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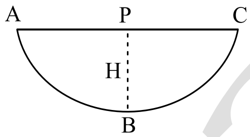
4.OSCILLATIONS,5.OSCILLATIONS

Single Correct Answer Type

1. A particle executes a SHM between $x = -A$ and $x = +A$. If T_1 is the time taken by it to go from $x = 0$ to $x = \frac{A}{2}$ and T_2 is the time to go from $x = \frac{A}{2}$ to A, then
   a) $T_1 = T_2$ b) $T_1 > T_2$
   c) $T_1 < T_2$ d) $T_1 = \frac{T_2}{2}$
2. When a particle performs S.H.M., its kinetic energy varies periodically. If the frequency of the particle is 10, then the kinetic energy of the particle will vary with frequency equal to
   a) 10 b) 20 c) 5 d) 30
3. A particle performing linear S. H. M. of amplitude 0.1 m has displacement 0.02 m and acceleration 0.5 m/s^2. The maximum velocity of the particle in m/s is
   a) 0.05 b) 0.50
   c) 0.01 d) 0.25
4. A particle is executing S.H.M. with amplitude A. At displacement $x = \frac{-A}{4}$, force acting on the particle is F, potential energy of the particle is P.E., velocity of particle is v and kinetic energy is K.E. If potential energy to be zero at mean position, then at displacement $x = \frac{A}{2}$
   a) Force acting on the particle will be 4 F
   b) Potential energy of particle will be 2 P.E.
   c) Velocity of particle will be $\sqrt{\frac{2}{5}}$ v
   d) Kinetic energy of particle will be 0.8 K.E.
5. A particle starting at the end of its swing performs S.H.M. of amplitude 0.1 m and frequency 60 vibrations per minute. The displacement of the particle at the end of 2 s is
   a) 0.2 m b) 0.1 m c) 0.15 m d) 0.02 m
6. The ratio of kinetic energy to total energy of a particle is S. H. M. is $\frac{5}{9}$. The displacement in terms of amplitude 'a' is
   a) $\frac{a}{2}$ b) $\frac{2a}{3}$
   c) $\frac{a}{4}$ d) $\frac{a}{3}$
7. A simple pendulum with a bob of mass 'm' oscillates from A to C and back to A such that PB is H. If the acceleration due to gravity is 'g', then the velocity of the bob, as it passes through B, is



   a) mgH b) $\sqrt{2gH}$ c) 2gH d) Zero
8. The frequency of a particle performing linear S. H. M. is 7/2π Hz. The differential equation of S. H. M. is
   a) $\frac{d^2x}{dt^2} + 64x = 0$ b) $\frac{d^2x}{dt^2} + 49x = 0$
   c) $\frac{d^2x}{dt^2} + 14x = 0$ d) $\frac{d^2x}{dt^2} + 25x = 0$
9. A body has a time period T_1 under the action of one force and T_2 under the action of another force, the square of the time period when both the forces are acting in the same direction is
   a) $T_1^2 T_2^2$ b) T_1^2/T_2^2
   c) $T_1^2 + T_2^2$ d) $T_1^2 T_2^2/(T_1^2 + T_2^2)$
10. Consider a simple pendulum of length 1 m. Its bob performs a circular motion in horizontal plane with its string making an angle 60° with the vertical. If the mass of the bob is 50 gm, then the tension in the string is
   a) 1 N b) 0.29 N c) 0.5 N d) 2 N
11. A mass 'm_1' is suspended from a spring of negligible mass. A spring is pulled slightly in downward direction and released, mass performs S. H. M. of period 'T_1'. If the mass is increased by 'm_2', the time period becomes 'T_2'. The ratio $\frac{m_2}{m_1}$ is
   a) $\frac{T_1^2 + T_2^2}{T_1^2}$ b) $\frac{T_1 - T_2}{T_1}$
   c) $\frac{T_2^2 - T_1^2}{T_1^2}$ d) $\frac{T_1^2 - T_2^2}{T_1^2}$
12. A particle of mass m is executing oscillations about the origin on the x-axis. Its potential energy is $P.E.(x) = k[x]^3$, where k is a positive

constant. If the amplitude of oscillations is A, then its period T is

a) Proportional to $\frac{1}{\sqrt{A}}$ b) Independent to A
c) Proportional to $\sqrt{A}$ d) Proportional to $A^{3/2}$

13. A particle is executing SHM with an amplitude a. When the PE of a particle is one-fourth of its maximum value during the oscillation, its displacement from the equilibrium position will be

a) $a/4$ b) $a/3$
c) $a/2$ d) $2a/3$

14. If a spring extends by x on loading, then energy stored by the spring is (if T is the tension in the spring and k is the spring constant)

a) $\frac{T^2}{2x}$ b) $\frac{T^2}{2k}$ c) $\frac{2k}{T^2}$ d) $\frac{2T^2}{k}$

15. The maximum speed of a particle in S. H. M. is 'V'. The average speed is

a) $\frac{2V}{\pi^2}$ b) $\frac{2\pi}{V}$
c) $\frac{2V^2}{\pi}$ d) $\frac{2V}{\pi}$

16. A bob of a simple pendulum has mass 'm' and is oscillating with an amplitude 'a'. If the length of the pendulum is 'L' then the maximum tension in the string is
$\cos 0^0 = 1, g =$ acceleration due to gravity

a) $mg\left[1 - \left(\frac{L}{a}\right)^2\right]$ b) $mg\left[1 + \left(\frac{a}{L}\right)^2\right]$
c) $mg\left[1 - \left(\frac{a}{L}\right)^2\right]$ d) $mg\left[1 + \left(\frac{L}{a}\right)^2\right]$

17. When a particle undergoes S.H.M., there is always a constant ratio between its displacement and

a) Period b) Acceleration
c) Mass d) Velocity

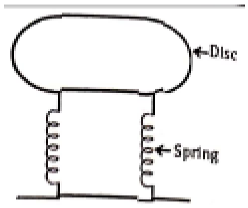
18. A clock S is based on oscillation of a spring and a clock P is based on pendulum motion. Both clocks run at the same rate on earth. On a planet having the same density as earth but it has twice the radius,

a) S will run faster than P b) P will run faster than S
c) both will run at the same rate as on the earth d) both will run at the same rate which will be different from that on the earth

19. In a period of kinetic energy, the number of times kinetic energy and potential energy are equal in magnitude is

a) single times b) twice
c) thrice d) four times

20. A uniform circular disc of mass 12 kg is held by two identical springs as shown in figure. When the disc is slightly pressed down and released, it executes S. H. M. of period 2 second. The force constant of each spring is $(\pi^2 = 10)$



a) 240 N/m b) 180 N/m
c) 60 N/m d) 120 N/m

21. A particle executes SUM of period $\frac{2\pi}{\sqrt{3}}$ second along a straight line 4 cm long. The displacement of the particle at which the velocity is numerically equal to the acceleration is

a) 2 cm b) 1 cm
c) 4 cm d) 3 cm

22. Potential energy of the particle performing S.H.M.is

a) harmonic motion and oscillatory
b) periodic motion but not oscillatory
c) oscillatory motion but not periodic
d) periodic and oscillatory motion

23. The velocity of a particle performing simple harmonic motion, when it passes through its mean position is

a) Infinity b) Zero
c) Minimum d) Maximum

24. A particle performs SHM with amplitude 25 cm and period 3 s. The minimum time required for it to move between two points 12.5 cm on either side of the mean position is

a) 0.6 s b) 0.5 s
c) 0.4 s d) 0.2 s

25. The graph between the length and square of the period of a simple pendulum is a

a) circle b) parabola
c) straight line d) hyperbola

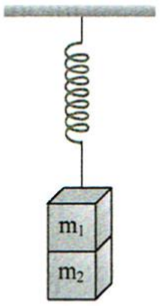
26. A simple pendulum of length 'L' has mass 'm' and it oscillates freely with amplitude 'A'. At extreme position, its potential energy is (g = acceleration due to gravity)

a) $\frac{2gA}{2L}$ b) $\frac{mgA^2}{2L}$

c) $\frac{2gA^2}{L}$ d) $\frac{mgA}{L}$

27. The phase of a particle executing simple harmonic 14 motion starts from mean position is $(\pi/2)$, when it has
a) maximum velocity
b) minimum acceleration
c) maximum kinetic energy
d) maximum displacement

28. Two masses m_1 and m_2 are suspended together by a massless spring of constant k. When the masses are in equilibrium, m_1 is removed without disturbing the system. The amplitude of oscillations is



a) $\frac{m_1 g}{k}$ b) $\frac{m_2 g}{k}$
c) $\frac{(m_1+m_2)g}{k}$ d) $\frac{(m_1-m_2)g}{k}$

29. A particle starts S.H.M. from mean position. Its amplitude is 'a'. At one instant, its velocity is half of the maximum velocity. Its displacement at this instant is
a) $\frac{\sqrt{3}}{2}a$ b) $\frac{\sqrt{2}}{3}a$ c) $\frac{2}{3}a$ d) $\frac{3}{2}a$

30. The position at which the net force on the oscillating particle is zero, the position is
a) mean position b) equilibrium position
c) extreme position d) both' a' or 'b'

31. The graph between instantaneous velocity and angular displacement of a particle performing S.H.M. is
a) parabola b) straight line
c) sinusoidal d) circle

32. The maximum velocity and maximum acceleration of a particle performing a linear SHM are α and β, respectively. Then, path length of the particle is
a) $\frac{\alpha^2}{\beta}$ b) $\frac{\beta}{2\alpha^2}$
c) $\frac{2\alpha^2}{\beta}$ d) $\frac{2\beta}{\alpha^2}$

33. The differential equation for linear SHM of a particle of mass 2 gm is $\frac{d^2x}{dt^2}+16x=0$ Then force constant is :
a) 32 N/m b) 32 dyne/cm
c) 12 dyne/cm d) 12 N/m

34. The steel bob of a simple pendulum is replaced by a wooden bob of same volume. Then its time period
a) increases b) decreases
c) does not change d) is zero

35. The equation of motion of a body in S.H.M. is $x = 4\sin\left(\pi t+\frac{\pi}{3}\right)$. The velocity at the end of 4 seconds will be
a) π cm/s b) $\frac{\pi}{2}$ cm/s
c) $\frac{3}{2}\pi$ cm/s d) 2π cm/s

36. If a particle executes an un damped S.H.M. of period T, then the period with which the kinetic energy fluctuate is
a) T b) 0 c) T/2 d) ∞

37. For a particle performing linear SHM, its average speed over one oscillation is (where, $a =$ amplitude of SHM, $n =$ frequency of oscillation)
a) $2an$ b) $4an$
c) $6an$ d) $8an$

38. A body performs S. H. M. under the action of force 'F_1' with period 'T_1' second. If the force is changed to 'F_2' it performs S. H. M. with period 'T_2' second. If both forces 'F_1' and 'F_2' act simultaneously in the same direction on the body, the period in second will be
a) $\frac{T_1+T_2}{T_1T_2}$ b) $\frac{T_1^2+T_2^2}{T_1T_2}$
c) $\frac{T_1T_2}{\sqrt{T_1^2+T_2^2}}$ d) $\frac{T_1T_2}{T_1+T_2}$

39. A pendulum clock is running fast. To correct its time, we should
a) Reduce the mass of the bob
b) Reduce the amplitude of oscillation
c) Increase the length of the pendulum
d) Reduce the length of the pendulum

40. A musical instrument X produces sound waves of frequency 'n' and amplitude 'A'. Another musical instrument Y produces sound waves of frequency n/4. The waves produced by both the instruments have equal energies. The amplitude of waves produced by instrument Y will be
a) 2A b) A

c) 4A d) 3A

41. A simple pendulum of length 'L' has mass 'm' and it oscillates freely with amplitude 'A'. At extreme position its potential energy is (g = acceleration due to gravity)

a) $\frac{mgL^2}{A}$ b) $\frac{A}{mgL}$

c) $\frac{mgA^2}{2L}$ d) $\frac{mgA}{L}$

42. When two displacements represented by $y_1 = a\sin(\omega t)$ and $y_2 = b\cos(\omega t)$ are superimposed the motion is

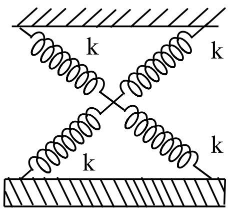
a) Not a simple harmonic

b) Simple harmonic with amplitude $\frac{a}{b}$

c) Simple harmonic with amplitude $\sqrt{a^2+b^2}$

d) Simple harmonic with amplitude $\frac{(a+b)}{2}$

43. As shown in figure, a simple harmonic motion oscillator having identical four springs has time period



a) $T = 2\pi\sqrt{\frac{m}{4k}}$ b) $T = 2\pi\sqrt{\frac{m}{2k}}$

c) $T = 2\pi\sqrt{\frac{m}{k}}$ d) $T = 2\pi\sqrt{\frac{2m}{k}}$

44. A particle of amplitude A is executing simple harmonic motion. When the potential energy of particle is half of its maximum potential energy, then displacement from its equilibrium position is

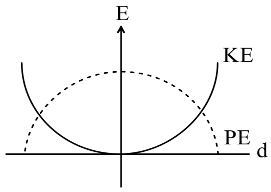
a) $\frac{A}{4}$ b) $\frac{A}{3}$

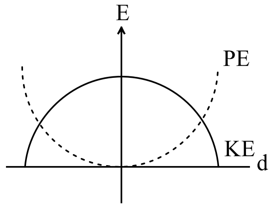
c) $\frac{A}{2}$ d) $\frac{A}{\sqrt{2}}$

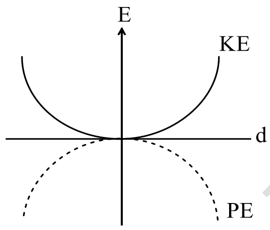
45. The phase difference between the displacement and acceleration of a particle performing linear S.H.M. is

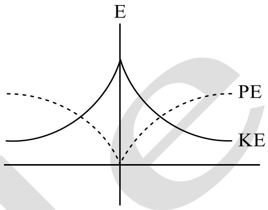
a) 0 b) 360° c) 180° d) 90°

46. For a simple pendulum, a graph is plotted between its kinetic energy (KE) and potential energy (PE) against its displacement d. Which one of the following represents, these correctly? (Graphs are schematic and not drawn to scale)

a) 

b) 

c) 

d) 

47. Starting from the extreme position, the time taken by an ideal simple pendulum to travel a distance of half the amplitude is

a) T/6 b) T/12 c) T/3 d) T/4

48. A block of mass 'm' attached to one end of the vertical spring produces extension 'x'. If the block is pulled and released, the periodic time of oscillation is

a) $2\pi\sqrt{\frac{x}{g}}$ b) $2\pi\sqrt{\frac{2x}{g}}$

c) $2\pi\sqrt{\frac{x}{2g}}$ d) $2\pi\sqrt{\frac{x}{4g}}$

49. A body of mass 'm' performs linear S. H. M. given by equation $x = P\sin\omega t + Q\sin\left(\omega t + \frac{\pi}{2}\right)$. The total energy of the particle at any instant is

a) $\frac{1}{2}m\omega^2 PQ$ b) $\frac{1}{2}\frac{m\omega^2}{P^2Q^2}$

c) $\frac{1}{2}m\omega^2(P^2+Q^2)$ d) $\frac{1}{2}m\omega^2 P^2Q^2$

50. A rectangular block of mass 'M' and cross-sectional area 'A' floats on a liquid of density 'ρ'. It is given a small vertical displacement from equilibrium, it starts oscillating with frequency 'n' then

a) $n \times A^2$ b) $n \propto \sqrt{A}$

c) $n \propto A$ d) $n \propto A^3$

51. The total energy of a simple harmonic oscillator is directly proportional to

a) Square of amplitude b) Frequency

c) Amplitude d) Velocity

52. Graph between velocity and displacement of a particle executing S.H.M. is

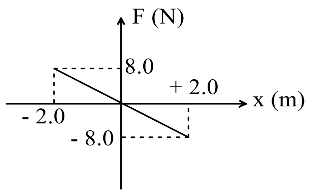
a) A straight line b) A parabola

c) A hyperbola d) An ellipse

53. Two particles are executing simple harmonic motion of the same amplitude A and frequency ω along the x-axis. Their mean position is separated by distance $x_0 (x_0 > A)$. If the maximum separation between them is $(x_0 + A)$, the phase difference between their motion is

a) $\frac{\pi}{2}$ b) $\frac{\pi}{3}$ c) $\frac{\pi}{4}$ d) $\frac{\pi}{6}$

54. A body of mass 0.01 kg executes simple harmonic motion (S.H.M.) about x = 0 under the influence of a force shown below: The period of the S.H.M. is



a) 1.05 s b) 0.52 s c) 0.25 s d) 0.30 s

55. The potential energy of a particle performing S.H.M. at extreme position is

a) minimum
b) maximum
c) remains constant
d) 1/2 m m $\omega^2 x^2$

56. Two springs of spring constants k_1 and k_2 have equal maximum velocities when executing simple harmonic motion. The ratio of their amplitudes (masses are equal) will be

a) $\left(\frac{k_2}{k_1}\right)^{1/2}$
b) $\left(\frac{k_1}{k_2}\right)^{1/2}$
c) $\frac{k_1}{k_2}$
d) $k_1 k_2$

57. A simple pendulum oscillates about its mean position with amplitude 'a' and periodic time 'T'. The linear speed of pendulum when its displacement is half the amplitude is

a) $\frac{\pi a}{T}$
b) $\frac{\pi a\sqrt{3}}{T}$
c) $\frac{3\pi^2 a}{T}$
d) $\frac{\pi a\sqrt{3}}{2T}$

58. The time period of a simple pendulum of infinitely long length is(R is radius of the earth)

a) $T=2\pi\sqrt{\frac{R}{g}}$
b) $T=2\pi\sqrt{\frac{R}{2g}}$
c) $T=2\pi\sqrt{\frac{2R}{g}}$
d) T=infinite

59. displacement equation of a simple harmonic oscillator is given by
$y = A\sin\omega t - B\cos\omega t$
The amplitude of the oscillator will be

a) $A - B$
b) $A + B$
c) $\sqrt{A^2 + B^2}$
d) $(A^2 + B^2)$

60. A pendulum clock is running fast. To correct its time, we should

a) Reduce the mass of the bob
b) Reduce the amplitude of oscillation
c) Reduce the length of pendulum
d) Increase the length of the pendulum

61. The total energy of a particle executing SHM is proportional to

a) frequency of oscillation
b) maximum velocity of motion
c) square of amplitude of motion
d) square of mass of particle

62. Differential equation of SHM along X-axis is

a) $\frac{d^2x}{dt^2} = \omega^2 x.$
b) $\frac{d^2x}{dt^2} = -\omega^2 x.$
c) $\frac{dx}{dt} = \omega^2 x.$
d) $\frac{dx}{dt} = -\omega^2 x.$

63. The displacement of an object attached to a spring and executing simple harmonic motion is given by $x = 2 \times 10^{-2} \cos \pi t$ metre. The time at which the maximum speed first occurs is

a) 0.5 s
b) 0.75 s
c) 0.125 s
d) 0.25 s

64. A particle starts oscillating simple harmonically from its mean position with time 'T'. At time t = T/12, the ratio of the potential energy to kinetic energy of the particle is
$(\sin 30^0 = \cos 60^0 = 0.5, \cos 30^0 = \sin 60^0 = \sqrt{3}/2)$

a) 3:1
b) 1:3
c) 1:2
d) 2:1

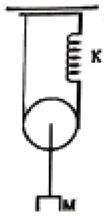
65. In S.H.M., maximum acceleration is at

a) Amplitude
b) Equilibrium
c) Acceleration is constant
d) None of these

66. A particle executes simple harmonic motion of amplitude A. At what distance from the mean position is its kinetic energy equal to its potential energy?

a) 0.51 A b) 0.61 A c) 0.71 A d) 0.81 A

67. The time period of mass 'M' when distributed from its equilibrium position and then released, for the system shown in figure is



a) $2\pi\sqrt{\frac{M}{K}}$ b) $2\pi\sqrt{\frac{M}{2K}}$

c) $2\pi\sqrt{\frac{M}{2K}}$ d) $2\pi\sqrt{\frac{4M}{K}}$

68. The motion of a simple pendulum when it oscillates with small amplitude is
    a) angular S.H.M. only
    b) angular and linear S.H.M.
    c) linear S.H.M. only
    d) linear complex oscillatory motion
69. Two pendulums of lengths 1 metre and 16 metre start oscillating one behind the other from the same stand. At some instant, the two are in the mean position in the same phase. The time period of shorter pendulum is T. The minimum time, after which the two threads of the pendulum will be one behind the other, is
    a) T/4 b) T/3 c) 4T/3 d) 4T
70. Two bar magnets 'P' and 'Q' are kept in uniform magnetic field 'B' with magnetic moments 'M_P' and 'M_Q' respectively. Magnet 'P' is oscillating with frequency twice that of magnet 'Q'. If the moment of inertia of the magnet 'P' is twice that of magnet 'Q' then
    a) $M_Q = 2M_P$ b) $M_P = 2M_Q$
    c) $M_P = 8M_Q$ d) $M_Q = 8M_P$
71. A block resting on the horizontal surface executes S.H.M. in horizontal plane with amplitude 'A'. The frequency of oscillation for which the block just starts to slip is (μ = coefficient of friction, g = gravitational acceleration)
    a) $\frac{1}{2\pi}\sqrt{\frac{\mu g}{A}}$ b) $\frac{1}{4\pi}\sqrt{\frac{\mu g}{A}}$ c) $2\pi\sqrt{\frac{A}{\mu g}}$ d) $4\pi\sqrt{\frac{A}{\mu g}}$
72. A particle executes linear S. H. M. along the principal axis of a convex lens of focal length 8 cm. The mean position of oscillation is at 14 cm from the lens with amplitude 1 cm. The amplitude of oscillating image of the particle is nearly
    a) 3 cm b) 5 cm
    c) 2 cm d) 4 cm
73. If a hole is bored along the diameter of the earth and a stone is dropped into hole, then
    a) The stone reaches the centre of the earth and stops there
    b) The stone reaches the other side of the earth and stops there
    c) The stone executes simple harmonic motion about the centre of the earth
    d) The stone reaches the other side of the earth and escapes into space
74. A particle performs simple harmonic motion with period of 3 s. The time taken by it to cover a distance equal to half the amplitude from mean position is (Take, $\sin 30^\circ = 0.5$)
    a) $\frac{1}{4}$ s b) $\frac{3}{2}s$
    c) $\frac{3}{4}$ s d) $\frac{1}{2}$ s
75. A spring-mass system oscillates with a frequency v. If it is taken in an elevator slowly accelerating upward, the frequency will
    a) increase b) decrease
    c) remains same d) become zero
76. A body of mass 64 g is made to oscillate turn by turn on two different springs A and B. Spring A and B has force constant 4 N/m and 16 N/m, respectively. If T_1 and T_2 are period of oscillations of springs A and B respectively, then $\frac{T_1+T_2}{T_1-T_2}$ will be
    a) 1: 2 b) 1: 3
    c) 3: 1 d) 2: 1
77. For a particle performing S. H. M. the equation $\left(\frac{d^2x}{dt^2}\right) + \alpha x = 0$. Then the time period of the motion will be
    a) $\frac{2\pi}{\alpha}$ b) $2\pi\alpha$
    c) $2\pi\sqrt{\alpha}$ d) $\frac{2\pi}{\sqrt{\alpha}}$
78. A horizontal spring executes S. H. M. with amplitude 'A_1', when mass 'm_1' is attached to it. When it passes through mean position another mass 'm_2' is placed on it. Both masses move together with amplitude 'A_2'. Therefore $A_2 : A_1$ is
    a) $\left[\frac{m_1+m_2}{m_2}\right]^{\frac{1}{2}}$ b) $\left[\frac{m_1+m_2}{m_1}\right]^{\frac{1}{2}}$
    c) $\left[\frac{m_2}{m_1+m_2}\right]^{\frac{1}{2}}$ d) $\left[\frac{m_1}{m_1+m_2}\right]^{\frac{1}{2}}$
79. A pendulum clock shows correct time at 0^0C. On a summer day

a) it runs slow and gains time
b) it runs fast and loses time
c) it runs slow and. loses time
d) it runs fast and gains time

80. A body is executing S. H. M. Its potential energy is E_1 and E_2 at displacement x and y respectively. The potential energy at displacement $(x + y)$ is

a) $E_1 - E_2 = E$ b) $\sqrt{E_1} - \sqrt{E_2} = \sqrt{E}$
c) $E_1 + E_2 = E$ d) $\sqrt{E_1} + \sqrt{E_2} = \sqrt{E}$

81. The potential energy of a particle with displacement x is $U(x)$. The motion is simple harmonic, when (k is a positive constant)

a) $U = -\frac{kx^2}{2}$ b) $U = kx^2$
c) $U = k$ d) $U = kx$

82. A ball is released from height 'h' which makes perfectly elastic collision with ground. The frequency of periodic vibratory motion is (g = acceleration due to gravity)

a) $\frac{1}{2}\sqrt{\frac{g}{2h}}$ b) $\frac{1}{2}\sqrt{\frac{2h}{g}}$
c) $\frac{1}{2\pi}\sqrt{\frac{2h}{g}}$ d) $\frac{1}{2\pi}\sqrt{\frac{g}{2h}}$

83. When metallic simple pendulum is replaced and wooden simple pendulum of same diameter then:

a) period increases
b) period decreases
c) period remains unchanged
d) None of these

84. Two particles are executing S.H.M. The equations of their motion are

$y_1 = 10 \sin\left(\omega t + \frac{\pi T}{4}\right)$

$y_2 = 25 \sin\left(\omega t + \frac{\sqrt{3}\pi T}{4}\right)$

What is the ratio of their amplitudes?

a) 1 : 1 b) 1 : 2 c) 2 : 5 d) 5 : 2

85. The bob of simple pendulum of mass m and total energy E will have maximum linear momentum equal to

a) $\sqrt{2m/E}$ b) $\sqrt{2mE}$
c) 2mE d) mE^2

86. A coin is placed on a horizontal platform which undergoes vertical simple harmonic motion of angular frequency ω. The amplitude of oscillation is gradually increased. The coin will leave contact with the platform for the first time

a) For an amplitude of g/ω^2
b) For an amplitude of g^2/ω^2
c) At the highest position of the platform
d) At the mean position of the platform

87. A clock pendulum having coefficient of linear expansion $\alpha = 9 \times 10^{-7}$ /°C has a period of 0.5 s at 20°C. If the clock is used in a climate where the temperature is 30°C, how much time does the clock lose in each oscillation? (g = constant)

a) 2.25×10^{-6} s b) 5×10^{-7} s
c) 2.5×10^{-7} s d) 1.125×10^{-6} s

88. The equation of a S.H.M. of amplitude 'A' and angular frequency w in which all distances are measured from one extreme position and time is taken to be z ro, at the other extreme position is

a) x=A sin ωt b) x=A-A sin ωt
c) x = A cos ωt d) x = A - A cos ωt

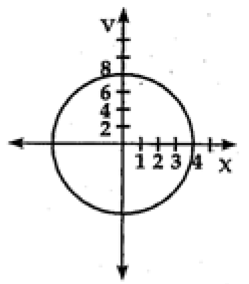
89. A spring executes S. H. M. with mass 10 kg attached to it. The force constant of the spring is 10 N/m. If at any instant its velocity is 40 cm/s, the displacement at that instant is (Amplitude of S. H. M. = 0.5 m)

a) 0.3 m b) 0.4 m
c) 0.2 m d) 0.45 m

90. A particle of mass 5 g is executing S. H. M. with an amplitude 0.3 m and time period $\frac{\pi}{5}$ s. The maximum value of the force acting on the particle is

a) 0.15 N b) 4 N
c) 5 N d) 0.3 N

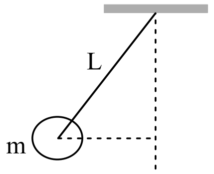
91. A graph is plotted between the, instantaneous velocity of a particle performing S.H.M. and displacement. Then the period of S.H.M. is



a) 2s b) πs c) $\frac{1}{\pi} s$ d) 0.5 s

92. A ball of mass (m) 0.5 kg is attached to the end of a string having length (L) 0.5 m. The ball is rotated on a horizontal circular path about vertical axis. The maximum tension that the

string can bear is 324 N. The maximum possible value of angular velocity of ball (in radian/s) is



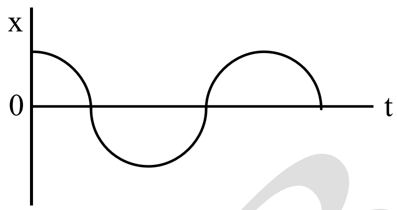
a) 9 b) 18 c) 27 d) 36

93. The period of oscillation of a mass, M, hanging from a spring of force constant k is T. When additional mass m is attached to the spring, the period of oscillation becomes 5T/4. m/M =
a) 9 : 16 b) 25 : 16 c) 25 : 9 d) 16 : 9

94. The total energy of simple harmonic oscillator is 'E'. What will be the kinetic energy of the particle, when the displacement is $\left(\frac{4}{5}\right)$th of the amplitude?
a) $\frac{9}{25}E$
b) $\frac{5E}{4}$
c) $\frac{4E}{5}$
d) $\frac{25}{9}E$

95. The displacement of a particle in SHM in one time period is
a) A b) 2A c) 4A d) zero

96. The displacement-time graph of a particle executing SHM is shown.

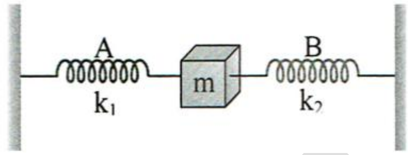


Which of the following statement(s) is/are true?
The force is zero at $= 3\,T/4$.
II. The acceleration is maximum at $t = T$.
III. The velocity is maximum at $t = T/4$.
IV. The potential energy is equal to kinetic energy at $t = T/2$
a) I and II
b) I, II and III
c) I and IV
d) All of these

97. A block of mass 16 kg moving with velocity 4 m/s on a frictionless surface compresses an ideal spring and comes to rest. If force constant of the spring is 100 N/m then how much will be the spring compressed?
a) 0.4 m
b) 1.6 m
c) 1.2 m
d) 0.8 m

98. An . ideal simple pendulum cannot exist practically because
a) heavy point mass and in extensible string is not possible
b) perfectly rigid support is not possible
c) the bob is not symmetric
d) both (A) & (B)

99. In arrangement given in the figure, if the block of mass m is displaced, the frequency is given by



a) $n = \frac{1}{2\pi}\sqrt{\left(\frac{k_1 - k_2}{m}\right)}$
b) $n = \frac{1}{2\pi}\sqrt{\left(\frac{k_1 + k_2}{m}\right)}$
c) $n = \frac{1}{2\pi}\sqrt{\left(\frac{m}{k_1 + k_2}\right)}$
d) $n = \frac{1}{2\pi}\sqrt{\left(\frac{m}{k_1 - k_2}\right)}$

100. If a particle performs SHM with a frequency n, then its KE. will oscillate with a frequency
a) n/2 b) n c) 2n d) zero

101. Two bodies A and B of equal mass are suspended from two separate massless springs of force constant k_1 and k_2, respectively. The bodies oscillate vertically such that their maximum velocities are equal. The ratio of the amplitudes of body A to that of body B is
a) $\sqrt{\frac{k_2}{k_1}}$
b) $\frac{k_2}{k_1}$
c) $\frac{k_1}{k_2}$
d) $\sqrt{\frac{k_1}{k_2}}$

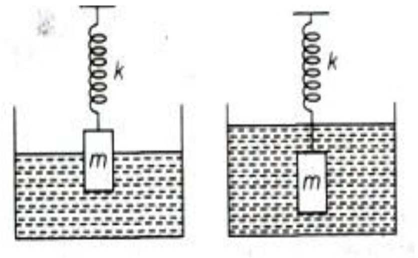
102. The amplitude of a particle executing SHM is made three-fourth keeping its time period constant. Its tots energy will be
a) $\frac{E}{2}$
b) $\frac{3}{4}E$
c) $\frac{9}{16}E$
d) None of these

103. Two simple pendulums of length 0.5 m and 20 m respectively are given small linear displacement in one direction at the same time. They will again be in the phase when the pendulum of shorter length has completed k oscillations. Here, k is
a) 5
b) 1
c) 2
d) 3

104. Which of the following functions represents a simple harmonic oscillation?
a) $\sin \omega t - \cos \omega t$
b) $\sin^2 \omega t$
c) $\sin \omega t + \sin 2\omega t$
d) $\sin \omega t - \sin 2\omega t$

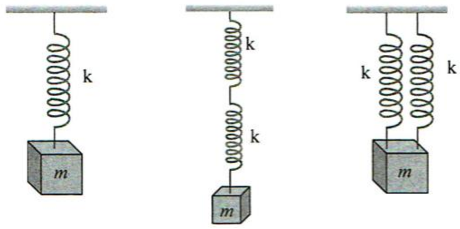
105. Period of small oscillations in the two cases

shown in the figure is T_1 and T_2 respectively, then



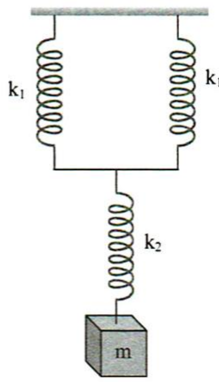
a) $T_1 = T_2$
b) $T_1 < T_2$
c) $T_1 > T_2$
d) Cannot say anything

106. Five identical springs are used in the following three configuration. The time periods of vertical oscillations in configurations (i), (ii) and (iii) are in the ratio



a) $1 : \sqrt{2} : \frac{1}{\sqrt{2}}$
b) $2 : \sqrt{2} : \frac{1}{\sqrt{2}}$
c) $\frac{1}{\sqrt{2}} : 2 : 1$
d) $2 : \frac{1}{\sqrt{2}} : 1$

107. What will be the force constant of the spring system shown in the figure?



a) $\frac{k_1}{2} + k_2$
b) $\left[\frac{1}{2k_1} + \frac{1}{k_2}\right]^{-1}$
c) $\frac{1}{2k_1} + \frac{1}{k_2}$
d) $\left[\frac{2}{k_1} + \frac{1}{k_2}\right]^{-1}$

108. A particle executing SHM on X-axis with origin as mean position, then graph of speed (v) versus displacement (x) will be

a) parabola
b) ellipse
c) circle
d) hyperbola

109. Which one of the following statements is true for a particle performing S. H. M.?

a) Kinetic energy is half the potential energy of the particle at displacement equal to amplitude of S. H. M.
b) Kinetic energy of the particle is maximum at displacement equal to amplitude of S. H. M.
c) Kinetic energy of the particle is maximum at displacement equal to zero
d) Kinetic energy of the particle is minimum at displacement equal to zero

110. The length of a pendulum is halved. Its energy will be

a) Decreased to half
b) Increased to 2 times
c) Decreased to one fourth
d) Increased to 4 times

111. A body of mass m performs linear S. H. M. given by equation, $x = P\sin\omega t + Q\sin\left(\omega t + \frac{\pi}{2}\right)$. The total energy of the particle at any instant is

a) $\frac{1}{2}m\omega^2(P^2 + Q^2)$
b) $\frac{1}{2}m\omega^2/PQ$
c) $\frac{1}{2}m\omega^2 PQ$
d) $\frac{1}{2}m\omega^2 P^2Q^2$

112. The maximum potential energy of a simple harmonic oscillator is $U_{\max}$. Then, the PE of the oscillator when it is half way to its end point, is

a) $\frac{U_{\max}}{2}$
b) $\frac{U_{\max}}{3}$
c) $\frac{U_{\max}}{4}$
d) $2U_{\max}$

113. Two particles A and B execute simple harmonic motion of period T and $5T/4$. They start from mean position. The phase difference between them when the particle A complete an oscillation will be

a) $\pi/2$
b) zero
c) $2\pi/5$
d) $\pi/4$

114. A man measures time period of a pendulum (T) in stationary lift. If the lift moves upward with acceleration $\frac{g}{4}$, then new time period will be

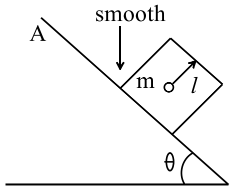
a) $\frac{2T}{\sqrt{5}}$
b) $\frac{\sqrt{5}T}{2}$
c) $\frac{\sqrt{5}}{2T}$
d) $\frac{2}{\sqrt{5}T}$

115. The lengths of second's pendulum on the surface of the earth and at an altitude 'h' from the surface of the earth are 'I_s' and 'I_h' respectively. The radius of the earth 'R' is

a) $\frac{\sqrt{I_h}}{h\left(\sqrt{I_s} - \sqrt{I_h}\right)}$
b) $\frac{\sqrt{I_s}}{\sqrt{I_h} - \sqrt{I_s}}$
c) $\frac{h\sqrt{I_h}}{\left(\sqrt{I_s} - \sqrt{I_h}\right)}$
d) $\frac{h\sqrt{I_s}}{h\left(\sqrt{I_h} - \sqrt{I_s}\right)}$

116. A box placed on a smooth inclined plane is free

to move. Find the time period of oscillation of the simple pendulum attached to the ceiling of the box

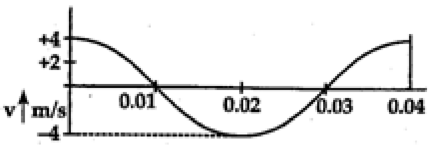


a) $2\pi\sqrt{\frac{l}{g}}$ b) $2\pi\sqrt{\frac{l}{g\sin\theta}}$

c) $2\pi\sqrt{\frac{l}{g\cos\theta}}$ d) $2\pi\sqrt{\frac{l}{g\tan\theta}}$

117. Time period of simple pendulum of wire is independent
a) mass of the bob and amplitude of oscillation
b) amplitude of oscillation
c) temperature of the bob
d) acceleration due to gravity

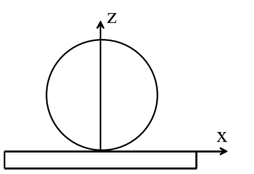
118. The velocity time diagram of a harmonic oscillator is shown in the figure, then the frequency of oscillation is



a) 25 Hz b) 12.25 Hz c) 50 Hz d) 33.3 Hz

119. In SHM, restoring force is $F = -kx$, where k is force constant, x is displacement and A is amplitude of motion, then total energy depends upon
a) k, A and M b) k, x, M
c) k, A d) k, x

120. A cylinder of mass M, radius R is kept on a rough horizontal plane at one extreme end of the platform at $t = 0$. Axis of the cylinder is parallel to z-axis. The platform is oscillating in the xy-plane and its displacement from origin is represented by $x = 4\cos(2\pi t)$ metres. There is no slipping between the cylinder and the platform. Find the acceleration of the centre of mass of cylinder at $t = \frac{1}{6}$ s

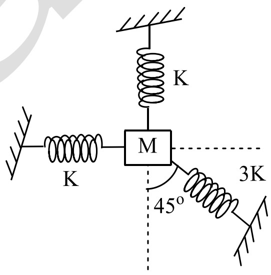


a) $\frac{-5}{3}\pi^2$ b) $\frac{-2}{3}\pi^2$ c) $\frac{-8}{3}\pi^2$ d) $\frac{-4}{3}\pi^2$

121. A bob of simple pendulum of mass 'm' perform SHM with amplitude 'A' and period 'T'. Kinetic energy of pendulum of displacement $x = \frac{A}{2}$ will be
a) $\frac{2m\pi^2 A}{3T^2}$ b) $\frac{3m\pi^2 A}{2T}$
c) $\frac{2m\pi A^2}{3T}$ d) $\frac{2m\pi^2 A^2}{2T^2}$

122. A block resting on the horizontal surface executes SHM in horizontal plane with amplitude A. The frequency of oscillation for which the block just starts to slip is (where, μ = coefficient of friction and g = gravitational acceleration)
a) $\frac{1}{2\pi}\sqrt{\frac{\mu g}{A}}$ b) $\frac{1}{4\pi}\sqrt{\frac{\mu g}{A}}$
c) $2\pi\sqrt{\frac{A}{\mu g}}$ d) $4\pi\sqrt{\frac{A}{\mu g}}$

123. A block of mass M is attached to three springs A, B, C having force constants K, K_1 and 3K as shown in the figure. If the block is slightly pushed against spring C. Then find the frequency of oscillations



a) $f = 2\pi\sqrt{\frac{M}{K}}$ b) $f = \frac{1}{2\pi}\sqrt{\frac{K}{M}}$

c) $f = \frac{1}{2\pi}\sqrt{\frac{2K}{M}}$ d) $f = \frac{1}{2\pi}\sqrt{\frac{3K}{M}}$

124. A particle executes simple harmonic motion with amplitude 'A' and period 'T'. If it is half way between mean position and extreme position, then its speed at that point is
a) $\frac{\sqrt{3}\pi A}{2T}$ b) $\frac{\pi A}{T}$
c) $\frac{\sqrt{3}\pi A}{T}$ d) $\frac{3\pi A}{T}$

125. If a hole is bored along the diameter of the earth and the stone is dropped into the hole:
a) The stone reaches the centre of the earth and stop there .
b) The stone reaches the other end of the earth and stop there.
c) The stone executes SHM about the centre of

the earth.

d) The stone reaches the other side of the earth and escapes into the space.

126. The ratio of kinetic energy to the potential energy of a particle executing SHM at a distance equal to half its amplitude, the distance being measured from its equilibrium position is

a) 2: 1 b) 3: 1
c) 8: 1 d) 4: 71

127. A body is executing a linear SHM. At a displacement x, its potential energy is E_1 and at a displacement y, its potential energy is E_2. What is its potential energy E at displacement $(x + y)$?

a) $\sqrt{E} = \sqrt{E_1} + \sqrt{E_2}$ b) $E = E_1 + E_2$
c) $E = E_1 = E_2$ d) $\sqrt{E} = \sqrt{E_1} - \sqrt{E_2}$

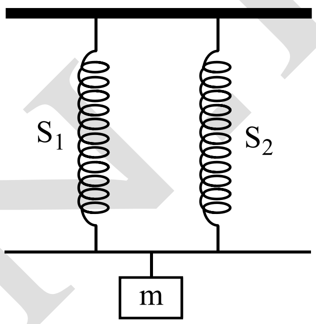
128. The period of oscillation of a simple pendulum of constant length at a place in mine is :

a) More than it is on the surface of the earth
b) Less than it is on the surface of the earth
c) Same as it is on the surface of the earth
d) Same as it is on the surface of moon

129. A simple pendulum is suspended from roof of lift. If lift moves downward with acceleration a then period of pendulum $T = 2\pi\sqrt{\frac{l}{g}}$ then g' will be:

a) g + a b) g - a
c) $\sqrt{g^2 + a^2}$ d) g

130. Two identical springs S_1 and S_2 are joined as shown in the figure. The oscillation frequency of the mass m is v. What will be the frequency of mass m, if one spring is removed?

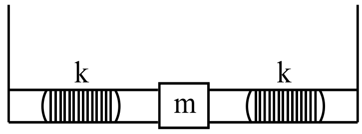


a) $\sqrt{2}v$ b) v
c) $\frac{v}{\sqrt{2}}$ d) $2v$

131. A particle performs S. H. M. with amplitude 'A'. Its speed is tripled at the instant when it is at a distance of $\frac{2A}{3}$ from the mean position. The new amplitude of the motion is

a) $\frac{2A}{3}$ b) $\frac{A}{3}$
c) $\frac{5A}{3}$ d) $\frac{7A}{3}$

132. If f is the frequency when mass m is attached to a spring of spring constant k, then new frequency tor this arrangement, is



a) $f/2$ b) $\sqrt{2}f$
c) $f/\sqrt{2}$ d) $2\sqrt{2f}$

133. 1 The force constant (k) of SHM is measured. in :

a) Nm b) N c) Nm^{-1} d) N^{-1} m

134. A simple pendulum has a length 1. The inertial and gravitational masses of the bob are m_j and m_g, respectively. Then, the time period T is given by

a) $T = 2\pi\sqrt{\frac{m_g l}{m_i g}}$ b) $T = 2\pi\sqrt{\frac{m_i l}{m_g g}}$
c) $T = 2\pi\sqrt{\frac{m_i \times m_g \times l}{g}}$ d) $T = 2\pi\sqrt{\frac{1}{m_1 \times m_g \times g}}$

135. The amplitude of particle performing S.H.M. is

a) tensor
b) vector
c) scalar
d) depending upon magnitude

136. For a particle executing simple harmonic motion, which of the following statements is not correct?

a) The total energy of the particle always remains the same
b) The restoring force is always directed towards a fixed point
c) The restoring force is maximum at the extreme positions
d) The acceleration of the particle is maximum at the equilibrium position

137. Two simple harmonic motions of angular frequency 100 and 1000 rad s^{-1} have the same displacement amplitude. The ratio of their maximum acceleration is

a) $1: 10^3$ b) $1: 10^4$ c) 1 : 10 d) $1: 10^2$

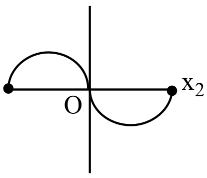
138. A second's pendulum performs 100 oscillations in

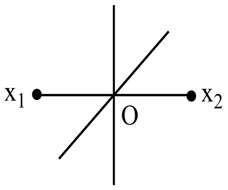
a) 200 second b) 100 second

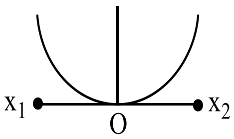
c) 50 second d) 25 second

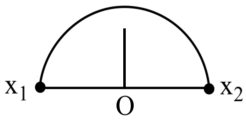
139. The term phase in S.H.M.
a) Is the angle measured in degree only
b) Specifies the position of the particle only
c) Specifies the direction of motion only
d) Specifies both the position and direction of motion

140. A particle of mass m oscillates with simple harmonic motion between points x_1 and x_2, the equilibrium position being O. Its potential energy is plotted. It will be as given below in the graphs

a) 

b) 

c) 

d) 

141. The P.E. of particle of mass 0.1 kg moving along x-axis is given by $U = 5x(x-4)$ J where x is in metres.
It can be concluded that the wrong option is
a) The particle is acted upon by a constant force
b) The speed of the particle is maximum at $x = 2$ m
c) The particle executes SHM
d) The period of oscillation of particle is $\frac{\pi}{5}$ s

142. The oscillatory motion is simple harmonic motion Since
a) its path is straight line
b) its displacement, velocity and acceleration are represented by trigonometric function sine and cosine
c) its displacement, velocity and acceleration are represented by trigonometric function sine, cosine and tangent
d) both 'a' and 'b'

143. A particle is suspended from a vertical spring which is executing S. H. M. of frequency 5 Hz. The spring is un-stretched at the highest point of oscillation. Maximum speed of the particle is $(g = 10\ \mathrm{m/s^2})$
a) $\frac{1}{\pi}$ m/s b) $\frac{1}{4\pi}$ m/s
c) $\frac{1}{2\pi}$ m/s d) π m/s

144. A clock with iron pendulum keeps correct time at 15°C. If the room temperature is 20°C, the error in second per day will be nearly (coefficient of linear expansion of iron is $1.2 \times 10^{-5}/°\mathrm{C}$)
a) 2.6 s b) 6.2 s
c) 3.1 s d) 1.3 s

145. Identify correct statement among the following
a) the greater the mass of a pendulum bob, the shorter is its frequency of oscillation
b) a simple pendulum with a bob of mass m swings with an angular amplitude of 400 its angular amplitude is 200, the tension in the string earlier is less than the 'tension in the string later
c) as the length of a simple pendulum is increased, the maximum velocity of its bob during its oscillation will also increases.
d) the fractional change in the time period of a pendulum on changing the temperature is independent of the length of the pendulum

146. The ratio of the kinetic energy at mean position to the potential energy at half of the amplitude is
a) 1 : 4 b) 1 : 2 c) 2 : 1 d) 4 : 1

147. If length of a simple pendulum is increased by 44%, then what is the gain in the time period of pendulum?
a) 40% b) 20% c) 10% d) 21%

148. A body is performing S. H. M. of amplitude 'A'. The displacement of the body from a point where kinetic energy is maximum to a point where potential energy is maximum, is
a) Zero b) $\pm A$
c) $\pm\frac{A}{2}$ d) $\pm\frac{A}{4}$

149. A body is executing S. H. M. It potential energy is 'P_1' and 'P_2' at displacements 'X' and 'Y' respectively. The potential energy at displacement $(x+y)$ is
a) $P_1 - P_2 = P$ b) $\sqrt{P_1} + \sqrt{P_2} = P$
c) $\sqrt{P_1} - \sqrt{P_2} = \sqrt{P}$ d) $P_1 + P_2 = P$

150. If simple pendulum performing SHM the ratio of K.E. at mean and P.E. at maximum displacement is:
a) Equal to one b) Less than one
c) Greater than one d) Equal to half

151. This time period of a particle undergoing SHM is 16 s. It starts motion from the mean position. Atter 2 s, its velocity is $0.4\ \mathrm{ms^{-1}}$. The amplitude is

a) 1.44 m   b) 0.72 m
c) 2.88 m   d) 0.36 m

152. All oscillatory motions are necessarily periodic motions but
a) All periodic motions are not oscillatory
b) All periodic motions are oscillatory
c) All periodic motions are not periodic motions
d) All periodic motions are non harmonic

153. A body performing simple harmonic motion has potential energy 'P_1' at displacement 'x_1'. Its potential energy is 'P_2' at displacement 'x_2'. The potential energy 'P' at displacement $(x_1 + x_2)$ is
a) $P_1 + P_2$ b) $P_1 + P_2 + 2\sqrt{P_1 P_2}$
c) $\sqrt{P_1 P_2}$ d) $\sqrt{P_1^2 + P_2^2}$

154. For a particle in SHM, the graph of the velocity vs displacement is
a) a straight line   b) a circle
c) an ellipse   d) a hyperbola

155. A simple pendulum of length / has a bob of mass m. It executes SHM of small amplitude A. The maximum tension in the string is (g = acceleration due to gravity)
a) mg b) $mg\left(\frac{A^2}{R^2} + 1\right)$
c) 2mg   d) $mg\left(\frac{A}{l} + 1\right)$

156. A simple pendulum of mass 'm' having length 'L' is oscillating with amplitude 'A'. The maximum tension in the string is
a) $\frac{mgA}{L}$ b) $mg\left[1 - \left(\frac{A}{L}\right)^2\right]$
c) $mg\left[1 + \left(\frac{A}{L}\right)^2\right]$ d) $\frac{mgA^2}{L^2}$

157. The dimensions of restoring torque per unit angular displacement are
a) $M^1L^1T^2$ b) $M^2L^2T^2$
c) $M^{-1}L^1T^2$ d) $M^1L^2T^2$

158. The kinetic energy and the potential energy of a particle executing S.H.M. are equal. The ratio of its displacement and amplitude will be
a) $\frac{1}{\sqrt{2}}$ b) $\frac{\sqrt{3}}{2}$ c) $\frac{1}{2}$ d) $\sqrt{2}$

159. Two simple harmonic motions are represented as $y_1 = 10 \sin \omega t$ and $y_2 = 10 \sin \omega t + 5 \cos \omega t$. The ratio of the amplitudes of y_1 and y_2 is
a) 1:1   b) $1:\sqrt{2}$
c) $\sqrt{2}:1$ d) 1:4

160. A ball suspended by a thread of length L, at a point O on the wall, forms a small angle α with the vertical. Then the thread with the ball was deviated through a small angle $\beta > \alpha$ and set free. Assuming the collision of the ball with the wall as elastic, find the time period of oscillation of such as pendulum
a) $2\sqrt{\frac{g}{l}}\cos^{-1}\left(\frac{\alpha}{\beta}\right)$ b) $\sqrt{\frac{g}{l}}\cos^{-1}\left(\frac{\alpha}{\beta}\right)$
c) $2\sqrt{\frac{g}{l}}\cos^{-1}\left(\frac{\beta}{\alpha}\right)$ d) $\sqrt{\frac{g}{l}}\cos^{-1}\left(\frac{\beta}{\alpha}\right)$

161. Time period of pendulum is 6.28 s and amplitude of oscillation is 3 cm. Maximum acceleration of pendulum is
a) 8 cm/s^2 b) 0.3 cm/s^2
c) 3 cm/s^2 d) 58.2 cm/s^2

162. In a simple harmonic oscillator, at the mean position
a) Kinetic energy is minimum, potential energy is maximum
b) Both kinetic and potential energies are maximum
c) Kinetic energy is maximum, potential energy is minimum
d) Both kinetic and potential energies are minimum

163. When a particle in U.C.M. performs complete circle on a reference circle, its projection
a) Performs one to fro motion on horizontal diameter
b) Two back and forth motion on diameter
c) Follows the same motion on circumference of the circle
d) Remains stationary at any time

164. When a particle in linear S.H.M. completes two oscillations, its phase increases by
a) 2π radian   b) 3π radian
c) 4π radian   d) π radian

165. A particle executing S. H. M. has velocities 'v_1' and 'v_2' at distance 'x_1' and 'x_2' respectively from mean position. The angular velocity (ω) of the particle is given by
a) $\sqrt{\frac{x_2^2 - x_1^2}{v_1^2 - v_2^2}}$ b) $\sqrt{\frac{v_1^2 - v_2^2}{x_2^2 - x_1^2}}$
c) $\sqrt{\frac{v_1^2 - v_2^2}{x_1^2 - x_2^2}}$ d) $\sqrt{\frac{v_1^2 - v_2^2}{x_1^2 - x_2^2}}$

166. Projection of U.C.M. on a diameter is
a) linear S.H.M.   b) angular S.H.M.

c) rotational motion d) torsional motion

167. A pendulum clock that keeps correct time on the earth is taken to the moon it will run (it is given that $g_{Moon} = g_{Earth}/6$)
a) At correct rate b) 6 time faster
c) $\sqrt{6}$ times faster d) $\sqrt{6}$ times slower

168. The maximum velocity of a particle in S.H.M. is $0.16\ m/s$ and maximum acceleration is $0.64\ m/s^2$. The amplitude is
a) $4 \times 10^{-2} m$ b) $4 \times 10^{-1} m$
c) $4 \times 10\ m$ d) $4 \times 10^{0} m$

169. Time period of a pendulum on earth surface is T_1. It is arranged on earth surface at a height R and thus its time period is T_2. What is the ratio of T_1 and T_2?
a) 0.8 b) 0.5 c) 1 d) 0.2

170. A loaded vertical spring executes simple harmonic oscillations with period of 4 s. The difference between the kinetic energy and potential energy of this system oscillates with a period of
a) 8 s b) 1 s c) 2 s d) 4 s

171. A simple pendulum of length l has a brass bob attached at its lower end. Its period is T. If a steel bob of same size having density x times that of brass replaces the brass bob and its length is changed so that period becomes 2T, then new length is
a) $2l$ b) $4l$ c) $4l$ x d) $\frac{4l}{x}$

172. A particle executes S. H. M. starting from the mean position. Its amplitude is 'A' and its periodic time is 'T'. At a certain instant, its speed 'u' is half that of maximum speed 'v_{max}'. The displacement of the particle at that instant is
a) $\frac{A}{\sqrt{2}}$ b) $\frac{\sqrt{3}A}{2}$
c) $\frac{\sqrt{2}A}{3}$ d) $\frac{A}{\sqrt{3}}$

173. A particle is performing SHM given by equation $\frac{d^2x}{dt^2} + 9x = 0$, then time period is
a) 2π b) $\frac{1}{3}\pi$
c) $\frac{2}{3}\pi$ d) 4π

174. A particle executing simple harmonic motion of amplitude 5 cm has maximum speed of $31.4 cms^{-1}$. The frequency of its oscillation is
a) 3 Hz b) 2 Hz
c) 4 Hz d) 1 Hz

175. What is the velocity of the bob of a simple pendulum at its mean position, if it is able to rise to a vertical height of 10 cm? ($g = 9.8\ m/s^2$)
a) 2.2 m/s b) 1.8 m/s c) 1.4 m/s d) 0.6 m/s

176. In damped S. H. M., the SI unit of damping constant is
a) $\frac{N}{s}$ b) $\frac{kg}{s}$
c) $\frac{kg}{m}$ d) $\frac{N}{m}$

177. A simple pendulum of length L is hanging from a rigid support on the ceiling of a stationary train. If the train moves forward with an acceleration a, then the time period of the pendulum will be
a) $2\pi\sqrt{\frac{L}{(g^2+a^2)^{1/2}}}$ b) $2\pi\sqrt{\frac{L}{(g^2-a^2)^{1/2}}}$
c) $2\pi\sqrt{\frac{L}{(g+a)}}$ d) $2\pi\sqrt{\frac{L}{(g-a)}}$

178. By applying the same load, the ratio of the period of vibration of spring of length 'L' and that of length $\frac{L}{3}$ is
a) 3 b) $\sqrt{3}$
c) $\frac{1}{\sqrt{3}}$ d) $\frac{1}{3}$

179. A spring has a certain mass suspended from it and its period for vertical oscillation is T. The spring is now cut into two equal halves and the same mass is suspended from one of the halves. The period of vertical oscillation is now
a) $\frac{T}{2}$ b) $\frac{T}{\sqrt{2}}$ c) $\sqrt{2}T$ d) 2T

180. A large horizontal surface moves up and down in S.H.M. with an amplitude of 1 cm. If a mass of 10 kg (which is placed on the surface) is to remain continually in contact with it, the maximum frequency of S.H.M. will be
a) 0.5 Hz b) 1.5 Hz c) 5 Hz d) 10 Hz

181. Maximum kinetic energy of a particle suspended from a spring in oscillating state is 5 joule and amplitude is 10 cm. The force constant of the spring will be
a) 100 N/m b) 10 N/m
c) 1000 N/m d) 500 N/m

182. A block of mass m attached to one end of the vertical spring produces extension x. If the block is pulled and released, the periodic time

of oscillation is

a) $2\pi\sqrt{\frac{x}{4g}}$ b) $2\pi\sqrt{\frac{2x}{g}}$

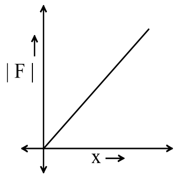
c) $2\pi\sqrt{\frac{x}{2g}}$ d) $2\pi\sqrt{\frac{x}{g}}$

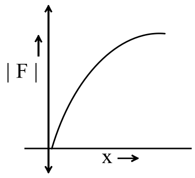
183. The total energy of the body executing simple harmonic motion is E. When the displacement is half of the amplitude then the kinetic energy is

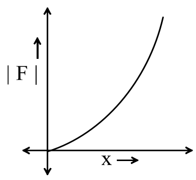
a) $\frac{3E}{4}$ b) $\frac{\sqrt{3}E}{4}$

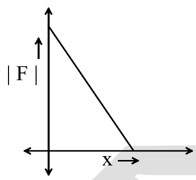
c) $\frac{E}{2}$ d) $\frac{E}{4}$

184. Which of the following graphs correctly shows variation between the restoring force |F| and distance from the mean position (x) of a particle performing linear S.H.M.?

a) 

b) 

c) 

d) 

185. The package on a platform is performing vertical S.H.M. with a period of 0.5 sec. The package can lose contact with the platform,

a) if a mass exceeds a certain limit
b) at the highest point of its motion
c) at the lowest point of its motion
d) at the middle point of its motion

186. A particle moves in S. H. M. such that its acceleration is $a = -px$, where 'x' is the displacement of particle from equilibrium position and 'p' is a constant. The period of oscillation is

a) $2\sqrt{\frac{\pi}{p}}$ b) $\frac{2\pi}{p}$

c) $\frac{2\pi}{\sqrt{p}}$ d) $2\pi\sqrt{p}$

187. The condition for oscillations of the body is

a) inertial property
b) applied force
c) elastic property
d) inertial and elasticity property

188. The period of oscillation of a simple pendulum of constant length at earth surface is T. Its period inside a mine is

a) Greater than T b) Less than T
c) Equal to T d) Cannot be compared

189. The total energy of a particle executing S.H.M. is 80 J. What is the potential energy when the particle is at a distance of 3/4 of amplitude from the mean position?

a) 60 J b) 10 J c) 40 J d) 45 J

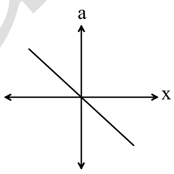
190. In simple harmonic motion, the ratio of acceleration of the particle to its displacement at any time is a measure of

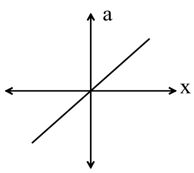
a) Spring constant b) Angular frequency
c) (angular frequency)^2 d) Restoring force

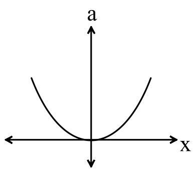
191. The potential energy of a particle with displacement X is u (x). The motion is simple harmonic, when(k is force constant)

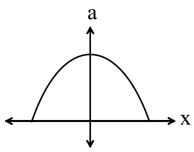
a) $u=\frac{-kx^2}{2}$ b) $u = kx^2$ c) $u = k$ d) $u = kx$

192. The variation of acceleration (a) and displacement (x) of the particle executing S.H.M. is indicated by which of the following curves?

a) 

b) 

c) 

d) 

193. A mass is suspended from a spring having spring constant 'K' is displaced vertically and released, it oscillates with period 'T'. The weight of the mass suspended is (g = gravitational acceleration)

a) $\frac{KTg}{4\pi^2}$ b) $\frac{KT^2g}{4\pi^2}$ c) $\frac{KTg}{2\pi^2}$ d) $\frac{KT^2g}{2\pi^2}$

194. A body attached to a spring oscillates in horizontal plane with frequency 'n'. Its total energy is 'E'. If the velocity in the mean position is V, then the spring constant is

a) $\frac{E\pi^2n^2}{v^2}$ b) $\frac{2E\pi^2n^2}{v^2}$

c) $\frac{8E\pi^2n^2}{v^2}$ d) $\frac{4E\pi^2n^2}{v^2}$

195. The phase change from right to left extreme position is

a) π b) $\pi/2$ c) 2π d) $3\pi/2$

196. The potential energy of a simple harmonic

oscillator when the particle is half way to its end point is

a) $\frac{1}{4}E$ b) $\frac{1}{2}E$

c) $\frac{2}{3}E$ d) $\frac{1}{8}E$

197. A mass 'M' is suspended from a spring of negligible mass. The spring is pulled a little and then released so that the mass executes S. H. M. of period T. If the mass is increased by 'm', the time period becomes '$\frac{5T}{3}$'. What is the ratio $\left(\frac{M}{m}\right)$?

a) $\frac{25}{9}$ b) $\frac{9}{16}$

c) $\frac{16}{9}$ d) $\frac{9}{25}$

198. The necessary and sufficient condition for S.H.M. IS

a) constant period and inertial property

b) constant acceleration and elasticity property

c) proportionality between restoring force and displacement from equilibrium position in opposite direction

d) periodic and harmonic

199. Acceleration amplitude of a particle performing S.H.M. is the product of

a) amplitude and velocity

b) amplitude and acceleration

c) amplitude and square of angular velocity .

d) square of amplitude and angular velocity

200. A particle starts simple harmonic motion from the mean position. Its amplitude is A and total energy E. At one instant, its kinetic energy is 3E/4. Its displacement at that instant is

a) $\frac{A}{\sqrt{2}}$ b) $\frac{A}{2}$ c) $\frac{A}{\sqrt{3/2}}$ d) $\frac{A}{\sqrt{3}}$

N.B.Navale

Date : 28.03.2025
Time : 03:00:00
Marks : 200

TEST ID: 51
PHYSICS

4.OSCILLATIONS,5.OSCILLATIONS

: ANSWER KEY :

1)	c	2)	b	3)	b	4)	d
5)	b	6)	b	7)	b	8)	b
9)	d	10)	a	11)	c	12)	a
13)	c	14)	b	15)	d	16)	b
17)	b	18)	b	19)	c	20)	c
21)	b	22)	b	23)	d	24)	b
25)	c	26)	b	27)	d	28)	a
29)	a	30)	d	31)	c	32)	c
33)	b	34)	c	35)	d	36)	c
37)	b	38)	c	39)	c	40)	c
41)	c	42)	c	43)	c	44)	d
45)	c	46)	b	47)	a	48)	a
49)	c	50)	b	51)	a	52)	d
53)	b	54)	d	55)	b	56)	a
57)	b	58)	a	59)	c	60)	d
61)	c	62)	b	63)	a	64)	b
65)	a	66)	c	67)	c	68)	c
69)	c	70)	c	71)	a	72)	c
73)	c	74)	a	75)	c	76)	c
77)	d	78)	d	79)	c	80)	d
81)	a	82)	a	83)	c	84)	c
85)	b	86)	a	87)	a	88)	d
89)	a	90)	a	91)	b	92)	d
93)	a	94)	a	95)	d	96)	b
97)	b	98)	d	99)	b	100)	c
101)	a	102)	c	103)	a	104)	a

105)	b	106)	a	107)	b	108)	b
109)	c	110)	b	111)	a	112)	c
113)	a	114)	a	115)	c	116)	c
117)	c	118)	a	119)	c	120)	c
121)	d	122)	a	123)	c	124)	c
125)	c	126)	b	127)	a	128)	a
129)	b	130)	c	131)	d	132)	b
133)	d	134)	b	135)	b	136)	d
137)	d	138)	a	139)	d	140)	c
141)	a	142)	b	143)	a	144)	a
145)	b	146)	d	147)	b	148)	b
149)	b	150)	a	151)	a	152)	a
153)	b	154)	c	155)	b	156)	c
157)	d	158)	a	159)	c	160)	a
161)	c	162)	c	163)	a	164)	c
165)	c	166)	a	167)	d	168)	a
169)	b	170)	c	171)	b	172)	b
173)	c	174)	d	175)	c	176)	b
177)	a	178)	b	179)	b	180)	c
181)	c	182)	d	183)	a	184)	a
185)	b	186)	c	187)	d	188)	a
189)	d	190)	c	191)	b	192)	a
193)	b	194)	c	195)	a	196)	a
197)	b	198)	c	199)	c	200)	b

N.B.Navale

Date : 28.03.2025
Time : 03:00:00
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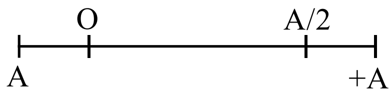
TEST ID: 51
PHYSICS

4.OSCILLATIONS,5.OSCILLATIONS

: HINTS AND SOLUTIONS :

Single Correct Answer Type

1 **(c)**



Time to go from O to $\frac{A}{2}, \frac{A}{2} = A\sin\left(\frac{2\pi T_1}{T}\right)$

$$\therefore \ \frac{1}{2} = \sin\frac{\pi}{6} = \sin\left(\frac{2\pi T_1}{T}\right)$$

$$\Rightarrow \frac{2\pi T_1}{T} = \frac{\pi}{6}$$

$$\Rightarrow T_1 = \frac{T}{12}$$

Time to go from O to A is $\frac{T}{4}$.

Time to go from $\frac{A}{2}$ to $A = \frac{T}{4} - \frac{T}{12} = \frac{T}{6}$

Thus,

and

$$T_1 = \frac{T}{12}$$

$$T_1 < T_2$$

2 **(b)**

$\mathrm{K.E.} = \frac{1}{2}\mathrm{k}(\mathrm{A}^2 - \mathrm{x}^2)$

As $\mathrm{x} = \mathrm{A}\sin(\omega t + \alpha)$

$\therefore \mathrm{K.E.} = \frac{1}{2}\mathrm{k}[\mathrm{A}^2 - \mathrm{A}^2\sin^2(\omega t + \alpha)]$

$= \frac{1}{2}\mathrm{kA}^2[(1 - \sin^2(\omega t + \alpha)]$

$= \frac{1}{2}\mathrm{kA}^2\cos^2(\omega t + \alpha)$ ...(i)

As $\cos^2\theta = \frac{1+\cos 2\theta}{2}$

$\cos^2(\omega t + \alpha) = \frac{1 + \cos 2(\omega t + \alpha)}{2}$

$\therefore$ Eq. (i) becomes

$\mathrm{K.E.} = \frac{1}{2}\mathrm{kA}^2\left(\frac{1 + \cos 2(\omega t + \alpha)}{2}\right)$

$\therefore$ Kinetic energy of particle vary with frequency two times of frequency of particle

$\therefore$ If frequency of particle is 10 then the kinetic energy of the particle will vary with frequency $2 \times 10 = 20$

3 **(b)**

Acceleration $\mathrm{a} = \omega^2\mathrm{x}$

$$\therefore \omega^2 = \frac{\mathrm{a}}{\mathrm{x}} = \frac{0.5}{0.02} = 25$$

$$\therefore \omega = 5\frac{\mathrm{rad}}{\mathrm{s}}$$

$$\mathrm{V_{max}} = \mathrm{A}\omega^2 = 0.1 \times 5 = 0.5 \text{ m/s}$$

4 **(d)**

Force increases linearly, i.e. $\mathrm{F} \propto -\mathrm{x}$

$\therefore \frac{\mathrm{F}'}{\mathrm{F}} = \frac{\mathrm{x}'}{\mathrm{x}}$

$\therefore \frac{\mathrm{F}'}{\mathrm{F}} = \frac{\mathrm{A}}{2} \times \left(-\frac{4}{\mathrm{A}}\right) = -2$

$\therefore \mathrm{F}' = -2\mathrm{F} \Rightarrow \frac{\mathrm{x}'}{\mathrm{x}} = -2$

Potential energy, $\mathrm{P.E.} \propto \mathrm{x}^2$

$\therefore \frac{\mathrm{P.E.}'}{\mathrm{P.E.}} = \left(\frac{\mathrm{x}'}{\mathrm{x}}\right)^2 = (-2)^2 = 4$

$\therefore \mathrm{P.E.}' = 4\mathrm{P.E.}$

Speed of particle is given by

$\mathrm{v} = \omega\sqrt{\mathrm{A}^2 - \mathrm{x}^2} \Rightarrow \mathrm{v} \propto \sqrt{\mathrm{A}^2 - \mathrm{x}^2}$

At $\mathrm{x} = \frac{-\mathrm{A}}{4}$,

$$\mathrm{v} \propto \sqrt{\mathrm{A}^2 - \left(\frac{\mathrm{A}}{4}\right)^2} = \sqrt{\frac{15}{16}}\mathrm{A}$$

$\therefore$ At $\mathrm{x} = \frac{\mathrm{A}}{2}$,

$$\mathrm{v} \propto \sqrt{\mathrm{A}^2 - \left(\frac{\mathrm{A}}{2}\right)^2} = \sqrt{\frac{3}{4}}\mathrm{A}$$

$$\therefore \frac{\mathrm{v}'}{\mathrm{v}} = \sqrt{\frac{3}{4}} \times \sqrt{\frac{15}{16}} = \sqrt{\frac{4}{5}}$$

$\therefore$ Velocity at $\mathrm{x} = \mathrm{A}/2$ may be $\pm\sqrt{\frac{4}{5}}\mathrm{v}$

Kinetic energy will be

$$\frac{K.E.'}{K.E.} = \left(\frac{v'}{v}\right)^2 = \frac{4}{5} = 0.8$$

$\therefore K.E.' = 0.8\ K.E.$

5 **(b)**

When particle starts from extreme position,

$x = A\cos\omega t$ ...(i)

$n = 60\ r.p.m. = \frac{60}{60} = 1\ r.p.s.$

$\omega = 2\pi n = 2\pi \times 1 = 2\pi$

$x = 0.1\cos(2\pi \times 2)$ ...[From (i)]

$= 0.1\cos 4\pi = 0.1\ m$ ... [$\because \cos 4\pi = 1$]

6 **(b)**

kinetic energy $= \frac{1}{2}m\omega^2(A^2 - x^2)$

Total energy $= \frac{1}{2}m\omega^2 A^2$

$\therefore \frac{K.E.}{T.E.} = \frac{5}{9} = \frac{A^2 - x^2}{A^2}$

$\therefore 9x^2 = 4A^2$

$\therefore x = \frac{2}{3}A$

7 **(b)**

At B, the velocity is maximum. Using conservation of mechanical energy,

$\Delta P.E. = \Delta K.E.$

$\therefore mgH = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2gH}$

8 **(b)**

Frequency $f = \frac{7}{2\pi}$

$\therefore \omega = 2\pi f = 2\pi \times \frac{7}{2\pi} = 7\frac{rad}{s}$

The standard differential equation of S. H. M. is

$$\frac{dx^2}{dt^2} + \omega^2 x = 0$$

Putting the value of ω we get

$$\frac{dx^2}{dt^2} + 49x = 0$$

9 **(d)**

As, $F_1 = \frac{m4\pi^2 a}{T_1^2}$ and $F_2 = \frac{m4\pi^2 a}{T_2^2}$

Net force, $F = F_1 + F_2 = 4\pi^2 ma\left(\frac{1}{T_1^2} + \frac{1}{T_2^2}\right)$

or $\frac{4\pi^2 ma}{T^2} = 4\pi^2 ma\left(\frac{1}{T_1^2} + \frac{1}{T_2^2}\right)$

or $\frac{1}{T^2} = \frac{1}{T_1^2} + \frac{1}{T_2^2}$

$$\Rightarrow T^2 = \frac{T_1^2 T_2^2}{T_1^2 + T_2^2}$$

10 **(a)**

$T\cos\theta = mg$

$\therefore T = m\omega^2 l = \frac{mg}{\cos\theta} = \frac{50 \times 10^{-3} \times 10}{0.5} = 1N$

11 **(c)**

$$T_1 = 2\pi\sqrt{\frac{m_1}{k}}, T_2 = 2\pi\sqrt{\frac{m_1 + m_2}{k}}$$

$$\therefore \frac{T_2}{T_1} = \sqrt{\frac{m_1 + m_2}{k}}$$

$$\therefore \frac{T_2^2}{T_1^2} = \frac{m_1 + m_2}{m_1}$$

$$\therefore \frac{T_2^2 - T_1^2}{T_1^2} = \frac{m_2}{m_1}$$

12 **(a)**

$U = k|x|^3$

$\therefore F = -\frac{d(P.E.)}{dx} = -3k|x|^2$ ...(i)

Also, for S.H.M., $x = \alpha\sin\omega t$ and

$\frac{d^2x}{dt^2} + \omega^2 x = 0$

Acceleration, $a = \frac{d^2x}{dt^2} = -\omega^2 x \Rightarrow F = ma$

$= m\frac{d^2x}{dt^2} = -m\omega^2 x$ ...(ii)

From equation (i) and (ii) we get, $\omega = \sqrt{\frac{3kx}{m}}$

$\therefore T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{3kx}} = 2\pi\sqrt{\frac{m}{3k(A\sin\omega t)}}$

$\therefore T \propto \frac{1}{\sqrt{A}}$

13 **(c)**

Potential energy $= \frac{1}{2}m\omega^2 y^2 = \frac{1}{4} \times \frac{1}{2}m\omega^2 a^2$

$$\Rightarrow y = \pm\frac{a}{2}$$

$$y^2 = \frac{a^2}{4}$$

$$y = \pm\frac{a}{2}$$

14 **(b)**

$U = \frac{1}{2}kx^2$ but $T = kx$

So energy stored $= \frac{1}{2}\frac{(kx)^2}{k} = \frac{1}{2}\frac{T^2}{k}$

15 **(d)**

Maximum speed $V = A\omega$

Where A is the amplitude and ω angular frequency

Averate speed $v_A = \frac{\text{Total distance}}{\text{Total time}} = \frac{4A}{T}$

where $T = \frac{2\pi}{\omega}$ = Period of S. H. M.

$\therefore v_A = \frac{4A\omega}{2\pi} = \frac{2A\omega}{\pi} = \frac{2V}{\pi}$

16 **(b)**

Tension in the string is maximum when the bob passes through the mean position.

$T_{max} = mg + \frac{mV^2}{L} \quad \ldots (1)$

In S. H. M. velocity at the mean position is given by $V = a\omega$

For simple pendulum

$T = 2\pi\sqrt{\frac{L}{g}}$

$\therefore \omega = \frac{2\pi}{T} = \sqrt{\frac{g}{L}}$

$\therefore V = a\sqrt{\frac{g}{L}}$ or $V^2 = a^2\frac{g}{L}$

Putting this value of V^2 in Eq. (1) we get

$T_{max} = mg\left[1 + \left(\frac{a}{L}\right)^2\right]$

17 **(b)**

$F = -kx \Rightarrow ma = -kx$

$\therefore \frac{x}{a} = \left(-\frac{m}{k}\right) = \text{constant}$

18 **(b)**

Acceleration due to gravity,

$g = \frac{GM}{R^2} = \frac{G \times \frac{4}{3}\pi R^3\rho}{R^2} = \frac{4}{3}\pi G\rho R$

or $g \propto R$

For pendulum clock, g will increase on the plane, so time period will decrease. But for spring clock, it will not change. Hence, P will run faster than S.

20 **(c)**

$m = 12\text{ kg}, T = 2\text{ sec}, \pi^2 = 10$

$T = 2\pi\sqrt{\frac{m}{K}}$

$\therefore 2 = 2\pi\sqrt{\frac{m}{K}}$

$\therefore 1 = \pi\sqrt{\frac{m}{K}}$

$\therefore 1 = \pi^2\frac{m}{K}$

$\therefore K = \pi^2 m = 10 \times 12$

$= 120\frac{N}{m}$ (force constant of the combination)

The two springs are in parallel. Hence force constant of each will be $\frac{120}{2} = 60\text{ N/m}$

21 **(b)**

$T = \frac{2\pi}{\sqrt{3}}\text{s}, ZA = 4\text{ cm}$

$\therefore A = 2\text{ cm} = 2 \times 10^{-2}\text{m}$

Acceleration,

$a = \omega^2 x$

Velocity, $v = \omega\sqrt{A^2 - x^2}$

$\therefore \omega^2 x = \omega\sqrt{A^2 - x^2}$

$\omega x = \sqrt{A^2 - x^2}$

$\omega^2 x^2 = A^2 - x^2$

$\therefore 3x^2 = A^2 - x^2 \quad \left(\therefore \omega = \frac{2\pi}{T} = \sqrt{3}\right)$

$\therefore 4x^2 = A^2$

$c = \frac{A}{2} = \frac{2}{2} = 1\text{ cm}$

23 **(d)**

In S.H.M., at mean position, velocity is maximum

So $v = A\omega$ (maximum)

24 **(b)**

Here, amplitude of particle,

$A = 25\text{ cm}$

and time period, $T = 3$ s

If the particle at $t = 0$ s is at mean position, its displacement equation will be

$x = A\sin\omega t$

i.e. $x = 25\sin\frac{2\pi t}{3}$ $\left(\because \omega = 2\pi v = \frac{2\pi}{T} = \frac{2\pi}{3}\right)$

If it takes time t_1 to move a distance $x = 125$ cm to one side of its mean position, then

$125 = 25\sin\frac{2\pi t_1}{3}$

or $\frac{1}{2} = \sin\frac{2\pi t_1}{3}$

or $\sin\frac{\pi}{6} = \sin\frac{2\pi t_1}{3}$

$\therefore \frac{\pi}{6} = \frac{2\pi t_1}{3}$

$\Rightarrow t_1 = \frac{1}{4}$

The same will be the time to move 12.5 cm to the other side of its mean position, therefore total time

$t = t_1 + t_2$

$= \frac{1}{4} + \frac{1}{4} = \frac{1}{2} = 0.5$ s

25 **(c)**

$T = 2\pi\sqrt{\frac{L}{g}}$ $T^2 = \frac{4\pi^2}{g}L$

i,e$T^2 \propto L$, y=mx

26 **(b)**

For simple pendulum, the restoring force is given by

$F = -mg\sin\theta = -mg\frac{x}{L}$

Comparing with the equation $F = -kx$

we get $k = \frac{mg}{L}$

The potential energy at extreme position is given by

$P.E. = \frac{1}{2}kA^2 = \frac{1}{2}\frac{mgA^2}{L}$

28 **(a)**

With mass m_2 alone, the extension of the spring l is given by,

$m_2g = kl$ ...(i)

With mass $(m_1 + m_2)$, the extension l' is given by,

$(m_1 + m_2)g = kl' = k(l + \Delta l)$ ...(ii)

The increase in extension is Δl which is the amplitude of vibration. Subtracting equation (i) from equation (ii), we get,

$m_1g = k\Delta l \Rightarrow \Delta l = \frac{m_1g}{k}$

29 **(a)**

$v = \frac{v_{max}}{2}$ ...(Given)

$x = a\sin\omega t$

$\therefore v = a\omega\cos\omega t$ and $v_{max} = a\omega$

$\therefore a\omega\cos\omega t = \frac{a\omega}{2}$

$\therefore \cos\omega t = \frac{1}{2} \Rightarrow \omega t = \frac{\pi}{3}$

$\therefore x = a\sin\frac{\pi}{3} = \frac{\sqrt{3}a}{2}$

32 **(c)**

$\therefore$ $\alpha = V_{max} = A\omega$ and $a_{max} = A\omega^2 = \beta$

$\because$ $\frac{\alpha^2}{\beta} = \frac{A^2\omega^2}{A\omega^2} = A$

$\therefore$ Path length $= \frac{2\alpha^2}{\beta}$

33 **(b)**

a=-kx

$\frac{d^2x}{dt^2} = -\frac{k}{m}x$

given equation is

$\frac{d^2x}{dt^2} = \frac{-16x}{m}$

$\therefore \frac{k}{m} = 16,$

m=2 gm

$k = 16\,m = 32\,dyne/cm$

35 **(d)**

$v = \frac{dx}{dt} = 4 \times \pi \times \cos\left(\pi t + \frac{\pi}{3}\right)$

$= 4\pi\cos\left(4\pi + \frac{\pi}{3}\right) = 4\pi\cos\left(\frac{\pi}{3}\right)$

$= 4\pi \times \frac{1}{2} = 2\pi$ cm/s

37 **(b)**

Given, amplitude of SHM $= a$

Frequency of oscillation $= n$

Distance travelled in one oscillation,

$= 4 \times$ Amplitude of SHM

$= 4a$

We know that,

$$\text{velocity} = \frac{\text{distance travelled in one oscillation}}{\text{time period}}$$

$$v = \frac{4a}{T}$$

$$\therefore\ v = 4an \left(\because\ \text{frequency}, n = \frac{1}{T}\right)$$

38 **(c)**

$F_1 = K_1x$
$F_2 = K_2x$
$F = (K_1 + K_2)x$

$$\therefore T_1 = 2\pi\sqrt{\frac{m}{K}}$$

$$T_2 = 2\pi\sqrt{\frac{m}{K}}$$

$$\therefore T_1^2 = 4\pi^2 \frac{m}{K_1}$$

$$T_2^2 = 4\pi^2 \frac{m}{K_2}$$

$$T^2 = 4\pi^2 \frac{m}{K_1 + K_2}$$

$$\therefore \frac{1}{T^2} = \frac{K_1 + K_2}{4\pi^2 m} = \frac{K_1}{4\pi^2 m} + \frac{K_2}{4\pi^2 m}$$

$$= \frac{1}{T_1^2} + \frac{1}{T_2^2} = \frac{T_1^2 + T_2^2}{T_1^2 T_2^2}$$

$$\therefore T^2 = \frac{T_1^2 T_2^2}{T_1^2 + T_2^2}$$

$$\therefore T = \frac{T_1 T_2}{\sqrt{T_1^2 + T_2^2}}$$

39 **(c)**

The periodic time of a pendulum is given by

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$\therefore T \propto \sqrt{l}$$

Hence to increase the periodic time, length has to be increased. The periodic time is independent of mass and amplitude.

40 **(c)**

Energy of oscillations is given by

$$E = \frac{1}{2} m\omega^2 A^2 \text{ where } \omega = 2\pi n$$

$\therefore E \propto n^2 A^2$

$\therefore n_1^2 A_1^2 = n_2^2 A_2^2$ or $n_1 A_1 = n_2 A_2$

$\therefore \frac{A_2}{A_1} = \frac{n_1}{n_2} = 4A$

41 **(c)**

The potential energy at the extreme position is given by

$$P.E. = \frac{1}{2} KA^2$$

For simple pendulum $K = \frac{mg}{L}$

$$\therefore P.E. = \frac{1}{2}\frac{mgA^2}{L}$$

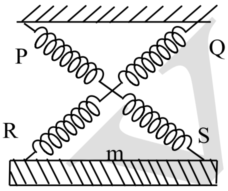
42 **(c)**

Amplitude of resultant S.H.M.

$$R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos 90°}$$

$$R = \sqrt{A_1^2 + A_2^2} = \sqrt{a^2 + b^2}$$

43 **(c)**



Springs P and Q, R and S are in parallel

Then, $x = k + k = 2k$ ...[for P, Q]

and $y = k + k = 2k$ ...[for R, S]

x and y both in series

$$\therefore \frac{1}{k''} = \frac{1}{x} + \frac{1}{y} = \frac{1}{k}$$

$$\therefore \text{Time period } T = 2\pi\sqrt{\frac{2}{k''}} = 2\pi\sqrt{\frac{m}{k}}$$

44 **(d)**

Potential energy of particle, $U = \frac{1}{2} m\omega^2 y^2$

Potential energy of maximum particle, $E = \frac{1}{2} m\omega^2 A^2$

According to given position, the potential energy, $U = \frac{E}{2}$

or $\frac{1}{2} m\omega^2 y^2 = \frac{1}{2} \times \frac{1}{2} m\omega^2 A^2$

$$\Rightarrow y^2 = \frac{A^2}{2}, y = \frac{A}{\sqrt{2}}$$

46 **(b)**

K.E. is maximum at mean position and P.E. is minimum at mean position

48 **(a)**

$mg = -kx$

$$\therefore k = \frac{mg}{x}$$

$$\omega^2 = \frac{k}{m}$$
$$\left(\frac{2\pi}{T}\right)^2 = \frac{k}{m}$$
$$\frac{4\pi^2}{T^2} = \frac{k}{m}$$
$$\therefore T^2 = \frac{4\pi^2 m}{k} = \frac{4\pi^2 mx}{mg} \Longrightarrow T = 2\pi\sqrt{\frac{x}{g}}$$

49 **(c)**

$$x = P\sin\omega t + Q\sin\left(\omega t + \frac{\pi}{2}\right)$$

It can be considered as composition of two S. H. M. of amplitudes P and Q having phase difference $\frac{\pi}{2}$.

$\therefore$ Resultant amplitude $R = \sqrt{P^2 + Q^2}$

Total energy $E = \frac{1}{2}m\omega^2 R^2 = \frac{1}{2}m\omega^2(P^2 + Q^2)$

50 **(b)**

Let the block be pushed through a small distance x in the liquid. The volume of the liquid displaced by it will be = A x and its weight will be $A \times \rho g$.

The weight of the liquid displaced will be equal to the up-thrust, which will provide the restoring force.

$\therefore F = -(A\rho g)x = -kx$

where $k = A\rho g$

$$k = m\omega^2 \text{ or } \omega = \sqrt{\frac{k}{m}}$$

$$\therefore f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\sqrt{\frac{A\rho g}{m}}$$

$\therefore f \propto \sqrt{A}$ or $n \propto \sqrt{A}$

51 **(a)**

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

52 **(d)**

In simple harmonic motion,
$y = A\sin\omega t$ and $v = A\omega\cos\omega t$. From these equations, we obtain $\frac{y^2}{A^2} + \frac{v^2}{A^2\omega^2} = 1$, which is an equation of ellipse

53 **(b)**

$x_1 = A\sin(\omega t + \phi_1), x_2 = A\sin(\omega t + \phi_2)$

$$\therefore x_1 - x_2 = A\left[2\sin\left(\omega t + \frac{\phi_1 + \phi_2}{2}\right)\sin\left(\frac{\phi_1 - \phi_2}{2}\right)\right]$$
$$\therefore A = 2A\sin\left(\frac{\phi_1 + \phi_2}{2}\right)$$
$$\therefore \sin\left(\frac{\phi_1 + \phi_2}{2}\right) = \frac{1}{2} \Rightarrow \frac{\phi_1 + \phi_2}{2} = \frac{\pi}{6}$$
$$\therefore \frac{\phi_1 - \phi_2}{2} = \frac{\pi}{6} \Rightarrow \phi_1 - \phi_2 = \frac{\pi}{3}$$

54 **(d)**

From graph, slope $K = \frac{F}{x} = \frac{8}{2} = 4$

$$T = 2\pi\sqrt{\frac{m}{k}}$$
$$\therefore T = 2\pi\sqrt{\frac{0.01}{4}} = 0.3 \text{ s}$$

56 **(a)**

The angular frequency of spring is given by

$$\omega = \sqrt{\frac{k}{m}} \propto \sqrt{k}$$

For equal maximum velocities, we have

$$A_1\omega_1 = A_2\omega_2$$

Or $\frac{A_1}{A_2} = \frac{\omega_2}{\omega_1} = \sqrt{\frac{k_2}{k_1}} = \left(\frac{k_2}{k_1}\right)^{\frac{1}{2}}$

$(\because m = m_1 = m_2)$

57 **(b)**

$$v = a\omega = a\frac{2\pi}{T}$$

$$v = \omega\sqrt{a^2 - \frac{a^2}{4}} = \omega\frac{\sqrt{3}}{2}a = \frac{2\pi}{T}\frac{\sqrt{3}}{2}n = \frac{\sqrt{3}\pi n}{T}$$

59 **(c)**

Displacement equation, $y = A\sin\omega t - B\cos\omega t$

Let $A = a\cos\theta$ and $B = a\sin\theta$

So, $A^2 + B^2 = a^2 \Rightarrow a = \sqrt{A^2 + B^2}$

Then, $y = a\cos\theta\sin\omega t - a\sin\theta\cos\omega t = a\sin(\omega t - \theta)$ which is the equation of simple harmonic oscillator. The amplitude of the oscillator, $a = \sqrt{A^2 + B^2}$.

60 **(d)**

The period of simple pendulum is given by

$$T = 2\pi\sqrt{\frac{l}{9}}$$

$\therefore T \propto \sqrt{l}$

The period of oscillation will increase if length is increased.

63 **(a)**
Given, $x = (2 \times 10^{-2})\cos \pi t$
Here, $a = 2 \times 10^{-2}$ m $= 2$ cm
At $= 0, x = 2$ cm, i.e. the object is at positive extreme, so to acquire maximum speed, i.e. to reach mean position, it takes $\frac{1}{4}$th of time period.

$\therefore$ Required time $= \frac{T}{4}$ (where, $\omega = \frac{2\pi}{T} = \pi$)

$\Rightarrow T = 2$ s

So, required time $= \frac{T}{4} = \frac{2}{4} = 0.5$ s

64 **(b)**
$x = A \sin \omega t$

at $t = \frac{T}{12}, x = A \sin \frac{2\pi}{T}.\frac{T}{12} = A \sin \frac{\pi}{6}$

$\therefore x = A \times \frac{1}{2} = \frac{A}{2}$

$$P.E = \frac{1}{2}kx^2 = \frac{1}{2}K\left(\frac{A}{2}\right)^2 = \frac{1}{2}\left[\frac{KA^2}{4}\right]$$

$$K.E. = \frac{1}{2}K(A^2 - x^2) = \frac{1}{2}K\left(A^2 - \frac{A^2}{4}\right) = \frac{1}{2}\left[\frac{3}{4}KA^2\right]$$
$$= 3P.E.$$

$\therefore \frac{P.E.}{K.E.} = \frac{1}{3}$

65 **(a)**
$a_{max} = \omega^2 A$

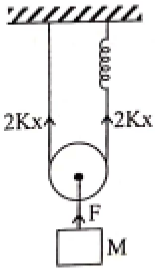
66 **(c)**
K.E. = P.E.

$\therefore \frac{1}{2}m\omega^2(A^2 - x^2) = \frac{1}{2}m\omega^2x^2$

$\therefore A^2 - x^2 = x^2 \Rightarrow 2x^2 = A^2 \Rightarrow x = \frac{A}{\sqrt{2}}$

$\therefore x = 0.71A$

67 **(c)**



If block moves by distance x, the pulley also moves x and the spring is stretched by 2x.

The restoring force $F = -4Kx$

Comparing it with the equation

$F = -K'x$

We get $K' = 4K$

$\therefore T = 2\pi\sqrt{M/K'} = 2\pi\sqrt{M/4K}$

69 **(c)**
$T_1 = T$

$\frac{T_1}{T_2} = \sqrt{\frac{l_1}{l_2}} = \sqrt{\frac{1}{16}} = \frac{1}{4}$ ... (i)

$x_1 = A \sin \omega_1 t$ and $x_2 = B \sin \omega_2 t$
They are in phase after time t and phase difference is 2π

$\therefore \omega_1 t - \omega_2 t = 2\pi$

$\therefore \left(\frac{2\pi}{T_1} - \frac{2\pi}{T_2}\right)t = 2\pi$

$\therefore \left(\frac{t}{T_1} - \frac{t}{T_2}\right)t = 1$

$\therefore \frac{t}{T_1}\left(1 - \frac{T_1}{T_2}\right) = 1$

$\therefore \frac{t}{T}\left(1 - \frac{1}{4}\right) = 1$ ....[From (i)]

$\therefore \frac{t}{T} \times \frac{3}{4} = 1 \Rightarrow t = \frac{4}{3}T$

70 **(c)**
The frequency of oscillation is given by

$$f_P = \frac{1}{2\pi}\sqrt{\frac{M_P B}{I_P}} \text{ and } f_Q = \frac{1}{2\pi}\sqrt{\frac{M_Q B}{I_Q}}$$

$f_P = 2f_Q$

$$\therefore \frac{1}{2\pi}\sqrt{\frac{M_P B}{I_P}} = 2.\frac{1}{2\pi}\sqrt{\frac{M_Q B}{I_Q}}$$

$$\therefore \frac{M_P}{I_P} = 4\frac{M_Q}{I_Q}$$

$\therefore \frac{M_P}{M_Q} = 4\frac{I_P}{I_Q} = 8 \quad [\because I_P = 2I_Q]$

71 **(a)**

Force of friction $= \mu mg = m\omega^2 A$

$= m(2\pi n)^2 A$

$\therefore n = \frac{1}{2\pi}\sqrt{\frac{\mu g}{A}}$

72 **(c)**

f = 8 cm, when the particle is at mean position, u = −14 cm

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{8} - \frac{1}{14} = \frac{3}{56}$$

$$\therefore v = \frac{56}{3} = 19 \text{ cm}$$

When the particle is at one of the extreme positions its distance from the lens is 14 + 1 = 15 cm

$$\therefore u = -15 \text{ cm}$$

$$\text{Again,} \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{8} - \frac{1}{15} = \frac{7}{120}$$

$$\therefore v = \frac{120}{7} = 17 \text{ cm}$$

Amplitude of the image = 19 − 17 = 2 cm

73 **(c)**

The stone executes S.H.M. about centre of earth with time period $T = 2\pi\sqrt{\frac{R}{g}}$; where R = Radius of earth

74 **(a)**

The displacement of particle in SHM at any instant,

$$x = A\sin\omega t$$

$$\frac{A}{2} = A\sin\omega t$$

$$\left(\text{given, } x = \frac{A}{2}\right)$$

$$\sin\omega t = \frac{1}{2} = \sin\frac{\pi}{6}$$

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

$$\Rightarrow \frac{2\pi}{T}\cdot t = \frac{\pi}{6}$$

$$\left(\because \omega = \frac{2\pi}{T}\right)$$

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

$$\Rightarrow t = \frac{1}{4}\text{ s}$$

(given, $T = 3s$)

76 **(c)**

Given, $m = 64 \text{ g} = 64 \times 10^{-3}$ kg,

and $k_A = 4$ N/m, $k_B = 16$ N/m

The time period of oscillation of a spring,

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$\Rightarrow T_A = T_1 = 2\pi\sqrt{\frac{m}{k_A}} = 2\pi\sqrt{\frac{64\times 10^{-3}}{4}}$$

$$= 2\pi\sqrt{16\times 10^{-3}} \qquad \text{.....(i)}$$

$$\text{and } T_B = T_2 = 2\pi\sqrt{\frac{m}{k_B}} = 2\pi\sqrt{\frac{64\times 10^{-3}}{16}}$$

$$= 2\pi\sqrt{4\times 10^{-3}} \qquad \text{......(ii)}$$

On dividing Eq. (i) by Eq. (ii), we get

$$\frac{T_1}{T_2} = \sqrt{\frac{16\times 10^{-3}}{4\times 10^{-3}}} = 2$$

$$\Rightarrow T_1 = 2T_2$$

$$\therefore \frac{T_1+T_2}{T_1-T_2} = \frac{2T_2+T_2}{2T_2-T_2} = \frac{3T_2}{T_2} = \frac{3}{1} \text{or } 3:1$$

77 **(d)**

Comparing with the standard equation

$$\frac{d^2x}{dt^2} + \omega^2 x = 0$$

we get $\omega^2 = \alpha$

$$\therefore \omega = \sqrt{\alpha}$$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\alpha}}$$

78 **(d)**

At mean position $f_{net} = 0$

$\therefore$ Applying conservation of momentum

$m_1 v_1 = (m_1 + m_2) v_2$

$m_1 \omega_1 A_1 = (m_1 + m_2) \omega_2 A_2$

But $\omega_1 = \sqrt{\dfrac{k}{m_1}}$

$\omega_2 = \sqrt{\dfrac{k}{m_1 + m_2}} A_2$

$\therefore m_1 \sqrt{\dfrac{k}{m_1}} A_1 = (m_1 + m_2) \sqrt{\dfrac{k}{m_1 + m_2}} A_2$

$\dfrac{A_1}{A_2} = \sqrt{\dfrac{m_1 + m_2}{m_1}}$

80 **(d)**
$\sqrt{E_1} + \sqrt{E_2} = \sqrt{E}$

81 **(a)**
$F = -kx$
$\therefore dW = Fdx = -kxdx$
$\therefore \int_a^W dW = \int_0^x -kx\, dx$
$\therefore W = U = -\dfrac{1}{2} kx^2$

82 **(a)**
If t is the time to reach the ground then

$h = \dfrac{1}{2} gt^2$

$\therefore t = \sqrt{\dfrac{2h}{g}}$

Same time will be taken to bounce back to height h.

$\therefore$ Period of oscillation $T = 2t = 2\sqrt{\dfrac{2h}{g}}$

Frequency $f = \dfrac{1}{T} = \dfrac{1}{2}\sqrt{\dfrac{g}{2h}}$

84 **(c)**
Comparing given equations with standard from,
$A_1 = 10$ and $A_2 = 25$

$\therefore \dfrac{A_1}{A_2} = \dfrac{10}{25} = \dfrac{2}{5}$

85 **(b)**
Linear momentum will be maximum, if velocity of bob is maximum .
In SHM V max = ω A
$E = \frac{1}{2} m\omega^2 A^2$
$\frac{2E}{m} = \omega^2 A^2 = V^2_{max}$
$\therefore Vmax = \sqrt{\frac{2E}{m}}$
Linear momentum $P_{max} = mV_{max}$
$= m\sqrt{\dfrac{2E}{m}} = \sqrt{2mE}$

86 **(a)**
The coil will leave contact when it is at the highest point and for that condition
Maximum acceleration = Acceleration due to gravity
$\omega^2 A = g \Rightarrow A = \dfrac{g}{\omega^2}$

87 **(a)**
$T = 2\pi\sqrt{\dfrac{l_0(l + \alpha\Delta\theta)}{g}} = 2\pi\sqrt{\dfrac{l_0}{g}}\left(l + \dfrac{\alpha}{2}\Delta\theta\right)$ & $T_0 = 2\pi\sqrt{\dfrac{l_0}{g}}$

$T = T_0\left(l + \dfrac{\alpha}{2}\Delta\theta\right)$

$\therefore T = 0.5\left(1 + \dfrac{9 \times 10^{-7}}{2} \times 10\right)$

$T - T_0 = 2.25 \times 10^{-6}$ sec

89 **(a)**

$V = \omega\sqrt{A^2 - x^2} = \sqrt{\dfrac{k}{m}}.\sqrt{A^2 - x^2}$

$k = 10\dfrac{N}{m}, m = 10\text{ kg}, A = 0.5\text{ m}$

$V = 40\dfrac{cm}{s} = 0.4\dfrac{m}{s}$

Substituting the values and solving we get $x = 0.3$ m

90 **(a)**
$m = 5\text{ g} = 5 \times 10^{-3}\text{ kg}, A = 0.3\text{ m}, T = \dfrac{\pi}{5}\text{s}$

$$\omega = \frac{2\pi}{T} = 10\frac{rad}{s}$$

Maximum force $F = m\omega^2 A$

$$= 5 \times 10^{-3} \times (10)^2 \times 0.3$$
$$= 0.15\ N$$

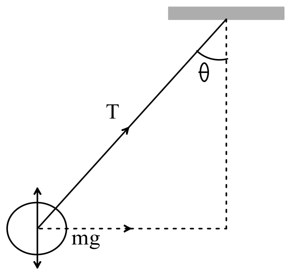
91 **(b)**

$V_m = 8\,; \quad A = 4$

$V_m = A\omega$

$\therefore \omega = \frac{V_m}{A} = \frac{8}{4} = 2$

92 **(d)**



$T\sin\theta = mL\sin\theta\omega^2$

$324 = 0.5 \times 0.5 \times \omega^2$

$\therefore \omega^2 = \frac{324}{0.5 \times 0.5}$

$\therefore \omega = \sqrt{\frac{324}{0.5 \times 0.5}}$

$\therefore \omega = \frac{18}{0.5} = 36\ rad/s$

93 **(a)**

$T' = \frac{5T}{4} \Rightarrow \frac{T'}{T} = \frac{5}{4}$

Here, the hanging mass performs S.H.M.

With $T = 2\pi\sqrt{\frac{M}{K}}$ and

$T' = 2\pi\sqrt{\frac{M+m}{K}}$

$\therefore \frac{T'}{T} = \sqrt{\frac{M+m}{K} \times \frac{K}{M}}$

$\therefore \frac{5}{4} = \sqrt{\frac{M+m}{M}}$

$\therefore \frac{M+m}{M} = \frac{25}{16}$

$\therefore 9M = 16m \Rightarrow \frac{m}{M} = \frac{9}{16}$

94 **(a)**

Total energy $E = \frac{1}{2}KA^2$

Potential energy $P = \frac{1}{2}Kx^2$

$\therefore P = \frac{x^2}{A^2}E$

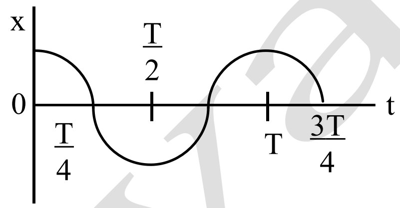
when $x = \frac{4}{5}A, \frac{x^2}{A^2} = \frac{16}{25}$

$\therefore P = \frac{16}{25}E$

kinetic energy $K = E - P = E - \frac{16}{25}E = \frac{9}{25}E$

96 **(b)**

I. The force will be zero at $t = \frac{3T}{4}$ (when the particle is at mean position)



II. The acceleration will be maximum at extreme position (for $= T$).

III. Velocity will be maximum at mean position, $\left(t = \frac{T}{4}\right)$.

IV. At $\frac{T}{2}$, PE will be maximum KE will be zero

97 **(b)**

$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$

$\frac{1}{2} \times 100 \times x^2 = \frac{1}{2} \times 16 \times 4^2$

$50x^2 = 128$

$\therefore x = 1.6\ m$

99 **(b)**

With respect to the block, the springs are connected in parallel combination

$\therefore$ Combined stiffness $k = k_1 + k_2$

$\therefore n = \frac{1}{2\pi}\sqrt{\frac{k_1 + k_2}{m}}$

101 **(a)**

The maximum velocity of body in SHM,

$v = A\omega$

where, A is amplitude of body and ω is the angular frequency.

It is given that, the maximum velocities of bodies are equal, i.e.

$V_A = V_B$

$A_A\omega_A = A_B\omega_B$

$A_A\sqrt{\frac{k_1}{m}} = A_B\sqrt{\frac{k_2}{m}}$

$\Rightarrow \frac{A_A}{A_B} = \sqrt{\frac{k_2}{k_1}}$

102 **(c)**
The kinetic energy of a particle executing SHM,
$E = \frac{1}{2}m\omega^2a^2$ (where, a = amplitude of particle)
$\because \frac{E'}{E} = \frac{a'^2}{a^2} = \frac{\left(\frac{3}{4}a\right)^2}{a^2}$ $\left(\because a' = \frac{3}{4}a\right) \therefore E' = \frac{9}{16}E$

103 **(a)**
Let T_1 and T_2 be the time period of shorter length and longer length pendulums, respectively. As per question, $nT_1 = (n-1)T_2$
So, $n2\pi\sqrt{\frac{0.5}{g}} = (n-1)2\pi\sqrt{\frac{20}{g}}$

or $n = (n-1)\sqrt{40} \approx (n-1)6$

Hence,

$5n = 6$

Hence, after 5 oscillations, they will be in same phase, i.e $k = 5$.

104 **(a)**
Let $y = \sin\omega t - \cos\omega t$
$\therefore \frac{dy}{dt} = \omega\cos\omega t + \omega\sin\omega t$
and $\frac{d^2y}{dt^2} = -\omega^2\sin\omega t + \omega^2\cos\omega t$
or $a = -\omega^2(\sin\omega t - \cos\omega t)$
or $a = -\omega^2 y$
$\Rightarrow a \propto -y$
Thus, it is a simple harmonic motion, this condition does not satisfied with other functions.

105 **(b)**

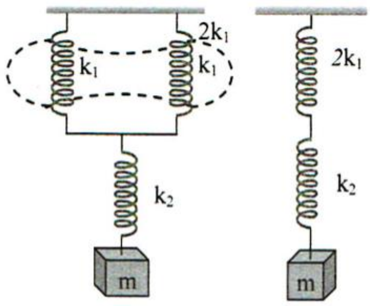
$T_1 = 2\pi\sqrt{\frac{m}{k + \rho Ag}}$

But $T_2 = 2\pi\sqrt{\frac{m}{k}}$

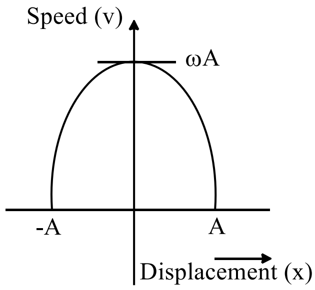
Hence, $T_1 < T_2$

106 **(a)**
$\mathrm{T} \propto \frac{1}{\sqrt{\mathrm{k}}} \Rightarrow \mathrm{T_1 : T_2 : T_3}$
$= \frac{1}{\sqrt{\mathrm{k}}} : \frac{1}{\sqrt{\mathrm{k}/2}} : \frac{1}{\sqrt{2\mathrm{k}}} = 1 : \sqrt{2} : \frac{1}{\sqrt{2}}$

107 **(b)**
In series combination
$\frac{1}{\mathrm{k_s}} = \frac{1}{2\mathrm{k_1}} + \frac{1}{\mathrm{k_2}}$
$\Rightarrow \mathrm{k_s} = \left[\frac{1}{2\mathrm{k_1}} + \frac{1}{\mathrm{k_2}}\right]^{-1}$



108 **(b)**
Speed, $v = \omega\sqrt{A^2 - x^2}$



$\Rightarrow v^2 + \omega^2x^2 = \omega^2A^2$

$\Rightarrow \frac{v^2}{\omega^2A^2} + \frac{x^2}{A^2} = 1$ (on solving)

which is an ellipse.

109 **(c)**
Kinetic energy is maximum at mean position.

110 **(b)**
For a simple pendulum,
$\mathrm{T} \propto \sqrt{l}$ or $\mathrm{T}^2 \propto l$
$\therefore \mathrm{E} \propto \omega^2 \propto \frac{1}{\mathrm{T}^2} \Rightarrow \mathrm{E} \propto \frac{1}{l}$

Hence energy will become two times if length is halved

111 **(a)**

$$x = P\sin\omega t + Q\sin\left(\omega t + \frac{\pi}{2}\right)$$

$$= P\sin\omega t + Q\cos\omega t$$

Let $P = A\cos\theta$

$Q = A\sin\theta$

$\therefore P^2 + Q^2 = A^2$

$\therefore x = A\sin(\omega t + \theta)$

$$E_{total} = \frac{1}{2}m\omega^2A^2 = \frac{1}{2}m\omega^2(P^2 + Q^2)$$

112 **(c)**

PE at $x = \frac{A}{2}$ is $\frac{1}{2}m\omega^2 \times \frac{A^2}{4}$

$$PE = \frac{1}{4}\left(\frac{1}{2}m\omega^2A^2\right) = \frac{U_{max}}{4}$$

113 **(a)**

Given, the time period of particle $A = T$ and the time period of particle $B = \frac{5T}{4}$.

Hence, the time difference, $\Delta T = \frac{5T}{4} - T \Rightarrow \Delta T = \frac{T}{4}$

The relation between phase difference and time difference,

$$\Delta\phi = \frac{2\pi}{T}\Delta T \Rightarrow \Delta\phi = \frac{2\pi}{T} \times \frac{T}{4} \Rightarrow \Delta\phi = \frac{\pi}{2}$$

114 **(a)**

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$\therefore \frac{T'}{T} = \sqrt{\frac{g}{g'}} = \sqrt{\frac{g}{g + \frac{g}{4}}} = \sqrt{\frac{4}{5}} = \frac{2}{\sqrt{5}}$$

115 **(c)**

For second's pendulum period is 2 s

$$T = 2 = 2\pi\sqrt{\frac{l_s}{g_s}} = 2\pi\sqrt{\frac{l_h}{g_h}}$$

$$\therefore \frac{l_s}{g_s} = \frac{l_h}{g_h} \text{ or } \frac{l_s}{l_h} = \frac{g_s}{g_h} = \frac{(R + h)^2}{R^2}$$

$$\therefore \frac{\sqrt{l_s}}{\sqrt{l_h}} = \frac{R + h}{R} = 1 + \frac{h}{R}$$

$$\therefore \frac{h}{R} = \frac{\sqrt{l_s}}{l_h} - 1 = \frac{h}{R} = \frac{\sqrt{l_s} - \sqrt{l_h}}{\sqrt{l_h}}$$

$$\therefore \frac{R}{h} = \frac{\sqrt{l_n}}{\sqrt{l_s} - \sqrt{l_n}}$$

$$\therefore R = \frac{h\sqrt{l_h}}{\left(\sqrt{l_s} - \sqrt{l_h}\right)}$$

118 **(a)**

From figure ,

T=0.04 $\therefore = \frac{1}{2} = 25\ Hz$

119 **(c)**

In SHM, total energy = potential energy + kinetic energy

Or

$$E \ = U + K = \frac{1}{2}m\omega^2x^2 +$$

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

where, k = force constant = $m\omega^2$

Thus, total energy depends upon k and A.

121 **(d)**

$$\text{Kinetic energy} = \frac{1}{2}m\omega^2(A^2 - x^2)$$

$$\text{At } x = \frac{A}{2}, \text{K.E.} = \frac{1}{2}m\omega^2\left(\frac{3}{4}A^2\right) = \frac{3}{8}m\omega^2A^2$$

$$= \frac{3}{8}m\left(\frac{2\pi}{T}\right)^2.A^2 = \frac{3}{8}m.\frac{4\pi^2}{T^2}.A^2 = \frac{3}{2}.\frac{m\pi^2A^2}{T^2}$$

122 **(a)**

When restoring force will become equal to the frictional force, block will start to slip.

$\therefore$ Restoring force = Friction force

$\Rightarrow \ kA = \mu mg$ .... (i)

Frequency,

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \Rightarrow f = \frac{1}{2\pi}\sqrt{\frac{\mu g}{A}}$$

[from Eq. (i)]

124 **(c)**

$$v = \omega\sqrt{(A^2 - x^2)} = \frac{2\pi}{T}\sqrt{A^2 - \frac{A^2}{4}} = \frac{\sqrt{3}A}{2} \times \frac{2\pi}{T}$$
$$= \frac{\sqrt{3}\pi A}{T}$$

126 **(b)**

Potential energy of a particle executing simple harmonic motion also periodic with period T/2. So, potential energy is zero at the mean position and maximum at the extreme displacements. Let the amplitude of SHM be A.

Now, potential energy of SHM $= \frac{1}{2}kx^2$. Here, $x = \frac{A}{2}$

$U = \frac{1}{2}k\frac{A^2}{4}$ ..... (i)

Kinetic energy, $K = \frac{1}{2}kA^2 - \frac{1}{2}k\frac{A^2}{4} = \frac{3}{8}kA^2$ ....(ii)

On dividing Eq. (ii) by Eq. (i), we get

$$\frac{K}{U} = \frac{3}{8} \times \frac{8}{1} = 3/1$$

127 **(a)**

PE at a displacement x,

$$E_1 = \frac{1}{2}kx^2$$

$$x = \sqrt{\frac{2E_1}{k}}$$

$$\Rightarrow x = \sqrt{\frac{2E_1}{k}}$$

and

$$\Rightarrow E_2 = \frac{1}{2}ky^2$$

$$y = \sqrt{\frac{2E_2}{k}}$$

and

$\Rightarrow$ Putting the values from Eqs. (i) and (ii) in Eq. (iii), we get

$$\sqrt{\frac{2E_1}{k}} + \sqrt{\frac{2E_2}{k}} = \sqrt{\frac{2E}{k}}$$
$$\sqrt{E_1} + \sqrt{E_2} = \sqrt{E}$$

130 **(c)**

If k is the spring constant of one spring, then theeffective spring constant is$2k$. Because in this case, they act as parallel springs and $v = \frac{1}{2\pi}\sqrt{\frac{2k}{m}}$ .... (i)

When one of the spring is removed, the effective spring

constant is k and $v' = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$ ....(ii)

On dividing Eq.(ii) by Eq. (i), we get

$$\frac{v'}{v} = \sqrt{\frac{k}{m} \times \frac{m}{2k}} = \frac{1}{\sqrt{2}}$$

$$\Rightarrow v' = \frac{v}{\sqrt{2}}$$

131 **(d)**

Kinetic energy of a particle performing S. H. M. is given by

$$k = \frac{1}{2}m\omega^2(A^2 - x^2)$$

when $x = \frac{2}{3}A$,

$$k = \frac{1}{2}m\omega^2\left(A^2 - \frac{4}{9}A^2\right)$$

$$= \frac{1}{2}m\omega^2A^2 \times \frac{5}{9}$$

If the velocity is tripled, its kinetic energy will become 9 times.

The new kinetic energy will be

$$k' = \frac{1}{2}m\omega^2\left(A^2 - \frac{4}{9}A^2\right) = \frac{1}{2}m\omega^2A^2 \times \frac{5}{9}$$

If the velocity is tripled, its kinetic energy will become 9 times.

The new kinetic energy will be

$$k' = \frac{1}{2}m\omega^2A^2 \times 5$$

The potential energy $p = \frac{1}{2}m\omega^2\left(\frac{2}{3}A\right)^2$
$$= \frac{1}{2}m\omega^2A^2.\frac{4}{9}$$

If A' is the new amplitude then the total energy e is given by

$$E = \frac{1}{2}m\omega^2A'^2$$

Also, $E = P + k'$

$$\therefore \frac{1}{2}m\omega^2A'^2 = \frac{1}{2}m\omega^2A^2.\frac{4}{9} + \frac{1}{2}m\omega^2A^2.5$$

$$\therefore A'^2 = \left(\frac{4}{9}+5\right)A^2$$

$$\therefore A' = \frac{7}{3}A$$

132 **(b)**

The frequency of oscillation of spring mass system is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \quad \text{... (i)}$$

For the given arrangement, $k' = k_1 + k_2 = k + k = 2k$ Hence, frequency of oscillation,

$$f' = \frac{1}{2\pi}\sqrt{\frac{k'}{m}} = \frac{1}{2\pi}\sqrt{\frac{2k}{m}} = \sqrt{2} \text{ [from Eq. (i)]}$$

134 **(b)**

Torque acting on the bob $= l\alpha = -(mg)\,l\sin\theta$

or $(m_i l^2)\alpha = -(m_g g)l\theta$

$(\because \sin\theta \approx \theta)$

or $\alpha = -\left(\frac{m_g g}{m_i l}\right)\theta = -\omega^2\theta$

where, $\omega^2 = \frac{m_g g_T}{m_i l} = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m_i l}{m_g g}}$

136 **(d)**

Acceleration $\propto -$ displacement and acceleration is always directed towards the equilibrium position

137 **(d)**

Maximum acceleration, $a_{max} = \omega^2 A$

Amplitude remaining constant, $a_{max} \propto \omega^2$

$$\frac{(a_{max})_1}{(a_{max.})_2} = \left(\frac{\omega_1}{\omega_2}\right)^2 = \left(\frac{100}{1000}\right)^2 = \left(\frac{1}{10}\right)^2$$

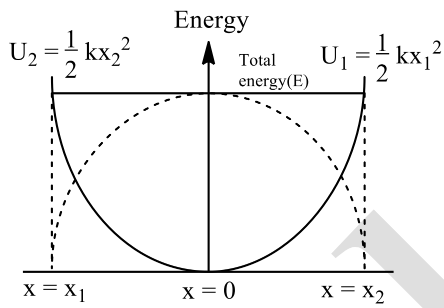
$\therefore$ Ratio of max. acceleration $= \frac{1}{10^2}$

138 **(a)**

Period of seconds pendulum is 2 s. It will perform 100 oscillations in 200 s

140 **(c)**

Potential energy is given by $U = \frac{1}{2}kx^2$ The corresponding graph is shown in figure.



At equilibrium position $(x = 0)$, potential energy is minimum. At extreme positions x_1 and x_2, its potential energies are

$$U_1 = \frac{1}{2}kx_1^2 \text{ and } U_2 = \frac{1}{2}kx_2^2$$

143 **(a)**

At the highest point the particle will come to rest momentarily, hence it is at extreme position and has maximum force and acceleration. Since the spring is un-stretched, the restoring force to provide by the weight of the particle.

$$\therefore mA\omega^2 = mg \text{ or } A\omega^2 = g$$

$$\therefore A = \frac{g}{\omega^2}$$

$$\omega = 2\pi f = 2\pi \times 5 = 10\pi$$

$$\therefore A = \frac{10}{100\pi^2} = \frac{1}{10\pi^2}$$

$$V_{max} = A\omega = \frac{1}{10\pi^2} \times 10\pi = \frac{1}{\pi}$$

144 **(a)**

Periodic time of a pendulum is given by

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$\therefore \frac{\Delta T}{T} = \frac{1}{2}.\frac{\Delta l}{l}$$

$$\Delta l = l\alpha.\Delta\theta$$

$$\therefore \frac{\Delta l}{l} = \alpha.\Delta\theta = 1.2 \times 10^{-5} \times 5 = 6 \times 10^{-5}$$

$\therefore \frac{\Delta T}{T} = \frac{1}{2} \times 6 \times 10^{-5} = 3 \times 10^{-5}$

This is the time lost per second.

Hence time lost in a day (86400 s) is= $86400 \times 3 \times 10^{-5} = 2.6$ s

146 **(d)**

K.E. at mean position

$= \frac{1}{2} m\omega^2 (A^2 - 0) = \frac{1}{2} m\omega^2 A^2$

P.E. at $x = \frac{A}{2} = \frac{1}{2} m\omega^2 \left(\frac{A}{2}\right)^2 = \frac{1}{8} m\omega^2 A^2$

$\therefore$ The required ratio

$= \frac{\left(\frac{1}{2} m\omega^2 A^2\right)}{\left(\frac{1}{8} m\omega^2 A^2\right)} = 4:1$

147 **(b)**

$l_2 = 44\%$ of $l_1 \Rightarrow l_2 = 1.44l$

$T \propto \sqrt{l} \Rightarrow T_1 \propto \sqrt{l_1}$ and $T_2\sqrt{l_2}$

$\therefore \frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}} \Rightarrow \frac{T_2}{T_1} = \sqrt{1.44} = 1.2$

$\therefore$ % change in $\frac{T_2 - T_1}{T_1} \times 100 = \left(\frac{1.2-1}{1}\right) \times 100 = 20\%$

148 **(b)**

Kinetic energy is maximum at the mean position and potential energy is maximum at the extreme positions on either side,

The distance between mean and extreme positions is A.

149 **(b)**

$P_1 = \frac{1}{2} ky^2$

$\therefore x - \sqrt{\frac{2P_1}{k}}$ ... (i)

$P_2 = \frac{1}{2} ky^2$

$\therefore v = \sqrt{\frac{2P_2}{k}}$ ... (ii)

$P = \frac{1}{2} k(x^2 + y^2)$

$\therefore x + y = \sqrt{\frac{2P}{k}}$ ... (iii)

Putting values of x and y from eqs. (i) and (ii) in Eq. (iii)

$\sqrt{\frac{2P_1}{k}} + \sqrt{\frac{2P_2}{k}} = \sqrt{\frac{2P}{k}}$

$\therefore \sqrt{P_1} + \sqrt{P_2} = \sqrt{P}$

151 **(a)**

Velocity, $v = r\omega \cos \omega t$

$$\Rightarrow \ 0.4 = r \times \frac{2\pi}{16} \times \cos\frac{2\pi}{16} \cdot 2 = r \times \frac{2\pi}{16} \times \frac{1}{\sqrt{2}}$$

$$\text{or } r = \frac{0.4 \times 16 \times \sqrt{2}}{2\pi} = \frac{3.2\sqrt{2}}{\pi} = 1.44 \text{ m}$$

152 **(a)**

Linear S.H.M and its equation

153 **(b)**

$P = \frac{1}{2} k(x_1 + x_2)^2$

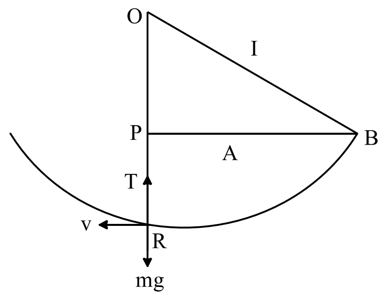
$= \frac{1}{2} k(x_1^2 + x_2^2 + 2x_1x_2)$

$= \frac{1}{2} kx_1^2 + \frac{1}{2} kx_2^2 + 2\left(\sqrt{\frac{k}{2}} x\right)\left(\sqrt{\frac{k}{2}} x_2\right)$

$= P_1 + P_2 + 2P_1P_2$

155 **(b)**

Consider the figure shown below



The string possess maximum tension when bob is at mean position of oscillation, i.e. at position R.

From geometry, $OP = \sqrt{1^2 - A^2}$

Also, $RP = OR - OP = I - \sqrt{1^2 - A^2}$

The whole kinetic energy of bob at position R is converted into its potential energy at position B.

$\therefore \ \frac{1}{2} mv^2 = mg\left(I - \sqrt{I^2 - A^2}\right)$

$$v^2 = 2g\left(I - \sqrt{1^2 - A^2}\right)$$

Balancing forces at R,

$$T - mg = \frac{mv^2}{I} = \frac{2mg\left(I - \sqrt{l^2 - A^2}\right)}{1}$$

$$\therefore T = mg + 2mg\left(1 - \sqrt{1 - \frac{A^2}{1^2}}\right)$$

Using approximation, $\sqrt{1 - x^2} = 1 - \frac{x^2}{2}$ for $x \ll 1$, we get

$$T = mg + 2mg\left[1 - \left(1 - \frac{A^2}{2l^2}\right)\right]$$

$$= mg + mg\left(\frac{A}{1}\right)^2$$

$$= mg\left[1 + \left(\frac{A}{1}\right)^2\right]$$

156 **(c)**

The tension in the string is maximum when the bob passes through the mean position.

$$T_{max} = mg + \frac{mv^2}{L} \quad \dots(1)$$

In S. H. M. velocity at the mean position is given by $V = A\omega$

For simple pendulum $T = 2\pi\sqrt{\frac{L}{g}}$

$$\omega = \frac{2\pi}{T} = \sqrt{\frac{g}{L}}$$

$$\therefore V = A\sqrt{\frac{g}{L}} \text{ or } V^2 = \frac{A^2 g}{L}$$

Putting this value of V^2 in eq. (1):

$$T_{max} = mg\left[1 + \frac{A^2}{L^2}\right]$$

157 **(d)**

$$C = \frac{\tau}{\theta} = \frac{M^1L^2T^{-2}}{M^0L^0T^0} = M^1L^2T^2$$

158 **(a)**

$$K.E. = P.E. \Rightarrow \frac{1}{2}mv^2 = \frac{1}{2}kx^2$$

$$\therefore \frac{1}{2}m\omega^2(A^2 - x^2) = \frac{1}{2}m\omega^2x^2$$

$$\therefore A^2 - x^2 = x^2$$

$$\therefore x^2 = \frac{A^2}{2} \Rightarrow \frac{x}{A} = \frac{1}{\sqrt{2}}$$

159 **(c)**

$$y_1 = 10\sin\omega t$$

$\therefore$ Amplitude of $y_1 = 10$

This can be considered as combination of two S. H. M. of amplitudes 10 and 5 with a phase difference of $\frac{\pi}{2}$.

$$\therefore \text{Resultant amplitude } R = \sqrt{(10)^2 + (5)^2}$$
$$= \sqrt{125} = 5\sqrt{5}$$

$$\therefore \text{Rate of the two amplitudes} = \frac{10}{5\sqrt{2}} = \sqrt{2}$$

161 **(c)**

$$a_{max} = A\omega^2 = A.\frac{4\pi^2}{T^2} = \frac{3 \times 4 \times (3.14)^2}{(2 \times 3.14)}$$

$$= \frac{12}{4} = 3 \text{ cm/s}^2$$

164 **(c)**

Phase change $= 2 \times 2\pi = 4\pi$ radian

165 **(c)**

$$v_1 = \omega\sqrt{(A^2 - x_1^2)};$$

$$v_2 = \omega\sqrt{(A^2 - x_2^2)};$$

$$\therefore v_1^2 = \omega^2(A^2 - x_1^2)$$

$$\therefore v_2^2 = \omega^2(A^2 - x_1^2)$$

$$\therefore v_2^2 - v_1^2 = \omega^2(x_1^2 - x_2^2)$$

$$\therefore \omega = \sqrt{\frac{v_1^2 - v_2^2}{x_1^2 - x_2^2}}$$

167 **(d)**

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$\therefore \frac{T_e}{T_m} = \sqrt{\frac{g_m}{g_e}} = \sqrt{\frac{g_e/6}{g_e}} = \frac{1}{\sqrt{6}}$$

$\therefore T_m = \sqrt{6}T_e \Rightarrow$ clock becomes slower

168 **(a)**

$v_{max} = A\omega$ and $a_{max} = A\omega^2$

$\therefore \dfrac{a_{max}}{v_{max}} = \dfrac{A\omega^2}{A\omega} = \dfrac{0.64}{0.16} \Rightarrow \omega = 4\ \text{rad/s}$

$\therefore 0.16 = A \times 4 \Rightarrow A = 0.04\ \text{m} = 4 \times 10^{-2}\text{m}$

169 **(b)**

On earth's surface, $g = \frac{GM}{R^2}$

$\therefore$ At a height R, $g_R = \frac{GM}{(R+R)^2} = \frac{GM}{4R^2} = \frac{1}{4}.\frac{GM}{R^2}$

$\therefore g_R = \dfrac{1}{4}g$

Now, $T \propto \frac{1}{\sqrt{g}} \Rightarrow T_1 \propto \frac{1}{\sqrt{g}}$ and $T_2 \propto \frac{1}{\sqrt{g_R}}$

$\therefore \dfrac{T_1}{T_2} = \sqrt{\dfrac{g_R}{g}} = \sqrt{\dfrac{1}{4}} = 0.5$

170 **(c)**

$K.E. = \dfrac{1}{2}m\omega^2A^2\cos^2\omega t,$

$P.E. = \dfrac{1}{2}m\omega^2A^2\sin^2\omega t$

$K.E. - P.E. = \dfrac{1}{2}m\omega^2A^2[\cos^2\omega t - \sin^2\omega t]$

$= \dfrac{1}{2}m\omega^2A^2.\cos 2\omega t$

$\therefore$ Angular frequency $= 2\omega$

$\therefore T' = \dfrac{2\pi}{2\omega} = \dfrac{\pi}{\omega} = \dfrac{\pi \times T}{2\pi} = 2s$

171 **(b)**

$T \propto \sqrt{l}$. Time period depends only on effective length. Density has no effect on time period. If length is made 4 times, then time period becomes 2 times

172 **(b)**

Speed of the particle $V = \omega\sqrt{A^2 - x^2}$

Maximum speed of the particle $V_m = A\omega$

If $u = \dfrac{A\omega}{2} = \omega\sqrt{A^2 - x^2}$

$\therefore \dfrac{A}{2} = \sqrt{A^2 - x^2}$

$\therefore \dfrac{A^2}{4} = A^2 - x^2$

$\therefore x^2 = \dfrac{3}{4}A^2$ or $x = \dfrac{\sqrt{3}}{2}A$

173 **(c)**

Given, $\frac{d^2x}{dt^2} = -9x$

Comparing with $\frac{d^2x}{dt^2} = -\omega^2 x$

$\Rightarrow\ \omega^2 = 9, \omega = 3$

$\therefore$ Time period $= \dfrac{2\pi}{\omega} = \dfrac{2\pi}{3} = \dfrac{2}{3}\pi$

174 **(d)**

Given, $A = 5$ cm and $v_{max} = 31.4\text{cms}^{-1}$

$\Rightarrow\ A\omega = 31.4$

$\Rightarrow$

$\Rightarrow\ = \dfrac{314}{5}$

$\Rightarrow\ 2\pi v = \dfrac{314}{5}$

$\Rightarrow\ v = \dfrac{314}{2 \times 3.14 \times 5} = 1\ \text{Hz}$

175 **(c)**

$h = 10\ \text{cm} = 10 \times 10^{-2}\text{m} = 0.1\ \text{m}$

According to the principle of conservation of energy, $\frac{1}{2}mv^2 = mgh$

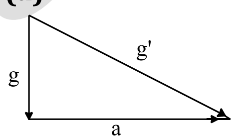
or $v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 0.1} = 1.4\ \text{m/s}$

176 **(b)**

$F = -bv$

$\therefore b = \dfrac{F}{v} = \dfrac{\text{kg m/s}^2}{\text{m/s}} = \dfrac{\text{kg}}{\text{s}}$

177 **(a)**



$T = 2\pi\sqrt{\dfrac{L}{g''}}$

Let $a'' = (g^2 + a^2)^{1/2}$

$\therefore T = 2\pi\sqrt{\dfrac{L}{(g^2 + a^2)^{1/2}}}$

178 **(b)**

When the length of the spring is reduced from L to $\frac{L}{3}$, its spring constant increases from k to 3k.

Period $T = 2\pi\sqrt{\dfrac{m}{k}}$

$\therefore \dfrac{T_1}{T_2} = \sqrt{3k/k} = \sqrt{3}$

179 **(b)**

$T = 2\pi\sqrt{\dfrac{m}{k}}$

Also, spring constant (K) $\propto \frac{1}{\text{Lenght}\ (l)}$

When the spring is half in length, then K becomes twice

$$\therefore T' = 2\pi\sqrt{\frac{m}{2K}} \Rightarrow \frac{T'}{T} = \frac{1}{\sqrt{2}} \Rightarrow T' = \frac{T}{\sqrt{2}}$$

180 **(c)**

For body to remain in constant $a_{max} = g$

$\therefore \omega^2 A = g \Rightarrow 4\pi^2 n^2 A = g$

$$\therefore n^2 = \frac{g}{4\pi^2 A} = \frac{10}{4 \times (3.14)^2 \times 0.01} = 25$$

$\therefore n = 5$ Hz

181 **(c)**

$A = 10 \times 10^{-2}\text{m} = 10^{-1}\text{m}$

$$K.E_{max} = \frac{1}{2}m\omega^2 A^2 = \frac{1}{2}kA^2$$

$$\therefore 5 = \frac{1}{2} \times k \times (10^{-1})^2$$

$$\therefore \frac{10}{10^{-2}} = k \Rightarrow k = 1000 \text{ N/m}$$

182 **(d)**

For vertical spring, the periodic time of oscillation,

$$T = 2\pi\sqrt{\frac{m}{k}}$$

As, restoring force, $|F| = kx$

$$\Rightarrow k = \frac{F}{x} = \frac{mg}{x}$$

$$\therefore T = 2\pi\sqrt{\frac{m}{\frac{m}{x}}} = 2\pi\sqrt{\frac{x}{g}}$$

183 **(a)**

Total energy $E = \frac{1}{2}m\omega^2 A^2$

At $x = \frac{A}{2}$, Potential energy $E_1 = \frac{1}{2}m\omega^2 A^2$

$$= \frac{1}{2}m\omega^2 \frac{A^2}{4}$$

$$= \frac{1}{4}\left(\frac{1}{2}m\omega^2 x^2\right) = \frac{1}{4}E$$

$$\therefore K.E. = E - E_P = E - \frac{1}{4} = \frac{3}{4}E$$

184 **(a)**

As $F = -kx \Rightarrow |F| \propto x$

186 **(c)**

Given $a = -px$

We have standard equation $a = -\omega^2 x$

$\therefore \omega^2 = p$

$\therefore \omega = \sqrt{p}$

$$\therefore T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{p}}$$

188 **(a)**

Inside the mine, g decreases

Hence from $T = 2\pi\sqrt{\frac{l}{g}}$, we conclude that T increases

189 **(d)**

$x = \frac{3}{4}A \Rightarrow \frac{A^2}{x^2} = \frac{16}{9}$ ...(i)

$\therefore \frac{T.E.}{P.E.} = \frac{\frac{1}{2}m\omega^2 A^2}{\frac{1}{2}m\omega^2 x^2} = \frac{A^2}{x^2} = \frac{16}{9}$ ...[From (i)]

$$\therefore \frac{80}{P.E.} = \frac{16}{9} \Rightarrow P.E. = 45 \text{ J}$$

190 **(c)**

$$a = -\omega^2 x \Rightarrow \left|\frac{a}{x}\right| = \omega^2$$

191 **(b)**

$$P.E. = \frac{1}{2}M\omega^2 X^2$$

$\therefore P.E. \propto X^2 = KX^2$

193 **(b)**

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$\therefore m = \frac{KT^2}{4\pi^2}$$

$\therefore$ weight $= mg$

$$= \frac{KT^2}{4\pi^2} \times g = \frac{KT^2 g}{4\pi^2}$$

194 **(c)**

$V = A\omega = A \times 2\pi f$

$$\therefore A = \frac{V}{2\pi f}$$

Total energy $E = \frac{1}{2}kA^2 = \frac{1}{2}k \times \frac{V^2}{4\pi^2 f^2}$

$$\therefore k = \frac{8E\pi^2 n^2}{V^2}$$

196 **(a)**

Potential energy of a simple harmonic oscillator,

$$U = \frac{1}{2}m\omega^2 y^2$$

When the particle is half way to its end point, i.e. at half of its amplitude, then $y = \frac{A}{2}$.

Hence, potential energy,

$$U=\frac{1}{2}m\omega^2\left(\frac{A}{2}\right)^2=\frac{1}{4}\left(\frac{1}{2}m\omega^2A^2\right)=\frac{E}{4}$$

197 **(b)**

$$\mathrm{T}=2\pi\sqrt{\frac{\mathrm{M}}{\mathrm{k}}};$$

$$\frac{5\mathrm{T}}{3}=2\pi\sqrt{\frac{\mathrm{M}+\mathrm{m}}{\mathrm{k}}}$$

$$\therefore\frac{25}{9}.\frac{\mathrm{M}}{\mathrm{k}}=\frac{\mathrm{M}+\mathrm{m}}{\mathrm{k}}$$

$$\therefore\frac{25}{9}\mathrm{M}=\mathrm{M}+\mathrm{m}$$

Dividing by M, $\frac{25}{9}=1+\frac{\mathrm{m}}{\mathrm{M}}$

$$\therefore\frac{\mathrm{m}}{\mathrm{M}}=\frac{25}{9}-1=\frac{16}{9}$$

$$\frac{\mathrm{M}}{\mathrm{m}}=\frac{9}{16}$$

200 **(b)**

$$\mathrm{K.E.}=\frac{3\mathrm{E}}{4}$$

$$\frac{\mathrm{K.E.}}{\mathrm{T.E.}}=\frac{\frac{1}{2}\mathrm{m}\omega^2(\mathrm{A}^2-\mathrm{x}^2)}{\frac{1}{2}\mathrm{m}\omega^2\mathrm{x}^2}=\frac{\mathrm{A}^2-\mathrm{x}^2}{\mathrm{A}^2}=1-\frac{\mathrm{x}^2}{\mathrm{A}^2}$$

$$\therefore\frac{\left(\frac{3\mathrm{E}}{4}\right)}{\mathrm{E}}=1-\frac{\mathrm{x}^2}{\mathrm{A}^2}$$

$$\therefore\frac{\mathrm{x}^2}{\mathrm{A}^2}=1-\frac{3}{4}=\frac{1}{4}\Rightarrow\mathrm{x}=\frac{\mathrm{A}}{2}$$