MCQ 50 marks

1. **D.** 14 g
Explanation: Here, $n_{O_2} = \frac{16}{32} = 0.5$ mol
At constant V and T, $P \propto n$, so an equal number of moles must be added to double the total pressure, i.e. $n_{N_2} = 0.5$ mol
Therefore, $m = 0.5 \times 28 = 14$ g

2. **A.** 3.66×10^5 Pa
Explanation: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$, where $T_1 = 273$ K and $T_2 = 333$ K
So, $P_2 = 3 \times 10^5 \times \frac{333}{273}$
Therefore, $P_2 = 3.66 \times 10^5$ Pa

3. **C.** 433.00 K
Explanation: Here, $n = \frac{20}{4} = 5$ mol, $V = 0.12\ m^3$, $P = 1.5 \times 10^5\ Nm^{-2}$
So, $T = \frac{PV}{nR}$
Therefore, $T = \frac{1.5\times10^5\times0.12}{5\times8.314} = \frac{18000}{41.57} = 433.00$ K

4. **B.** 24.57 gm^{-3}
Explanation: The actual vapour density is $f = RH \times F$
Here, $f_1 = 0.75 \times 45 = 33.75\ gm^{-3}$
Again, $f_2 = 0.54 \times 17 = 9.18\ gm^{-3}$
Therefore, vapour condensed $= f_1 - f_2 = 24.57\ gm^{-3}$
33.75 and 9.18 are the initial and final densities, not the condensed amount.

5. **A. Wet bulb reading** 16.73°C **and relative humidity 45.62%**
Explanation: By Glaisher's formula, $11.5 = 24 - 1.72(24 - \theta_2)$
So, $24 - \theta_2 = \frac{12.5}{1.72} = 7.267$, hence $\theta_2 = 16.73$°C
Again, the vapour pressure at 11.5°C is $f = 9.90 \times 10^{-3} + (10.52 - 9.90) \times 10^{-3} \times 0.5 = 10.21 \times 10^{-3}$ m Hg
Therefore, $R = \frac{f}{F} \times 100 = \frac{10.21\times10^{-3}}{22.38\times10^{-3}} \times 100 =$ 45.62 percent

6. **C. Absolute zero is** −273°C
Explanation: By Charles's law, $\Delta V = V_0\gamma_p\theta$
So, $\gamma_p = \frac{\Delta V}{V_0\theta} = \frac{1\times10^{-3}}{4\times10^{-3}\times68.25} = \frac{1}{273}\ °C^{-1}$
Therefore, absolute zero $= -\frac{1}{\gamma_p} = -273$°C

7. **D. The volume will increase by 59.6%**
Explanation: Here, $T_2 = 300$ K, $T_1 = 273 + (27 - 6 \times 0.5) = 297$ K, $P_2 = 1.013 \times 10^5$ Pa
Again, $P_1 = P_a + h\varrho g = 1.013 \times 10^5 + 6 \times 1000 \times 9.8 = 1.601 \times 10^5$ Pa
So, $\frac{V_2}{V_1} = \frac{P_1T_2}{P_2T_1} = \frac{1.601\times10^5\times300}{1.013\times10^5\times297} = 1.596$
Therefore, the volume change $= (1.596 - 1) \times 100 = 59.6$ percent increase

8. **B. 3.93% of the air will escape**
Explanation: The volume and pressure are fixed, so the number of moles of air $n \propto \frac{1}{T}$ (the room dimensions are not needed)
Here, $T_1 = 293$ K, $T_2 = 305$ K
So, the fraction escaping $= \frac{n_1 - n_2}{n_1} = 1 - \frac{T_1}{T_2} = \frac{12}{305}$
Therefore, $\frac{12}{305} \times 100 = 3.93$ percent
4.10 percent is $\frac{12}{293}$, which is relative to the remaining air, not the initial air.

9. **D. Number of oxygen molecules** 2.733×10^{22}
Explanation: Here, $n_{total} = \frac{PV}{RT} = \frac{1\times5.5}{0.0821\times310} = 0.2161$ mol
So, $n_{O_2} = 0.21 \times 0.2161 = 0.04538$ mol
Therefore, $N_{O_2} = 0.04538 \times 6.023 \times 10^{23} = 2.733 \times 10^{22}$

10. **A.** 29.93 kJ
Explanation: By the equipartition principle, $E_k = \frac{f}{2}nRT$
Here, $f = 6$, $n = 4$ mol, $T = 300$ K
So, $E_k = 3 \times 4 \times 8.314 \times 300 = 29930.4$ J
Therefore, $E_k = 29.93$ kJ

11. **C.** 380.4 J, 0.003 m^3
Explanation: Work done by the gas, $W_{gas} = \int_{V_1}^{V_2} P\ dV = \int_{0.001}^{0.003} (4 \times 10^5 - 5 \times 10^7 V)\ dV$
$= 4 \times 10^5(0.002) - \frac{5 \times 10^7}{2}\left(0.003^2 - 0.001^2\right)$
$= 800 - 200 = 600$ J
Displacement of the piston, $h = \frac{\Delta V}{A} =$

$\frac{0.002}{0.02} = 0.1$ m

Work against the atmosphere = $P_{atm}\Delta V$ = $10^5 \times 0.002 = 200$ J

Work against gravity = $mgh = 20 \times 9.8 \times 0.1 = 19.6$ J

$W_{net} = 600 - 200 - 19.6 = 380.4$ J

Net force on the piston, $F_{net} = (P - P_{atm})A - mg$

Even at $V = 0.003$ m^3, $P = 2.5 \times 10^5$ Pa, so $F_{net} = (1.5 \times 10^5)(0.02) - 196 = 2804$ N > 0

Hence the piston keeps accelerating over the whole range and its speed is maximum at the end, $V = 0.003$ m^3

12. **C.** 3.97 gm^{-3}

Explanation: Here, $f_1 = 0.70 \times 31.8 = 22.26$ mm Hg $= 2967.75$ Pa

So, $\varrho_1 = \frac{f_1 M}{RT_1} = \frac{2967.75 \times 0.018}{8.314 \times 303} = 21.21$ gm^{-3}

Again, $F_2 = 17.5$ mm Hg $= 2333.14$ Pa, so $\varrho_2 = \frac{2333.14 \times 0.018}{8.314 \times 293} = 17.24$ gm^{-3}

Therefore, condensed mass $= \varrho_1 - \varrho_2 = 3.97$ gm^{-3}

13. **B.** 433.01 ms^{-1}

Explanation: $T = \frac{PV}{nR} = \frac{P_0(V - \beta V^2)}{nR}$

For maximum T, $\frac{dT}{dV} = \frac{P_0}{nR}(1 - 2\beta V) = 0$, so $V = \frac{1}{2\beta}$

Here, $T_{max} = \frac{P_0}{4nR\beta} = \frac{1.0 \times 10^5}{4 \times 8.314 \times 100} = 30.07$ K

Therefore, $c_{rms,max} = \sqrt{\frac{3RT_{max}}{M}} = \sqrt{\frac{3 \times 8.314 \times 30.07}{4 \times 10^{-3}}} = \sqrt{187500} = 433.01$ ms^{-1}

14. **D. Pressure ratio** 1.252 **and pressure gradient** 2.810×10^5 Pam^{-1}

Explanation: On rotation, $\frac{dP}{dr} = \frac{M\omega^2 r}{RT}P$, so $P(r) = P_0 e^{\frac{M\omega^2 r^2}{2RT}}$

Here, $\frac{M\omega^2 R_0^2}{2RT} = \frac{28 \times 10^{-3} \times 10^6 \times 0.04}{2 \times 8.314 \times 300} = 0.2245$

So, $\frac{P(R_0)}{P_0} = e^{0.2245} = 1.252$ and $P(R_0) = 1.252 \times 10^5$ Pa

Therefore, $\frac{dP}{dr}\Big|_{R_0} = P(R_0)\frac{M\omega^2 R_0}{RT} = 1.252 \times 10^5 \times \frac{5600}{2494.2} = 2.810 \times 10^5$ Pam^{-1}

15. **A.** $\sqrt{3} : \sqrt{\frac{8}{\pi}} : \sqrt{2}$**; remain unchanged**

Explanation: $c_{rms} : c_{avg} : c_{mp} = \sqrt{\frac{3RT}{M}} : \sqrt{\frac{8RT}{\pi M}} : \sqrt{\frac{2RT}{M}} = \sqrt{3} : \sqrt{\frac{8}{\pi}} : \sqrt{2} \approx 1.225 : 1.128 : 1$

In an isothermal process T is constant and the kinetic energy $E_k = \frac{f}{2}nRT$ depends only on T

Therefore, the kinetic energy and the speed ratio remain unchanged

16. **C.** $P = \text{const} \Rightarrow \lambda \propto T$**;** $V = \text{const} \Rightarrow \lambda = \text{const}$

Explanation: $\lambda = \frac{1}{\sqrt{2}\pi\sigma^2 n_V} = \frac{kT}{\sqrt{2}\pi\sigma^2 P}$

At constant P, $\lambda \propto T$

Again, at constant V, $n_V = \frac{N}{V}$ stays constant

Therefore, λ does not depend on temperature

17. **C.** $c_{rms} = 500.00$ ms^{-1}**,** $c_{avg} = 460.66$ ms^{-1}**,** $c_{mp} = 408.25$ ms^{-1}

Explanation: $c_{rms} = \sqrt{\frac{3P}{\varrho}} = \sqrt{\frac{3 \times 10^5}{1.2}} = 500.00$ ms^{-1}

Again, $c_{avg} = \sqrt{\frac{8P}{\pi\varrho}} = \sqrt{\frac{8 \times 10^5}{3.1416 \times 1.2}} = 460.66$ ms^{-1}

Therefore, $c_{mp} = \sqrt{\frac{2P}{\varrho}} = \sqrt{\frac{2 \times 10^5}{1.2}} = 408.25$ ms^{-1}

18. **B. Collisions are perfectly inelastic**

Explanation: In the kinetic theory postulates, collisions between molecules are perfectly elastic

So, the total momentum and total kinetic energy are conserved in a collision

Therefore, the statement that collisions are perfectly inelastic is incorrect

19. **D.** 177°C **(**450 K**)**

Explanation: The volume is fixed, so $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Here, $P_1 = 20$ atm, $T_1 = 300$ K, $P_2 = 30$ atm

So, $T_2 = 300 \times \frac{30}{20} = 450$ K

Therefore, $t_2 = 450 - 273 = 177$°C

20. **B.** 160 kPa

Explanation: Let the mass of each gas be m, so $n_1 = \frac{m}{28}$ and $n_2 = \frac{m}{32}$

So, $x_{N_2} = \frac{n_1}{n_1 + n_2} = \frac{\frac{1}{28}}{\frac{1}{28} + \frac{1}{32}} = \frac{32}{60} = \frac{8}{15}$

Therefore, $P_{N_2} = \frac{8}{15} \times 300 = 160$ kPa

21. **D.** nRT

Explanation: $PV = nRT$ can be written as $P = (nRT) \times \frac{1}{V}$

This is a line of the form $y = mx$ with $y = P$ and $x = \frac{1}{V}$

Therefore, the slope = nRT

22. **C. 100%**

Explanation: The dew point is the temperature at which the vapour present just saturates the air

Here, 15°C is the dew point of this air

So, the air is saturated at that temperature

Therefore, the relative humidity is 100 percent

23. **A.** 7.15×10^{-11} s

Explanation: Molecular diameter $d = 3.7 \times 10^{-10}$ m, $P = 2.0 \times 10^5$ Pa, $T = 300$ K (temperature constant)

Mean free path, $\lambda = \frac{kT}{\sqrt{2}\pi d^2 P} = \frac{1.38 \times 10^{-23} \times 300}{\sqrt{2}\pi(3.7 \times 10^{-10})^2(2.0 \times 10^5)} \approx 3.403 \times 10^{-8}$ m

Mean speed, $\bar{c} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8 \times 8.314 \times 300}{\pi \times 0.028}} \approx 476.27$ m s^{-1} (the mean speed $\bar{c}$, not c_{rms}, is used here)

$\tau = \frac{\lambda}{\bar{c}} = \frac{3.403 \times 10^{-8}}{476.27} \approx 7.15 \times 10^{-11}$ s

24. **A.** 151.95 J

Explanation: Translational kinetic energy, $E_k = \frac{3}{2}nRT = \frac{3}{2}PV$

Here, $P = 1.013 \times 10^5$ Pa, $V = 1 \times 10^{-3}$ m^3

Therefore, $E_k = 1.5 \times 1.013 \times 10^5 \times 10^{-3} = 151.95$ J

25. **A.** $M_X = 128$ gmol^{-1}, $\frac{c_{rms,X}}{c_{rms,O_2}} = 0.5$

Explanation: By Graham's law, $\frac{r_X}{r_{O_2}} = \sqrt{\frac{M_{O_2}}{M_X}} = 0.5$

So, $\frac{32}{M_X} = 0.25$, hence $M_X = 128$ gmol^{-1}

Again, $c_{rms} \propto \frac{1}{\sqrt{M}}$

Therefore, $\frac{c_{rms,X}}{c_{rms,O_2}} = \sqrt{\frac{32}{128}} = 0.5$

26. **C.** 722.22 Hz

Explanation: Take the direction towards the cliff as positive; the wind blows towards the train

Here, the effective speed of sound towards the cliff is $v_1 = 330 - 30 = 300$ ms^{-1} and on the return path $v_2 = 330 + 30 = 360$ ms^{-1}

So, the frequency incident on the cliff is $f_1 = 600 \times \frac{300}{300-30} = 666.67$ Hz

Again, the driver moves towards the cliff at 30 ms^{-1}, so $f_2 = f_1 \times \frac{360+30}{360}$

Therefore, $f_2 = 722.22$ Hz

Reversing the wind direction would give 720 Hz, which does not apply here.

27. **B.** 340 ms^{-1}**,** 0.01 m

Explanation: Here, $\frac{\lambda}{2} = L_2 - L_1 = 0.50 - 0.16 = 0.34$ m, so $\lambda = 0.68$ m

So, $v = f\lambda = 500 \times 0.68 = 340$ ms^{-1}

Again, $L_1 + e = \frac{\lambda}{4} = 0.17$ m

Therefore, $e = 0.17 - 0.16 = 0.01$ m

28. **D.** 42.7°C

Explanation: Let the speed of sound at the required temperature be v

Given, $\frac{v}{400} - \frac{v}{408} = 0.0175$

Or, $v = \frac{0.0175 \times 400 \times 408}{8} = 357$ ms^{-1}

Again, $\frac{v}{v_0} = \sqrt{\frac{T}{273}}$, so $T = 273 \times (\frac{357}{332})^2 = 315.7$ K

Therefore, $t = 315.7 - 273 \approx 42.7$°C

29. **A.** 2.67 m

Explanation: Let the distance from S_1 be y; the path difference is $\Delta r = \sqrt{y^2 + 25} - y$, which decreases as y increases

For destructive interference, $\Delta r = (2n - 1)\frac{\lambda}{2} = 1, 3, 5$ m and $\Delta r < 5$ m for $y > 0$

For the minimum y, take the largest possible $\Delta r = 3$ m

So, $\sqrt{y^2 + 25} = y + 3$, or $25 = 6y + 9$

Therefore, $y = \frac{16}{6} = 2.67$ m

$\Delta r = 1$ m gives $y = 12$ m, which is not the minimum.

30. **B.** 3 Hz**,** 49

Explanation: Here, $f_1 = \frac{500\pi}{2\pi} = 250$ Hz and $f_2 = \frac{506\pi}{2\pi} = 253$ Hz

So, the beat frequency = $253 - 250 = 3$ Hz

Again, $A_{max} = 0.04 + 0.03 = 0.07$ m and

$A_{min} = 0.04 - 0.03 = 0.01$ m
Therefore, $\frac{I_{max}}{I_{min}} = (\frac{0.07}{0.01})^2 = 49$

31. **D.** 100 Hz
Explanation: Here, the effective length is $L_{eff} = 0.85 + 0.02 = 0.87$ m, so $\lambda = 4 \times 0.87 = 3.48$ m
Again, $v_{27} = 332\sqrt{\frac{300}{273}} = 348\ ms^{-1}$
Therefore, $f = \frac{v_{27}}{\lambda} = \frac{348}{3.48} = 100$ Hz

32. **A.** 87.89 dB
Explanation: Here, $I_1 = 10^{-4}\ Wm^{-2}$, $I_2 = 1.995 \times 10^{-4}\ Wm^{-2}$, $I_3 = 3.162 \times 10^{-4}\ Wm^{-2}$
So, $I_{total} = 6.157 \times 10^{-4}\ Wm^{-2}$
Therefore, $\beta = 10 \log_{10} \frac{6.157 \times 10^{-4}}{10^{-12}} = 87.89$ dB
Intensity levels cannot be added directly, so 248 dB is wrong.

33. **C.** 0.05 m**,** 0.05 m**,** 180°
Explanation: Here, $\sqrt{\mu_1} = 0.1$ and $\sqrt{\mu_2} = 0.3$
Reflected amplitude, $A_r = \left|\frac{\sqrt{\mu_1} - \sqrt{\mu_2}}{\sqrt{\mu_1} + \sqrt{\mu_2}}\right| A_i = \frac{0.2}{0.4} \times 0.10 = 0.05$ m
Transmitted amplitude, $A_t = \frac{2\sqrt{\mu_1}}{\sqrt{\mu_1} + \sqrt{\mu_2}} A_i = \frac{0.2}{0.4} \times 0.10 = 0.05$ m
Therefore, reflection from the denser medium causes a phase change of 180°

34. **B.** 101.342 kHz**,** 1342 Hz
Explanation: The frequency incident on the cliff is $f_1 = f\frac{v}{v-u}$
The echo frequency is $f_2 = f_1\frac{v+u}{v} = f\frac{v+u}{v-u}$
Here, $f_2 = 100 \times \frac{1500+10}{1500-10} = 101.342$ kHz
Therefore, the beat frequency = 101342 − 100000 = 1342 Hz

35. **D.** 10 cm**,** 53.13°
Explanation: $y_2 = 8\cos(100\pi t) = 8\sin(100\pi t + \frac{\pi}{2})$, so the phase difference is $\phi = 90°$
So, $A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi} = \sqrt{6^2 + 8^2} = 10$ cm
Again, $\tan\delta = \frac{A_2\sin\phi}{A_1 + A_2\cos\phi} = \frac{8}{6}$
Therefore, $\delta = 53.13°$
36.87° results from taking $\tan\delta = \frac{6}{8}$, which is wrong.

36. **A.** 3 cm**,** 10 cm
Explanation: Here, $k = \frac{2\pi}{\lambda} = \frac{\pi}{3}$, so $\lambda = 6$ cm
So, the distance between nodes = $\frac{\lambda}{2} = 3$ cm
Again, $A(x) = 10\sin(\frac{\pi x}{3})$
Therefore, at x = 1.5 cm, $A = 10\sin(\frac{\pi}{2}) = 10$ cm

37. **C.** 261 Hz
Explanation: Here, $f_A = 256 \pm 5 = 261$ Hz or 251 Hz
Wax lowers the frequency of A
Since the beats decreased from 5 to 3, f_A moved closer to f_B, so $f_A > f_B$
Therefore, $f_A = 261$ Hz
If f_A were 251 Hz, lowering it would have increased the beats.

38. **D.** 66.02 dB**,** 0.20
Explanation: Intensity follows the inverse square law: $I_2 = I_1(\frac{r_1}{r_2})^2 = 10^{-4} \times \frac{1}{25} = 4 \times 10^{-6}\ Wm^{-2}$
So, $\beta = 10\log_{10}\frac{4 \times 10^{-6}}{10^{-12}} = 10\log_{10}(4 \times 10^6) = 66.02$ dB
Again, amplitude $\propto \frac{1}{r}$
Therefore, $\frac{A_2}{A_1} = \frac{r_1}{r_2} = \frac{4}{20} = 0.20$

39. **C.** 100 Hz**,** 0.25 m**,** 6.28 ms^{-1}
Explanation: Here, $m = \frac{0.02}{2} = 0.01\ kgm^{-1}$, so $v = \sqrt{\frac{100}{0.01}} = 100\ ms^{-1}$
In the 4th harmonic, $\lambda_4 = \frac{2L}{4} = 1$ m, so $f_4 = \frac{100}{1} = 100$ Hz
So, the node to antinode distance = $\frac{\lambda_4}{4} = 0.25$ m
Therefore, $v_{p,max} = A\omega = 0.01 \times 2\pi \times 100 = 2\pi = 6.28\ ms^{-1}$

40. **A.** 104 Hz**,** 100 dB
Explanation: Here, $v_1 = \sqrt{\frac{100}{0.01}} = 100\ ms^{-1}$, so $f_1 = \frac{v_1}{2L} = 100$ Hz
So, $f_A = 100 \pm 4 = 104$ Hz or 96 Hz
Again, with $T_2 = 1.1664T_1$, $f_2 = 100\sqrt{1.1664} = 108$ Hz
For 4 beats, $|108 - f_A| = 4$, so $f_A = 104$ Hz (with 96 Hz there would be 12 beats)
Here, $I = \frac{P}{4\pi r^2} = \frac{12.566}{4\pi \times 100} = 10^{-2}\ Wm^{-2}$
Therefore, $\beta = 10\log_{10}\frac{10^{-2}}{10^{-12}} = 100$ dB

41. **C.** $9.6\pi\,\text{ms}^{-1}$, $1152\pi^2\,\text{ms}^{-2}$, $30\,\text{ms}^{-1}$, $27.648\pi^2\,\text{W}$
Explanation: Comparing, $A = 0.08\,\text{m}$, $\omega = 120\pi\,\text{rads}^{-1}$, $k = 4\pi\,\text{radm}^{-1}$
So, $v_{p,max} = A\omega = 0.08 \times 120\pi = 9.6\pi\,\text{ms}^{-1}$
Again, $a_{p,max} = A\omega^2 = 0.08 \times (120\pi)^2 = 1152\pi^2\,\text{ms}^{-2}$ and $v = \frac{\omega}{k} = 30\,\text{ms}^{-1}$
Therefore, $P_{avg} = \frac{1}{2}mv\omega^2A^2 = \frac{1}{2}(0.02)(30)(120\pi)^2(0.08)^2 = 27.648\pi^2\,\text{W}$

42. **B.** $10\,\text{Hz}$, $-2.0\,\text{cm}$
Explanation: Here, $f_o = \frac{v}{2L_o} = \frac{336}{1.6} = 210\,\text{Hz}$ and $f_c = \frac{v}{4L_c} = \frac{336}{1.68} = 200\,\text{Hz}$
So, the beat frequency $N = 210 - 200 = 10\,\text{Hz}$
Again, for resonance, $L_c' = \frac{v}{4f_o} = \frac{336}{840} = 0.40\,\text{m} = 40.0\,\text{cm}$
Therefore, $\Delta L_c = 40.0 - 42.0 = -2.0\,\text{cm}$ (it must be decreased)

43. **D.** $1.0\,\text{m}$, $0.5\,\text{m}$, $5\pi\,\text{ms}^{-1}$, $0.5\pi^2\,\text{J}$
Explanation: Here, $k = \pi$, so $\lambda = 2.0\,\text{m}$
So, $d = \frac{\lambda}{2} = 1.0\,\text{m}$ and $b = \frac{\lambda}{4} = 0.5\,\text{m}$
Again, $v_p = \frac{\partial y}{\partial t} = -5\pi\sin(\pi x)\sin(50\pi t)$, so at $x = 0.5\,\text{m}$, $v_{p,max} = 5\pi\sin(0.5\pi) = 5\pi\,\text{ms}^{-1}$
Therefore, $E = \int_0^2 \frac{1}{2}m\,(5\pi\sin\pi x)^2\,dx = 0.5\pi^2\int_0^2 \sin^2(\pi x)\,dx = 0.5\pi^2 \times 1 = 0.5\pi^2\,\text{J}$

44. **B.** $408\,\text{ms}^{-1}$
Explanation: The fundamental frequency of an open pipe is $f = \frac{v}{2L}$
Given, $f_1 - f_2 = \frac{v}{2}(\frac{1}{1.0} - \frac{1}{1.02}) = 4$
Or, $\frac{v}{2} \times \frac{0.02}{1.02} = 4$
Therefore, $v = \frac{4\times2\times1.02}{0.02} = 408\,\text{ms}^{-1}$

45. **A.** $87.77\,\text{dB}$, $81.75\,\text{dB}$, $0.362\,\text{Nm}^{-2}$
Explanation: Here, $I_1 = I_2 = 10^{-4}\,\text{Wm}^{-2}$ and $I_3 = 10^{-12} \times 10^{8.6} = 3.981 \times 10^{-4}\,\text{Wm}^{-2}$
So, $I_{total} = 5.981 \times 10^{-4}\,\text{Wm}^{-2}$, hence $\beta_{total} = 10\log_{10}(5.981 \times 10^8) = 87.77\,\text{dB}$
Again, doubling the distance gives $I' = \frac{I_{total}}{4} = 1.495 \times 10^{-4}\,\text{Wm}^{-2}$, so $\beta_{new} = 87.77 - 6.02 = 81.75\,\text{dB}$
Therefore, $P_{max} = \sqrt{2I'\varrho v} = \sqrt{2 \times 1.495 \times 10^{-4} \times 1.29 \times 340} = 0.362\,\text{Nm}^{-2}$
$0.256\,\text{Nm}^{-2}$ is the root mean square pressure $\sqrt{I'\varrho v}$, not the amplitude.

46. **C.** 2.0, $89.21\,\text{Hz}$
Explanation: $f = \frac{1}{2L}\sqrt{\frac{T}{\varrho\pi r^2}}$, so $\frac{f_A}{f_B} = \frac{L_B}{L_A}\sqrt{\frac{T_A}{T_B} \cdot \frac{\varrho_B}{\varrho_A} \cdot \frac{r_B^2}{r_A^2}} = 2\sqrt{2 \times 2 \times \frac{1}{4}} = 2.0$
Again, $m_A = \varrho_A\pi r_A^2 = 8000 \times \pi \times (10^{-3})^2 = 0.02513\,\text{kgm}^{-1}$
So, $v_A = \sqrt{\frac{200}{0.02513}} = 89.21\,\text{ms}^{-1}$
Therefore, $f_A = \frac{v_A}{2L_A} = \frac{89.21}{1.0} = 89.21\,\text{Hz}$

47. **D.** $337.92\,\text{ms}^{-1}$, $0.015\,\text{m}$, $0.81\,\text{m}$, $0.158\,\text{m}$
Explanation: Here, $\frac{\lambda}{2} = L_2 - L_1 = 0.33\,\text{m}$, so $\lambda = 0.66\,\text{m}$ and $v = f\lambda = 512 \times 0.66 = 337.92\,\text{ms}^{-1}$
So, $e = \frac{\lambda}{4} - L_1 = 0.165 - 0.15 = 0.015\,\text{m}$
Again, $L_3 = \frac{5\lambda}{4} - e = 0.825 - 0.015 = 0.81\,\text{m}$
If the speed rises by 5%, $\lambda' = 1.05 \times 0.66 = 0.693\,\text{m}$
Therefore, $L_1' = \frac{\lambda'}{4} - e = 0.17325 - 0.015 \approx 0.158\,\text{m}$

48. **B.** $0.122\,\text{m}$, $34.72°$, $38.22\,\text{ms}^{-1}$, $12007\,\text{ms}^{-2}$
Explanation: Here, the phase difference is $\phi = 60°$
Resultant amplitude, $A_R = \sqrt{0.06^2 + 0.08^2 + 2(0.06)(0.08)\cos 60°} = \sqrt{0.0148} = 0.122\,\text{m}$
Initial phase, $\tan\delta = \frac{0.08\sin 60°}{0.06+0.08\cos 60°} = \frac{0.0693}{0.10}$, so $\delta = 34.72°$
So, $v_{p,max} = A_R\omega = 0.1217 \times 100\pi = 38.22\,\text{ms}^{-1}$
Therefore, $a_{p,max} = A_R\omega^2 = 0.1217 \times (100\pi)^2 \approx 12007\,\text{ms}^{-2}$

49. **A.** $315\,\text{Hz}$, $6.30 \times 10^{-4}\,\text{kgm}^{-1}$
Explanation: Wax lowers f_A; the beats increased from 5 to 8, so f_A moved further from f_B, i.e. $f_A < f_B$
So, $f_A = 320 - 5 = 315\,\text{Hz}$
Again, from $f_A = \frac{1}{2L}\sqrt{\frac{T}{m}}$, $\sqrt{\frac{T}{m}} = 315 \times 1.6 = 504$
Therefore, $m = \frac{160}{504^2} = 6.30 \times 10^{-4}\,\text{kgm}^{-1}$

50. **C.** $44.72\,\text{m}$, $10^{-3}\,\text{Wm}^{-2}$, $0.937\,\text{Nm}^{-2}$
Explanation: Here, $I = I_0 \times 10^{\beta/10} = 10^{-12} \times 10^9 = 10^{-3}\,\text{Wm}^{-2}$
So, from $I = \frac{P}{4\pi r^2}$, $r_{min} = \sqrt{\frac{8\pi}{4\pi\times10^{-3}}} = \sqrt{2000} = 44.72\,\text{m}$

Therefore, $P_{max} = \sqrt{2I\varrho v} = \sqrt{2 \times 10^{-3} \times 1.29 \times 340} = 0.937\,\mathrm{Nm}^{-2}$

$0.662\,\mathrm{Nm}^{-2}$ is the root mean square pressure $\sqrt{I\varrho v}$, not the amplitude.