 2 × 10^{-2} m

Diameter of Pipe Q = 4 × 10^{-2} m

Acc. to the equation of continuity;

$$a_1v_1=a_2v_2 \quad a_p v_p = a_Q v_Q \quad \rightarrow A)$$

a_Q, a_P = Cross – section area of pipe P and Q

v_P, v_Q = Velocity of liquid at pipe P and Q

Now, $a_Q = \pi r^2$ r=radius

$$a_Q = \pi\left(\frac{d_Q}{2}\right)^2$$

$$a_Q = \frac{\pi}{4} d_Q{}^2 \rightarrow 1)$$

$$a_P = \frac{\pi}{4} d_P{}^2 \rightarrow)$$

Now, from equation A)

$$\left(\frac{\pi}{4} d_P{}^2\right) V_P = \left(\frac{\pi}{4} d_Q{}^2\right) V_Q$$

$$d_P{}^2 \ \mathrm{V_P} = \mathrm{d_Q}^2 \ \mathrm{V_Q}$$

$$\frac{V_P}{V_Q} = \left(\frac{d_Q}{d_P}\right)^2$$

$$\frac{\mathrm{V_P}}{\mathrm{V_Q}} = \left(\frac{4\times10^{-2}}{2\times10^{-2}}\right)^2$$

$$\frac{\mathrm{V_P}}{\mathrm{V_Q}} = (2)^2$$

$$\mathrm{V_P} = 4\mathrm{V_Q}$$

i.e. Velocity of water in pipe P is four times the velocity of water in pipe Q.

Ans 06. Acc. to equation of continuity,

$$a_1 v_1 = a_2 v_2$$

$$v_2 = \frac{a_1 v_1}{a_2} \rightarrow 1)$$

Now, v_1 = velocity at1 = 2m/s

v_2 = velocity at 2 = ? a_2, a_1 = Cross – Sectional Area at 2 & 1.

$$a_2 = \pi \times r_2{}^2; \quad \mathrm{r_2 = 2cm}$$

$$a_2 = \pi \times (0.02)^2 \ m^2 \ = 2\times10^{-2}\mathrm{m}$$

$a_1 = \pi \times r_1^2$

$a_1 = \pi \times (0.1)^2\ m^2$ $\quad r_1 = 10cm$

$= 10 \times 10^{-2} m$

$= 10^{-1} m$

$= 0.1m$

Now, from equation 1)

$$v_2 = \frac{\pi \times (0.1)^2 \times 2}{\pi \times (0.02)^2}$$

$$v_2 = \frac{0.01 \times 2}{2 \times 10^{-4}}$$

$$\boxed{v_2 = 50m/s}$$

Acc. to Bernoulli's theorem, for the horizontal pipeline, we have,

P_2, P_1 = Pressure at1 & 2

s = Density

$$P_1 + \frac{1}{2} s v_1^2 = P_2 + \frac{1}{2} s v_2^2$$

$$P_2 = P_1 - \frac{1}{2} s \left(v_2^2 - v_1^2\right)$$

$$P_1 = 10^7\ N/m^2$$

$$v_2 = 50m/s$$

$$v_1 = 2m/s$$

$$s = 10^3\ Kg/m^3$$

So, $P_2 = 10^7 - \frac{1}{2} \times 10^3 \left[(50)^2 - (2)^2\right]$

$$= 10^7 - \frac{1}{2} \times 10^3 [2500 - 4]$$

$$= 10^7 - 12.48 \times 10^5$$

$$\boxed{P_2 = 8.752 \times 10^6\ N/m^2}$$

Ans 07. Pressure $\Rightarrow P_1 = 2.5 \times 10^5 N/m^2$

at end 1

Pressure $\Rightarrow P_2 = 2.0 \times 10^5 N/m^2$

end 2

$v_1 = 0$ ($\because$ Initially pipe was closed)

$v_2 = ?$

Density of water = s = 1000 Kg|m^3

Acc. to Bernoulli's theorem for a horizontal pipe,

$$P_1 + \frac{1}{2}sv_1^2 = P_2 + \frac{1}{2}sv_2^2$$

$$P_1 = P_2 + \frac{1}{2}sv_2^2$$

$$v_2^2 = \frac{2(P_1 - P_2)}{s}$$

$$v_2^2 = \frac{2(2.5\times10^5 - 2\times10^5)}{1000}$$

$$v_2^2 = \frac{2\times10^5\times0.5}{1000}$$

$$v_2 = \sqrt{100}$$

$$\boxed{v_2 = 10m/s}$$

Ans 08. $Q_1 = \dfrac{\pi P_1 R^4}{8\eta_1 l}$

Q_1 = rate of flow of liquid in case 1

P_1 = Pressure

R = Radius

s_1 = specific gravity in 1st Case

η_1 = Co-efficient of viscosity

s_2 = Density of water

$$Q_1 = \frac{v}{t_1}$$

v = volume of liquid

t_1 = time Case 1

$$Q_1 = \frac{v}{t_1};\ Q_2 = \frac{\pi P_2^{\ 2} R^4}{8\eta_2 l} = \frac{v}{t_2}$$

Now, $\frac{Q_1}{Q_2} = \frac{t_2}{t_1} = \frac{5}{2} \rightarrow 1)\ \left(\because \frac{t_2}{t_1} = \frac{5}{2}(given)\right)$

Now, $\frac{Q_1}{Q_2} = \frac{P_1\eta_2}{P_2\eta_1} \rightarrow ii)$

$$P_1 = s_1 gh$$
$$P_2 = s_2 gh$$
$$\frac{p_1}{P_2} = \frac{s_1}{s_2} = \frac{10^3}{0.8X10^3} = 1.25 \rightarrow 3)$$

Equating equation 1) & 2) for $\frac{Q_1}{Q_2}$

$$\frac{5}{2} = \frac{P_1\eta_2}{P_2\eta_1}$$
$$\frac{5}{2} = 1.25 \times \frac{\eta_2}{\eta_1}\ \ (\text{from equation } 3))$$
$$\frac{\eta_1}{\eta_2} = 1.25 \times \frac{2}{5} = 0.5$$
$$\boxed{\frac{\eta_1}{\eta_2} = 1:2}$$

Ans 09. From Poisudlie's equation for flow liquid through a tube of radius R and length l $: \rightarrow$

$$Q = \frac{\pi P R^4}{8\eta l} \rightarrow A)$$

Now if diameter is halved:→

$$D^1 = \frac{D}{2}$$

For radius = $2R^1 = 2\left(\frac{R}{2}\right)$

$$R^1 = \frac{R}{2} \rightarrow 1)$$

Length is doubled :→ $l_1 = 2l \rightarrow 2)$

Rate of flow liquid $\Rightarrow Q^1 = \frac{\pi P R^{14}}{8\eta l^1}$

$$Q^1 = \frac{\pi P\left(\frac{R}{2}\right)^4}{8\eta \times 2l}$$

$$Q^1 = \frac{1}{32}\frac{\pi P R^4}{8\eta l}$$

$$\boxed{Q^1 = \frac{Q}{32}} \qquad (\because \text{ from equation 1})$$

Ans 10. Acc. to Bernoulli's theorem, total energy is conserved:→

$$\frac{P}{s} + gh + \frac{1}{2}v^2 = \text{Constant}$$

For a horizontal pipe, h = 0

$$\frac{P}{s} + \frac{1}{2}v^2 = \text{Constant}$$

At ends 1 and 2 :→

$$\frac{P_1}{s} + \frac{v_1^2}{2} = \frac{P_2}{s} + \frac{v_2^2}{2}$$

$$\frac{P_1 - P_2}{s} = \frac{1}{2}\left(v_2^2 - v_1^2\right) \rightarrow 1)$$

Change in K. E = $\frac{1}{2}m\left(v_2^2 - v_1^2\right)$

Change in K. E. per Kg = $\frac{1}{2}\left(v_2^2 - v_1^2\right)$

$$= \frac{P_1 - P_2}{s} \ \left(\text{from equation 2}\right)$$

Given, $P_1 - P_2 = 5$ N|m^2,

S = 800 Kg /m^3

Change in K. E. = $\frac{5}{800} = 6.25 \times 10^{-3}\ J/Kg$

Ans 11. 1) Velocity of water = $\dfrac{\text{Rate of flow}}{\text{Area of Cross-Section}}$

Given, Rate of flow = 8×10^{-3} m^3/s

Area of cross – Section = 40×10^{-4} m^2

So, Velocity of water = $\dfrac{8\times10^{-3}}{40\times10^{-4}}$

= 2 m /s

2) Total Pressure = Static Pressure + $\dfrac{1}{2}sv^2$

$$=3\times10^4+\frac{1}{2}\times1000\times(2)^2 \quad (\because v=2m/s(given))$$

$$=3.2\times10^4\,Pa$$

3) Total Pressure = Static Pressure + $\dfrac{1}{2}sv^2$

$\dfrac{1}{2}sv^2 =$ Total Pressure – Static Pressure

$$\frac{1}{2}\times1000\times v^2=3.6\times10^4-3\times10^4$$

$$\frac{1}{2}v^2=0.6\times10^4$$

$$\boxed{v=\sqrt{\frac{2\times0.6\times10^4}{1000}}=3.5m/s}$$

CBSE TEST PAPER-01
CLASS - XI PHYSICS (Thermodynamics)
Topic: - Thermometry and Thermal Expansion

1. Why is mercury used in making thermometers? [1]

2. How would a thermometer be different if glass expanded more with increasing temperature than mercury? [1]

3. Show the variation of specific heat at constant pressure with temperature? [1]

4. Two thermometers are constructed in the same way except that one has a spherical bulb and the other an elongated cylindrical bulb. Which one will response quickly to temperature change? [1]

5. A thermometer has wrong calibration. It reads the melting point of ice as – 10^0C. It reads 60^0C in place of 50^0C. What is the temperature of boiling point of water on the scale? [2]

6. Write the advantages and disadvantages of platinum resistance thermometer? [2]

7. If the volume of block of metal changes by 0.12% when it is heated through 200C. What is the co-efficient of linear expansion of the metal? [2]

8. The density of a solid at0^0C and 500^0C is in the ratio 1.027 : 1. Find the co-efficient of linear expansion of the solid? [2]

9. If one Mole of a monatomic gas is mixed with 3 moles of a diatomic gas. What is the molecular specific heat of the mixture at constant volume? [2]

10. Calculate the difference between two principal specific heats of 1g of helium gas at N. T. P. Given Molecular weight of Helium = 4 and J = 4.186 J/cal and Universal Gas constant, R = 8.314J / mole / K? [2]

11. Why does heat flow from a body at higher temperature to a body at lower temperature? [2]

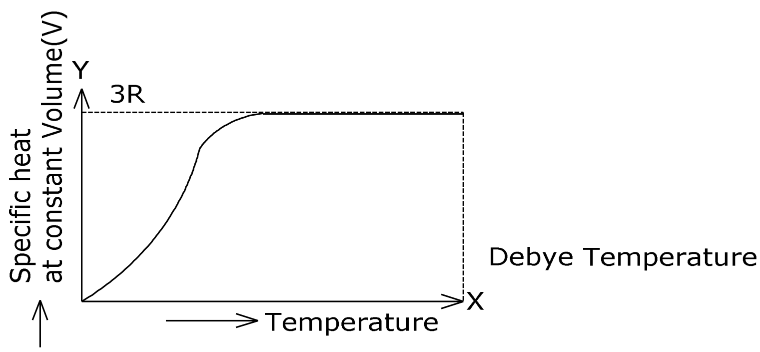
12. A one liter flask contains some mercury. IT is found that at different temperatures, then volume of air inside the flask remains the same. What is the volume of mercury in the flask? Given the co-efficient of linear expansion of glass = 9×10^{-6} / ^{0}C and co-efficient of volume expansion of mercury = 1.8×10^{-4} / ^{0}C [2]

CBSE TEST PAPER-01
CLASS - XI PHYSICS (Thermodynamics)
Topic: - Thermometry and Thermal Expansion [ANSWERS]

Ans 01. Mercury is used in making thermometers because it has wide and useful temperature range and has a uniform rate of expansion.

Ans 02. If glass expanded more with increasing temperature than mercury, the scale of the thermometer would be upside down.

Ans 03.



Ans 04. The thermometer with cylindrical bulb will respond quickly to temperature changes because the surface area of cylindrical bulb is greater than the of spherical bulb.

Ans 05. Lower fixed point on the wrong scale = -10^{0}C.

Let 'n' = no. divisions between upper and lower fixed points on this scale. If Q = reading on this scale, then $\frac{C-O}{100}=\frac{Q-(-10)}{n}$

Now, C = Incorrect Reading = 60^{0}C

Q = Correct Reading = 50^{0}C

So, $\frac{50-0}{100}=\frac{60-(-10)}{n}$

$$\frac{50}{100} = \frac{70}{n}$$

$$n = 70 \times \frac{100}{50}$$ $\boxed{n = 140}$

Now, $\dfrac{C-O}{100} = \dfrac{Q-(-10)}{140}$

On, the Celsius scale, Boiling point of water is 100^0C

So, $\dfrac{100-0}{100} = \dfrac{Q+10}{140}$

$Q = 140 - 10$ $\boxed{Q = 130^0\text{C}}$

Ans06. Advantages of Platinum Resistance thermometer:-

1) High accuracy of measurement

2) Measurements of temperature can be made over a wide range of temperature i.e. from – 260^0C to 1200^0C.

→ Disadvantages of Platinum Resistance thermometer:-

1) High Cost

2) Requires additional equipment such as bridge circuit, Power supply etc.

Ans 07. The co-efficient of cubical expansion y of the metal is given by:-

$$Y = \frac{1}{V} \times \frac{\Delta V}{\Delta T}$$

$$Y = \frac{\Delta V}{V} \times \frac{1}{\Delta T}$$

Here, $\dfrac{\Delta V}{V} = \dfrac{0.12}{100}$

$\Delta T = 20^0 C$

$$Y = \frac{0.12}{100} \times \frac{1}{20}$$

$$Y = 6 \times 10^{-5} |^0 C$$

∴ Co-efficient of linear expansion of the metal is :-

$$\alpha = \frac{Y}{3} = \frac{6.0 \times 10^{-5}}{3}$$ $\boxed{\alpha = 2.0 \times 10^{-5} |^0 C}$

Ans 08. Density at 0^0C = S_O

Density at 500^0C = S_{500}

Now, $S_O = S_{500}\left(1+Y\Delta T\right)$

Where, Y = Co-efficient of volume expansion

ΔT = Change in temperature

$\because \frac{SO}{S_{500}} = \frac{1.027}{1}$

ΔT = Change in temperature

ΔT = Final Temperature – Initial temperature

$\Delta T = 500 - 0^0C$

$\Delta T = 500^0C$

Or $1.027 = 1\times\left(1+Y\Delta T\right)$

$1.027 = 1+Y\Delta T$

$1.027-1 = Y\Delta T$

$0.027 = Y\Delta T$

$\frac{0.027}{500} = Y$

$Y = 54\times10^{-6} |^0 C$

Now, Co-efficient of linear expansion (α) is related to co-efficient of volume expansion (Y) as :-

$\alpha = \frac{Y}{3}$

$\alpha = \frac{54\times10^{-6}}{3}$

$$\boxed{\alpha = 18\times10^{-6} |^0 C}$$

Ans 09. For, a monatomic gas, Specific heat at consent volume = $C_{V1} = \frac{3}{2}R$; R = Universal Gas Constant

No. of moles of monatomic gas = n_1 = 1 mole

No. of moles of diatomic gas = n_2 = 3 moles.

For, diatomic gas, specific heat at constant volume $C_{V2} = \frac{5}{2}R.$

Applying, conservation of energy.

Let C_V = Specific heat of the mixture;

$$C_V = \frac{n_1 Cv_1 + n_2 Cv_2}{n_1 + n_2}$$

$$C_V = \frac{1 \times \frac{3}{2}R + 3 \times \frac{5}{2}R}{1+3}$$

$$C_V = \frac{\frac{3}{2}R + \frac{15}{2}R}{4}$$

R = Universal Gas constant

$$C_V = \frac{18R}{2 \times 4}$$

$$C_V = \frac{9R}{4}$$

$$C_V = \frac{9}{4} \times 8.31$$

$$C_V = 18.7 J \,|\, mol \,|^0\ K$$

Ans 10. Molecular weight of Helium = M = 4

Universal Gas Constant, R = 8.31J | mole | K

C_P = specific heat at constant Pressure

C_V = specific heat at constant Volume

Now, $C_P - C_V = \frac{r}{J}$ for 1 mole of gas.

$$C_P - C_V = \frac{R}{MJ}$$

Where R = Universal Gas Constant = 8.31J | mole | K

J = 4.186 J | cal

M = Molecular weight of Helium = 4

$$C_P - C_V = \frac{8.31}{4 \times 4.186}$$

$$\boxed{C_P - C_V = 0.496\ cal \,|\, g \,|\, K}$$

Ans 11. When a body at higher temperature is in contact with a body at lower temperature, molecule with more kinetic energy that are in contact with less energetic molecules give up some of their kinetic energy to the less energetic ones.

Ans 12. It is given that volume of air in the flask remains the same at different temperature. This is possible only when the expansion of glass is exactly equal to the expansion of mercury,

Co-efficient of cubical expansion of glass is :-

$$\gamma_g = 3\alpha_g = 3\times9\times10^{-6}$$

$$=27\times10^{-6}|^0C$$

Co-efficient of cubical expansion of mercury is :→

$$\gamma_m = 1.8\times10^{-4}\,|^0\,C\left(Given\right)$$

Volume of flask, V = 1 liter = 1000 cm^3.

Let V_m Cm^3 be the volume of mercury in the flask.

Expansion of flask = Expansion of Mercury

$$CX\,\gamma_g \times t = V_m X\,\gamma_m \times t$$

∴ Volume of Mercury, $V_m = \dfrac{V\times\gamma g}{\gamma_m}$

$$V_m = \frac{1000\times27\times10^{-6}}{1.8\times10^{-4}} = 150cm^3$$

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Thermometry Thermal Expansion and Specific Heat

1.	Define triple point of water?	[1]
2.	State Dulong and petit law?	[1]
3.	Why the clock pendulums are made of invar, a material of low value of coefficient of linear expansion?	[1]
4.	Why does the density of solid | liquid decreases with rise in temperature?	[2]
5.	Two bodies at different temperatures T_1, and T_2 are brought in thermal contact do not necessarily settle down to the mean temperature of T_1 and T_2?	[2]
6.	The resistance of certain platinum resistance thermometer is found to be 2.56 Ω at 0^0c and 3.56 Ω at 100^0c. When the thermometer is immersed in a given liquid, its resistance is observed to 5.06 Ω. Determine the temperature of liquid?	[2]
7.	Calculate C_p for air, given that C_v =0.162 cal g^{-1} k^{-1} and density air at N.T. P is 0.001293 g|cm^3?	[3]
8.	Develop a relation between the co-efficient of linear expansion, co-efficient superficial expansion and coefficient of cubical expansion of a solid?	[3]
9.	Calculate the amount of heat required to convert 1.00kg of ice at – 10^0c into steam at 100^0c at normal pressure. Specific heat of ice = 2100J|kg|k. Latent heat of fusion of ice = $3.36\text{x}10^5$J|kg, specific heat of water = 4200J|kg|k. Latent heat of vaporization of water = 2.25 $\text{x}10^6$J|kg?	[3]
10.	A ball is dropped on a floor from a height of 2cm. After the collision, it rises up to a height of 1.5m. Assuming that 40% of mechanical energy lost goes to thermal energy into the ball. Calculate the rise in temperature of the ball in the collision. Specific heat capacity of the ball is 800J/k. Take g = 10m/s^2	[2]

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Thermometry Thermal Expansion and Specific Heat [ANSWERS]

Q1.Ans. Triple point of water represents the values of pressure and temperature at which water co-exists in equilibrium in all the three states of matter.

Q2.Ans. Acc. to this law, the specific heat of all the solids is constant at room temperature and is equal to 3R.

Q3.Ans. The clock pendulums are made of Inver because it has low value of α (co-efficient of linear expansion) i.e. for a small change in temperature, the length of pendulum will not change much.

Q4.Ans. Let P = Density of solid | liquid at temperature T

P^1 = Density of solid | liquid at Temperature T+ΔT

Since Density = $\frac{Mass}{Volume}$

So, P = $\frac{M}{V} \rightarrow (1)$ $P^1 = \frac{M}{v^1} \rightarrow (2)$

V^1 = Volume of solid at temperature T + ΔT

V = Volume of solid at temperature T

Since on increasing the temperature, solids | liquids expand that is their volumes increases, so by equation

i) & 2) Density is inversely proportional to volumes, so if volume increases on increasing the temperature, Density will decrease.

Q5.Ans. Two bodies at diff temperatures T_1 and T_2 when in thermal contact do not settle always at their mean temperature because the thermal capacities of two bodies may not be always equal.

Q6.Ans. R_o = Resistance at0^0c = 2.56Ω

R_t = Resistance at temperature T = 100^0c = 3.56Ω 100

R_t = Resistance at unknown temperature t ;

R_t = 5.06Ω

Since,

t = $\frac{R_t - R_o}{R_{100} - R_o} \times 100$

= $\frac{(5.06-2.56)}{(3.56-2.56)} \times 100$

= $\frac{2.5 \times 100}{1}$

= $\frac{25}{10} \times 100$

$\boxed{t = 250^0 c}$

Q7.Ans. Specific heat at constant pressure = C_p= ?

Specific heat at constant volume = C_v = 0.162 Cal g^{-1} k^{-1}

Now, Cp – Cv = $\frac{r}{J} = \frac{PV}{TJ}$ $(\because PV = nRT)$

Or CP – Cv = $\frac{P \times 1}{s \times TJ}$ $(s = Density)$

Cp – Cv = $\frac{1.01 \times 10^6}{273 \times 4.2 \times 10^7 \times 1.293 \times 10^{-3}}$

= $\frac{1.01 \times 10^{6+3-7}}{273 \times 4.2 \times 1.293}$

= $\frac{1.01 \times 10^2}{1482.5}$

= $6.8 \times 10^{-4+2}$

Cp – Cv = 0.068

Cp = 0.162+0.068

$\boxed{Cp = 0.23 \text{ Cal } g^{-1} k^{-1}}$

Q8.Ans. Since, co-efficient of linear expansion = α = $\frac{\Delta L}{L\Delta T}$

ΔL = change in length

L = length

ΔT = change in temperature

Similarly, co-efficient of superficial expansion = β = $\frac{\Delta S}{S\Delta T}$

ΔS = change in area

S = original area

ΔT = change in temperature

Co-efficient of cubical expansion, = Y = $\frac{\Delta V}{V\Delta T}$

ΔV = change in volume

V = original volume

ΔT = change in temperature.

Now, ΔL=αL ΔT

L + ΔL = L + αL ΔT

L + ΔL = L (1+αΔT) → (1)

Similarly V+ ΔV = V (1+YΔT) →(2)

And S+ΔS=S (1+βΔT) → (3)

Also, (V+ΔV) = $(L+\Delta L)^3$

V+ΔV = $\left[L\left(1+\alpha\Delta T\right)\right]^3$

V+ΔV = L^3 $\left(1+3\alpha\Delta T+3\alpha^2\Delta T^2+\alpha^3T^3\right)$

Since α^2, α^3 are negligible, so,

V+γ VΔT= V(1+3αΔT) [as L^3=V]

So, V+γVΔT = V+V3αΔT

γVΔT = 3αΔT

$$\boxed{Y = 3\alpha}$$

Similarly, β = 2α [using L^2 = S (Area)]

So, $$\boxed{\alpha=\frac{\beta}{2}=\frac{\gamma}{3}}$$

Q9.Ans. (1) Here, heat is required to raise the temperature of ice from – 10^0c to 0^0c.

So, change in temperature = $\Delta T = T_2 - T_1 = 0-(-10) = 10^0c$

So, $\Delta Q_1 = cm\Delta T$

C = specific heat of ice

M = Mass of ice

$\Delta T = 10^0c$

$\Delta Q_1 = 2100\times1\times10=21000J$

(2) Heat required to melt the ice to 0^0c water:-

$\Delta Q_2 = mL$

L = Latent heat of fusion of ice = 3.36×10^5J/kg

m = Mass of ice

$\Delta Q_2 = 1\times3.36\times10^5 J/kg$

$\Delta Q_2 = 3.36\times10^5 J$

$\Delta Q_2 = 336000J$

(3) Heat required to raise the temperature of water from 0^0c to 100^0c:-

$\Delta T = T2-T1 = 100-0=100^0c$

$\Delta Q_3 = cm\Delta T$ c = specific heat of water

$= 4200\times1\times100$

= 420,000J

(4) Heat required to convert 100^0c water to steam at 100^0c

$\Delta Q_4 = mL$ L = Latent heat of vapourisation = 2.25×10^6J/kg

$\Delta Q_4 = 1\times2.25\times10^6 J|kg$

$\Delta Q_4 = 2250000J$

$\therefore$ Total Heat required = $\Delta Q_1+\Delta Q_2+\Delta Q_3+\Delta Q_4$

ΔQ total = 21000+336000+420000+2250000

ΔQ total = 3027000J

ΔQ total = 3.027×10^6J

Q10.Ans. Initial height = h_1=2m

Final height = h_2=1.5m

Since potential energy = mechanical energy for a body at rest as K.E =0

Mechanical energy lost = $\left|mg\left(h_1 - h_2\right)\right|$

= $\left|1\times 10\left(105-2\right)\right|$

= $\left|10\times\left(.5\right)\right|$

= 5 J

Now (mechanical energy lost) × 40% = heat gained by ball

$$\frac{40}{100}\times 5 = cm\Delta T \quad \text{C = specific heat of ball}$$

$$\frac{40}{100}\times 5 = 800\times 1\times \Delta T \quad \text{m = Mass of ball =1kg}$$

$$\Delta T = \frac{\cancel{40}^{\cancel{2}\ 1}\times \cancel{5}^{1}}{\cancel{100}_{\cancel{5}}\times \cancel{800}_{400}} = \frac{1}{400}$$

$$\frac{1}{400} = \Delta T$$

$$\boxed{\Delta T = 2.5\times 10^{-3}\ {}^{0}C}$$

CBSE TEST PAPER-03
CLASS - XI PHYSICS (Thermodynamics)
Topic: - Specific heat, Calorimetry and Hygrometer

1. Why is temperature gradient required for flow of heat from one body to another? [1]

2. Why are Calorimeters made up of metal only? [1]

3. If a body has infinite heat capacity? What does it signify? [1]

4. A gas can have any value of specific heat depending upon how heating is carried out. Explain? [2]

5. A 0.20 Kg aluminum block at 80^0C is dropped in a copper calorimeter of mass 0.05 Kg containing 200 cm^3 of ethyl alcohol at 20^0C. What is the final temperature of the mixture? Given Density of ethyl alcohol = 0.81 g | cm^3 ; specific heat of ethyl alcohol = 0.6 cal | g | ^0C ; specific heat of copper = 0.094 cal | g | ^0C, specific heat of Al = 0.22 cal | g | ^0C? [2]

6. Why is there a difference in the specific heat curve as given by Delong's petit law and the experimental result at low temperatures? [2]

7. Specific heat of Argon at constant Pressure is o.125 cal | g | K and at constant volume is 0.075 cal | g | K. Calculate the density of argon at N.T.P. Given that J = 4.2J | cal? [2]

8. How is heat loss reduced in Calorimeter? [2]

9. Calculate the amount of heat necessary to raise the temperature of 2 moles of HE gas from 20^0C to 50^0C using:- [3]
   1) Constant – Volume Process 2) Constant Pressure Process
   Here for, He; C_V = 1.5 R and C_P = 2.49R

10. What is critical temperature? How will you differentiate between a gas and a vapour depending on critical temperature? [2]

11. If for hydrogen CP – CV = a and for oxygen CP – CV = b where CP & CV refer to specific heat at constant pressure and volume then what is the relation between a and b? [2]

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Specific heat, Calorimetry and Hygrometer [ANSWERS]

Ans 01. Heat flows from higher temperature to lower temperature. Therefore, temperature gradient (i.e. temperature difference) is required for the heat to flow one part of solid to another.

Ans 02. Calorimeters are made up of metal only because they are good conductor of heat and hence the heat exchange is quick which the basic requirement for the working of calorimeter.

Ans 03. Infinite heat capacity means that there will be no change in temperature whether heat is taken out or given to the substance.

Ans 04. If m = Mass of gas

Q = heat supplied

ΔT = Change in temperature

then specific heat of gas, $C = \frac{Q}{m\Delta T}$

1) Let gas is compressed suddenly, So no heat is supplied from outside (i.e. Q = 0) but the temperature of the gas in the gas increases due to compression,

$$C = \frac{Q}{m\Delta T} = 0$$

2) Let the gas is heated in a way that the temperature is constant (ΔT = O) then,

$$C = \frac{Q}{m\Delta T} = \frac{Q}{mXo} = \alpha$$

Hence, depending upon conditions of heating. The value of C will be different.

Ans 05. Let θ^0C = final temperature of the mixture.

Mass of ethyl alcohol = volume ×Density

= 200 × 0.81

= 162 g

Heat lost by Aluminum block = Mass X specific heat X fall in temperature

$$= (0.20\times10^{3})\times0.22\times(80-\theta)$$
$$= 20\times22\times10^{-4}\times10^{3}(80-\theta)$$
$$= 440\times10^{-1}(80-\theta)$$
$$= 44(80-\theta) \rightarrow 1)$$

Heat gained by the ethyl alcohol and calorimeter = (Mass of ethyl alcohol × specific heat × change in Temperature) + Mass of copper calorimeter × specific heat X change in Temperature

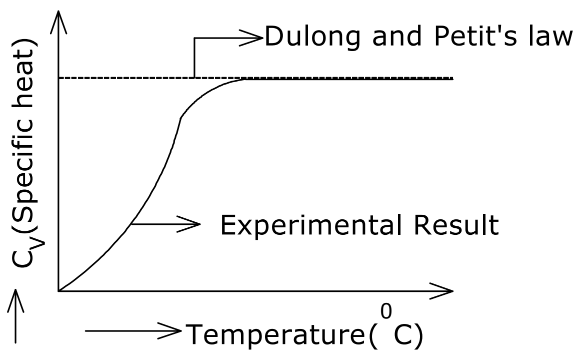
$$= [162\times0.6\times(\theta-20)]+[0.05\times10^{3}\times0.094\times(\theta-20)]$$
$$= 101.9(\theta-20) \quad \rightarrow 2)$$

But, Heat gained = Heat Lost

So, from equation 1) & 2)

$$44(80-\theta) = 101.9(\theta-20)$$
$$\Rightarrow 3520-44\theta = 101.9\theta-2038$$
$$3520+2038=101.9\theta+44\theta$$
$$5558=145.9\theta$$
$$\theta=\frac{5558}{145.9} \qquad \boxed{\theta = 38.1^{0}C}$$

Ans 06. Now, from Dulong & Petit law, the specific heat is independent of temperature but it is experimentally seen that specific heat at lower temperatures is directly proportional to the cube of temperatures. The above dependence is because of the fact that the particles in the crystal oscillate as if they are coupled Quantum Harmonic Oscillator.



Ans 07. Specific heat at constant and Pressure, C_P = 0.125 cal | g | K

C_P = 0.125 × 4.2 × 1000 J | Kg | K

C_P = 525 J | Kg | K $\rightarrow$1)

Specific heat at constant volume, C_V = 0.075 cal | g | K

$$C_V = 0.075 \times 4.2 \times 1000$$
$$C_V = 315 J | Kg | K$$

The gas constant, r for I kg of gas is given by:-

$$r = C_P - C_V = 525 - 315 = 210 J | Kg | K$$

Normal pressure = P = h P g = 0.76 ×13600 × 9.8 = 101292.8N | m^2

Normal Temperature = T = 273K.

Suppose V = Volume of argon in m^3 at N. T. P.

$$PV = \text{n r T}$$

for n = 1 mole

$$\frac{PV}{T} = r$$

$$\text{V} = \frac{rT}{P} = \frac{210 X 273}{101292.8} = 0.566 m^3$$

∴ Density of Argon, $P = \frac{Mass}{Volume} = \frac{1}{0.566} = 1.8 Kg | m^3$.

Ans 08. 1) Heat loss due to radiation is reduced by polishing inner and outer surfaces of the Calorimeter.

2) Heat loss due to conduction is reduced by filling the space between the calorimeter and insulating jacket with poor conductor of heat.

3) Heat loss due to convection is done by using a insulating lid.

Ans 09. 1) The amount of heat required for constant – volume process is :- $Q_V = nC_V \Delta T$

Here, n = 2 moles, C_V = 1.5 R = 1.5 X 8.314 J | mol | ^{0}C

T_2 = final Temperature

T_1 = Initial Temperature

$$\Delta T = T_2 - T_1$$
$$= 50 - 20$$
$$= 30^0\text{C}$$
$$Q_V = 2 \times 1.5 \times 8.314 \times 30$$
$$Q_V = 748\text{J}$$

2) The amount of heat required for constant – Pressure process is :-

$$Q_p = nC_P \Delta T$$

Here, n = 2 moles, $C_P = 2.49R = 2.49 \times 8.314$ $\boxed{\Delta T = 30}$

$$Q_P = 2 \times 2.49 \times 8.314 \times 30 \quad \boxed{Q_P = 1242J}$$

Since the temperature rise is same in both the cases, the change in internal energy is the same i.e. 748J. However, in constant – pressure Process excess heat is supplied which is used in the expansion of gas.

Ans 10. The temperature above which a gas connot be liquefied, no matter how great the pressure is called critical temperature. If the substance lies above the critical temperature then it falls in the gaseous region. If the substance lies below the critical temperature than it falls in the vapour stage.

Ans 11. For H_2, $C_P - C_V = a$

C_P = Specific heat at constant pressure

C_V = Specific heat at constant Volume

For O_2 = $C_P - C_V = b$

And r = $\frac{R}{MJ}$

M = Molecular weight

I = Mechanic cal equivalent of heat

Now, we know that, $C_P - C_V = r$

$$C_P - C_V = \frac{R}{MJ}$$

So, for $H_2 \Rightarrow C_P - C_V = a = \frac{R}{2J}$

$M_{H2} = 2 \Big| C_P - C_V = a = \frac{R}{2J} \rightarrow 1)$

$For\ O_2 \Rightarrow C_P - C_V = b = \frac{R}{32J} \rightarrow 2)$

from equation 1)

$$2a = \frac{R}{J}$$

from equation 2)

$$32b = \frac{R}{J}$$

Equating above equations for $\frac{R}{J} :\rightarrow$

$$2a = 32\,b \quad \boxed{a = 16\,b}$$

CBSE TEST PAPER-04

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Specific heat, Calorimetry and Hygrometer

1. Which has a higher specific heat ; water or sand? [1]

2. Why is latent heat of vaporization of a material greater than that of latent heat of fusion? [1]

3. Draw a P – V diagram for Liquid and gas at various temperatures showing critical point? [1]

4. If for a gas, $\frac{R}{C_V}$ = 0.67 then which gas is this:- monatomic, diatomic and tri atomic? [2]

5. A 50g lead bullet, specific heat 0.02 cal |g | ^{0}C is initially at 30^{0}C. It is fixed vertically upward with a speed of 840m |s and on returning to the starting level strikes a cake of ice at 0^{0}C. How much ice is melted? Assume that all energy is spent in melting ice only? [2]

6. A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. If we neglect all vibration modes, find the total energy of the system? [2]

7. Show that C_P - C_V = R Where [C_P = specific heat at constant pressure ; C_V = specific heat at constant volume and R = Universal Gas constant] for an ideal gas? [2]

8. How do you justify that when a body is being heated at melting point, the temperature remains Constant? [2]

9. If half mole of helium is contained in a container at S. T. P. How much heat energy is needed to double the pressure of the gas, keeping the volume of the gas constant? Given specific heat of gas = 3J | g |K. [3]

10. Draw and explain a P – T diagram for water showing different phases? [2]

11. From what height should a piece of ice fall so that it completely melts? Only one – quarter of heat produced is absorbed by the ice. Given latent heat of ice is 3.4 × 10^5 J | Kg and acceleration due to gravity, g = 10m | s^2? [2]

CBSE TEST PAPER-04

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Specific heat, Calorimetry and Hygrometer [ANSWERS]

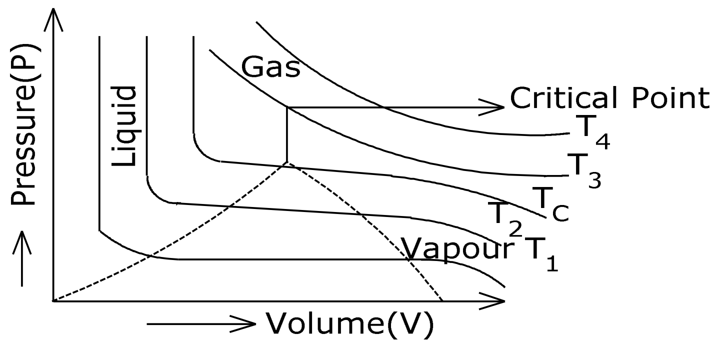
Ans 01. Water has higher specific heat than sand as

$\Delta T = \frac{Q}{mc}$, where T = Temperature, Q = Heat, m = Mass,

C = Specific heat; Since for water temperature increases less slowly than sand hence the result.

Ans 02. When a liquid changes into a gas, there is large increase in the volume and a large amount of work has to be done against the surrounding atmosphere and heat associated with change from solid to gas is latent heat of vaporization and hence the answer.

Ans 03.



Ans 04. Since for an ideal gas, $C_P - C_V = R \rightarrow 1)$

C_P = Specific heat at constant pressure

C_V = Specific heat at constant volume

R = Universal Gas Constant

And given $\frac{R}{C_V} = 0.67$

or $\frac{C_P - C_V}{C_V} = 0.67 \quad (\because \text{ Using equation 1)})$

$$\frac{C_P}{C_V} - 1 = 0.67$$

$$\frac{C_P}{C_V} = 1 + 0.67$$

$$\frac{C_P}{C_V} = 1.67$$

And we know, that $\frac{C_P}{C_V}$ = 1.67 is for monatomic gas ; So the gas is monatomic in question.

Ans 05. Speed of bullet hitting the ice = V = 840 m | s

Heat produced due to kinetic energy of the bullet:- = $\frac{1}{2}mV^2$

Now, m = Mass of bullet = $50g = \left(50\times10^{-3}\right)Kg$

Hence $\Rightarrow \frac{1}{2}mV^2 = \frac{1}{2}\times\left(50\times10^{-3}\right)\times\left(840\right)^2$

$$= \frac{1}{2}\times50\times10^{-3}\times705600$$

$$= 17640J$$

$$= \frac{17640}{4.2}Cal \;\left[\because \text{ To convert J } \rightarrow \text{ Cal we divide by 4.2}\right]$$

$$\frac{1}{2}mV^2 = 4200 \text{ Cal } \rightarrow 1)$$

Now, heat given by bullet due to temperature difference = m c $\left(Q_2 - Q_1\right)$

$$= 50\times0.02\left(30-0\right)$$

$$= 30 \; Cal \;\; \rightarrow 2)$$

From 1) & 2)

m = Mass of bullet

c = Specific heat of bullet

Q_2 = Initial Temperature

Q_1 = Final Temperature

Total heat given by bullet = 4200 + 30 = 4230 Cal.

Now, entire heat of bullet is used in melting the ice only, Let M = Mass of Ice that melted

L = Latent heat of ice

Hence $m \times L = 4230$

$$m = \frac{4230}{L} = \frac{4230}{80}$$

$$\boxed{m = 52.88g}$$

Ans 06. Let N_A = Avogadro's Number

No. of degrees of freedom of O_2 molecule (diatomic) = 5

No. of degrees of freedom of 2 moles of oxygen = 2 N_A × 5 = 10 N_A

No. of degrees of freedom of 4 moles of argon (monatomic) = 4 N_A × 3

= 12 N_A ($\because$ 3 = degrees of freedom)

Total degrees of freedom of mixture = 10 N_A + 12 N_A = 22 N_A →1)

Energy associated with each degree of freedom | molecule = $\frac{1}{2}KT$

Total energy of mixture = 22 N_A × $\frac{1}{2}KT$ ($\because$ Using equation1)

$$= 11K\ \mathrm{N_A}\ \mathrm{T}$$
$$= 11\mathrm{RT}\ \left(KN_A = R\right)$$

Ans 07. Now, Let first heat the gas at constant volume and temperature increases by ΔT, So, $\Delta Q = C_V \Delta T \rightarrow 1)$

Since volume remains the same, hence no work is heating the gas then according to law of conservation of energy, the entire heat supplied goes into raising the internal energy and hence the temperature of the gas.

Now, $CV\Delta T = \Delta U$

$\therefore$ ΔU = increase in the internal energy of the gas Let heat the gas at constant pressure and if the temperature of the gas increases by ΔT but here external work is done to expand the gas hence

$\Delta Q^1 = \Delta U + \Delta W$

$C_P \Delta T = C_V \Delta T + \Delta W \left(Q \text{ from equation } 1) \right)$

But $\Delta W = P\Delta V, so$

$C_P \Delta T = C_V \Delta T + P\Delta V \rightarrow 2)$

Now, form ideal gas equation :→

$PV = RT \rightarrow 3)$ or $P(V + \Delta V) = R(T + \Delta T) \rightarrow 4)$

Subtracting equation 3) from equation 4)

$P\Delta V = R\Delta T$

Put $P\Delta V = R\Delta T$ in equation 2)

$$C_P \Delta T = C_V \Delta T + P\Delta V$$
$$C_P \Delta T = C_V \Delta T + R\Delta T$$
$$C_P = C_V + R$$

or $\boxed{C_P - C_V = R}$

Ans 08. When a body is being heated below the malting point, the heat supplied increases the potential as well as the kinetic energy of the molecules. Due to the increase in the kinetic energy of the mole clues, the temperature increases. But at melting point, heat goes, to increase only the potential energy of molecules and hence the temperature remains the same.

Ans 09. Number of moles of Helium gas = $n = \frac{1}{2}$.

Specific heat of Helium gas = $C_V = 3J \mid g \mid K$

Molecular weight = M = 4

Temperature, T_1 = 273 K.

∴ Molar specific heat at constant volume = $C_V = M_{CV}$

$C_V = 4 \times 3$

C_V = 12 J | mol | K

Since, Volume is constant, P α T or $\frac{P}{T}$ = Constant

$\therefore \frac{P_2}{T_2} = \frac{P_1}{T_1}$ P = Pressure; T = Temperature

Or $\frac{P_2}{P_1} = \frac{T_2}{T_1}$

P_2 = Final Pressure = 2 P

P_1 = Initial Pressure = P

$$\frac{2P}{P} = \frac{T_2}{T_1}$$

$$\frac{T_2}{T_1} = 2$$

$$T_2 = 2T_1$$

$$T_2 = 2X\,273$$

$$\boxed{T_2 = 546K}$$

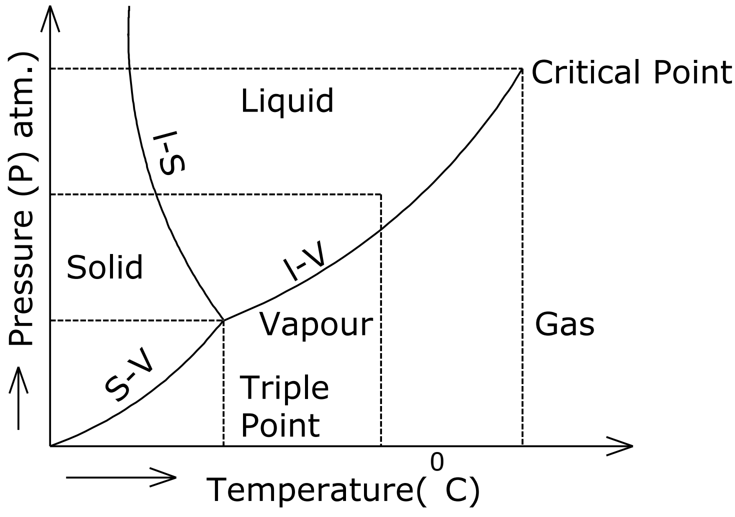
$$\Delta T = T_2 - T_1 = 546 - 273 = 273K$$

Now, Heat required, $= Q = nC_V \Delta T$

$$= \frac{1}{2} \times 12 \times 273$$

Heat required = 1638 J

Ans 10.



1) The l - V curve represent those points where the liquid and vapour phases are in equilibrium.

2) The s – l curve represent the points where the solid and liquid phases exist in equilibrium.

3) The s – v is the sublimation curve where a solid changes into vapour phase without passing through the liquid stage

4) Triple point → Intersection of three curves is the triple point. It represents a unique temperature and pressure and it is only at this point that the three phases can exist together in equilibrium.

Ans 11. Let m = Mass of piece of ice

h = height from which it falls.

∴ Loss of Potential energy = m g h

The Potential energy of ice is converted into heat.

Since the ice absorbs only one – quarter of this,

∴ Heat absorbed by ice, $Q = \frac{1}{4} mgh \rightarrow 1)$

If L Joules | Kg is the latent heat of ice, them

$$Q = mL \rightarrow 2)$$

Equating 1) & 2) for Q

$$\frac{1}{4} \cancel{m}gh = \cancel{m}2$$

$$h = \frac{4L}{g}$$

$$h = \frac{4 \times \left(3.4 \times 10^5\right)}{10}$$

$$h = 136 \times 10^3 m$$

$$\boxed{h = 136 Km}$$

CBSE TEST PAPER-05
CLASS - XI PHYSICS (Thermodynamics)
Topic: - Transfer of Heat

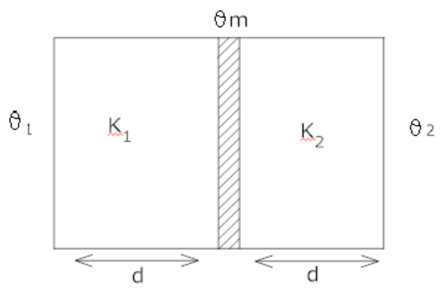
1. On a winter night, you feel warmer when clouds cover the sky than when sky is clear. Why? [1]

2. If a body is heated from 27^0 C to 927^0C then what will be the ratio of energies of radiation emitted? [1]

3. Two rods A and B are of equal length. Each rod has its ends at temperatures T_1 and T_2. What is the condition that will ensure equal rates of flow of heat through the rods A and B? [2]

4. A layer of ice 10cm thick is formed on a pond. The temperature of air is – 10^0C. Calculate how long it will take for the thickness of ice to increase by 1mm. Density of ice = 1g|cm^3; Thermal conductivity of ice = 0.005Cal|s|cm|^{0}C; Latent heat of ice = 80Cal|g? [2]

5. Two conducting slabs of thermal conductivities K_1 and K_2 are joined as shown in the figure. The temperature of the ends of slab are θ_1 and θ_2 ($\theta_1 > \theta_2$). Find the final temperature of (θm)? [2]



6. The ends of the two rods of different materials with their thermal conductivities, radii of cross – section and length in the ratio 1:2 are maintained at the same temperature difference. If the rate of flow of heat through the larger rod is 4 cal |s, what is the rate of flow through the shorter rod? [2]

7. What are thermal radiation? Write its properties of thermal radiation? [2]

8. An indirectly heated filament is radiating maximum energy of wavelength 2.16x 10^{-7}m. Find the net amount of heat energy lost per second per unit area, the temperature of surrounding air is 13^0C. Given b = 2.88x10^{-3} mk, σ = 5.77x10^{-8} J|s|m^2|k^4? [2]

9. Animals in the forest find shelter from cold in holes in the snow. Why? [2]

10. A brass boiler has a base area of 0.15m^2 and thickness 1.0cm. It boils water at the rate of 6kg| min when placed on a gas stove, Estimate the temperature of the part of flame in contact with the boiler. Thermal conductivity of brass = 109J|s|m|^{0}C, heat of vaporization of water = 2256J|g? [2]

11. How do you explain heating of rooms based on principle of convection? [2]

CBSE TEST PAPER-05
CLASS - XI PHYSICS (Thermodynamics)
Topic: - Transfer of Heat [ANSWERS]

Ans 01. We know that earth absorbs heat in day and radiates at night. When sky is covered, with clouds, the heat radiated by earth is reflected back and earth becomes warmer. But if sky is clear the heat radiated by earth escapes into space.

Ans 02. Since, By Stefan's law:→

E = Energy radiated

T = Temperature.

E_1, T_1 $\Rightarrow$ Initial energy and temperature

E_2, T_2 $\Rightarrow$ Final energy and temperature.

$T_1 = 27^0C = 27+273 = 300K$

$T_2 = 927^0C = 927+273K = 1200K.$

$E = \text{constant } T^4$

So, $E_1 = \text{constant } T_1^4$

$$\frac{E_1}{T_1^4} = \text{constant} \rightarrow (1)$$

$$\text{Also, } \frac{E_2}{T_2^4} = \text{constant} \rightarrow (2)$$

Equating equation 1) &2)

$$\frac{E_1}{T_1^4} = \frac{E_2}{E_2^4}$$

$$or \ \frac{E_1}{E_2} = \left(\frac{T_1}{T_2}\right)^4$$

$$\frac{E_1}{E_2} = \left(\frac{\cancel{300}^1}{\cancel{1200}_4}\right)^4$$

$$\frac{E_1}{E_2} = \left(\frac{1}{4}\right)^4$$

$$\frac{E_1}{E_2} = \frac{1}{256}$$

or $\boxed{E_1 : E_2 = 1 : 256}$

Ans 03. Since $\theta = \dfrac{KA(\theta_1-\theta_2)t}{x}$

Θ = heat flow

K = co – efficient of thermal conductivity

A = Cross – Sectional Area

$\Theta 1$ = Temperature of hot body

$\Theta 2$ = Temperature of cold body

X = distance between hot and cold faces

t = time

For rod A :

$$\frac{\theta_A}{t} = \frac{K_A(T_1-T_2)A_A}{x}$$

And $\dfrac{\theta_A}{t} = \dfrac{K_A(T_1-T_2)A_B}{x}$

For equal rates of flow, $\dfrac{\theta_A}{t} = \dfrac{\theta_B}{t}$ $\boxed{K_A A_A = K_B A_B}$

Ans 04. Let t = time required to increase the thickness of ice by 1mm (=0.1cm)

Mass of ice required to be formed is :-

m = Volume x Density

Let A = Area of upper surface

Volume = Area x Thickness

$= A \times 0.1$

$m = (A \times 0.1) \times 1$

m = 0.1 A gram →1)

Now, heat must flow from lower surface to the upper surface of ice and finally into atmosphere.

Θ = heat that flows out of pond into atmosphere.

λ = Latent heat of ice

m = Mass of ice

k = co – efficient of thermal conductivity

A = Cross – sectional Area

t = time

x = Distance between hot and cold surface

θ_1 = temperature of hot surface

θ_2 = temperature of cold surface

∴ θ = m L ;

Θ = 0.1×A×80 (Using equation 1)

Θ = 8 A Cal → 2)

$$\theta = \frac{KA(\theta_1 - \theta_2)\iota}{x}$$

Usinge quation 2)

But $8A = \frac{KA(\theta_1 - \theta_2)\iota}{x}$

$$t = \frac{8x}{K(\theta_1 - \theta_2)}$$

Now, x = 10cm,

K = 0.005 cal|cm|Δ|^{0}C

$\Theta_1 - \theta_2 = 0 - (-10) = 10^0C$

$$t = \frac{8 \times 10}{0.005 \times 10} = 1600 \text{ Sec}$$

Ans 05. Let θ_1 = temperature of hot slab

Θ_2 = temperature of cold slab

K_1 = Co – efficient of thermal conductivity of hot slab

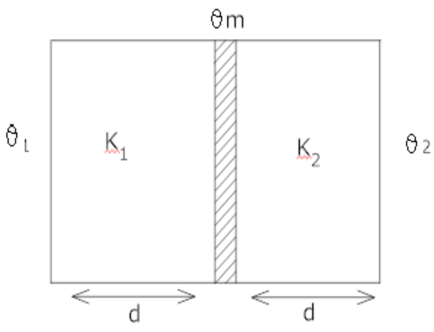
K_2 = Co – efficient of thermal conductivity of cold slab

Θ_m = final temperature

d = Distance b/w hot and cold surface

A = Area of cross – section

t = time



Now, since is steady state, the rate of heat transfer in both the slabs is same i. e

$$\frac{\theta_1}{t} = \frac{\theta_2}{t}$$

$$\text{or } \frac{K_1 \cancel{A}(\theta_1 - \theta_m)}{\cancel{d}} = \frac{K_2 \cancel{A}(\theta_m - \theta_2)}{\cancel{d}}$$

$$K_1(\theta_1-\theta_m)=K_2(\theta_m-\theta_2)$$

$\Theta_1 - \theta_m$ = because first heat flows from θ_1 to the junction

$\Theta_2 - \theta_m$ = then heat flows from junction to second surface

So,
$$\begin{aligned} K_1(\theta_1-\theta_m)&=K_2(\theta_m-\theta_2)\\ K_1\theta_1-K_1\theta_m&=K_2\theta_m-K_2\theta_2\\ K_1\theta_1+K_2\theta_2&=K_2\theta_2+K_1\theta_m\\ K_1\theta_1+K_2\theta_2&=\theta_m(K_1+K_2)\end{aligned}$$

So, $$\boxed{\theta_m=\frac{K_1\theta_1+K_2\theta_2}{K_1+K_2}}$$

Ans 06. K_1 = thermal conductivity of first region

K_2 = thermal conductivity of second region

r_1 = radius of cross section of first region

r_2 = radius of cross – section of second region

l_1 – length of first region

l_2 = length of second region

Θ_1 = heat flow of first region

Θ_2 = heat flow of second region

Now, $\frac{K_1}{K_2}=\frac{1}{2}$

Also, $\frac{r_1}{r_2}=\frac{1}{2}$ and $\frac{l_1}{l_2}=\frac{1}{2}(Given)$

$\frac{\theta_2}{t}$ = rate of flow of heat from second region

and $\frac{\theta_2}{t}$ =4cal/sec

θ_1-θ_2 =Same.

Now, we know,
$$\frac{\theta}{t}=\frac{KA(\theta_1-\theta_2)}{x}$$
$$\frac{\theta}{t}=\frac{K\pi r^2(\theta_1-\theta_2)}{}$$

So, Let

$$\theta_1 = T_1$$
$$\theta_2 = T_2$$
$$\frac{\theta_1}{t_1} = \frac{K_1 \pi r_2^{\,2} (T_1 - T_2)}{l_1}$$
$$\frac{\theta_2}{t_2} = \frac{K_2 \pi r_2^{\,2} (T_1 - T_2)}{l_2}$$

Now, Divide eq⁴ 1) & 2)

$$\frac{\theta_1}{t_1} X \frac{t_2}{\theta_2} = \frac{K_1 (\pi r_1^{\,2})(\theta_1 - \theta_2)}{K_2 (\pi r_2^{\,2})(\theta_1 - \theta_2)} X \frac{l_2}{l_1}$$

Since

$$\frac{\theta_2}{t_2} = 4, \frac{t_2}{\theta_2} = \frac{1}{4}; \frac{r_1}{r_2} = \frac{1}{2}\left(\frac{r_1}{r_2}\right)^2 = \frac{1}{4}$$
$$\frac{l_1}{l_2} = \frac{1}{2}; \frac{l_2}{l_1} = \frac{2}{1}$$
$$\frac{\theta_1}{t_1} \times \frac{1}{4} = \frac{1}{2} \times \left(\frac{1}{2}\right)^2 \times \left(\frac{1}{2}\right)$$
$$\frac{\theta_1}{t_1} \times \frac{\cancel{1}}{\cancel{4}} = \frac{\cancel{1}}{\cancel{2}} \times \frac{\cancel{1}}{\cancel{4}} \times \cancel{2}$$

$$\boxed{\frac{\theta_1}{t_1} = 1 \text{cal/sec}}$$

Ans 07. The radiant energy emitted be a body solely on account of its temperature is called thermal radiation.

Properties of thermal Radiation:-

1) They travel through vacuum
2) They obey laws of refraction
3) They can be refracted
4) They travel with the speed of light
5) They do not heat the medium through which they passes.
6) They exhibit phenomena of interference, diffraction and polarization.

Ans 08. By Wien's Law:-

The product of wavelength (λm) at which maximum energy is emitted and the absolute temperature (T) of the black body is always constant.

i.e λm T = constant = b →(1)

b = Wien's constant = 2.9×10^{-3} mK

$\lambda m = 2.16\text{x}10^{-7}\text{m}$

Now, T=Temperature of filament

So, $T = \frac{b}{\lambda m}$ (by equation 1)

$$T = \frac{2.9\times10^{-3}}{2.16\times10^{-7}}$$

$$T = \frac{2.9\times10^{-3+7}}{2.16}$$

$$T = \frac{29\times10^{5}}{216}$$

$$\boxed{T = 13333.3K}$$

Now, Temperature of surrounding, To = 13 + 273 = 286K.

Net amount of heat energy lost per second per unit area:-

$E = \sigma\left(T^4 - To^4\right) \Rightarrow$ By stefan's law: →

$$E = 5.77\times10^{-8}\left[(13333.3)^4 - (286)^4\right]$$

$$\boxed{E = 1.824 \times 10^8 \text{ J/s/m}^2}$$

Ans 09. Animals in the forest find shelter from cold in holes in the snow because snow has trapped air (as in ice there is no air) so, it acts as a heat insulator. Therefore, the snow prevents the transmission of heat from the body of the animal to the outside.

Ans 10. Rate of boiling of water is = 6.0Kg / min

$$= \frac{6\times10^3 g}{60 \text{ sec}}$$

= 100 g/s

∴ Rate at which heat is supplied by the flame to water is :-

m = Rate of boiling of water

L = heat of vaporization of water

θ = m L

$= \frac{100g}{s} \times \frac{2256J}{g}$

Θ = 225 600J/s

Now, T_2 = Temperature of cold junction = 100^0C

$$\theta = \frac{KA(T_1 - T_2)x}{t}$$

$\theta = heatflow$

$A = Area\ of\ cross - section$

T_1 = Temperature of hot junction

T_2 = Temperature of cold junction

t = time

x = Distance b/w hot and cold junction

$$225600 = \frac{KA(T_1 - T_2)x}{t}$$

$$(T_1 - T_2) = \frac{225600 \times x}{KAt}$$

Now, x = 1.0 cm = 1.0 X 10^{-2}m

K = 109 J|s|m|^{0}C

A = 0.15 m^2

t = 1 s

$$T_1 - T_2 = \frac{225600 \times 1.0 \times 10^{-2}}{109 \times 0.15 \times 1}$$

$$T_1 - T_2 = 137.98^0C$$

$$T_1 = 137.98^0C + T_2$$

$$T_1 = 137.98 + 100$$

$$\boxed{T_1 = 237.98^0C}$$

Ans 11. Convection is the process by which heat is transmitted from one point to another due to the movement of heated particles of the substance.

During heating of the room by a heater, the air molecules in immediate contact with heater are heated up, they acquire sufficient energy and rise upward. The cool air particles near to the roof are dense and more down and in turn it is heated and the moves upwards. Hence by the movement of heated air particles, the entire room heats up.

CBSE TEST PAPER-06
CLASS - XI PHYSICS (Thermodynamics)
Topic: - Transfer of Heat

1. Why is the energy of thermal radiation less than that of visible light? [1]

2. Two rods A and B are of equal length. Each rod has its ends at temperature T_1 and T_2 ($T_1 > T_2$). What is the condition that will ensure equal rates of flow through the rods A and B? [1]

3. A Sphere is at a temperature of 6oo k. Its cooling rate is R in an external environment of 200k. If temperature falls to 400k. What is the cooling rate R_1 in terms of R? [1]

4. If the temperature of the sun is doubled, the rate of energy received on each will increases by what factor? [1]

5. How do you explain the emission of long - wavelength by the object at low temperature? [1]

6. If the radiation from the moon gives maxima at λ = 4700 A^0 and λ = $14x10^{-6}$m. What conclusion can be drawn from the above information? [2]

7. Differentiate between conduction, convection and radiation? [2]

8. The tile floor feels colder than the wooden floor even though both floor materials are at same temperature. Why? [2]

9. A spherical black body of radius 12cm radiates 450w power at 500k. If the radius were halved and the temperature doubled, what would be the power radiated? [2]

10. A cylinder of radius R made of a material of thermal conductivity K_1 is surrounded by a cylindrical shell of inner radius R and other radius 2R made of material of thermal conductivity K_2. The 2 ends of combined system are maintained at two different temperatures. There is no loss of heat across the clinical surface and the system is in steady state calculate the effective thermal conductivity of the system? [2]

11. A room has a 4m x 4m x10cm concrete roof (K_1 = 1.26w|m|^{0}C). At some instant, the temperature outside is 46^{0}c and radius 32^{0}c. [2]
    1) Calculate amount of heat flowing per second into the room through the roof.
    2) If bricks (K_2 – 0.56w |m|^{0}c) of thickness 7.5cm are laid down on roof, calculate the new rate of heat flow under the same temperature conditions?

12. A bar of copper of length 75cm and a bar of length 125cm are joined end to end. Both are of circular cross – section with diameters 2cm. The free ends of copper and steel are maintained at 100^{0}c and 0^{0}c respectively. The surfaces of the bars are thermally insulated. What is the temperature of copper – steel junction? Thermal conductivity of copper = $9.2x10^{-2}$k cal |m|^{0}c|s and that of steel is $1.1x10^{-2}$ k cal|m|^{0}c|s? [2]

Ans 01. The energy of an electromagnetic ware is given by :- E = hf

h = Planck's constant; f = frequency of wave.

Since the frequency of thermal radiation is less than that of visible light, the energy associated with thermal radiation is less than associated with visible light.

Ans 02. Heat flow, $Q=\frac{KA(T_1-T_2)}{d}$

K = Thermal conductivity

A = Area

T_1 = Temperature of hot body

T_2 = Temperature of cold body

d = distance between hot and cold body.

Q = heat flow

When the rods have the same rate of conduction,

$Q_1 = Q_2$

$$\frac{K_1A_1(T_1-T_2)}{d} = \frac{K_2A_2(T_1-T_2)}{d}$$

K_1, K_2 → Thermal conductivity of first and second region

A_1, A_2 → Area of first and second region

or, $K_1 A_1 = K_2 A_2$

or $\boxed{\frac{A_1}{A_2} = \frac{K_2}{K_1}}$

Ans 03. Acc. to Stefan's law;

E = constant T^4

Also, R_1 = constant $(T_2^4 - T_1^4)$

R = constant $(T_3^4 - T_1^4)$

T_2 = heat of hot junction = 400K

T_1 = heat of cold junction = 200K

T_3 = heat of hot junction = 600K

R_1 = constant $\left[(400)^4-(200)^4\right] \rightarrow (1)$

R_1 = constant $\left[(600)^4-(200)^4\right] \rightarrow (2)$

Divide eq^4 1) & 2)

$$\frac{R_1}{R}=\frac{\left[(400)^4-(200)^4\right]}{\left[(600)^4-(200)^4\right]}$$

$$\frac{R_1}{R}=\frac{256\times10^8-16\times10^8}{1296\times10^8-16\times10^8}=\frac{24\cancel{0}\times\cancel{10^8}}{128\cancel{0}\times\cancel{10^8}}$$

$$\frac{R_1}{R}=\frac{24}{128}$$

$\dfrac{R_1}{R}=\dfrac{3}{16}$ Therefore, $\boxed{R_1=\left(\dfrac{3}{16}\right)R}$

Ans 04. By Stefan's law : →

Rate of energy radiated α T^4

T = Temperature

E_1 = constant T_1^4

E_2 = constant T_2^4

T_1 = Initial temperature

T_2 = Final temperature

$T_2 = 2T_1$

$T_2^4 = (2)^4\, T_1^4$

$T_2^4 = 16T_1^4$

E_2 = constant $(16\, T_1^4)$

E_2 = 16 (constant T_1^4) $\boxed{E_2 = 16\, E_1}$

Ans 05. Since by Wein's law: →

$$\lambda m \;\alpha\; \frac{1}{T}$$

λm = constant T

i.e temperature is inversely proportional to the wavelength so, if temperature is less, then wavelength will be long. If temperature is high, then wavelength will be short.

Ans 06. Acc. to wien's displacement law, λm T = b

Now, according to the question, λ m = 4700 A^0 = 4700×10^{-10}m

T_1 = Temperature of moon,

$$T_1 = \frac{b}{\lambda m}$$

b = 2.9 $\times10^{-3}$ mK

$$T_1 = \frac{2.9\times10^{-3}}{4700\times10^{-10}}$$

$$= \frac{29\times10^{-4}\times10^{10}}{4700}$$

$$T_1 = 6170K$$

Let the temperature corresponding to $\lambda m = 14\times10^{-6}\,m = T_2$

$$\text{So, } T_2 = \frac{b}{\lambda m}$$

$$T_2 = \frac{2.9\times10^{-3}\,mK}{14^{-}\times10^{-6}\,m} = \frac{29\times10^{-4+6}}{14}K = 207K$$

Ans 07.

	Properties	Conduction	Convection	Radiation
1.	Material Medium	Essential	Essential	Not Essential
2.	Molecules	Do not leave their mean position	More bodily from one place to another.	Medium does not play any part
3.	Transfer of heat	Can be in any direction along any part	Only vertically upward	In all direction in straight lines
4.	Speed of transfer of heat	Slow	Rapid	Fastest with the speed of light.

Ans 08. This happens because the tile is better heat conductor than wood. The heat conducted from our foot to the wood is not conducted away rapidly. So, the wood quickly heats up on its surface to the temperature of our foot. But the tile conducts the heat away rapidly and thus can take more heat from our foot, so its surface temperature drops.

Ans. 09. From Stefan's law,

Power Radiated = P = A σ T^4

If r = radius of spherical body

Surface

A = Area of body

σ = Stefan's constant

T = Temperature

$A = 4\pi\ r^2$

$P = 4\pi\ r^2\ \sigma\ T^4$

Now, since 4, π and σ = constant,

$So,\ P \alpha\ r^2\ T^4$

let P_1 = power radiated when r = 12 cm

T_1 = Initial temperature

T_2 = Final temperature

r_1 = Initial radius

r_2 = Final radius

Now, $r_2 = \frac{r_1}{2}$ $(\because radius$ is halved$)$

Now, $T_2 = 2T_1$ $(\because$ tempr is doubled$)$

So, $P_1 = r_1^2\ T_1^4 \rightarrow (1)$

$P_2 = r_2^2\ T_2^4 \rightarrow (2)$

Divide equation by (2) by (1)

$$\frac{P_2}{P_1} = \frac{r_2^{\ 2}\ T_2^{\ 4}}{r_1^{\ 4}\ T_1^{\ 4}}$$

Put

$r_2 = \frac{r_1}{2}, T_2 = 2T_1$

$$\frac{P_2}{P_1} = \frac{\left(\frac{r_1}{2}\right)^2 \times (2T_1)^4}{r_1^2\ T_1^4}$$

$$\frac{P_2}{P_1} = \frac{\cancel{r_1}^2 \times \cancel{16}^4 \cancel{T_1}^4}{\cancel{4}_1 \cancel{r_1}^2 \times \cancel{T_1}^4}$$

$\frac{P_2}{P_1} = 4$ $\boxed{P_2 = 4 \text{ x } P_1 = 4 \times 450 = 1800\text{w}}$

Given $P_1 = 450$ w

Ans 10. R_1 = Initial radius = R

R_2 = final radius = 2R

The two conductors are thermally in parallel. Therefore, equivalent thermal resistance R is given by:-

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R = \frac{KA}{l} \text{ by } Q = \frac{KA\,(T_1 - T_2)}{l}$$

$$R_1 = \frac{K_1 A_1}{l_1} \text{ If } (T_1 - T_2) = \text{Same temperature}$$

$$R_2 = \frac{K_2 A_2}{l_2}$$

$$\frac{KA}{l} = \frac{K_1 A_1}{l_1} + \frac{K_2 A_2}{l_2} \rightarrow (1)$$

$$Here; l_1 = l_2 = 1,\ A_1 = \pi R_1^2;\ A_2 = \pi(2R)^2 - \pi R_2 = 3\pi R_2$$

$$A = \pi(2R)^2 = 4\pi R^2$$

$$\frac{Kx4\pi R^2}{l} = \frac{K_1 \pi R^2}{l} + \frac{K_2 x 3\pi R^2}{l}$$

$$\boxed{K = \frac{K_1 + 3K_2}{4}}$$

Ans 11. 1) Area of roof = 4 × 4 = 16 m²

Thickness of roof, x_1 = 10 cm = 0.1m,

Thermal resistance of the roof is given by :-

$$R_1 = \frac{x_1}{K_1A_1} = \frac{0.1}{1.26\times16} = 4.96\times10^{-3}\ {}^0c/w$$

∴ Rate of heat flow through the roof is:-

$$H_1 = \frac{\theta}{t} = \frac{\theta_1-\theta_2}{R} = \frac{46-32}{4.96\times10^{-3}}$$

$$H_1 = \frac{14\times10^3}{4.96}$$

$$H_1 = 2822w$$

2) The thermal resistance of the brick is given by:-

$$R_2 = \frac{x_2}{K_2A_2} = \frac{7.5\times10^{-2}}{0.65\times16} = 7.2\times10^{-3}\ {}^0C/W$$

The equivalent thermal resistance of the roof now is :→

$$R = R_1 + R_2 = (4.96+7.2)\times10^{-3} = 1.216\times10^{-2}oC/W$$

∴ Rate of heat through the roof is :→

$$H_2 = \frac{\theta}{t} = \frac{\theta1-\theta2}{R} = \frac{46-32}{1.216\times10^{-2}} = 1152W$$

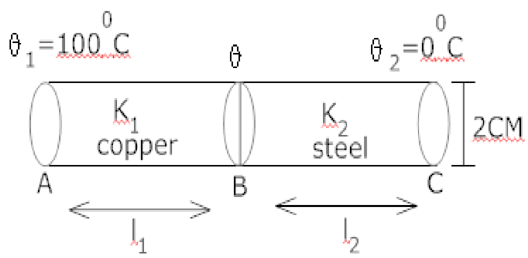
Ans 12. l_1 = lengths of copper bars AB

l_2 = length of steel bars BC.

Θ_1 = temperature of free ends A

Θ_2 = temperature of free ends C.

Θ = temperature of copper – steel.



In steady state, the heat flowing per second through two bars is the same i.e

$H_1 = H_2$

$$\frac{K_1A(\theta_1-\theta_2)}{l_1} = \frac{K_2A(\theta-\theta_2)}{l_2}$$

$$\frac{K_1\theta_1}{l_1} - \frac{K_1\theta_2}{l_1} = \frac{K_2\theta}{l_2} - \frac{K_2\theta_2}{l_2}$$

$$or \ \frac{K_1\theta_1}{l_1} + \frac{K_2\theta_2}{l_2} = \frac{K_2\theta}{l_2} + \frac{K_1\theta}{l_1}$$

$$\frac{K_1}{l_1}\theta_1 + \frac{K_2}{l_2}\theta_2 = O\left(\frac{K_1}{l_1} + \frac{K_2}{l_2}\right)$$

∴ Temperature of junction = θ :→

$$\theta = \frac{\frac{K_1}{l_1}\theta_1 + \frac{K_2}{l_2}\theta_2}{\frac{K_1}{l_1} + \frac{K_2}{l_2}}$$

Given;

$K_1 = 9.2x10^{-2}$K Cal|m|°C|s

$K_2 = 1.1x10^{-2}$K Cal|m|°C|s

l_1 = 75cm = 0.75m

l_2 = 125cm = 1.25m

$\theta_1 = 100^0C$; $\theta 2 = 0^0C$

Putting true above values is eq⁴ for θ

$$\theta = \frac{\left(\frac{9.2\times10^{-2}}{0.75}\right)\times100 + \left(\frac{1.1\times10^{-2}}{1.25}\right)x0}{\left(\frac{9.2\times10^{-2}}{0.75}\right) + \left(\frac{1.1\times10^{-2}}{1.25}\right)}$$

$$\theta = \frac{\frac{9.2\times10^{-2+2}}{0.75} + 0}{\frac{9.2\times10^{-2}}{0.75} + \frac{1.1\times10^{-2}}{1.25}}$$

$$\theta = \frac{12.26}{12.26\times10^{-2} + 0.88\times10^{-2}}$$

$$\theta = \frac{12.26}{10^{-2}(12.26+0.88)} = \frac{12.26\times10^{2}}{13.14}$$

$\Theta = 0.9331\times10^2$

$$\boxed{\Theta = 93.31^0C}$$

CBSE TEST PAPER-07

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Transfer of Heat

1. If air is a bad conductor of heat, why do we not feel warm without clothes? [1]
2. A body with large reflectivity is a poor emitter why? [1]
3. Animals curl into a ball, when they feel very cold? [1]
4. Why is it hotter at the same distance over the top of the fire than in front of it? [2]
5. A metal rod of length 20cm and diameter 2cm is covered with a non-conducting substance. One of it ends is maintained at 100^0c while the other is at 0^0c. It is found that 25g of ice melts in 5 min calculate coefficient of thermal conductivity of metal? [2]
6. Calculate the temperature in Kelvin at which a perfectly black body radiates at the rate of 5.67 w/cm^2? [2]
7. How do you derive Newton's law of cooling from Stefan's law? [3]
8. Define the terms reflectance, absorptance and transmittance. How are they related? [3]
9. Discuss briefly energy distribution of a black body radiation. Hence deduce wien's displacement law? [5]

CBSE TEST PAPER-07

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Transfer of Heat [ANSWERS]

Q1.Ans. This is because when we are without clothes air carries away heat from our body due to convection and we feel cold.

Q2.Ans. This is because a body with large reflectivity is a poor absorber of heat and poor absorbers are poor emitters.

Q3.Ans. When animals curl, they decrease their surface area and since energy radiated varies directly to surface area hence loss of heat due to radiation is also reduced.

Q4.Ans. At a point in front of fire, heat is received due to the process of radiation only, while at a point above the fire, heat reaches both due to radiation and convection. Hence the result.

Q5.Ans. Length of rod = Δx = 20cm = 2×10^{-3}m

Diameter = 2cm

R = 10^{-2}m

Area of cross-section = πr^2

$= \pi (10^{-2})^2$

$= 10^{-4} \pi$ sq. m

$\Delta T = T_2 - T_1 = 100 - 0 = 100^0c$

Mass of ice melted = m = 25g

Latent heat office = 80 cal/g

Heat conducted, $\Delta Q = mL$

= 25 x 80

= 2000 cal

$= 2000 \times 4.2$J

Δt = 5 min = 300s

So, $\frac{\Delta Q}{\Delta t}$ = KA$\frac{\Delta T}{\Delta x}$

K = $\frac{\Delta Q / \Delta t}{A\Delta T / \Delta x}$ = $\frac{\Delta Q\Delta x}{\Delta t A\Delta T}$

= $\frac{2000\times 4.2\times 20\times 10^{-2}}{300\times 10^{-4}\pi\times 100}$

K = 1.78J |s|m|^{0}c

K = coefficient of thermal conductivity

Q6.Ans. E = 5.67w|cm^2 ; E = energy radiated

= 5.67 x 10^7 erg | s | cm^2

σ = Stefan's constant = 5.67 × 10^{-5} ergs |s | cm^2| K^4, from Stefan's law

E = σ T^4

$$T = \left(\frac{E}{\sigma}\right)^{\frac{1}{4}}$$

$$T = \left(\frac{5.67\times 10^7}{5.67\times 10-^5}\right)^{\frac{1}{4}}$$

$$T = \left(10^{12}\right)^{\frac{1}{4}} = 10^3 = 1000K$$

Q7.Ans. Acc. to Newton's law of cooling, the rate of loss of heat of a liquid is directly proportional to the difference in temperature of the liquid and the surrounding, provided the difference in temperature is very small.

$E\alpha(T - To)$

Let a body be maintained at T K. Let T_o be the temperature of the surroundings. Let T ≫ To. There will be loss of heat be the body

Acc. to Stefan's law, amount of heat energy lost per second per unit area of the body is

E = ϵ σ $\left(T^4 - To^4\right)$

σ = Stefan's constant

ε = Emissivity of the body and surroundings

E = $\varepsilon\sigma\left(T^2 - To^2\right)\left(T^2 + To^2\right)$

$\left(\because \left(a^4 - b^4\right) = \left(a^2 - b^2\right)\left(a^2 + b^2\right)\right)$

Incase of Newton's cooling, T ≈ To

E = ε σ $\left(T - To\right)\left(To + T\right)\left(To^2 + To^2\right)$

E = ε σ $\left(\text{T-To}\right)4T_o^3$

$E = K\left(T - T_o\right)$

$K = 4\varepsilon\sigma To^3$

Hence, $\boxed{E \ \alpha \ \left(T - T_o\right)}$ → Hence the Newton's law of cooling

Q8.Ans. 1) Reflectance – Ratio of amount of thermal radiations reflected by the body in a given time to total amount of thermal radiations incident on body It is represented by r, 2) Absorptance – is the ratio of the amount of thermal to the total amount of thermal radiations incident on it. It is represented by a

3) Transmittance – It is the ratio of the amount of thermal radiations transmitted by body in a given time to the total amount of thermal radiations incident on the body in a given time. It is represented by t.

Let Q = Amount of the radiations incident by the body in a given time

Q_1 = Amount of thermal radiations reflected by the body in a given time.

Q_2 = Amount of thermal radiations absorbed by the body in a given time.

Q_3 = Amount of thermal radiations transmitted by the body in a given time,

∴ By definition,

$$r = \frac{Q_1}{Q}$$

$$a = \frac{Q_2}{Q}$$

$$t = \frac{Q_3}{Q}$$

New, r + a + t = $\frac{Q_1}{Q} + \frac{Q_2}{Q} + \frac{Q_3}{Q}$

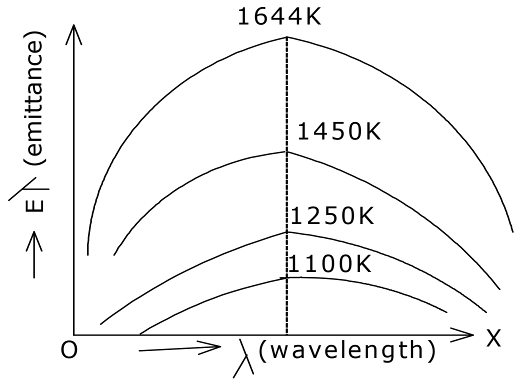
R + a + t = $\frac{Q_1+Q_2+Q_3}{Q}$ $\boxed{R + a + t = 1}$

$\left(\because Q^1+Q_2+Q_3=Q\right)$

If t = 0 $\boxed{A = 1 - r}$

that is good reflectors are bad absorbers

Q9.Ans. For a black body, the monochromatic emittance $\left(E\pi\right)$ of the black body and the wavelength $\left(\lambda\right)$ of the radiation emitted.



So, at a given temperature of black body :→

a) The energy emitted is not distributed uniformly amongst all wavelengths.

b) The energy emitted in maximum corresponding to a certain wavelength $\left(\lambda m\right)$ and its falls on either side of it.

As temperature of black body is increased.

a) The total energy emitted rapidly increases for any given wavelength.

b) The wavelength corresponding to which energy emitted is maximum is shifted towards shorter wavelength side i. e, λ m decreases with rise in temperature i.eλm $\alpha \frac{1}{T}$

or $\boxed{\lambda \text{ m T = constant}}$

$\Rightarrow$ Thus is the wein's displacement law.

CBSE TEST PAPER-08

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Thermodynamics

1. Can you design heat energy of 100% efficiency? [1]

2. Does the working of an electric refrigerator defy second law of thermodynamics? [2]

3. A Carnot engine absorb 6×10^5 cal at 227^0c calculate work done per cycle by the engine if it sink is at 127^0c? [2]

4. How does second law of thermodynamics explain expansion of gas? [2]

5. Calculate difference in efficiency of a Carnot energy working between:- [3]

   1) 400K and 350K

   2) 350K and 300K

6. Derive an expression for the work done during isothermal expansion? [5]

7. Briefly describe a Carnot cycle and derive an expression for the efficiency of Carnot cycle? [5]

Q1.Ans. Since efficiency of heat engine = $1-\frac{T_2}{T_1}$, so, efficiency will be 100% or 1 if T_2 = OK or $T_1 = \alpha$. Since both these conditions cannot be practically attained, so heat engine cannot have 100% efficiency.

Q2.Ans. No, it is not against the second law; this is because external work is done by the compressor or for this transfer of heat.

Q3.Ans. Here, heat abs or bed = $Q_1 = 6 \times 10^5$ cal.

Initial temperature = $T_1 = 227^0c = 227+273 = 500K$

Final temperature = $T_2 = 127^0c = 127 + 273 = 400K$

As, for Carnot engine;

$$\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$$

$$Q_2 = Q_1 \frac{T_2}{T_1}$$

$$Q_2 = \frac{400}{500} \times 6 \times 10^5$$

$Q_2 = 4.8 \times 10^5$ cal

Q_2 = Final heat emitted

As $w = Q_1 - Q_2 = 6 \times 10^5 - 4.8 \times 10^5$

$= 1.2 \times 10^5$ cal

Work = $w = 1.2 \times 10^5 \times 4.2$ J

Dore = 5.04×10^5 J

Q4.Ans. Since from second law,.

$dS \geq 0$ dS = change in entropy

During the expansion of gas, the thermodynamic probability of gas is larger and hence its entropy is also very large. Since form second law, entropy cannot decrease ∴ following the second law, gas molecules move from one partition to another.

Q5.Ans. Efficiency of heat engine = n = 1 - $\frac{T_2}{T_1}$

T_2 = final temperature

T_1 = Initial temperature

1) 400K and 350K,

$T_2 = 350$, $T_1 = 400$

$n = 1 - \frac{350}{400}$

$= \frac{50}{400}$

$n_1 = \frac{1}{8}$ or $\frac{100\%}{8} = 12.5\%$

2) 350K and 300K

$T_2 = 300K$; $T_1 = 350K$

$n_1 = 1 - \frac{T_2}{T_1}$

$= 1 - \frac{300}{350}$

$= \frac{50}{350}$

$n_1 = \frac{1}{7} = \frac{100\%}{7} = 14.3\%$

Change in efficiency = $n_2 - n_1$ = 14.3% - 12.5% = 1.8%

Q6.Ans. Consider one gram mole of ideal gas initially with pressure, volume and temperature as P, V, T, Let the gas expand to a volume V_2, when pressure reduces to P_2 and at the same temperature T

If A = Area of cross – section of piston

Force = Pressure × Area

F = P x A

If we assume that piston moves a displacement d x, the work done : → d w = F d x

d w = P × A × d x

d w = P × d v

Total work done in increasing the volume from V_1 to V_2

W = $\int_{V_1}^{V_2} PdV$

Since, PV = RT (from ideal gas equation)

P = $\frac{RT}{V}$

W = $\int_{V_1}^{V_2} \frac{RT}{V} dV$

W = RT $\int_{V_1}^{V_2} \frac{dV}{V}$

$\left(\because \int \frac{dx}{x} = Loge\ x \right)$

W = R T Loge $V \Big|_{V_1}^{V_2}$

W = R T $\left[LogeV_2 - LogeV_1 \right]$

W = R T Loge $\frac{V_2}{V_1}$

$\left(\because Log \text{ m-Log n} = \text{Log } \frac{m}{n} \right)$

$$\boxed{\text{W} = 2.3026 \text{ R T Log } 10 \left(\frac{V_2}{V_1} \right)}$$

As $P_1 V_1 = P_2 V_2$

$\frac{P_1}{P_2} = \frac{V_2}{V_1}$

So W = 2.3026 R T Log 10 $\left(\frac{P_1}{P_2} \right)$

Q7.Ans. The construction of a heat engine following Carnot cycle is :-

1) Source of heat :- It is maintained at higher temperature T_1

2) Sink of heat – It is maintained at lower temperature T_2

3) Working base :- A perfect ideal gas is the working substance.

Theory :- Carnot cycle consist of four stages:-

1) I so thermal expansion

2) Adiabatic expansion

3) I so thermal compression

4) Adiabatic compression.

1) In, I so thermal expansion, gas expands from a volume V_1 to V_2 and pressure decreases from P_1 to P_2

Work Done = $\int_{V_1}^{V_2} P.dV = RT_1 \text{ Loge } \frac{V_2}{V_1} \rightarrow (1)$

2) In adiabatic expansion gas increases the volume from V_2 to V_3

Work done = $\int_{V_2}^{V_3} PdV = \frac{R(T_2 - T_1)}{(1-\gamma)}$ = W_2

3) In isothermal compression work done on the gas in compressing its volume from V_3 to V_4 is

Work done = $\int_{V_3}^{V_4} -PdV$

= - R T_2 Loge $\frac{V_4}{V_3}$

= - R T_2 Loge $\frac{V_3}{V_4} = W_3$

4) In adiabatic compression, the gas is compressed without any heat exchange,

Work done = $\frac{R(T_1 - T_2)}{1-\gamma}$

Total work done = $W_1 + W_2 - W_3 - W_4$

$\Rightarrow W_2 = W_4$ $\boxed{W = W_1 - W_3}$

Efficiency of Carnot's engine → It is defined as the ratio of net mechanical work done per cycle by the gas to the amount of heat absorbed per cycle from the source.

n = $\frac{W}{Q_1}$

Since $W = Q_1 - Q_2$

n = efficiency = $\frac{Q_1 - Q_2}{Q_1}$

= 1 - $\frac{Q_2}{Q_1}$

At A (P_1, V_1) and B (P_2, V_2) lie on isothermal, $P_1 V_1 = P_2 V_2$ →(1)

At B (V_2, P_2) and C (V_3, P_3) lie on adiabatic, $P_2 V_2^\gamma = P_3 V_3^\gamma$ →(2)

At C and D ⇒ $P_3 V_3 = P_4 V_4$ →(3)

At D and A ⇒ $P_4 V_4^\gamma = P_1 V_1^\gamma$ →(4)

Multi Plying equation 1, 2, 3, & 4

$$V_1 V_2^\gamma V_3 V_4^\gamma = V_1^\gamma V_2 V_3^\gamma V_4$$

$$V_2^{\gamma-1} V_4^{\gamma-1} = V_1^{\gamma-1} V_3^{\gamma-1}$$

$$(V_2 V_4)^{\gamma-1} = (V_1 V_3)^{\gamma-1} \left(\because a^x . b^x = (ab)^x\right)$$

or Log $\frac{V_2}{V_3} = \frac{V_1}{V_4}$

Log $\frac{V_2}{V_1} = Log \frac{V_3}{V_4}$

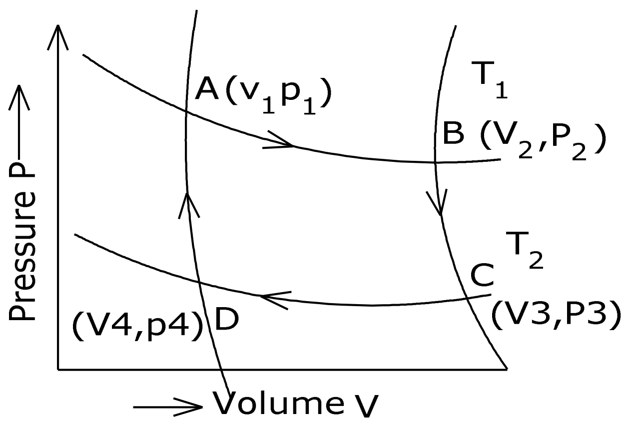
$$\frac{Q_2}{Q_1} = \frac{RT_2 Loge\ V_3|V_4}{RT_1 Loge\ V_2|V_1}$$

∵ Q2 and Q1 are heat absorbed and released during isothermal process

$$\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$$

So, n = 1- $\frac{Q_2}{Q_1}$

$$\boxed{n = 1 - \frac{T_2}{T_1}}$$



CBSE TEST PAPER-09

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Thermodynamics

1. Draw a p – v diagram for isothermal and adiabatic expansion? [1]

2. State zeroth law of thermodynamics? [1]

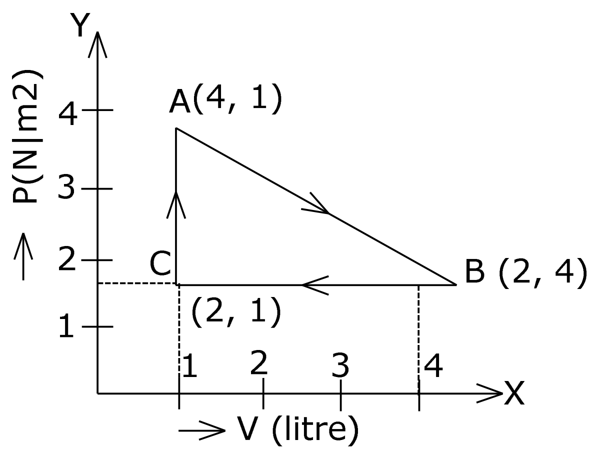
3. Can a gas be liquefied at any temperature by increase of pressure alone? [1]

4. A certain gas at atmospheric pressure is compressed adiabatically so that its volume becomes half of its original volume. Calculate the resulting pressure? [2]

5. Why is conversion of heat into work not possible without a sink at lower temperature? [2]

6. Write the sign conventions for the heat and work done during a thermodynamic process? [2]

7. Deduce the work done in the following complete cycle? [3]



8. One kilogram molecule of a gas at 400k expands isothermally until its volume is doubled. Find the amount of work done and heat produced? [3]

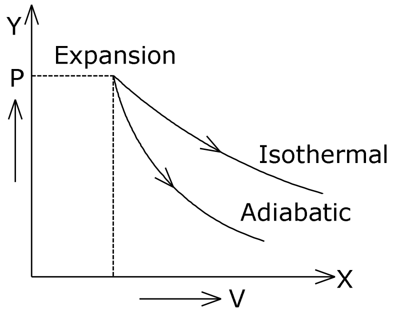
9. Derive the equation of state for adiabatic change? [5]

CBSE TEST PAPER-01

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Thermodynamics [ANSWERS]

Q1.Ans.



Q2.Ans. Acc. to this, when the thermodynamic system A and B are separately in thermal equilibrium with a third thermodynamic system C, then the system A and B are in thermal equilibrium with each other also.

Q3.Ans. No, a gas can be liquefied by pressure alone, only when temperature of gas is below its critical temperature.

Q4.Ans. Let the original volume, V_1=V

∴ final volume $V_2 = \frac{V}{2}$ (∴volume become half)

Initial pressure P_1 = o.76m of Hg column

Final pressure P_2 after compression =?

As the change is adiabatic, so

$P_1V_1^y = P_2V_2^y$ Y = $\frac{CP}{cv}$ = 1.4 for air

$P_2 = P_1 \left(\frac{V_1}{V_2}\right)^4$

$= 0.76 \times \left(\frac{V}{V/2}\right)^{1.4}$

$P_2 = 0.76 \times (2)^{1.4}$

P_2 = 2m of Hg column

$P_2 = h\,sg$

$P_2 = 2\times(13.6\times10^3)\times 9.8$

$\boxed{P_2 = 2.672 \times 10^5\ N|m^2}$

h = height of Hg column

s = Density of air

g = Acceleration due to gravity

Q5.Ans. For converting heat energy in to work continuously a part of heat energy absorbed from the source has to be rejected. The heat energy can be rejected only to a body at lower temperature which is sink, so we require a sink to convert heat into work.

Q6.Ans. 1) When heat is supplied to a system d Q is taken positive but when heat is supplied by a system, d Q is taken negative.

2) When a gas expands, d w is taken as positive but when a gas compresses, work done is taken as negative.

Q7.Ans. 1) Work done during the process from A to B = W_{AB}

W_{AB} = area ABKLA ($\therefore$ because area under p-v curve gives work done)

= area of Δ ABC + area of rectangle

$$= \left(\frac{1}{2}\times BC\times AC\right)+\left(KL\times LC\right)$$

BC = KL = 4-1 = 3l = $3\times10^{-3}m^3$

AC = 4-2 = 2N|m²

LC = 2-0 = 2N|m²

$$W_{AB} = \left(\frac{1}{2}\times3\times10^{-3}\times2\right)+\left(3\times10^{-3}\times2\right)$$

$= 3\times10^{-3}+6\times10^{-3}$

$W_{AB} = 9\times10^{-3}J$

Since gas expands during this process, hence $W_{AB} = 9\times10^{-3}J$

2) Work done during the process from B to C(compression) is W_{BC} = -area BCLK

(- ve because gas compresses during BC)

= - KL × LC

$W_{BC} = -3\times10^{-3}\times2$

$= -6\times10^{-3}J$

3) Work done during the process from C to A :-

As there is no change in volume of gas in this process, W_{CA} = O

So, net work done during the complete cycle = $W_{AB} + W_{BC} + W_{CA}$

$= 9\times10^{-3}-6\times10^{-3}+0$

Net work done = 3×10^{-3}J

Q8.Ans. Initial volume, V_1= V

Final volume, V_2= 2V

Initial temperature T = 400k

Find temperature = 400k ($\therefore$ process is isothermal)

Gas constant, R = 8. 3kJ |mole |k=$8.3\text{x}10^{-3}$J|mole|k

Work done during is thermal process=w=2.3026RT Log 10 $\left(\frac{V_2}{V_1}\right)$

$W = 2.3026\times8.3\times10^{-3}\times400\times\log 10\left(\frac{2V}{V}\right)$

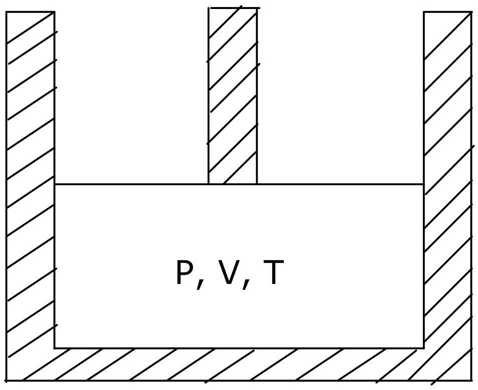
$W = 2.3026\times8.3\times10^{-3}\times400\times\text{Log } 10\ (2)$

W = 2.3016J

If H is the amount of heat produced than,

$$H=\frac{W}{J} = \frac{2.3016}{4.2} = 0.548 \text{ cal}$$

Q9.Ans. Let P = pressure, V = volume and T = Temperature of the gas in a cylinder fitted with a perfectly frictionless piston.



Suppose a small amount of heat d Q is given to the system. The heat is spent in two ways:-

1) In increasing the temperature of the gas by la small range d T, at constant volume

2) In expansion of gas by a small volume d v

So, d Q = C_V d T + P d V

In adiabatic change, no heat is supplied from outside

So, d Q = O

$C_V\, d\, t + P\, d\, V = O \rightarrow (1)$

Acc. to standard gas equation

$PV = RT$

Diff both sides

$P\, d\, V + V\, d\, P = R\, d\, R$

$R\, d\, T = P\, d\, V + V\, d\, P$ ($d\, R = O$ as R is a constant)

$$d\,T = \frac{PdV + VdP}{R}$$

Using this in equation i)

$$C\,v \left(\frac{PdV + VdP}{R} \right) + PdV = O$$

$C_V\, P\, d\, V + C_V\, V\, d\, P + R\, P\, d\, V = O$

$(C_V + R)\, P\, d\, V + C_V\, V\, d\, P = O \rightarrow 2)$

As, $C_P - C_V = R$

or $C_P = R + C_V$

So equation 2) becomes

$C_P\, P\, d\, V + C_V\, V\, d\, P = O$

Dividing above equation by $C_V\, P_V$

$$\frac{C_P PdV}{C_V PV} + \frac{C_V VdP}{C_V PV} = O \qquad \left(\because \frac{C_P}{C_V} = 4 \right)$$

$$\gamma \frac{dV}{V} + \frac{dP}{P} = O$$

Integrating both sides

$$\gamma \int \frac{dV}{V} + \int \frac{dP}{P} = \int O$$

$\gamma\, Loge\, V + Loge\, P = \text{constant}$

$Loge\, V^{\gamma} + Loge\, P = \text{constant} \; \left(\because a \text{ Log b} = \text{Log(b)}^{a} \right)$

$Loge\, P\, V^{\gamma} = \text{constant} \; \left(\because Loga + Logb = Log\ a\ b \right)$

$PV^{\gamma} = \text{antilog (constant)}$

$\boxed{PV^{\gamma} = K}$ K = another constant

CBSE TEST PAPER-10

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Thermodynamics

1. What is the foundation of Thermodynamics? [1]

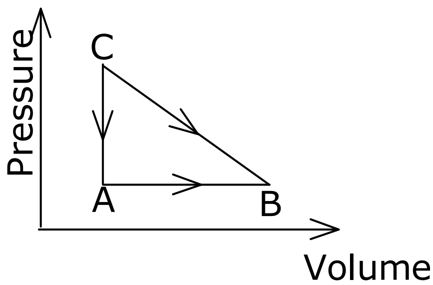
2. State Carnot's Theorem? [1]

3. Differentiate between isothermal and adiabatic process? [1]

4. A Carnot engine develops 100 H.P. and operates between 27^0C and 227^0C. Find 1) thermal efficiency; 2) heat supplied3) heat rejected? [2]

5. The internal energy of a compressed gas is less than that of the rarified gas at the same temperature. Why? [2]

6. Consider the cyclic process A B C A on a sample 2 mol of an ideal gas as shown. The temperature of the gas at A and B are300 K and 500K respected. Total of 1200 J of heat is with drawn from the sample. Find the work done by the gas in part BC? [2]

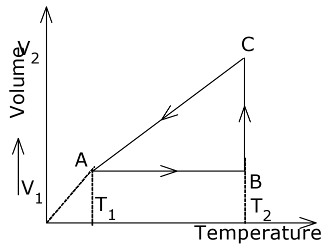


7. A refrigerator placed in a room at 300 K has inside temperature 264K. How many calories of heat shall be delivered to the room for each 1 K cal of energy consumed by the refrigerator, ideally? [2]

8. If the door of a refrigerator is kept open in a room, will it make the room warm or cool? [2]

9. Five moles of an ideal gas are taken in a Carnot engine working between 100^0C and 30^0C. The useful work done in 1 cycle is 420J. Calculate the ratio of the volume of the gas at the end and beginning of the isothermal expansion? [3]

10. The following figure shows a process A B C A per formed on an ideal gas, find the net heat given to the system during the process? [2]



11. A quantity of oxygen is compressed isothermally until its pressure is doubled. It is then allowed to expand adiabatically until its original volume is restored. Find the final pressure in terms of initial pressure? Take Y = 1.4? [2]

CBSE TEST PAPER-04

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Thermodynamics [ANSWERS]

Ans 01. The foundation of thermodynamics is the law of conservation of energy and the fact the heat flows from a hot body to a cold body.

Ans 02. According to Carnot's Theorem, no engine working between two temperatures can be more efficient than a Carnot's reversible engine working between the same temperatures.

Ans 03.

	Isothermal process		Adiabatic process
1)	In this, temperature remains constant	1)	In this, no heat is added or removed.
2)	It occurs slowly	2)	It occurs suddenly.
3)	Here, system is thermally conducting to surroundings	3)	Here, system is thermally insulated from surroundings.
4)	State equation :→ PV = constant	4)	State equation : → PV^{γ} = constant.

Ans 04. Here, energy = W = 100 H. P.

= 100 × 746 W (1 H.P. = 746W)

$$= \frac{(100\times746)}{4.2} cal | s \quad \left(1W = \frac{cal | s}{4.2}\right)$$

High temperature, $T_H = 227^0C = 227 + 273 = 500K$

Low temperature, $T_h = 27^0C = 27 + 273 = 300K$

1) Thermal efficiency, $\eta = 1 - \frac{T_L}{T_H}$

$$\eta = 1 - \frac{300}{500}$$

$$\eta = \frac{200}{500} = 0.4 \text{ or } 40\%$$

2) The heat supplied Q_H is given by:-

$$Q_H = \frac{W}{\eta} = \frac{100 \times 746}{4.2 \times 0.4} = 4.44 \times 10^4 \, cal \,|\, s$$

3) The heat rejected Q_L is given by:-

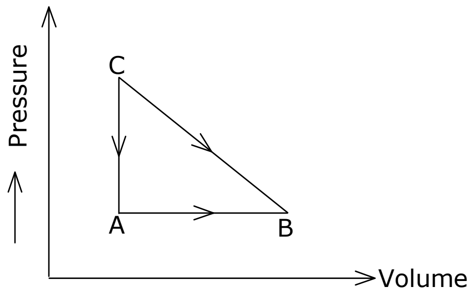
$$Q_L = Q_H \frac{T_L}{T_H} \quad \text{or} \quad \frac{Q_L}{Q_H} = \frac{T_L}{T_H}$$

$$Q_L = 4.44 \times 10^4 \times \frac{3\cancel{00}}{5\cancel{00}}$$

$$Q_L = 2.66 \times 10^4 \, cal \,|\, \Delta$$

Ans 05. The internal energy of a compressed gas is less than that of rarified gas at the same temperature because in compressed gas, the mutual attraction between the molecules increases as the molecules comes close. Therefore, potential energy is added to internal energy and since potential energy is negative, total internal energy decreases.

Ans 06. The change in internal energy during the cyclic process is zero. Therefore, heat supplied to the gas is equal to work done by it,



∴ $W_{AB} + W_{BC} + W_{CA} = -\,1200J \rightarrow (1)$

(- ve because the cyclic process is traced anticlockwise the net work done by the system is negative)

The work done during the process AB is

$W_{AB} = P_A\,(V_B - V_A) = nR(T_B - T_A)\ (QP_V = nRT)$

WAB = 2×8.3(500-300) = 3320J →2)

R = Universal gas constant

N = No. of volume

Since in this process, the volume increases, the work done by the gas is positive.

Now, WCA = O (∵ volume of gas remains constant)

∴ 3320 + WBC + O = - 1200 (Using equation 1) & 2)

WBC = - 1200 – 3320 $\boxed{W_{BC} = -\,4520J}$

Ans 07. High temperature, $T_H = 300K$

Low temperature, $T_h = 264K$

Energy = 1K cal.

Co - efficient of performance, is given by:-

$$COP = \frac{T_H}{T_H - T_L} = \frac{264}{300-264} = \frac{22}{3}$$

Now, COP = $\frac{Q_L}{W}$

Q_L = heat rejected

$Q_L = COP \times W$

$Q_L = \frac{22}{3} \times 1 = \frac{22}{3} Kal$

The mechanical work done by the compressor of the refrigerator is:-

$W = Q_H - Q_L$

$Q_H = W + Q_L$

$Q_H = \frac{22}{3} + 1$

$Q_H = \frac{25}{3} Kal$

$Q_H = 8.33$ K cal

Ans 08. Since a refrigerator is a heat engine that operates in the reverse direction i.e. it extracts heat from a cold body and transforms it to hot body. Since it exhaust more heat into room than it extracts from it. Therefore, the net effect is an increase in temperature of the room.

Ans 09. High temperature, $T_H = 100^0C = 100 + 273 = 373K$

Low temperature, $T_L = 30^0C$, $= 30 + 273 = 303K$

Amount of the gas, n = 5 moles

Useful work done per cycle, $W = Q_H - Q_L$

Now, W = 420 J

So, $Q_H - Q_L = 420J \rightarrow 1)$

Now, $\frac{Q_H}{Q_L} = \frac{T_H}{T_L}$

$$\frac{Q_H}{Q_L} = \frac{373}{303}$$

Or $Q_H = \frac{373}{303} Q_L$ in equation 1)

$$\frac{373}{303} Q_L - Q_L = 420J$$

$$\frac{373Q_L - 303Q_L}{303} = 420J$$

$$\frac{70\ Q_L}{303} = 420$$

$$Q_L = \frac{420X\,303}{70}$$

$Q_L = 1818J$

or, $Q_H - Q_L = 420J$

$Q_H - 1818 = 420J$

$Q_H = 420 + 1818 = 2238J$

When the gas is carried through Carnot cycle, the heat absorbed Q_H during isothermal expansion is equal to the work done by gas.

V_1 – Initial Volume

V_2 = Final Volume,

In isothermal expansion,

$Q_H = 2.303\ nRT_H \text{ Log } 10 \ \frac{V_2}{V_1}$

$22\ 38 = 2.303 \times 5 \times 8.4 \times 373 \text{ Log } 10 \ \frac{V_2}{V_1}$

$$\text{Log } 10 \ \frac{V_2}{V_1} = \frac{2238}{2.303 \times 5 \times 8.4 \times 373}$$

$$\text{Log } 10 \ \frac{V_2}{V_1} = 0.0620$$

$$\boxed{\frac{V_2}{V_1} = 1.153}$$

Ans 10. Since the process is cyclic, the change in internal energy is zero. Therefore, the heat given to the system is equal to work done by it. The net work done by the gas in the process ABCA is:-

$W = W_{AB} + W_{BC} + W_{CA}$

Now $W_{AB} = 0$ $(\because \text{Volume remains constant})$

During the path BC, temperature remains constant. So it is an isothermal process.

So, $W_{BC} = nRT_2 \text{ Loge } \frac{V_2}{V_1}$

During the CA, $V \alpha T$ so that $\frac{V}{T}$ is constant.

$$P = \frac{nRT}{V} = cons\tan t$$

$\therefore$ Work done by the gas during the part CA is :-

$W_{CA} = P (V_1 - V_2)$

$= nR (T_1 - T_2)$

$= - nR (T_2 - T_1)$ $\rightarrow$ Using equation 1)

$W = 0 + nR\,T_2 \text{ Loge } \frac{V_2}{V_1} - nR (T_2 - T_1)$

$$\boxed{W = nR\left[T_2 Loge\frac{V_2}{V_1} - (T_2 - T_1)\right]}$$

CBSE TEST PAPER-11

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Thermodynamics

1. If a air is a cylinder is suddenly compressed by a piston. What happens to the pressure of air? [1]

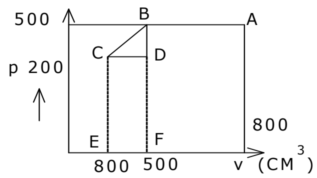
2. What is the ratio of find volume to initial volume if the gas is compressed adiabatically till its temperature is doubled? [1]

3. What is the ratio of slopes of P-V graphs of adiabatic and isothermal process? [1]

4. A motor car tyre has a Pressure of four atmosphere at a room temperature of 27^0C. If the tyre suddenly bursts, calculate the temperature of escaping gas? [2]

5. How does Carnot cycle operates? [2]

6. Calculate the work done by the gas in going from the P-V graph of the thermodynamic behavior of a gas from point A to point B to point C? [2]



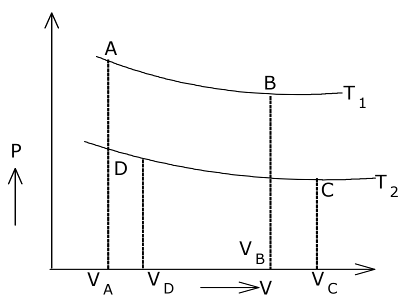
7. Why does absolute zero not correspond to zero energy? [2]

8. State the Second law of thermodynamics and write 2 applications of it? [2]

9. At 0^0C and normal atmospheric pressure, the volume of 1g of water increases from $1cm^3$ to $1.091\ cm^3$ on free zing. What will be the change in its internal energy? Normal atmospheric pressure is $1.013x10^5\ N|m^2$ and the latent heat of melting of ice is 80 cal/g? [2]

10. Calculate the work done during the isothermal Process? [3]

11. Two different adiabatic paths for the same gas intersect two thermals at T_1 and T_2 as shown in P-V diagram. How does $\frac{VA}{VD}$ Compare with $\frac{VB}{VC}$? [2]



CBSE TEST PAPER-11

CLASS - XI PHYSICS (Thermodynamics)

Topic: - Thermodynamics [ANSWERS]

Ans 01. Since the sudden compression causes heating and rise in temperature and if the piston is maintained at same Position then the pressure falls as temperature decreases.

Ans 02. Since for an adiabatic Process,

PV^Y= constant

Since PV = RT

$$P = \frac{RT}{V}$$

So, $\frac{\text{RT VY}}{\text{V}}$ = constant

Or TV y - 1 = constant T_1, V_1 = Initial temperature and Initial Volume

∴ T_1 V_1 y - 1 = T_2 V_2 y - 1 T_2, V_2 = Final temperature and Final volume.

$$\frac{V_2}{V_1} = \left(\frac{T_1}{T_2}\right)^{\frac{1}{Y-1}}$$

Since T_2 = 2 T_1(Given)

$$\frac{T_1}{T_2} = \frac{1}{2}$$

So, $\frac{V_2}{V_1} = \left(\frac{1}{2}\right)^{\frac{1}{Y-1}}$

Since $\frac{4}{Y}$ > 1, $\frac{V_2}{V_1}$ is less than $\frac{1}{2}$.

Ans 03. The slope of P-V graph is $\frac{dP}{dV}$

For an isothermal process, (PV = constant)

$$\text{So, } \frac{dP}{dV} = \frac{P}{V} \rightarrow (1)$$

For an adiabatic process (PV^Y = constant)

$$\frac{dP}{dV} = \frac{YP}{V} \rightarrow (2)$$

Divide 2) by 1)

So, the ratio of adiabatic slope to isothermal slope is Y.

Ans 04. Since the tyre suddenly bursts, the change taking place is adiabatic, for adiabatic change:-

$$\frac{P_1^{Y-1}}{T_1^4} = \frac{P_2^{Y-1}}{T_2^4}$$

$$\text{Or } T_2^4 = T_1^4\left(\frac{P_2}{P_1}\right)^{Y-1} \rightarrow (1)$$

Hence, $T_1 = 273 + 27 = 300K$

P_1 = Initial Pressure; P_2 = final Pressure

So, $\frac{P_1}{P_2} = 4,\ 4 = 1.4$

So, Putting the above values in eq[4] i)

$$T_2^{1.4} = (300)^{1.4} \times \left(\frac{1}{4}\right)^{1.4-1}$$

$$(T_2)^{1.4} = (300)^{1.4} \times \left(\frac{1}{4}\right)^{0.4}$$

Taking 1.4 Power

$$T_2 = (300)^{\frac{1.4}{1.4}} \times \left(\frac{1}{4}\right)^{\frac{0.4}{1.4}}$$

$$\boxed{W_1 = -150J} \rightarrow (1)$$

Work done by the gas in the process B → C is : →

$$W_2 = -[\textit{area} \text{ under the curve BC}]$$

$$W_2 = -[(\textit{area} \text{ of } \Delta \text{ B C D}) + \textit{area} \text{ of rectangle C B D E F}]$$

$$= -\left(\left[\frac{1}{2} \times \textit{Base} \times \text{Height}\right] + [\textit{Length} \times \text{Breadth}]\right)$$

$$\left(\left[\frac{1}{2}\times \text{ CD } \times \text{ BD}\right]+\left[CD \times \text{ EF}\right]\right)$$

$$=-\left(\left[\frac{1}{2}\times\left(3\times10^{5}\right)\times200\times10^{-6}\right]+\left[2\times10^{5}\times200\times10^{-6}\right]\right)$$

$W_2 = -70J \;\rightarrow (2)$

Adding equation i) & 2)

Net work done by the gas in the whole process is W = W_1 + W_2

$$\boxed{\text{W = 150 – 70 = - 22 OJ}}$$

$$T_2 = 300\times\left(\frac{1}{4}\right)^{\frac{0.4}{1.4}}$$

$$T_2 = 300\times\left(\frac{1}{4}\right)^{\frac{\cancel{4}^{2}}{\cancel{14}_{7}}}$$

T_2 = 201.8 K

∴ T_2 = 201.8 – 273 = - 71.2^{0}C

Ans 05. A Carnot cycle operates a follows:-

1) It receives thermal energy isothermally from some hot reservoir maintained at a constant high temperature T_H.

2) It rejects thermal energy isothermally to a constant low–temperature reservoir (T_2).

3) The change in temperature is reversible adiabatic process.

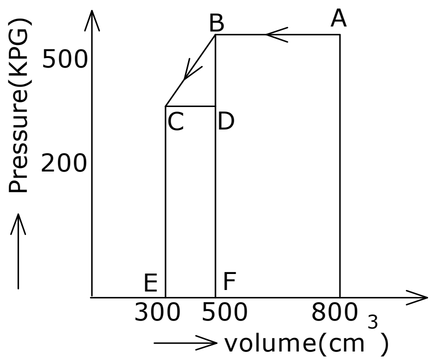
Such a cycle, which consist of two isothermal processes bounded by two adiabatic processes, is called Carnot cycle.

Ans 06. Work done by the gas in the process A → B is

W_1 = - (area under curve A B)

$= -\left[\left(P_{AB}\right)\times\left(V_2 - V_1\right)\right]$

$= -\left[5\times10^{5}\times\left(800-500\right)\times10^{-6}\right]$



P_{AB} = 500 Pa

= 5×10^5 N|m^2

$\left(V_2 - V_1\right) = \left(300\right)$ cm^3 or 300 × 10^{-6}m^3

Ans 07. The total energy of a gas is the sum of kinetic and potential energy of its molecules. Since the kinetic energy is a function of the temperature of the gas. Hence at absolute zero, the kinetic energy of the molecules ceases but potential energy is not zero. So, absolute zero temperature is not the temperature of zero energy.

Ans 08. According to second law of thermodynamics, when a cold body and a hot body are brought into contact with each other, heat always from hot Body to the cold body. Also, that no heat engine that works in cycle completely converts heat into work.

Second law of thermodynamics is used in working of heat engine and of refrigerator.

Ans 09. Since, heat is given out by 1 g of water in freezing is

m = Mass of water = 1 g

Q = - (mLf) Lf = Latent heat of melting of ice = 80 cal|g

[Negative sign is assigned to Q because it is given out by water]

During freezing, the water expands against atmospheric pressure. Hence, external work done (W) by water is :- W = P × Δ V

P = 1.013×10^5 N|m^2; Δ V = 1.091 – 1 = 0.091 cm^3 = o.o91 × 10^{-6} m^3

Δ V = $V_2 - V_1$; V_2 = final volume = 1.91 cm^3

V_1 = Initial volume = 1 cm^3

So, W = $\left(1.013\times10^{5}\right)\times\left(0.091\times10^{-6}\right)$

W = 0.0092 J

Since, 1 cal = 4.2J so,

$$W = \frac{0.0092}{4.2} = 0.0022 \text{ cal } \rightarrow 2)$$

Since the work has been done by ice, it will be taken positive.

Acc. to first law of thermodynamics,

Q = ΔU + W ΔU = change in internal energy

So, ΔU = Q – W

$= (-80)-(-0.0022)$ (Using 1) & 2))

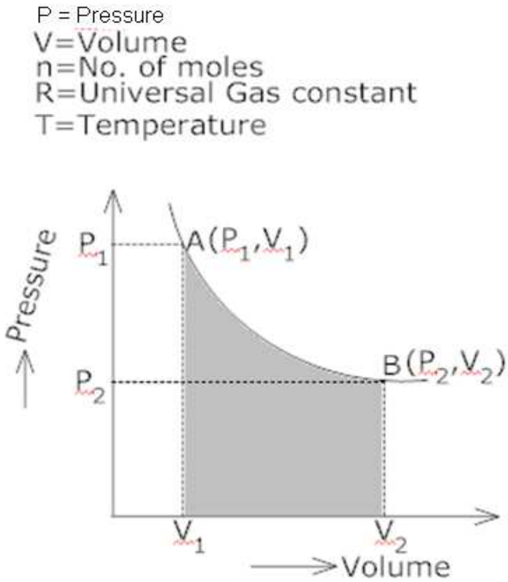
ΔU = - 80.0022 cal

Negative sign indicates that internal energy of water decreases on freezing.

Ans 10. Let an ideal gas is allowed to expand very slowly at constant temperature. Let the expands from state A (P_1, V_1) to state B (P_2, V_2)

The work by the gas in expanding from state A to B is

$$W = +\int_{V_1}^{V_2} PdV \rightarrow (1)$$



For ideal gas, PV = N R T

or P = $\frac{nRT}{V} \rightarrow (2)$

Use 2) in i)

W = $\int_{V_1}^{V_2} \frac{nRT}{V} dV$

Since n, R and T are constant so,

W = $nRT \int_{V_1}^{V_2} \frac{dV}{V} \quad \left(\because \int \frac{dn}{n} = Logem\right)$

W isothermal = nRT Loge V $\Big|_{V_1}^{V_2}$

W isothermal = $nRT\left[LogeV_2 - LogeV_1\right] \quad \left(\because Logm - Logn = Log\frac{m}{n}\right)$

W isothermal – nRT Loge$\frac{V_2}{V_1}$

W isothermal = 2.303 nRT Log 10 $\frac{V_2}{V_1} \quad (Loge = 2.303 Log10)$

If M = Molecular Mass of gas then for 1 gram of ideal gas,

W isothermal = 2.303 $\frac{RT}{M} Log10 \frac{V_2}{V_1}$

W isothermal 2.303 r T Log 10 $\frac{V_2}{V_1}$

r = Gas constant for 1 gm of an ideal gas,

Since $P_1 V_1 = P_2 V_2 \Rightarrow \frac{V_2}{V_1} = \frac{P_1}{P_2}$

So $\boxed{\text{W isothermal = 2.303 r T log 10 } P_1}$

Ans 11. Now, A B and C D are isothermals at temperature T_1 and T_2 respectively and BC and AD are adiabatic.

Since points A and D lie on the same adiabatic.

$\therefore T_A V_A^{Y-1} = T_D V_D^{Y-1}$

$T_1 V_A Y\text{-}1 = T_2 V_D Y\text{-}1$

$\backslash \frac{T_1}{T_2} = \left(\frac{V_D}{V_A}\right)^{Y-1}$

Also, points B and C lie on the same adiabatic,

$\backslash T_B V_B^{Y-1} = T_C V_C^{Y-1}$

or $T_1 V_B Y\text{-}1 = T_2 V_C Y\text{-}1$

$\because \frac{T_1}{T_2} = \left(\frac{V_C}{V_B}\right)^{Y-1}$

From equation 1) & 2)

$\left(\frac{VD}{VA}\right)^{Y-1} = \left(\frac{VC}{VB}\right)^{Y-1}$

$\frac{VD}{VA} = \frac{VC}{VB}$

$\frac{VA}{VD} = \frac{VB}{VC}$

$\therefore \frac{(VA/VD)}{(VB/VC)} = 1$

CBSE TEST PAPER-01

CLASS - XI PHYSICS (Behaviour of Perfect Gases and Kinetic Theory of Gases)

Topic: - Kinetic Theory of Gases

1. What is an ideal perfect gas? [1]

2. State Charles's law? If air is filled in a vessel at 60^0c. To what temperature should it be heated in order that $\frac{1^{rd}}{3}$ of air may escape out of vessel? [2]

3. Show that average kinetic energy of translation per molecule of gas is directly proportional to the absolute temperature of gas? [2]

4. Air pressure in a car tyre increases during driving? Why? [2]

5. Four molecules of gas have speeds 2, 4, 6, 8, km/s. respectively. [2]

   Calculate 1) Average speed

   2) Root Mean square speed?

6. Derive Avogadro's law? [3]

7. What are the assumptions of kinetic theory of gas? [3]

8. Derive an expression for the pressure due to an ideal gas? [5]

CBSE TEST PAPER-01

CLASS - XI PHYSICS (Behaviour of Perfect Gases and Kinetic Theory of Gases)

Topic: - Kinetic Theory of Gases [ANSWERS]

Q1.Ans. A gas which obeys the following laws or characteristics is called as ideal gas.

1) The size of the molecule of gas is zero

2) There is no force of attraction or repulsion amongst the molecules of gas.

Q2.Ans. Acc. to Charles's law, for pressure remaining constant the volume of the given mass of a gas is directly proportional to its Kelvin temperature i.e.

$V \alpha T$ if pressure is constant; V = volume T = Temperature

Or $\frac{V}{T}$ = constant

Now, $T_1 = 60+273 = 333k$

$V_1 = V$;

$T_2 = ?$

$V_2 = V + \frac{V}{3} = \frac{4}{3}V$

So, from Charles's show;

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{V_1}{V_2} = \frac{T_1}{T_2}$$

$$T_2 = T_1 \frac{V_2}{V_1}$$

$$T_2 \frac{333 \times 4V}{3 \times V}$$

$T_2 = 171^0c$ or 444k

Q3.Ans. Acc. to kinetic theory of gases, the pressure p exerted by one mole of an ideal gas is

$P = \frac{1MC^2}{3V}$ M = Mass of gas

or $PV = \frac{1MC^2}{3}$ V = Volume of gas

Since PV = RT (for 1mole of gas)

or $\frac{1}{3}MC^2 = RT$ R=Universal gas constant

$C^2 = \frac{3RT}{M}$ T=Temperature

So, C $\alpha\sqrt{T}$

Also, $\frac{1}{3}MC^2 = RT$

Dividing by number of molecules of gas = N

$\frac{1M}{3N}C^2 = \frac{R}{N}T$ K=Boltzman constant

$\frac{1}{3}mc^2 = KT \quad \rightarrow$ Dividing

or $\frac{1}{2}mc^2 = \frac{3}{2}KT$

Since, $\frac{1}{2}mc^2 = Kin$etic energy per molecule of gas

So, $\boxed{\frac{1}{2}mc^2 \alpha T}$ as $\frac{3}{2}k =$ constant

Q4.Ans. During driving, the temperature of air inside the tyre increases due to motion. Acc. to Charles's law, pressure α Temperature, ∴ As temperature increases, Pressure inside the tyres also increases

Q5.Ans. Here, C_1 = km/s= velocity of first gas

C_2=4km/s \=velocity of second gas

C_3=6km/s=velocity of third gas

C_4=8km/s=velocity of fourth gas

1) ∴ Average speed = $\frac{C_1 + C_2 + C_3 + C_4}{4}$

Average Speed = $\frac{2+4+6+8}{4}$

Average Speed = $\frac{20}{4} = 5$ km/s

2) Root Mean Square Speed = $\sqrt{\frac{C_1^{\,2} + C_2^{\,2} + C_3^{\,2} + C_4^{\,2}}{4}}$

R. m. s of gas = $\sqrt{\frac{2^2 + 4^2 + 6^2 + 8^2}{4}}$

R. m. s. of gas = $\sqrt{\frac{120}{4}}$ R. m. s of gas = 5.48km/s

Q6.Ans. Avogadro's law states that equal volumes of all gases under identical conditions of temperature and pressure, contain the same number of molecules consider two gas having equal volumes 'V' at temperature 'T' and pressure 'P'.

Let M_1=Mass of first gas

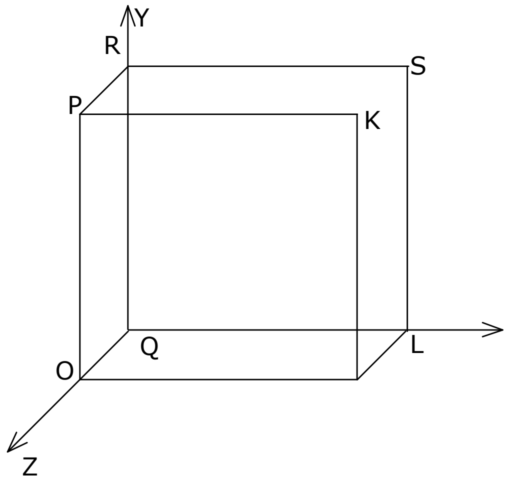
M_2=Mass of second gas

C_1=C_2=r.m.s velocity of gas molecules of 2 gases m1/ m2 = Mass of each molecule of gas

M_1, m_2=Number of molecules of gas

Now, $M_1=m_1\, n_1$ and $M_2=m_2\, n_2$

From kinetic theory of gas :-



For first gas $\Rightarrow P = \frac{1M_1}{3V} C_1^2 \rightarrow (1)$

For second gas $\Rightarrow P = \frac{1M_2}{3V} C_2^2 \rightarrow (2)$

Equating equation 1) 82) for pressure

$$\frac{1M_1}{3V} C_1^2 = \frac{1M_2}{3V} C_2^2$$

$M_1\, C_1^2 = M_2^2\, C_2^2 \rightarrow 3)$

$$\frac{Average K.E}{Molecule \text{ of first gas}} = \frac{Average \text{ K. E}}{Molecule of \text{ sec} ond\ gas} \Rightarrow for\ same \text{ temperatures}$$

$$\frac{1}{2} M_1 C_1^2 = \frac{1}{2} M_2 C_2^2$$

$M_1\, C^2{}_1 = M_2\, C_2^2 \rightarrow 4)$

Let C1, C2 ------ Cn = Random velocities of gases molecules

Let (x_1, y_1, z_1) ----- (xn, yn, zn) → Radom rectangular co-ordinates of η – molecules

So, $\left.\begin{matrix} x_1^2 + y_1^2 + z_1^2 = c_1^2 \\ x_n^2 + y_n^2 + z_n^2 = c_n^2 \end{matrix}\right]$ A)

Initial Molomentum of A, = mx_1

on collision with wall, Momentum = -mx,

Change in Momentum = $-mx_1-mx_1$

= $-2mx_1$

The molecule in between the collisions of two walls OPKT and QRSL covers a distance = 2a time between 2 collisions = $\frac{2a}{x_1}$

Momentum transferred in 1 second = 2m x_1 x $\frac{x_1}{2a}$ $= \frac{mx_1^2}{a}$

From Newton's second law $\Rightarrow f_1 = \frac{mx_1^2}{a}$

$$fn = \frac{mx_n^2}{a}$$

Total force in X-direction = f_1+f_2+ ------ fn

$= \frac{mx_1^2}{a} + \frac{mx_2^2}{a} + ----- \frac{mx_n^2}{a}$

Pressure exerted on wall QRSL = $\frac{Fx}{a^2} = \frac{m}{a^3}\left(x_1^2 + x_2^2 + ----- x_n^2\right)$

Dividing equation 4) by 3)

$\frac{M_1C_1^2}{m_1c_1^2} = \frac{M_2C_2^2}{m_2c_2^2}$ $\boxed{M = m \times n}$

$\frac{m_1n_1}{m_1} = \frac{m_2n_2}{m_2}$

$\boxed{n_1 = n_2}$ $\Rightarrow$ Avogadro's law

Q7.Ans. The assumptions of kinetic theory of gases are:-

1) A gas consists of a very large number of molecules which should be elastic spheres and identical for a given gas.
2) The molecules of a gas are in a state of continuous rapid and random motion.
3) The size of gas molecules is very small as compared to the distance between them.
4) The molecules do not exert any force of attraction or repulsion on each other.
5) The collisions of molecules with one another and with walls of the vessel are perfectly elastic.

Q8.Ans. Consider an ideal gas contained in a cubical container OPQ RSTKL, each of side a, having volume V now, $V=a^3$ ((Side)^3 = volume of cube)

Let n = Molecule of gas

m = Mass of each molecule

M = m x n = Mass of gas

Similarly Py = $\frac{m}{a^3}\left(y_1^2 + y_2^2 + -- y_n^2\right)$

$$Pz = \frac{m}{a^3}\left(z_1^2 + z_2^2 + -- z_n^2\right)$$

P = Total pressure = $\frac{P_x + P_y + P_z}{3}$

$$= \frac{1}{3}\left[\frac{m}{a^3}\left(x_1^2 + x_2^2 + -- x_n^2\right) + \frac{m}{a^3}\left(y_1^2 + y_2^2 + -- y_n^2\right) + \frac{m}{a^3}\left(z_1^2 + z_2^2 + -- z_n^2\right)\right]$$

P = $\frac{m}{3a^3}\left[\left(x_1^2 + y_1^2 + z_1^2\right) + --- \left(x_n^2 + y_n^2 + z_n^2\right)\right]$ (∵ from equation A)

$$P = \frac{m}{3v}\left[C_1^2 + C_2^2 + -- C_n^2\right]$$

→ Multiply & divide by n (no of molecules of gas)

$$P = \frac{1mxn}{3v}\left[\frac{C_1^2 + C_2^2 + -- C_n^2}{n}\right]$$

$$\boxed{P = \frac{1M}{3v}C^2}$$

C^2 = $\frac{C_1^2 + C_2^2 + -- C_n^2}{n}$ or C = $\sqrt{\frac{C_1^2 + C_2^2 + -- C_n^2}{n}}$

C = r. m s. velocity of gas.

CBSE TEST PAPER-02

CLASS - XI PHYSICS (Behaviour of Perfect Gases and Kinetic Theory of Gases)

Topic: - Kinetic Theory of Gases

1. State the law of equi-partition of energy? [1]

2. On what factors, does the average kinetic energy of gas molecules depend? [1]

3. Why the temperature less than absolute zero is not possible? [1]

4. If a vessel contains 1 mole of O_2 gas (molar mass 32) at temperature T. The pressure of the gas is P. What is the pressure if an identical vessel contains 1 mole of He at a temperature 2 T? [2]

5. At very low pressure and high temperature, the real gas behaves like ideal gas. Why? [2]

6. Two perfect gases at absolute temperature T_1 and T_2 are mixed. There is no loss of energy. Find the temperature of the mixture if the masses of molecules are m_1 and m_2 and number of molecules is n_1 and n_2? [3]

7. Calculate the degree of freedom for monatomic, diatomic and triatomic gas? [2]

8. Determine the volume of 1 mole of any gas at s. T. P., assuming it behaves like an ideal gas? [2]

9. A tank of volume $0.3m^3$ contains 2 moles of Helium gas at 20^0C. Assuming the helium behave as an ideal gas; [2]
   1) Find the total internal energy of the system.
   2) Determine the r. m. s. Speed of the atoms.

10. State Graham's law of diffusion and derive it? [2]

11. What is the relation between pressure and kinetic energy of gas? [1]

Ans 01. According to law of equi partition of energy, the average kinetic energy of a molecule in each degree of freedom is same and is equal to $\frac{1}{2}KT$.

Ans 02. Average kinetic energy depends only upon the absolute temperature and is directly proportional to it.

Ans 03. Since, mean square velocity is directly proportional to temperature. If temperature is zero then mean square velocity is zero and since K. E. of molecules cannot be negative and hence temperature less than absolute zone is not possible.

Ans 04. By ideal gas equation :→

$PV = nRT$

$P =$ pressure

V=volume

n=No. of molecule per unit volume

R=Universal Gas Constant

T=Temperature

Now, $\frac{PV}{T} = nR$ or $\frac{PV}{T} =$ constant

Hence $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \rightarrow 1)$

Now, according to question:→

$$\begin{array}{l|l} P_1 = P & T_1 = T \\ V_1 = V & T_2 = 2T \end{array}$$

Using above equations in equation 1)

$$P_2 = \frac{P_1V_1}{T_1} X \frac{T_2}{V_2}$$

$$P_2 = \frac{PV}{T} X \frac{2T}{V} \qquad V_1 = V_2 = V\ (\because \textit{idantical} \text{ vessels})$$

$\boxed{P_2 = 2P}$ Hence pressure gets doubled.

Ans 05. An ideal gas is one which has Zero volume of molecule and no intermolecular forces. Now:

1) At very low pressure, the volume of gas is large so that the volume of molecule is negligible compared to volume of gas.

2) At very high temperature, the kinetic energy of molecules is very large and effect of intermolecular forces can be neglected.

Hence real gases behave as an ideal gas at low pressure and high temperature.

Ans 06. In a perfect gas, there is no mutual interaction between the molecules.

Now, K.E of gas = $\frac{1}{2}mv^2$

By equi partition of energy:

$$\frac{1}{2}mv^2 = \frac{3}{2}KT.$$

K.E of one gas = $n_1 \times \left(\frac{3}{2}KT_1\right) \rightarrow 1)$

K.E. of other gas = $n_2 \times \left(\frac{3}{2}KT_2\right) \rightarrow 2)$

n_1, n_2 = Number of molecules in gases

K = Bolt zman' Constant

T_1, T_2 $\rightarrow$ Temperatures.

Total K.E. = $\frac{3}{2}K\left(n_1T_1 + n_2T_2\right)$ (adding equation 1)&2))

Let T be the absolute temperature of the mixture of gases

Then,

$$\text{Total Kinetic energy} = n_1 \times \left(\frac{3}{2}KT\right) + n_2 \times \left(\frac{3}{2}KT\right)$$

$$\text{Total K.E} = \frac{3}{2}KT\left(n_1 + n_2\right) \rightarrow 4)$$

Since there is no loss of energy, hence on equating eq[4] 3) &4) for total K.E.:→

$$\frac{\cancel{3}}{\cancel{2}}\cancel{K}T\left(n_1 + n_2\right) = \frac{\cancel{3}}{\cancel{2}}\cancel{K}\left(n_1T_1 + n_2T_2\right)$$

$$T\left(n_1 + n_2\right) = \left(n_1T_1 + n_2T_2\right)$$

$$\boxed{T = \frac{n_1T_1 + n_2T_2}{n_1 + n_2}}$$

Ans 07. The degrees of freedom of the system is given by:- $f = 3N - K$

Where, f = degrees of freedom

N = Number of Particles in the system.

K = Independent relation among the particles.

1) For a monatomic gas; N = 1 and K = 0 $\boxed{f = 3 \times 1 - 0 = 3}$

2) For a diatomic gas ; N = 2 and K = m1 $\boxed{f = 3 \times 2 - 1 = 5}$

3) For a triatomic gas; N = 3 and K = 3 $\boxed{f = 6}$

$f = 3 \times 3 - 3$

Ans 08. From ideal gas equation: $\rightarrow$

P = Pressure

V = Volume

n = No. of moles of gas

R = Universal Gas Constant

T = Temperature

$PV = nRT$

$$V = \frac{nRT}{P}$$

Here n = 1 mole; R = 8:31 J/mol/K ; T = 273K

$P = 1.01 \times 10^5$ N|m^2

$$V = \frac{1 \times (8.31) \times 273}{1.01 \times 10^5}$$

$$V = 22.4 \times 10^{-3} m^3$$

Since 1 litre

$$= 1000 cm^3$$

$$= 1 \times 10^{-3} m^3$$

Hence $\boxed{V = 22.4\ l}$

i.e. 1 mol of any gas has a volume of 22.4ℓ at S. T. P. (Standard Temperature & Pressure).

Ans 09. 1) n = No. of moles = 2

T = Temperature = 273+20 = 293K

R = Universal Gas constant = 8.31 J/mole.

Total energy of the system = E = $\frac{3}{2}nRT$

$$E=\frac{3}{2}\times n\times 8.31\times 293 \qquad \boxed{E=7.30\times 10^{3}J}$$

2) Molecular Mass of helium = 4 g | mol

$$=\frac{4\times 10^{-3}Kg}{mol}$$

Root Mean speed = Vr.m.s $=\sqrt{\frac{3RT}{M}} \quad =\sqrt{\frac{3X\,8.31X\,293}{4X10^{-3}}}$

Vr.m.s. = $1.35X10^{3}$ m|s

Ans 10. According to Graham's law of diffusion, the rates of diffusion of two gases are inversely proportional to the square roots of their densities.

Consider two gases A and B diffusing into each other at a Pressure P. Let S_A and S_B be their densities. The root Mean square velocities of the molecules of gases A and B will be:→

$$V^{A}\text{r.m.s}=\sqrt{\frac{3P}{S_A}}\rightarrow 1)$$

$$V^{B}\text{r.m.s}=\sqrt{\frac{3P}{S_B}}\rightarrow 2)$$

Dividing equation 1) by 2)

$$\frac{V^{A}\text{r.m.s.}}{V^{B}\text{r.m.s.}}=\sqrt{\frac{3P}{S_A}}X\sqrt{\frac{S_B}{3P}} \qquad =\sqrt{\frac{S_B}{S_A}}\rightarrow 1)$$

Now, the rate of diffusion of a gas is directly proportional to r.m.s. velocity of its molecules. If r_A and r_B are the rates of diffusion of gases A and B respectively then

$$\frac{r_A}{r_B}=\frac{V^{A}r.m.s.}{V^{B}r.m.s.}=\sqrt{\frac{S_B}{S_A}}$$

or $\boxed{\frac{r_A}{r_B}=\sqrt{\frac{S_B}{S_A}}}$ ⇒ This is Graham's law.

Ans 11. Let, Pressure = P

Kinetic energy = E

From, Kinetic theory of gases, $P = \frac{1}{3} Sc^2 \rightarrow 1)$

S = Density

C = r.m.s velocity of gas molecules

Mean Kinetic energy of translation per unit

Volume of the gas = $E = \frac{1}{2} Sc^2 \rightarrow 2)$

Dividing 1) by 2)

$$\frac{P}{E} = \frac{1Sc^2 2}{3 \times Sc^2} = \frac{2}{3}$$

$$\Rightarrow \boxed{P = \frac{2}{3} E}$$

CBSE TEST PAPER-03

CLASS - XI PHYSICS (Behaviour of Perfect Gases and Kinetic Theory of Gases)

Topic: - Kinetic Theory of Gases

1. Given Samples of 1 cm^3 of Hydrogen and 1 cm^3 of oxygen, both at N. T. P. which sample has a larger number of molecules? [1]
2. Find out the ratio between most probable velocity, average velocity and root Mean square Velocity of gas molecules? [1]
3. What is Mean free path? [1]
4. What happens when an electric fan is switched on in a closed room? [1]
5. If a certain mass of gas is heated first in a small vessel of volume V_1 and then in a large vessel of volume V_2. Draw the P – T graph for two cases? [2]
6. Derive the Boyle's law using kinetic theory of gases? [2]
7. At what temperature is the root mean square speed of an atom in an argon gas cylinder equal to the r.m.s speed of a helium gas atom at- 20^0C? Given Atomic Mass of Ar = 39.9 and of He = 4.0? [2]
8. Show that constant – temperature bulk modulus K of an ideal gas is the pressure P of the gas? [2]
9. If Nine particles have speeds of 5, 8, 12, 12, 12, 14, 14, 17 and 20 m/s. find : $\rightarrow$ [3]
   1) the average speed
   2) the Most Probable speed
   3) the r.m.s. Speed of the particles?
10. Establish the relation between $Y\left(=\frac{C_P}{C_V}\right)$ and degrees of freedom (n)? [3]
11. The earth with out its atmosphere would be inhospitably cold. Explain Why? [2]

Ans 01. Acc. to Avogadro's hypothesis, equal volumes of all gases under similar conditions of temperature and pressure contain the same number of molecules. Hence both samples have equal number of molecules. Hence both samples have equal number of molecules.

Ans 02. Since,

Most Probable velocity, $V_{mP} = \sqrt{\frac{2KT}{m}}$

Average velocity, $\bar{V} = \sqrt{\frac{8KT}{\pi m}}$

Root Mean Square velocity: Vr.m.s. $= \sqrt{\frac{3KT}{m}}$

So, $V_{mp} : \overline{V}$ Vr.m.s $= \sqrt{\frac{2KT}{m}} : \sqrt{\frac{3KT}{\pi m}} : \sqrt{\frac{3KT}{m}}$

$$= \sqrt{2} : \sqrt{\frac{8}{\pi}} : \sqrt{3}$$

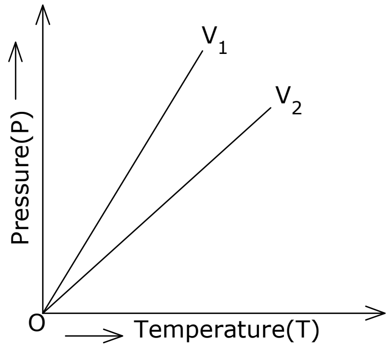
$V_{mp} : \overline{V}$ Vr.m.s. = 1 : 1.3 : 1.23

Ans 03. Mean free path is defined as the average distance a molecule travels between collisions. It is represented by $\lambda(\text{lambda})$. Units are meters (m).

Ans 04. When electric fan is switched on, first electrical energy is converted into mechanical energy and then mechanical energy is converted into heat. The heat energy will increase the Kinetic energy of air molecules; hence temperature of room will increase.

Ans 05. From Perfect gas equation; $P = \frac{RT}{V}$

For a given temperature, $P\alpha\frac{1}{V}$ therefore when the gas is heated in a small vessel (Volume V_1) , the pressure will increases more rapidly than when heated in a large vessel (Volume V_2). As a result, the slope of P – T graph will be more in case of small vessel than that of large vessel.



Ans 06. According to Boyle's law, temperature remaining constant, the volume v of a given mass of a gas is inversely proportional to the pressure P i.e. PV = constant.

Now, according to kinetic theory of gases, the pressure exerted by a gas is given by:-

P = Pressure

V = Volume

$\overline{V}$ = Average Velocity

m = Mass of 1 molecule

N = No. of molecules

M = mN (Mass of gas)

$$P = \frac{1mN\overline{V}^2}{3V}$$

$$P_V = \frac{1}{3}M\overline{V}^2$$

Ans 07. Suppose, Vr.m.s. and V^1r.m.s. are the root mean square speeds of Argon and helium atoms at temperature T and T^1 respectively.

R = Universal Gas constant

T = Temperature

M = Atomic Mass of Gas

Now, Vr.m.s. = $\sqrt{\frac{3RT}{M}}$

V^1r.m.s.=$\sqrt{\frac{3RT^1}{M^1}}$

Now, M = Mass of Argon = 39.9

M^1 = Mass of Helium = 4.0

T^1 = Temperature of helium = -20^0C

T^1 = 273 + (-20) = 253 K.

T = Temperature of Argon = ?

Since Vr.m.s. = V^1r.m.s

$$\sqrt{\frac{3RT}{M}} = \sqrt{\frac{3RT^1}{M^1}}$$

Squaring both side,

$$\frac{\cancel{3}\cancel{R}T}{M} = \frac{\cancel{3}\cancel{R}T^1}{M^1}$$

$$\frac{T}{M} = \frac{T^1}{M^1} \Rightarrow T = \frac{T^1 M}{M^1}$$

Putting the values of T^1, M^1 & M

$$T = \frac{253 \times 39.9}{4.0} = 2523.7K$$

Ans 08. When a substance is subjected to a Pressure increase ΔP will undergo a small fractional volume decrease $\frac{\Delta V}{V}$ That is related to bulk modulus K by :-

$$K = \frac{\Delta P}{\frac{-\Delta V}{V}} \quad \rightarrow 1)$$

Negative sign indicates decrease in volume. In case of an ideal gas at constant temperature before compression,

$$PV = \frac{m}{M} RT \quad \rightarrow 2)$$

M = Molecular Mass of gas

After compression at constant temperature,

$$(P + \Delta P)(V + \Delta V) = \frac{m}{M} RT$$

From equation 2)

$$PV = (P + \Delta P)(V + \Delta V)$$

$$\cancel{PV} = \cancel{PV} + P\Delta V + V\Delta P + \Delta P \Delta V$$

or $-P\Delta V = V\Delta P + \Delta P \Delta V$

$$-\frac{P\Delta V}{V} = \Delta P + \frac{\Delta P \Delta V}{V} \quad (\because \text{ Dividing by V on both sides})$$

$$-\frac{P\Delta V}{V} = \Delta P\left(1+\frac{\Delta V}{V}\right)$$

$$-\frac{\Delta V}{V} = \frac{\Delta P}{P}\left(1+\frac{\Delta V}{V}\right)$$

We are concerned with only a small fractional changes. Therefore, $\frac{\Delta V}{V}$ is much smaller than 1, As a result, it can be neglected as compared to 1.

$$\therefore -\frac{\Delta V}{V} = \frac{\Delta P}{P}$$

Substituting this value of $\frac{\Delta V}{V}$ in equation 1) we get

$$K = \frac{\Delta P}{\frac{\Delta P}{P}} = P$$

Hence, bulk modulus of an ideal gas is equal to the pressure of the gas in compression carried out at constant temperature.

Ans 09. 1) The average speed is the sum of speeds divided by the total number of particles.

Hence, Average speed, $\overline{V} = \frac{5+8+12+12+12+14+14+17+20}{9} = 12.7 m|s$

2) The average value of the square of speeds is given by:-

$$\overline{V}^2 = \frac{5^2+8^2+12^2+12^2+12^2+14^2+14^2+17^2+20^2}{9}$$

$$= \frac{25+64+144+144+144+196+196+289+400}{9} = \frac{1602}{9}$$

$$\overline{V}^2 = 178 m^2/s^2$$

$$\therefore R.M.S.speed, Vr.m.s = \sqrt{\overline{V}^2} = \sqrt{178} = 13.3 m/s$$

3) Three of particles have a speed of 12m|s; two have a speed of 14m|s and the remaining have different speeds. Therefore, the most probable speed,

V_{mP} = 12 m /s.

Ans 10. Now $y = \frac{C_P}{C_V}$

Where CP = specific heat at constant pressure

CV = Specific heat at constant volume.

and n = Degrees of freedom → is the total number of co-ordinates or independent quantities required to describe completely the position and configuration of the system.

Suppose, a polyatomic gas molecule has 'n' degrees of freedom.

∴ Total energy associated with a gram molecule of the gas i. e.

N = Total number of molecules

R = Universal Gas Constant

R = NK

K = Boltzmann Constant

E = $n \times \frac{1}{2}$ KT × N = $\frac{n}{2} RT$

As,

Specific heat at constant volume,

$$C_V = \frac{dE}{dT}$$
$$C_V = \frac{d}{dT}\left(\frac{n}{2}RT\right)$$
$$C_V = \frac{n}{2}R$$

Now Specific heat at constant Pressure, $C_P = C_V + R$

$$C_P = \frac{n}{2}R + R$$
$$C_P = \left(\frac{n}{2}+1\right)R$$

As, $Y = \dfrac{C_P}{C_V}$

$$Y = \frac{\left(\frac{n}{2}+1\right)R}{\frac{n}{2}R}$$

$$Y = \left(\frac{n}{2}+1\right)\times\frac{2}{n}$$

$$Y = \frac{\cancel{2}}{\cancel{n}}\times\frac{\cancel{n}}{\cancel{2}}+1\times\frac{2}{n}$$

$$\boxed{Y = \left(1+\frac{2}{n}\right)}$$

Ans 11. The lower layers of earth's atmosphere reflect infrared radiations from earth back to the surface of earth. Thus the heat radiations received by the earth from the sun during the day are kept trapped by the atmosphere. If atmosphere of earth were not there, its surface would become too cold to live.

CBSE TEST PAPER-01
CLASS - XI PHYSICS (Oscillations and Waves)
Topic: - Oscillations

1. The girl sitting on a swing stands up. What will be the effect on periodic time of swing? [1]

2. At what distance from the mean position, is the kinetic energy in a simple harmonic oscillator equal to potential energy? [1]

3. A simple harmonic oscillator is represented by the equation : Y = 0.40 Sin (440t+0.61) [2]
   Y is in metres
   t is in seconds
   Find the values of 1) Amplitude 2) Angular frequency 3) Frequency of oscillation 4) Time period of oscillation, 5) Initial phase.

4. The soldiers marching on a suspended bridge are advised to go out of steps. Why? [1]

5. The springs of spring factor k, 2k, k respectively are connected in parallel to a mass m. If the mass = 0.08kg m and k = 2N|m, then find the new time period? [2]

6. The bob of a vibrating simple pendulum is made of ice. How will the period of swing will change when the ice starts melting? [2]

7. An 8 kg body performs S.H.M. of amplitude 30 cm. The restoring force is 60N, when the displacement is 30cm. Find: - a) Time period b) the acceleration c) potential and kinetic energy when the displacement is 12cm? [2]

8. What is Simple pendulum? Find an expression for the time period and frequency of a simple pendulum? [5]

9. A particle executing SH.M has a maximum displacement of 4 cm and its acceleration at a distance of 1 cm from its mean position is 3 cm/s^2. What will be its velocity when it is at a distance of 2cm from its mean position? [2]

10. What is ratio of frequencies of the vertical oscillations when two springs of spring constant K are connected in series and then in parallel? [2]

11. The kinetic energy of a particle executing S.H.M. is 16J when it is in its mean position. If the amplitude of oscillations is 25cm and the mass of the particle is 5.12kg. Calculate the time period of oscillations? [2]

CBSE TEST PAPER-01
CLASS - XI PHYSICS (Oscillations and Waves)
Topic: - Oscillations [ANSWERS]

Ans 01. The periodic time T is directly proportional to the square root of effective length of pendulum (l). When the girl starts up, the effective length of pendulum (i.e. Swing) decreases, so the Time period (T) also decreases.

Ans 02. Let the displacement of particle executing S.H.M = Y
Amplitude of particle executing S.H.M = a
Mass of particle = m
Angular velocity = w

The kinetic energy = $\frac{1}{2}mw^2\left(a^2 - y^2\right)$

$Patential\ \text{energy} = \frac{1}{2}mw^2y^2$

$If\ \text{kinetic energy} = \text{Potential energy}$

$\frac{1}{2}mw^2\left(a^2-y^2\right) = \frac{1}{2}mw^2y^2$

$a^2 - y^2 = y^2$

$a^2 = 2y^2$

$a = \sqrt{2y} \rightarrow$ Square root on both sides

$$\boxed{Y = \frac{a}{\sqrt{2}}}$$

Ans 03. The given equation is:- Y = 0.40 Sin ($440t$ + 0.61)
Comparing it with equation of S.H.M. Y = a Sin (w t +$\emptyset_0$)
1) Amplitude = a = 0.40m
2) Angular frequency = w = 440Hz
3) Frequency of oscillation, $\upsilon = \frac{w}{2\pi} = \frac{440}{2\times\frac{22}{7}} = 70Hz$

4) Time period of oscillations, T = $\frac{1}{v} = \frac{1}{70} = 0.0143s$

5) Initial phase, $\emptyset$ = 0.61 rad.

Ans 04. The soldiers marching on a suspended bridge are advised to go out of steps because in such a case the frequency of marching steps matches with natural frequency of the suspended bridge and hence resonance takes place, as a result amplitude of oscillation increases enormously which may lead to the collapsing of bridge.

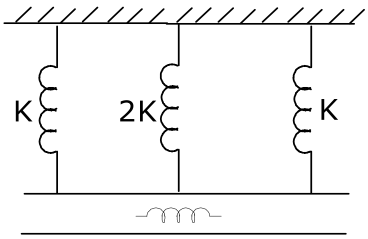
Ans 05. Total spring constant, $K^1 = K_1 + K_2 + K_3$ (In parallel)

$= K + 2K + K$

$= 4K$

$= 4 \times 2$ (k = 2 N | m)

$= 8$ N | m



Time period,

$$T = 2\pi\sqrt{\frac{m}{K^1}}$$

$$T = 2\pi\sqrt{\frac{m}{4K}}$$

$$T = 2\pi\sqrt{\frac{0.08}{4\times 2}}$$

$$T = 2\times\frac{22}{7}\times\sqrt{\frac{0.08}{8}}$$

$$T = 2\times\frac{22}{7}\times 0.1$$

$$T = 0.628 \text{ s}$$

Ans 06. The period of swing of simple pendulum will remain unchanged till the location of centre of gravity of the bob left after melting of the ice remains at the fixed position from the point of suspension. If centre of gravity of ice bob after melting is raised upwards, then effective length of pendulum decreases and hence time period of swing decreases. Similarly, if centre of gravity shifts downward, time period increases.

Ans 07. Here m = 8 kg

m = Mass, a = amplitude

a = 30cm = 0.30m

a) f = 60 N, Y = displacement = 0.30m

K = spring constant

Since, F = Ky

$$K = \frac{F}{Y} = \frac{60}{0.30} = 200 N \,|\, m$$

$$\text{As, Angular velocity} = w = \sqrt{\frac{k}{m}} = \sqrt{\frac{200}{8}} = 5 \,|\, s$$

$$\text{Time period, } T = \frac{2\pi}{w} = \frac{2\times 22}{7\times 5} = \frac{44}{35} = 1.256s$$

b) Y = displacement = 0.12m

Acceleration, A = w^2 y

$A = (5)^2 \times 0.12$

$A = 3.0 m |s^2$

P.E. = Potential energy = $\frac{1}{2}ky^2 = \frac{1}{2}\times 200\times(0.12)^2$

$= \frac{1}{2}\times 200\times 144\times 10^{-4} = 1.44J$

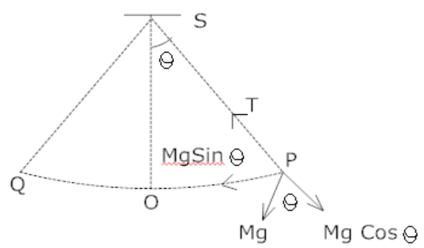
Kinetic energy = K.E = $\frac{1}{2}k(a^2 - y^2)$

$K.E. = \frac{1}{2}\times 200\times(0.3^2 - 0.12^2$

= $\frac{1}{2}\times 200\times(0.09 - 0.0144)$

Kinetic energy = K. E. = 7.56J

Ans 08. A simple pendulum is the most common example of the body executing S.H.M, it consist of heavy point mass body suspended by a weightless inextensible and perfectly flexible string from a rigid support, which is free to oscillate.



Let m = mass of bob

l = length of pendulum

Let O is the equilibrium position, OP = X

Let θ = small angle through which the bob is displaced.

The forces acting on the bob are:-

1) The weight = M g acting vertically downwards.

2) The tension = T in string acting along Ps.

Resolving Mg into 2 components as Mg Cos θ and Mg Sin θ,

Now, T = Mg Cos θ

Restoring force F = - Mg Sin θ

- ve sign shows force is directed towards mean position.

Let θ = Small, so Sin θ ≈ θ = $\frac{\text{Arc(op)}}{l} = \frac{x}{l}$

Hence F = - mg θ

F = - mg $\frac{x}{l} \rightarrow 3)$

Now, In S.H.M, F = k x →4) k = Spring constant

Equating equation3) & 4) for F

$- k x = - m g \dfrac{x}{l}$

Spring factor = k = $\dfrac{mg}{l}$

Inertia factor = Mass of bob = m

Now, Time period = T = $2\pi\sqrt{\dfrac{Inertia \text{ factor}}{Spring \text{ factor}}} = 2\pi\sqrt{\dfrac{m}{mg/l}}$

$$\boxed{T = 2\pi\sqrt{\dfrac{l}{g}}}$$

Ans 09. The acceleration of a particle executing S.H.M is –

A = w^2 Y

w = Angular frequency ; Y = Displacement

A = Acceleration

Given A = 3cm / s^2 ; Y = 1cm

So, 3 = w^2 × 1

w = $\sqrt{3} rad / s$

The velocity of a particle executing S.H.M is :-

$$V = w\sqrt{a^2 - y^2}$$

a = amplitude

$$V = \sqrt{3}\sqrt{(4)^2 - (2)^2}$$

$$V = \sqrt{3}\sqrt{16-4}$$

$$V = \sqrt{3}\times\sqrt{12}$$

$$V = \sqrt{3}\times 2\times\sqrt{3}$$

$$V = 2\times 3$$

$$V = 6 cm / s$$

Ans 10. If two spring of spring constant K are connected in parallel, then effective resistance in parallel = K_P = K + K = 2K

Let f_P = frequency in parallel combination.

$$f_P = \frac{1}{2\pi}\sqrt{\frac{K_P}{M}}$$

Put the value of K_P

$$f_P = \frac{1}{2\pi}\sqrt{\frac{2K}{M}} \rightarrow (1)$$

In Series combination, effective spring constant for 2 sprigs of spring constant K is :-

$$\frac{1}{K_S} = \frac{1}{K} + \frac{1}{K}$$

$$\frac{1}{K_S} = \frac{K+K}{K \times K} = \frac{2K}{K^2}$$

$$\frac{1}{K_S} = \frac{K}{2} \, or \; K_S = \frac{K}{2}$$

Let f_S = frequency in series combination

$$f_S = \frac{1}{2\pi}\sqrt{\frac{K_S}{M}}$$

$$f_S = \frac{1}{2\pi}\sqrt{\frac{\frac{K}{2}}{M}}$$

$$f_S = \frac{1}{2\pi}\sqrt{\frac{K}{2M}} \rightarrow 2)$$

Divide equation 2) by 1)

$$\frac{f_S}{f_P} = \frac{\frac{1}{2\pi}\sqrt{\frac{K}{2M}}}{\frac{1}{2\pi}\sqrt{\frac{2K}{M}}}$$

$$\frac{f_S}{f_P} = \frac{1}{\cancel{2}\cancel{\pi}}\sqrt{\frac{K}{2M}} \frac{\times \cancel{2}\cancel{\pi} \times \sqrt{M}}{\times \sqrt{2K}}$$

$$\frac{f_S}{f_P} = \sqrt{\frac{\cancel{K} \times \cancel{M}}{2\cancel{M} \times 2\cancel{K}}}$$

$$\frac{f_S}{f_P} = \sqrt{\frac{1}{4}}$$

$$\boxed{\frac{f_S}{f_P} = \frac{1}{2}} \qquad \boxed{f_S : f_P = 1:2}$$

Ans 11. K. E. = Kinetic energy = 16J

Now, m = Mass = 5.12kg

W = Angular frequency

a = amplitude = 25cm or 0.25m

CBSE TEST PAPER-02
CLASS - XI PHYSICS (Oscillations and Waves)
Topic: - Oscillations

1. Is the motion of a simple pendulum strictly simple harmonic? [1]

2. Can a simple pendulum experiment be done inside a satellite? [1]

3. Give some practical examples of S. H. M? [1]

4. The time period of a body suspended by a spring is T. What will be the new time period if the spring is cut into two equal parts and 1) the body is suspended by one part. 2) Suspended by both parts in parallel? [2]

5. A simple pendulum is executing Simple harmonic motion with a time T. If the length of the pendulum is increased by 21 %. Find the increase in its time period? [2]

6. A particle is executing S H M of amplitude 4 cm and T = 4 sec. find the time taken by it to move from positive extreme position to half of its amplitude? [2]

7. Two linear simple harmonic motions of equal amplitudes and angular frequency w and 2 w are impressed on a particle along axis X and Y respectively. If the initial phase difference between them is $\frac{\pi}{2}$, find the resultant path followed by the particle? [2]

8. The acceleration due to gravity on the surface of moon is 1.7 m/s^2. What is the time period of simple pendulum on moon if its time period on the earth is 3.5s? [2]

9. Using the correspondence of S. H. M. and uniform circular motion, find displacement, velocity, amplitude, time period and frequency of a particle executing SH.M? [2]

CBSE TEST PAPER-02
CLASS - XI PHYSICS (Oscillations and Waves)
Topic: - Oscillations [ANSWERS]

Ans 01. It is not strictly simple harmonic because we make the assumption that Sinθ =θ, which is nearly valid only if θ is very small.

Ans 02. Since time period of a simple pendulum is :- $T = 2\pi\sqrt{\frac{l}{g}}$

Since, inside a satellite, effective value of 'g' = 0

So, when g = 0, T = α. Therefore, inside the satellite, the pendulum does not oscillate at all. So, it can not be preformed inside a satellite.

Ans 03. Some practical examples of S. H. M. are :-

1) Motion of piston in a gas – filled cylinder.
2) Atoms vibrating in a crystal lattice.
3) Motion of helical spring.

Ans 04. Since time period of oscillation, a body of mass 'm' suspended from a spring with force constant 'k' are:- $T = 2\pi\sqrt{\frac{m}{k}}$

1) On cutting the spring in two equal parts, the length of one part is halved and the force constant of each part will be doubled (2k). Therefore, the new time period is :→

$$T_1 = 2\pi\sqrt{\frac{m}{2K}}$$

If Initial Time - Period is $T=2\pi\sqrt{\frac{m}{K}}$

So, $\boxed{T^1 = \frac{T}{\sqrt{2}}}$

2) If the body is suspended from both parts in parallel, then the effective force constant of parallel combination = 2k + 2k = 4k. Therefore, time period is:→

$$T_2 = 2\pi\sqrt{\frac{m}{4K}} \qquad \boxed{T_2 = \frac{T}{\sqrt{4}} \text{ or } \frac{T}{2}}$$

Ans 05. Now, time period of simple pendulum,

l = length of simple pendulum

g = acceleration due b gorily

$$T = 2\pi\sqrt{\frac{l}{g}}$$

If T_2 = Final time period

T_1 = Initial time period

So, $T_2 = 2\pi\sqrt{\frac{l_2}{g}}$

$$T_1 = 2\pi\sqrt{\frac{l_1}{g}}$$

Since 2π and g are constant, so;

$$T_2 = \sqrt{l_2} \rightarrow (1)$$
$$T_1 = \sqrt{l_1} \rightarrow (2)$$

Divide equation 2) by 1)

$$\frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}}$$

If $l_1 = l$

$$l_2 = l_1 + l_1 \times \frac{21}{100}$$
$$l_2 = 1.21l$$

So, $\frac{T_2}{T_1} = \sqrt{\frac{1.21\cancel{l}}{\cancel{l}}}$

$$\frac{T_2}{T_1} = 1.1 \qquad \boxed{T_2 = 1.1T_1}$$

Therefore percentage increase in time period = $\frac{T_2 - T_1}{T} \times 100\%$

$$= \frac{1.1T - T}{T} \times 100\%$$

$$= \frac{0.1\cancel{T}}{\cancel{T}} \times 100\%$$

$$= 10\%$$

Ans 06. If Y = displacement

t = time

a = amplitude

w = Angular frequency

Now, Y = a cos w t

Given Y = $\frac{a}{2}$

So, $\frac{\cancel{a}}{2} = \cancel{a}$ Cos w t

$\frac{1}{2} =$ Cos w t

Now, T = Time Period, w = $\frac{2\pi}{T}$

$$\frac{1}{2} = Cos \frac{2\pi}{T} Xt \quad (T = 4\sec)$$

$$\frac{1}{2} = Cos \frac{2\pi}{4} Xt$$

Let WA is work done by spring A & kA = Spring Constant

WB is work done by spring B& kB = Spring Constant

$$\frac{WA}{WB} = \frac{kA}{kB} = \frac{1}{3} \quad \therefore \quad \boxed{WA : WB = 1 : 3}$$

Ans 07. Let s = amplitude of each S.H.M.

Then give simple harmonic motions may be represented by: $\rightarrow$

W = Angular frequency

t = time

x = A Sin w t $\rightarrow$1)

Now, $y = a \text{ Sin } \left(200t + \frac{\pi}{2}\right)$

x $\rightarrow$ Displacement along X – axis

y $\rightarrow$ Displacement along y – axis.

$y = \text{a Cos 2 w t} \left[\because \text{ Sin } \left(\theta + \frac{\pi}{2}\right) = Cos\theta\right]$

Now, Cos 2 θ = 1 – 2 Sin^2 θ

$y = a\left(1 - 2Sin^2 w\ t\right)$

For equation 1) Sin w t = $\frac{x}{a}$; Putting the value

Of Sin w t in equation 2)

$$y = a\left(1 - \frac{2x^2}{a^2}\right)$$

$$y = a - \frac{2x^2}{a}$$

$$y + \frac{2x^2}{a} = a$$

$$\frac{2x^2}{a} = a - y$$

$$x^2 = \frac{a}{2}(a - y)$$

$$\boxed{x^2 = \frac{a^2}{2} - \frac{a}{2}y}$$

Ans 8. If l = length of simple pendulum,

T = Time Period

g = Acceleration due to gravity.

Then, on earth ; $T = 2\pi\sqrt{\frac{l}{g}} \to (1)$

On Moon ; $T_1 = 2\pi\sqrt{\frac{l}{g_1}} \to 2)$

g_1 = Acceleration due to gravity on moon = 1.7 m | S^2

g = Acceleration due to gravity on earth = 9.8m | s^2

Dividing equation 2) by (1)

$$\frac{T_1}{T} = \sqrt{\frac{g}{g_1}}$$

$$\frac{T_1}{T} = \sqrt{\frac{9.8}{1.7}}$$

$$T_1 = T \times \sqrt{\frac{9.8}{1.7}}$$

$$T_1 = 3.5 \times \sqrt{\frac{9.8}{1.7}} \qquad \boxed{T_1 = 8.4s}$$

Ans 9. If initially at t = 0

Particle is at D

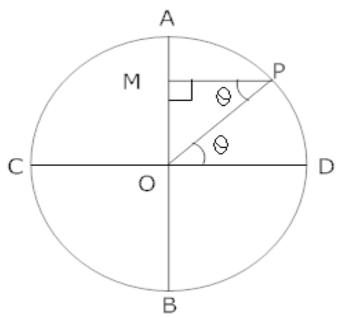
Then at time = t

Particle is at point P

Then Drop a perpendicular From P on AB,

If the displacement OM = Y

Ratios of circle of reference = Amplitude = a



then In Δ O P M :→ Angle POD = Angle OPM (∵ Alternate Angles)

$$\text{Sin } \theta = \frac{OM}{OP}$$

$$Sin\theta = \frac{y}{a}$$

Y = a Sin θ

Now, w = Angular speed $\Rightarrow$

T = time

Then $\theta = wt$

So, $\boxed{Y = a \text{ Sin w t}}$

2) Velocity, $V = \frac{dy}{dt}$

$$V = \frac{d}{dt}(\text{a Sin wt})$$
$$V = a\frac{d}{dt}(\text{Sin wt})$$
$$V = \text{a}[w.\text{Cos wt}]$$
$$V = \text{a w Cos wt}$$

Now, $\text{Sin}^2\ \theta + \text{Cos}^2\ \theta = 1$

$$\text{Cos}^2\ \theta = 1\text{-Sin}^2\ \theta$$
$$\text{Cos}\ \theta = \sqrt{1 - Sin^2\theta}$$

So, V = a w $\sqrt{1 - Sin^2 wt}$

Form equation of displacement :→ Sin wt = $\frac{y}{a}$

$$Sin^2 wt = \frac{y^2}{a^2}$$

So, V = a w $\sqrt{1-\frac{y^2}{a^2}}$

$$V = aw\sqrt{\frac{a^2-y^2}{a^2}}$$

$$\boxed{V = w\sqrt{a^2-y^2}}$$

3) Acceleration :→ A = $\frac{dV}{dt}$

$$A = \frac{d}{dt}(\text{a w Cos w t})$$

$$A = aw\frac{d}{dt}(\text{Cos w t})$$

$$A = aw \times w(-Sin\text{ w t})$$

$$A = -aw2\text{ Sin w t}$$

Now, Y = Sin w t

$$\boxed{A = -w^2Y}$$

The acceleration is proportional to negative of displacement is the characteristics of S. H. M.

4) T = $\frac{2\pi}{\text{w}}$ T=Time Period

5) r = $\frac{1}{\text{T}} = \frac{\text{w}}{2\pi}$ r = frequency.

CBSE TEST PAPER-03

CLASS - XI PHYSICS (Oscillations and Waves)

Topic: - Waves

1. Explosions on other planets are not heard on earth. Why? [1]

2. Why longitudinal waves are called pressure waves? [1]

3. Why do tuning forks have two prongs? [1]

4. A pipe 20 cm long is closed at one end. Which harmonic mode of the pipe is resonantly excited by a 430 Hz source? Will this source be in resonance with the pipe if both the ends are open? [2]

5. Can beats be produced in two light sources of nearly equal frequencies? [2]

6. A person deep inside water cannot hear sound waves produces in air. Why? [2]

7. If the splash is heard 4.23 seconds after a stone is dropped into a well. 78.4 metes deep, find the velocity of sound in air? [2]

8. How roar of a lion can be differentiated from bucking of a mosquito? [2]

9. Explain briefly the analytical method of formation of beats? [3]

10. Give two cases in which there is no Doppler effect in sound? [2]

11. The length of a sonometer wire between two fixed ends is 110cm. Where the two bridges should be placed so as to divide the wire into three segments whose fundamental frequencies are in the ratio of 1:2:3? [2]

CBSE TEST PAPER-03
CLASS - XI PHYSICS (Oscillations and Waves)
Topic: - Waves

Ans 01. This is because no material medium is present over a long distance between earth and planets and is absence of material medium for propagation, sound waves cannot travel.

Ans 02. Because propagation of longitudinal waves through a medium, involves changes in pressure and volume of air, when compressions and rarefactions are formed.

Ans 03. The two prongs of a tuning fork set each other is resonant vibrations and help to maintain the vibrations for a longer time.

Ans 04. Length of pipe = L = 20cm = 0.2m

Frequency of n^{th} node = υ_n = 430 Hz

Velocity of sound = v = 340m|s

Now, υ_n of closed pipe is :→

$$\upsilon_n = \frac{(2n-1)v}{4L}$$
$$430 = \frac{(2n-1)\times 340}{4\times 0.2}$$
$$2n-1 = \frac{430\times 4\times 0.2}{340}$$
$$2n-1 = 1.02$$
$$2n = 1.02+1$$
$$2n = 2.02$$
$$n = 1.01$$

Hence, it will be the first normal mode of vibration, In a pipe, open at both ends we, have

$$\upsilon_n = \frac{n\times v}{2L} = \frac{n\times 340}{2\times 0.2} = 430 \qquad So,\ 430 = \frac{n\times 340}{2\times 0.2}$$
$$n = \frac{430\times 2\times 0.2}{340} \qquad n = 0.5$$

As n has to be an integer, open organ pipe cannot be in resonance with the source.

Ans 05. No, because the emission of light is a random and rapid phenomenon and instead of beats we get uniform intensity.

Ans 06. Because as speed of sound in water is roughly four times the sound in air, hence refractive index u = $\frac{Sin\ \mathrm{i}}{Sin\ \mathrm{r}} = \frac{Va}{Vw} = \frac{1}{4} = 0.25$

For, refraction $r_{max} = 90^0$, $i_{max}=14^0$. Since $i_{max} \neq r_{max}$ hence, sounds gets reflected in air only and person deep inside the water cannot hear the sound.

Ans 07. Here, depth of well = S = 78.4m

Total time after which splash is heard = 4.23s

If t_1 = time taken by store to hit the water surface is the well

t_2 = time taken be splash of sound to reach the top of well.

then $t_1 + t_2 = 4.23$ sec.

Now, for downward journey of stone;

u = O, a = 9.8 m|s^2, S = 78.4m,

t = t1 = ?

As, s = ut + $\frac{1}{2}$ at^2

$$\therefore 78.4 = 0 + \frac{1}{2} \times 9.8 \times t_1^{\ 2}$$

$$78.4 = 4.9 t_1^{\ 2}$$

$$t_1^{\ 2} = \frac{78.4}{4.9}$$

$$t_1^{\ 2} = 16$$

$$t_1 = \sqrt{16} = 4\sec$$

$$Now, t1 + t2 = 4.23$$

$$4 + t_2 = 4.23$$

$$t_2 = 4.23 - 4.00$$

$$t_2 = 0.23s$$

If V = velocity of sound in air,

V = $\frac{dis\tan ce(s)}{time(t)} = \frac{78.4}{0.23} = 340.87 m \mid s.$

Ans 08. Roaring of a lion produces a sound of low pitch and high intensity whereas buzzing of mosquitoes produces a sound of high pitch and low intensity and hence the two sounds can be differentiated.

Ans 09. Let us consider two wares trains of equal amplitude 'a' and with different frequencies υ_1 and υ_2 in same direction.

Let displacements are y_1 and y_2 in time 't'.

w_1 = Angular vel. of first ware

$w_1 = 2\pi\upsilon_1$

$y_1 = a \ Sin \ w_1 \ t$

$y_1 = a \ Sin \ 2\pi\upsilon_1 \ t$

$y_2 = a \ Sin \ 2\pi\upsilon_2 \ t$

Acc. to superposition principle, the resultant displacement 'y' at the same time 't' is:-

y = y1 + y2

$y = a \left[Sin \ 2\pi\upsilon_1 t + Sin \ 2\pi\upsilon_2 t\right]$

Using $\text{Sin C} + \text{Sin D} = 2 \ \text{Cos} \ \frac{C-D}{2} \ \text{Sin} \ \frac{C+D}{2}$

We get,

$$y = 2a \ \cos \ \frac{2\pi(\upsilon_1 - \upsilon_2)t}{2} Sin \frac{2\pi(\upsilon_1 + \upsilon_2)t}{2}$$

$$y = 2a \ \text{Cos} \ \pi \ (\upsilon_1 - \upsilon_2)t \ \text{Sin} \ \pi(\upsilon_1 + \upsilon_2)t$$

$$\boxed{y = A \ \text{Sin} \ \pi(\upsilon_1 + \upsilon_2)t}$$

Where, A = 2a Cos $\pi(\upsilon_1 - \upsilon_2)t$.

Now, amplitude A is maximum when,

$Cos\pi(\upsilon_1 - \upsilon_2) + = \text{ma x} + \pm 1 = \text{Cos } k\pi$

$\pi(\upsilon_1 - \upsilon_2)t = k\pi,$ k=0,1,2--

$t = \frac{k}{(\upsilon_1 - \upsilon_2)}$

i.e resultant intensity of sound will be maximum at times, $t = 0, \frac{1}{(\upsilon_1 - \upsilon_2)}, \frac{3}{(\upsilon_1 - \upsilon_2)} - - - - -$

Time interval between 2 successive Maximaxs = $\dfrac{1}{(\upsilon_1-\upsilon_2)}-0=\dfrac{1}{(\upsilon_1-\upsilon_2)}\rightarrow(1)$

Similarly, A will be minimum,

$$\text{Cos}\ \pi\ (\upsilon_1-\upsilon_2)t=0$$

$$Cos\ \pi\ (\upsilon_1-\upsilon_2)t=Cos(2k+1)\frac{\pi}{2}, k=0,1,2,3-$$

$$\pi(\upsilon_1-\upsilon_2)t=(2k+1)\frac{\pi}{2}$$

$$t=\frac{(2k+1)}{2(\upsilon_1-\upsilon_2)}$$

i.e. resultant intensity of sound will be minimum at times

$$t=\frac{1}{2(\upsilon_1-\upsilon_2)},\frac{3}{2(\upsilon_1-\upsilon_2)},\frac{5}{2(\upsilon_1-\upsilon_2)}$$

Hence time interval between 2 successive minim as are

$$=\frac{3}{2(\upsilon_1-\upsilon_2)}-\frac{1}{2(\upsilon_1-\upsilon_2)}=\frac{1}{(\upsilon_1-\upsilon_2)}\rightarrow(2)$$

Combining 1) & 2) frequency of beats = $(\upsilon_1-\upsilon_2)$

$$\therefore \frac{No.\text{ of beats}}{\text{sec}\,onds}=\text{Difference in frequencies of two sources of sound.}$$

Ans 10. The following are the two cases in which there is no Doppler effect in sound (i.e no change in frequency):-

1) When the source of sound as well as the listener moves in the same direction with the same speed.

2) When one of source | listener is at the centre of the circle and the other is moving on the circle with uniform speed.

Ans 11. Let l_1, l_2 and l_3 be the length of the three parts of the wire and f_1, f_2 and f_3 be their respective frequencies.

Since T and m are fixed quantities, and 2 are constant

$$f=\frac{1}{2l}\sqrt{\frac{T}{m}}$$

$$f = \alpha\frac{1}{l}$$

$$or\ \mathrm{f}_1 = \text{constant}$$

So, $f_1\, l_1$ = Constant →(1)

$f_2\, l_2$ = Constant →(2)

$f_3\, l_3$ = Constant →(3)

Equating equation 1), 2) & 3)

$f_1\, l_1 = f_2\, l_2 = f_3\, l_3$

Now, $l_2 = \frac{f_1}{f_2} l_1$

$$l_2 = \frac{1}{2} l_1 \rightarrow (4)\left(\frac{f_1}{f_2} = \frac{1}{2}\right) Given$$

Also, $l_3 = \frac{f_1}{f_3} l_1$

$$l_3 = \frac{1}{3} l_1 \ \left(\frac{f_1}{f_3} = \frac{1}{3}(given)\right)$$

Now, Total length = 110cm

i.e $l_1 + l_2 + l_3 = 110$cm

$$l_1 + \frac{1}{2} l_1 + \frac{1}{3} l_1 = 110$$

$$\frac{11 l_1}{6} = 110$$

$$l_1 = \frac{\cancel{110}^{10} \times 6}{\cancel{11}} = 60cm$$

i. e. $\boxed{l_1 = 60\text{cm}}$

$$l_2 = \frac{l_1}{2}$$

$$l_2 = \frac{60}{2} \quad \boxed{l_2 = 30cm}$$

Now,

$$l_3 = \frac{l_1}{3} \qquad l_3 = \frac{60}{3} \qquad \boxed{l_3 = 20cm}$$

CBSE TEST PAPER-04
CLASS - XI PHYSICS (Oscillations and Waves)
Topic: - Oscillations

1. What is the relation between uniform circular motion and S.H.N? [1]

2. What is the minimum condition for a system to execute S.H.N? [1]

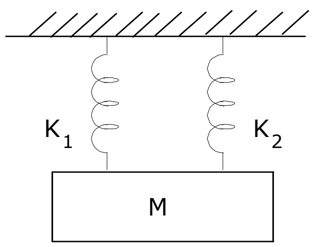
3. A particle executing S.H.N. along a straight line has a velocity of um/s when its displacement from mean position is 3 m and 3 m / s when displacement is 4m. Find the time taken to travel 2.5 m from the positive extremity of its oscillation? [2]

4. Springs is spring constant K, 2K, 4K, K ----- are connected in series. A mass M Kg is attached to the lower end of the last spring and system is allowed to vibrate. What is the time period of oscillation? [2]

5. A particle is moving with SHN in a straight line. When the distance of the particle from mean position has values x1 and x2 the corresponding values of velocities are v1 and v2. Show that the time period of oscillation is given by:→ [2]

$$T = 2\pi\left[\frac{x_2^{\,2} - x_1^{\,2}}{v_1^{\,2} - v_2^{\,2}}\right]^{1/2}$$

6. A mass = m suspend separately from two springs of spring constant k_1 and k_2 gives time period t_1 and t_2 respectively. If the same mass is connected to both the springs as shown in figure. Calculate the time period 't' of the combined system? [2]



7. Show that the total energy of a body executing SHN is independent of time? [3]

8. A particles moves such that its acceleration 'a' is given by a = -b x where x = displacement from equilibrium position and b is a constant. Find the period of oscillation? [2]

9. A particle is S.H.N. is described by the displacement function: → [2]

$$x = \text{A Cos }(wt + \Phi); w = \frac{2\pi}{T}$$

If the initial (t = 0) position of the particle is 1 cm and its initial velocity is π cm | s, What are its amplitude and phase angle?

10. Determine the time period of a simple pendulum of length = l when mass of bob = m Kg? [3]

CBSE TEST PAPER-04
CLASS - XI PHYSICS (Oscillations and Waves)
Topic: - Oscillations [ANSWERS]

Ans 01. Uniform form circular motion can be thought of as two simple harmonic motion operating at right angle to each other.

Ans 02. The minimum condition for a body to posses S.H.N. is that it must have elasticity and inertia.

Ans 03. Velocity = v_1 = u m/s

then, displacement = 3m let y_1 = displacement = 3m

$$Now,\ v^2 = w^2 \left(a^2 - y^2\right)$$

For first Case: $\rightarrow$

$$v_1^2 = w^2 \left(a^2 - y_1^2\right)$$

Putting the value of v_1 & y_1

$$16 = w^2\left(a^2 - 9\right) \rightarrow i)$$

For second case, $v_2 = 3m/s$ and y_2 = displacement = 4m

$$So, v_2^2 = w^2\left(a^2 - y_2^2\right)$$

$$9 = w^2\left(a^2 - 16\right) \rightarrow 2)$$

Dividing eq^4 1) by 2)

$$\frac{16}{9} = \frac{\cancel{w^2}\left(a^2 - 9\right)}{\cancel{w^2}\left(a^2 - 16\right)}$$

$$16\left(a^2 - 16\right) = 9\left(a^2 - 9\right)$$

$$16\ a^2 - 256 = 9\ a^2 - 81$$

$$16a^2 - 9a^2 = 81 + 256$$

$$7a^2 = 175$$

$$a^2 = \frac{175}{7}$$

$$a = \sqrt{\frac{175}{7}}$$

$$a = \sqrt{25}$$

$$a = 5m$$

$Now, v_1^2 = w^2\left(a_2 - y_1^2\right)$

$So, 16 = w^2(25-9)$

$16 = w^2\ 16$

$w^2 = 1$

w = 1 rad/s.

When the particle is 2.5m from the positive extreme position, its displacement from the mean position, y = 5 – 2.5 = 2.5m. Since the time is measured when the particle is at extreme position:→

$y = a$ Cos wt

2.5 = 5 Cos $(1\times t)$

Cos t = $\dfrac{2.5}{5\times 10}$

Cos t = $\dfrac{25}{50}$

Cos t = $\dfrac{1}{2}$

Cos t = $\dfrac{Cos\pi}{3}$

$t = \dfrac{\pi}{3}$

$t = \dfrac{3.14}{3}$

$t = 1.047s$

Ans 04. For effective resistance of spring of individual spring constant k_1, k_2, ------ k_n

$$\frac{1}{k} = \frac{1}{k_1} + \frac{1}{k_2} + ---\frac{1}{k_{3n}}$$

$Now,$ k_1=k; k_2=2k; k_3=4k; ------

$$\frac{1}{k_{eff}} = \frac{1}{k} + \frac{1}{2k} + \frac{1}{4k} + \frac{1}{8k} + ----$$

$$\frac{1}{k_{eff}} = \frac{1}{k}\left[1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + ----\right]$$

$\because$ Sum of in finite G.P. = $\dfrac{a}{1-r}$

$$\frac{1}{k_{eff}} = \frac{1}{k}\left[\frac{1}{1-\frac{1}{2}}\right]$$

$a = First$ Term

r=Common on Ratio

$$\frac{1}{k_{eff}} = \frac{1}{k}\left[\frac{1}{\frac{1}{2}}\right]$$

$$\frac{1}{k_{eff}} = \frac{2}{k}$$

$$k_{eff} = \frac{k}{2}$$

Since Time Perion, $T = 2\pi\sqrt{\frac{M}{k_{eff}}}$

$$T = 2\pi\sqrt{\frac{M}{\frac{k}{2}}} \qquad \boxed{T = 2\pi\sqrt{\frac{2M}{k}}}$$

Ans 05. If a = amplitude ; y = displacement; w = angular frequency

V = Velocity, then

$V^2 = w^2 (a^2 - y^2)$

For first case. $u_1^2 = w^2(a^2 - x_1^2) \rightarrow 1)$ ($\because$ velocity = u_1 Displacement = x_1)

For second case, $u_2^2 = w^2 (a^2 - x_2^2) \rightarrow 2)$ (velocity = u_2 Displacement = x_2)

Subtracting equation 2) from equation 1);

$$u_1^2 - u_2^2 = w^2\left(a^2 - x_1^2\right) - w^2\left(a^2 - x_2^2\right)$$

$$u_1^2 - u_2^2 = w^2a^2 - w^2x_1^2 - w^2a^2 + w^2x_2^2$$

$$u_1^2 - u_2^2 = w^2\left(x_2^2 - x_1^2\right)$$

$$Now,\ w^2 = \frac{u_1^2 - u_2^2}{x_2^2 - x_1^2}$$

$$So,\ w = \left[\frac{u_1^2 - u_2^2}{x_2^2 - x_1^2}\right]^{1/2}$$

$$So,\ \text{Time period, } T = \frac{2\pi}{w} = 2\pi\left[\frac{x_2^2 - x_1^2}{u_1^2 - u_2^2}\right]^{1/2}$$

Ans 06. If T = Time Period of simple pendulum

m = Mass

k = Spring constant

then, $T = 2\pi\sqrt{\frac{m}{k}}$

or k = $\frac{4\pi^2 m}{T^2}$

For first spring : $\rightarrow$ $k_1 = \frac{4\pi^2 m}{t_1^2}$ let T = t_1

For second spring : $\rightarrow k_2 = \frac{4\pi^2 m}{t_2^2}$ let T = t_2

When springs is connected in parallel, effective spring constant, k = k = $k_1 + k_2$

or k = $\frac{4\pi^2 m}{t_1^2} + \frac{4\pi^2 m}{t_2^2}$

If t = total time period

$$\frac{4\pi^2 m}{t^2} = \frac{4\pi^2 m}{t_1^2} + \frac{4\pi^2 m}{t_2^2}$$

$$\frac{1}{t^2} = \frac{1}{t_1^2} + \frac{1}{t_2^2}$$

Or $\boxed{t^{-2} = t_1^{-2} + t_2^{-2}}$

Ans 07. Let y = displacement at any time't'

a = amplitude

w = Angular frequency

v = velocity,

y = a Sin wt

So, $v = \frac{dy}{dt} = \frac{d}{dt}$ (a Sin wt)

v = a w Cos wt

Now, kinetic energy = K. E. = $\frac{1}{2} m \text{ v}^2$

$$K.E. = \frac{1}{2} \text{ m w}^2\text{a}^2 \text{ Cos}^2 \text{ wt} \rightarrow 1)$$

Potential energy = $\frac{1}{2} ky^2$

$P.E. = \frac{1}{2}ka^2 \text{ Sin}^2 \text{ wt } \rightarrow 2)$

Adding equation 1) & 2)

Total energy = K.E.+ P.E

$$= \frac{1}{2}mw^2a^2 \text{ Cos}^2 \text{ wt} + \frac{1}{2} \text{ ka}^2 \text{ Sin}^2 \text{ wt}$$

Since $\text{w} = \sqrt{\frac{k}{m}} \Rightarrow \text{w}^2\text{m} = \text{k}$

$$\text{Total energy} = \frac{1}{2}mw^2a^2Cos^2wt + \frac{1}{2}ka^2Sin^2wt$$

$$= \frac{1}{2}ka^2 \text{ Cos}^2 \text{ wt} + \frac{1}{2} \text{ ka}^2 \text{ Sin}_2 \text{ wt}$$

$$= \frac{1}{2}\text{ka}^2 \left(Cos^2 \text{ wt+Sin}^2 \text{ wt}\right)$$

$$\text{Total energy} = \frac{1}{2}ka^2$$

Thus total mechanical energy is always constant is equal to $\frac{1}{2}ka^2$. The total energy is independent to time. The potential energy oscillates with time and has a maximum value of $\frac{ka^2}{2}$. Similarly K. E. oscillates with time and has a maximum value of $\frac{ka^2}{2}$. At any instant = constant = $\frac{ka^2}{2}$. The K. E or P.E. oscillates at double the frequency of S.H.M.

Ans 08. Given that a = -b x, Since a $\propto$ x and is directed apposite to x, the particle do moves in S. H. M.

a = b x (in magnitude)

$$or \ \frac{x}{a} = \frac{1}{b}$$

$$\text{or } \frac{Displacement}{Accleration} = \frac{1}{b} \rightarrow 1)$$

$$\text{Time period} = \text{T} = 2\pi\sqrt{\frac{Displacement}{Accleration}}$$

Using equation 1)

$$\boxed{T = 2\pi\sqrt{\frac{1}{b}}}$$

Ans 09. At t = 0; x = 1cm; w = π|s

t = time

x = Postition

w = Argular frequency

$\therefore$ x = A Cos (Wt + ϕ)

1 = A Cos ($\pi \times 0 + \phi$)

1 = A Cos ϕ

$$Now, v = \frac{dx}{dt} = \frac{d}{dt}\left(\text{A Cos (wt+}\phi\text{)}\right)$$

At t = 0 v = π cm|s; w = π|s

$\cancel{\pi}$ = -A$\cancel{\pi}$ Sin ($\pi \times 0 + \phi$)

$\Rightarrow$ -1 = A Sin ϕ $\rightarrow$ 2)

Squaring and adding 1) & 2)

$A2 \text{ Cos}^2\ \phi + \text{A2 Sin}^2\phi = 1+1$

$\text{A2}\left(Cos^2\phi + Sin^2\phi\right) = 2$

$A^2 = 2$

$$\boxed{A = \sqrt{2}cm}$$

Dividing 2) by 1), we have :-

$$\frac{\cancel{A}\text{ Sin }\phi}{\cancel{A}\text{ Cos }\phi} = -1$$

$\tan\phi = -1$

$or\ \ \phi \equiv \tan^{-1}(-1)$

$$\boxed{\phi = \frac{3\pi}{4}}$$

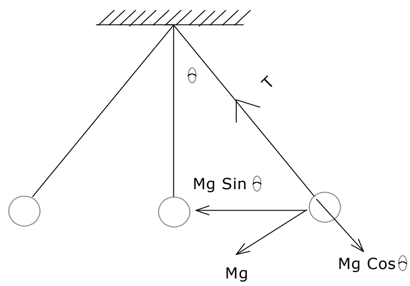
Ans 10. It consist of a heavy point mass body suspended by a weightless inextensible and perfectly flexible string from a rigid support which is free to oscillate.

The distance between point of suspension and point of oscillation is effective length of pendulum.

M = Mass of B ob

x = Displacement = OB

l = length of simple pendulum



Let the bob is displaced through a small angle θ the forces acting on it:-

1) weight = Mg acting vertically downwards.

2) Tension = T acting upwards.

Divide Mg into its components → Mg Cos θ & Mg Sin θ

T = Mg Cos θ

F = Mg Sin θ

- ve sign shows force is divested towards the ocean positions. If θ = Small,

$$\text{Sin } \theta \cong \theta = \frac{Arc\ \text{OB}}{l} = \frac{x}{l}$$

$$F = -Mg\frac{x}{l}$$

In S.H.M., vestoring fore, F = -mg θ F = -mg $\frac{x}{l} \rightarrow 1)$

Also, if k = spring constant

F = - k x

$$\cancel{-}\text{mg } \frac{\cancel{x}}{l} = \cancel{-}k\,\cancel{x}\left(\text{equating F = - mg } \frac{x}{l}\right)$$

$$k = \frac{mg}{l}$$

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$= 2\pi\sqrt{\frac{\cancel{m} \times l}{\cancel{m}g}} \qquad \boxed{T = 2\pi\sqrt{\frac{l}{g}}}$$

i.e.

1.) Time period depends on length of pendulum and ‘g’ of place where experiment is done.

2) T is independent of amplitude of vibration provided and it is small and also of the mass of bob.

CBSE TEST PAPER-05

CLASS - XI PHYSICS (Oscillations and Waves)

Topic: - Waves

1. Velocity of sound increases on a cloudy day. Why? [1]

2. Sound of maximum intensity is heard successively at an interval of 0.2 second on sounding two tuning fork to gather. What is the difference of frequencies of two tuning forks? [1]

3. If two sound waves has a phase difference of 60^0, then find out the path difference between the two waves? [1]

4. If string wires of same material of length l and 2l vibrate with frequencies 100HZ and 150 HZ. Find the ratio of their frequencies? [2]

5. Two similar sonometer wires of the same material produces 2 beats per second. The length of one is 50cm and that of the other is 50.1 cm. Calculate the frequencies of two wives? [2]

6. Why are all stringed instruments provided with hollow boxes? [2]

7. Two waves have equations:- [2]

   $X_1 = a \text{ Sin } (wt + \phi_1)$ $\qquad$ $X_2 = a \text{ Sin } (wt + \phi_2)$

   If in the resultant wave, the amplitude remains equal to the amplitude of the super posing waves. Calculate the phase difference between X_1 and X_2?

8. A Tuning fork of frequency 300HZ resonates with an air column closed at one end at 27^0C. How many beats will be heard in the vibration of the fork and the air column at 0^0C? [2]

9. A vehicle with horn of frequency 'n' is moving with a velocity of 30m|s in a direction perpendicular to the straight line joining the observer and the vehicle. If the observer perceives the sound to have a frequency of $n+n_1$. Calculate n_1? [2]

10. We cannot hear echo in a room. Explain? [2]

11. Show that the frequency of nth harmonic mode in a vibrating string which is closed at both the end is 'n' times the frequency of the first harmonic mode? [3]

CBSE TEST PAPER-05
CLASS - XI PHYSICS (Oscillations and Waves)
Topic: - Waves [ANSWERS]

Ans 01. Since on a cloudy day, the air is wet i.e. it contains a lot of moisture, As a result of which the density of air is less and since velocity is inversely proportioned to density, hence velocity increases.

Ans 02. The beat period is 0.2 second so that the beat frequency is fb = $\frac{1}{0.2}$ = 5HZ.

Therefore, the difference of frequencies of the two tuning forks is 5HZ.

Ans 03. Phase difference, $\Phi = 60^0 = \frac{\pi}{3}$ rad

Now, in general for any phase difference, (Φ), the path difference (x) :→

$$\phi = \frac{2\pi}{\pi} x$$

$$Given\ \phi = \frac{\pi}{3}, x = ?$$

$$\frac{\pi}{3} = \frac{2\pi}{\pi} \times x$$

$$x = \frac{\pi}{3} \div \frac{2\pi}{\pi}$$

$$x = \frac{\cancel{\pi}}{3} \times \frac{\pi}{2\cancel{\pi}}$$

$$\boxed{x = \frac{\pi m}{6}}$$

Ans 04. Since frequency = f of a vibrating string of mass and Tension = T is given by:→ l = length

$$f = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

Let for first case, f_1 = 100HZ ; l_1 = l ; T_1 = Initial Tension

For second case, f_2 = 150HZ ; l_2 = 2l ; T_2 = Final Tension

So, $f_1 = \frac{1}{2l_1}\sqrt{\frac{T_1}{m}}$

$$f_1 = \frac{1}{2l}\sqrt{\frac{T_1}{m}}$$

$$100 = \frac{1}{2l}\sqrt{\frac{T_1}{m}} \rightarrow (1)$$

$$and\ f_2 = \frac{1}{2l_2}\sqrt{\frac{T_2}{m}}$$

$$150 = \frac{1}{2_1 l}\sqrt{\frac{T_2}{m}} \rightarrow (2)$$

Divide equation 1) by equation 2)

$$\frac{100}{150} = \frac{\frac{1}{2l}\sqrt{\frac{T_1}{m}}}{\frac{1}{4l}\sqrt{\frac{T2}{m}}}$$

$$\frac{10\cancel{0}}{15\cancel{0}} = \frac{1}{{}_1\cancel{2}\cancel{l}}\sqrt{\frac{T1\times\cancel{m}\times\cancel{4}^{2}\,\cancel{l}}{\cancel{m}\times T_2}}$$

$$\frac{\cancel{10}\ 2}{\cancel{15}\ 3} = 2\sqrt{\frac{T_1}{T_2}}$$

$$\frac{2}{3} = 2\sqrt{\frac{T_1}{T_2}}$$

$$\frac{\cancel{2}}{3\times\cancel{2}} = \sqrt{\frac{T_1}{T_2}}$$

$$\frac{1}{3} = \sqrt{\frac{T_1}{T_2}} \rightarrow Squaring \text{ both sides}$$

$$\text{or } \frac{1}{9} = \frac{T_1}{T_2}$$

Hence, the ratio of tensions is $\boxed{1:9}$

Ans 05. The frequency (f) of a son meter wire of length = l, mass = m and lesion = T is given by

$$f = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

$$Let\ \text{k} = \frac{1}{2}\sqrt{\frac{T}{m}}$$

$so,\ f = \frac{k}{l}$

In first case; $f_1 = \frac{k}{l_1} \rightarrow 1)$ and $f2 = \frac{k}{l_2} \rightarrow 2)$

Subtract equation 1) & 2)

$f_1 - f_2 = \frac{k}{l_1} - \frac{k}{l_2} = k\left(\frac{1}{l_1} - \frac{1}{l_2}\right)$

Now, given $l_1 = 50cm$; $l_2 = 50.1cm$

$f_1 - f_2 = 2$

so, $2 = k\left[\frac{1}{50} - \frac{1}{50.1}\right]$

$$2 = k\left[\frac{50.1 - 50}{50 \times 50.1}\right]$$

$$2 = K\left[\frac{0.1}{2505.0}\right]$$

$$\frac{2 \times 2505}{0.1} = k$$

$$\frac{5010 \times 10}{01.1} = k$$

$$\boxed{50100 = k}$$

$$so,\ f_1 = \frac{k}{l_1} = \frac{5010\cancel{0}}{5\cancel{0}} = 1002HZ$$

$$f_2 = \frac{k}{l_2} = \frac{\cancel{5}\cancel{0}\cancel{1}\cancel{0}\cancel{0}\ ^{100} \times 10}{\cancel{5}\cancel{0}\cancel{1}\ 1} = 1002HZ$$

Ans 06. The stringed instruments are provided with a hollow box called sound box. When the strings are set into vibration, forced vibrations are produced in the sound box. Since sound box has a large area, it sets a large volume of air into vibration. This produces a loud sound of the same frequency of that of the string.

Ans 07. Given, the first wave:→ $X_1 = a \text{ Sin } (wt + \phi_1)$

The second : $\rightarrow X_2 = a \text{ Sin } (wt + \phi_2)$ wave

Where X_1 = wave function first wave

X_2 = wave function in second wave

a = amplitude

w = Angular frequency

t = time

ϕ_1 = phase difference of first wave

ϕ_2= phase difference of second wave.

Let The resultant amplitude = 'a' and phase difference

$= \phi$ so,

a = $\sqrt{a_1^{\ 2} + a_2^{\ 2} + 2a, a2Cos\phi}$

a_1 = amplitude of first wave

a_2 = amplitude of second wave

ϕ = phase difference between two waves.

Now, in our case,

$$a1 = a$$

$$a2 = a$$

$$so, a = \sqrt{a^2 + a^2 + 2a \times aCos\phi}$$

$$a = \sqrt{2a^2 + 2a^2Cos\phi}$$

$$a = \sqrt{2a^2(1 + Cos\phi)}$$

$$a = \sqrt{2a^2 \times 2Cos\frac{\phi}{2}} \qquad \left(\because 1 + Cos\theta = 2Cos\frac{\theta}{2}\right)$$

$$a = \sqrt{4a^2Cos\frac{\phi}{2}}$$

$$\boxed{a = 2aCos\frac{\theta}{2}}$$

$$\cancel{a} = 2\cancel{a}Cos\frac{\phi}{2}$$

$$\frac{1}{2} = Cos\frac{\phi}{2}$$

$$\frac{\Phi}{2} = Cos^{-1}\left(\frac{1}{2}\right) = \cancel{2} \times 6\cancel{0}^0\ \frac{\phi}{2} = 60^0$$

$$\phi = 2 \times 60^0$$

$$\boxed{\Phi = 120^0}$$

So, the phase difference between X_1 and X_2 is 120^0.

Ans 08. According to the question,

Frequency of air column at 27^0C is 300 HZ

Let l = length of air column and speed of sound = V_{27}

For a pipe; closed at one end, the frequency of n^{th} harmonic is:→

$$fn = n\left(\frac{v}{4l}\right)$$

n = 1, 3, 5, 7 --------

l = length of air column

v = velocity

So, Let at 0^0C, the speed of sound = v_o then,

$$f_1 = n_1\left(\frac{v_1}{4l}\right) and\ f_2 = n_2\left(\frac{v_2}{4l}\right)$$

f_1 = frequency at 27^0C = 300HZ

f_2 = frequency at 0^0C = ?

So, $f_1 = \frac{V_{27}}{4l}$

$$300 = \frac{V_{27}}{4l} \rightarrow 1)$$

$$f_2 = \frac{Vo}{4l} \rightarrow 2)$$

$$Now, \frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\frac{V_{27}}{Vo} \sqrt{\frac{(27+273)k}{(273)k}}$$

$$\frac{V_{27}}{Vo} = \sqrt{\frac{300}{273}}$$

$$\frac{V_{27}}{Vo} = \cancel{0.954}\sqrt{\frac{300}{273}}$$

$$or \frac{Vo}{V_{27}} = \sqrt{\frac{273}{300}}$$

$$\frac{Vo}{V_{27}} = 0.954$$

$$\boxed{Vo = (0.954)\ V_{27}}$$

$\therefore$ frequency of air column at 0^0C is :$\rightarrow$

$$f_2 = \frac{Vo}{4l}(equation\ 2)$$

Using Vo = (0.954) v_{27} We get

$$f_2 = \frac{(0.954)V_{27}}{4l}$$

$$Now, \frac{V_{27}}{4l} = 330(equation\ \ A)$$

$$f_2 = 0.954 \times 330 = 286HZ$$

The frequency of tuning fork remains 300HZ Number of beats = $f_1 - f_2$

= 300-286 = 14 Per second

Ans 09. By Doppler effect, the apparent change in frequency of wave due to the relative motion between the source of waves and observer.

If v_2 = velocity of the listener

v_s = velocity of the source

v = velocity of sound

γ = frequency of sound reaching from the source to the listener.

γ^1 = Apparent frequency (i.e. Changed frequency due to movement of source and listener)

$$\gamma^1 = \left(\frac{V - V_2}{V - V_S}\right) \times \gamma$$

But in our case, the source and observer move at right angles to each other. The Doppler Effect is not observed when the source of the sound and the observer are moving at right argyles to each other.

So, if n = original frequency of sound the observer will perceive the sound with a frequency of n (because of no Doppler effect). Hence the n_1 = charge frequency = 0.

Ans 10. We know that, the basic condition for an echo to be heard is that the obstacle should be rigid and of large size. Also the obstacle should be at least at a distance of 17m from the source. Since the length of the room is generally less than 17m, the conditions for the production of Echo are not satisfied. Hence no echo is heard in a room.

Ans 11. When a sting under tension is set into vibration, transverse harmonic wares propagate along its length when length of sting is fixed, reflected waves will also exist. The incident and reflected waves will superimpose on each short to produce transverse stationary waves in sting. Let a harmonic wave be set up in a sting of length = λ which is fixed at 2 ends: → x = 0 and x = L

Let the incident wave travels from left to right direction, the wave equation is:→

$$y_1 = r \text{ Sin } \frac{2\pi}{\pi}(Vt + x) \rightarrow 1)$$

The wave equation of reflected wave, will have the same amplitude, wavelength, velocity, time but the only difference between the incident and reflected waves will be in their direction of propagation So, :→

$$y_2 = r \text{ Sin } \frac{2\pi}{\pi}(vt - x)$$

$\because$ Reflected wave tracels from rght to left

Reflection, the wave will suffer a phase change of π. So,

$$y2 = r \text{ Sin } \frac{2\pi}{\pi}[vt - x + \pi]$$

$$y2 = -r \text{ Sin } \frac{2\pi}{\pi}[vt - x] \rightarrow (2)$$

According to the principle of superposition, the wave equation of resultant stationary wave will be:-

$$y = y_1 + y_2$$

Using equation 1) & 2)

$$\text{y=r Sin } \frac{2\pi}{\lambda}[vt + x] - rSin\frac{2\pi}{\lambda}(vt - x)$$

$$= r\left[Sin\frac{2\pi}{\lambda}(vt + x) - Sin\frac{2\pi}{\lambda}(vt - x)\right]$$

Using Sin C - Sin D = 2 Cos $\frac{C+D}{Z}.Sin\frac{C-D}{Z}$

$$y = r \times 2\ Cos\left[\frac{\frac{2\pi}{\lambda}(vt + x) + \frac{2\pi}{\lambda}(vt - x)}{2}\right]$$

$$Sin\left[\frac{\frac{2\pi}{\lambda}(vt+x)-\frac{2\pi}{\lambda}(vt-x)}{2}\right]$$

$$y=2r\ Cos\left(\frac{\frac{2\pi}{\lambda}vt+\frac{2\pi}{\cancel{\lambda}}\cancel{x}+\frac{2\pi}{\lambda}vt-\frac{2\pi}{\cancel{\lambda}}\cancel{x}}{2}\right)$$

$$\text{Sin}\left(\frac{\frac{\cancel{2\pi}}{\cancel{\lambda}}\cancel{vt}+\frac{2\pi}{\lambda}x-\frac{\cancel{2\pi}}{\cancel{\lambda}}\cancel{vt}+\frac{2\pi}{\lambda}x}{2}\right)$$

$$y=2r\ \text{Cos}\ \frac{2\pi}{\lambda}\left(\frac{\cancel{2}vt}{\cancel{2}}\right).\ \text{Sin}\ \frac{2\pi}{\lambda}\left(\frac{\cancel{2}x}{\cancel{2}}\right)$$

$$\boxed{y=2r\ \text{Cos}\ \frac{2\pi}{\lambda}vt.\ \text{Sin}\ \frac{2\pi x}{\lambda}}$$

$Now, at\ x=0\ \&\ x=L; y=0$

1) $At\ x=0, y=0\ is\ satisfied$

2) At x = L, y= 0

y=2 r Cos $\left(\frac{2\pi}{\lambda}vt\right).Sin\left(\frac{2\pi}{\lambda}\times L\right)$

o = 2r Cos $\left(\frac{2\pi}{\lambda}vt\right).Sin\left(\frac{2\pi}{\lambda}\times L\right)$

$Now, r\neq o, \frac{2\pi}{\lambda}vt\neq o$ so,

$$o=Sin\left(\frac{2\pi L}{\lambda}\right)$$

$$\cancel{S}in\ n\cancel{\pi}=\cancel{S}in\ \frac{2\cancel{\pi}2}{\lambda}$$

$i.e$ L = n $\left(\frac{x}{2}\right)$

1) Let n = 1 (i.e first harmonic mode or fundamental frequency

$\lambda=\lambda_1$

$L=\frac{\lambda_1}{2}$ $\boxed{\lambda_1=2L}$

Let v = velocity, γ_1 = frequency of first hamonic Mode

v = $\gamma_1\ \lambda_1$

v= $\gamma_1 \times 2L$ $\boxed{\frac{v}{2L} = \gamma_1}$

If n = 2 (second harmonic Mode or first overtone)

$$\boxed{L = \lambda 2}$$

$v = velocity, \gamma_2 =$ $f$erq4 of second harmoic Mode

v = $\gamma_2 \lambda_2$

$$\gamma_2 = \frac{v}{\lambda_2} = \frac{v}{2}$$

$$\gamma 2 = \frac{v \times 2}{L \times 2} \qquad \left(\because \frac{v}{2L} = \gamma_1\right)$$

$$\boxed{\gamma_2 = 2\gamma_1}$$

i.e frequency of second harmonic Mode is twice the frequency of first harmonic Mode Similarly, $\gamma n = n\gamma_1$ and frequency of nth harmonic Mode is n times the frequency of first harmonic Mode.

CBSE TEST PAPER-06
CLASS - XI PHYSICS (Oscillations and Waves)
Topic: - Waves

1. If the displacement of two waves at a point is given by:- [1]

$$Y_1 = a \sin wt$$

$$Y_2 = a \sin\left(wt + \frac{\pi}{2}\right)$$

Calculate the resultant amplitude?

2. Why do the stages of large auditoriums gave curved backs? [2]

3. Show that Doppler effect in sound is asymmetric? [2]

4. An organ pipe P_1 closed at one end vibrating in its first overtone and another pipe P_2 open at both the ends vibrating in its third overtone are in resonance with a given tuning fork. Find the ratio of length of P_1 and P_2? [2]

5. A simple Romanic wave has the equation [2]

$Y = 0.30 \text{ Sin } (314\ t - 1.57x)$

t = sec, x = meters, y = cm. Find the frequency and wavelength of this wave.

Another wave has the equation-

$Y_1 = 0.1 \text{ Sin } (314\ t - 1.57x + 1.57)$

Deduce the phase difference and ratio of intensities of the above two waves?

6. Two parts of a Sonometer wire divided by a movable knife differ by 2 mm and produce one beat per record when sounded together. Find their frequencies if the whole length of the wire is 1 meter? [2]

7. The component waves producing a stationary wave have amplitude, Frequency and velocity of 8 cm, 30HZ and 180 cm/s respected. Write the equation of the stationary wave? [2]

8. A wine of density a g/cm^3 is stretched between two clamps 1 m apart while subjected to an extension of 0.05 cm. What is the lowest frequency of transverse vibration in the wire? Let young's Modulus = y = 9×10^{10} N/m^2? [2]

9. Differentiate between the types of vibration in closed and open organ pipes? [3]

CBSE TEST PAPER-06

CLASS - XI PHYSICS (Oscillations and Waves)

Topic: - Waves

Ans 01. If a_1 = amplitude of first wave

a_2 = amplitude of second wave

a_r = resultant amplitude

ϕ = phase difference between 2 waves

then $a_r = \sqrt{a_1^2 + a_2^2 + 2a_1a_2 \cos\phi}$

In our case $a_1 = a$; $a_2 = a$; $\phi = \frac{\pi}{2}$ so

$$a_r = \sqrt{a^2 + a^2 + 2a \times a \operatorname{Cos}\left(\frac{\pi}{2}\right)}$$

$= \sqrt{2a^2}$ $\quad \left(\because \operatorname{Cos}\left(\frac{\pi}{2}\right) = 0\right)$ $\quad \boxed{a_r = \sqrt{2}\ a}$

Ans 02. The stages of large auditorium have curved backs because when speaker stands at or near the focus of curved surface his voice is rendered parallel after reflection from the concave or parabolic seer face. Hence the voice can be heard at larger distances.

Ans 03. The apparent frequency of sound when source is approaching the stationary listener (with velocity v^1) is not the same as the apparent frequency of sound when the listener is approaching the stationary source with a velocity v^1. This shows that Doppler Effect in sound is asymmetric.

Apparent frequency = $f^1 = \frac{V}{V - us} \times f$

This is when source approaches station any listener

V = Velocity of sound in air

u_s = Velocity of sound source = V_1

f^1 = Apparent frequency

f = Original frequency of sound

Apparent frequency $f'' = \frac{V + uo}{V} \times f$

→ This is when listener approaching stationary source $f'' = \frac{V + V^1}{V} \times f$

Since $f' = f''$ (Hence Doppler effect is asymmetric)

Ans 04. Length of pipe closed at one end for first overtone, $l_1 = \frac{3\pi}{4}$

Length of pipe closed at both ends for third overtone; $l_2 = \frac{3\pi}{4}$

π= wavelength

$$l_2 = \frac{4\pi}{2} = 2\pi \qquad \therefore \frac{l_1}{l_2} = \frac{\frac{3\pi}{4}}{2\pi} = \frac{3\pi}{4\times 2\pi} = \frac{3}{8} \qquad \boxed{l_1 : l_2 = 3:8}$$

Ans 5. If y is in meters, then equation becomes:→

$$y = \frac{0.30}{100} Sin\left(314\text{ t-1.57x}\right) \rightarrow (1)$$

The standard equation of plane progressive wave is

$$y = a\ \text{Sin}\ \left(wt - k\ \text{x}\right)\ \rightarrow (2)$$

Comparing equation 1) & 2)

$$w = 314, k1.57;\ \text{a=}\frac{0.30}{100} = 3\times10^{-3}m$$

$$\therefore\ \text{frequency = f=}\frac{w}{2\pi} = \frac{314}{2\pi} = 50HZ$$

$$\text{wave velocity, v = }\frac{w}{k} = \frac{314}{1.57} = 200m/s$$

$$\therefore wa\text{velenght = }\pi\text{=r}\frac{v}{f} = \frac{200}{50} = 4m$$

On inspection of the equations of the given two waves,

Phase difference,

$$\Delta\phi = 1.57\ \text{rad}$$

$$= 1.57\times\left(\frac{180}{\pi}\right) = 90^0$$

$$\text{Ratio of amplitudes of two waves = }\frac{a_1}{a_2} = \frac{0.3}{0.1} = 3$$

$$\therefore\ \text{Ratio of intensities = }\frac{\text{I}_1}{\text{I}_2} = \frac{a_1^{\ 2}}{a_2^{\ 2}} = \left(\frac{3}{1}\right)^2 = \frac{9}{1}$$

Ans 06. Let l_1 = length of first part of sonometer

l_2 = length of second part of sonometer

f_1 = frequency of first part

f_2 = frequency of second part

Given

$$l_1 + l_2 = 100cm \text{ and } l_1 - l_2 = 0.2cm$$

on Adding

$$l_1 + \cancel{l_2} = 100$$

$$l_1 - \cancel{l_2} = 0.2$$

$$2l_1 = 100.2$$

$$l_1 = \frac{100.0}{2} = 50.1cm$$

$$so,\ l_2 = 49.9cm$$

Ans 07. Since the ware equation of a travelling wave:- $y = a \sin 2\pi\left(\frac{t}{T} - \frac{x}{\pi}\right)$

a = Amplitude

t = time

T = Time Period

x = Path difference

π = wavelength

Let $y_1 = a \operatorname{Sin} 2\pi\left(\frac{t}{T} - \frac{x}{\pi}\right)$

$Y_2 = a \operatorname{Sin} 2\pi\left(\frac{t}{T} + \frac{x}{\pi}\right)$

(∵ It is travelling in opposite direction)

By principle of superposition, wave equation for the resultant wave = $y = y_1 + y_2$

$$y = a \operatorname{Sin} 2\pi\left(\frac{t}{T} - \frac{x}{\pi}\right) + a \operatorname{Sin} 2\pi\left(\frac{t}{T} + \frac{x}{\pi}\right)$$

$$= a\left(\operatorname{Sin} 2\pi\left(\frac{t}{T} - \frac{x}{\pi}\right) + a \operatorname{Sin} 2\pi\left(\frac{t}{T} + \frac{x}{\pi}\right)\right)$$

Using Sin C+ Sin D = a Cos $\frac{C-D}{z} . \frac{Sin\ C+D}{z}$

$$\boxed{y = 2a \operatorname{Cos} \frac{2\pi x}{\pi} . \frac{Sin\ 2\pi t}{T}}$$

Here a = 8cm; f = 30Hz, V = 180 cm/s

$T = \frac{1}{30}$ sec, π=wavelength = $\frac{v}{f} = VT$

$\pi = 180 \times \frac{1}{30} = 6cm$

$y = 2a \text{ Cos } \frac{2\pi x}{\pi} Sin \frac{2\pi t}{T}$

$y = 2 \times 8 \frac{Cos \cancel{2}\pi \times x}{\cancel{6}\ 3} \cdot \frac{Sin \cancel{2}\pi t}{\pi \cancel{30}\ 15}$ $\boxed{y = 16 \ \frac{\text{Cos}\pi\text{x}}{3} \cdot \frac{Sin 60\pi t}{15}}$

Ans 08. The lowest frequency of transverse vibrations is given by:→

Area = A

Density = P

$f = \frac{1}{2l}\sqrt{\frac{T}{m}}$

Here m = mass Per unit length = area × Density

because Density = $\frac{Mass}{Volume}$

m = $A \times P$ $\boxed{\text{F=35.3 vib/sec}}$

Ans 09. 1) In closed pipe, the wavelength of nth mode = $\pi n = \frac{4l}{n}$ where n = odd integer whereas in open pipe, $\pi n = \frac{2l}{n}$ and n = all integer

2) The fundamental frequency of open pipe is twice that of closed pipe of same length.

3) A closed pipe of length $\frac{2}{2}$ produces the same fundamental frequency as an open pipe of length L.

4) For an open pipe, harmonics are present for all integers and for a closed pipe, harmonics are present for only odd integers hence, open pipe gives richer note.

Put the value of n in equation for frequency

$f = \frac{1}{2l}\sqrt{\frac{T}{AP}}$

$f = \frac{1}{2l}\sqrt{\frac{T/A}{P}}$

Now, Force = Tension and $\frac{Force}{Area} = \text{Stress}$

f = $\frac{1}{2l}\sqrt{\frac{stress}{P}} \rightarrow 2)$

Now, young's Modulus = y = $\frac{Stress}{Strain}$

Or Stress = y× Strain

Stress = $y \times \frac{\Delta L}{L}$

Put the value of Stress in equation 2)

$$f = \frac{1}{2l}\sqrt{\frac{y \times \Delta L}{L \times P}}$$

Put y = 9×10^{10} N/m, ΔL=0.05×10^{-2}m

L = 1.0m, P = 9×10^{3} Kg/m^3

$$f = \frac{1}{2\times1}\sqrt{\frac{9\times10^{9}\times0.05\times10^{-2}}{1\times9\times10^{3}}}$$

Since fundamental frequency of a stretched spring $\frac{\alpha 1}{l}$

$$\frac{f_2}{f_1} = \frac{l_1}{l_2} = \frac{50.1}{49.9}$$

$$f_2 = \frac{50.1}{49.1} f_1$$

Now, f_2-f_1=1 or $\frac{50.1}{49.9} f_1 - f_1$

$$1 = \frac{50.1 f_1 - 49.9 f_1}{49.9}$$

$$1 = \frac{0.2 f_1}{49.9}$$

$$1\times49.9 = 0.2 f_1$$

$$f_1 = \frac{49.9}{0.2}$$

$$\boxed{f_1 = 249.5HZ}$$

And $f_2 - f_1 = 1$

$f_2 = 1 + f_1$

= 1 + 249.5

$$\boxed{f_2 = 250.5\ HZ}$$

CBSE MIXED TEST PAPER-01

(First Unit Test)

CLASS - XI PHYSICS

[Time : 1.50 hrs.] **[M. M.:** 40]

Instructions:-

(i) Attempt all questions.

(ii) Q. No. 1 to 4 carries ONE mark each, answer them in word or one sentence.

(iii) Q. No. 5 to 12 carries TWO marks each, answer to them should not exceed 40 words.

(iv) Q. No. 13 to 17 carries THREE marks each, answer to them should not exceed 80 words.

(v) Q. No. 18 carries FIVE marks, answer them in 150 words.

(vi) Use log table if necessary. There is no overall choice however internal options, one for 2 marks, 3 marks and 5 marks questions each is provide.

1. Define atomic mass unit (a.m.u). 1-mark
2. Arrange the basic forces in nature in ascending order of their strength. 1-mark
3. Name any two physical quantities which have dimensional formula $ML^{-1}T^{-2}$. 1-mark
4. Express 0.000003 m as a power of 10. 1-mark
5. Write the steps of learning in science. 1-mark
6. Round off to 3 significant figures: 2-marks

   (a)20.96 m, and

   (b) 0,0003125 Kg
7. State the number of significant figures in the following:- 2-marks

   (a)0.0007 $m^{2,}$

   (b) 2.64 x 10^{24} kg,

   (c) 6.320 J and

   (d) 0.2370 g cm^{-3}.

8 The fate of society depends upon Physics. How? Or 2-marks

Explain principle of homogeneity.

9. (i)Can a quantity have units but still be dimensionless? 2-marks

(ii) Can a quantity have dimensions but still have no units? justify your answer.

10. Why is SI of units preferred to others systems of unit? 2-marks

11. List any four characteristics of a standard unit. 2-marks

12. Write any four limitations of dimensional analysis. 2-marks

13. Check the correctness of the relation 3-marks

$T = I\alpha$ by dimensional method

Where, T is torque, I is moment of inertia and α Is a angular accelerator

14. Write the dimension of a/b in the relation 3-marks

$F = a\sqrt{x} + bt^2$

Where F is force X is distance, and t is time

15. Explain the parallax method to measure distance of an astronomical object. 3-marks

16. Convert 1^0, 1' and 1" into radian. 3-marks

17. A body has uniform acceleration of 5 km h^{-2}. Find its value in cgs system by dimensional method. OR 3-marks

A new unit of length is chosen, such that the speed of light in vacuum is unity. Find the distance between sun and earth in terms of new unit, if light takes 8 minutes and 20 seconds to cover the distance.

18. The time period 'T' of an oscillating drop depend upon its radius 'r', density 'p' and surface tension 'S'. Establish a relation among them by dimensional method. Or 5-marks

If the velocity of light 'C' gravitational constant 'G' and Plank's constant 'h' be chosen as fundamental units, find the dimension of :

(i)mass, (ii) length, and

(iii) time in new system

Sample Question Paper for Half Yearly Exam

Subject : Physics

Time : 3 hrs. **M.M : 70 (Theory)**

Note :

1) **All questions are compulsory.**
2) **Q1 – Q8 each carry one mark.**
3) **Q9 – Q18 each carry two mark.**
4) **Q19 – Q27 each carry three mark.**
5) **Q28 – Q30 each carry five mark.**
6) **There is internal choice in between the questions.**

Q1.What is difference between Nm & mN ?

Q2.Why wheels are made circular? Explain.

Q3.Why do different planets have different escape speed?

Q4.Which is more elastic: water or air ,why?

Q5.Find dimensions of moment of inertia. Is moment of inertia a vector or scalar?

Q6.The length of a second hand of a clock is 10 cm. find the speed of the tip of the hand?

Q7.An impulsive force of 100 N acts on a body for 1 second. What is the change in linear momentum?

Q8. Is $(\hat{i} + \hat{j})$ a unit vector? Explain.

Q9. IF the unit of force were Kilonewton, that of time millisecond and that of power kilowatt. What would be the units of mass and length.?

Q10. Show that average velocity of the object over an interval of time is either smaller or equal to average speed of object over the same interval.

Q11. A force of 5 N changes the velocity of a body 10m/s in 5 sec. How much force is required to bring about the same change in 2 sec?

Q12. A wagon of mass 2000 Kg. is separated form a train traveling at 9 Km/h and then the wagon comes to rest in 2 min. Find resistance between the wheels of the wagon and the track.

Q13. The driver of a truck traveling with a velocity (v) of suddenly notices a brick wall in front of him at a distance'd' . Is it better for him to apply breaks or to make a circular turn without applying breaks in order to just avoid crashing into the wall? Explain with reason.

Q14. If momentum to body is decreased by 50% then what will be the percentage change in K.E of the body? Find out.

Q15. The distance of two planets from the sun are 10^{11} and 10^{10} meter respectively what is the ratio of velocities of these two planets? Find.

Q16 Assuming that the earth is a sphere of radius 'R' and mass 'M'. Find at what altitude from earth surface the acceleration due to gravity will become $1/4^{th}$ of its value that on the surface of earth.

-Contd on page 2-

Q17. Three particles each of mass ‘m’ are placed at the vertices of an equilateral triangle of side ‘a’ what are the gravitational field and gravitional potiental at the centroid of the triangle..

Q18. Describe stress strain relationship for a loaded steel wire and hence explain the terms elastic limit, permanent set, breaking point.

Or

The ratio of radii of two wires of same material is 2:1. If these wires are stretched by equal force. Find the ratio of stresses produced in them.

Q19. The frequency ν of an oscillating drop may depend upon the radius (r) of the drop, density (ρ) and surface tension (s) of the liquid. Deduce the formula for frequency dimensionally.

Q20. A weight mg is suspended from the middle of a rope whose ends are at the same level, the rope is no longer horizontal. Find the minimum tension required to completely straighten the rope.

Q21. Explain with suitable diagram why it is easier to pull a lawn roller to push it.

Q22. Find the force required to move a train of 2000 quintals up an incline of 1 in 50, with an acceleration of $2 m/s^2$, the force of friction being 0.5N per quintal.

Q23.A block of mass 10 Kg is sliding on a surface inclined at an angle of 30° with the horizontal. Find acceleration of the block. ($\mu = 0.5$).

Q24.A light body and a heavy body have same momentum. Which one has greater linear Kinetic energy?

Q25. Four sphere each of diameter 2 a and mass M are placed with their centers on the four corners of a square of side ‘b’ . Calculate moment of inertia of the system about one side of the square taken as axis.

Q26.Obtain expression for orbital velocity and time period of a satellite revolving around a planet.

Q27. For identical hollow cylindrical column of steel support a big structure of mass 50,000 kg. The inner and outer radii of each column are 30 cm. and 60 cm respectively. Assume the load distribution to be uniform, calculate the compression strain of each column. The young modules of steel is $2 \times 10^{11} N/m^2$.

-Contd on page 3-

Q28. a) Derive expression for 1) time of flight 2) Range of the object when a body is given projection at an angle Θ from horizontal under gravity.

b) A particle is projected with a velocity 'u' so that its horizontal range is thrice the greatest height attained. What is its horizontal range?

OR

a) Derive position time relation for uniformly accelerated motion with the help of graph.

b) A body travels a distance of 10 m in 3^{rd} second and 5 meter in 4^{th} second. Find the distance it travels in 3 seconds after 5^{th} second.

Q29. Derive expression for torque in Cartesian and polar co-ordinates. When a body is rotating about an axis.

Or

a) Explain concept of angular momentum and obtain expression for angular momentum in Cartesian co-ordinates.

b) A car of 900 kg is traveling around a circular path of radius 300 m with a constant speed of 72 km/hour. Find its angular momentum.

Q30 a) Show that for a perfectly elastic collision in one dimensions the coefficient of restitution is equal to unity.

b) Two ball bearing of mass 'm' each moving in opposite directions with equal speed 'v' collide head on with each other. Predict the outcome of collision, assuming it to be perfectly elastic.

Or

a) Justify energy conservation in case of the vibration of a simple pendulum.

b) Two screens have force constant K_1 and K_2 ($K_1 > K_2$). On which spring is more work done when they are stretched by the same force?

Sample Question Paper for Half Yearly Exam

Subject : Physics

Time : 3 hrs.

Note :

1) **All questions are compulsory.**
2) **Q1 – Q8 each carry one mark.**
3) **Q9 – Q18 each carry two mark.**
4) **Q19 – Q27 each carry three mark.**
5) **Q28 – Q30 each carry five mark.**
6) **There is internal choice in between the questions.**

Q1. The radius of a sphere is measured to be (2.1 ± 0.5) cm. Calculate its surface area with error limits.

Q2. Draw a position time graph for stationary object .

Q3. Find the mass of a body weighing 100 dyne. Take g = 10 m/s^2 .

Q4. What is the apparent weight of the body of mass 'm' at (a) the highest and (b) lowest point, if it is just looking the loop in a vertical circle.

Q5. What is the angle between $\vec{A}$ and $\vec{B}$, if $\vec{A}$ and $\vec{B}$ denote the adjacent sides of a parallelogram drawn from a point and the area of the parallelogram is ½ AB.

Q6. If the ice on the polar caps of the earth melts, how will it affect the duration of the day? Explain.

Q7. A satellite revolving around earth loses height. How will its time period be changed?

Q8. Why is mercury preferred as a barometric substance over water?

Q9. When the planet Jupiter is at a distance of 824.7 million Kilometers from the Earth, its angular diameter is measured to be 35.72" of arc. Calculate the diameter of Jupiter?

Q10. What is the ratio of the distance travelled by a body falling freely from rest in the first, second, and third second of its fall.

Q11. With what acceleration (a) should a box descend so that a block of mass M placed in it exerts a force Mg/4 on the floor of the box?

Q12. Explain how first and third law of motion is contained in 2^{nd} law?

Q13. Find acceleration of a body down a rough inclined plane.

Q14. A molecule in a gas container hits the wall with speed 200 m/s at an angle 30^0 with the normal, and rebounds with the same speed. Is momentum conserved in the collision? Is the collision elastic or inelastic?

Q15. Draw graph showing the variation of acceleration due to gravity with (a) height above the surface of earth (b) depth below the surface of earth.

Q16. Two identical copper spheres of radius R are incontact with each other. If the gravitational attraction between them is F, find the relation between F and R.

Q17. Suppose there existed a planet that went around the sun twice as fast as the Earth. What would be its orbital size as compared to that of the Earth?

Q18. Why are the bridges declared unsafe after long years?

OR

Show that angular momentum of a particle about a given axis is twice the product of mass of particle and Arial velocity of position vector of the particle.

Q19. The time period of oscillation of simple pendulum is given by $t = 2\pi\ (L/g)^{1/2}$. What is the accuracy in the determination of 'g' if 10 cm length is known to 1 mm accuracy and 0.5 s time period is measured from time of 100 oscillations with a watch of 1 sec. resolution?

Q20. A person standing on a road has to hold his umbrella at 60^0 with the vertical to keep the rain away. He throws the umbrella and starts running at 20 ms^{-1}. He finds that rain drops are hitting his head vertically. Find the speed of the rain drops with respect to (a) the road (b) the moving person.

Q21. Define relative velocity of an object w.r.t another. Draw position-time graphs of two objects moving along a straight line, when their relative velocity is (i) zero and (ii) non-zero.

Q22. Define angle of friction and angle of repose and find the relation between them.

Q23. Obtain an expression for minimum, velocity of projection of a body at the lowest point for looping a vertical loop.

Q24. A car weighing 1120 Kg is going up an incline of 1 in 56 at the rate of 20 m in 2s. Find the power of the engine if frictional force is 64 N.

Q25. Three spheres each of radius 'R', mass 'm' are kept at the three corners of an equilateral triangle of side 'a'. Find moment of inertia of all the three sphere along any one side of the triangle.

Q26. Define Kepler's law of period and hence deduce Newton's law of Gravitation using it.

Q27. (a) What is Pascal's law for transmittion of pressure in a liquid?

(b) Explain why the blood pressure in human being is greater at the feet than at the brain.

(c) Hydrostatic pressure is a scalar quantity even though pressure is force divided by area and force is a vector.

OR

What you mean by Gravitational potential drive expression for the gravitational potential on the surface of earth and find a point where gravitational potential is 0.

Q28. (a) What is centripetal acceleration? Find its magnitude and direction in case of
uniform circular motion of an object.

(b) The kinetic energy K of a particle moving along a circle of radius r depends upon the distance covered (s) as, $K=a\ s^2$. What is the force acting on the particle?

OR

(a) Show that the path followed by a projectile fired horizontally is parabolic.

(b) Show that for two complementary angles of projection of a projectile thrown with the same velocity. The horizontal ranges are equal.

(c) For what angle of projection of a projectile the horizontal range is maximum.

Q29. (a) What do you mean by inelastic collision in one dimension? Show that there is
loss of kinectic energy in inelastic collision.

(b) A shot traveling at the rate of 100 ms^{-1} is just able to pierce a plank 4 cm thick. What velocity is required to just pierce a plank 9 cm thick?

OR

(c) What do you mean by conservative and non-conservative forces? Show that gravitation force is conservative force.

(d) An elevator weighing 500 Kg is to be lifted up at a constant velocity of 0.4 m/s. What should be the minimum horse power of the motor to be used?

Q30. (a) Obtain an expression for the position vector of centre of mass of two particle system.

(b) Given that $\vec{A} \times \vec{B} = \vec{B} \times \vec{C} = 0$. If $\vec{A}$, $\vec{B}$ and $\vec{C}$ are not null vectors, find the

Value of $\vec{C} \times \vec{A}$.

OR

(a) What do you mean by moment of force? Drive an expression for Torque in polar co-ordinates.

(b) Find the unit vector perpendicular to each of the vectors $3\hat{i} + \hat{j} + 2\hat{k}$ and

$2\hat{i} - 2\hat{j} + 4\hat{k}$.

CBSE TEST PAPER-04
Class – XI Physics

Time :-1.5 Hrs. **M.M. 40**

Q1. An impulsive force of 100N acts on a body for 1s. What is the change in its linear momentum. [1]

Q2. A stone tide to one end of a string is whirled in a circle. If the string breaks, the stone flies off tangentially. Why? [1]

Q3. Give an example of negative work done. [1]

Q4. Give the magnitude and direction of the net force acting an a stone of mass 0. 1kg just after it is dropped from the window of a train running at a constant velocity of 36km/hr. ($g = 10m/s^2$) [1]

Q5. Why does the direction of motion of a projectile become horizontal at the highest point of its trajectory? [1]

Q6. A stone tide to the end of a string 80cm long is whirled in a horizontal circle with constant speed. If the stone makes 14 revolution is 25 seconds, What is the magnitude and direction of acceleration of the stone. [2]

Q7. Two masses 8kg and 12kg are connected at the two ends of a light in entensible string that passes over a frictional less pulley. Find the acceleration of the masses and tension in the string, when the masses are released. [2]

Q8. Explain why : [2]

(a) It is easier to pull a lown mower than to push it.

(b) A cricketer moves his hands backwards while holding a catch.

Q9. State laws of limiting friction. [2]

Q10. A shell of mass 0.02kg is fired by a gun of mass 100kg. If the muzzle speed of the shell is $80ms^{-1}$, what is the recoil speed of the gun. [2]

Q11. A man of mass 70kg. stand on a weighing scale in a lift which is moving : [3]

(a) upwards with a uniform speed of 10m/s.

(b) downwards with a uniform acceleration of 5m/s^2.

(c) Upwards with a uniform acceleration of 5m/s^2. What would be the readings on the scale in each case?

Q12. State and prove 'work energy theorem' for a variable force. [3]

Q13. Show that projection angle θ for a projectile launched from the origin is given by [3]

$$\theta = tsn^{-1}\left(\frac{4H}{R}\right)$$

Where H $\rightarrow$ Maximum height

R $\rightarrow$ Horizontal Range of the Projectile

OR

Show that for a projectile the angle between the velocity and the x-axis as a function of time is given by.

$$Q(t) = \tan^{-1}\left(\frac{Vy - gt}{V_x}\right)$$

Q14. Deduce the expression for work done in moving a body up a Rough inclined plane. [3]

Q15. What is the need for banking a road? Obtain an expression for the maximum speed with which a vehicle can safely negotiate a curved road banked at an angle Q. [3]

Q16. Derive an expression for : [5]

(a) Maximum height (H)

(b) Horizontal Ranged (R)

(c) Time of flight

of a oblique projectile. Also mention, what should be the angles of to obtain (1) Maximum Range, (2) Maximum height, (3) Maximum time of flight?

Q17. (a) Find the value of 'n' so that vector $(2\hat{i} - 3\hat{j} + \hat{k})$is perpendicular to the vector $(3\hat{i} + 4\hat{j} + n\hat{k})$ [5]

(b) Find the magnitude and direction of $(\hat{i} + \hat{j})$ and $(\hat{i} - \hat{j})$, where $\hat{i}$ and $\hat{j}$ are unit vector along X-axis and Y-axis respectively.

OR

(a) Prove that $\vec{A} = \hat{i} + 2\hat{j} + 3\hat{k}$ and $\vec{B} = 2\hat{i} - \hat{j}$ are perpendicular to each other.

(b) Find the component of $\vec{A} = 3\hat{i} + 2\hat{j}$ along the direction of $(\hat{i} + \hat{j})$ and $(\hat{i} - \hat{j})$.