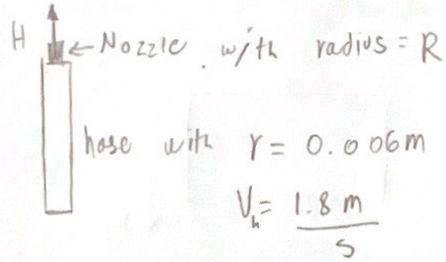
Exam 3 Review Solutions

1.



$H = 2\,m = y_{max}$

@ y_{max}, $V_f = 0$

$a = -9.8 \frac{m}{s^2}$, $\Delta X = H$

$V_f^2 = 0 = (V_{Nozzle})^2 + 2aH$

$-(V_N^2) = 2aH$

$V_N = \sqrt{-2aH}$

$V_N = \sqrt{-2 \cdot -9.8 \frac{m}{s^2} \cdot 2\,m}$

$V_N = 6.26 \frac{m}{s}$

$V_1 A_1 = V_2 A_2$

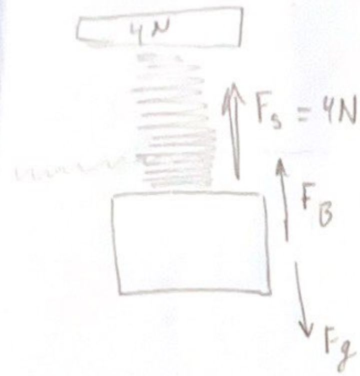
$V_{hose} A_{hose} = V_{nozzle} A_{nozzle}$

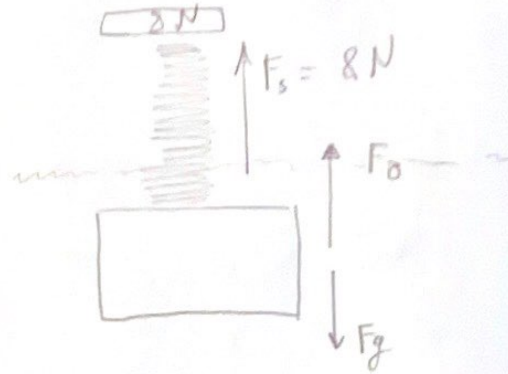
$1.8 \frac{m}{s} \cdot \cancel{\pi}(0.006^2 m^2) = 6.26 \frac{m}{s} \cdot \cancel{\pi} \cdot R^2$

$R = \sqrt{0.000010351\, m^2}$

$\boxed{R = 0.0032\, m = 0.32\, cm}$

2.





$\rho_w = \frac{1000\,kg}{m^3}$

Specific gravity $= \dfrac{\text{density of liquid}}{\text{density of water}} = 0.5$

$\therefore \rho_{liquid} = \frac{500\,kg}{m^3}$

$F_s + F_B - F_g = 0$

$\therefore F_g = F_B + F_s$

$F_g = F_B + 4N$

$* F_B = g \cdot V \cdot \rho_{water}$

$F_g = F_B + 8N$

$F_g = g \cdot V \cdot \frac{500\,kg}{m^3} + 8N$

$V = \dfrac{F_g - 8N}{g \cdot \frac{500\,kg}{m^3}}$

$F_g = \left(g \cdot V \cdot \frac{1000\,kg}{m^3}\right) + 4N$

$F_g = 2(F_g - 8N) + 4N$

$F_g = 2F_g - 12N$

$\boxed{F_g = 12N}$

3.

$P_{out} = 101 \, kPa$

$P_{in} = 85 \, kPa$

Pressure felt by top $= 101 \, kPa - 85 \, kPa$
$= 16000 \, Pa$

$P = \frac{F}{A}$

$P = \frac{F}{L^2}$

$F = P \cdot L^2 \longrightarrow F = 640 \, N$

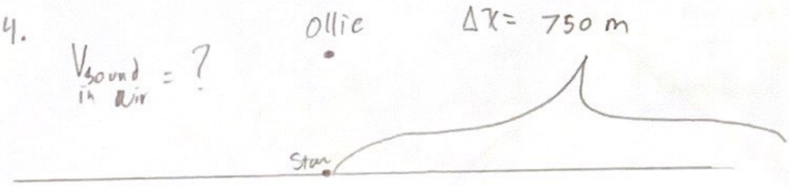
* They are asking for the mass of each "side". This includes the bottom of the box. There are 5 "sides" left that are pulling down on the top

$\therefore F = 5Mg$

$M = \frac{F}{5g} = \frac{640 \, N}{5 \cdot 9.8 \frac{m}{s^2}}$ $\boxed{= 13.06 \, kg}$

4.

$V_{\text{sound in air}} = ?$



$V_{\text{sound in metal}} = \frac{5790 M}{S}$

* The sound got to Stan 2.1 seconds faster

$t_{\text{total for Stan}} = \frac{\Delta x}{V_{metal}} = \frac{750 \cancel{m} \cdot s}{5790 \cdot \cancel{m}} = 0.1295$ seconds

$t_{\text{for Ollie}} = 0.1295 \, s + 2.1$ seconds $=$ 2.2295 seconds

$$V_{\substack{sound \\ in\ air}} = \frac{\Delta x}{t_{ollie}} = \frac{750\,m}{2.2295\,s} = \frac{336.39\,m}{s}$$

$$V_{sound} = V_0 \sqrt{\frac{T}{273.15\,K}}$$ $* \; V_0 = \frac{330\,m}{s}$ (in formula sheet!)

$$T = \left(\frac{V_{sound}}{V_0}\right)^2 \cdot 273.15\,K$$

$$T = 283.84\,K$$

$$T_{in\ ^\circ C} = 283.84\,K - 273.15\,K = \boxed{10.7\,^\circ C \sim 9.0\,^\circ C \text{ Rounding error}}$$

5. Before

$$f_B = f_0 \cdot \left[\frac{V_s \pm V_{obs}}{V_s \mp V_{source}}\right]$$

After

$$f_A = f_0 \cdot \left[\frac{V_s \pm V_{obs}}{V_s \mp V_{source}}\right]$$

• Car (source) is moving towards observer

∴

Obs

$V_{obs} = 0$

$V_s = 343 \frac{m}{s}$

• Car is moving Away

∴

$$f_B = f_0 \cdot \left[\frac{V_s}{V_s - V_{car}}\right]$$

$$f_A = f_0 \left[\frac{V_s}{V_s + V_{car}}\right]$$

Problem states that $f_A = 0.5 f_B$

∴

$$f_A = \cancel{f_0}\left[\frac{\cancel{V_s}}{V_s + V_{car}}\right] = 0.5\,\cancel{f_0}\left[\frac{\cancel{V_s}}{V_s - V_{car}}\right] = 0.5 f_B$$

$$V_s - V_{car} = \frac{V_s}{2} + \frac{V_{car}}{2}$$

$$\frac{V_s}{2} = \frac{3V_{car}}{2}$$

$$V_{car} = \frac{V_s}{3} = \frac{343\,m}{s} \cdot \frac{1}{3} = \boxed{\frac{114.3\,m}{s}}$$

6.

$$\beta = 10 \log_{10}\left(\frac{I}{I_0}\right) \qquad \beta = 70\,dB \qquad I_0 = 10^{-12}\,\frac{W}{m^2}$$

$$\frac{\beta}{10} = \log_{10}\left(\frac{I}{I_0}\right)$$

$$10^{\beta/10} = \frac{I}{I_0}$$

$$I = I_0 \cdot 10^{\beta/10}$$

$$I = 10^{-12}\,\frac{W}{m^2} \cdot 10^{7}$$

$$\boxed{I = 10^{-5}\,\frac{W}{m^2}}$$

Answer

7.

$$I = \frac{P_0}{4\pi r^2}$$

A

$I = 0.1\,\frac{W}{m^2}$

$r = 2m$

$$0.1\,\frac{W}{m^2} = \frac{P_0}{4\pi\,(4m^2)}$$

$P_0 = 5.03\ W$

B

$I' = 0.01\,\frac{W}{m^2}$

$R = ?$

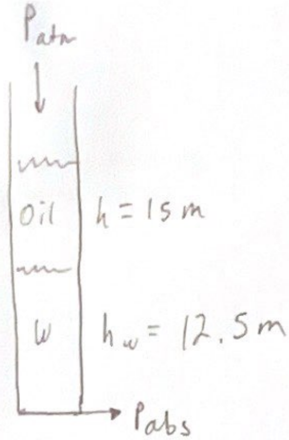
$$0.01\,\frac{W}{m^2} = \frac{5.03\,W}{4\pi \cdot R^2}$$

$$R = \sqrt{\frac{5.03\,W \cdot m^2}{4\pi \cdot 0.01\,W}}$$

$$\boxed{R = 6.3\,m}$$

Answer

8.



$\rho_{oil} = \frac{800\,kg}{m^3}$ $\quad \rho_{water} = \frac{1000\,kg}{m^3}$

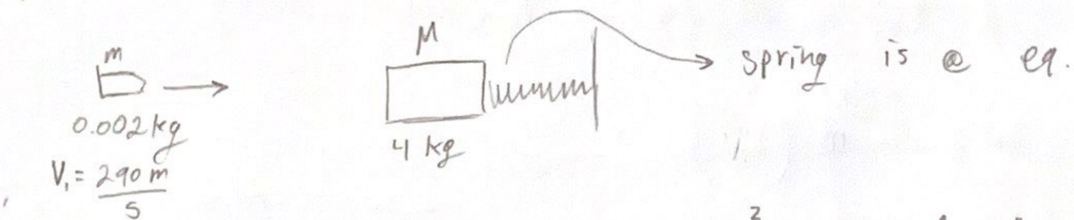
$P_{absolute} = P_{atm} + \rho_o g h_{oil} + \rho_w \cdot g h_w$

$= 101000\,Pa + \frac{800\,kg}{m^3} \cdot \frac{9.8\,m}{s^2} \cdot 15\,m + \frac{1000\,kg}{m^3} \cdot \frac{9.8\,m}{s^2} \cdot 1$

$\boxed{P_{abs} = 3.4 \times 10^5\,Pa}$

Answer

9.



$M V_1 = (m + M) V_2$

$V_2 = \frac{m \cdot V_1}{(m + M)}$

$V_2 = \frac{0.002\,kg \cdot 290\,m/s}{(4.002\,kg)}$

$V_2 = 0.14\,\frac{m}{s}$

$\frac{1}{2} m' V_2^2 = \frac{1}{2} k \cdot x^2$ $\quad X = 0.04\,m$

$k = \frac{m' V_2^2}{x^2}$

$k = \frac{4.002\,kg \cdot (0.14\,m/s)^2}{(0.04\,m)^2}$

$k = 52.5\,\frac{N}{m}$

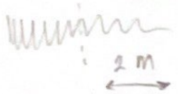
$m + M = m'$

$W = \sqrt{\frac{k}{m'}} = \frac{2\pi}{T}$ $\quad \therefore T = 2\pi \sqrt{\frac{m'}{k}}$

$\boxed{T = 1.73\,s}$ Answer

10.

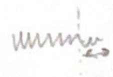
A



$V_a = 1 \frac{m}{s}$

$X_a = 2m$

B



$V_b = 3 \frac{m}{s}$

$X_b = 1.0m$

$$\cancel{\tfrac{1}{2}} m (V_a)^2 + \cancel{\tfrac{1}{2}} k (X_a)^2 = \cancel{\tfrac{1}{2}} m (V_b)^2 + \cancel{\tfrac{1}{2}} k (X_b)^2$$

$$k (X_a)^2 - k (X_b)^2 = m (V_b)^2 - m (V_a)^2$$

$$3m^2 \cdot k = m \cdot \left(\frac{8m^2}{s^2} \right)$$

$$\frac{k}{m} = \frac{8}{3} \implies \omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{8}{3}}$$

$$\boxed{\omega = \frac{1.63 \text{ rad}}{s}}$$

Answer

11.

$2V \leftarrow$ observer $\qquad V \leftarrow$ source

$V_{sound} = \frac{343m}{s}$ $\qquad f_o = 500\,Hz$

$V = \frac{20m}{s}$

what is f observed (f')

$$f' = f_o \left[\frac{V_{sound} \pm V_{obser}}{V_{sound} \mp V_{source}}\right]$$

$$f' = f_o \left[\frac{V_{sound} - V_{obser}}{V_{sound} - V_{source}}\right] \rightarrow f' = 500\,Hz \left[\frac{\frac{343m}{s} - \frac{40m}{s}}{\frac{343m}{s} - \frac{20m}{s}}\right]$$

$$\boxed{f' = 469.0\,Hz}$$

12.

$$W = \sqrt{\frac{g}{L}} = \frac{2\pi}{T} \quad \therefore \quad T = 2\pi\sqrt{\frac{L}{g}}$$

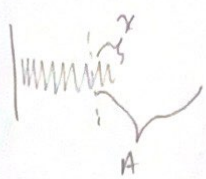
$$T' = 2\pi\sqrt{\frac{L}{g/4}} = 2\pi\sqrt{\frac{4L}{g}} = 2\left[\overbrace{2\pi\sqrt{\frac{L}{g}}}^{T}\right]$$

$$\boxed{T' = 2T}$$

Answer

13.

$m = 2\,kg$ $\qquad x = 3m$



$k = \frac{200\,N}{m}$ $\qquad V = 40\,\frac{m}{s}$

$A = ?$

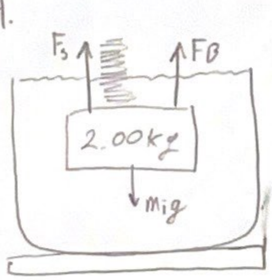
$$\cancel{\tfrac{1}{2}}\, m \cdot v^2 + \cancel{\tfrac{1}{2}}\, k \cdot x^2 = \cancel{\tfrac{1}{2}}\, k A^2$$

$$2\,kg \cdot 1600\,\frac{m^2}{s^2} + \frac{200\,N}{m} \cdot 9m^2 = \frac{200\,N}{m} \cdot A^2$$

$$A^2 = 25\,m^2$$

$$\boxed{A = 5\ m}$$

14.



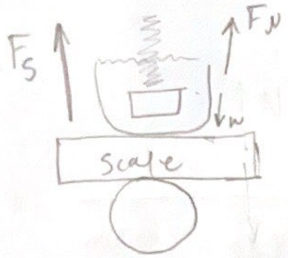
$\rho_{iron} = 7.86 \times 10^3\,\frac{kg}{m^3}$

$\rho_{oil} = 916\,\frac{kg}{m^3}$

$F_s + F_B - m_i g = 0$

$F_s = m_i g - F_B \qquad * \; F_B = \rho_{oil} \cdot V_{iron} \cdot g \qquad * \; V_{iron} = \frac{2.00\,kg \cdot m^3}{7.86 \times 10^3\,kg}$

$F_s = 17.3\,N \uparrow$



$$F_N + F_S - W = 0$$

$$F_N = W - F_S$$

$$= M_T \cdot g - F_S$$

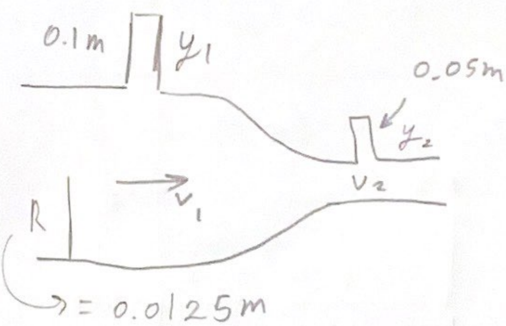
$$F_N = (\underbrace{3.00\,kg}_{\text{Beaker}} + \underbrace{2.00\,kg}_{\text{oil}} + \underbrace{2.00\,kg}_{\text{iron}}) \cdot g - 17.3\,N$$

$$\boxed{F_N = 51.3\,N}$$

Answer

15.

$$Q = 1.80 \times 10^{-4} \frac{m^3}{s} = A_1 V_1 = A_2 V_2$$



$$1.80 \times 10^{-4} \frac{m^3}{s} = \pi R^2 \cdot V_1$$

$$V_1 = \frac{1.80 \times 10^{-4}\, m^3/s}{\pi \cdot R^2}$$

$$V_1 = 0.367\, m/s$$

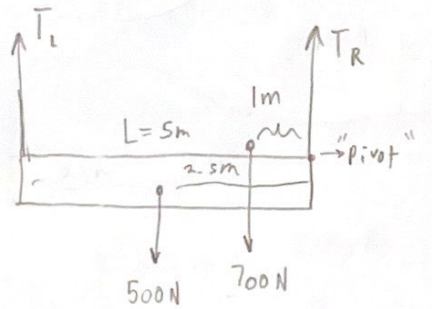
$$\cancel{P} + \rho g y_1 + \frac{1}{2}\rho V_1^2 = \cancel{P} + \rho g y_2 + \frac{1}{2}\rho V_2^2$$

$$V_2 = \sqrt{\frac{\rho g y_1 + \frac{1}{2}\rho V_1^2 - \rho g y_2}{\frac{1}{2}\cdot\rho}}$$

$$V_2 = \sqrt{\frac{\frac{1000\,kg}{m^3}\cdot\frac{9.8\,m}{s^2}\cdot 0.1\,m + \frac{1}{2}\cdot\frac{1000\,kg}{m^3}\cdot(0.367\,m/s)^2 - \frac{1000\,kg}{m^3}\cdot\frac{9.8\,m}{s^2}\cdot 0.05\,m}{\frac{1}{2}\cdot\frac{1000\,kg}{m^3}}}$$

$$\boxed{V_2 = \frac{1.06\,m}{s}}$$

16.



$T_L = ?$

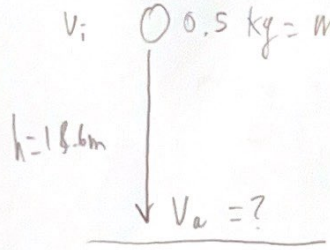
$$500\,N\cdot 2.5\,m + 700\,N\cdot 1\,m - T_L\cdot 5\,m = 0$$

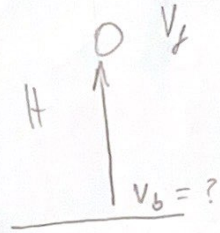
$$T_L = \frac{500\,N\cdot 2.5\,m + 700\,N\cdot 1\,m}{5\,m}$$

$$\boxed{T_L = 390\,N}$$

Answer

17.





$J = 16.73 N \cdot s$

$V_a^2 = V_i^2 + 2a\Delta X$

$0 \frac{m}{s}$

$V_a = \sqrt{2g \cdot h}$

$V_a = 19.093 \frac{m}{s} \downarrow$

$J = 16.73 N \cdot s = m \cdot (V_b - V_a)$

$\frac{16.73 N \cdot s}{m} + V_a = V_b$

$V_a = -19.093 m$

b/c it's pointing down

$V_b = 14.367 \frac{m}{s}$

$V_f^2 = V_b^2 + 2aH$

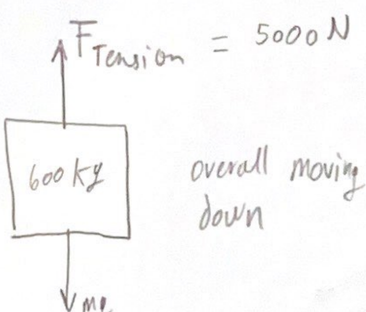
0

$\frac{-V_b^2}{2(-9.8 \frac{m}{s^2})} = H$

$\boxed{H = 10.53 \text{ M}}$

Answer

18.



overall moving down

$F_{net} = -ma = F_T - mg$

$a = -\frac{F_T}{m} + g$

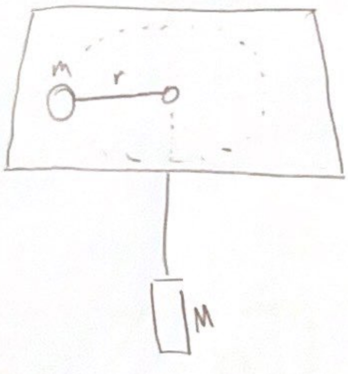
$a = 1.47 \frac{m}{s^2} \downarrow$

$V_i = 0$

$\Delta X = \overset{0}{\cancel{V_i t}} + \frac{a}{2} \cdot t^2$

@ t = 5 s, $\Delta X = \frac{1.47 m}{2 s^2} \cdot 25 s^2 = \boxed{18.3 \text{ M}}$

19.



$r = 2.0\,m$

$m = 2\,kg$

$T = 2.5\,s$

$M = ?$

$$\omega = \frac{2\pi}{T} = \frac{2.51\,rad}{s}$$

$$V_{tan} = \omega \cdot r = \frac{5.03\,m}{s}$$

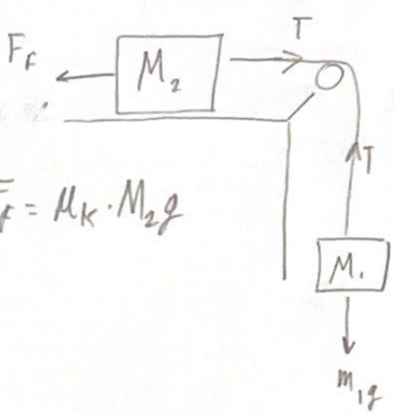
$$Mg = m a_c$$

$$Mg = m \cdot \frac{v^2}{r}$$

$$M = \frac{m v^2}{g \cdot r}$$

$$\boxed{M = 2.58\,kg}$$

20.



$F_f = \mu_k \cdot M_2 g$

$M_2 = 1\,kg$

$\mu_s = 0.5$

$\mu_k = 0.2$

$T_{\text{after release}} = 7.84\,N$

$M_1 = ?$

$$x: \; T - \mu_k \cdot M_2 g = M_2 a$$

$$\frac{T}{M_2} - \mu_k \cdot g = a$$

$$y: \; T - m_1 g = -m_1 a$$

$$T = m_1 g - m_1 \left[\frac{T}{m_2} - \mu_k \cdot g\right]$$

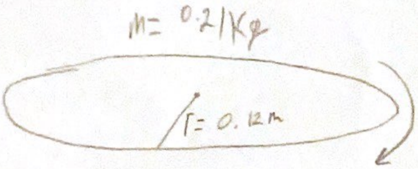
$$T = m_1 \left[g - \frac{T}{m_2} + \mu_k g\right]$$

$$7.84N = m_1 \left[\frac{9.8m}{s^2} - \frac{7.84N}{1kg} + 0.2 \cdot \frac{9.8m}{s^2} \right]$$

$$7.84N = m_1 \left[3.92 \frac{m}{s^2} \right]$$

$$\boxed{m_1 = 2 \text{ kg}}$$

4.



$$\tau = 0.059 \text{ Nm}$$

$$= I\alpha$$

$$\tau = \frac{1}{2} m r^2 \cdot \alpha$$

$$\alpha = \frac{2\tau}{mr^2}$$

$$\omega_i = 0$$

$$\omega_f = \frac{1800 \text{ rev}}{\text{min}} \cdot \frac{1 \text{ min}}{60 s} \cdot \frac{2\pi}{\text{rev}}$$

$$\omega_f = \frac{188.50 \text{ rads}}{s}$$

$$V_f = v_i + at$$

$$\frac{V_f}{r} = \frac{V_i}{r} + \frac{at}{r}$$

$$\omega_f = \underset{0}{\cancel{\omega_i}} + \alpha \cdot t$$

$$\omega_f = \frac{2\tau}{mr^2} \cdot t$$

$$t = \frac{mr^2 \cdot \omega_f}{2\tau}$$

$$t = \frac{0.21kg \, (0.12m)^2}{2 \cdot 0.059 \text{ Nm}} \cdot \frac{188.50 \text{ rads}}{s}$$

$$\boxed{t = 4.83 \text{ s}}$$

Answer

22.

$P = 15\ kW$

$\Delta x = 140\ m$

$t = 5$ seconds

Force generated by Car = Forces from friction, drag, etc.

$F_{\leftarrow} = ?$

$m = 1600\ kg$

$P = \frac{work}{time}$ $work = F \cdot \Delta x \cdot \cos\theta$

*mass of the Car was not needed

$15000\ W = \frac{F \cdot \Delta x}{5\ s}$

$F = 536\ N$

Answer

$\frac{5\ s \cdot 15000\ W}{\Delta x} = F$

23.

$T_m = 687\ days \cdot \frac{24\ hr}{day} \cdot \frac{3600\ s}{1\ hr} = 59356800$ seconds

$M_{sun} = 1.99 \times 10^{30}\ kg$

$T = \sqrt{\frac{4\pi^2 r^3}{G M_{sun}}}$

$r = ?$

$T^2 = \frac{4\pi^2 r^3}{G M_{sun}}$

$\sqrt[3]{\frac{T^2 G M_{sun}}{4\pi^2}} = r$ $\boxed{r = 2.28 \times 10^{11}\ m}$

Answer

24.

Piano Wire

L = 0.4 m

T = 500 N

m = 0.003 kg

$f_1 = ?$

$$\lambda = \frac{2L}{n} \qquad V = \sqrt{\frac{T \cdot L}{m}}$$

$$f = \frac{V}{\lambda}$$

$$f = \sqrt{\frac{TL}{m}} \cdot \frac{n}{2L}$$

$$f_1 = \sqrt{\frac{500\,N \cdot 0.4m}{0.003kg}} \cdot \frac{1}{2 \cdot 0.4m}$$

$\boxed{f = 323\ Hz}$

Answer

25.

$$\Delta B = \cancel{10}\,dB = \cancel{10}\log_{10}\left(\frac{I_A}{I_0}\right) - \cancel{10}\,\log_{10}\left(\frac{I_B}{I_0}\right)$$

$$1dB = \log_{10}\left(\frac{I_A}{I_0}\right) - \log_{10}\left(\frac{I_B}{I_0}\right)$$

$$1dB = \log_{10}\left[\frac{I_A / \cancel{I_0}}{I_B / \cancel{I_0}}\right]$$

$$1dB = \log_{10}\left(\frac{I_A}{I_B}\right) \longrightarrow \boxed{\frac{I_A}{I_B} = 10^1} \longrightarrow \text{Answer}$$