Engineering Daily 13 [Set 03] EV

Structural Properties of Matter + Periodic motion

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

MCQ 50 marks

1. A seconds pendulum loses 2.0 s per hour at a mountain. By what percentage should its length be decreased there to restore a 1 s period?

Ⓐ 0.0278% Ⓑ 0.0556%

Ⓒ 0.111% Ⓓ 0.222%

2. Two capillary tubes of radii 0.3 mm and 0.5 mm are dipped in water. If the surface tension of water is $7.2 \times 10^{-2}\ \text{Nm}^{-1}$, find the difference in the heights of water in the two tubes. (Angle of contact = 0°)

Ⓐ 0.0098 m Ⓑ 0.0294 m

Ⓒ 0.0784 m Ⓓ 0.0196 m

3. If the energy of a spring oscillator decreases by 20% while m and k remain unchanged, by what percentage does the amplitude decrease?

Ⓐ ≈ 10.56% Ⓑ 10%

Ⓒ 20% Ⓓ ≈ 11.18%

4. A glass ball (density $2600\ \text{kgm}^{-3}$) falls with terminal velocity $0.02\ \text{ms}^{-1}$ through a liquid of density $1000\ \text{kgm}^{-3}$ and viscosity $0.5\ \text{Pa} \cdot \text{s}$. Find the radius of the ball.

Ⓐ 1.69×10^{-2} m Ⓑ 1.69×10^{-3} m

Ⓒ 0.85×10^{-3} m Ⓓ 3.39×10^{-3} m

5. An identical sphere is dropped into two different liquids whose viscosities are in ratio $\eta_1 : \eta_2 = 1 : 3$ (liquid densities negligible in comparison). Find the ratio of terminal velocities $v_1 : v_2$.

Ⓐ 1 : 3 Ⓑ 1 : 9 Ⓒ 3 : 1 Ⓓ 9 : 1

6. When a pressure of 2×10^6 Pa is applied to 100 cm^3 of water, its volume decreases by 0.01 cm^3. Find the bulk modulus of water.

Ⓐ 1×10^{10} Pa Ⓑ 2×10^8 Pa

Ⓒ 4×10^{10} Pa Ⓓ 2×10^{10} Pa

7. A quantity of water equal in volume to a sphere of radius 2 mm breaks up into 1000 equal small droplets. Find the work done in this process. (Surface tension = $7.2 \times 10^{-2}\ \text{Nm}^{-1}$)

Ⓐ 3.26×10^{-6} J Ⓑ 1.63×10^{-5} J

Ⓒ 6.51×10^{-5} J Ⓓ 3.26×10^{-5} J

8. An SHM has total energy 0.18 J, m = 0.20 kg and A = 0.12 m. Find its angular frequency and maximum speed.

Ⓐ $12.50\ \text{rads}^{-1}$, $1.500\ \text{ms}^{-1}$

Ⓑ $11.18\ \text{rads}^{-1}$, $1.118\ \text{ms}^{-1}$

Ⓒ $11.18\ \text{rads}^{-1}$, $1.342\ \text{ms}^{-1}$

Ⓓ $10.00\ \text{rads}^{-1}$, $1.200\ \text{ms}^{-1}$

9. Two spheres of the same material fall through the same liquid; their radii are in ratio 1 : 2. Find the ratio of their terminal velocities $v_1 : v_2$.

Ⓐ 1 : 4 Ⓑ 1 : 2 Ⓒ 4 : 1 Ⓓ 1 : 8

10. A pendulum's length is changed from 1.00 m to 1.21 m. If g is unchanged, by what percentage does its period increase?

Ⓐ 21% Ⓑ 10% Ⓒ 9.54% Ⓓ 11%

11. An SHM has A = 6 cm. If the speed is 0.5 of the maximum speed, find |x| and U : E.

Ⓐ 3 cm, $\frac{3}{4}$ Ⓑ 3 cm, $\frac{1}{2}$

Ⓒ $3\sqrt{\frac{3}{2}}$ cm, $\frac{1}{4}$ Ⓓ $3\sqrt{3}$ cm, $\frac{3}{4}$

12. An SHM has total energy 12 J. How much does its kinetic energy decrease when the particle moves from $x = \frac{A}{2}$ to $x = \frac{3A}{4}$?

Ⓐ 3.75 J Ⓑ 1.50 J Ⓒ 4.50 J Ⓓ 2.25 J

13. Two wires of the same material have lengths in ratio 3 : 4 and radii in ratio 1 : 5. If pulled by the same force, find the ratio of their elongations.

Ⓐ 3 : 100 Ⓑ 75 : 4 Ⓒ 4 : 75 Ⓓ 25 : 12

14. A particle follows $x = 0.12 \sin(5t)$ m. At t = 0.20 s, with m = 0.50 kg, find its acceleration and kinetic energy.

Ⓐ $-2.524\ \text{ms}^{-2}$, 0.102 J Ⓑ $-3.000\ \text{ms}^{-2}$, 0.180 J

Ⓒ $-2.524\ \text{ms}^{-2}$, 0.0263 J Ⓓ $+2.524\ \text{ms}^{-2}$, 0.0263 J

15. A liquid flows through a tube of radius 0.5 mm and length 0.15 m under a pressure difference of 1200 Pa, at a rate of $2 \times 10^{-6}\ \text{m}^3\text{s}^{-1}$. Find the viscosity of the liquid.

Ⓐ $4.91 \times 10^{-5}\ \text{Pa} \cdot \text{s}$ Ⓑ $1.96 \times 10^{-4}\ \text{Pa} \cdot \text{s}$

Ⓒ $9.82 \times 10^{-5}\ \text{Pa} \cdot \text{s}$ Ⓓ $9.82 \times 10^{-3}\ \text{Pa} \cdot \text{s}$

16. In an SHM, $A = 6\,\text{cm}$. If the maximum speed is $6\,\text{ms}^{-1}$, find the speed at $x = \frac{A}{2}$.

(A) $3\sqrt{3}\,\text{ms}^{-1}$ (B) $3\,\text{ms}^{-1}$

(C) $3\sqrt{2}\,\text{ms}^{-1}$ (D) $\sqrt{3}\,\text{ms}^{-1}$

17. An SHM has $T = 0.50\,\text{s}$. If the total distance travelled in one complete cycle is $1.6\,\text{m}$, find A and the maximum speed.

(A) $0.40\,\text{m},\ 2.51\,\text{ms}^{-1}$ (B) $0.40\,\text{m},\ 5.03\,\text{ms}^{-1}$

(C) $0.80\,\text{m},\ 10.05\,\text{ms}^{-1}$ (D) $0.20\,\text{m},\ 2.51\,\text{ms}^{-1}$

18. For $x = 5\sin\left(2t + \frac{\pi}{3}\right)\,\text{cm}$, find x and v at $t = \frac{\pi}{12}\,\text{s}$.

(A) $x = 2.5\,\text{cm},\ v = 5\,\text{cms}^{-1}$

(B) $x = 5\sqrt{\frac{3}{2}}\,\text{cm},\ v = 5\,\text{cms}^{-1}$

(C) $x = -5\,\text{cm},\ v = 0$

(D) $x = 5\,\text{cm},\ v = 0$

19. A cube of aluminium with side $3\,\text{cm}$ has its bottom face fixed rigidly. A tangential force of 4×10^{10} dyne is applied on the top face, producing a displacement of $0.005\,\text{cm}$ relative to the bottom face. Find the rigidity modulus of aluminium.

(A) $2.67 \times 10^{12}\,\text{dynecm}^{-2}$ (B) $5.33 \times 10^{12}\,\text{dynecm}^{-2}$

(C) $1.33 \times 10^{12}\,\text{dynecm}^{-2}$ (D) $2.67 \times 10^{10}\,\text{dynecm}^{-2}$

20. If the length of a seconds pendulum decreases by 4% , approximately how many seconds will it gain per day?

(A) $\approx 864\,\text{s}$ (B) $\approx 1782\,\text{s}$

(C) $\approx 176\,\text{s}$ (D) $\approx 3528\,\text{s}$

21. Water (viscosity $1 \times 10^{-3}\,\text{Pa}\cdot\text{s}$) flows through a tube of radius $1\,\text{mm}$ and length $0.2\,\text{m}$ under a pressure difference of $500\,\text{Pa}$. Using Poiseuille's equation, find the volume flow rate Q.

(A) $1.96 \times 10^{-6}\,\text{m}^3\text{s}^{-1}$ (B) $9.82 \times 10^{-9}\,\text{m}^3\text{s}^{-1}$

(C) $9.82 \times 10^{-7}\,\text{m}^3\text{s}^{-1}$ (D) $4.91 \times 10^{-7}\,\text{m}^3\text{s}^{-1}$

22. If the radius of a raindrop doubles (assuming Stokes' law still applies), by what factor does its terminal velocity increase?

(A) 8 times (B) 2 times

(C) 16 times (D) 4 times

23. An SHM has $T = 0.80\,\text{s}$ and $A = 5\,\text{cm}$. Starting at $x = \frac{A}{\sqrt{2}}$ and moving toward the mean position, how long does it take to reach the mean position?

(A) $0.30\,\text{s}$ (B) $0.20\,\text{s}$ (C) $0.10\,\text{s}$ (D) $0.05\,\text{s}$

24. An oscillator has $f = 5\,\text{Hz}$ and $A = 4\,\text{cm}$. What is its average speed from the mean position to an extreme?

(A) $0.80\,\text{ms}^{-1}$ (B) $0.20\,\text{ms}^{-1}$

(C) $0.40\,\text{ms}^{-1}$ (D) $1.00\,\text{ms}^{-1}$

25. For $x = 0.20\cos\left(4\pi t - \frac{\pi}{6}\right)\,\text{m}$, find x and v at $t = \frac{1}{12}\,\text{s}$.

(A) $x = 0.20\,\text{m},\ v = 0$

(B) $x = 0.10\sqrt{3}\,\text{m},\ v = -0.4\pi\,\text{ms}^{-1}$

(C) $x = -0.10\sqrt{3}\,\text{m},\ v = -0.4\pi\,\text{ms}^{-1}$

(D) $x = 0.10\sqrt{3}\,\text{m},\ v = +0.4\pi\,\text{ms}^{-1}$

26. A mass m is connected to a wall by two parallel springs k_1 and k_2, with period T. What is the new period when $k_1 + k_2$ is doubled?

(A) $2T$ (B) $\frac{T}{2}$ (C) $\sqrt{2}T$ (D) $\frac{T}{\sqrt{2}}$

27. Two spheres fall through the same liquid, with radii in ratio $r_1 : r_2 = 2 : 3$ and, at a certain instant, velocities in ratio $v_1 : v_2 = 3 : 2$. Find the ratio of the viscous forces acting on them $F_1 : F_2$.

(A) 9 : 4 (B) 1 : 1 (C) 2 : 3 (D) 4 : 9

28. A liquid (density $1000\,\text{kgm}^{-3}$, viscosity $1 \times 10^{-3}\,\text{Pa}\cdot\text{s}$) flows through a tube of diameter $0.02\,\text{m}$ at $0.5\,\text{ms}^{-1}$. Find the Reynolds number and determine whether the flow is laminar or turbulent.

(A) 10000 (turbulent) (B) 5000 (laminar)

(C) 2500 (laminar) (D) 20000 (turbulent)

29. What force must be applied to a copper wire of length $1.5\,\text{m}$ and diameter $0.8\,\text{mm}$ to produce an elongation of $0.9\,\text{mm}$? ($Y = 1.1 \times 10^{11}\,\text{Nm}^{-2}$)

(A) $132.7\,\text{N}$ (B) $66.4\,\text{N}$

(C) $33.2\,\text{N}$ (D) $16.6\,\text{N}$

30. An SHM has maximum acceleration $20\,\text{ms}^{-2}$ and maximum speed $4\,\text{ms}^{-1}$. Find its amplitude and angular frequency.

(A) $0.40\,\text{m},\ 10\,\text{rads}^{-1}$ (B) $0.10\,\text{m},\ 40\,\text{rads}^{-1}$

(C) $0.20\,\text{m},\ 20\,\text{rads}^{-1}$ (D) $0.80\,\text{m},\ 5\,\text{rads}^{-1}$

31. The compressibility of pure water is $4.96 \times 10^{-12}\,\text{cm}^2\text{dyne}^{-1}$, and at a depth of $8\,\text{km}$ its density is $1002.5\,\text{kgm}^{-3}$. Find the density of water at the surface (normal conditions).

(A) $1002.5\,\text{kgm}^{-3}$ (B) $1006.4\,\text{kgm}^{-3}$

(C) $998.6\,\text{kgm}^{-3}$ (D) $962.3\,\text{kgm}^{-3}$

32. A particle in SHM moves from an extreme position toward the mean. If its speed at $x = \frac{A}{\sqrt{2}}$ is $2\ \text{ms}^{-1}$, what is its maximum speed?

(A) $2\sqrt{2}\ \text{ms}^{-1}$ (B) $2\sqrt{3}\ \text{ms}^{-1}$

(C) $4\ \text{ms}^{-1}$ (D) $\sqrt{2}\ \text{ms}^{-1}$

33. Two pendulums have lengths in ratio 4 : 9. At the same location, what are the ratios of period and frequency?

(A) 4 : 9 and 9 : 4 (B) 2 : 3 and 3 : 2

(C) 1 : 1 and 1 : 1 (D) 3 : 2 and 2 : 3

34. A wire is under stress $1.5 \times 10^8\ \text{Nm}^{-2}$ and has Young's modulus $1.25 \times 10^{11}\ \text{Nm}^{-2}$. Find the elastic energy stored per unit volume.

(A) $1.8 \times 10^5\ \text{Jm}^{-3}$ (B) $9 \times 10^7\ \text{Jm}^{-3}$

(C) $9 \times 10^4\ \text{Jm}^{-3}$ (D) $4.5 \times 10^4\ \text{Jm}^{-3}$

35. A vertical spring has an equilibrium extension of 4 cm. For $g = 9.8\ \text{ms}^{-2}$, find its angular frequency. Does moving it 3 cm from equilibrium change ω?

(A) $15.65\ \text{rads}^{-1}$; yes (B) $7.83\ \text{rads}^{-1}$; yes

(C) $49.0\ \text{rads}^{-1}$; no (D) $15.65\ \text{rads}^{-1}$; no

36. How much work must be done to increase the radius of a soap bubble from 1 cm to 5 cm? (Surface tension $= 2.7 \times 10^{-2}\ \text{Nm}^{-1}$)

(A) $1.63 \times 10^{-3}\ \text{J}$ (B) $3.26 \times 10^{-3}\ \text{J}$

(C) $8.14 \times 10^{-4}\ \text{J}$ (D) $6.79 \times 10^{-4}\ \text{J}$

37. For $m = 0.40\ \text{kg}$, $k = 160\ \text{Nm}^{-1}$ and $A = 5\ \text{cm}$, what is the kinetic energy at $x = 3\ \text{cm}$?

(A) 0.160 J (B) 0.128 J

(C) 0.032 J (D) 0.096 J

38. A seconds pendulum has a spherical bob of diameter 6 cm and density $7800\ \text{kgm}^{-3}$. If 30% of the bob's volume is immersed in water, find the effective g and the new period. ($\rho_{\text{water}} = 1000\ \text{kgm}^{-3}$)

(A) $g_{\text{eff}} = 9.615\ \text{ms}^{-2}$, $T \approx 1.96\ \text{s}$

(B) $g_{\text{eff}} = 9.23\ \text{ms}^{-2}$, $T \approx 2.02\ \text{s}$

(C) $g_{\text{eff}} = 9.615\ \text{ms}^{-2}$, $T \approx 2.04\ \text{s}$

(D) $g_{\text{eff}} = 9.23\ \text{ms}^{-2}$, $T \approx 1.98\ \text{s}$

39. If k is reduced by 25% and m is increased by 44%, what factor multiplies the original frequency?

(A) 1.25 (B) 0.75

(C) 0.694 (D) ≈ 0.722

40. A liquid has surface tension $3.5 \times 10^{-2}\ \text{Nm}^{-1}$ and density $450\ \text{kgm}^{-3}$. If the angle of contact with a capillary tube of diameter 6×10^{-5} m is 26°, to what height will the liquid rise?

(A) 0.529 m (B) 0.476 m

(C) 0.238 m (D) 0.952 m

41. An SHM has $T = 3\ \text{s}$. At $t = 0$, $x = \frac{A}{2}$ and the velocity is positive. How long until it first reaches $x = -\frac{A}{2}$?

(A) 1.50 s (B) 2.00 s (C) 2.25 s (D) 0.75 s

42. Two soap bubbles of the same liquid (surface tension $= 5 \times 10^{-2}\ \text{Nm}^{-1}$), with radii 2 mm and 5 mm, are connected by a tube. Find the difference in the excess pressure inside the two bubbles.

(A) 30 Pa (B) 120 Pa (C) 140 Pa (D) 60 Pa

43. A glass ball of mass 1.5×10^{-4} kg and diameter 5×10^{-3} m falls with uniform (terminal) velocity through a liquid of density $950\ \text{kgm}^{-3}$, covering 0.4 m in 7 s. Find the coefficient of viscosity of the liquid.

(A) $0.32\ \text{Pa} \cdot \text{s}$ (B) $0.64\ \text{Pa} \cdot \text{s}$

(C) $1.28\ \text{Pa} \cdot \text{s}$ (D) $0.16\ \text{Pa} \cdot \text{s}$

44. An SHM satisfies $a = -16x$ (SI units). If $A = 0.25\ \text{m}$, find the maximum speed and period.

(A) $1.0\ \text{ms}^{-1}$, $\frac{\pi}{4}\ \text{s}$ (B) $1.0\ \text{ms}^{-1}$, $\frac{\pi}{2}\ \text{s}$

(C) $4\ \text{ms}^{-1}$, $\frac{\pi}{4}\ \text{s}$ (D) $2.0\ \text{ms}^{-1}$, $\frac{\pi}{2}\ \text{s}$

45. An SHM has $T = \frac{\pi}{2}\ \text{s}$. By how many radians does its phase change in 0.30 s?

(A) 0.3π rad (B) 0.6 rad

(C) 1.2 rad (D) 1.5 rad

46. An object is suspended by two wires of equal length, each making an angle of 20° with the horizontal. The tension in each wire is 150 N and each wire has cross-sectional area $1 \times 10^{-6}\ \text{m}^2$. Find the longitudinal strain in each wire. ($Y = 5 \times 10^{11}\ \text{Nm}^{-2}$)

(A) 1.5×10^{-4} (B) 6×10^{-4}

(C) 3×10^{-5} (D) 3×10^{-4}

47. A liquid has surface tension $6 \times 10^{-2}\ \text{Nm}^{-1}$. Compare the excess pressure inside an air bubble of radius 1 mm submerged in the liquid to that inside a soap bubble of the same radius in air (ratio: liquid-bubble : soap-bubble).

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

48. The length of a wire increases from 1 m to 1.02 m, and its diameter decreases from 0.5 mm to 0.478 mm. Find Poisson's ratio.

Ⓐ 4.4 Ⓑ 2.2 Ⓒ 0.22 Ⓓ 1.1

49. A liquid lies between two parallel plates. A force of 0.02 N on the top plate makes it move at 0.4 ms^{-1}. The plate area is 0.05 m^2 and the liquid layer thickness is 0.002 m. Using Newton's law of viscosity, find the coefficient of viscosity.

Ⓐ 1×10^{-3} Pa · s Ⓑ 2×10^{-1} Pa · s

Ⓒ 2×10^{-3} Pa · s Ⓓ 4×10^{-3} Pa · s

50. How much work is needed to increase the radius of a soap bubble from 2 cm to 4 cm? (Surface tension = 2.5×10^{-2} Nm^{-1})

Ⓐ 1.88×10^{-4} J Ⓑ 1.51×10^{-3} J

Ⓒ 3.77×10^{-4} J Ⓓ 7.54×10^{-4} J