Engineering Daily 13 [Home Practice] EV

Structural Properties of Matter + Periodic motion

Total Marks: 50 **Negative Marks:** 0.25 **Time:** 1 Hour

MCQ 50 marks

1. A liquid has surface tension $4.5 \times 10^{-2}\ \text{Nm}^{-1}$ and density $800\ \text{kgm}^{-3}$. If the angle of contact with a capillary tube of radius 0.4 mm is 40°, find the height to which it rises.

(A) 0.0184 m (B) 0.0440 m
(C) 0.0220 m (D) 0.0110 m

2. A spring-mass oscillator has $T = 1$ s. With k unchanged, what factor must the mass be changed by to make $T = 1.5$ s?

(A) 2.25 (B) 2.00 (C) 1.5 (D) 3.00

3. Two wires of the same material have lengths in ratio 2 : 5 and radii in ratio 3 : 2. If the same force is applied to both, find the ratio of their elongations $\Delta L_1 : \Delta L_2$.

(A) 45 : 8 (B) 4 : 25 (C) 6 : 15 (D) 8 : 45

4. 27 water droplets, each of radius 5 mm, fall with terminal velocity $3\ \text{cms}^{-1}$. If the droplets merge to form one large drop, find the amount of heat released. (Surface tension = $72 \times 10^{-3}\ \text{Nm}^{-1}$)

(A) 1.22×10^{-3} J (B) 4.07×10^{-4} J
(C) 8.14×10^{-4} J (D) 2.04×10^{-4} J

5. An oscillator has $A = 10$ cm and $T = 1$ s. Starting at $x = 8$ cm and moving toward the mean, find the time to reach the mean and the magnitude of the change in acceleration.

(A) 0.148 s, $2.53\ \text{ms}^{-2}$ (B) 0.148 s, $3.16\ \text{ms}^{-2}$
(C) 0.102 s, $3.16\ \text{ms}^{-2}$ (D) 0.148 s, $6.32\ \text{ms}^{-2}$

6. In an SHM, at $x = \frac{A}{2}$, is $K = U$? If not, what is $K : U$?

(A) 2 : 1 (B) 1 : 1 (C) 3 : 1 (D) 1 : 3

7. For an SHM with $A = 0.20$ m and $\omega = 10\ \text{rads}^{-1}$, at $x = 0.12$ m find the kinetic-energy fraction and acceleration.

(A) 0.36, $+12\ \text{ms}^{-2}$ (B) 0.64, $-12\ \text{ms}^{-2}$
(C) 0.64, $+12\ \text{ms}^{-2}$ (D) 0.36, $-12\ \text{ms}^{-2}$

8. A particle in SHM has amplitude 5 cm and maximum speed $80\ \text{cms}^{-1}$. What is its time period?

(A) $\frac{5\pi}{16}$ s (B) $\frac{\pi}{8}$ s (C) $\frac{5\pi}{8}$ s (D) $\frac{\pi}{10}$ s

9. A sphere (density $2500\ \text{kgm}^{-3}$) is released from rest into a liquid (density $1000\ \text{kgm}^{-3}$). Find its acceleration at $t = 0$ (assuming the viscous force is still zero at that instant).

(A) $3.92\ \text{ms}^{-2}$ (B) $5.88\ \text{ms}^{-2}$
(C) $9.8\ \text{ms}^{-2}$ (D) $2.94\ \text{ms}^{-2}$

10. For $x = A\cos\omega t$, what total phase change is required to go from the positive extreme to the mean and then to the negative extreme?

(A) $\frac{\pi}{2}$ (B) 2π (C) $\frac{3\pi}{2}$ (D) π

11. If the flow velocity of a liquid is tripled (tube diameter and fluid properties unchanged), by what factor does the Reynolds number change?

(A) 1.5 times (B) 3 times
(C) unchanged (D) 9 times

12. Two identical-sized spheres of densities $8000\ \text{kgm}^{-3}$ and $2700\ \text{kgm}^{-3}$ are dropped into the same liquid (density $1000\ \text{kgm}^{-3}$). Find the ratio of their terminal velocities $v_1 : v_2$.

(A) 2.7 : 8 (B) 1 : 4.12
(C) 4.12 : 1 (D) 8 : 2.7

13. 27 water droplets, each of diameter 2.2×10^{-7} m, coalesce to form one large drop. Find the diameter of the large drop.

(A) 3.96×10^{-6} m (B) 1.32×10^{-6} m
(C) 4.40×10^{-6} m (D) 6.60×10^{-7} m

14. Water has compressibility $5 \times 10^{-11}\ \text{Pa}^{-1}$. At a depth of 6 km, the density of water is $1015\ \text{kgm}^{-3}$. Find the density of water at the surface.

(A) $1018.0\ \text{kgm}^{-3}$ (B) $1012.0\ \text{kgm}^{-3}$
(C) $1015.0\ \text{kgm}^{-3}$ (D) $1006.0\ \text{kgm}^{-3}$

15. A wire elongates by 2 mm when a force of 500 N is applied. Find the elastic potential energy stored in the wire.

(A) 1.0 J (B) 0.25 J (C) 0.5 J (D) 1000 J

16. A spring-mass system has $T = 0.60$ s. If the mass is decreased by 25% and k is increased by 44%, what is the new period?

(A) 0.500 s (B) 0.450 s
(C) 0.375 s (D) 0.433 s

17. A sphere is subjected to a uniform pressure of 4×10^7 Pa. If the bulk modulus of the material is 1.6×10^{11} Pa, find the fractional decrease in volume $\frac{\Delta V}{V}$.

(A) 5×10^{-4} (B) 2.5×10^{-4}
(C) 1.25×10^{-4} (D) 2.5×10^{-6}

18. For mercury, surface tension is $0.465\ \text{Nm}^{-1}$, angle of contact is 140°, and density is $13600\ \text{kgm}^{-3}$. Find the depression of mercury in a capillary tube of radius 0.5 mm.

(A) 1.07×10^{-2} m (B) 5.35×10^{-3} m
(C) 2.14×10^{-2} m (D) 1.07×10^{-4} m

19. The length of a seconds pendulum is increased by 5%. Approximately how many fewer oscillations will it complete in 24 h than the original pendulum?

(A) ≈ 2048 (B) ≈ 2082 (C) ≈ 1800 (D) ≈ 1041

20. For $x = A\cos(\omega t)$, what is the phase interval per cycle during which both velocity and acceleration are negative?

(A) $\frac{\pi}{2}$ (B) π (C) $\frac{3\pi}{2}$ (D) $\frac{\pi}{4}$

21. The equation $2\frac{d^2y}{dt^2} + 50y = 0$ represents SHM. If the amplitude is 4 cm, which pair gives the time period and maximum acceleration?

(A) $\frac{2\pi}{5}$ s, $0.50\ \text{ms}^{-2}$ (B) $\frac{\pi}{5}$ s, $0.50\ \text{ms}^{-2}$

(C) $\frac{2\pi}{5}$ s, $1\ \text{ms}^{-2}$ (D) $\frac{\pi}{5}$ s, $1\ \text{ms}^{-2}$

22. A 10 kg block is attached in series with a $120\ \text{Nm}^{-1}$ spring, while $40\ \text{Nm}^{-1}$ and $60\ \text{Nm}^{-1}$ springs are in parallel. Find the period of oscillation.

(A) 3.01 s (B) 2.45 s (C) 1.91 s (D) 2.69 s

23. The amplitude of an SHM is tripled while ω remains unchanged. By what factors do maximum speed and total mechanical energy change?

(A) 3, 9 (B) 3, 3 (C) 9, 9 (D) 9, 3

24. A particle follows $x = A\cos(\omega t + \varphi)$. At $t = 0$, $x = \frac{A}{2}$ and the particle is moving in the negative direction. What is the least positive φ?

(A) $\frac{\pi}{6}$ (B) $\frac{2\pi}{3}$ (C) $\frac{5\pi}{3}$ (D) $\frac{\pi}{3}$

25. Two SHMs have equal amplitudes and phase difference $\frac{\pi}{3}$. When the first has maximum positive velocity, what fraction of A is the displacement of the second?

(A) $\frac{1}{2}$ (B) $-\frac{\sqrt{3}}{2}$ (C) $\frac{\sqrt{3}}{2}$ (D) 1

26. Two particles of equal amplitude execute SHM and, at a certain instant, cross while moving in opposite directions. If the crossing position is $x = \frac{A}{3}$, what is the least positive phase difference?

(A) 2.462 rad (B) 0.680 rad

(C) 1.231 rad (D) 0.340 rad

27. A soap solution has surface tension $4 \times 10^{-2}\ \text{Nm}^{-1}$. If the excess pressure inside a soap bubble is 16 Pa, find the radius of the bubble.

(A) 4×10^{-2} m (B) 2×10^{-2} m

(C) 1×10^{-2} m (D) 5×10^{-3} m

28. Two wires of different materials are joined in series: the first is 2 m long ($Y_1 = 2 \times 10^{11}\ \text{Nm}^{-2}$), the second is 3 m long ($Y_2 = 1 \times 10^{11}\ \text{Nm}^{-2}$), both with diameter 2 mm. Find the total elongation when a force of 300 N is applied.

(A) 2.86 mm (B) 7.64 mm

(C) 1.91 mm (D) 3.82 mm

29. A rigidly clamped metal rod is heated so its temperature rises by 40°C. The linear expansion coefficient is $1.2 \times 10^{-5}\ \text{K}^{-1}$ and Young's modulus is $2 \times 10^{11}\ \text{Nm}^{-2}$. Find the thermal stress developed in the rod.

(A) $1.92 \times 10^{8}\ \text{Nm}^{-2}$ (B) $9.6 \times 10^{7}\ \text{Nm}^{-2}$

(C) $4.8 \times 10^{7}\ \text{Nm}^{-2}$ (D) $9.6 \times 10^{5}\ \text{Nm}^{-2}$

30. A rod of diameter 4 cm projects horizontally 0.5 m from a wall. If a 40 kg mass is hung from its free end, find the vertical deflection at the end. ($Y = 2 \times 10^{11}\ \text{Nm}^{-2}$)

(A) 0.65 mm (B) 0.325 mm

(C) 6.5 mm (D) 1.30 mm

31. In an SHM, it takes 0.10 s to move from the mean position to $x = 0.8A$, starting in the positive direction. Find the period.

(A) 0.800 s (B) 0.558 s (C) 0.678 s (D) 0.279 s

32. A steel ball of radius 1.5 mm (density $7800\ \text{kgm}^{-3}$) falls with terminal velocity through glycerin (density $1260\ \text{kgm}^{-3}$), covering 0.6 m in 12 s. Find the viscosity of glycerin.

(A) $0.641 \times 10^{-2}\ \text{Pa}\cdot\text{s}$ (B) $0.320\ \text{Pa}\cdot\text{s}$

(C) $1.282\ \text{Pa}\cdot\text{s}$ (D) $0.641\ \text{Pa}\cdot\text{s}$

33. A 0.10 kg particle executes SHM with amplitude 0.10 m. Its kinetic energy at the mean position is 8×10^{-3} J. If it starts with phase 45°, what is its displacement equation?

(A) $x = 0.10\cos\left(4t + \frac{\pi}{4}\right)$ m

(B) $x = 0.20\cos\left(4t + \frac{\pi}{4}\right)$ m

(C) $x = 0.10\cos\left(8t + \frac{\pi}{4}\right)$ m

(D) $x = 0.10\sin\left(4t + \frac{\pi}{4}\right)$ m

34. A tiny sphere of radius 2×10^{-4} m moves through air (viscosity $1.8 \times 10^{-5}\ \text{Pa}\cdot\text{s}$) at $0.03\ \text{ms}^{-1}$. Using Stokes' law, find the viscous drag force on it.

(A) 2.04×10^{-7} N (B) 2.04×10^{-9} N

(C) 4.07×10^{-9} N (D) 1.02×10^{-9} N

35. Two identical springs, each of constant k, are connected first in parallel and then in series. For the same mass, what is $T_{\text{parallel}} : T_{\text{series}}$?

(A) 1 : 2 (B) 1 : 4 (C) 2 : 1 (D) $1 : \sqrt{2}$

36. Two rods of equal cross-sectional area are pulled by the same force. Their lengths are in ratio $L_1 : L_2 = 1 : 3$ and Young's moduli in ratio $Y_1 : Y_2 = 2 : 1$. Find the ratio of their elongations $\Delta L_1 : \Delta L_2$.

(A) 3 : 2 (B) 6 : 1 (C) 2 : 3 (D) 1 : 6

37. At $x = \frac{A}{3}$ in an SHM, the potential energy is 1.5 J. Find total energy and maximum kinetic energy.

(A) 9.0 J, 9.0 J (B) 4.5 J, 3.0 J

(C) 13.5 J, 13.5 J (D) 6.0 J, 4.5 J

38. A 0.10 kg bob on a 1 m pendulum is released from 30° from the vertical. What is its kinetic energy when the string makes 20° with the vertical? Take $g = 10\ ms^{-2}$.

(A) 7.37×10^{-2} J (B) 6.82×10^{-2} J

(C) 8.19×10^{-2} J (D) 1.37×10^{-1} J

39. The surface tension of water is $7.2 \times 10^{-2}\ Nm^{-1}$. To what height will water rise in a capillary tube of radius 0.2 mm? (Angle of contact = 0°)

(A) 0.0735 m (B) 0.0367 m

(C) 7.35 m (D) 0.147 m

40. A wire is under stress $2 \times 10^{8}\ Nm^{-2}$ and has Young's modulus $2 \times 10^{11}\ Nm^{-2}$. Find the elastic energy stored per unit volume in the wire.

(A) $5 \times 10^{4}\ Jm^{-3}$ (B) $2 \times 10^{5}\ Jm^{-3}$

(C) $1 \times 10^{5}\ Jm^{-3}$ (D) $2 \times 10^{8}\ Jm^{-3}$

41. A spring has natural length 30 cm and $k = 100\ Nm^{-1}$. A 0.50 kg mass is hung from it. Find the equilibrium extension and then the period if the mass is displaced 2 cm downward and released. Take $g = 10\ ms^{-2}$.

(A) 5 cm, 0.314 s (B) 5 cm, 0.444 s

(C) 2 cm, 0.444 s (D) 10 cm, 0.628 s

42. A particle has maximum speed $10\ ms^{-1}$ and amplitude 0.25 m. Find ω and a_{max}.

(A) $40\ rads^{-1}$, $400\ ms^{-2}$ (B) $40\ rads^{-1}$, $100\ ms^{-2}$

(C) $20\ rads^{-1}$, $200\ ms^{-2}$ (D) $25\ rads^{-1}$, $250\ ms^{-2}$

43. A wire of length 4.5 m has mass 25 gm and density $5600\ kgm^{-3}$. If a force of 760 N produces an elongation of 1.5 mm, find the elastic potential energy stored in the wire.

(A) 1.14 J (B) 1140 J

(C) 0.57 J (D) 0.285 J

44. An SHM has $A = 8$ cm and $T = 4$ s. Starting from the mean position moving positive, how long does it take to first reach $\frac{A}{2}$?

(A) 1 s (B) $\frac{1}{3}$ s (C) $\frac{2}{3}$ s (D) $\frac{1}{6}$ s

45. An SHM has total energy 5 J and $A = 0.10$ m. At $x = 0.08$ m, what is the ratio $U : K$?

(A) 8 : 3 (B) 9 : 16 (C) 4 : 5 (D) 16 : 9

46. An SHM has $a_{max} = 12\ ms^{-2}$. At $x = 0.60A$, what are the acceleration magnitude and the fraction of total energy that is potential?

(A) $7.2\ ms^{-2}$, 0.36 (B) $12\ ms^{-2}$, 0.60

(C) $4.8\ ms^{-2}$, 0.36 (D) $7.2\ ms^{-2}$, 0.64

47. A soap bubble has radius 1 cm and surface tension $3 \times 10^{-2}\ Nm^{-1}$. Find the excess pressure inside the bubble.

(A) 12 Pa (B) 24 Pa (C) 6 Pa (D) 3 Pa

48. A wire ring of radius 2 cm is to be pulled off the surface of water. Find the minimum force required. (Surface tension of water = $7.2 \times 10^{-2}\ Nm^{-1}$)

(A) 0.0362 N (B) 0.00452 N

(C) 0.0181 N (D) 0.00905 N

49. Two wires of different materials are given the same strain (1×10^{-3}). Their Young's moduli are 2×10^{11} and $1 \times 10^{11}\ Nm^{-2}$ respectively. Find the ratio of elastic energy per unit volume $u_1 : u_2$.

(A) 4 : 1 (B) 1 : 2 (C) 1 : 1 (D) 2 : 1

50. A wire under a force of 600 N has cross-sectional area $2 \times 10^{-6}\ m^2$, length 2 m, and elongation 1 mm. Find the elastic energy stored per unit volume.

(A) $1.5 \times 10^{5}\ Jm^{-3}$ (B) $7.5 \times 10^{7}\ Jm^{-3}$

(C) $7.5 \times 10^{4}\ Jm^{-3}$ (D) $3.75 \times 10^{4}\ Jm^{-3}$