Previous IPE

SOLVED PAPERS

MARCH -2023 (TS)

PREVIOUS PAPERS

IPE: MARCH-2023(TS)

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

SECTION-A

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

1. What is the contribution of S.Chandra Sekhar to Physics?
2. Can the coefficient of friction be greater than one?
3. When does a real gas behave like an ideal gas?
4. State Dalton's law of partial pressures.
5. How can systematic errors be minimised or eliminated?
6. Give the expression for the excess pressure in a liquid drop.
7. What is the principle behind the carburetor of an automobile?
8. Can a substance contract on heating? Give an example.
9. What is greenhouse effect? Explain global warming.
10. If $\vec{A} = \vec{i} + \vec{j}$ What is the angle between vector $\vec{A}$ with x -axis?

SECTION-B

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

11. If $|\vec{a}+\vec{b}| = |\vec{a}-\vec{b}|$ then what is the angle between $\vec{a}$ and $\vec{b}$?
12. A ball is dropped from the roof of a tall building and simultaneously another ball is thrown horizontally with some velocity from the same roof. Which ball lands first? Explain your answer.
13. Explain the advantages and disadvantages of friction
14. Distinguish between centre of mass and centre of gravity.
15. Define angular acceleration and torque. Establish the relation between angular acceleration and torque.
16. What is orbital velocity? Obtain an expression for it.
17. Define Young's modulus, Bulk modulus and Shear Modulus.
18. Pendulum clocks generally go fast in winter and slow in summer. Why?

SECTION-C

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

19. What are collisions? Explain the possible types of collisions? Develop the theory of one dimensional elastic collision.
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?
21. State second law of thermodynamics. How is heat engine different from a refrigerator.

IPE TS MARCH-2023
ANSWERS

SECTION-A

1. What is the contribution of S. Chandra Sekhar to physics ?

A: Chandra Sekhar limit, structure and evolution of stars, motion of Galaxy.

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2. Can the coefficient of friction be greater than one?

A: 1) Yes. In general, coefficient of friction is less than one.

2) If the surfaces are polished heavily then adhesive forces between the molecules increase and then coefficient of friction will be greater than one.

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3. When does a real gas behave like an ideal gas?

A: At 'low pressures and high temperatures', a real gas behaves like an ideal gas.

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4. State Dalton's law of partial pressures.

A: 1) **Dalton's law of partial pressures: Total pressure(P) of a mixture** of ideal gases is equal to **sum of partial pressures.**

2) $P = p_1 + p_2 + p_3 + - - - -$ where p_1, p_2, p_3, ...are partial pressures.

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5. How can systematic errors be minimised or eliminated?

A: The Systematic errors can be minimized by

(i) selecting 'better instruments' with 'higher resolution'

(ii) avoiding personal bias in taking reading.

(iii) improving the 'experimental techniques'.

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6. Give the expression for the excess pressure in a liquid drop.

A: 1) Liquid drop in air contains only one interface.

2) Hence excess pressure in a liquid drop $= P_{inside} - P_{outside} \Rightarrow P_{excess} = \frac{2T}{r} = P_{inside} - P_{outside}$

Where r = radius of the liquid drop

T = surface tension of the liquid-air interface.

7. What is the principle behind the carburetor of an automobile?

A: **1)** 'Bernoulli's principle' works behind the carburetor of an automobile .

2) Working: The carburetor of automobile contains a nozzle through which air flows with a high speed. The pressure is then lowered at the narrow neck and the petrol is sucked up in the chamber. It provides the correct mixture of air to fuel necessary for combustion.

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8. Can a substance contract on heating? Give an example.

A: **1)** Yes. Some substances contract on heating.

2) Ex: Cast iron, Rubber, Typemetal.

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9. What is greenhouse effect? Explain global warming.

A: **1) Greenhouse effect:** The thermal radiation from earth's surface absorbed by atmospheric greenhouse gases(carbon dioxide, methane, nitrous oxide) is re-radiated in all directions. A 'part of this re-radiation reflects back' towards the surface of the earth. It results in more heating up of earth's surface and atmosphere. This phenomenon is called Greenhouse effect.

2) Global warming: Global warming is the 'observed and projected increase' in the average temperature of Earth's atmosphere and oceans.

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10. 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:** $\tan\theta = \frac{y}{x} = \frac{1}{1} = 1 = \tan 45^\circ \Rightarrow \theta = 45^\circ$

SECTION-B

11. If $|\vec{a}+\vec{b}|=|\vec{a}-\vec{b}|$ then what is the angle between $\vec{a}$ and $\vec{b}$?

A: 1) Given that $|\vec{a}+\vec{b}|=|\vec{a}-\vec{b}| \Rightarrow \sqrt{a^2+b^2+2ab\cos\theta} = \sqrt{a^2+b^2-2ab\cos\theta}$

2) Squaring on both sides, $a^2+b^2+2ab\cos\theta = a^2+b^2-2ab\cos\theta \Rightarrow 4ab\cos\theta = 0$

$\Rightarrow \cos\theta = 0 \quad \therefore \theta = 90^\circ$.

Hence the angle between $\vec{a}$ and $\vec{b}$ is 90°

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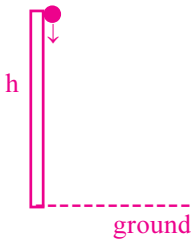
12. A ball is dropped from the roof of a tall building and simultaneously another ball is thrown horizontally with some velocity from the same roof. Which ball lands first? Explain your answer.

A: **1) For the dropped ball:**



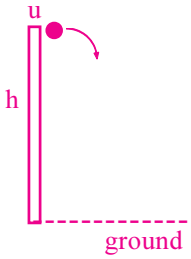
Let the height of the tower = h

Initial velocity u = 0, acceleration a = + g,

displacement s = h; Time of jouney = t_1

Now, $s = ut + \frac{1}{2}at^2 \Rightarrow h = 0 + \frac{1}{2}gt_1^2 \Rightarrow t_1^2 = \frac{2h}{g} \Rightarrow t_1 = \sqrt{\frac{2h}{g}}$ ....(1)

2) For the horizontally projected ball:



Here, Initial vertical velocity $u_y = 0$,

Initial vertical displacement s = h,

acceleration $a_y = +g$, Time of journey = t_2

Now, $s = ut + \frac{1}{2}at^2 \Rightarrow h = 0 + \frac{1}{2}gt_2^2 \Rightarrow t_2^2 = \frac{2h}{g} \Rightarrow t_2 = \sqrt{\frac{2h}{g}}$ .....(2)

3) From (1) & (2), $t_1 = t_2$. So, both the bodies reach to the ground simultaneously

13. Explain the advantages and disadvantages of friction.

A: A) Advantages of Friction:

1) Friction helps us to 'walk on the road'.
2) Friction helps us to 'pick and hold a book' in our hands.
3) Friction helps to 'drive Nails and Screws' into the walls.
4) Friction helps to 'stop a moving vehicle' when we apply breaks.

B) Disadvantages of Friction:

1) Friction decreases the 'speed of moving vehicles'.
2) Friction causes 'Wear and Tear' of machines.
3) Friction between tree branches causes 'forest fire'.
4) Friction produces 'unwanted heat' in engines which lead to loss of energy.

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14. Distinguish between centre of mass and centre of gravity.

A:

Centre of mass	Centre of gravity
1) This is the point at which entire mass of the body is supposed to be concentrated.	1) This is the point at which the weight of the body acts.
2) Centre of mass is independent of acceleration due to gravity.	2) Centre of gravity depends upon acceleration due to gravity.
3) It lies inside or outside the body.	3) It always lie inside the body.
4) This concept is useful while dealing with motion of body	4) This concept is useful while dealing with stability of body.

15. Define Angular acceleration and Torque. Establish the relation between angular acceleration and torque.

A: **1) Angular acceleration(α):** Rate of change of angular velocity(ω) is called angular acceleration.

Formula: Angular acceleration, $\alpha = \frac{d\omega}{dt}$ .....(i)

2) Torque(τ): The turning effect about an axis of rotation is called torque.

Torque is the rate of change of angular momentum(L).

Formula: Torque, $\tau = \frac{dL}{dt}$ .....(ii)

3) Relation between angular acceleration(α) and torque(τ):

If I is moment of inertia of a rotating body with angular velocity 'ω' then its

Angular momentum is L= Iω

4) On differentiating the above equation w.r.t time 't' we get, $\frac{dL}{dt} = I\frac{d\omega}{dt}$

$\therefore$ from (i) & (ii) we get $\tau = I\alpha$

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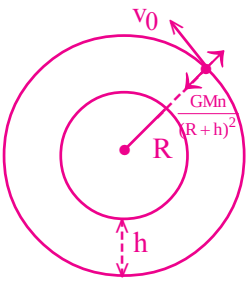
16. What is orbital velocity? Obtain an expression for it.

A: **1) Orbital Velocity(V_0) :** The **horizontal velocity** required for a body to revolve around a planet in a circular orbit is called "orbital velocity".

2) Derivation: Consider a body of mass m revolving around planet of mass M and radius R.Let 'h' be the distance of centre of mass of the body from the surface of the planet. Let V_0 be the horizontal speed of the body when it revolves around the planet .

3) Centrifugal force on the body = Gravitational force of attraction of the planet on the body.

$$\therefore \frac{mV_0^2}{(R+h)} = \frac{GMm}{(R+h)^2} \Rightarrow V_0^2 = \frac{GM}{(R+h)} \Rightarrow V_0 = \sqrt{\frac{GM}{(R+h)}}$$



4) As h<<R we take $R+h \approx R$. Also we know $GM = gR^2$

5) $\therefore V_0 = \sqrt{\frac{GM}{R+h}} \cong \sqrt{\frac{gR^2}{R}} = \sqrt{gR}$

$\therefore V_0 = \sqrt{gR}$. (Its value for the earth is V_0=7.92 km/s)

17. Define Young's modulus, Bulk modulus and Shear Modulus. **[TS 23]**

A: **Young's modulus (Y):** With in the elastic limit, Young's modulus is the ratio of longitudinal stress to the longitudinal strain.

$$Y = \frac{\text{longitudinal stress}}{\text{longitudinal strain}} = \frac{\mathbf{F/A}}{\mathbf{e/}l} = \frac{\mathbf{F}l}{\mathbf{Ae}}$$

Bulk modulus (K): With in the elastic limit, Bulk modulus is the ratio of volume stress to volume strain

$$K = \frac{\text{Volume stress}}{\text{Volume strain}} = \frac{\mathbf{F/A}}{-\Delta\mathbf{V/V}}$$

Shear Modulus (Rigidity modulus (η)): With in the elastic limit, **Rigidity modulus** is the ratio of Shear stress to the Shear strain $\eta = \frac{\text{Shear stress}}{\text{Shear strain}}$

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18. Pendulum clocks generally go fast in winter and slow in summer. Why?

Sol: The time period of pendulum clock is given by $T = 2\pi\sqrt{\frac{l}{g}}$.

At a given place, $T \propto \sqrt{l}$

The pendulum of a clock expands in summer, so its time period increases.

Hence, it makes less number of oscillations than required per day. Hence it will lose time or clock goes slow.

The pendulum of a clock contracts in winter, its length decreases so its time period decreases. Hence, it makes more number of oscillations than required per day. Hence it will gain time or clock goes fast.

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 .

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.

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

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

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

$\Rightarrow u_1+v_1 = v_2+u_2$. 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'

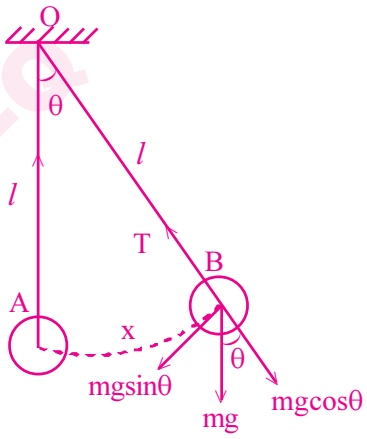
suspended from a rigid support as shown in the figure.

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 $F = ma$

$\therefore ma = -mg\sin\theta$

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

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

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), $a \propto -x$, $\left(\because \left(\frac{g}{l}\right)\right.$ is constant)

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, $\omega^2 x = \left(\frac{g}{l}\right)x \Rightarrow \omega^2 = \frac{g}{l} \Rightarrow \omega = \sqrt{\frac{g}{l}}$.

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

(c) Seconds pendulum:

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

21. State second law of thermodynamics. How is heat engine different from a refrigerator.

A: **A) Second law of thermodynamics**: It consists of two statements.

I) Kelvin - Plank Statement: It is impossible to construct a heat engine which absorbs heat from a hot reservoir that converts completely the heat into work .

(or) It is impossible to construct an ideal heat engine with 100% thermal efficiency.

II) Clausius Statement: It is impossible to transfer heat from a colder object to a hotter object.

(or) It is impossible to construct an ideal refrigerator.

B) Differences between Heat engine and Refrigerator:

HEAT ENGINE	REFRIGERATOR
1) 'Heat engine' converts heat into work.	1) 'Refrigerator' works 'reverse to heat engine'.
2) The 'working substance' absorbs heat (Q_1) from the 'hot reservoir' at high temperature (T_1)	2) The 'working substance' absorbs heat (Q_2) from the 'cold reservoir' at low temperature (T_2)
3) The 'working substance' rejects heat (Q_2) to 'cold reservoir' at lower temperature (T_2)	3) The 'working substance' rejects heat (Q_1) to the 'hot reservoir' at high temperature (T_1)
4) Here, work (W) is done by the system.	4) Here, work is done on the system
5) The efficiency (η) of a heat engine is $\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$	5) The coefficient of performance of a refrigerator is $\alpha = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2}$
6) η is less than 1.	6) α is greater than 1.