Engineering Daily 13 [Set 04] EV

Structural Properties of Matter + Periodic motion

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

MCQ 50 marks

1. Two wires of the same material and equal length, with cross-sectional areas in ratio $A_1 : A_2 = 2 : 5$, are joined end to end (in series). If the same force is applied, find the ratio of elongations ($\Delta L_1 : \Delta L_2$).

(A) 5:2 (B) 2:5 (C) 4:25 (D) 25:4

2. Two wires of the same length and same material support a rigid bar in parallel, so that both wires undergo equal elongation. Their cross-sectional areas are 2×10^{-6} m^2 and 3×10^{-6} m^2 respectively. Find the ratio of the forces they carry ($F_1 : F_2$).

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

3. A seconds pendulum is taken to a planet where g is 64% of Earth's. What multiple of Earth's length is needed to keep the same period?

(A) 0.80 (B) 1.5625 (C) 0.64 (D) 1.25

4. In an SHM, speed is 5 ms^{-1} at x = 3 cm and 4 ms^{-1} at x = 4 cm. Find the maximum speed.

(A) 5.50 ms^{-1} (B) 6.25 ms^{-1}
(C) 5.657 ms^{-1} (D) 6.047 ms^{-1}

5. A particle has amplitude 12 cm. When its speed is one-third of maximum speed, what fraction of the amplitude is its displacement?

(A) $\frac{\sqrt{8}}{3}$ (B) $\frac{\sqrt{7}}{3}$ (C) $\frac{1}{3}$ (D) 25

6. An SHM has A = 10 cm and T = 2 s. What is the speed when the particle is at x = 6 cm?

(A) 0.157 ms^{-1} (B) 0.251 ms^{-1}
(C) 0.314 ms^{-1} (D) 0.188 ms^{-1}

7. By what percentage must the effective length of a simple pendulum be increased to increase its period by 45%?

(A) 45.00% (B) 145.00%
(C) 110.25% (D) 90.00%

8. In an inclined capillary tube, liquid rises to a vertical height of 0.06 m. If the tube makes an angle of 30° with the vertical, find the actual length of the liquid column along the tube.

(A) 0.0520 m (B) 0.0300 m
(C) 0.1200 m (D) 0.0693 m

9. A cube of side 5 cm has its bottom face fixed. A tangential force of 8×10^4 N applied to the top face causes it to displace by 0.02 mm. Find the rigidity modulus of the material.

(A) 8×10^{10} Nm^{-2} (B) 1.6×10^{11} Nm^{-2}
(C) 8×10^{8} Nm^{-2} (D) 4×10^{10} Nm^{-2}

10. A wire of length 0.8 m and radius 1 mm is twisted through an angle of 0.05 radian. If the rigidity modulus of the wire is 8×10^{10} Nm^{-2}, find the required torque.

(A) 7.85×10^{-5} N · m (B) 7.85×10^{-3} N · m
(C) 3.93×10^{-3} N · m (D) 1.57×10^{-2} N · m

11. A spring-mass system has m = 0.50 kg and k = 200 Nm^{-1}. If mass is increased by 20% and k is decreased by 20%, how many times does the new period become?

(A) 1.020 (B) 1.500 (C) 1.225 (D) 1.091

12. In vacuum (external pressure negligible), two soap bubbles of radii 3 cm and 4 cm combine to form a single bubble. Find the radius of the new bubble.

(A) 5.00 cm (B) 7.00 cm
(C) 3.50 cm (D) 4.50 cm

13. For $x = 7\cos(3\pi t + \pi/4)$ cm, at what first positive time are the magnitudes of velocity and acceleration equal?

(A) 0.0721 s (B) 0.0417 s
(C) 0.125 s (D) 0.0938 s

14. A wire has longitudinal strain 0.002 and Poisson's ratio 0.25. Find the fractional change in volume ($\Delta V / V$). [Formula: $\Delta V / V$ = (longitudinal strain)$(1 - 2\sigma)$]

(A) 5×10^{-4} (B) 1×10^{-3}
(C) 1.5×10^{-3} (D) 2×10^{-3}

15. A narrow frictionless tunnel is made along the diameter through the centre of a uniform sphere of density 6800 kgm^{-3}. What is the oscillation period of a particle moving inside it? Take G = 6.67×10^{-11} Nm^{2}kg^{-2}.

(A) 77.8 min (B) 71.9 min
(C) 76.0 min (D) 74.0 min

16. 8 water droplets, each of radius 1 mm, merge to form one large drop. Find the amount of heat released. (Surface tension = 7.2×10^{-2} Nm^{-1})

(A) 9.05×10^{-7} J (B) 1.81×10^{-6} J
(C) 7.24×10^{-6} J (D) 3.62×10^{-6} J

17. Two capillary tubes of diameter 4 mm and 7 mm are partly dipped vertically in a vessel of water. Find the difference in the heights to which water rises in the two tubes. (Surface tension of water = 7.5×10^{-2} Nm^{-1}, angle of contact = 8°)

(A) 1.19×10^{-2} m (B) 3.25×10^{-3} m
(C) 6.50×10^{-3} m (D) 1.625×10^{-3} m

18. How much work is needed to increase the radius of a water drop from 1 cm to 2 cm? (Surface tension = $7.2 \times 10^{-2}\ \text{Nm}^{-1}$; consider only one free surface)

(A) $2.71 \times 10^{-4}\ \text{J}$ (B) $1.36 \times 10^{-4}\ \text{J}$

(C) $5.43 \times 10^{-4}\ \text{J}$ (D) $1.36 \times 10^{-3}\ \text{J}$

19. For $x = A \sin \omega t$, what is the change in displacement from $t = T/12$ to $t = 5T/12$?

(A) $+\frac{\sqrt{3}}{2}A$ (B) 0

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

20. An air bubble of radius 1 mm rises upward through water (density $1000\ \text{kgm}^{-3}$, viscosity 1.0 Pa s). Taking the density of air as $1.2\ \text{kgm}^{-3}$ (negligible), find the magnitude of the bubble's velocity.

(A) $2.18 \times 10^{-1}\ \text{ms}^{-1}$ (B) $4.35 \times 10^{-3}\ \text{ms}^{-1}$

(C) $2.18 \times 10^{-3}\ \text{ms}^{-1}$ (D) $1.09 \times 10^{-3}\ \text{ms}^{-1}$

21. The same liquid flows through two tubes of equal length under the same pressure difference. If the radii are in ratio $r_1 : r_2 = 1 : 2$, find the ratio of flow rates ($Q_1 : Q_2$).

(A) 1:8 (B) 1:4 (C) 16:1 (D) 1:16

22. A steel wire of length 2 m and diameter 1 mm stretches by 1.2 mm when a force of 200 N is applied. Find the Young's modulus of the wire.

(A) $2.12 \times 10^{11}\ \text{Nm}^{-2}$ (B) $4.24 \times 10^{11}\ \text{Nm}^{-2}$

(C) $2.12 \times 10^{9}\ \text{Nm}^{-2}$ (D) $1.06 \times 10^{11}\ \text{Nm}^{-2}$

23. Two identical wires, each of length 1.2 m and diameter 1 mm, support a total load of 400 N in parallel, each stretching equally by 0.5 mm. Find the Young's modulus of the wire material.

(A) $1.22 \times 10^{12}\ \text{Nm}^{-2}$ (B) $6.11 \times 10^{11}\ \text{Nm}^{-2}$

(C) $3.06 \times 10^{11}\ \text{Nm}^{-2}$ (D) $6.11 \times 10^{9}\ \text{Nm}^{-2}$

24. According to Poiseuille's equation, if the radius of the tube is doubled while everything else remains unchanged, by what factor does the flow rate (Q) increase?

(A) 8 times (B) 2 times

(C) 16 times (D) 4 times

25. Two wires of different materials, each 5 m long and 3 mm in diameter, are joined in series to form a composite wire. What force must be applied so that the total elongation is 0.5 mm? ($Y_1 = 2 \times 10^{11}\ \text{Nm}^{-2}$, $Y_2 = 5 \times 10^{11}\ \text{Nm}^{-2}$)

(A) 202 N (B) 35.3 N (C) 50.5 N (D) 101 N

26. A rod of diameter 5 cm projects horizontally 6.3 cm from a wall. When a 1500 kg mass is hung from its free end, find the vertical deflection at the end of the rod. (Young's modulus = $4.5 \times 10^{10}\ \text{Nm}^{-2}$)

(A) $8.87 \times 10^{-5}\ \text{m}$ (B) $1.77 \times 10^{-4}\ \text{m}$

(C) $8.87 \times 10^{-4}\ \text{m}$ (D) $4.44 \times 10^{-5}\ \text{m}$

27. For an SHM with $v_{max} = 8\ \text{ms}^{-1}$ and $a_{max} = 32\ \text{ms}^{-2}$, find acceleration magnitude and speed at $x = A/2$.

(A) $16\ \text{ms}^{-2}, 4\sqrt{3}\ \text{ms}^{-1}$ (B) $32\ \text{ms}^{-2}, 4\sqrt{3}\ \text{ms}^{-1}$

(C) $8\ \text{ms}^{-2}, 4\sqrt{3}\ \text{ms}^{-1}$ (D) $16\ \text{ms}^{-2}, 4\ \text{ms}^{-1}$

28. A particle has $x = 4\cos(5t)$ cm. After passing $x = 2$ cm, what is the minimum time to reach $x = -2$ cm next?

(A) $\frac{\pi}{5}$ s (B) $\frac{\pi}{10}$ s

(C) $\frac{\pi}{15}$ s (D) $\frac{2\pi}{15}$ s

29. In an SHM, the potential energy is 2 J at $x = A/\sqrt{3}$. What is the maximum kinetic energy?

(A) 3 J (B) $2\sqrt{3}$ J (C) 4 J (D) 6 J

30. A glass tube of length l and radius r is dipped into soap water. When taken out, a soap film is found stretched across its upper end. If the surface tension of the soap solution is T, find the force exerted by the film at the upper end of the tube.

(A) $4\pi rT$ (B) $8\pi rT$

(C) $\pi r^2 T$ (D) $2\pi rT$

31. A particle follows $x = A\cos \omega t$. For $T = 1.2$ s, how long after $t = 0$ does it first reach $x = -A/2$ while its velocity is negative?

(A) 0.80 s (B) 0.40 s (C) 0.20 s (D) 1.00 s

32. In an SHM, speed is $3\ \text{ms}^{-1}$ at $x = A/2$. What is the speed at $x = A/\sqrt{2}$?

(A) $1.5\ \text{ms}^{-1}$ (B) $\frac{3}{2}\ \text{ms}^{-1}$

(C) $\sqrt{6}\ \text{ms}^{-1}$ (D) $3\sqrt{2}\ \text{ms}^{-1}$

33. In an SHM, how much of one period is required to move in the same direction from $x = A/2$ to $x = A/\sqrt{2}$?

(A) $\frac{1}{8}$ (B) $\frac{1}{6}$ (C) $\frac{1}{12}$ (D) $\frac{1}{24}$

34. 64 water droplets, each of radius 3×10^{-7} m, coalesce to form one large drop. Find the diameter of the large drop.

(A) $2.4 \times 10^{-6}\ \text{m}$ (B) $1.92 \times 10^{-5}\ \text{m}$

(C) $4.8 \times 10^{-6}\ \text{m}$ (D) $1.2 \times 10^{-6}\ \text{m}$

35. A steel ball of radius 1 mm (density $7800\ \text{kgm}^{-3}$) falls through an oil of density $900\ \text{kgm}^{-3}$ and viscosity 0.99 Pa s. Find its terminal velocity.

(A) $0.76 \times 10^{-2}\ \text{ms}^{-1}$ (B) $1.52 \times 10^{-2}\ \text{ms}^{-1}$

(C) $3.04 \times 10^{-2}\ \text{ms}^{-1}$ (D) $1.52 \times 10^{-4}\ \text{ms}^{-1}$

36. Water rises to a height of 5 cm in a certain capillary tube. If the radius of the tube is doubled for the same liquid (everything else unchanged), find the new height.

(A) 10 cm (B) 1.25 cm

(C) 2.5 cm (D) 5 cm

37. In an SHM, the particle's speed is 0.8 times the maximum speed. What fraction of the total energy is kinetic?

Ⓐ 0.16 Ⓑ 0.36 Ⓒ 0.64 Ⓓ 0.80

38. A pendulum has period 2.00 s. If g decreases by 1% at a mountain, with length unchanged, what is the new period?

Ⓐ 1.990 s Ⓑ 2.020 s

Ⓒ 2.100 s Ⓓ 2.010 s

39. A pendulum has $L = 1.44$ m and small-angle period 2.4 s. Find g.

Ⓐ $9.87\ \text{ms}^{-2}$ Ⓑ $10.00\ \text{ms}^{-2}$

Ⓒ $9.60\ \text{ms}^{-2}$ Ⓓ $9.42\ \text{ms}^{-2}$

40. A spring constant is increased by 44% while the mass remains unchanged. By what percentage does the period decrease?

Ⓐ 30.56% Ⓑ 16.67%

Ⓒ 44% Ⓓ 20%

41. In an SHM, the kinetic energy is 3.0 J when $x = A/2$. What is the total mechanical energy?

Ⓐ 6.0 J Ⓑ 3.5 J Ⓒ 4.0 J Ⓓ 12.0 J

42. A wire has diameter 2 mm and breaking stress $3.6 \times 10^8\ \text{Nm}^{-2}$. Find the maximum load it can bear before breaking.

Ⓐ 565.5 N Ⓑ 2262 N

Ⓒ 282.7 N Ⓓ 1131 N

43. In an SHM, speed is $4\ \text{ms}^{-1}$ at $x = 3$ cm and $3\ \text{ms}^{-1}$ at $x = 4$ cm. Find the amplitude.

Ⓐ 6 cm Ⓑ 5 cm Ⓒ 4 cm Ⓓ 7 cm

44. A particle follows $x = A\cos(\omega t + \pi/6)$. At $t = 0$, what are speed/v_{max} and $|a|/a_{max}$?

Ⓐ $\frac{\sqrt{3}}{2}, \frac{1}{2}$ Ⓑ $\frac{1}{2}, \frac{1}{2}$

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

45. A seconds pendulum clock loses 15 s in 5 h when taken to the top of a mountain. Taking Earth's radius as 6400 km, find the mountain's height.

Ⓐ 10.67 km Ⓑ 2.67 km

Ⓒ 8.00 km Ⓓ 5.33 km

46. A spring has $k = 250\ \text{Nm}^{-1}$ and $m = 0.40$ kg, oscillating with $A = 0.08$ m. At $x = 0.04$ m, what is the difference between K and U?

Ⓐ 0.40 J Ⓑ 0.60 J Ⓒ 0.80 J Ⓓ 0.20 J

47. A soap bubble has radius 3 cm and surface tension $3 \times 10^{-2}\ \text{Nm}^{-1}$. Find the total surface energy of the bubble (both surfaces).

Ⓐ 1.36×10^{-3} J Ⓑ 6.79×10^{-4} J

Ⓒ 2.26×10^{-4} J Ⓓ 3.39×10^{-4} J

48. A wire's length increases from 2 m to 2.004 m, and its diameter decreases from 2 mm to 1.9988 mm. Find the Poisson's ratio of the wire's material.

Ⓐ 0.6 Ⓑ 0.15 Ⓒ 3.33 Ⓓ 0.3

49. A pendulum has length 80 cm and measured period 1.8 s. Using the measured period, what is the effective g?

Ⓐ $9.75\ \text{ms}^{-2}$ Ⓑ $9.88\ \text{ms}^{-2}$

Ⓒ $10.20\ \text{ms}^{-2}$ Ⓓ $9.65\ \text{ms}^{-2}$

50. A wire has Young's modulus $2 \times 10^{11}\ \text{Nm}^{-2}$ and its maximum elastic-limit strain is 0.0015. Find the maximum stress it can bear at the elastic limit.

Ⓐ $3 \times 10^6\ \text{Nm}^{-2}$ Ⓑ $3 \times 10^8\ \text{Nm}^{-2}$

Ⓒ $1.5 \times 10^8\ \text{Nm}^{-2}$ Ⓓ $6 \times 10^8\ \text{Nm}^{-2}$