Previous IPE

SOLVED PAPERS

MARCH-2019 (AP)

PREVIOUS PAPERS

IPE: MARCH-2019(AP)

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

SECTION-A

I. Answer ALL questions : $10 \times 2 = 20$

1. What is the discovery of C.V. Raman
2. The error in measurement of radius of a sphere is 1 %. What is the error in the measurement of volume ?
3. The vertical component of a vector is equal to its horizontal component. What is the angle made by vector with X - axis ?
4. What is inertia ? What gives the measure of inertia ?
5. What is the principle behind the carburettor of an automobile ?
6. Give the expression for the excess pressure in an air bubble inside the liquid ?
7. What are the lower and upper fixing points in Celsius and Fahrenheit scales?
8. Why gaps are left between rails on a railway track ?
9. Define mean free path.
10. When does a real gas behave like an ideal gas ?

SECTION-B

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

11. A man walks on a straight road from his home to a market 2.5 km away with a speed of 5 kmh^{-1}. Finding the market closed, he instantly turns and walks back home with speed of 7.5 kmh^{-1}. What is the (a) magnitude of average velocity and (b) average speed of the man over the time interval 0 to 50 minutes ?
12. Explain the terms the average velocity and instantaneous velocity. When they are equal ?
13. State Newton's second law of motion. Hence derive the equation of motion F = ma from it.
14. Define angular velocity (ω). Derive $v = r\omega$.
15. Define angular acceleration and torque. Establish the relation between angular acceleration and torque.
16. What is escape velocity ? Obtain an expression for it.
17. Define stress and explain the types of stress.
18. Explain conduction, convection and radiation with examples.

SECTION-C

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

19. What are collisions ? Explain the possible types of collisions, develop the theory of one dimensional elastic collision.
20. Define simple harmonic motion. Show that the motion of (point) projection of a particle performing uniform circular motion, on any diameter, is simple harmonic.
    On an average a human heart is found to beat 75 times in a minute. Calculate its frequency and period
21. State second law of thermodynamics. How is heat engine different from a refrigerator?

IPE AP MARCH-2019
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.

---

2. The error in measurement of radius of a sphere is 1%. What is the error in the measurement of volume? [AP 19,19]

A. Error in the radius of sphere, $\frac{dr}{r}\times 100 = 1$

Volume of the sphere, $V = \frac{4}{3}\pi r^3$; $dV = \frac{4}{3}\pi \times 3r^2 dr$

$$\frac{dV}{V} = \frac{\frac{4}{3}\pi \times 3r^2 dr}{\frac{4}{3}\pi r^3} = \frac{3dr}{r}$$

$$\Rightarrow \frac{dV}{V} = 3\frac{dr}{r} \Rightarrow \frac{dV}{V}\times 100 = 3\times\frac{dr}{r}\times 100 = 3\times 1 = 3$$

$\therefore$ Error in the measurement of volume is 3%.

---

3. The vertical component of a vector is equal to its horizontal component. What is the angle made by the vector with X-axis ?

A . 1) Let 'θ' be angle made by the vector $\vec{R}$ with X-axis.

2) Vertical component of $\vec{R}$ = R sinθ and Horizontal component of $\vec{R}$ = R cosθ

3) $\therefore R\cos\theta = R\sin\theta \Rightarrow \frac{\sin\theta}{\cos\theta} = 1 \Rightarrow \tan\theta = 1 \Rightarrow \theta = 45^\circ$

---

4. What is inertia ? What gives the measure of inertia ?

A. Inertia : Inertia is an inherent property of a body, by which it resists any change in its state.

Mass is the measure of inertia.

5. 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.

---

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 are the lower and upper fixing points in Celsius and Fahrenheit scales?

[AP 19]

A. On Celsius scale of temperature, the lower fixed point is 0^0C and the upper fixed point is 100^0C. On Fahrenheit scale of temperature, the lower fixed point is 32^0F and the upper fixed point is 212^0F.

---

8. Why gaps are left between rails on a railway track?

A. 1) A small gap is left between the 'ends of successive rails' on a railway track.

2) This is to **allow 'linear expansion of rails', in summer.**

---

9. Define mean free path.

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

---

10. 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.

SECTION-B

11. A man walks on a straight road from his home to a market 2.5 km away with a speed of 5 kmh^{-1}. Finding the market closed, he instantly turns and walks back home with a speed of 7.5 kmh^{-1}. What is the (a) magnitude of average velocity and (b) average speed of the man over the time interval 0 to 50 min.

A. Time taken to go from home to market, $t_1 = \frac{\text{distance}}{\text{speed}} = \frac{2.5\text{km}}{5\text{kmh}^{-1}} = 0.5\text{hr} = \frac{5}{10}\text{hr} = \frac{1}{2}\text{hr}$

Time taken to come to home from market,

$$t_2 = \frac{\text{distance}}{\text{speed}} = \frac{2.5\text{km}}{7.5\ \text{kmh}^{-1}} = \frac{1}{3}\text{hr} = \frac{1}{3}\times 60\,\text{min} = 20\,\text{min}$$

(a) Average velocity $= \frac{\text{Total displacement}}{\text{Total time taken}} = \frac{0}{50} = 0$

(∵ In 50 minutes the man reaches his home)

(b) Average speed $= \frac{\text{Total distance travelled}}{\text{Total time taken}} = \frac{2.5+2.5}{\frac{1}{2}+\frac{1}{3}} = \frac{5}{\frac{3+2}{6}} = \frac{30}{5} = 6\ \text{km/hr}$

---

12. Explain the terms average velocity and instantaneous velocity. When are they equal?

A. **Average velocity :** Suppose a body is at a point x_1 at time t_1 and at some other point x_2 at time t_2, then the displacement of the body is $x_2 - x_1$. Hence its average velocity is given by

$$V_{avg} = \frac{\text{displacement}}{\text{time interval}} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$

Instantaneous velocity: The velocity of an object at a particular point of its path or at a particular instant of time is called as instantaneous velocity.

Instantaneous velocity $v = \underset{\Delta t \to 0}{\text{Lt}} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$ i.e, $v = \frac{dx}{dt}$

During uniform motion, the average and instantaneous velocity are always same because the velocity during uniform motion is same at each point of its path or at each instant.

13. State Newton's IInd law of motion. Hence derive the equation of motion F=ma.

A. 1) Newton's Second Law: "The 'rate of change of momentum' of a body is directly proportional to the external force acting on the body and it is in the direction of the force".

Thus, $\frac{dp}{dt} \propto F$

2) Derivation of F = ma

Let F = external force applied on the body ,

m = mass of the body,

v = velocity of the body,

$\therefore$ Momentum, p = mv

3) Rate of change of momentum $= \frac{dp}{dt}$

4) From Newton's second law, $\frac{dp}{dt} \propto F \Rightarrow F \propto \frac{dp}{dt}$

$$\Rightarrow F = k.\frac{dp}{dt} = k\frac{d}{dt}(mv) = km\frac{dv}{dt} = kma$$

When k = 1 we get F = ma.

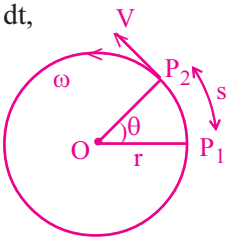
---

14. Define angular velocity (ω). Derive v = rω.

A. 1) Angular velocity(ω): The rate of change of angular displacement is called angular velocity.

If a particle undergoes an angular displacement dθ in the time interval dt,

then its angular velocity, $\omega = \frac{d\theta}{dt}$



2) Derivation of the relation v=rω

Let us consider a particle moving along a circular path

Let r = radius of the circular path

s = distance travelled by the particle when it moves from p_1 to p_2 in time t.

v = linear velocity (or tangential velocity) of the particle

ω = angular velocity of the particle.

3) The arc $\overset{\frown}{P_1P_2}$ of length s subtends an angle θ at the centre, then s = rθ

4) Differentiating s=rθ w.r.to 't', we get

$$\frac{ds}{dt} = \frac{d}{dt}(r\theta) = r\frac{d\theta}{dt} \quad (\because r \text{ is constant})$$

$$\therefore v = r\omega. \qquad \left(\because \frac{ds}{dt} = v \text{ and } \frac{d\theta}{dt} = \omega\right)$$

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 $\tau = I\alpha$

---

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

A. 1) Escape Velocity(V_e) : The **minimum velocity** required for an body to escape from the gravitational influence of a planet is known as "escape velocity".

2) Derivation: Consider an body of mass 'm' at rest on the surface of a planet of mass M and radius R.

3) The gravitational potential on the surface of a planet = $\frac{-GM}{R}$

The gravitational P.E of the system=Gravitational potential×mass of the body= $\frac{-GMm}{R}$ .....(i)

4) When a body of mass m is projected with a velocity V_e then its K.E= $\frac{1}{2}mV_e^2$ .....(ii)

After crossing the Gravitational limits, the total energy becomes zero.

5) Applying the Law of conservation of energy, from (i) & (ii) we have

$$\frac{1}{2}mV_e^2 = -\left(\frac{-GMm}{R}\right) \Rightarrow \frac{1}{2}mV_e^2 = \frac{GMm}{R} \Rightarrow V_e^2 = \frac{2GM}{R}$$

6) $V_e = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2gR^{\cancel{2}}}{\cancel{R}}}$ $[\because GM = gR^2]$

$\therefore V_e = \sqrt{2gR}$. (Its value for the earth is V_e=11.2 km/s)

17. Define stress and explain the types of stress.

A. Stress: Stress is defined as the restoring force developed in the body per unit area

1) **Longitudinal stress or Tensile stress**: The stress produced with in the body ,when its length is changed by applying force normal to the surface of a body is **Longitudinal stress.**

2) **Bulk stress (or) Volume stress :** The stress produced with in the body ,when its volume is changed by applying force normally and uniformly all over its surfaces is called **Bulk stress.**

3) **Shear stress (or) Tangential stress:** The stress produced with in the body, when its shape is changed by applying tangential force on its surface is called **Shear stress.**

---

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 .

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.

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

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

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

$\Rightarrow u_1+v_1 = v_2+u_2$. 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. Define simple harmonic motion. Show that the motion of (point) projection of a particle performing uniform circular motion, on any diameter, is simple harmonic.

A. 1) Simple Harmonic Motion (SHM): The 'to and fro motion' of a particle along a straight line, about a fixed point is said to be **Simple Harmonic motion**, when the acceleration is always proportional to its displacement, but in opposite direction.

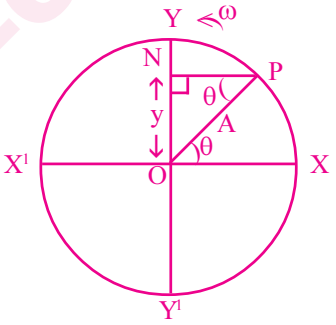
2) Proof: Suppose a particle P is moving along the circumference of a circle of radius A.

Let N be the projection of P on the diameter Y-axis.

If P completes one revolution then its projection point N makes one oscillation on the diameter.

3) If θ is the angular displacement of P at time t and

ω is uniform angular velocity then $\theta = \omega t$



4) From ΔOPN, $\sin\theta = \frac{ON}{OP} = \frac{y}{A} \Rightarrow y = A\sin\theta$

$\therefore$ Displacement $y = A\sin(\omega t)$..... (i)

5) Velocity is the 'rate of change of displacement'.

$\therefore$ Velocity $v = \frac{d}{dt}(y) = \frac{d}{dt}A\sin(\omega t) = A\frac{d}{dt}\sin(\omega t)$

$= A\omega\cos(\omega t)$ $\left[\because \frac{d}{dx}\sin(kx) = k\cos(kx)\right]$

6) Acceleration is the 'rate of change of velocity'.

$\therefore$ Acceleration $a = \frac{d}{dt}(v) = \frac{d}{dt}A\omega\cos(\omega t) = A\omega\frac{d}{dt}[\cos(\omega t)]$

$= -A\omega(\omega)[\sin(\omega t)] = -\omega^2[A\sin(\omega t)] = -\omega^2 y$, [from (i)] $\left[\because \frac{d}{dx}\cos(kx) = -k\sin(kx)\right]$

7) $\therefore a \propto -y$ $(\because \omega$ is a constant$)$

8) Hence the motion of projection N on any diameter is S.H.M.

P. On an average a human heart is found to beat 75 times in a minute. Calculate its frequency and period.

A. The beat frequency of heart = 75 / (1 min) = 75 / (60s) = 1.25 s^{-1} = 1.25 Hz
The time period T = 1/(1.25 s^{-1}) = 0.8 s.

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.