I. *Answer all Questions*
II. *There are **five options** for each question, shade the correct option with **HB PENCIL***
III. *Fill in your personal details in the space provided on top of the answer sheet with **HB** Pencil*
IV. ***Shade your Option/Type correctly***
V. ***No cell phones (handset) are allowed in the examination hall***

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1. Two cars moving away from each other with speeds of 18m/s and 15m/s respectively. A whistle of frequency 550Hz is sounded from one of the cars. Find the frequency heard by the driver in the second car (V = 340m/s) (a)558Hz (b)499Hz (c)564Hz (d)200Hz (e)None of the above
2. The equation of motion for a point mass is given by $2\ddot{x} + 3\dot{x} + 5x = 12\cos(20t + \emptyset)$. Calculate its resonance frequency. (a) 1.63rad/s (b) 1.91rad/s (c) 1.17rad/s (d) 4.22rad/s (e) 1.53rad/s
3. A Uniform pipe opened at both ends has length 15cm and a fundamental frequency of 200Hz. If the displacement antinode occur at a distance of 0.5cm from one open end, calculate the velocity of the wave produced. (a) 64 m/s (b) 80 m/s (c) 72 m/s (d) 32 m/s (e) None of the above
4. Which of the following statements are/is true? (i) Optical density is the ability of a material to allow transmission of light (ii) During reflection, there is no total conservation of energy (iii) For a boundary that is infinitely massive of a reflective surface, there is no refraction (iv) Physical optics is the use of straight lines and angles to investigate optical properties (a) i, ii and iii (b) ii, iii and iv (c) i and ii (d) ii and iv (e) ii only
5. A man 1.8m tall, whose eye is 1.6m above the ground looks at his image in a vertical mirror. Calculate the minimum vertical length of the mirror if the man is to see the whole of himself. (a) 0.9m (b) 0.8m (c) 0.7m (d) 0.6m (e) 0.5m
6. The equation of motion for a point mass is given by $2\ddot{x} + 7\dot{x} + 10x = 10\sin(20t + \emptyset)$. Find the mechanical impedance per unit mass. (a) 20.06Ω/kg (b) 19.97 Ω/kg (c) 40.11Ω/kg (d) 59.11Ω/kg (e) $14.84\Omega/kg$
7. A glass material of $\eta = 1.55$ is used to construct a prism such that the minimum deviation is equal to the apex angle. Calculate the apex angle (a) 55.64° (b) 78.38° (c) 63.58° (d) 47.58° (e) 50.64°
8. Two closed pipes having lengths 0.55m and 0.35m respectively; carrying a gas at the same temperature is set into vibrations in their fundamental frequencies. 3 beats per second were heard between them. What is the velocity of sound contained in the pipes. (a) 35.1m/s (b) 42.3m/s (c) 29.4m/s (d) 39.2m/s (e) 16m/s
9. One end of a 2.00kg rope is tied to a support at the top of a mine shaft 80.0m deep. The rope is stretched taut by a 20kg box of rock attached at the bottom. A Scientist at the bottom of the shaft signals to a colleague at the top by jerking the rope sideways. What is the speed of transverse wave on the rope? (a) 44.2 m/s (b) 80.5 m/s (c) 21.5 m/s (d) 89.4 m/s (e) None of the above

10. A guitar string lies along the x-axis when in equilibrium. The end of the string at x=0 is fixed. A sinusoidal wave with frequency F=440Hz travels along the string in the x-direction at 143m/s. What are the 1st three node positions. (a) 0, 0.163m 0.488m (b) 0.163m, 0.325m, 0.488m (c) 0, 0.163m, 0.532m (d) 0.325m, 0.488m, 0.650m (e) 0, 0.163m, 0.325m
11. The world is referred to as a "global village" because signal consisting of data, voice and video can be transmitted using …….. wave in a matter of seconds (a) longitudinal (b) Electromagnetic wave (c) seismic wave (d) shock wave (e) Rayleigh waves
12. The siren of a fire engine has a frequency of 500Hz. If the fire engine approaches a stationary car at 20m/s. what frequency does a person in the car hear? (a) 531Hz (b) 472Hz (c) 529Hz (d) 500Hz (e) 400Hz
13. Which of the following statements are/is true about a concave mirror: (i) image formed with a concave mirror are always virtual, diminished and upright (ii) objects placed between focal length and center of curvature produce images that are real, upright and magnified (iii) objects placed beyond center of curvature produce images that are real, inverted and magnified (iv) objects placed at center of curvature are real, upright and diminished (a) I, ii and iv (b) ii and iv (c)ii and iii (d) I and iv (e) None of the above
14. If refractive index of glass to water is 7:4 and the refractive index of glass to air is 5:3. What is the refractive index of water to air. (a) 15:21 (b) 21:15 (c) 21:25 (d)25:21 (e) None of the above
15. The equation of motion for an harmonic oscillator is given as; $d^2x/dt^2 = -16x$, where x is the displacement and t is time. What type of oscillation is this and what is the period of the oscillation. (a) Damped oscillation and T=1.57secs (b) forced oscillation and T=1.57secs (c) underdamped oscillation and T=1.57secs (d) Critically damped Oscillation and T=1.57secs (e) forced oscillation and T=1.27secs
16. Consider n object placed 20cm from an achromatic objective lens forming a real image 30cm from the lens. If the dispersive power of the two glasses are in the ratio of 2:3, compute the focal length of the individual lenses. (a) -4cm & 6cm (b) 4cm & - 6cm (c) 12cm & -8cm (d) -12cm & 8cm (e) None of the above
17. Suppose the absolute values of the radii of curvature of a double convex lens are both equal and equal to 10cm and the refractive index of the glass is 1.52. What is the focal length of the lens? (a) -906cm (b) +906cm (c) +6.5cm (d) +9.6cm (e) 6.8cm
18. Refractive index of water relative to air is 1.55 and that of oil with respect to air is 1.73. Calculate the refractive index of water with respect to oil (a) 0.90 (b) 0.81 (c) 1.11 (d) 1.12 (e) None of the above
19. A closed pipe has a length of 0.35m. If the air inside the pipe is maintained at a temperature of 27°C, calculate the fundamental frequency and the frequency of the next two overtones (If the velocity of sound in air at 0°C is 350m/s) (a)144Hz, 432Hz, 720Hz (b)247Hz, 741Hz, 1235Hz (c)262Hz, 786Hz, 1310Hz (d) 250Hz, 750Hz, 1250Hz (e) 144Hz, 288Hz, 720Hz
20. A prism has an apex angle of 65° is made of a material with refractive index of 1.75. What is the angle of minimum deviation (a) 86.8° (b) 59.3° (c) 95.4° (d) 107.7° (e) 207.7°
21. Two strings of a guitar are placed such that X is above Y, with both having fundamental frequencies of 300Hz and 450Hz respectively. If they both similar linear densities and length, what is the tension ratio in strings Y to X. (a) 2.82 (b) 2.25 (c) 0.44 (d) 0.35 (e) None of the above
22. A particle executes simple harmonic motion with amplitude A. At what displacement is its kinetic energy 2/5 of its maximum value. (a) $\sqrt{1/5}\,A$ (b) $\sqrt{2/5}\,A$ (c) $\sqrt{3/5}\,A$ (d) $\sqrt{4/5}\,A$ (e)None of the above
23. Which of the following statements are/is true about a convex lens: (i) objects at F have image formed and refracted ray are parallel (ii) object between 2F and F have real, erect and magnified image beyond 2F (iii)

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① $f_o = \left[\frac{V \pm V_o}{V \mp V_s}\right] f_s$

Since they move away from each other

$f_o = \left[\frac{V - V_o}{V + V_s}\right] f_s$

$f_o = \left[\frac{340 - 15}{340 + 18}\right] 550$

$= 499\,Hz$ (B)

② $2\ddot{x} + 3\dot{x} + 5x = 12\cos(2t + \phi)$

$m\ddot{x} + b\dot{x} + kx = F\cos(\omega t + \phi)$

Comparing both equations

$m = 2,\ b = 3,\ k = 5$

$\omega_m = \omega_0\sqrt{1 - \frac{1}{2Q^2}}$

$\omega_0 = \sqrt{\frac{k}{m}} = \sqrt{\frac{5}{2}} = \sqrt{2.5}$

$Q = \frac{\omega_0}{(b/m)} = \frac{\sqrt{2.5}}{(3/2)} = 1.054$

$\omega_m = \sqrt{2.5}\sqrt{1 - \frac{1}{2 \times 1.054^2}}$

$\omega_m = 1.17\,rad/s$ (C)

③ $\frac{\lambda}{2} = L = 15cm = 0.15m$

$\lambda = 0.3m$

$V = f\lambda = 200 \times 0.3$

$V = 60\,m/s$ (E)

④ A

⑤ $L = H_{1/2} = \frac{1.8}{2}$

$= 0.9m$ (B)

⑥ $2\ddot{x} + 7\dot{x} + 10x = 10\sin(2t + \phi)$

$m\ddot{x} + b\dot{x} + kx$

$m = 2,\ b = 7,\ k = 10$

$\omega = 20$

$Z_m^2 = R_m^2 + \left(m\omega - \frac{k}{\omega}\right)^2$

$Z_m^2 = b^2 + \left(m\omega - \frac{k}{\omega}\right)^2$

$Z_m^2 = 7^2 + \left(2 \times 20 - \frac{10}{20}\right)^2$

$Z_m^2 = 1609.25$

$Z_m = 40.11\Omega$ (C)

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(7) $\mu = \frac{\sin i}{\sin r} = \frac{\sin\left(\frac{D_m + A}{2}\right)}{\sin(A/2)}$

given $D_m = A$

$\mu = \frac{\sin(2A/2)}{\sin(A/2)}$

$\mu = \frac{\sin A}{\sin(A/2)}$

but $\sin A = 2\sin(A/2)\cos(A/2)$

$\mu = 2\cos(A/2)$

$1.55 = \cos(A/2) \times 2$

$A = \frac{\cos^{-1}(1.55/2)}{2}$

$A = \frac{\cos^{-1}(1.55/2) \times 2}{2}$

$A = 63.58°$ // (C)

(8) For closed pipe

$f = v/4L$

$f_{beat} = f_1 - f_2 = 3$

$\frac{v}{4\times0.55} - \frac{v}{4\times0.35} = 3$

$v = 35.1 m/s$ (A)

(9) $v = \sqrt{\frac{T}{\mu}}$

$\mu = \frac{m}{L} = \frac{2}{80} = 0.025$

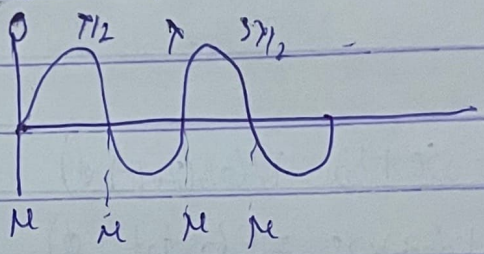
$T = mg = 20 \times 9.8 = 196 N$

$v = \sqrt{\frac{196}{0.025}} = 88.58 m/s$

(E)

(10) Node positions occur at

$x = 0, \lambda/2, 2\lambda/2, 3\lambda/2$



1. $x = 0$ (fixed end)

2. $x = \lambda/2 = \frac{0.325}{2} = 0.1625$

3. $x = \lambda = 0.325 m$

0, 0.163m, 0.325m //

(11) B

(12) $f_s = 500 Hz$, $v_s = 20 m/s$

$f_o = ?$ $v_o = 0$

$f_o = \left[\frac{v \pm v_o}{v - v_s}\right] f_s = \frac{v}{v - v_s} \times f_s$

$f_o = \frac{343}{343 - 20} \times 500 = 531 Hz$

(A)

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(13) (B)

(14) $g\mu_w = 7:4 = 7/4$

$g\mu_a = 5:3 = 5/3$

$w\mu_a = ?$

$w\mu_a = w\mu_g \times g\mu_a$

$= \frac{1}{g\mu_w} \times g\mu_a$

$= \frac{1}{7/4} \times 5/3$

$= 5/3 \times 4/7$

$= 20:21$ (B)

(15) $\frac{d^2x}{dt^2} = -16x$

$\frac{d^2x}{dt^2} + 16x = 0$

$\frac{d^2x}{dt^2} + \omega^2 x = 0$

$\omega^2 = 16, \omega = 4$

$\omega = 2\pi/T, T = \frac{2\pi}{4} = \pi/2$

$T = 1.57$ secs (C)

(16) $v = 20$cm [real object]

$u = 30$cm [real image]

$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$\frac{1}{f} = \frac{1}{30} + \frac{1}{20}$

$\frac{1}{f} = 60/5 = 12$cm

$\frac{\omega_1}{\omega_2} = \frac{2}{3}$ / $\omega_1 = 2$, $\omega_2 = 3$

$\frac{f_1}{\omega_1} = \frac{f_2}{\omega_2} = f$

$\frac{f_1}{2} = \frac{f_2}{3} = 12$

$P_1 = 2 \times 12/3 \times 2 = 8$cm (I)

$P_2 = 3 \times 12/3 \times 3$

$P_2 = -12$cm (I) (D)

(17) $\frac{1}{F} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

$\frac{1}{f} = (1.52 - 1)\left[\frac{1}{10} - \frac{1}{-10}\right]$

$F = 9.615$ (D)

(18) $w\mu_a = w\mu_a \times \frac{1}{a\mu_a}$

$= 1.55 \times 1.73 = 0.896$

0.9 (A)

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(19) $v = v_0\sqrt{T/T_0}$

$T = 27°C = 300K$

$T_0 = 273K$

$v_0 = 350$

$v = 350\sqrt{\frac{300}{273}}$

$v = 366.8 m/s$

NB: Close pipes have odd harmonics (1, 3, 5 ...)

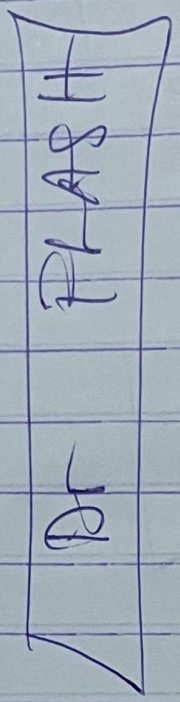
$F_1 = v/4L$

$= 366.8/(4\times0.35)$

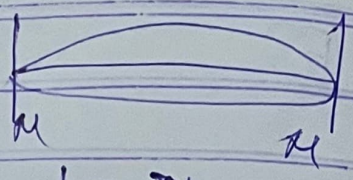
$= 262 Hz$

$F_2 = 3F_1 = 786 Hz$

$F_3 = 5F_1 = 1310 Hz$ (C)



(21)



$L = \lambda/2$, $\lambda = 2L$

$v = \sqrt{\frac{T}{\mu}}$

but $v = f\lambda = 2fL$

$2fL = \sqrt{T/\mu}$

$f = \frac{1}{2L}\sqrt{T/\mu}$

$\mu_x = \mu_y$, $L_x = L_y$

$\therefore f \propto \sqrt{T}$

$\frac{300}{\sqrt{T_x}} = \frac{450}{\sqrt{T_y}}$

$\frac{T_y}{T_x} = 2.25$ (B)

(20) $A = 65°$, $\eta = 1.75$

$D_m = 2i - 2r$

$i = \frac{D_m + 2r}{2}$

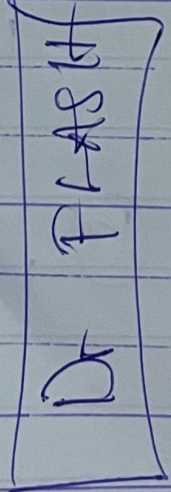
$\eta = \frac{\sin\left(\frac{D_m+2r}{2}\right)}{\sin(A/2)}$

$\eta = \frac{\sin\left(\frac{D_m+A}{2}\right)}{\sin(A/2)}$

$1.75 = \frac{\sin\left(\frac{D_m+65}{2}\right)}{\sin(65/2)}$

$D_m = 75.195°$ //

for Good Check for errors



(22)

$K.E = \frac{1}{2}mv^2$

$\frac{1}{2}mv^2 = \frac{2}{5}\left(\frac{1}{2}mv_{max}^2\right)$

$v^2 = \frac{2}{5}v_{max}^2$

$v_{max} = \omega A$

$v^2 = \frac{2}{5}\omega^2 A^2$

$\left(\omega\sqrt{A^2 - x^2}\right)^2 = 2/5\,\omega^2 A^2$

$A^2 - x^2 = 2A^2/5$

$\frac{7A^2}{5} = x^2$, $x = \sqrt{\frac{7}{5}}A$

(D)