BK BIRLA CENTRE FOR EDUCATION

SARALA BIRLA GROUP OF SCHOOLS
SENIOR SECONDARY CO-ED DAY CUM BOYS' RESIDENTIAL SCHOOL

ANNUAL EXAMINATION (2023-24)

SUBJECT- PHYSICS (042)

Class: XI — Duration: **3 Hrs**
Date: 26/02/2024 — **Answer Key** — Max. Marks: **70**

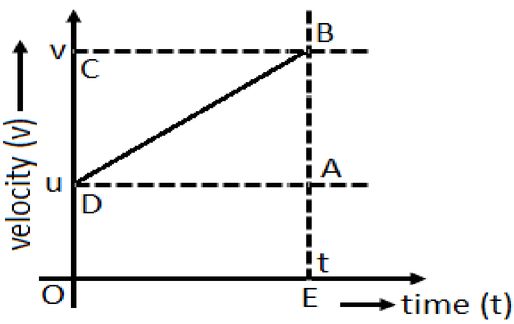
SECTION-A

1. (b) $[ML^{-1}T^{-1}]$
2. (c) Slope of the graph will keep on increasing.
3. (a) acceleration
4. (d) Kinetic energy is minimum.
5. (c) 1:4
6. (b) KE= $1/2\ I\omega^2$
7. (d) All of these
8. (b) hydraulic pressure
9. (b) Mercury
10. (c) Conduction
11. (b) decreases
12. (d) 40%
13. (c) If Assertion is true but Reason is false.
14. (a) If both Assertion and Reason are true and Reason is correct explanation of Assertion.
15. (d) If both Assertion and Reason are false.
16. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

SECTION-B

17. Newton's third law of motion states that for every action, there is an equal and opposite reaction. This means that when one object exerts a force on another object, the second object exerts an equal and opposite force on the first object.
The mathematical representation of Newton's third law of motion is
$\mathbf{F_{AB}=-F_{BA}}$, where
F_{AB} is the force exerted on object B by object A, and
F_{BA} is the force exerted on object A by object B. 2

18. 2



Distance covered by the object in the given time "t" is given by the area of the trapezium ABDOE.
Let in the given time (t), the distance covered by the moving object = s

the area of trapezium, ABDOE.
Distance (s) = Area of ΔABD + Area of ADOE.
s = ½ x AB x AD + (OD x OE)
s = ½ x DC x AD + (u x t) [∵ AB = DC]
s = ½ x at x t + ut [∵ DC = at]
s = ½ x at x t + ut Or s = ut + ½ at^2.
It is the expression gives the distance covered by the object moving with uniform acceleration.

OR

Given $u = 126 \text{ km/h} = 126 \times \frac{5}{18} \text{ m/s} = 35 \text{ m/s}$

$S = 200$ m and $v = 0$

As $v^2 - u^2 = 2as$

∴ $0 - (35)^2 = 2a \times 200$

⇒ $a = \frac{-(35)^2}{400} = -3.06 \text{ m/s}^2$

Also, $v = u + at$

⇒ $t = \frac{v-u}{a} = \frac{0-35}{-3.06} = 11.4$ s. 2

19. Work energy theorem -
It states that the work done by the net force acting on a body is equal to the changed produced in kinetic energy of the body.
Let F be the variable force
∴ Work done by this variable force, $W=\int_{xi}^{xf} F\cdot dx$
Where xi is the initial position and xf is final position.
Also Kinetic energy of an object, $K=1/2(mv^2)$
$\Rightarrow dK/dt=mvdv/dt$
$\Rightarrow dK/dt=madx/dt$
$\Rightarrow dK/dt=Fdx/dt$
$\Rightarrow dK=Fdx$
$\Rightarrow \int_{Ki}^{Kf} dK=\int_{xi}^{xf} F\cdot dx$
$\Rightarrow \Delta K=W$
Where ΔK is the change in kinetic energy 2

20.

$$W = \int_{V_1}^{V_2} PdV \quad ...(1)$$

The ideal gas equation is,

$$PV = nRT$$

or $$P = \frac{nRT}{V} \quad ...(2)$$

Substituting (2) in (1), we get,

$$W = \int_{V_1}^{V_2} \frac{nRT}{V} dV$$

For isothermal process T is constant

∴ $$W = nRT \int_{V_1}^{V_2} \frac{1}{V} dV$$

$$= nRT[\text{Ln}(V_2) - \text{Ln}(V_1)]$$

or $$W_{iso} = nRT\left[\text{Ln}\frac{V_2}{V_1}\right]$$ 2

21. Standing wave is also called stationary wave, combination of two waves moving in opposite directions, each having the same amplitude and frequency. The phenomenon is the result of interference that is when waves are superimposed, their energies are either added together or cancelled out. The necessary condition for the formation of a stationary wave is that the length of the rope must be an integral multiple of the wave length of the wave. Therefore, $l = n\lambda$, Where 'n' is a positive integer. 2

SECTION-C

22. Surface tension and surface energy, impulse and linear momentum, torque and work, frequency, angular velocity and velocity gradient.(Any Three) (1+1+1)

23. Uniform circular motion is motion in a circle at constant speed. Centripetal acceleration $\rightarrow a_C$ is the acceleration a particle must have to follow a circular path. Centripetal acceleration always points toward the center of rotation and has magnitude $a_C = v^2/r$. 3

24. Static friction is a force that keeps an object at rest. Kinetic friction is defined as a force that acts between moving surfaces. A body moving on the surface experiences a force in the opposite direction of its movement. The magnitude of the force will depend on the coefficient of kinetic friction between the two materials. Ball bearing reduce friction by using smooth balls lubricated with oil or grease that freely roll between a smooth inner and outer surface. The area of contact between inner and outer surface decreases hence friction decreases between them. 3

25. It is a type of collision in which momentum is conserved but energy is not conserved.
From conservation of momentum
$m_1v_1 = (m_1+m_2)\, v_2 \rightarrow v_2 = m_1 v_1 /(m_1+m_2)$ 1
The ratio of kinetic energies before & after collision is
$KE_f/KE_i = 1/2(m_1+m_2)[m_1v_1/(m_1+m_2)]^2/(1/2)m_1v_1^2 = m_1/(m_1+m_2)$ 1
The fraction of kinetic energy lost is
$(KE_i - KE_f)/KE_i = [1 - m1/(m1+m2)]KE_i/KE_i = m_2/(m_1+m_2)$ 1
Hence energy always loss in inelastic collision.

26. Moment of inertia, in physics, is the measure of the volume of rotating inertia of the body, i.e., the resistance of the body showing its rotational speed relative to the axis altered by the use of torque.
SI unit Kgm^2. Dimensional formula $[ML^2T^0]$
The moment of inertia depends on the following: Mass of the body. Size and shape of the body. 3
27.

$$\text{Compressibility} = \frac{1}{K} = (45.8 \times 10^{-11})\ \text{Pa}^{-1}$$

Pressure, $P = 80$ atm

$= 80 \times 1.013 \times 10^5$ Pa

Let change in volume,

$$\Delta V = \frac{M}{\rho} - \frac{M}{\rho d} = M\left(\frac{1}{\rho} - \frac{1}{\rho d}\right)$$

∴ Volumetric strain

$$= \frac{\Delta V}{V}$$

$$= M\left[\frac{1}{\rho} - \frac{1}{\rho_d}\right] \frac{E}{M} = 1 - \frac{\rho}{\rho_d} \quad 1$$

where ρ is density of water at surface and ρ_d is the density of water at depth.

$$\frac{\Delta V}{V} = \frac{1}{K}$$

$$1 - \left(\frac{1.03 \times 10^3}{\rho_d}\right) = 80 \times 1.013 \times 10^5$$

$$\times 45.8 \times 10^{-11}$$

$$P = 1.034 \times 10^3\ \text{kg m}^{-3}. \quad 1$$

3

Or

Ans. Torricelli's theorem : The velocity of efflux i.e., the velocity with which the liquid flows out of an orifice (i.e., a narrow hole) is equal to that which is freely falling body would acquire in falling through a vertical distance equal to the depth of orifice below the free surface of liquid.

Consider ideal liquid of density ρ contained in a tank provided with a narrow hole.

Let h = Height of free surface of liquid above O.

P = Atmospheric pressure

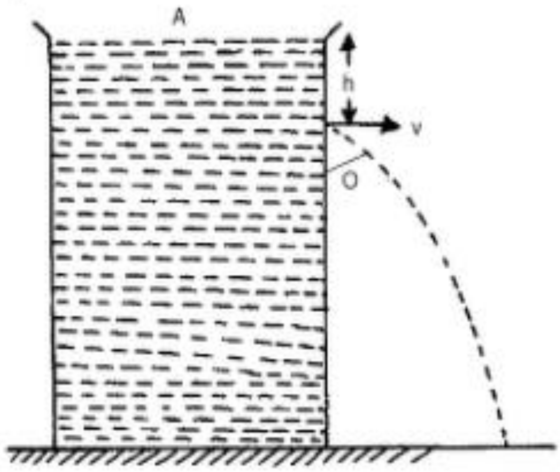
v = Velocity of efflux

Applying Bernoulli's theorem at A and O

$$(P + \rho gh + 0)_{at A} = [P + 0 + \frac{1}{2}\rho v^2]_{at O}$$

$$P + \rho gh = P + \frac{1}{2}\rho v^2 = \rho gh = \frac{1}{2}\rho v^2$$

$$v = \sqrt{2gh}$$



3

28. According to Newton, velocity of sound in any medium is given by v=E/ρ where E is the modulus of elasticity and ρ is the density of the medium. 3

For gases E = B, bulk modulus

∴v=B/ρ............(1)

When sound waves travel through a gas alternate compressions and rarefactions are produced. At the compression region pressure increases and volume decreases and at the rerefaction region pressure decreases and volume increases. Newton assumed that these changes take place under isothermal conditions i.e., at a constant temperature.

Under isothermal condition, B = P, pressure of the gas.
∴ In (1) $v=P/\rho$............(2)
This is Newton's formula for velocity of sound in gas.
For air at NTP, P=101.3 kPa and p=1.293 kgm^{-3}
Substituting the values of P and p in, equation (1) we get v = 280 m/s. This is much lower than the experimental value of 332 m/s. Thus Newton's formula is discarded.Laplace's correction:
According to Laplace, in a compressed region temperature increases and in a rarefied region it decreases and these changes take place rapidly. Since air is an insulator, there is no conduction of heat. Thus changes are not isothermal but adiabatic.
Under adiabatic condition, B=y P, where y is the ratio of specific heats of the gas.
Substituting in equation (1) $v=\gamma P/\rho$
The above equation is called Newton - Laplace's equation
Substituting the values of P, p and y in the above equation, give the velocity of sound in air at NTP to be about 331 m/s. This is in close agreement with the experimental value.

SECTION-D
Case Study Based Questions

29. (i) (c) 80 s 1
(ii) (a) 50 km/h 1
(iii) (a) 17.14 m/s
OR
(iii) (d) 15 m/s 1
(iv) (b) 2 1

30.
(i) (a) Water 1
(ii) (c) no change in temperature whether heat is taken in or given out 1
(iii) (c) it has high specific heat. 1
(iv) (a) From 14.5°C to 15.5°C at 760 mm of Hg 1
Or
(iv) (d) 33.6 J/°C

SECTION-E

31. Acceleration due to gravity can be defined as the acceleration produced in an object due to the gravitational force of the earth.
The force acting on a body due to gravity is given by-
$F=m'g$ (1)
The Universal law of Gravitation states that $f= GmEm /r^2$ (2)
Here, f= force between two bodies; g= universal gravitational constant; m'= mass of body; m= mass of earth; r= radius of earth.
On equating (1) and (2),
$m'g = Gm_E m/r^2$
Since mass of the object (m') is constant,
$g = Gm_E/r^2$
Hence, the expression for acceleration due to gravity is $g = GmE/r^2$
We know that,
$g=GM/R^2 \Rightarrow M=gR^2/G$
Substituting the values,

M=9.8 × $(6400\times10^{3})^{2}/6.67\times10^{-11}$
M=6.01×1024kg
Density= mass/ volume

= 6 x 10^{24}/ (4/3 X3.14) × $(6400\times10^{3})^{2}$ = 5.5 X 10^{3} kg/m^{3} 5

OR

Escape speed is the minimum speed with which a mass should be projected from the Earth's surface in order to escape Earth's gravitation field. Consider the escape speed, the minimum speed required by an object to escape Earth's gravitational field, hence replace vi with v_e. 5

$$\frac{1}{2}Mv_i^2 = \frac{GMM_E}{R_E}$$

$$v_e^2 = \frac{GMM_E}{R_E}\cdot\frac{2}{M}$$

$$\text{Using } g = \frac{GM_E}{R_e^2}$$

$$v_e^2 = \frac{2GM_E}{R_E}$$

$$v_e^2 = 2gR_E$$

$$v_e = \sqrt{2gR_E} \quad ...(4)$$

The escape velocity on the surface of moon is lesser than the RMS velocity of the molecules of gas at the surface temperature of moon. Therefore, the gas molecules escape and hence moon cannot hold an atmosphere.

32. (i)

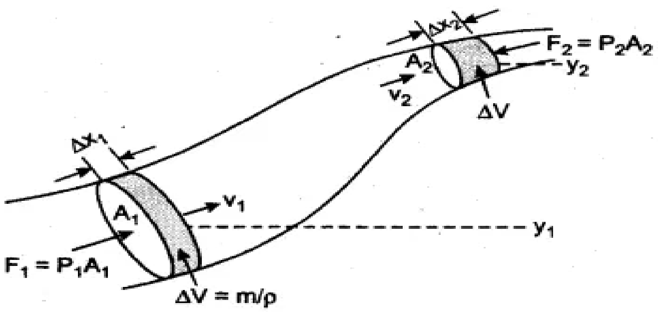


Fig. : The flow ideal liquid in the tube of non uniform area of cross section.

3

$$E_B = m\frac{P_B}{\rho} + \frac{1}{2}mv_B^2 + mg\,h_B$$

From the law of conservation of energy, $E_A = E_B$

$$m\frac{P_A}{\rho} + \frac{1}{2}mv_A^2 + mgh_A = m\frac{P_B}{\rho} + \frac{1}{2}mv_B^2 + mg\,h_B$$

$$\frac{P_A}{\rho} + \frac{1}{2}v_A^2 + gh_A = \frac{P_B}{\rho} + \frac{1}{2}v_B^2 + gh_B = \text{constant}$$

Thus, the above equation can be written as

$$\frac{P}{\rho g} + \frac{1}{2}\frac{v^2}{g} + h = \text{constant}$$

(ii)

Given : $A_a = 8mm^2$ $A_n = 4mm^2$ $P_a - P_n = 24$ Pa

Let the speed of blood in artery and narrow part be v_a and v_n respectively.

From continuity equation : $A_a v_a = A_n v_n$

$\therefore\ 8v_a = 4v_n \implies v_n = 2v_a$

Using Bernoulli's equation : $P_a + \rho g h_a + \frac{1}{2}\rho v_a^2 = P_n + \rho g h_n + \frac{1}{2}\rho v_n^2$ where

$h_n = h_n$

$\therefore\ P_a - P_n = \frac{1}{2}\rho(v_n^2 - v_a^2)$

$\therefore\ 24 = \frac{1}{2} \times 1.06 \times 10^3 (4v_a^2 - v_a^2)$

$\implies v_a = 12.5 \times 10^{-2}\ m/s$

2

Or

(I) There are three modes of heat transfer: 3

1. Conduction

Heat conduction is a process in which heat is transferred from the hotter part to the colder part of a body without involving any actual movement of the molecules of the body.

For example: When frying vegetables in a pan. Heat transfer takes place from the flame to the pan and then to the vegetables.

2. Convection

In this process, heat is transferred in the liquid and gases from a region of higher temperature to a region of lower temperature. Heat transfer through convection occurs partly due to the actual movement of molecules or due to the mass transfer.

For example. Heating of milk in a milk bowl.

3. Radiation

is the process in which heat is transferred from one body to another body without involving the molecules of the medium. Heat transfer through radiation does not depend on the medium.

For example Heat energy transfers from the sun to earth through radiation.

(i)

Here, $\Delta T = 30°C$

and $\gamma = 49 \times 10^{-5}\ °C^{-1}$

$V = V_0 [1 + \gamma \Delta T]$, we get

$V = V_0 [1 + (49 \times 10^{-5})(30)]$

$= 1.015\ V_0$

Initial density, $\rho_0 = \frac{m}{V_0}$

Final density, $\rho = \frac{m}{V} = \frac{m}{1.015 V_0} = \frac{\rho_0}{1.015}$

$= 0.986\ \rho_0$

Fractional change in density

$= \frac{\rho_0 - \rho}{\rho_0} = \frac{\rho_0 - \rho}{\rho_0} (0.986)$

$= 0.014$

2

33. On comparing this displacement equation with y (x, t) = a sin (kx – ωt), we find

(a) The amplitude of the wave is 0.005 m = 5 mm.

(b) The angular wave number k and angular frequency ω are $k = 80.0\ m^{-1}$ and $\omega = 3.0\ s^{-1}$.

We, then, relate the wavelength λ to k through Eq. $\lambda = 2\pi/k$

(c) $= 2\pi\ /80.0\ m^{-1} = 7.85$ cm

Now, we relate T to ω by the relation $T = 2\pi/\omega = 2\pi\ /3.0\ s^{-1} = 2.09$ s

And frequency, $v = 1/T = 0.48$ Hz

The displacement y at x = 30.0 cm and time t = 20 s is given by

$y = (0.005\ m) \sin (80.0 \times 0.3 - 3.0 \times 20) = (0.005\ m) \sin (-36 + 12\pi) = (0.005\ m) \sin (1.699) = (0.005\ m) \sin (97^o) = 5$ mm

Or

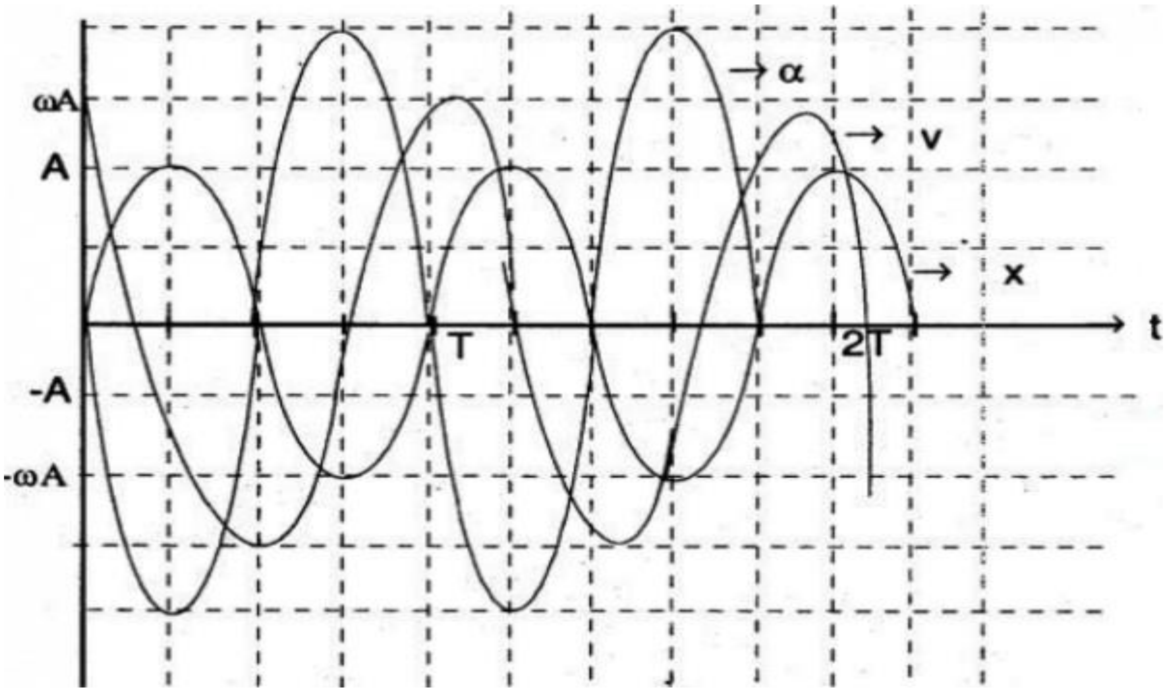
The relation in phase between displacement, velocity and acceleration in SHM can be shown graphically.

Displacement $x=A\sin(\omega t+\varphi 0)$ 5

Velocity, $v=\omega A\cos(\omega t+\varphi 0)$

Acceleration $a=-\omega 2A\sin(\omega t+\varphi 0)$

Here, x and v differ in phase by π/2, v and a differ in phase by π/2.



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