Previous IPE

SOLVED PAPERS

MARCH-2020 (AP)

PREVIOUS PAPERS

IPE: MARCH-2020(AP)

Time : 3 Hours **JR.PHYSICS** Max.Marks : 60

SECTION-A

I. Answer ALL the following VSAQs: $10 \times 2 = 20$

1. What is the discovery of Sir C.V.Raman?
2. The percentage error in the mass and speed are 2% and 3% respectively. What is the maximum error in kinetic energy calculated using these quantities?
3. If $\vec{A} = \vec{i} + \vec{j}$ What is the angle between vector $\vec{A}$ with x -axis?
4. Why does the car with a flattened tyre stop sooner than the one with inflated tyres ?
5. Define Average Pressure. Mention its unit.
6. What are water proofing agents and water wetting agents? What do they do?
7. State Newton's Law of cooling.
8. Ventilators are provided in rooms just below the roof. Why?
9. Define mean free path.
10. State Boyle's law and Charles law.

SECTION-B

II. Answer any SIX of the following SAQs: $6 \times 4 = 24$

11. A car moving along a straight high way with speed of 126km/h is brought to a 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?
12. State Parallelogram law of vectors. Derive an expression for the magnitude and direction of the resultant vector.
13. Define the terms momentum and impulse. State and explain the law of conservation of momentum. Give example.
14. Define vector product. Explain the properties of a vector product with two examples.
15. The moment of inertia of a fly wheel making 300 revolutions per minute is 0.3 kgm^2. Find the torque required to bring it to rest in 20s.
16. What is a geostationary satellite? State its uses.
17. Describe the behavior of a wire under gradually increasing load.
18. Explain conduction, convection and radiation with examples.

SECTION-C

III. Answer any TWO of the following LAQs: $2 \times 8 = 16$

19. What are collisions? Explain the types of collisions. Show that in case of one dimensional elastic collision, the relative velocity of approach of two colliding bodies before collision is equal to the relative velocity of separation after collision.
20. Show that the motion of a simple pendulum is simple harmonic and hence derive an equation for its time period. The mass and radius of a planet are double that of the earth. If the time period of a simple pendulum on the earth is T, find the time period on the planet.
21. Describe the working of Carnot engine. Obtain an expression for the efficiency. A refrigerator is to maintain eatables kept inside at 9°C. If room temperature is 36°C, calculate the coefficient of performance.

IPE AP MARCH-2020
ANSWERS

SECTION-A

1. What is the discovery of C.V. Raman ?

A. 1) The discovery of C.V.Raman is **Raman effect**.

2) It deals with **scattering of light** by air molecules.

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2. The percentage error in the mass and speed are 2% and 3% respectively. What is the maximum error in kinetic energy calculated using these quantities? [TS 20] [AP 18,20]

A. Percentage error in mass is 2% $\Rightarrow \frac{\Delta m}{m}\times 100 = 2$

Percentage error in velocity is 3% $\Rightarrow \frac{\Delta v}{v}\times 100 = 3$

Now , K.E is given by $K = \frac{1}{2}mv^2 \Rightarrow \frac{\Delta K}{k}\times 100 = \frac{\Delta m}{m}\times 100 + 2\times\frac{\Delta v}{v}\times 100 = 2 + 2 \times 3 = 2 + 6 = 8$

$\therefore$ Maximum error in the K.E = 8%

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3. If $\vec{A} = \vec{i} + \vec{j}$ What is the angle between vector $\vec{A}$ with x -axis?

A. 1) Comparing the vector $\vec{i} + \vec{j}$ with $x\vec{i} + y\vec{j}$, we get x=1 and y=1

2) **Formula:** $\tan\theta = \frac{y}{x} = \frac{1}{1} = 1 = \tan 45^o \Rightarrow \theta = 45^o$

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4. Why does the car with a flattened tyre stop sooner than the one with inflated tyres?

A. 1) A flattened tyre gets **more deformation**. Then **'rolling friction' becomes more** to that tyre.

2) Hence a car with flattened tyre comes to rest sooner than a car with inflated tyres.

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5. Define average pressure. Mention it's unit and dimensional formula. Is it a scalar or a vector? [AP 17,20,22]

A. The average pressure is defined as the normal force acting per unit area.

$$P_{avg} = \frac{F}{A}$$

S.I unit: Nm^{-2} (or) Pascal   Dimensional formula : $[ML^{-1}T^{-2}]$

It is a scalar quantity.

6. What are water proofing agents and water wetting agents? What do they do?

A. 1) **Water proofing agents** are the materials which **increase the angle of contact.**

When they are added to water they do not penetrate through cloth.

Ex: Rain coat fabric.

2) **Water Wetting agents** are the materials which **decrease the angle of contact.**

When they are added to water they easily penetrate through cloth.

Ex: Soaps, detergents and dying substances.

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7. State Newton's law of cooling.

A. **Newton's law of cooling:** It states that the 'rate of loss of heat of a hot body' is directly proportional to the 'difference in temperature' between the 'body and its surroundings'.

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8. Ventilators are provided in rooms just below the roof. Why?

A. 1) Hot air has less density. So it moves upwards due to **convection.**

2) To escape this hot air outoff the room, ventilators are provided just below the roof.

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9. Define mean free path.

A. **Mean free path:** It is the **'average distance'** covered by a molecule between **'two successive collisions'.**

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10. State Boyle's law and Charles law.

A. 1) **Boyle's law:** Pressure (P)is 'inversely proportional' to its volume(V),at constant temperature(T). for a given mass of gas. Thus $P \propto \frac{1}{V}$, (T is constant) (or) PV = Constant,

2) **Charles law:** Volume(V) is 'directly proportional' to its absolute temperature(T) , at constant pressure(P) for a given mass of gas.

Thus $V \propto T$, (or) $\frac{V}{T}$ = Constant

SECTION-B

11. A car moving along a straight high way with speed of 126km/h is brought to a 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? [AP 20]

A. Given u=126km/hr $= 126\times\frac{5}{18}\text{m}/\text{s} = 35\text{m}/\text{s}$, v=0, s= 200m, a=?

Formula $v^2-u^2=2as \Rightarrow 0^2-(35)^2=2a(200)$

$$\Rightarrow a = -\frac{35\times35}{2(200)} = \frac{-49}{16}\text{m}/\text{s}^2$$

And from v = u + at

$$\Rightarrow 0 = 35-\frac{49}{16}t \Rightarrow \frac{49}{16}t = 35 \quad \Rightarrow t = \frac{35(16)}{49} = \frac{80}{7}\text{sec}$$

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12. State Parallelogram law of vectors. Derive an expression for the magnitude and direction of the resultant vector.

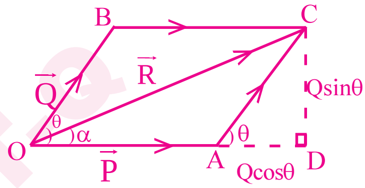
A. 1) Parallelogram law: "If two vectors act as two adjacent sides of a parallelogram drawn from a point then their resultant is the diagonal passing through the same point".

2) Let two vectors $\vec{P} = \overrightarrow{OA}$ and $\vec{Q} = \overrightarrow{OB}$ be acting at a point 'O' as shown in the figure.

Let 'θ' be the angle between $\vec{P}$ and $\vec{Q}$.

The horizontal component of $\vec{Q}$ is AD=Qcosθ ....(1)

The vertical component of $\vec{Q}$ is CD=Qsinθ ....(2)



3) Magnitude of the Resultant vector $\vec{R}$:

From ΔCOD,

$OC^2 = OD^2 + CD^2$

$\Rightarrow OC^2 = (OA+AD)^2 + CD^2$ (Since, OD = OA+AD)

$\Rightarrow OC^2 = [OA^2+AD^2+2(OA)(AD)]+CD^2$ [As per $(a+b)^2$ formula]

$\Rightarrow OC^2 = OA^2+AD^2+CD^2 +2(OA)(AD)$

$\Rightarrow R^2 = P^2 + Q^2\cos^2\theta + Q^2\sin^2\theta + 2P(Q\cos\theta)$ [From (1) & (2)]

$\Rightarrow R^2 = P^2 + Q^2(\cos^2\theta + \sin^2\theta) + 2PQ\cos\theta$

$\Rightarrow R^2 = P^2 + Q^2(1) + 2PQ\cos\theta$

$\Rightarrow R^2 = P^2 + Q^2 + 2PQ\cos\theta$

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

4) Direction of the resultant(α) : Let the resultant $\vec{R}$ makes an angle 'α' with $\vec{P}$.

From ΔCOD, $\tan\alpha = \dfrac{CD}{OA+AD} = \dfrac{Q\sin\theta}{P+Q\cos\theta}$ [From (1) & (2)]

$$\therefore \alpha = \text{Tan}^{-1}\left(\frac{Q\sin\theta}{P+Q\cos\theta}\right)$$

13. Define the terms momentum and impulse. State and explain the law of conservation of momentum. Give example.

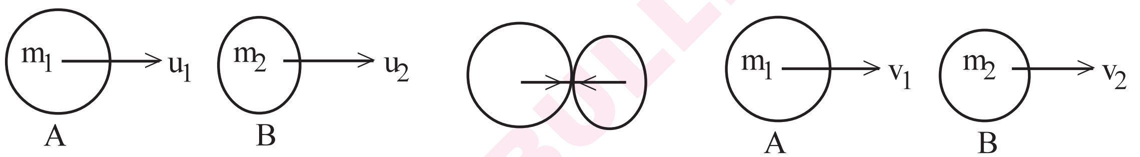
A. 1) **Momentum:** The product of mass and velocity of a body is called its momentum.

Formula: Momentum, $p = mv$.

2) **Impulse:** The product of 'average force' during the impact of a body and the 'time of impact' is called Impulse.

Formula: Impulse, $I = F_{av} \times \Delta t$

3) **Law of conservation of Momentum :** When there is 'no resultant external force', the total momentum of all the interacting bodies in a system , remains constant.



Before collision **During collision** **After collision**

Action = Rate of change of momentum of $B = \frac{m_2v_2 - m_2u_2}{t}$

Reaction = Rate of change of momentum of $A = \frac{m_1v_1 - m_1u_1}{t}$

4) According to Newton's 3rd law , Action = –Reaction

$$\Rightarrow \frac{m_2v_2 - m_2u_2}{t} = -\left(\frac{m_1v_1 - m_1u_1}{t}\right)$$

$$\Rightarrow m_2v_2 - m_2u_2 = -m_1v_1 + m_1u_1$$

$$\therefore m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

Thus, Total momentum before collision = Total momentum after collision

5) **Ex:** Motion of a rocket satisfies the Law of conservation of momentum.

14. Define vector product. Explain the properties of vector product with 2 examples.

A. 1) Vector Product: The vector product of two vectors $\bar{a},\bar{b}$ with angle θ between them, is $\bar{a}\times\bar{b} = |\bar{a}||\bar{b}|\sin\theta\,\hat{n}$

Here, $\hat{n}$ is the unit vector normal to the plane of $\bar{a},\bar{b}$.

2) Properties of Vector Product :

(i) Commutative law is not satisfied: $\bar{a}\times\bar{b}\neq\bar{b}\times\bar{a}$

(ii) Distributive law is satisifed : $\bar{a}\times(\bar{b}+\bar{c})=(\bar{a}\times\bar{b})+(\bar{a}\times\bar{c})$

(iii) Vector product of two parallel vectors is null vector.

Ex: $\bar{i}\times\bar{i}=\bar{j}\times\bar{j}=\bar{k}\times\bar{k}=\bar{o}$

(iv) Vector product of two perpendicular unit vectors is unit normal vector.

Ex: $\bar{i}\times\bar{j}=\bar{k},\ \ \bar{j}\times\bar{k}=\bar{i},\ \ \bar{k}\times\bar{i}=\bar{j}$

3) Examples : Torque $\bar{\tau}=\bar{r}\times\bar{F}$; Velocity $\bar{v}=\bar{\omega}\times\bar{r}$

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15. The moment of inertia of a fly wheel making 300 revolutions per minute is 0.3 kgm^2. Find the torque required to bring it to rest in 20s. [AP 20]

A. Given that $n = 300\text{ rpm} = \frac{300}{60} = 5\text{ rps}$; $I = 0.3\text{kgm}^2, \omega_2 = 0, t = 20\text{ s}$

Now, $\omega_1 = 2\pi n = 2\pi\times5 = 10\pi$ rad/sec

Torque $\tau = I\propto \Rightarrow I\frac{(\omega_2-\omega_1)}{t} = \frac{0.3(0-10\pi)}{20} = \frac{0.3(0-10(3.12))}{20} = -0.471\text{ N}-\text{m}$

–ve sign indicates that the torque is opposing torque.

16. What is a geostationary satellite? State its uses.

A. I) Geostationary satellite : If the period of revolution of an artificial satellite is equal to the period of rotation of the earth then such a satellite is called geostationary satellite.

II) Uses :

Geostationary satellites can be used to

1) Study the upper layers of the atmosphere.
2) Forecast the changes in the atmosphere.
3) Know the shape and size of the earth.
4) Transmit the T.V programmes to distant places.
5) Identify the minerals and natural resources present inside and on the surface of the earth.

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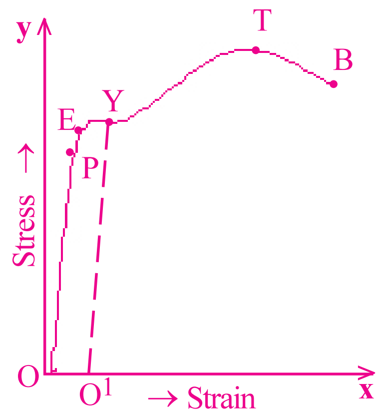
17. Describe the behaviour of a wire under gradually increasing load.

A. Consider a wire suspended from a rigid support and loaded at the other end.

Suppose the load is increased gradually until it breaks.

A graph is plotted between strain on the X-axis and the stress on the Y-axis.

The nature of graph is shown here.



Behaviour of a wire under increasing load:

1) **Proportionality limit(OP):** The part OP is a straight line which shows that stress is proportional to strain. The wire obeys Hooke's law upto the point P . So P is called the proportionality limit of the wire.

2) **Elastic limit (PE):** Beyond P upto E, the graph is slightly curved. When the load is removed, the wire will regain its natural length. Upto E, the wire can be deformed elastically.

3) **Yielding point(Y):** Beyond elastic limit, when the load is removed at the point Y, the wire does not regain its natural length completely. It will have a permanent increase in length. In the region EY the wire shows plastic behaviour.

4) **Tensile Point(T):** Beyond the point Y, the strain increases rapidly without any increase in the load. Even if the load is not removed, the strain increases continuously till the wire reaches the point T. The stress corresponding to T is called the tensile strength of the given material.

5) **Breaking Point(B):** Beyond the point T, the wire shows necks at few points along the length of the wire. Consequently, the wire breaks at B. This point B is called 'breaking point'.

18. Explain conduction, convection and radiation with examples.

A. 1) **Conduction:** Transfer of heat from one place to another place **without the actual movement** of the particles is called conduction.

Ex: Heat transfer from the hot end of the rod to the other end.

2) **Convection:** Transfer of heat from one place to another place **with the actual movement** of particles is called convection.

Ex: Sea breeze, Land breeze, Trade wind.

3) **Radiation:** Transfer of heat from one place to another place **without the help of the material** of the medium is called Radiation. Radiation is the quickest mode of heat transmission.

Ex: Transfer of heat energy from the Sun to Earth.

SECTION-C

19. What are collisions? Explain the possible types of collisions? Develop the theory of one dimensional elastic collision.

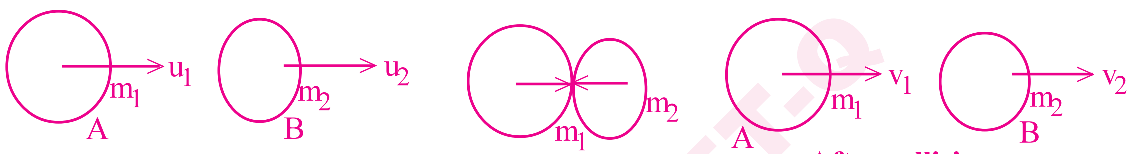
A. 1) **Collision:** It is a strong interaction between bodies, in a very short interval of time, which involves exchange of their momenta. Collisions are of two types.

2) **Elastic collision:** It is the collision in which both Momentum and Kinetic energy are conserved.
Ex: Collision between gas molecules

3) **Inelastic collision:** It is the collision in which only Momentum is conserved but not K.E.
Ex: Collision between a bullet and its target

4) One dimensional elastic collision:

Consider two spheres A and B of masses m_1 and m_2 moving with initial velocities u_1 and u_2 undergo an elastic collision . Let v_1 ,v_2 be the velocities after collision .



Before collision **During collision** **After collision**

5) From the law of **conservation of momentum,**
Total momentum before collision = Total momentum after collision.
$\Rightarrow m_1u_1+m_2u_2 = m_1v_1+m_2v_2$ ....(i) $\Rightarrow m_1(u_1-v_1) = m_2(v_2-u_2)$..........(ii)

6) From the law of **conservation of K.E,**
Total K.E before collision = Total K.E after collision.

$$\Rightarrow \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 \Rightarrow m_1u_1^2 + m_2u_2^2 = m_1v_1^2 + m_2v_2^2$$

$$\Rightarrow m_1(u_1^2 - v_1^2) = m_2(v_2^2 - u_2^2) \text{ -------(iii)}$$

Now, $\frac{(iii)}{(ii)} \Rightarrow \frac{m_1(u_1^2 - v_1^2)}{m_1(u_1 - v_1)} = \frac{m_2(v_2^2 - u_2^2)}{m_2(v_2 - u_2)} \Rightarrow \frac{(u_1 + v_1)(u_1 - v_1)}{(u_1 - v_1)} = \frac{(v_2 + u_2)(v_2 - u_2)}{(v_2 - u_2)}$

$\Rightarrow u_1 + v_1 = v_2 + u_2$. Hence $v_1 = v_2 + u_2 - u_1$.......(iv). Also $v_2 = u_1 + v_1 - u_2$.....(v)

7) To find v_1: From (i) & (v) we get

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2(u_1 + v_1 - u_2) \Rightarrow m_1u_1 + m_2u_2 = m_1v_1 + (m_2u_1 + m_2v_1 - m_2u_2)$$

$$\Rightarrow m_1u_1 + 2m_2u_2 = v_1(m_1 + m_2) + m_2u_1 \Rightarrow v_1(m_1 + m_2) = m_1u_1 - m_2u_1 + 2m_2u_2$$

$$\Rightarrow v_1(m_1 + m_2) = (m_1 - m_2)u_1 + 2m_2u_2 \Rightarrow \boxed{v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2}$$

8) To find v_2: From (i) & (iv) we get

$$m_1u_1 + m_2u_2 = m_1(v_2 + u_2 - u_1) + m_2v_2 \Rightarrow m_1u_1 + m_2u_2 = (m_1v_2 + m_1u_2 - m_1u_1) + m_2v_2$$

$$\Rightarrow 2m_1u_1 + m_2u_2 - m_1u_2 = m_1v_2 + m_2v_2 \Rightarrow v_2(m_1 + m_2) = 2m_1u_1 + (m_2 - m_1)u_2$$

$$\Rightarrow \boxed{v_2 = \left(\frac{2m_1}{m_1 + m_2}\right)u_1 + \left(\frac{m_2 - m_1}{m_1 + m_2}\right)u_2}$$

20. Show that the motion of a simple pendulum is simple harmonic and hence derive an equation for its time period. What is seconds pendulum?

A. (a) To show that motion of simple pendulum is simple harmonic:

1) Consider a simple pendulum of length '*l*', mass '*m*' suspended from a rigid support as shown in the figure.

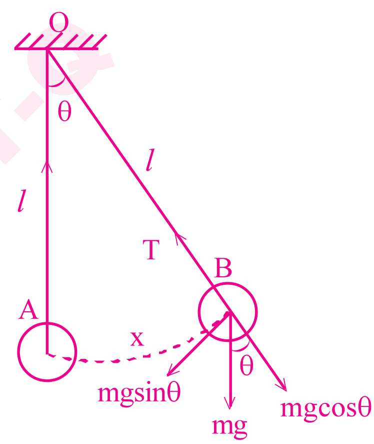
Let the bob makes an angle 'θ' with the vertical at an instant.

2) The weight 'mg' is resolved into two perpendicular components.

One component 'mgcosθ' balances the 'tension(T)'.

The other component 'mgsinθ' provides 'restoring force(F)'.

3) Restoring force is given by $F = -mg\sin\theta$



But we know $F = ma$

$\therefore \cancel{m}a = -\cancel{m}g\sin\theta$

$\Rightarrow a = -g\sin\theta$

$\Rightarrow a = -g\,\theta$ ....(i)[when θ is very small, sinθ=θ]

4) Also $\theta = \frac{x}{l}$ [$\because x = r\theta$ as arc length = radius × angle]

From (i), $a = -g\left(\frac{x}{l}\right) \Rightarrow a = -\left(\frac{g}{l}\right)x$ ....(ii)

5) From (ii), $a \propto -x$, $\left(\because \left(\frac{g}{l}\right) \text{ is constant}\right)$

Hence, proved that the motion of the simple pendulum is S.H.M.

(b) Derivation for time period T:

6) If ω is angular velocity of the bob then its acceleration is $a = -\omega^2 x$.............(iii)

Equating (iii) & (ii) we get, $\cancel{-}\omega^2\cancel{x} = \cancel{-}\left(\frac{g}{l}\right)\cancel{x} \Rightarrow \omega^2 = \frac{g}{l} \Rightarrow \omega = \sqrt{\frac{g}{l}}$.

7) Time period $T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{g}{l}}} = 2\pi\sqrt{\frac{l}{g}}$ $\quad \therefore T = 2\pi\sqrt{\frac{l}{g}}$

(c) Seconds pendulum:

8) A pendulum with time period **2 seconds** is called seconds pendulum.

b) The mass and radius of a planet are double that of the earth. If the time period of a simple pendulum on the earth is T, find the time period on the planet. [AP 20]

A. Let mass of earth = M and radius of earth = R

So mass of planet = 2M and radius of planet = 2R

Now, acceleration due to gravity on earth, $g_e = \frac{GM}{R^2}$

Acceleration due to gravity on planet, $g_P = \frac{G(2M)}{(2R)^2} = \frac{G \times 2M}{4R^2} = \frac{GM}{2R^2} = \frac{g_e}{2}$

We know that, time period of a simple pendulum $T = 2\pi\sqrt{\frac{l}{g}}$

As the length of simple pendulum is kept constant, $T \propto \frac{1}{\sqrt{g}}$

$$\therefore \frac{T_e}{T_P} = \sqrt{\frac{g_P}{g_e}} \quad \Rightarrow \frac{T}{T_P} = \sqrt{\frac{g_e/2}{g_e}} = \sqrt{\frac{1}{2}} = \frac{1}{\sqrt{2}} \qquad \therefore T_P = \sqrt{2}T$$

$\therefore$ On the planet, time period of simple pendulum = $\sqrt{2}T$ s

21. Explain reversible and irreversible processes. Describe the working of Carnot engine. Obtain an expression for the efficiency.

A. **1) Reversible process:** A process that can be 'retraced back' in the opposite direction is called a reversible process.

Ex: Fusion of ice and vaporisation of water.

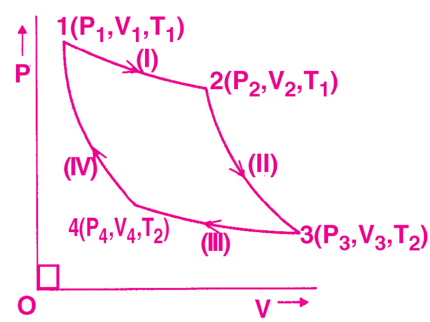
2) Irreversible process: A process that can not be retraced back in the opposite direction is called an irreversible process.

Ex: Work done against friction.

3) Carnot engine: A reversible heat engine operating between two temperatures is called Carnot engine.

Working of Carnot engine: The carnot engine undergoes a cycle of four processes called carnot cycle. It consists of two isothermal processes connected by two adiabatic processes. Ideal gas acts as the working substance in the carnot engine.

4) The 4 steps of Carnot cycle:



a) Step I: Isothermal Expansion(IE) of the gas from $1(P_1,V_1,T_1)$ to $2(P_2,V_2,T_1)$.

Work done by the gas on the environment = Heat(Q_1) absorbed by the gas, from the reservoir, at constant temperature (T_1).

$$W_1 = Q_1 = nRT_1\log_e\left(\frac{V_2}{V_1}\right) \text{ - - - - -(i)}$$

b) Step II : Adiabatic Expansion(AE) of the gas from $2(P_2,V_2,T_1)$ to $3(P_3,V_3,T_2)$.

Work done by the gas in this adiabatic process is $W_2 = \frac{nR}{(\gamma-1)}(T_1 - T_2)$ - - - - (ii)

c) Step III : Isothermal Compression(IC) of the gas from $3(P_3,V_3,T_2)$ to $4(P_4,V_4,T_2)$.

Work done on the gas by the environment = Heat(Q_2) released by the gas to the reservoir, at constant temperature(T_2).

$$W_3 = Q_2 = nRT_2\log_e\left(\frac{V_3}{V_4}\right) \text{ - - - - (iii)}$$

d) Step IV: Adiabatic Compression (AC) of the gas from $4(P_4,V_4,T_2)$ to $1(P_1,V_1,T_1)$.

Work done on the gas in this adiabatic process is $W_4 = \frac{nR}{(\gamma-1)}(T_1 - T_2)$ - - - - (iv)

5) $\therefore$ Total work done by the gas in one complete cycle is

$$W = W_1 + W_2 - W_3 - W_4$$

$$= nRT_1\log_e\left(\frac{V_2}{V_1}\right) + \cancel{\frac{nR}{(\gamma-1)}(T_1-T_2)} - nRT_2\log_e\left(\frac{V_3}{V_4}\right) - \cancel{\frac{nR}{(\gamma-1)}(T_1-T_2)}$$

6) $\therefore W = nRT_1\log_e\left(\frac{V_2}{V_1}\right) - nRT_2\log_e\left(\frac{V_3}{V_4}\right)$

7) The efficiency of the Carnot engine is

$$\eta = \frac{W}{Q_1} = \frac{\cancel{nR}T_1\log_e\left(\frac{V_2}{V_1}\right) - \cancel{nR}T_2\log_e\left(\frac{V_3}{V_4}\right)}{\cancel{nR}T_1\log_e\left(\frac{V_2}{V_1}\right)}$$

$$= \frac{T_1\log_e\left(\frac{V_2}{V_1}\right) - T_2\log_e\left(\frac{V_3}{V_4}\right)}{T_1\log_e\left(\frac{V_2}{V_1}\right)}$$

$\because$ **Step (b) & (d) are adiabatic processes.**

$\therefore TV^{\gamma-1} = \text{constant}$

$\Rightarrow T_1V_2^{\gamma-1} = T_2V_3^{\gamma-1}$ and $T_1V_1^{\gamma-1} = T_2V_4^{\gamma-1}$

Dividing the above two equations, we get

$$\frac{\cancel{T_1}V_2^{\gamma-1}}{\cancel{T_1}V_1^{\gamma-1}} = \frac{\cancel{T_2}V_3^{\gamma-1}}{\cancel{T_2}V_4^{\gamma-1}} \Rightarrow \frac{V_2}{V_1} = \frac{V_3}{V_4}$$

$$= \cancel{\frac{T_1\log_e\left(\frac{V_2}{V_1}\right)}{T_1\log_e\left(\frac{V_2}{V_1}\right)}} - \frac{T_2\log_e\left(\frac{V_3}{V_4}\right)}{T_1\log_e\left(\frac{V_2}{V_1}\right)}$$

$$= 1 - \left(\frac{T_2}{T_1}\right)\cancel{\frac{\log_e\left(\frac{V_3}{V_4}\right)}{\log_e\left(\frac{V_2}{V_1}\right)}}$$

8) $\therefore \eta = 1 - \frac{T_2}{T_1}$

b) A refrigerator is to maintain eatables kept inside at 9^0C. If room temperature is 36^0C, calculate the coefficient of performance.

A: The coefficient of performance of a refrigerator $\alpha = \frac{T_2}{T_1 - T_2}$

Here $T_1 = 273 + 36 = 309$ K, $T_2 = 273 + 9 = 282$ K

$$\therefore \alpha = \frac{282}{309 - 282} = \frac{282}{27} = 10.4$$