The unit presented herein is a sequel to the unit on Rotational motion posted earlier. The contents of the document are intended to give the student a revision of the unit OSCILLATIONS in class XI.

OSCILLATIONS

Multiple Choice Questions
1. The displacement $y$ in cm is given in terms of time $t$ (s) by the equation
   
   $$y = 3 \sin 314t + 4 \cos 314t.$$  
   The amplitude of S.H.M. is
   
   a. $3$ cm  
   b. $4$ cm  
   c. $5$ cm  
   d. $7$ cm

2. Which of the following is necessary and sufficient condition for S.H.M?
   
   a. Constant period  
   b. Constant acceleration  
   c. Proportionality between acceleration and mass of the oscillating body  
   d. Proportionality between restoring force and displacement from equilibrium position.

3. If the length of a simple pendulum is increased by 44%, its time period increases by
   
   a. $10\%$  
   b. $30\%$  
   c. $20\%$  
   d. $44\%$

4. A particle executes S.H.M. having time period $T$. Then the time period with which the potential energy changes is
   
   a. $T$  
   b. $2T$  
   c. $T/2$  
   d. Infinity

5. The displacement of a particle executing S.H.M. is given by $y = 0.25 \sin 200t$ (in cm).  
   The maximum speed of the particle is
   
   a. $200$ cm/s  
   b. $100$ cm/s
c. 50cm/s

d. 5.25cm/s

6. Two pendulums have time period $T$ and $5T/4$. They start S.H.M. at the same time from the mean position. The phase difference between the two after the bigger pendulum completes one oscillation is

a. 45 degree
b. 90 degree
c. 60 degree
d. 30 degree

7. A mass $M$, attached to a spring, oscillates with a period of 2 sec. If the mass is increased by 4 kg, the time period increases by one second. Assuming that Hooke’s law is obeyed, initial mass $M$ was

a. 3.2 kg
b. 1 kg
c. 2 kg
d. 8 kg

8. A particle undergoes simple harmonic motion having time period $T$. The time taken for displacement to be $\sqrt{3}/2^{\text{th}}$ of the amplitude after passing through the mean position is

a. $(\sqrt{3}/2)T$

b. $(\sqrt{3}/4) T$

c. $(\sqrt{3}) T$

d. $(1/6) T$

9. The work done by the tension in the string of a simple pendulum during half the oscillation is equal to

a. Total energy of the pendulum
b. kinetic energy of pendulum
c. Potential energy of the pendulum
d. zero
10. The displacement of a particle executing SHM is given by \( x = 0.01 \sin 100\pi (t+0.05) \). The time period is
   a. 0.01 sec
   b. 0.02 sec
   c. 0.1 sec
   d. 0.2 sec

11. A body executes S.H.M. with an amplitude \( A \). What displacement from the mean position is the potential energy of the body is one fourth of its total energy
   a. \( A/4 \)
   b. \( A/2 \)
   c. \( 3A/4 \)
   d. \( A/\sqrt{2} \)

12. For a particle executing SHM along \( x \)-axis force is given by
   a. \(-A kx\)
   b. \(A \cos kx\)
   c. \(A e^{-kx}\)
   d. \(A kx\)

13. A second pendulum is mounted in a rocket. Its period of oscillation will decrease when rocket is:
   a. Moving up with uniform velocity
   b. Moving up with uniform acceleration
   c. Moving down with uniform acceleration
   d. Moving in a geostationary orbit

14. Two simple pendulums of length 2.5 m and 10 m respectively are given small linear displacement in one direction at the same time. They will be again in same phase at the earliest when the pendulum of shorter length has completed oscillations
   a. 1
   b. 2
15. The time period of a simple pendulum is 2 seconds. If its length is increased by 3 times, then its period becomes

a. 16 s
b. 12 s
c. 8 s
d. 4 s

16. A simple harmonic oscillator has a period $T$ and energy $E$. The amplitude of the oscillator is doubled. Choose the correct answer;

a. Period and energy get doubled
b. Period gets doubled while energy remains the same
c. Energy gets the doubled while period remains the same
d. Period remains the same and energy becomes four times

17. A child is sitting on a swing. Its minimum and maximum heights from the ground are 0.75 m and 2 m respectively. Taking $g=10\,\text{m/s}^2$, its maximum speed will be

a. 10 m/s
b. 5 m/s
c. 8 m/s
d. 15 m/s

18. When an oscillator completes 100 oscillations its amplitude reduces to $1/3$ of its initial value. What will be its amplitude, when it further completes 200 oscillations?

a. 1/9
b. 2/3
c. 1/6
d. 1/27
19. The spring constant of a spring is $K$. When it is divided into $n$ equal parts, then what is the spring constant of one piece?

a. $nK$

b. $K/n$

c. $k$

d. $(n+1)K/n$

20. A particle doing simple harmonic motion, amplitude = 4 cm, time period = 12 sec. Ratio of time taken by it in going from its mean position to 2 cm and from 2 cm to extreme position is

a. 1

b. $1/3$

c. $1/4$

d. $1/2$

**ANSWERS**

1. - C
2. - D
3. - C
4. - C
5. - C
6. - B
7. - A
8. - C
9. - D
10. - B
11. - B
12. - A
13. - B
14. - B
15. – D
16. - D
17. - B
18. - D
19. - A
20. - D

SOLUTIONS (Next Page)
1. Here \( a = 3 \text{ cm} \); \( b = 4 \text{ cm} \) \( \therefore R = \sqrt{a^2 + b^2} = \sqrt{3^2 + 4^2} = 5 \text{ cm} \) (Option c)

2. By definition, \( \sin \theta = \frac{a}{R} \), hence \( \sin \theta = \frac{3}{5} \) (Option 2)

3. We have \( T = 2\pi \sqrt{\frac{4}{g}} \) and \( T' = 2\pi \sqrt{\frac{14.4}{g}} = 2\pi \sqrt{\frac{14.4}{g}} = 1.2T \)

4. In a period of oscillation, the energy becomes purely potential

5. Maximum speed = \( v_0 = a\omega = \left(\frac{3}{5}\right) \times 200 = 50 \text{ cm} \) (Option c)

6. We have \( T = 2\pi \sqrt{\frac{g}{4}} \) So larger length implies longer length.

   Also, \( \frac{T_1}{T} = \frac{5}{4} \) So the smaller pendulum oscillates through one-fourth of its oscillation in time \( \frac{T_1}{4} \).

   These differences = \( \frac{2\pi}{T_1} \) in \( \frac{T_1}{T} = \frac{T_1}{4} \) = 90° (Option b)

7. We have \( T = \frac{2\pi}{\sqrt{\frac{g}{m}}} \) and \( T + t = \frac{2\pi}{\sqrt{\frac{g}{m + \frac{1}{4} \text{ mass}}} \Rightarrow m + \frac{1}{4} \text{ mass} = (2 + 1)^2 \frac{9}{16} \text{ or } m = 4m_0 + \frac{1}{4} \text{ mass} \)

   \( m = \frac{16}{5} = 5.2 \text{ kg} \) (Option a)

8. Take \( y = a \sin \omega t \) as the starting position in the mean position.

   From \( \frac{dy}{dt} = \frac{3}{2} a \); we get \( \frac{dy}{dt} a = a \sin \omega t \) or \( \sin \omega t = \frac{3}{2} a \)

   \( \sin x = 1 \sin \frac{3}{2} \Rightarrow \omega t = \frac{3}{2} \text{ or } \frac{2\pi}{3} \text{ or } t = T/6 \) (Option d)

9. Zero; as \( T \perp \) velocity and \( N = F \cdot t = F \cdot v \cdot t = \text{force} \times \text{time} \times 90° = 0 \) (Option d)

10. Comparing with \( x = a \sin \frac{2\pi}{T} (t + \phi) \) we get

    \( 100 \pi = 2\pi \Rightarrow T = \frac{T}{50} \Delta = 0.02 \text{ second} \) (Option b)
\( P.E. = \frac{\text{Total energy}}{4} \times \frac{1}{2} k \left( \frac{\Delta x}{L} \right)^2 \text{ or } y^2 = \frac{v^2}{2} \text{ or } y = \frac{v^2}{2} \) (Option d)

By definition, \( F \text{ = force} \cdot \Delta x \text{ = displacement} \) (Option a)

Upward acceleration simple, \( g^2 = g \cdot g \) so \( T_2 = 2\pi \sqrt{\frac{g}{2}} \leq T_1 \)

We have \( T_2 = 2\pi \sqrt{\frac{g}{2}} \text{ or } T_1 = 2\pi \sqrt{\frac{5g}{9}} \)

If \( n \) is the no. of oscillations of the smaller pendulum and \( d \) is of the longer pendulum.

Then \( \sqrt{\frac{5g}{9}} = (n-1) \sqrt{\frac{g}{2}} \) or \( n = (n-1)2 \Rightarrow n = 2 \) (Option b)

We show \( T = 2\pi \sqrt{\frac{g}{L}} = 2\pi \) sec for simple pendulum.

\( T_1 = 2\pi \sqrt{\frac{5g}{9}} = 2\pi \sqrt{\frac{2g}{9}} = \frac{2}{3} T = 4/3 \) [Option d]

\( T \) as \( T \) is independent of amplitude and \( E = \frac{1}{2} k \Delta x^2 \text{ is the energy becomes more twice} \) (Option a)

For the swing's vertical fall \( w = 2 - 0.25 = 1.75 \text{ m} = \frac{g}{2} \)

\( v = 2gh = \sqrt{2gh} = 5 \text{ m/s} \) (Option d)

Damping after 1st oscillation reduces the amplitude to \( \frac{1}{3} \). So a further 100 oscillations will lead amplitude to reduced to another \( \frac{1}{3} \) or \( \frac{1}{3} \) of its original amplitude (Option d)

For a given force, the extension is inversely proportional to its original length. As length becomes \( \frac{L}{n} \), the extension becomes \( \frac{1}{n} \). Spring factor becomes \( n \) (Option a)

Taking \( y = A \Delta x \) & \( y = \frac{A}{2} \) when \( \Delta x = \frac{1}{2} \)

\( w = \frac{m}{2} \text{ or } 2 \frac{m}{2} = \frac{y}{5} \text{ or } t = \frac{m}{2} \) (say)

\( y = A \text{ when } t = \frac{m}{2} \)

Time taken from 2 cm to zero = \( \frac{m}{2} \frac{T_1}{T_2} = 2T_1 \) [Option d]