# Physicsaholics

**DPP – 2 (SHM)**

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Q 1. A particle executing S.H.M of amplitude 4 cm and T = 4 sec. The time taken by it to move from positive extreme position to half the amplitude is -

(a) 1 sec (b) 1/3 sec (c) 2/3 sec (d) $\sqrt{\frac{3}{2}}$sec

Q 2. A particle performing S.H.M. undergoes displacement of A/2 (where A = amplitude of S.H.M.) in one second. At t = 0 the particle was located at either extreme position or mean position. The time period of S.H.M. can be : (consider all possible cases)

(a) 12s (b) 2.4 (c) 6s (d) 1.2s

Q 3. A particle performs SHM in a straight line. In the first second, starting from rest, it travels a distance a and in the next second it travels a distance b in the same direction. The amplitude of the SHM is

(a) a – b (b) $\frac{2a-b}{3}$ (c) $\frac{2a^2}{3a-b}$ (d) None

Q 4. Displacement-time equation of a particle executing SHM is:

$x = A\sin\left(\omega t + \frac{\pi}{6}\right)$.

Time taken by the particle to go directly from $x = -\frac{A}{2}$ to $x = +\frac{A}{2}$ is:

(a) $\frac{\pi}{3\omega}$ (b) $\frac{\pi}{2\omega}$ (c) $\frac{2\pi}{\omega}$ (d) $\frac{\pi}{\omega}$

Q 5. A particle is executing SHM on a straight line. A and B are two points at which its velocity is zero. It passes through a certain point P (AP <BP) at successive intervals of 0.5 s and 1.5 s with a speed of 3 m/s:

(a) the maximum speed of particle is $3\sqrt{2}$ m/s

(b) the maximum speed of particle is $\sqrt{2}$ m/s

(c) the ratio $\frac{AP}{BP}$ $is$ $\frac{\sqrt{2}-1}{\sqrt{2}+1}$

(d) the ratio $\frac{AP}{BP}$ $is$ $\frac{1}{\sqrt{2}}$

Q 6. In simple harmonic motion of a particle maximum kinetic energy is 40 J and maximum potential energy is 60 J.Then:

(a) minimum potential energy will be 20 J

(b) potential energy at half the displacement will be 30 J

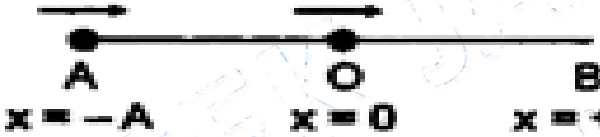
(c) kinetic energy at x = A/2 is 30 J . Where A is amplitude.

(d) potential energy or kinetic energy at some intermediate position cannot be found from the given data

Q 7. The displacement-time equation of a particle executing SHM is : $x = A \sin(\omega t + \phi)$. At time t =0 position of the particle is x = A/2 and it is moving along negative x-direction. Then the angle $\phi$ may be:
(a) $\pi/6$ (b) $\pi/3$ (c) $2\pi/3$ (d) $5\pi/6$

Q 8. A linear harmonic oscillation of force constant $2 \times 10^6$ N/m and amplitude 0.01 m has a total mechanical energy of 160 joules. Its -
(a) Maximum potential energy is 100 J
(b) Maximum K.E. is 100 J
(c) Maximum P.E. is 40 J
(d) Minimum P.E is zero

Q 9. Two particles undergo SHM along the same line with the same time period (T) and equal amplitudes (A). At a particular instant one particle is at x = - A and the other is at x = 0. They move in the same direction. They will cross each other at:




(a) 4T/3 (b) 3T/8 (c) x = A/2 (d) $x = \frac{A}{\sqrt{2}}$

Q 10. Two Particles A & B are executing SHM along same line about same point with same amplitude but different time periods 3 sec and 6 sec respectively. At t = 0 , A is at –ve extreme and B is at +ve extreme . Find t when they meet first time
(a) 1sec
(b) 2 sec
(c) 3 sec
(d) 4 sec

Q 11. Two Particles A & B are executing SHM along same line about same point with same amplitude 2 meter and same time period 4 sec. Phase difference between A and B is $\pi/3$. maximum separation between them during motion is
(a) 1m
(b) 2m
(c) 1.5 m
(d) None of these

Q 12. Two particles are in SHM on same straight line with amplitude A and 2A and with same angular frequency $\omega$. It is observed that when first particle is at a distance $A/\sqrt{2}$ from origin and going toward mean position, other particle is at extreme position on other side of mean position. Find phase difference between the two particles
(a) $45^o$ (b) $90^o$ (c) $135^o$ (d) $180^o$

Q 13. Two particles are in SHM with same angular frequency and amplitudes A and 2A respectively along same straight line with same mean position. They cross each other at position A/2 distance from mean position while moving in opposite direction. The phase difference between them is :

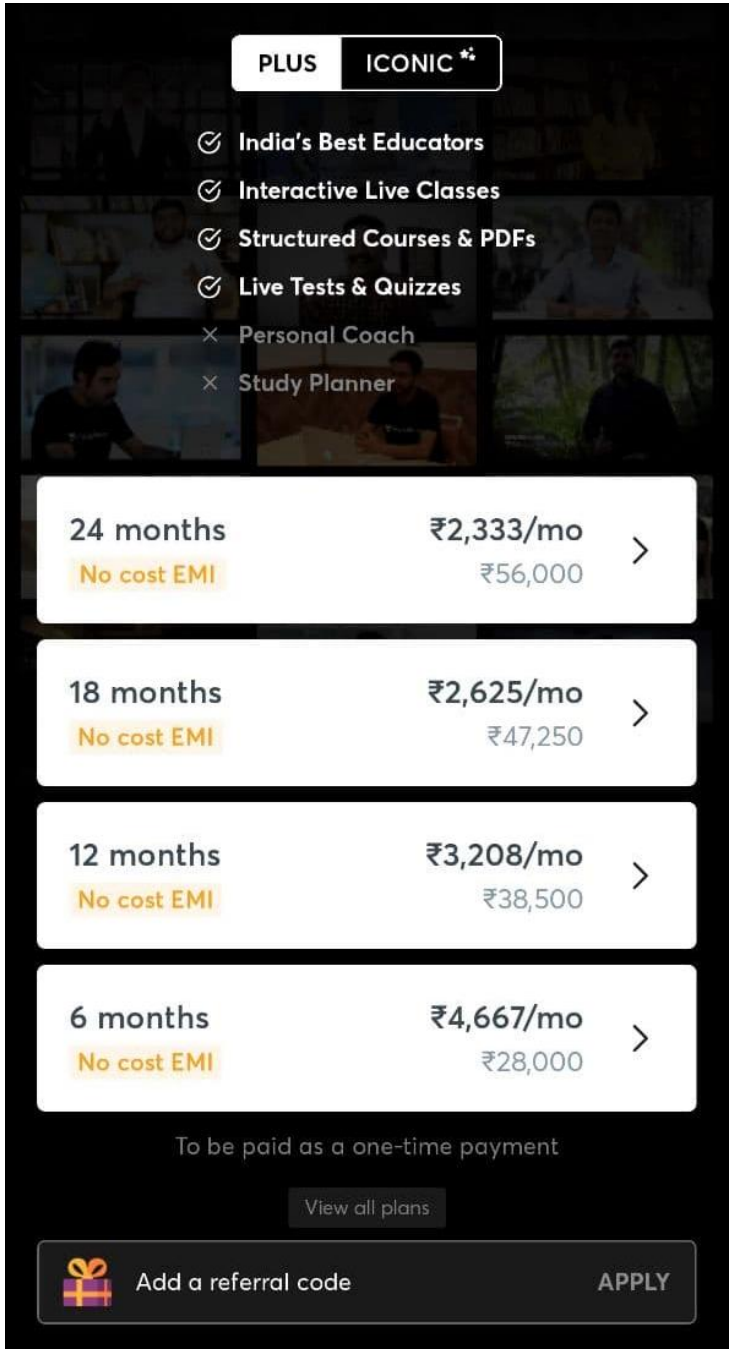
(a) $\frac{5\pi}{6} - sin^{-1}\left(\frac{1}{4}\right)$ (b) $\frac{\pi}{6} - sin^{-1}\left(\frac{1}{4}\right)$

(c) $\frac{5\pi}{6} - cos^{-1}\left(\frac{1}{4}\right)$ (d) $\frac{\pi}{6} - cos^{-1}\left(\frac{1}{4}\right)$



# Answer Key

| | | | | |
|---|---|---|---|---|
| **Q.1 c** | **Q.2 a, b, c, d** | **Q.3 c** | **Q.4 a** | **Q.5 a, c** |
| **Q.6 a, b, c** | **Q.7 d** | **Q.8 b** | **Q.9 b, d** | **Q.10 a** |
| **Q.11 b** | **Q.12 c** | **Q.13 a** | | |

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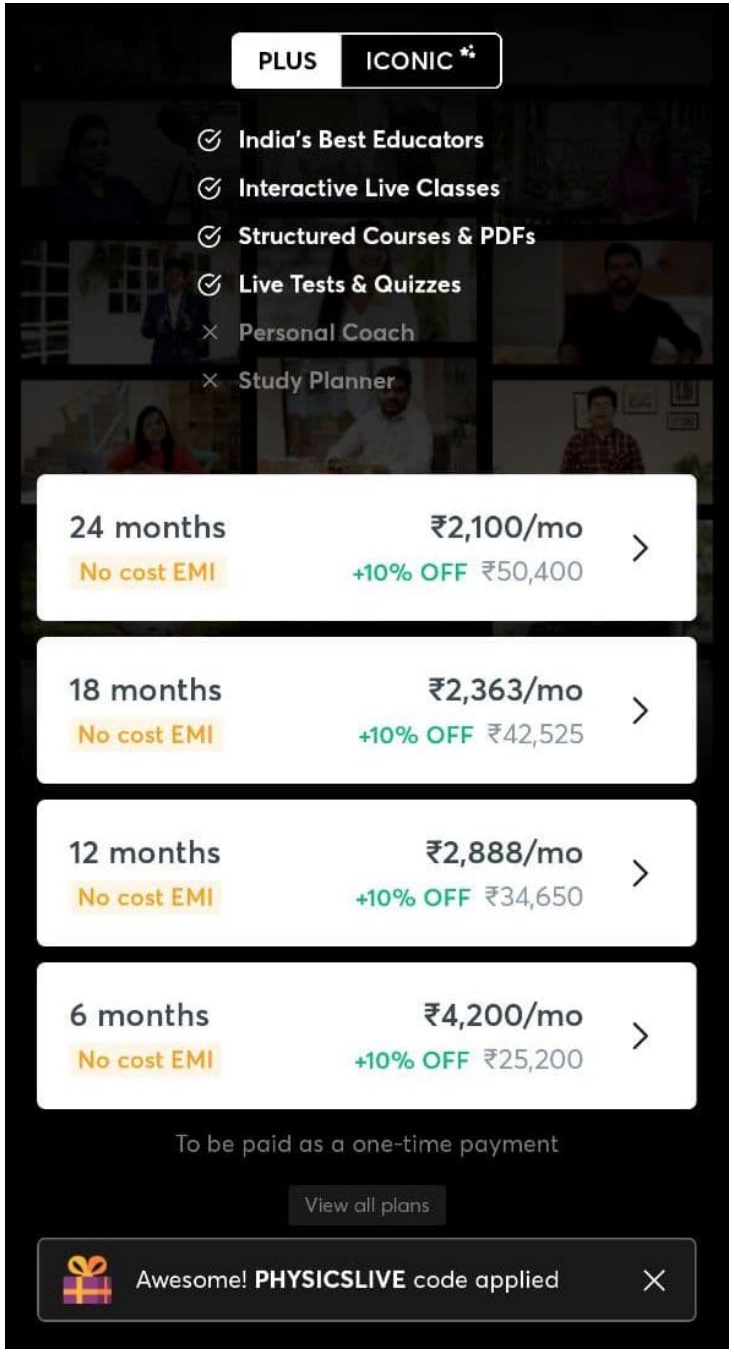
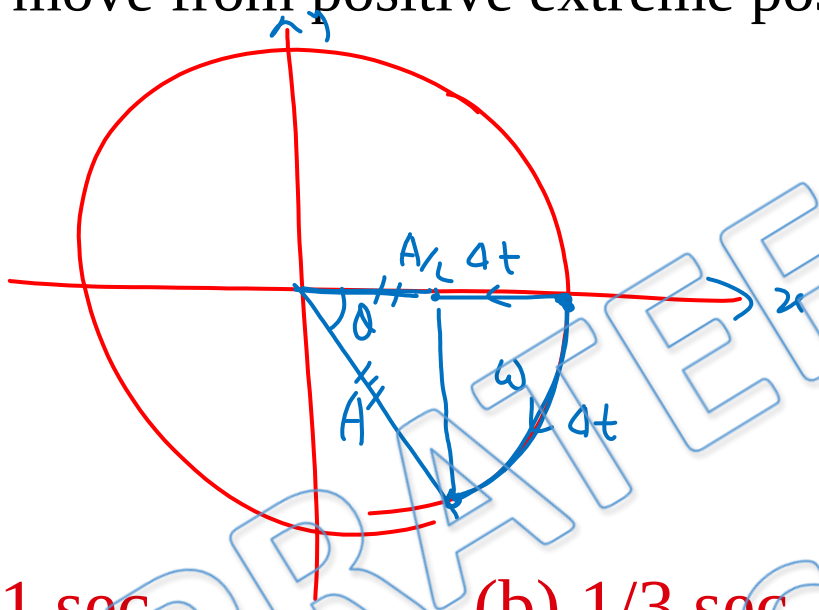


# JEE Main & Advanced, NSEP, INPhO, IPhO
# Physics DPP - Solution

## DPP- 2 S.H.M. : S.H.M. as a Projection of Uniform Circular Motion and Energy of S.H.M.

By Physicsaholics Team

Q1) A particle executing S.H.M of amplitude 4 cm and T = 4 sec. The time taken by it to move from positive extreme position to half the amplitude is -




$$\omega = \frac{2\pi}{T} = \pi/2$$

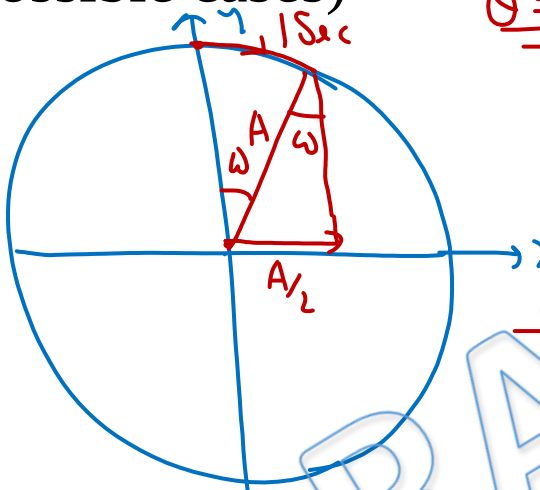
$$\cos\theta = \frac{A/2}{A} = 1/2$$

$$\theta = \pi/3$$

$$t = \frac{\theta}{\omega} = \frac{\pi/3}{\pi/2} = 2/3 \text{ Sec}$$

(a) 1 sec (b) 1/3 sec (c) 2/3 sec (d) $\sqrt{\frac{3}{2}}$sec

Q2) A particle performing S.H.M. undergoes displacement of A/2 (where A = amplitude of S.H.M.) in one second. At t = 0 the particle was located at either extreme position or mean position. The time period of S.H.M. can be : (consider all possible cases)




$\theta = \omega t$

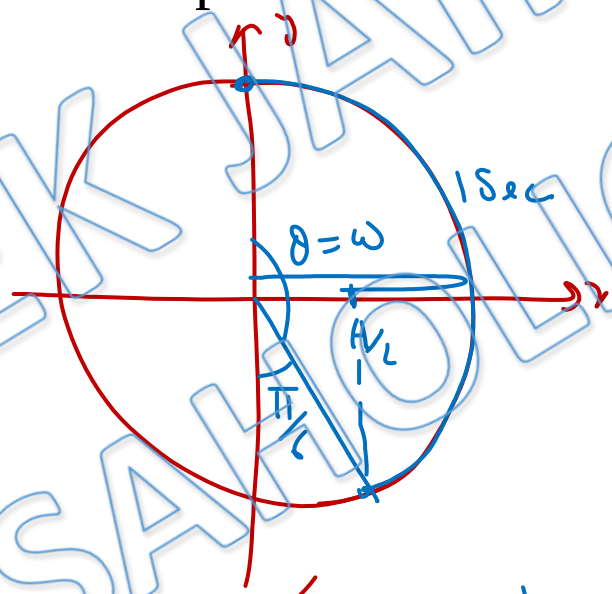
$\sin\omega = \frac{1}{2}$

$\omega = \frac{\pi}{6}$

$T = \frac{2\pi}{\omega} = \frac{2\pi \times 6}{\pi}$

$= 12\,Sec$

(a) 12s

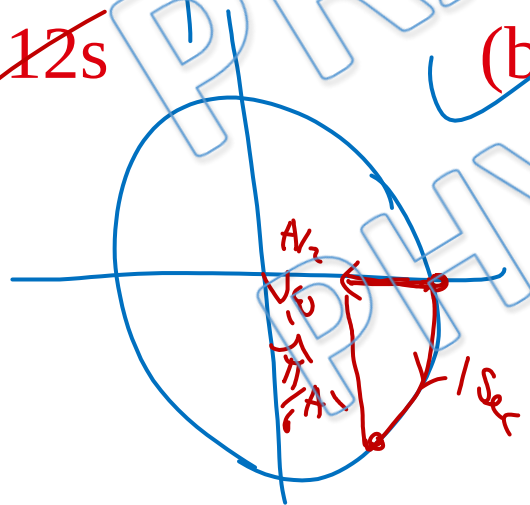



$\theta = \pi - \frac{\pi}{6} = \frac{5\pi}{6}$

$T = \frac{2\pi}{\omega} = \frac{2\pi \times 6}{5\pi}$

$= 2.4\,Sec$

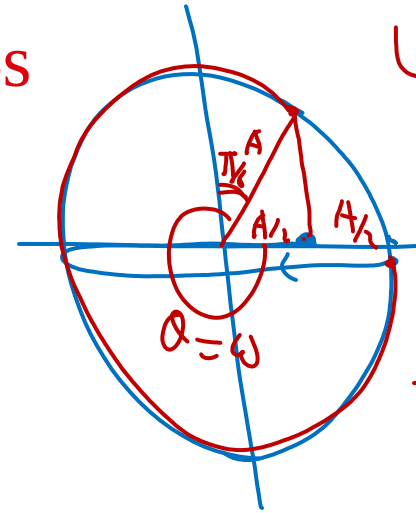
(b) 2.4




$\omega = \frac{\pi}{2} - \frac{\pi}{6} = \frac{3\pi - \pi}{6} = \frac{\pi}{3}$

$T = \frac{2\pi \times 3}{\pi} = 6\,Sec.$

(c) 6s




$\theta = \frac{3\pi}{2} + \frac{\pi}{6}$

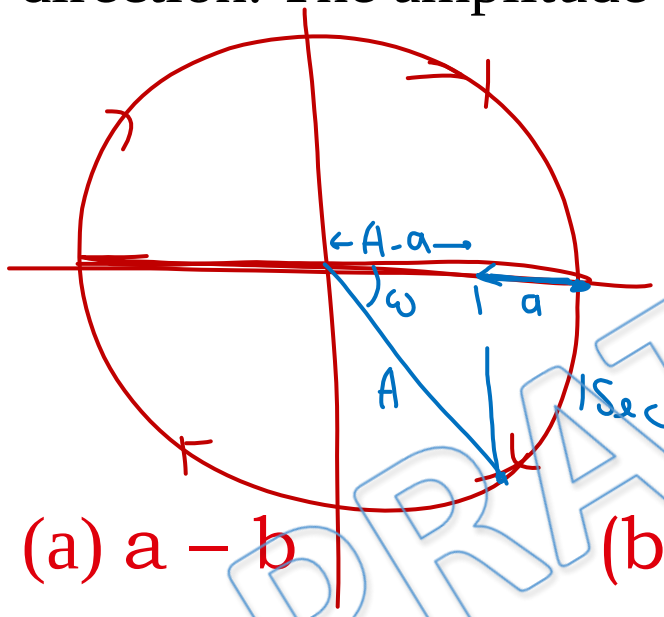
$\omega = \frac{9\pi + \pi}{6}$

$\omega = \frac{5\pi}{3}$

$T = \frac{2\pi \times 3}{5\pi} = 1.2\,Sec$

(d) 1.2s

Q3) A particle performs SHM in a straight line. In the first second, starting from rest, it travels a distance a and in the next second it travels a distance b in the same direction. The amplitude of the SHM is




$A - a = A\cos\omega$

$a = A(1-\cos\omega) \quad --(I)$

$a+b = A(1-\cos 2\omega) \quad --(II)$

$= A(1-1+2\sin^2\omega)$

(a) a – b (b) $\frac{2a-b}{3}$ (c) $\frac{2a^2}{3a-b}$ (d) None

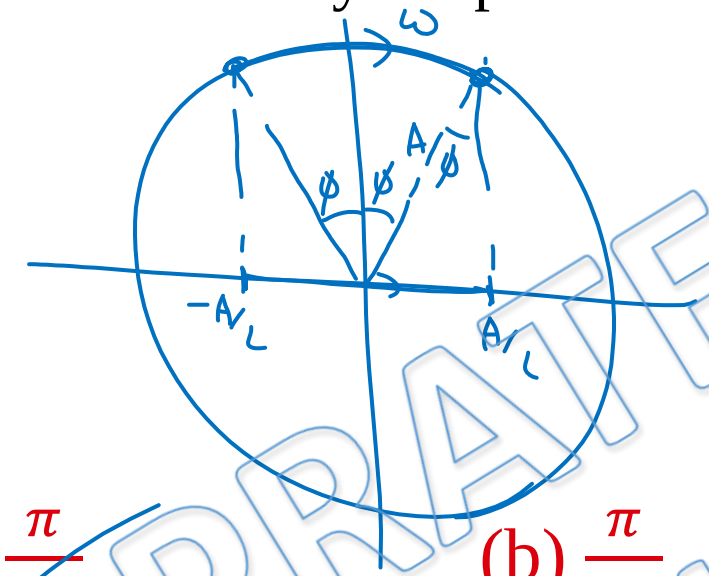
$\frac{a+b}{2A} = 1-\cos^2\omega = (1-\cos\omega)(1+\cos\omega) = \frac{a}{A}\left(1+1-\frac{a}{A}\right)$

$\frac{a+b}{2a} = 2-\frac{a}{A} \Rightarrow \frac{a}{A} = 2-\frac{a+b}{2a} = \frac{3a-b}{2a}$

$A = \frac{2a^2}{3a-b}$

Q4) Displacement-time equation of a particle executing SHM is: $x = A\,sin\left(\omega t + \frac{\pi}{6}\right)$ .

Time taken by the particle to go directly from $x = -\frac{A}{2}$ to $x = +\frac{A}{2}$ is:




$\cos\phi = A/2 / A$

$\phi = \pi/6$

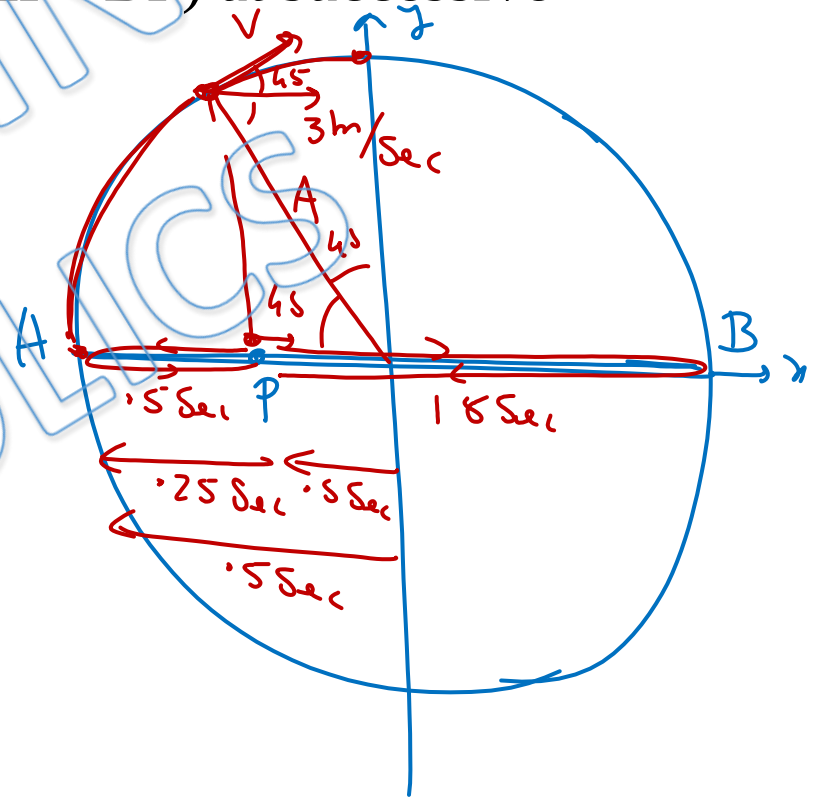
$2\phi = \pi/3$

$t = \frac{2\phi}{\omega} = \frac{\pi}{3\omega}$

(a) $\frac{\pi}{3\omega}$ (b) $\frac{\pi}{2\omega}$ (c) $\frac{2\pi}{\omega}$ (d) $\frac{\pi}{\omega}$

Q5) A particle is executing SHM on a straight line. A and B are two points at which its velocity is zero. It passes through a certain point P (AP <BP) at successive intervals of 0.5 s and 1.5 s with a speed of 3 m/s:

$T = 5 + 1 = 2\ Sec$, $T/4 = 5\ Sec$




(a) the maximum speed of particle is $3\sqrt{2}$ m/s

(b) the maximum speed of particle is $\sqrt{2}$ m/s

(c) the ratio $\frac{AP}{BP}$ *is* $\frac{\sqrt{2}-1}{\sqrt{2}+1}$

(d) the ratio $\frac{AP}{BP}$ *is* $\frac{1}{\sqrt{2}}$

$V\cos 45 = 3$

$V = 3\sqrt{2}\ m/Sec$

$\frac{AP}{BP} = \frac{A - A/\sqrt{2}}{A + A/\sqrt{2}} = \frac{\sqrt{2}-1}{\sqrt{2}+1}$

Q6) In simple harmonic motion of a particle maximum kinetic energy is 40 J and maximum potential energy is 60 J.Then:

$U_{A/2} = U_0 + \frac{1}{2} m\omega^2 \left(\frac{A}{2}\right)^2 = 20 + \frac{1}{4} \times \left(\frac{1}{2} m\omega^2 A^2\right)$

$= 20 + 10 = 30\,J$

$K_{max} = \frac{1}{2} m\omega^2 A^2 = 40$

$U_{max} = U_0 + \frac{1}{2} m\omega^2 A^2 = 60$

$U_0 = 20\,J$

PE at mean position → minimum PE

(a) minimum potential energy will be 20 J

(b) potential energy at half the displacement will be 30 J

(c) kinetic energy at x = A/2 is 30 J . Where A is amplitude.

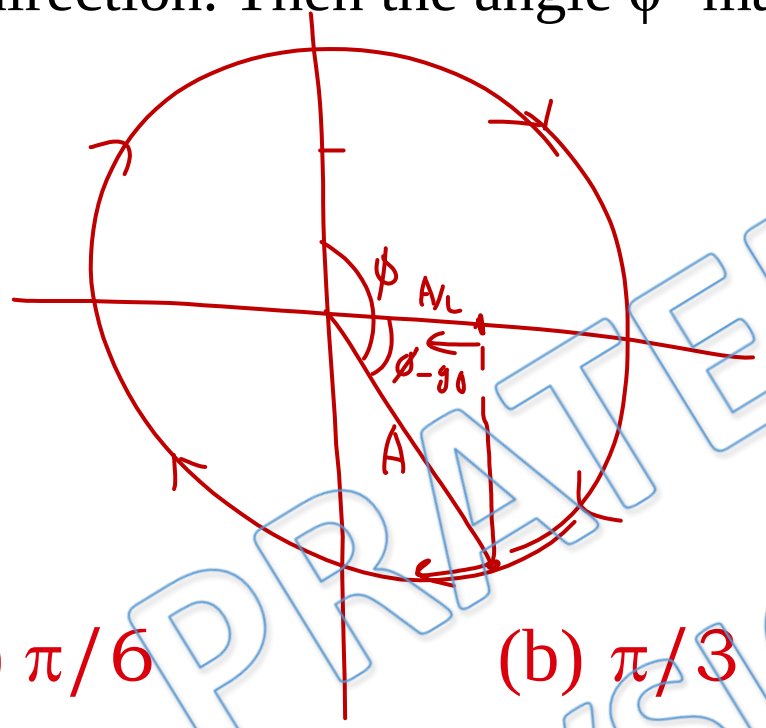
(d) potential energy or kinetic energy at some intermediate position cannot be found from the given data

T.ME = max PE = 60

at $x = A/2$, $U = 30\,J$

$K = 60 - 30 = 30\,J$

Q7) The displacement-time equation of a particle executing SHM is : $x = A \sin(\omega t + \phi)$. At time t =0 position of the particle is x = A/2 and it is moving along negative x-direction. Then the angle $\phi$ may be:




$\cos(\phi - 90) = \frac{1}{2}$

$\phi - 90^\circ = \pi/3$

$\phi = \frac{\pi}{2} + \frac{\pi}{3}$

$= \frac{5\pi}{6}$

(a) $\pi/6$ (b) $\pi/3$ (c) $2\pi/3$ (d) $5\pi/6$

Q8) A linear harmonic oscillation of force constant $2 \times 10^6$ N/m and amplitude 0.01 m has a total mechanical energy of 160 joules. Its -

$T.ME = PE_{max} = U_0 + \frac{1}{2} m\omega^2 A^2 = 160\,J$

$\min PE = U_0 = 160 - 100$

$= 60\,J.$

(a) Maximum potential energy is 100 J

(b) ~~Maximum~~ Maximum K.E. is 100 J

(c) Maximum P.E. is 40 J

(d) Minimum P.E is zero

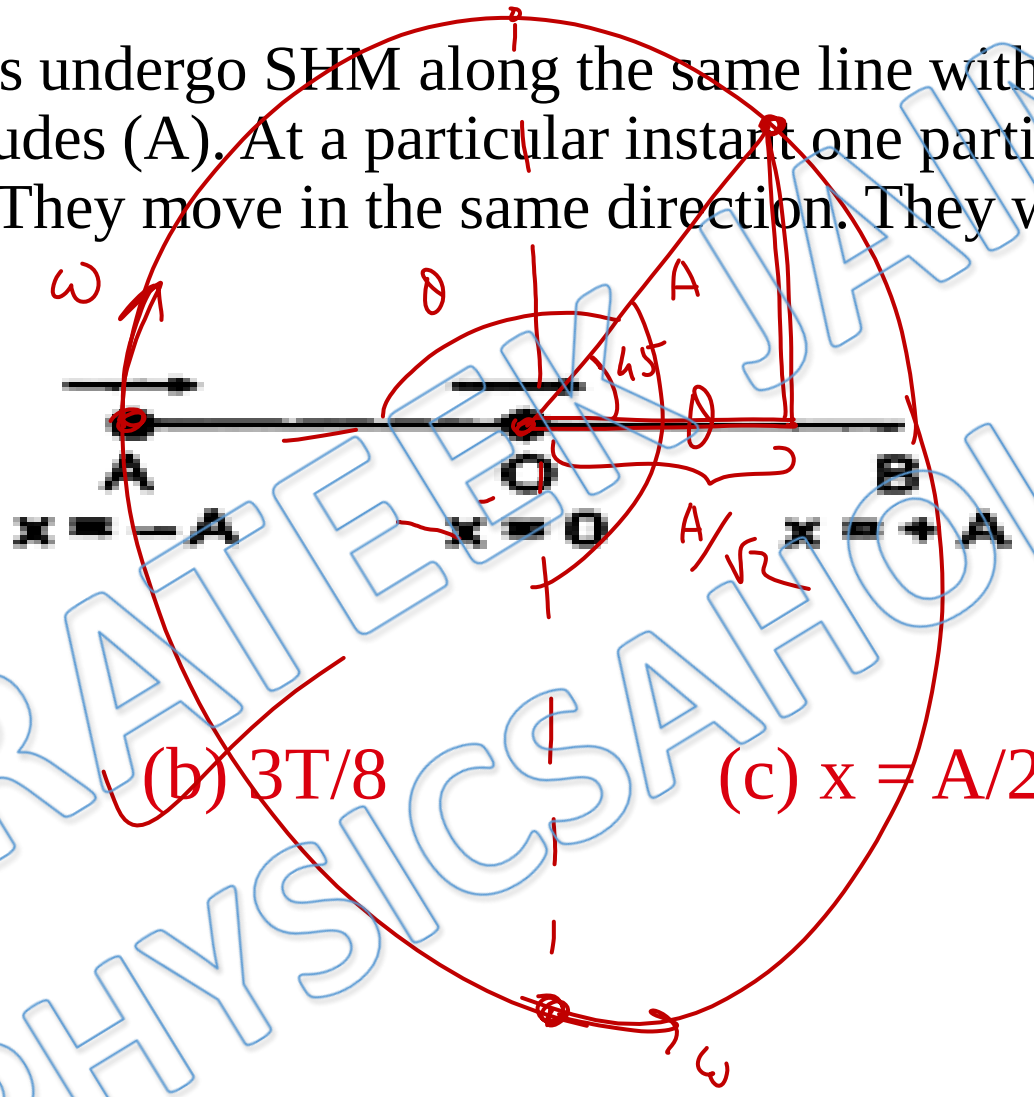
$KE_{max} = \frac{1}{2} m\omega^2 A^2$

$= \frac{1}{2} KA^2$

$= \frac{1}{2} \times 2 \times 10^6 \times 10^{-4}$

$= 100\,J.$

Q9) Two particles undergo SHM along the same line with the same time period (T) and equal amplitudes (A). At a particular instant one particle is at x = - A and the other is at x = 0. They move in the same direction. They will cross each other at:




$2\theta = 3\pi/2$

$\theta = 3\pi/4$

$t = \frac{\theta}{\omega} = \frac{3\pi}{4 \times 2\pi} T$

$= 3T/8$

(a) 4T/3 (b) 3T/8 (c) x = A/2 (d) $x = \frac{A}{\sqrt{2}}$

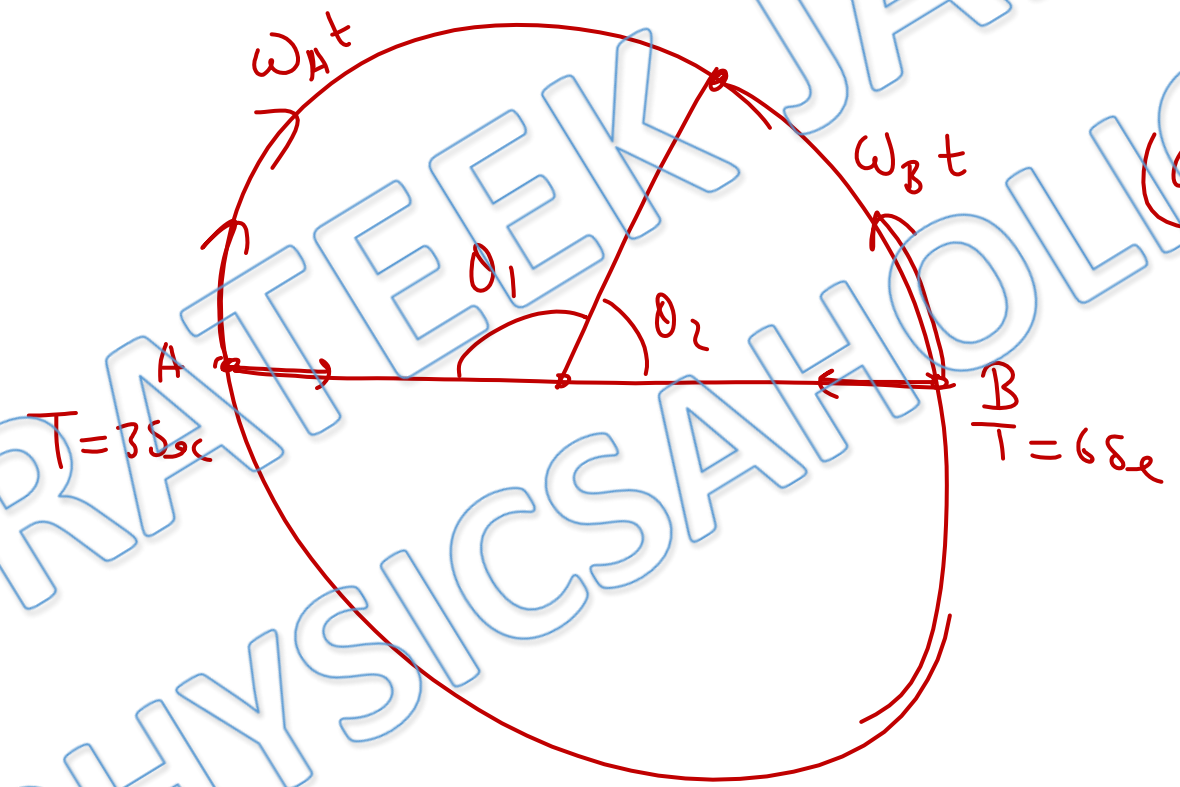
Q10) Two Particles A & B are executing SHM along same line about same point with same amplitude but different time periods 3 sec and 6 sec respectively. At t = 0 , A is at –ve extreme and B is at +ve extreme . Find t when they meet first time

(a) 1sec

(b) 2 sec

(c) 3 sec

(d) 4 sec




$\theta_1 + \theta_2 = \pi$

$(\omega_A + \omega_B)\, t = \pi$

$$t = \frac{\pi}{\frac{2\pi}{3} + \frac{2\pi}{6}}$$

$= 1\,Sec$

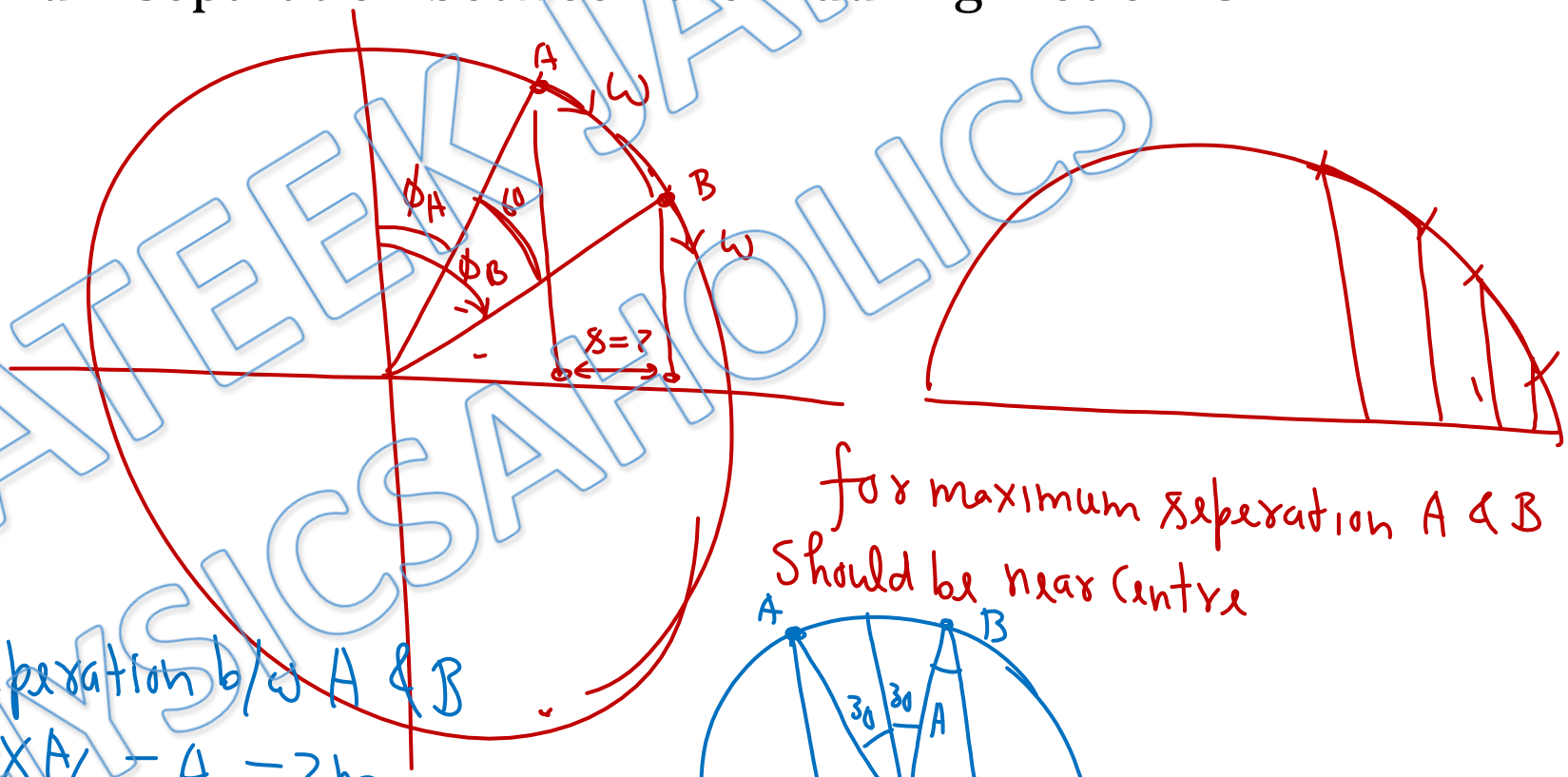
Q11) Two Particles A & B are executing SHM along same line about same point with same amplitude 2 meter and same time period 4 sec. Phase difference between A and B is $\pi/3$. maximum separation between them during motion is

(a) 1m

(b) 2m

(c) 1.5 m

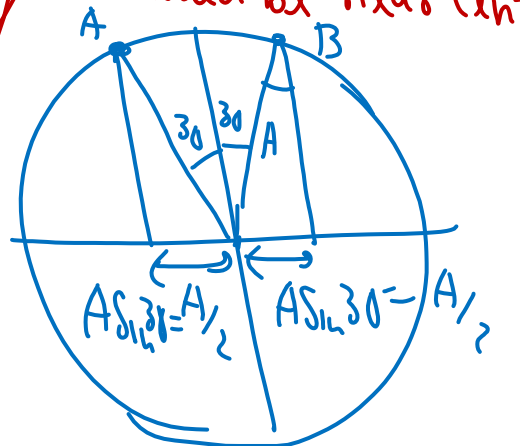
(d) None of these



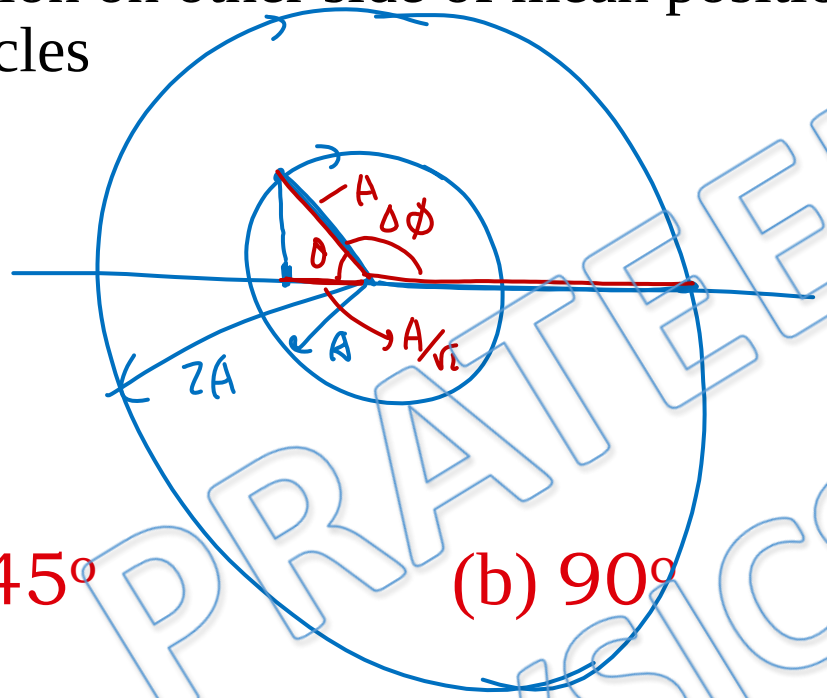

max separation b/w A & B
$= 2 \times A/2 = A = 2m$



for maximum separation A & B
Should be near centre



Q12) Two particles are in SHM on same straight line with amplitude A and 2A and with same angular frequency ω. It is observed that when first particle is at a distance $A/\sqrt{2}$ from origin and going toward mean position, other particle is at extreme position on other side of mean position. Find phase difference between the two particles




$\cos\theta = 1/\sqrt{2}$

$\theta = 45^\circ$

$\Delta\phi = \pi - \theta$

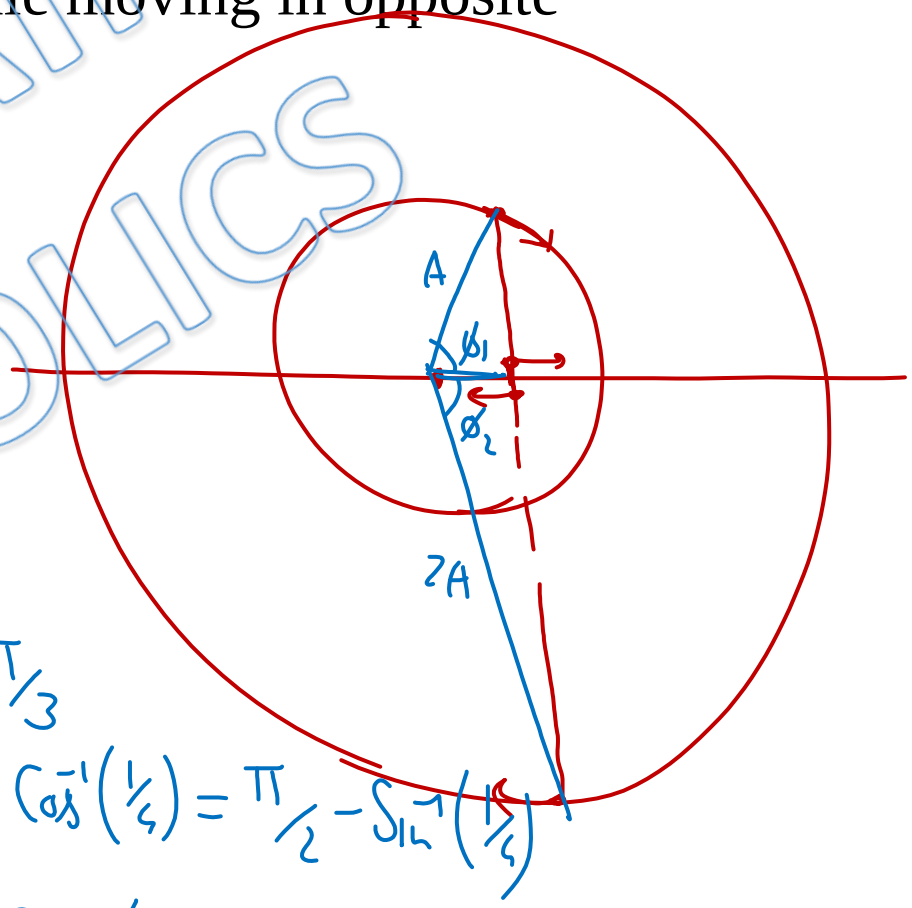
$= 135^\circ$

(a) 45° (b) 90° (c) 135° (d) 180°

Q13) Two particles are in SHM with same angular frequency and amplitudes A and 2A respectively along same straight line with same mean position. They cross each other at position A/2 distance from mean position while moving in opposite direction. The phase difference between them is :

(a) $\frac{5\pi}{6} - sin^{-1}\left(\frac{1}{4}\right)$ (b) $\frac{\pi}{6} - sin^{-1}\left(\frac{1}{4}\right)$

(c) $\frac{5\pi}{6} - cos^{-1}\left(\frac{1}{4}\right)$ (d) $\frac{\pi}{6} - cos^{-1}\left(\frac{1}{4}\right)$




$\cos\phi_1 = 1/2 \Rightarrow \phi_1 = \pi/3$

$\cos\phi_2 = 1/4 \Rightarrow \phi_2 = \cos^{-1}(1/4) = \pi/2 - \sin^{-1}(1/4)$

$\Delta\psi = \phi_1 + \phi_2 = \pi/3 + \pi/2 - \sin^{-1}(1/4)$

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