MCQ 50 marks

1. A. 5:2

Explanation: $\Delta L = \frac{FL}{AY}$

Here, $\frac{\Delta L_1}{\Delta L_2} = \frac{A_2}{A_1} = \frac{5}{2}$

Therefore, the ratio is 5 : 2.

2. B. 2:3

Explanation: $F = \frac{Y A \Delta L}{L}$

Since ΔL, L, Y are equal for both wires, $\frac{F_1}{F_2} = \frac{A_1}{A_2} = \frac{2}{3}$

Therefore, the ratio is 2 : 3.

3. C. 0.64

Explanation: For the same T, $\frac{L}{g}$ must remain constant

Therefore, $\frac{L'}{L} = \frac{g'}{g} = 0.64$

4. D. $6.047\ ms^{-1}$

Explanation: $v^2 = \omega^2(A^2 - x^2)$

Subtracting the two equations, $\omega^2 \approx 12857.14$

Then, $25 = \omega^2(A^2 - 0.0009)$ gives $A \approx 0.05333$ m

Therefore, $v_{max} = \omega A \approx 6.047\ ms^{-1}$

5. A. $\frac{\sqrt{8}}{3}$

Explanation: Using $v^2 = \omega^2(A^2 - x^2)$ and $v = \frac{\omega A}{3}$

$\frac{x^2}{A^2} = 1 - \frac{1}{9} = \frac{8}{9}$

Hence, $\frac{|x|}{A} = \frac{\sqrt{8}}{3}$

6. B. $0.251\ ms^{-1}$

Explanation: $v = \omega\sqrt{A^2 - x^2}$, with $\omega = \pi\ rads^{-1}$

Here, A = 0.10 m, x = 0.06 m

Therefore, $v = \pi\sqrt{0.10^2 - 0.06^2} \approx 0.251\ ms^{-1}$

7. C. 110.25%

Explanation: $T \propto \sqrt{L}$

Here, $\frac{T'}{T} = 1.45 = \sqrt{\frac{L'}{L}}$

So, $\frac{L'}{L} = 1.45^2 = 2.1025$

Thus the length must increase by 110.25%

8. D. 0.0693 m

Explanation: Vertical height, $h = l\cos\alpha$ (α measured from the vertical)

So, $l = \frac{h}{\cos\alpha} = \frac{0.06}{\cos 30^\circ}$

Therefore, $l \approx 0.0693$ m

9. A. $8 \times 10^{10}\ Nm^{-2}$

Explanation: $\eta = \frac{FL}{Ax}$

Here, $A = (0.05)^2 = 2.5 \times 10^{-3}\ m^2$, L = 0.05 m, $x = 2 \times 10^{-5}$ m

So, $\eta = \frac{8 \times 10^4 \times 0.05}{2.5 \times 10^{-3} \times 2 \times 10^{-5}} = 8 \times 10^{10}\ Nm^{-2}$

10. B. $7.85 \times 10^{-3}\ N \cdot m$

Explanation: $\tau = \frac{\pi \eta r^4 \theta}{2L}$

Here, $\eta = 8 \times 10^{10}\ Nm^{-2}$, $r = 1 \times 10^{-3}$ m, $\theta = 0.05$, L = 0.8 m

So, $\tau = \frac{\pi \times 8 \times 10^{10} \times (10^{-3})^4 \times 0.05}{2 \times 0.8} \approx 7.85 \times 10^{-3}\ N \cdot m$

11. C. 1.225

Explanation: $T = 2\pi\sqrt{\frac{m}{k}}$

So, $\frac{T'}{T} = \sqrt{\frac{1.20}{0.80}} = \sqrt{1.5}$

Hence, $\frac{T'}{T} \approx 1.225$

12. D. 4.50 cm

Explanation: Since volume is conserved, $R^3 = r_1^3 + r_2^3$

Here, $R^3 = 27 + 64 = 91$

So, $R = 91^{1/3} \approx 4.50$ cm

13. A. 0.0721 s

Explanation: $|v| = 21\pi|\sin\theta|$ and $|a| = 63\pi^2|\cos\theta|$

Equating them, $\tan\theta = 3\pi$, with $\theta = 3\pi t + \pi/4$

Therefore, $t = \frac{\theta - \pi/4}{3\pi} \approx 0.0721$ s

14. B. 1×10^{-3}

Explanation: $\frac{\Delta V}{V}$ = (longitudinal strain)$(1 - 2\sigma)$

Here, $\frac{\Delta V}{V} = 0.002 \times (1 - 2 \times 0.25) = 0.002 \times 0.5$

So, $\frac{\Delta V}{V} = 1 \times 10^{-3}$

15. C. 76.0 min

Explanation: Inside a uniform sphere, $g(r) = \frac{4\pi G\rho r}{3}$

So, $\omega^2 = \frac{4\pi G\rho}{3}$

Hence, $T = \frac{2\pi}{\omega} \approx 4558\,s \approx 76.0\,min$

16. D. 3.62×10^{-6} J

Explanation: $n = 8$, $R = n^{1/3}r = 2r$

Heat released $= T \times 4\pi r^2(n - n^{2/3})$

So, $= 7.2 \times 10^{-2} \times 4\pi \times (10^{-3})^2 \times (8 - 4) \approx 3.62 \times 10^{-6}$ J

17. B. 3.25×10^{-3} m

Explanation: $h = \frac{2T\cos\theta}{r\rho g}$

$r_1 = 2 \times 10^{-3}$ m $\Rightarrow h_1 \approx 7.58 \times 10^{-3}$ m; $r_2 = 3.5 \times 10^{-3}$ m $\Rightarrow h_2 \approx 4.33 \times 10^{-3}$ m

So, $\Delta h = h_1 - h_2 \approx 3.25 \times 10^{-3}$ m

18. A. 2.71×10^{-4} J

Explanation: An ordinary drop has only one free surface, $W = T \times 4\pi(R^2 - r^2)$

So, $W = 7.2 \times 10^{-2} \times 4\pi \times ((0.02)^2 - (0.01)^2)$

Therefore, $W \approx 2.71 \times 10^{-4}$ J

19. B. 0

Explanation: First, $x_1 = A\sin\left(\frac{\pi}{6}\right) = \frac{A}{2}$

Later, $x_2 = A\sin\left(\frac{5\pi}{6}\right) = \frac{A}{2}$

Hence, $\Delta x = x_2 - x_1 = 0$

20. C. 2.18×10^{-3} ms^{-1}

Explanation: Since $\rho_{bubble} < \rho_{water}$, the net force is upward

$|v| = \frac{2}{9}r^2(\rho_{liquid} - \rho_{air})\frac{g}{\eta}$

So, $|v| = \frac{2}{9} \times (10^{-3})^2 \times (1000 - 1.2) \times \frac{9.8}{1.0} \approx 2.18 \times 10^{-3}$ ms^{-1}

21. D. 1:16

Explanation: By Poiseuille's equation, $Q \propto r^4$

So, $\frac{Q_1}{Q_2} = \left(\frac{r_1}{r_2}\right)^4 = \left(\frac{1}{2}\right)^4 = \frac{1}{16}$

Hence, the ratio is 1 : 16

22. B. 4.24×10^{11} Nm^{-2}

Explanation: $Y = \dfrac{FL}{A\Delta L}$

$A = \pi(0.5 \times 10^{-3})^2 = 7.854 \times 10^{-7}$ m^2

$Y = \dfrac{200 \times 2}{7.854 \times 10^{-7} \times 1.2 \times 10^{-3}} \approx 4.24 \times 10^{11}$ Nm^{-2}

23. B. 6.11×10^{11} Nm^{-2}

Explanation: Since the wires are identical, each carries half the load: $F_{each} = 200$ N

$A = \pi(0.5 \times 10^{-3})^2 = 7.854 \times 10^{-7}$ m^2

So, $Y = \frac{F_{each}L}{A\Delta L} = \frac{200 \times 1.2}{7.854 \times 10^{-7} \times 0.5 \times 10^{-3}} \approx 6.11 \times 10^{11}$ Nm^{-2}

24. C. 16 times

Explanation: $Q \propto r^4$

So, doubling the radius increases Q by a factor of $2^4 = 16$

25. D. 101 N

Explanation: In series, both wires carry the same force F, and total elongation $\Delta L = \frac{FL}{A}\left(\frac{1}{Y_1} + \frac{1}{Y_2}\right)$

$A = \pi(1.5 \times 10^{-3})^2 = 7.07 \times 10^{-6}$ m^2, $\frac{1}{Y_1} + \frac{1}{Y_2} = 7 \times 10^{-12}$

So, $F = \frac{\Delta L \cdot A}{L \times 7 \times 10^{-12}} \approx 101$ N

26. A. 8.87×10^{-5} m

Explanation: For a cantilever rod, deflection $\delta = \frac{FL^3}{3YI}$, where $I = \frac{\pi r^4}{4}$

With $r = 0.025$ m, $I \approx 3.07 \times 10^{-7}$ m^4; $F = 1500 \times 9.8 = 14700$ N, $L = 0.063$ m

So, $\delta = \frac{14700 \times 0.063^3}{3 \times 4.5 \times 10^{10} \times 3.07 \times 10^{-7}} \approx 8.87 \times 10^{-5}$ m

27. A. $16\,ms^{-2}$, $4\sqrt{3}\,ms^{-1}$

Explanation: $a = a_{max}\left(\frac{x}{A}\right) = 32 \times \frac{1}{2} = 16\,ms^{-2}$

$v = v_{max}\sqrt{1 - \frac{1}{4}} = 8 \times \frac{\sqrt{3}}{2}$

So, $v = 4\sqrt{3}\,ms^{-1}$

28. C. $\frac{\pi}{15}$ s

Explanation: $x = 2 \Rightarrow \theta = \frac{\pi}{3}$ on the forward branch

$x = -2 \Rightarrow \theta = \frac{2\pi}{3}$, so $\Delta\theta = \frac{\pi}{3}$

Thus, $\Delta t = \frac{\pi}{15}$ s

29. D. 6 J

Explanation: $\frac{U}{E} = \frac{x^2}{A^2} = \frac{1}{3}$

So, $E = \frac{2}{1/3} = 6$ J

At the mean position, $K_{max} = E = 6$ J

30. A. $4\pi rT$

Explanation: A soap film has two free surfaces, each with circumference $2\pi r$

Total force = surface tension × total edge length = $T \times 2 \times (2\pi r)$

So, force = $4\pi rT$ (the length l of the tube does not enter this calculation - it is irrelevant data)

31. B. 0.40 s

Explanation: $x = -A/2 \Rightarrow \cos \omega t = -\frac{1}{2}$

The first suitable phase with negative velocity is $\frac{2\pi}{3}$

Thus, $t = \frac{T}{3} = 0.40\,s$

32. C. $\sqrt{6}\,ms^{-1}$

Explanation: $v^2 = \omega^2(A^2 - x^2)$; at the first position $v_1^2 = \frac{3}{4}\omega^2 A^2 = 9$

At $x = A/\sqrt{2}$, $v_2^2 = \frac{1}{2}\omega^2 A^2$, so $\frac{v_2}{v_1} = \sqrt{\frac{2}{3}}$

Hence, $v_2 = 3\sqrt{\frac{2}{3}} = \sqrt{6} \approx 2.45\,ms^{-1}$

33. D. $\frac{1}{24}$

Explanation: $\theta_1 = \frac{\pi}{3}$ and $\theta_2 = \frac{\pi}{4}$

Moving in the same direction, $\Delta\theta = \frac{\pi}{12}$

So, $\frac{\Delta t}{T} = \frac{\Delta\theta}{2\pi} = \frac{1}{24}$

34. A. 2.4×10^{-6} m

Explanation: $n = 64$, $n^{1/3} = 4$

$R = 4r = 4 \times 3 \times 10^{-7} = 1.2 \times 10^{-6}$ m

So, diameter $D = 2R = 2.4 \times 10^{-6}$ m

35. B. $1.52 \times 10^{-2}\,ms^{-1}$

Explanation: $v = \frac{2}{9}r^2(\rho_{ball} - \rho_{liquid})\frac{g}{\eta}$

So, $v = \frac{2}{9} \times (10^{-3})^2 \times (7800 - 900) \times \frac{9.8}{0.99}$

Therefore, $v \approx 1.52 \times 10^{-2}\,ms^{-1}$

36. C. 2.5 cm

Explanation: $h \propto \frac{1}{r}$

So, doubling the radius halves the height

Hence, new $h = \frac{5}{2} = 2.5$ cm

37. C. 0.64

Explanation: $\frac{K}{E} = \frac{v^2}{v_{max}^2}$

So, $\frac{K}{E} = (0.8)^2 = 0.64$

38. D. 2.010 s

Explanation: $T \propto \frac{1}{\sqrt{g}}$

So, $\frac{T'}{T} = \frac{1}{\sqrt{0.99}} \approx 1.00504$

Hence, $T' \approx 2.010$ s

39. A. $9.87\,ms^{-2}$

Explanation: $g = \frac{4\pi^2 L}{T^2}$

So, $g = \frac{4\pi^2 \times 1.44}{2.4^2}$

Therefore, $g \approx 9.87\,ms^{-2}$

40. B. 16.67%

Explanation: $T \propto \frac{1}{\sqrt{k}}$

So, $\frac{T'}{T} = \frac{1}{\sqrt{1.44}} = \frac{5}{6}$

Hence, the decrease is $(1 - \frac{5}{6}) \times 100 = 16.67\%$

41. C. 4.0 J

Explanation: $\frac{U}{E} = \frac{x^2}{A^2} = \frac{1}{4}$

So, $\frac{K}{E} = \frac{3}{4}$

Hence, $E = \frac{3}{3/4} = 4$ J

42. D. 1131 N

Explanation: F_{max} = stress × A

Here, $A = \pi(1 \times 10^{-3})^2$

So, $F_{max} = 3.6 \times 10^8 \times \pi \times (10^{-3})^2 \approx 1131$ N

43. B. 5 cm

Explanation: From $v_1^2 - v_2^2 = \omega^2(x_2^2 - x_1^2)$, $\omega^2 = 10000$

Then, $16 = 10000(A^2 - 0.0009)$, giving $A^2 = 0.0025$

Hence, A = 5 cm

44. C. $\frac{1}{2}, \frac{\sqrt{3}}{2}$

Explanation: $\theta = \frac{\pi}{6}$

$\frac{|v|}{v_{max}} = |\sin\theta| = \frac{1}{2}$

and $\frac{|a|}{a_{max}} = |\cos\theta| = \frac{\sqrt{3}}{2}$

45. D. 5.33 km

Explanation: The fractional period increase is $\frac{15}{5 \times 3600} = \frac{1}{1200}$

For small h, $\frac{\Delta T}{T} \approx \frac{h}{R}$

So, $h = \frac{6400}{1200} \approx 5.33$ km

46. A. 0.40 J

Explanation: $E = \frac{1}{2}kA^2 = 0.8$ J

$U = \frac{1}{2}kx^2 = 0.2$ J, so $K = 0.6$ J

Therefore, $K - U = 0.40$ J

47. B. 6.79×10^{-4} J

Explanation: A soap bubble has two surfaces, so $E = 2T \times 4\pi r^2$

So, $E = 2 \times 3 \times 10^{-2} \times 4\pi \times (0.03)^2$

Therefore, $E \approx 6.79 \times 10^{-4}$ J

48. D. 0.3

Explanation: Longitudinal strain = $\frac{0.004}{2}$ = 0.002

Lateral strain = $\frac{0.0012}{2}$ = 0.0006

So, $\sigma = \frac{0.0006}{0.002} = 0.3$

49. A. $9.75\,ms^{-2}$

Explanation: $g = \frac{4\pi^2 L}{T^2}$

Here, L = 0.80 m, T = 1.8 s

So, $g = \frac{4\pi^2 \times 0.80}{1.8^2} \approx 9.75\,ms^{-2}$

50. B. $3 \times 10^8\,Nm^{-2}$

Explanation: Stress = Y × strain

So, stress = $2 \times 10^{11} \times 0.0015$

Therefore, stress = $3 \times 10^8\,Nm^{-2}$