Problems of Simple Harmonic Motion (S.H.M.)

1) An object executes simple harmonic motion with an amplitude of 1.72 m and a maximum speed of 135.1 m/s. At $t = 0$ its position is 1.72 m, determine:

a) Frequency of the motion.

b) Position of the object as a function of time.

c) The maximum acceleration.

Answer: **a)** 12.5 Hz, **b)** $x(t) = 1.72 \sin(78.54\, t + \pi/2)$, **c)** 10610 m/s^2.

2) A particle vibrates in simple harmonic motion with a maximum velocity of 2.196 m/s and a maximum acceleration of 2.152 m/s^2. At $t = 0$ its position is 1.12 m, find:

a) Frequency and angular frequency.

b) Amplitude of the motion.

c) Position of the particle as a function of time.

d) The velocity of the particle when its position is 1.187 m.

Answer: **a)** 0.156 Hz, 0.9802 rad/s, **b)** 2.24 m, **c)** $x(t) = 2.24 \sin(0.9802\, t + \pi/6)$, **d)** 1.862 m/s

3) The velocity of a block is given by the expression $v(t) = 82.8 \cos(22.44\, t + 3.6)$ where v is in meters/seconds and t is in seconds. Determine:

a) The frequency and the amplitude of the motion.

b) Position of the block as a function of time.

c) The maximum acceleration of the block.

Answer: **a)** 3.571 Hz, 3.69 m, **b)** $x(t) = 3.69 \sin(22.44\, t + 3.6)$, **c)** 1858 m/s^2.

4) A particle vibrates in simple harmonic motion with an amplitude of 1.08 m and a period of 0.24 s. At $t = 0$ its position is 0 m, determine:

a) Position of the particle as a function of time.

b) The frequency of the motion.

c) The maximum velocity of the particle.

Answer: **a)** $x(t) = 1.08 \sin(26.18\, t)$, **b)** 4.167 Hz, **c)** 28.27 m/s.

5) The position of a block is given by the expression $x(t) = 2.39 \sin(33.07\, t + 3.9)$ where x is in meters and t is in seconds. Find:

a) The frequency and period of the motion.

b) The maximum velocity and maximum acceleration.

c) The velocity of the block when its position is 0.5258 m.

Answer: **a)** 5.263 Hz, 0.19 s, **b)** 79.04 m/s, 2614 m/s^2, **c)** 77.1 m/s.

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6) We have an object of mass 33 g attached to a spring. The object vibrates in simple harmonic motion. Its position is given by the expression $x(t) = 2.49 \sin(1.74\, t)$ where x is in meters and t is in seconds. Find:

a) Force constant of the spring.

b) Maximum velocity of the object.

c) Maximum force of the spring.

Answer: **a)** 0.09997 N/m, **b)** 4.334 m/s, **c)** 0.2489 N.

7) The position of the *bob* of a simple pendulum is given by the expression $x(t) = 2.02 \sin(0.8149\, t + \pi/6)$ where x is in meters and t is in seconds. If $g = 9.8$ m/s^2, determine:

a) Frequency of the motion.

b) Length of the pendulum.

c) Velocity of the *bob* when its position is 0.6666 m.

Answer: **a)** 0.1297 Hz, **b)** 14.76 m, **c)** 1.554 m/s.

8) A simple pendulum has a length of 13.78 m. The pendulum moves in simple harmonic motion with an amplitude of 1.31 m. At $t = 0$ its position is 1.31 m and $g = 9.8$ m/s^2. Find:

a) Period of the motion.

b) Position of the *bob* as a function of time.

c) Maximum velocity of the *bob*.

Answer: **a)** 7.45 s, **b)** $x(t) = 1.31 \sin(0.8434\, t + \pi/2)$, **c)** 1.105 m/s.

9) A 249–g block attached to a spring vibrates in simple harmonic motion with an amplitude of 0.31 m and a period of 7.15 s. At $t = 0$ its position is 0.31 m. Determine:

a) Force constant of the spring.

b) Position of the block as a function of time.

c) Maximum force of the spring.

Answer: **a)** 0.1923 N/m, **b)** $x(t) = 0.31 \sin(0.8788\, t + \pi/2)$, **c)** 0.05961 N.

10) The force constant of a spring is 1.72 N/m. A particle is attached to the spring and vibrates in simple harmonic motion with an amplitude of 1.52 m and a frequency of 0.4739 Hz. At $t = 0$ its position is 1.52 m. Find:

a) The mass of the particle.

b) Position of the particle as a function of time.

c) Maximum force of the spring.

Answer: **a)** 194 g, **b)** $x(t) = 1.52 \sin(2.978\, t + \pi/2)$, **c)** 2.615 N.

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11) An object of 385 g is attached to a spring with a force constant of 0.2405 N/m and vibrates in simple harmonic motion with an amplitude of 0.63 m. At $t = 0$ its position is 0.63 m. Determine:

a) Frequency of the motion.

b) Position of the object as a function of time.

c) Maximum velocity of the object.

Answer: **a)** 0.1258 Hz, **b)** $x(t) = 0.63 \sin(0.7903\, t + \pi/2)$, **c)** 0.4979 m/s.

12) A block of 269 g is attached to a spring and vibrates in simple harmonic motion with an amplitude of 1.97 m. Its velocity at equilibrium position is 19.34 m/s and at $t = 0$ its position is 1.97 m. Find:

a) Period of the motion.

b) Force constant of the spring.

c) Position of the block as a function of time.

Answer: **a)** 0.64 s, **b)** 25.93 N/m, **c)** $x(t) = 1.97 \sin(9.817\, t + \pi/2)$.

13) A particle of 159 g is attached to a spring and vibrates in simple harmonic motion with a frequency of 2.381 Hz. Its maximum velocity is 54.45 m/s and at $t = 0$ its position is 3.64 m. Determine:

a) Amplitude of the motion.

b) Force constant of the spring.

c) Position of the particle as a function of time.

d) Maximum force of the spring.

Answer: **a)** 3.64 m, **b)** 35.58 N/m, **c)** $x(t) = 3.64 \sin(14.96\, t + \pi/2)$, **d)** 129.5 N.

14) We have a block of 375 g attached to a spring. The block vibrates in simple harmonic motion with an amplitude of 3.34 m and a maximum velocity of 80.71 m/s. At $t = 0$ its position is 0 m. Determine:

a) Force constant of the spring.

b) Position of the block as a function of time.

c) Kinetic energy when the position of the block is 0.7348 m.

Answer: **a)** 219 N/m, **b)** $x(t) = 3.34 \sin(24.17\, t)$, **c)** 1162 J.

15) A particle of 88 g is attached to a spring with a force constant of 31.9 N/m and vibrates in simple harmonic motion with an amplitude of 2.03 m. At $t = 0$ its position is 1.015 m. Determine:

a) Frequency of the motion.

b) Position of the particle as a function of time.

c) The mechanical energy of the system.

Answer: **a)** 3.03 Hz, **b)** $x(t) = 2.03 \sin(19.04\, t + \pi/6)$, **c)** 65.73 J.

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16) A hanging spring stretches by 0.1589 cm when a block of mass 259 g is hung on it at rest. In this situation, we define its position as $x = 0$. The block is pulled down an additional 3.54 m and released from rest to oscillate. Find:

a) Force constant of the spring.

b) Kinetic energy, potential energy, and mechanical energy when the position is 1.274 m.

c) Maximum velocity of the block.

Answer: **a)** 1598 N/m, **b)** 8713 J, 1297 J, 10010 J, **c)** 278 m/s.

17) An object of 224 g is attached to a spring and vibrates in simple harmonic motion with an amplitude of 1.61 m and a frequency of 2.041 Hz. At $t = 0$ its position is 0 m. Determine:

a) Force constant of the spring.

b) Position of the object as a function of time.

c) Kinetic energy, potential energy, and mechanical energy when the position is 0.966 m.

Answer: **a)** 36.83 N/m, **b)** $x(t) = 1.61 \sin(12.82\, t)$, **c)** 30.55 J, 17.18 J, 47.74 J.

18) A 340−g particle attached to a spring vibrates in simple harmonic motion. The position of the particle is given by the expression $x(t) = 1.03 \sin(29.92\, t + \pi/6)$ where x is in meters and t is in seconds. Find:

a) Force constant of the spring.

b) Frequency of the motion.

c) Velocity at the equilibrium position.

d) Mechanical energy of the system.

Answer: **a)** 304.4 N/m, **b)** 4.762 Hz, **c)** 30.82 m/s, **d)** 161.5 J.