(1

$$\frac{PV}{T} = C \Rightarrow \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\Rightarrow V_2 = V_1 \times \frac{T_2}{T_1} \times \frac{P_1}{P_2}$$

$$= 100 \times \frac{290}{300} \times \frac{1}{0.8} = 100 \times \frac{29}{24}$$

$$= \boxed{120.8\bar{3}\,(m^3)}\ (\text{آ})$$

| فشار 0/8bar | فشار 1/0bar | دما (°C) |
|---|---|---|
| 11.08 | 10.99 | 12 |
| 15.07 | 14.96 | 17 |
| 20.22 | 20.12 | 22 |
| 26.94 | 26.77 | 27 |

$$\Delta U = \frac{5}{2}(P_2V_2 - P_1V_1) = \frac{5}{2}\left(P_1V_1 \times \frac{T_2}{T_1} - P_1V_1\right)$$

$$= \frac{5}{2} \times P_1V_1\left(\frac{T_2}{T_1} - 1\right)$$

$$= \frac{5}{2} P_1V_1 \times \frac{T_2 - T_1}{T_1}$$

$$= \frac{5}{2} \times 10^5 \times 100 \times \frac{1}{30} = \frac{10^7}{12} = \boxed{8.\bar{3} \times 10^5\,(J)}\ (\text{ب})$$

$$\Delta m = m_1 - m_2 = V_1 n_1 - V_2 n_2 = 100\left(26.77 - \frac{29}{24} \times 15.07\right) \simeq \boxed{856.0\,(g)}\ (\text{پ})$$

$$Q = mL = \boxed{2054.5\,(kJ)}\ (\text{ت})$$

$$m = 100 \times 100 \times 10 \times 26.77 = \boxed{2677\,(kg)}\ (\text{ث})$$

$$\Delta m = 10^3 \times 856.0 \times 10^{-3} = \boxed{856.0\,(kg)}\ (\text{ج})$$

$$\frac{PV}{T} = C \quad m = C \Rightarrow \frac{PV}{mT} = \frac{P}{\rho T} = C$$

$$\frac{P_1}{\rho_1 T_1} = \frac{P_2}{\rho_2 T_2} \Rightarrow \rho_2 = \frac{P_2}{P_1} \times \frac{T_1}{T_2}\rho_1$$

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$$\rho A u = C$$

$$\Rightarrow \rho_1 \times 100 \times 100 \times 10 = \rho_2 \times 100 \times h \times 30$$

$$\Rightarrow 100 \rho_1 = 3 h \rho_2 \Rightarrow h = \frac{100}{3} \times \frac{\rho_1}{\rho_2}$$

$$= \frac{100}{3} \times \frac{T_2}{T_1} \times \frac{P_1}{P_2}$$

$$= \frac{100}{3} \times \frac{29}{30} \times \frac{1}{0.8} = \frac{100}{3} \times \frac{29}{24} = \boxed{40.2\overline{7}\,(m)} \quad (ج)$$

$$Q = 2054.5 \times 10^6 - 833.3 \times 10^6 = 1221.2 \times 10^6 \,(J)$$

$$Q = \rho_0 A u g H = 1.2 \times 10^4 \times 10 \times 10 \times H$$

$$\Rightarrow H = \frac{1221.2}{1.2} \simeq \boxed{1018\,^{(m)}} \quad (ح)$$

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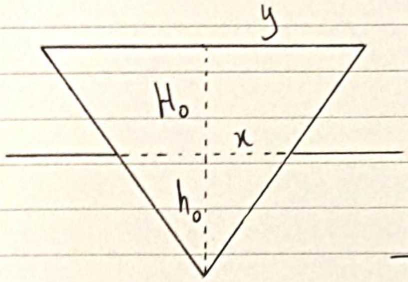
## سوال 2 ) دماسنج الکتریکی



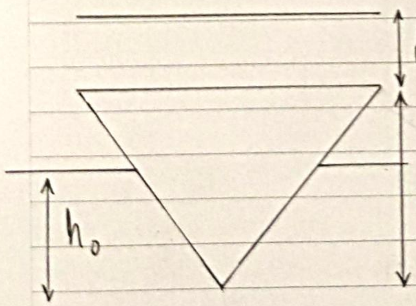

$$\frac{h_0}{H_0} = \frac{x}{y} \ ، \ \rho_A H_0 y = \rho_{Hg} h_0 x$$

$$\longrightarrow h_0 = \frac{\rho_A}{\rho_{Hg}} H_0 \frac{y}{x} = \frac{\rho_A}{\rho_{Hg}} \frac{H_0^2}{h_0}$$

$$\longrightarrow \boxed{h_0 = H_0 \sqrt{\frac{\rho_A}{\rho_{Hg}}}} \longrightarrow \Delta h = H_0 (1 + \alpha_A \Delta T) \sqrt{\frac{\rho_A (1 - 3\alpha \Delta T)}{\rho_{Hg} (1 - \beta \Delta T)}}$$

$$\longrightarrow \boxed{\Delta h = H_0 \sqrt{\frac{\rho_A}{\rho_{Hg}}} (\beta_{Hg} - \alpha_A) \frac{\Delta T}{2}}$$

$$\longrightarrow \Delta h_0 = 20 \times 10^{-2} \times \sqrt{\frac{1}{4}} \times \frac{25}{2} \times 16 \times 10^{-5} = \boxed{2 \times 10^{-4} \ m}$$




$d_0 + H_0 - h_0$ ثابت

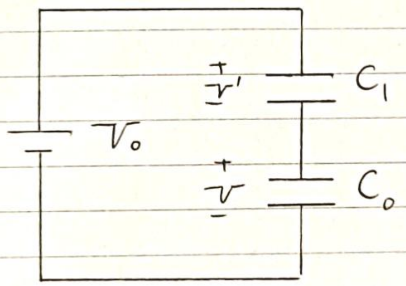
$$\longrightarrow \Delta d = \Delta h - \Delta H$$

$$\Delta H = H_0 \alpha \Delta T$$

$$\longrightarrow \Delta d = H_0 \frac{\Delta T}{2} \left( \sqrt{\frac{\rho_A}{\rho_{Hg}}} \beta_{Hg} - \left(2 + \sqrt{\frac{\rho_A}{\rho_{Hg}}}\right) \alpha_A \right)$$

$$C = \frac{\epsilon_0 A}{d} \longrightarrow \Delta C = -\frac{\epsilon_0 A}{d^2}\Delta d \longrightarrow \frac{\Delta C}{C} = \frac{-\Delta d}{d}$$

$$\longrightarrow \boxed{\frac{\Delta C}{C} = \frac{H_0}{d}\left(\left(2+\sqrt{\frac{\rho_A}{\rho_{Hg}}}\right)\alpha_A - \sqrt{\frac{\rho_A}{\rho_{Hg}}}\,\beta_{Hg}\right)\frac{\Delta T}{2}}$$



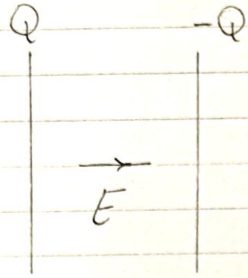

$$\left.\begin{aligned} v + v' &= V_0 \\ C_0 v &= C_1 v' \end{aligned}\right\} \longrightarrow \quad v = \frac{C_1}{C_1 + C_0} V_0$$

$$\longrightarrow \Delta V = \frac{-C_1 V_0}{(C_1 + C_0)^2}\Delta C = \frac{-C_0 V_0}{4C_0^2}\Delta C$$

$$\longrightarrow \Delta V = -\frac{V_0}{4}\frac{\Delta C}{C_0} = \frac{-2}{4} \times 200 \times \frac{25}{2}\left(\frac{5}{2} \times 2 \times 10^{-5} - 9 \times 10^{-5}\right)$$

$$\longrightarrow \Delta V = \frac{2 \times 25 \times 200}{8} \times 4 \times 10^{-5} \longrightarrow \boxed{\Delta V = 0.05\,V}$$

## سوال 3) نوسان پلاسما




$$Q = nAxe \rightarrow \sigma = nxe$$

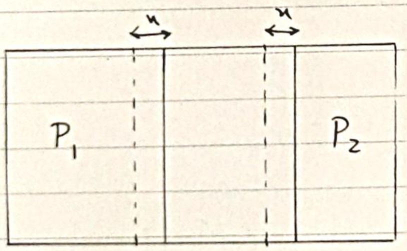
میدان ایجاد شده توسط صفحه سمت چپ برابر $\frac{\sigma}{2\epsilon_0}$

$$\rightarrow E = \frac{nxe}{2\epsilon_0} \rightarrow F = -\frac{nex}{\epsilon_0} nAxe$$

$$F = nAx\, m_e\, a \rightarrow a = -\frac{ne^2}{\epsilon_0 m_e} x$$

$$\rightarrow \omega_1 = \sqrt{\frac{ne^2}{\epsilon_0 m_e}} \rightarrow \boxed{f_1 = \frac{1}{2\pi}\left(\frac{ne^2}{\epsilon_0 m_e}\right)^{1/2}}$$

$\lambda_n = \frac{2L}{n} \rightarrow \lambda = 3d = 6l$ ؛ $l = \frac{d}{3}$ تعریف می‌کنیم




T ثابت $\rightarrow$ PV ثابت

$$\rightarrow P_2(l-x) = P_0 l$$

$$\rightarrow \left.\begin{array}{l} P_2 = P_0\left(1+\frac{x}{l}\right) \\ P_1 = P_0\left(1-\frac{x}{l}\right) \end{array}\right\} \rightarrow$$

$$\Delta P = -2P_0\frac{x}{l} \rightarrow F = -2P_0 A\frac{x}{l} = \rho A l a$$

$$\rightarrow a = -\frac{2P_0}{\rho l^2}x \ ،\ P_0 = \frac{nN_A k_B T}{Al} \ ،\ \rho = \frac{nN_A m_e}{Al}$$

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$$\rightarrow \omega^2 = \frac{2nN_A k_B T}{A\ell \dfrac{nN_A k_B m_e}{A\ell} \ell^2} \longrightarrow \omega^2 = \frac{2k_B T}{m_e \ell^2}$$

$$\rightarrow \boxed{\omega_2 = \left(\frac{72 k_B T}{m_e \lambda^2}\right)^{1/2}}$$

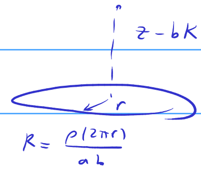
$$\frac{F}{M} \quad Cte \longrightarrow -M\omega_1^2 x - M\omega_2^2 x = Ma \longrightarrow$$

$$\Omega^2 = \omega_1^2 + \omega_2^2 \longrightarrow \Omega^2 = \frac{ne^2}{2\epsilon_0 m_e} + \frac{72 k_B T}{m_e \lambda^2}$$

$$\rightarrow \boxed{f_3 = \frac{1}{2\pi}\left(\frac{ne^2}{2\epsilon_0 m_e} + \frac{72 k_B T}{m_e \lambda^2}\right)^{1/2}}$$

$$\varepsilon = -\frac{d\phi}{dt} = -\frac{d\phi}{dz}\dot{z} = -\frac{d\phi}{dz}(-u) = u\frac{d\phi}{dz} \Rightarrow P_{\text{اتلاف}} = \frac{\varepsilon^2}{R} = \frac{u^2}{R}\left(\frac{d\phi}{dz}\right)^2 \Rightarrow \vec{F}\cdot(-u\hat{z}) = -\frac{u^2}{R}\left(\frac{d\phi}{dz}\right)^2 \qquad (4$$

$$\Rightarrow \boxed{\vec{F} = \frac{u}{R}\hat{z}\left(\frac{d\phi}{dz}\right)^2} \quad \text{(آ)}$$




$$\varepsilon_K = -\frac{d}{dt}\phi(z-bK) = -\frac{d\phi(z-bK)}{d(z-bK)}(-u) = u\frac{d\phi(z-bK)}{d(z-bK)} \Rightarrow P_{\text{اتلاف}} = -\sum_{k=-N}^{N}\frac{\varepsilon_K^2}{\frac{2\pi r\rho}{ab}}$$

$$= \frac{-au^2}{2\pi r\rho}\sum_{k=-N}^{N} b\left(\frac{d\phi(z-bK)}{d(z-bK)}\right)^2 = \frac{au^2}{2\pi r\rho}\sum_{k=-N}^{N}\Delta(z-bK)\left(\frac{d\phi(z-bK)}{d(z-bK)}\right)^2$$

$$P_{\text{اتلاف}} = \vec{F}\cdot(-u\hat{z}) \Rightarrow \boxed{\vec{F} = \frac{-au\hat{z}}{2\pi r\rho}\sum_{k=-N}^{N}\Delta(z-bK)\left(\frac{d\phi(z-bK)}{d(z-bK)}\right)^2} \quad \text{(ب)}$$

$$\vec{F} = \frac{-au\hat{z}}{2\pi r\rho}\sum_{\eta=\infty}^{-\infty}\Delta\eta\left(\frac{d\phi(\eta)}{d\eta}\right)^2 \ : \ \eta := z-bK \Rightarrow$$

$$\boxed{\vec{F} = \frac{au}{2\pi r\rho}\sum_{\eta=-\infty}^{\infty}\Delta\eta\left(\frac{d\phi(\eta)}{d\eta}\right)^2 \ : \ \eta := z-bK} \quad \text{(ج)}$$

$$mg = \frac{au}{2\pi r\rho}\underbrace{\sum(\cdots)}_{\text{کمیت ثابت}} \Rightarrow \frac{u}{\rho} = cte \Rightarrow \boxed{\frac{u_{Cu}}{u_{Al}} = \frac{\rho_{Cu}}{\rho_{Al}}} \quad \text{(د)}$$

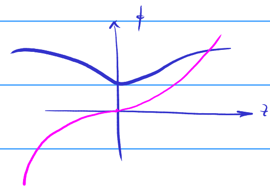
در این حالت باید تمام شارها را جمع کنیم و یک $\varepsilon_{t.t}$ خواهیم داشت و یک $R_{t.t}$ که جمع مقاومت‌های سری شده است:

$$\varepsilon_{t.t} = u\sum_{k=-N}^{N}\frac{d\phi(z-bK)}{d(z-bK)} \Rightarrow P_{\text{اتلاف}} = -\frac{1}{\frac{\rho}{ab}\times 2\pi r(2N+1)}u^2\left(\sum_{k=-N}^{N}\frac{d\phi(z-bK)}{d(z-bK)}\right)^2$$

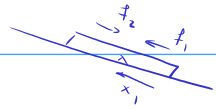
$$= \frac{-u^2ab}{2\pi r\rho(2N+1)}\times\frac{L}{L}\left(\sum_{k=-N}^{N}\frac{d\phi(z-bK)}{d(z-bK)}\right)^2 = \frac{-u^2a}{2\pi r\rho L}b^2\left(\sum_{k=-N}^{N}\frac{d\phi(z-bK)}{d(z-bK)}\right)^2$$

$$\Rightarrow \vec{F}\cdot(-u\hat{z}) = \frac{-u^2a}{2\pi r\rho L}b^2\left(\sum_{k=-N}^{N}\frac{d\phi(z-bK)}{d(z-bK)}\right)^2 \Rightarrow \boxed{\vec{F} = \frac{au\hat{z}}{2\pi r\rho L}\left(\sum_{k=-N}^{N}\frac{d\phi(z-bK)}{d(z-bK)}\Delta(z-bK)\right)^2} \quad \text{(ه)}$$

$$\boxed{\vec{F} = \frac{au\hat{z}}{2\pi r\rho L}\Big(\underbrace{\sum_{\eta=-\infty}^{\infty}\frac{d\phi(\eta)}{d\eta}\Delta\eta}_{\text{[illegible]}}\Big)^2 = 0} \quad \text{(و)}$$

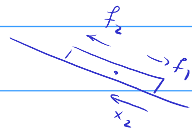


5) جرم واحد سطح σ باشد:




انبساط : $a=0 \Rightarrow F_{ext}=0 \Rightarrow$ $\boxed{\sigma b L g \sin\theta + \mu\sigma b(L-x_1)g\cos\theta = \mu\sigma b x_1 g\cos\theta}$ (آ)

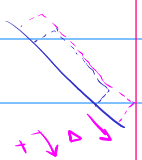
$\Rightarrow \boxed{x_1 = \frac{L_c}{2}\,\frac{tg\theta+\mu_K}{\mu_K}}$ (ب)




انقباض : $a=0 \Rightarrow F_{ext}=0 \Rightarrow$ $\boxed{\sigma b L g \sin\theta - \mu\sigma b(L-x_2)g\cos\theta = -\mu\sigma b x_2 g\cos\theta}$ (آ)

$\mu \rightarrow -\mu$ در حالت $\longrightarrow$ با تبدیل $\boxed{x_2 = \frac{L}{2}\,\frac{tg\theta-\mu}{-\mu} = \frac{L}{2}\,\frac{\mu_K - tg\theta}{\mu_K}}$ (پ)

اگر جابجایی نقطه‌ی پایینی را با Δ نشان دهیم:



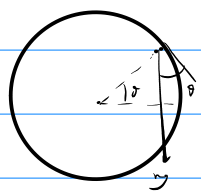

$$\begin{cases} D_{C\rightarrow H} = x_1\alpha\Delta T\big|_{L=L_c} \quad ; \quad \Delta T := T_H - T_C \\ D_{H\rightarrow C} = x_2\alpha(-\Delta T)\big|_{L=L_c(1+\alpha\Delta T)\approx L_c} \end{cases} \Rightarrow D_{\substack{C\rightarrow H\\ H\rightarrow C}} = \alpha\Delta T\left(\frac{L_c}{2}\,\frac{tg\theta+\mu_K}{\mu_K} + \frac{L_c}{2}\,\frac{tg\theta-\mu_K}{\mu_K}\right) = \alpha\Delta T\,\frac{L_c\, tg\theta}{\mu_K} \Rightarrow$$

تنها جملات تا مرتبه ۱ درستند

(ت) $\boxed{\Delta = \text{مقدار جابجایی به سمت پایین} = \alpha(T_H - T_C)\,\frac{L_c\, tg\theta}{\mu_K}}$

6)

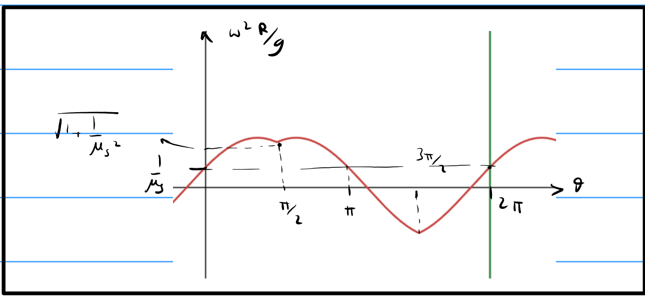
(آ) $\boxed{\begin{matrix} f = mg \\ N = mR\omega^2 \end{matrix}} \Rightarrow mg \leqslant \mu_s \cancel{m} R\omega^2 \longrightarrow \boxed{\omega_{min} = \sqrt{\frac{g}{\mu_s R}}}$ (ب)




(پ) $\boxed{\begin{matrix} N + mg\sin\theta = mR\omega^2 \longrightarrow N = mR\omega^2 - mg\sin\theta \\ f = mg\cos\theta \end{matrix}} \Rightarrow \mu_s \cancel{m}(R\omega^2 - g\sin\theta) \geqslant \cancel{m}g|\cos\theta|$

$\Rightarrow R\omega^2 \geqslant g\sin\theta + \frac{g}{\mu_s}|\cos\theta| \longrightarrow \boxed{\omega^2 \geqslant \frac{g}{R}\left(\sin\theta + \frac{1}{\mu_s}|\cos\theta|\right)}$ (ت)

(ث)




$\Rightarrow \boxed{\omega_{min} = \sqrt{\frac{g}{R}\sqrt{1+\frac{1}{\mu_s^2}}}}$ (ج)

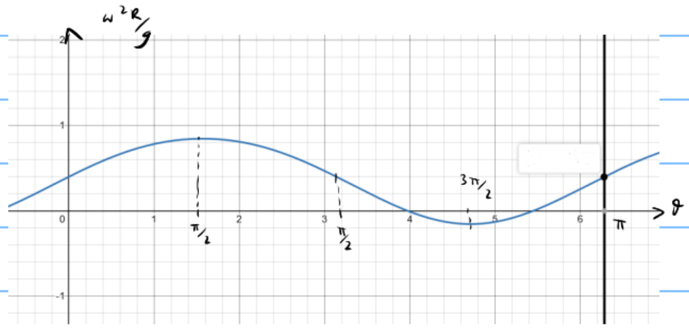
$$\boxed{\vec{g} = -g\sin\alpha\,\hat{i} - g\cos\alpha\,\hat{j}} \quad (2.)$$

$$N + mg\cos\alpha\sin\theta = mR\omega^2 \longrightarrow \boxed{N = mR\omega^2 - mg\cos\alpha\sin\theta} \quad (2.)$$

$$mg\cos\alpha\cos\theta = f_1$$
$$mg\sin\alpha = f_2 \longrightarrow \boxed{f = mg\sqrt{\sin^2\alpha + \cos^2\alpha\cos^2\theta}} \quad (2.)$$

$$\Rightarrow R\omega^2 - g\cos\alpha\sin\theta \geq \frac{g}{\mu_s}\sqrt{\sin^2\alpha + \cos^2\alpha\cos^2\theta}$$

$$\longrightarrow \boxed{\omega^2 \geq \frac{g}{R}\left(\cos\alpha\sin\theta + \frac{1}{\mu_s}\sqrt{\sin^2\alpha + \cos^2\alpha\cos^2\theta}\right)}$$
(2.)




$$\frac{dG}{d\theta} = 0 : \quad 0 = \cos\alpha\cos\theta + \frac{1}{\mu_s}\,\frac{-\cos^2\alpha\,\cancel{2}\cos\theta\sin\theta}{\cancel{2}\sqrt{\sin^2\alpha + \cos^2\alpha\cos^2\theta}} \longrightarrow \cancel{\cos\alpha}\,\cancel{\cos\theta}\,\mu_s = \frac{\cos^{\cancel{2}}\alpha\,\cancel{\cos\theta}\sin\theta}{\sqrt{\sin^2\alpha + \cos^2\alpha\cos^2\theta}}$$

$$\rightarrow \begin{cases} \cos\theta = 0 \longrightarrow \theta = \frac{\pi}{2},\ \frac{3\pi}{2} \longrightarrow \boxed{\begin{cases} \theta = \pi/2 : & G = g/R\left(\cos\alpha + \frac{\sin\alpha}{\mu_s}\right) \\ \theta = 3\pi/2 : & G = g/R\left(-\cos\alpha + \sin\alpha/\mu_s\right) \end{cases}} \\ \mu_s\sqrt{\sin^2\alpha + \cos^2\alpha\cos^2\theta} = \cos\alpha\sin\theta \longrightarrow \underbrace{\cancel{\sin^2\alpha + \cos^2\alpha}}_{1} - \cos^2\alpha\sin^2\theta = \frac{\cos^2\alpha}{\mu^2}\sin^2\theta \longrightarrow \sin^2\theta = \frac{1}{\cos^2\alpha\left(1 + \frac{1}{\mu_s^2}\right)} \end{cases}$$

$$\Rightarrow \sin\theta = \pm\frac{1}{\cos\alpha}\,\frac{1}{\sqrt{1 + \frac{1}{\mu_s^2}}} \Rightarrow \begin{cases} + : & G = g/R\left(\frac{1}{\sqrt{1 + 1/\mu^2}} + \frac{1}{\mu^2}\,\frac{1}{\sqrt{1 + 1/\mu^2}}\right) \\ - : & G = g/R\left(\frac{-1}{\sqrt{1 + 1/\mu^2}} + \frac{1}{\mu^2}\,\frac{1}{\sqrt{1 + 1/\mu^2}}\right) \end{cases}$$

$$\Rightarrow \boxed{\begin{cases} + : & G = \frac{g}{R}\sqrt{1 + \mu_s^2} \\ - : & G = g/R\,\frac{1/\mu^2 - 1}{\sqrt{\frac{1}{\mu^2} + 1}} \end{cases}} \qquad \Rightarrow \boxed{\begin{cases} \cos\alpha\sqrt{1 + 1/\mu_s^2} \geq 1 : & \omega_{min} = \sqrt{\frac{g}{R}\left(\cos\alpha + \frac{\sin\alpha}{\mu_s}\right)} \\ \cos\alpha\sqrt{1 + 1/\mu_s^2} \leq 1 : & \omega_{min} = \sqrt{\frac{g}{R}\sqrt{1 + 1/\mu_s^2}} \end{cases}}$$

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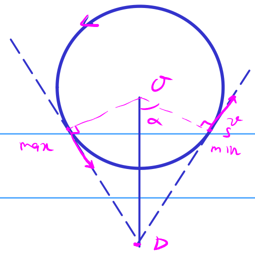
$$f = \frac{f_0}{1-\frac{v}{c}\cos\theta} \Rightarrow$$

$\cos\theta = -1 : f_{min}$

$\cos\theta = 1 : f_{max}$




(آ1)

(آ2) $$\boxed{f_{max} = \frac{f_0}{1-v/c}\ ,\ f_{min} = \frac{f_0}{1+v/c}}$$ $\Rightarrow$

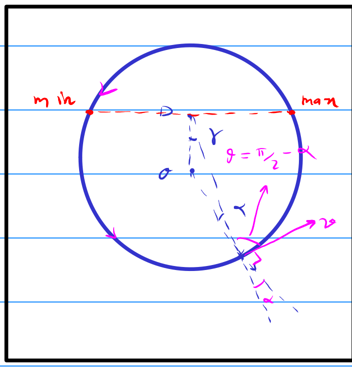
هر دو پرنده بیرون نشسته‌اند، چون ساختار اکسترمم که در بیرون تابع فاصله نیست و ثابت است، پس هر دو بیرون نشسته‌اند!

(آ3)

$$\begin{cases} f = \dfrac{f_0}{1-\frac{v}{c}\cos\theta} = \dfrac{f_0}{1-\frac{v}{c}\sin\alpha} \\ \dfrac{\sin\alpha}{d} = \dfrac{\sin\gamma}{R} \end{cases} \Rightarrow \boxed{f = \frac{f_0}{1-\frac{v}{c}\frac{d}{R}\sin\gamma}}$$

(ب1)

$\xrightarrow{\text{اکسترمم}}$




(ب2)

$$\begin{cases} \gamma = \pi/2 \rightarrow f_{max} = \dfrac{f_0}{1-\frac{v}{c}\,d/R} \\ \gamma = 3\pi/2 \rightarrow f_{min} = \dfrac{f_0}{1+\frac{v}{c}\,d/R} \end{cases}$$

(ب3)

(ب4) با توجه به اینکه اکسترمم‌های هر دو در یک زمان رخ می‌دهد، پس هر دو در داخل نشسته‌اند چون در یک نقطه‌ی دو دریافت کننده قرار نمی‌گیرند.

(ج)

$$\begin{rcases} f_{min}^{\text{درون}} = \dfrac{f_0}{1+\frac{v}{c}\,d/R} \\ f_{min}^{\text{بیرون}} = \dfrac{f_0}{1+\frac{v}{c}} \end{rcases} \longrightarrow \frac{f_{min}^{\text{درون}}}{f_{min}^{\text{بیرون}}} > 1 \Rightarrow$$

1 در بیرون قرار دارد، 2 در داخل قرار دارد.

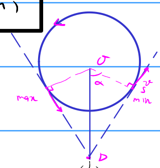
برای بیرون داریم:

$$\begin{matrix} f_{min}^{out} = \dfrac{f_0}{1+v/c} \\ f_{max}^{out} = \dfrac{f_0}{1-v/c} \end{matrix} \Rightarrow \frac{f_{min}^{out}}{f_{max}^{out}} = \frac{1-v/c}{1+v/c} \rightarrow \frac{v}{c} = \frac{1-\frac{f_{min}^{out}}{f_{max}^{out}}}{1+\frac{f_{min}^{out}}{f_{max}^{out}}} = \frac{1-\frac{425}{575}}{1+\frac{475}{575}} = \frac{1-\frac{17}{23}}{1+\frac{17}{23}}$$

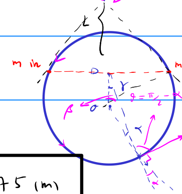
$$= \frac{6}{40} = \frac{3}{20} \Rightarrow \boxed{v = 49.5\ m/s}$$ (ت2)

$$f_0 = (1+v/c)\, f_{min}^{out} = 425 \times \frac{23}{20}\ (1/s) \rightarrow \boxed{f_0 = 488.75\ (1/s)}$$ (ت1)

$$T_{period} = \frac{2\pi R}{v} \rightarrow R = \frac{v}{2\pi} T_{period} = \frac{\cancel{99}^{9}}{\cancel{2}} \cdot \frac{1}{2 \times \frac{22}{7}} \times \cancel{30}^{15} = \frac{9\times15\times7}{4} = 236.25\ (m) \Rightarrow \boxed{R \approx 236.25\ (m)}$$ (ت3)




$$\frac{2\alpha}{2\pi} = \frac{T_{max\to min}}{T_{period}} = \frac{10}{30} = 1/3 \rightarrow \boxed{\alpha = \pi/3}$$ (ت4)




$$\frac{2\beta}{2\pi} = \frac{T_{max\to min}}{T_{period}} = 1/3 \rightarrow \boxed{\beta = \pi/3}$$ (ت5)

$$\begin{cases} d_1 = \dfrac{R}{\cos\alpha} = \dfrac{R}{1/2} = 472.5\ (m) \\ d_2 = R\cos\alpha = R/2 = 118.125\ (m) \end{cases}$$ (ت7) ، $\boxed{L = 354.375\ (m)}$

(ت8)