MCQ 50 marks

1. C. 0.111%

Explanation: $\frac{\Delta T}{T} = \frac{2}{3600} = \frac{1}{1800}$

Since $T \propto \sqrt{L}$, $\frac{\Delta L}{L} \approx 2\frac{\Delta T}{T}$

$\frac{\Delta L}{L} = \frac{1}{900} = 0.111\%$

2. D. 0.0196 m

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

$h_1 = \frac{2\times7.2\times10^{-2}}{0.3\times10^{-3}\times1000\times9.8} \approx 0.0490\,\text{m}$

$h_2 = \frac{2\times7.2\times10^{-2}}{0.5\times10^{-3}\times1000\times9.8} \approx 0.0294\,\text{m}$

Difference $= 0.0490 - 0.0294 = 0.0196\,\text{m}$

3. A. $\approx 10.56\%$

Explanation: $E \propto A^2$

$\frac{A'}{A} = \sqrt{0.80} \approx 0.8944$

Decrease $\approx 10.56\%$

4. B. 1.69×10^{-3} m

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

$r = \sqrt{\frac{9\times0.5\times0.02}{2\times9.8\times1600}}$

$r \approx 1.69 \times 10^{-3}\,\text{m}$

5. C. 3 : 1

Explanation: By Stokes' law $v \propto \frac{1}{\eta}$

$\frac{v_1}{v_2} = \frac{\eta_2}{\eta_1} = 3$

Ratio = 3 : 1

6. D. 2×10^{10} Pa

Explanation: $B = \frac{\Delta P}{\Delta V/V}$

$B = \frac{2\times10^6}{0.01/100}$

$B = 2 \times 10^{10}\,\text{Pa}$

7. D. 3.26×10^{-5} J

Explanation: $n = 1000$, $n^{1/3} = 10$

$W = T \times 4\pi R^2(n^{1/3} - 1)$

$W = 7.2 \times 10^{-2} \times 4\pi \times (2 \times 10^{-3})^2 \times 9 \approx 3.26 \times 10^{-5}\,\text{J}$

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

Explanation: $E = \frac{1}{2}m\omega^2A^2 \Rightarrow \omega = \sqrt{\frac{2E}{mA^2}}$

$\omega = \sqrt{\frac{2\times0.18}{0.20\times0.12^2}} \approx 11.18\,\text{rads}^{-1}$

$v_{max} = \omega A \approx 1.342\,\text{ms}^{-1}$

9. A. 1 : 4

Explanation: By Stokes' law $v \propto r^2$

$\frac{v_1}{v_2} = \left(\frac{r_1}{r_2}\right)^2 = \frac{1}{4}$

Ratio = 1 : 4

10. B. 10%

Explanation: $\frac{T'}{T} = \sqrt{1.21} = 1.10$

Increase = 10%

11. D. $3\sqrt{3}$ cm, $\frac{3}{4}$

Explanation: $\frac{v^2}{v_{max}^2} = 1 - \frac{x^2}{A^2} = \frac{1}{4}$

$\frac{x^2}{A^2} = \frac{3}{4}$

$|x| = 3\sqrt{3}$ cm, $\frac{U}{E} = \frac{3}{4}$

12. A. 3.75 J

Explanation: At $x = \frac{A}{2}$: $K = E\left(1 - \frac{1}{4}\right) = 9\,\text{J}$

At $x = \frac{3A}{4}$: $K = E\left(1 - \frac{9}{16}\right) = 5.25\,\text{J}$

Decrease $= 9 - 5.25 = 3.75\,\text{J}$

13. B. 75 : 4

Explanation: $\Delta L = \frac{FL}{\pi r^2 Y}$

$\frac{\Delta L_1}{\Delta L_2} = \frac{L_1}{L_2} \times \left(\frac{r_2}{r_1}\right)^2 = \frac{3}{4} \times 25 = \frac{75}{4}$

Ratio = 75 : 4

14. C. $-2.524\,\text{ms}^{-2}$, 0.0263 J

Explanation: At $\theta = 5t = 1$ rad, $x \approx 0.1010\,\text{m}$

$a = -\omega^2 x \approx -2.524\,\text{ms}^{-2}$

$v \approx 0.3242\,\text{ms}^{-1}$, $K = \frac{1}{2}mv^2 \approx 0.0263\,\text{J}$

15. C. 9.82×10^{-5} Pa · s

Explanation: $\eta = \frac{\pi\Delta P r^4}{8QL}$

$\eta = \frac{\pi\times1200\times(0.5\times10^{-3})^4}{8\times2\times10^{-6}\times0.15}$

$\eta \approx 9.82 \times 10^{-5}\,\text{Pa}\cdot\text{s}$

16. A. $3\sqrt{3}\,\text{ms}^{-1}$

Explanation: $v = v_{max}\sqrt{1 - \frac{x^2}{A^2}}$

$v = 6\sqrt{1 - \frac{1}{4}} = 6\sqrt{\frac{3}{4}}$

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

17. B. 0.40 m, $5.03\,\text{ms}^{-1}$

Explanation: Distance in one cycle $= 4A = 1.6\,\text{m}$

$A = 0.40\,\text{m}$

$\omega = \frac{2\pi}{T} = 4\pi$, $v_{max} = \omega A \approx 5.03\,\text{ms}^{-1}$

18. D. $x = 5\,\text{cm},\ v = 0$

Explanation: $\theta = 2\left(\frac{\pi}{12}\right) + \frac{\pi}{3} = \frac{\pi}{2}$

$x = 5\sin\frac{\pi}{2} = 5\,\text{cm}$

$v = 10\cos\frac{\pi}{2} = 0$

19. A. $2.67 \times 10^{12}\,\text{dynecm}^{-2}$

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

$\eta = \frac{4\times10^{10}\times3}{9\times0.005}$

$\eta \approx 2.67 \times 10^{12}\,\text{dynecm}^{-2}$

20. B. $\approx 1782\,\text{s}$

Explanation: $\frac{T'}{T} = \sqrt{0.96}$

Gain fraction $= \frac{1}{\sqrt{0.96}} - 1 \approx 0.02062$

Gain $\approx 86400 \times 0.02062 \approx 1782\,\text{s}$

21. C. $9.82 \times 10^{-7}\,\text{m}^3\text{s}^{-1}$

Explanation: $Q = \frac{\pi\Delta P r^4}{8\eta L}$

$Q = \frac{\pi\times500\times(10^{-3})^4}{8\times10^{-3}\times0.2}$

$Q \approx 9.82 \times 10^{-7}\,\text{m}^3\text{s}^{-1}$

22. D. 4 times

Explanation: $v \propto r^2$

Doubling the radius increases v by $2^2 = 4$ times

23. C. $0.10\,\text{s}$

Explanation: $x = A\cos\theta = \frac{A}{\sqrt{2}} \Rightarrow \theta = \frac{\pi}{4}$

Mean position at $\theta = \frac{\pi}{2}$, so $\Delta\theta = \frac{\pi}{4}$

$\Delta t = \frac{T}{8} = 0.10\,\text{s}$

24. A. $0.80\,\text{ms}^{-1}$

Explanation: Distance $= A = 0.04\,\text{m}$

Time $= \frac{T}{4} = \frac{1}{4\times5} = 0.05\,\text{s}$

Average speed $= \frac{0.04}{0.05} = 0.80\,\text{ms}^{-1}$

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

Explanation: $\theta = 4\pi\left(\frac{1}{12}\right) - \frac{\pi}{6} = \frac{\pi}{6}$

$x = 0.20\cos\frac{\pi}{6} = 0.10\sqrt{3}\,\text{m}$

$v = -0.4\pi\,\text{ms}^{-1}$

26. D. $\frac{T}{\sqrt{2}}$

Explanation: For parallel springs, $k_{eq} = k_1 + k_2$ and $T = 2\pi\sqrt{\frac{m}{k_{eq}}}$

Doubling k_{eq} gives $T' = \frac{T}{\sqrt{2}}$

27. B. 1 : 1

Explanation: By Stokes' law, $F = 6\pi\eta r v$

$\frac{F_1}{F_2} = \frac{r_1 v_1}{r_2 v_2} = \frac{2\times3}{3\times2} = 1$

Ratio = 1 : 1

28. A. 10000 **(turbulent)**

Explanation: $\text{Re} = \frac{\rho v d}{\eta}$

$\text{Re} = \frac{1000\times0.5\times0.02}{1\times10^{-3}} = 10000$

Since Re exceeds the critical value, the flow is turbulent

29. C. $33.2\,\text{N}$

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

$A = \pi(0.4 \times 10^{-3})^2 \approx 5.027 \times 10^{-7}\,\text{m}^2$

$F = \frac{1.1\times10^{11}\times5.027\times10^{-7}\times0.9\times10^{-3}}{1.5} \approx 33.2\,\text{N}$

30. D. $0.80\,\text{m},\ 5\,\text{rads}^{-1}$

Explanation: $\omega = \frac{a_{max}}{v_{max}} = \frac{20}{4} = 5\,\text{rads}^{-1}$

$A = \frac{v_{max}}{\omega} = \frac{4}{5} = 0.80\,\text{m}$

31. C. $998.6\,\text{kgm}^{-3}$

Explanation: $K = 4.96 \times 10^{-11}\,\text{Pa}^{-1}$

$\Delta P = \rho g h \approx 7.86 \times 10^7\,\text{Pa}$

$\rho_0 = \rho(1 - K\Delta P) \approx 998.6\,\text{kgm}^{-3}$

32. A. $2\sqrt{2}\,\text{ms}^{-1}$

Explanation: $v = \frac{v_{max}}{\sqrt{2}}$ at $x = \frac{A}{\sqrt{2}}$

$v_{max} = v\sqrt{2} = 2\sqrt{2}\,\text{ms}^{-1}$

33. B. 2 : 3 **and** 3 : 2

Explanation: $T \propto \sqrt{L}$ gives $T_1 : T_2 = 2 : 3$

Frequency is inversely proportional to period

$f_1 : f_2 = 3 : 2$

34. C. $9 \times 10^4\,\text{Jm}^{-3}$

Explanation: $u = \frac{(\text{stress})^2}{2Y}$

$u = \frac{(1.5\times10^8)^2}{2\times1.25\times10^{11}}$

$u = 9 \times 10^4\,\text{Jm}^{-3}$

35. D. $15.65\,\text{rads}^{-1}$**; no**

Explanation: $mg = kx_{eq} \Rightarrow \frac{k}{m} = \frac{g}{x_{eq}} = \frac{9.8}{0.04} = 245\,\text{s}^{-2}$

$\omega = \sqrt{245} \approx 15.65\,\text{rads}^{-1}$

For ideal SHM, ω does not depend on amplitude, so no

36. A. $1.63 \times 10^{-3}\,\text{J}$

Explanation: A soap bubble has two surfaces

$W = 2T \times 4\pi(R^2 - r^2)$

$W = 2 \times 2.7 \times 10^{-2} \times 4\pi \times (0.05^2 - 0.01^2) \approx 1.63 \times 10^{-3}\,\text{J}$

37. B. 0.128 J

Explanation: $E = \frac{1}{2}kA^2 = 0.20\,J$

$U = \frac{1}{2}kx^2 = 0.072\,J$

$K = E - U = 0.128\,J$

38. C. $g_{eff} = 9.615\,ms^{-2},\ T \approx 2.04\,s$

Explanation: The buoyant force reduces the effective acceleration

$g_{eff} \approx 9.615\,ms^{-2}$

For the seconds pendulum, $L = \frac{g}{\pi^2} \approx 1.013\,m$

$T = 2\pi\sqrt{\frac{L}{g_{eff}}} \approx 2.04\,s$

39. D. ≈ 0.722

Explanation: $f \propto \sqrt{\frac{k}{m}}$

$\frac{f'}{f} = \sqrt{\frac{0.75}{1.44}}$

$\frac{f'}{f} \approx 0.722$

40. B. 0.476 m

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

$h = \frac{2\times3.5\times10^{-2}\times\cos 26^\circ}{3\times10^{-5}\times450\times9.8}$

$h \approx 0.476\,m$

41. A. 1.50 s

Explanation: $x = A\cos\theta$ and $v > 0$ gives initial $\theta = \frac{5\pi}{3}\left(= -\frac{\pi}{3}\right)$

Next, at $x = -\frac{A}{2}$, $\Delta\theta = \pi$

$\Delta t = \frac{T}{2} = 1.5\,s$

42. D. 60 Pa

Explanation: $\Delta P_1 = \frac{4T}{r_1} = 100\,Pa$

$\Delta P_2 = \frac{4T}{r_2} = 40\,Pa$

Difference $= 100 - 40 = 60\,Pa$

43. A. $0.32\,Pa\cdot s$

Explanation: $v = \frac{0.4}{7} \approx 0.0571\,ms^{-1}$

$\rho_{ball} = \frac{m}{V} \approx 2292\,kgm^{-3}$

$\eta = \frac{2r^2(\rho_{ball}-\rho_{liquid})g}{9v} \approx 0.32\,Pa\cdot s$

44. B. $1.0\,ms^{-1},\ \frac{\pi}{2}\,s$

Explanation: $a = -\omega^2 x \Rightarrow \omega = 4\,rads^{-1}$

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

$T = \frac{2\pi}{\omega} = \frac{\pi}{2}\,s$

45. C. 1.2 rad

Explanation: $\omega = \frac{2\pi}{T} = 4\,rads^{-1}$

$\Delta\varphi = \omega t = 4\times0.30$

$\Delta\varphi = 1.2\,rad$

46. D. 3×10^{-4}

Explanation: Strain $= \frac{F/A}{Y}$

Strain $= \frac{150/1\times10^{-6}}{5\times10^{11}}$

Strain $= 3\times10^{-4}$

47. A. 1 : 2

Explanation: Air bubble in liquid (one surface): $\Delta P = \frac{2T}{r}$

Soap bubble in air (two surfaces): $\Delta P = \frac{4T}{r}$

Ratio = 1 : 2

48. B. 2.2

Explanation: Longitudinal strain $= \frac{0.02}{1} = 0.02$

Lateral strain $= \frac{0.022}{0.5} = 0.044$

Poisson's ratio $= \frac{0.044}{0.02} = 2.2$

49. C. $2\times10^{-3}\,Pa\cdot s$

Explanation: $F = \eta A\frac{dv}{dx}$

$\eta = \frac{F\cdot dx}{A\cdot dv} = \frac{0.02\times0.002}{0.05\times0.4}$

$\eta = 2\times10^{-3}\,Pa\cdot s$

50. D. $7.54\times10^{-4}\,J$

Explanation: $W = 2T\times4\pi(R^2 - r^2)$

$W = 2\times2.5\times10^{-2}\times4\pi\times(0.04^2 - 0.02^2)$

$W \approx 7.54\times10^{-4}\,J$