

$$46] \frac{1}{\lambda} = R \left(\frac{1}{n'^2} - \frac{1}{n^2} \right) \Rightarrow \frac{1}{\lambda_{\min}} = R \left(\frac{1}{n'^2} - \frac{1}{\infty} \right) \Rightarrow \frac{1}{\lambda_{\min}} = \frac{R}{n'^2}$$

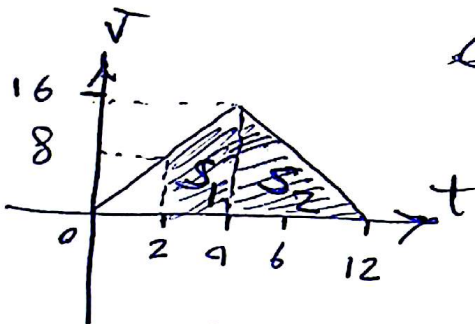
$$\Rightarrow \lambda_{\min} = \frac{n'^2}{R} = \frac{2^2}{R} = \frac{4}{R} \rightarrow \boxed{4 \text{ in } \text{Å}}$$

$$47] \text{ } \vec{v} = at + \vec{v}_0 = 4t + 0$$

$$-2 \text{ m/s}^2 \text{ } \vec{v}' = at' + \vec{v} = at' + 4t = -2(12 - t) + 4t$$

$$\vec{v}' = 0 \Rightarrow 0 = -2(12 - t) + 4t \rightarrow 6t = 24 \rightarrow t = 4 \text{ s}$$

$$0 \rightarrow 9 + 4 \text{ m/s}^2 \text{ } 4 \text{ s } \text{ } \checkmark$$



$$\vec{v} \Big|_{t=2} = 4t + 0 = 4 \times 2 = 8 \text{ m/s}$$

$$S_1 + S_2 = \frac{2(8+16)}{2} + \frac{1}{2}(16 \times 8)$$

$$\Delta x = 24 + 64 = 88 \text{ m}$$

$$\vec{v}_{\text{avg}} = \frac{88}{10} = 8.8 \text{ m/s}$$

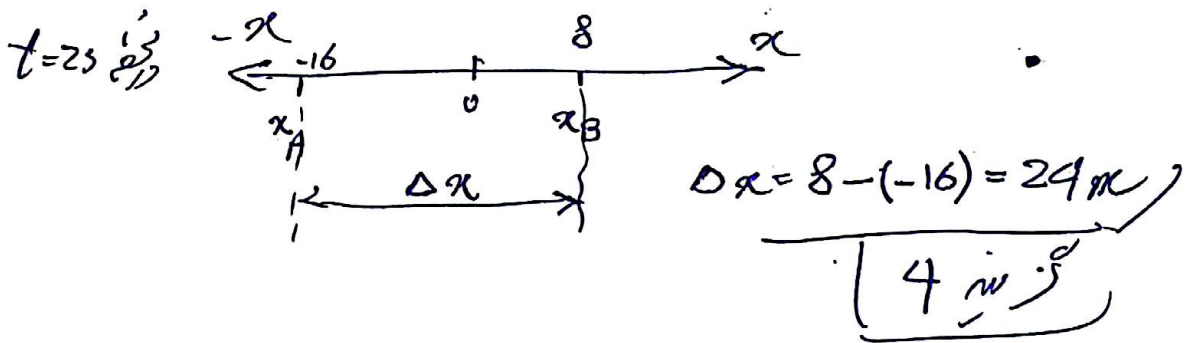
ترتیب ۱

$$48) \frac{s}{av} = \frac{\Delta v}{\Delta t} = \frac{(81-56)+81}{19} = \frac{25+81}{19} = \frac{106}{19} = \frac{53}{9} \quad \boxed{3 \text{ m/s}^2}$$

$$49) \left\{ \begin{array}{l} x_A = 50 \text{ m} \\ v_{0A} = -28 \text{ m/s} \end{array} \right\}, \left\{ \begin{array}{l} x_B = 0 \\ v_{0B} = -10 \text{ m/s} \end{array} \right\} \quad \left\{ \begin{array}{l} a_A = \frac{\Delta v}{\Delta t} = \frac{0 - (-28)}{4} = \frac{28}{4} = 7 \text{ m/s}^2 \\ a_B = \frac{\Delta v}{\Delta t} = \frac{0 - (-10)}{5} = \frac{10}{5} = +2 \text{ m/s}^2 \end{array} \right.$$

$$\left. \begin{array}{l} v_A \\ t=2s \end{array} \right| = a_A t + v_{0A} = (7 \times 2) - 28 = -14 \text{ m/s} \Rightarrow x_B = \left(\frac{v + v_0}{2} \right) \Delta t + x_0 = \frac{-6-10}{2} \times 2 + 0 = -16 \text{ m}$$

$$\left. \begin{array}{l} v_B \\ t=2s \end{array} \right| = a_B t + v_{0B} = (2 \times 2) - (10) = -6 \text{ m/s} \Rightarrow x_A = \left(\frac{-14-28}{2} \right) \times 2 + 50 = 8 \text{ m}$$



$$50) a = -3 \text{ m/s}^2, \frac{s}{av} = \frac{51}{8} = \frac{1}{\Delta t}, v_0 = ?$$

$$\Delta x = -\frac{1}{2} a t^2 + v_0 t \Rightarrow 13.5 = -\frac{1}{2} \times (-3) (t^2) \Rightarrow t = 3 \text{ s}$$

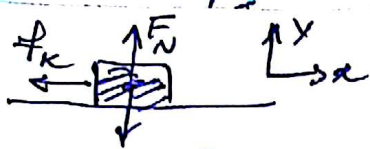
$$\Delta x = 51 - (2 \times 13.5) = 24 \text{ m}$$

$$\Delta x = \frac{1}{2} a t^2 + v_0 t \Rightarrow 24 = \frac{1}{2} (-3) (3^2) + 8 v_0 \Rightarrow 8 v_0 = 24 + 96 = 120$$

$$\Rightarrow v_0 = \frac{120}{8} = 15 \text{ m/s}$$

$\boxed{2 \text{ m/s}^2}$

51)



$$\mu_k = 0.2, \quad l = 6.25 \text{ m}, \quad g = 10 \text{ N/kg}$$

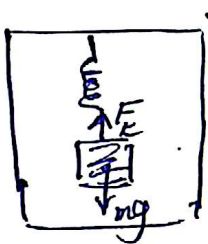
$$\sum F = ma \rightarrow -f_k = ma \rightarrow -\mu_k mg = ma \rightarrow a = -2 \text{ m/s}^2$$

$$v^2 - v_0^2 = 2a\Delta x \rightarrow 0 - v_0^2 = 2(-2)(6.25) \rightarrow v_0 = 5 \text{ m/s}$$

$$\Delta x = \left(\frac{v + v_0}{2}\right) \Delta t \rightarrow 6.25 = \left(\frac{0 + 5}{2}\right) \Delta t \rightarrow \Delta t = \frac{12.5}{5} = 2.5 \text{ s}$$

1 نتیجه

52)



$$\sum F = ma \rightarrow F - mg = ma \rightarrow F = m(g + a)$$

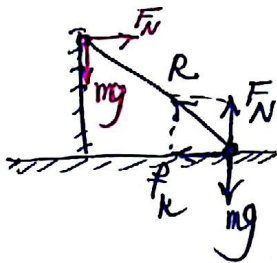
$$250 \times \Delta l = 0.5(9.8 + a) \rightarrow \Delta l = \frac{5.15}{250} = 0.0206 \text{ m}$$

$$\Delta x = \frac{1}{2}at^2 + v_0t \rightarrow 16 = \frac{1}{2}a \times (8)^2 + 0 \rightarrow a = 0.5 \text{ m/s}^2$$

$$\Delta l = 0.0206 \text{ m} = +20.6 \text{ mm}$$

4 نتیجه

53)

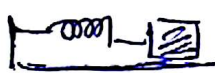


$$R = \sqrt{F_N^2 + f_k^2} = \sqrt{(mg)^2 + f_k^2} = \sqrt{(mg)^2 + (\mu_k mg)^2}$$

ان R نیروی پارشیال است
نیروی سنجی

$$mg < R \rightarrow 3 \text{ نتیجه}$$

39)



$$x = A \cos(\omega t)$$

$$\pi = 3$$

$$\frac{\pi}{4} = 0.15 \text{ s} \Rightarrow \pi = 0.6 \text{ s}$$

$$v = v_{\max} = A\omega \Rightarrow 0.5 = A \times \frac{2\pi}{\pi} = A \times \frac{6}{0.6}$$

$$\Rightarrow A = \frac{0.5 \times 0.6}{6} = 0.05 \text{ m} = 5 \text{ cm}$$

2 نتیجه

55

جزء ٥: $K_{\max} = 9 \text{ mJ} = 9 \times 10^{-3} \text{ J}$, $A = 4 \text{ cm} = 4 \times 10^{-2} \text{ m}$

$|a| = ? \Rightarrow |a| = \omega^2 |x| \Rightarrow |a| = 50 \times 3 \times 10^{-2} = 1.5 \text{ m/s}^2$

$x = 3 \text{ cm}$

$K_{\max} = \frac{1}{2} m \omega^2 A^2 \Rightarrow 9 \times 10^{-3} = \frac{1}{2} \times 10^{-3} \times \omega^2 \times (4 \times 10^{-2})^2$

$\Rightarrow 4 \times 10^{-3} = \frac{1}{2} \times 10^{-3} \times \omega^2 \times 16 \times 10^{-4} \Rightarrow \omega^2 = \frac{4}{8 \times 10^{-2}} = 0.5 \times 10^2 = 50 \text{ s}^{-2}$

$\boxed{3 \text{ cm}}$

56

جزء ٥: $M \text{ cm}$

$v_{\max} = A \omega = A (2\pi f)$ $A = 10 \text{ cm} = 0.1 \text{ m}$ $f = 8 \text{ Hz}$ $v_{\max} = 2\pi \times \frac{1}{10} \times 8 = \frac{8\pi}{5}$

$\boxed{1 \text{ m/s}}$

57

$\beta_2 - \beta_1 = -14 \text{ dB} = 10 \log \frac{I_2}{I_1} \xrightarrow{I \propto \frac{1}{r^2}} -14 = 10 \log \left(\frac{r_1}{r_2} \right)^2$

$\Rightarrow \frac{14}{20} = \log \left(\frac{r_2}{r_1} \right) = \log \left(\frac{r_2 + 20}{r_1} \right)$

~~$\log 2 = 0.3$~~

~~$\log 5 = 0.7$~~

$\log 2 = 0.3 \rightarrow \log 4 = 2 \log 2 = 0.6$

$\log 5 = \log \left(\frac{10}{2} \right) = \log 10 - \log 2 = 1 - 0.3 = 0.7$

$\Rightarrow 0.7 = \log 5 = \log \left(\frac{r_1 + 20}{r_1} \right) \Rightarrow 5 r_1 = r_1 + 20 \Rightarrow r_1 = 5 \text{ cm}$

$\boxed{1 \text{ m/s}}$

58) $n_B > n_A \Rightarrow \lambda_B < \lambda_A \Rightarrow \frac{1}{\lambda_B} > \frac{1}{\lambda_A} \rightarrow$ پهنای موج بیشتر در B است
 پرتو A سخت‌تر است
 [2 نمره]

59) $N(t) = \frac{1}{3} N_0$, $N(t_{1/2}) = ?$

$$N(t) = N_0 \left(\frac{1}{2}\right)^n \Rightarrow \frac{1}{3} N_0 = N_0 \left(\frac{1}{2}\right)^n \Rightarrow \left(\frac{1}{2}\right)^n = \frac{1}{3}$$

$$N(t_{1/2}) = N_0 \left(\frac{1}{2}\right)^{n/2} = N_0 \left(\left(\frac{1}{2}\right)^n\right)^{1/2} = N_0 \left(\frac{1}{3}\right)^{1/2} = N_0 \sqrt{\frac{1}{3}} = \frac{\sqrt{3}}{3} N_0$$

[4 نمره]

60) $|F_{T3}| = |F_{13}|$, $q_1 = 9 \mu C$, $q_2 = ?$

$$|F_{13}| = k \frac{q_1 q_3}{(3d)^2} = \cancel{k} \frac{q_1 q_3}{d^2} = \frac{k q_3}{d^2} \Rightarrow |F_{T3}| = |F_{13}| + |F_{23}|$$

$$|F_{23}| = k \frac{q_2 q_3}{(d^2)} = \dots$$

$$|F_{T3}| = \frac{k q_3}{d^2} + \frac{k q_2 q_3}{d^2} = \frac{k q_3}{d^2}$$

$$\Rightarrow |q_3| + |q_2| |q_3| = |q_3| \Rightarrow q_2 = -2 \mu C$$

ایستادن نیروی جاذبه انداز F_{13} شود پس F_{23} و F_{13} در جهت مخالف است
 پس $q_2 < 0$ و $q_1 = +9 \mu C$

[3 نمره]

61) $q_2 = 18 \text{ nC}$ $q_1 = 8 \text{ nC}$ $r = 20 \text{ cm}$ $d_1 + d_2 = ?$

$$|E_1| = 4|E_2| \Rightarrow k \frac{q_1}{d_1^2} = 4k \frac{q_2}{(r-d_1)^2} \Rightarrow \frac{8}{d_1^2} = \frac{4 \times 18}{(r-d_1)^2}$$

$$\Rightarrow 9d_1^2 = (r-d_1)^2 \Rightarrow 3d_1 = r-d_1 \Rightarrow 4d_1 = 20 \Rightarrow d_1 = 5 \text{ cm}$$

$$|E_1| = 4|E_2| \Rightarrow k \frac{q_1}{(d_2)^2} = 4k \frac{q_2}{(20+d_2)^2} \Rightarrow \frac{8}{d_2^2} = \frac{4 \times 18}{(20+d_2)^2}$$

$$\Rightarrow 9d_2^2 = (20+d_2)^2 \Rightarrow 3d_2 = 20+d_2 \Rightarrow 2d_2 = 20 \Rightarrow d_2 = 10 \text{ cm}$$

$$d_1 + d_2 = 5 + 10 = 15 \text{ cm}$$

2 marks

$$U_1 = \frac{1}{2} \frac{q^2}{C} = \frac{1}{2} \times \frac{50 \times 50}{10} = \frac{250}{2} = 125 \text{ nJ}$$

$$U_2 = \frac{1}{2} C' V^2 = \frac{1}{2} \times (5 \times 10) \times (5^2) \Rightarrow U_2 = 625 \text{ nJ}$$

$$C = k \epsilon \frac{A}{d} \Rightarrow C' = 5C$$

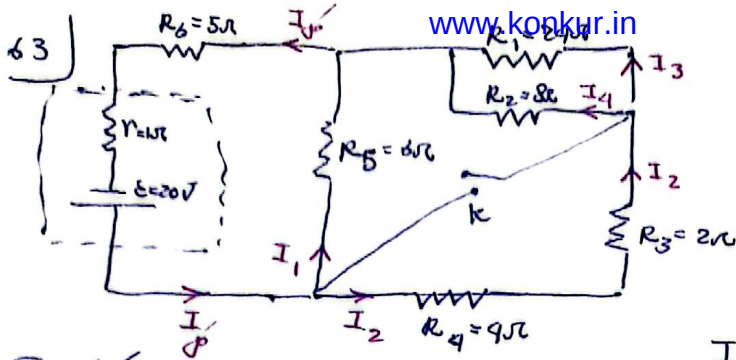
$$C' = k' \epsilon \frac{A}{d}$$

$$V = \frac{Q}{C} = \frac{50}{10} = 5 = V' \rightarrow \text{potential difference remains same}$$

$$625 \text{ nJ}$$

$$\Rightarrow \Delta U = 625 - 125 = 500 \text{ nJ}$$

3 marks



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$I_4 = \dots$

$I'_4 = \dots$

$\frac{I'_4}{I_4} = ?$

$R_1 \parallel R_2 \Rightarrow R_{12} = \frac{2 \times 8}{2+8} = 6 \Omega$

$R_{12} - R_3 - R_4 \Rightarrow R_{1234} = 6 + 2 + 4 = 12 \Omega$

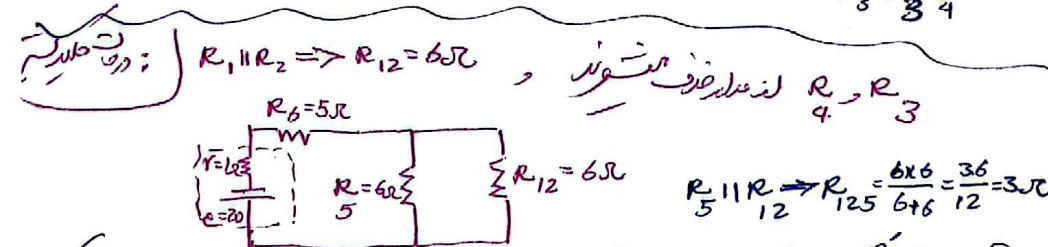
$R_{1234} \parallel R_5 \Rightarrow R_{12345} = \frac{12 \times 6}{12+6} = 4 \Omega$

$R_{12345} - R_6 \Rightarrow R = R_{123456} = 4 + 5 = 9 \Omega$

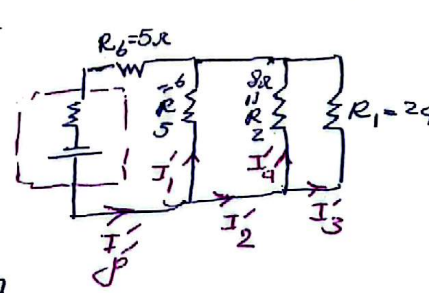
$I'_1 = \frac{\epsilon}{R + r} = \frac{20}{9+1} = 2 A$

$R_{1234} \parallel R_5 \Rightarrow \begin{cases} I_1 + I_2 = 2 A \\ V_1 = V_2 \Rightarrow I_1 = 2 I_2 \end{cases} \Rightarrow \begin{cases} I_2 = \frac{2}{3} A \\ I_1 = \frac{4}{3} A \end{cases}$

$R_1 \parallel R_2 \parallel R_3 \Rightarrow \begin{cases} I_3 + I_4 = I_2 = \frac{2}{3} A \\ V_3 = V_4 \Rightarrow I_3 R_1 = R_2 I_4 \Rightarrow 2 I_3 = 8 I_4 \Rightarrow I_4 = \frac{1}{4} I_3 \end{cases} \Rightarrow \begin{cases} I_4 = \frac{1}{5} A \\ I_3 = \frac{1}{3} A \end{cases}$



$I'_1 = \frac{\epsilon}{R' + r} = \frac{20}{\frac{85}{11} + 1} = \frac{20}{\frac{96}{11}} = \frac{20 \times 11}{96} A$



$I'_1 R_5 = I'_2 R_{12} \Rightarrow I'_1 = 2 I'_2$

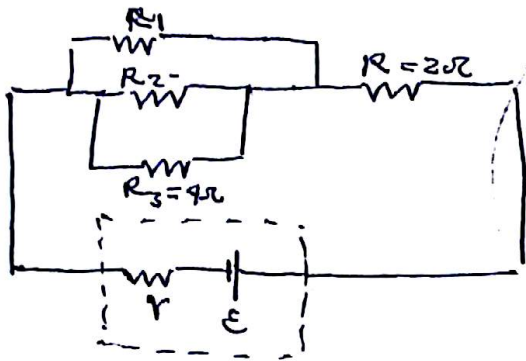
$I'_1 + I'_2 = \frac{20}{9} \Rightarrow 2 I'_2 + I'_2 = \frac{20}{9} \Rightarrow I'_2 = \frac{10}{9} A$

$I'_4 R_2 = I'_3 R_1 \Rightarrow 8 I'_4 = 2 I'_3 \Rightarrow I'_3 = 4 I'_4$

$I'_4 + I'_3 = I'_2 = \frac{10}{9} A \Rightarrow I'_4 + 4 I'_4 = \frac{10}{9} \Rightarrow I'_4 = \frac{2}{9} A$

$\frac{I'_4}{I_4} = \frac{\frac{2}{9}}{\frac{1}{2}} = \frac{2 \times 2}{9} = \frac{4}{9}$

69



$$P = P_1 + P_2 + P_3$$

$$P_1 = 2P_2$$

$$R_1, R_2 = ?$$

$$R_1 \parallel R_2 \parallel R_3 \Rightarrow R_{123} = R_P$$

جواب سوال، معادله توان و معادله مقاومت
1. معادله توان

$$R = R_P = 20 \Omega$$

$$\frac{1}{R} = \frac{1}{R_P}$$

$$\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{R_P} \Rightarrow \frac{1}{2} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{9} \Rightarrow \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{9}$$

$$R_1 = 6, R_2 = 12$$

4 نمره

$$65) R = \rho \frac{L}{A} \Rightarrow \frac{R_2}{R_1} = \frac{\rho_2}{\rho_1} \times \frac{L_2}{L_1} \times \frac{A_1}{A_2}$$

$$L_2 = 0.8L_1, A_1 = \pi \left(\frac{d_1}{2}\right)^2 \Rightarrow A_2 = \pi \left(\frac{0.8d_1}{2}\right)^2$$

$$\frac{R_2}{R_1} = \frac{0.8L_1}{L_1} \times \frac{\pi \left(\frac{d_1}{2}\right)^2}{\pi \left(\frac{0.8d_1}{2}\right)^2} \Rightarrow \frac{R_2}{R_1} = \frac{0.8}{0.8 \times 0.8} = \frac{1}{0.8} = \frac{10}{8} = \frac{5}{4}$$

2 نمره

$$66) \rho = 1.4 \Rightarrow \frac{m_A + m_B}{V_A + V_B} \Rightarrow \frac{1.2V_A + 1.8V_B}{V_A + V_B} = 1.4 \Rightarrow 1.2V_A + 1.8V_B = 1.4V_A + 1.4V_B$$

$$\rho_A = 1.2 \frac{g}{cm^3}$$

$$\rho_B = 1.8 \frac{g}{cm^3}$$

$$\rho = \frac{m}{V} \Rightarrow m = \rho V$$

$$0.2V_A = 0.4V_B \Rightarrow V_A = 2V_B$$

$$\frac{m_A}{m_B} = \frac{\rho_A V_A}{\rho_B V_B} = \frac{1.2 \times 2V_B}{1.8 \times V_B} = \frac{2.4}{1.8} = \frac{4}{3}$$

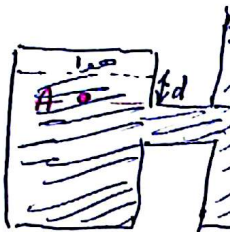
3 نمره

67) $\Delta p = \rho g \Delta h \Rightarrow 6000 = \rho \times 10 \times \left(\frac{20}{100}\right) \Rightarrow \rho = 3000 \frac{\text{kg}}{\text{m}^3}$

$\Delta p' = \rho g \Delta h' \Rightarrow \Delta p' = 3000 \times 10 \times \left(\frac{23}{100}\right) = 6900 \text{ Pa}$

$\Rightarrow \Delta p' = 6.9 \text{ kPa}$ / 4 نمره

68



$P_A = P_B \Rightarrow P + \rho g d = P + \rho g D$

$P = P - P = \rho g (D - d)$

$P_g = P_r \times g (74.8 - 6.8) = 68 P_r g$

$P_r = 13.6 P_r$

$P_g = 5 \text{ cm-Hg}$ / 1 نمره

$P_r h_r g = \rho h g \Rightarrow h = \frac{P_r \times 68}{13.6 P_r} = 5 \text{ cm-Hg}$

69

$\eta_{\text{کل}} = \eta_{\text{محرک}} \times \eta_{\text{مکانیک}} = \frac{25}{100} \times \frac{60}{100} = \frac{1500}{10000} = \frac{15}{100} = \frac{1}{5}$ / 4 نمره

70

$Q = mL_f \Rightarrow \frac{Q_A}{Q_B} = \frac{m_A}{m_B} \times \frac{L_A}{L_B} \rightarrow \frac{L_A}{L_B} = \frac{Q_A/Q_B}{m_A/m_B} = \frac{50/150}{0.4/3} = 2.5$

$m_A = 0.4 \text{ kg}, Q_A = 50 \text{ kJ}$

$m_B = 3 \text{ kg}, Q_B = 150 \text{ kJ}$ / 2 نمره

71

$Q_r + Q = 0 \Rightarrow 1369.1 \theta_e = 90087 \rightarrow \theta_e \cong 66^\circ \text{C}$

$Q_r = m_r c_r (\Delta \theta) = (0.3 \times 4187 \times (\theta_e - 70)) = 1256.1 \theta_e - 87927$

$Q = m c (\Delta \theta) = (0.12 \times 900 \times (\theta_e - 20)) = 108 \theta_e - 2160$

3 نمره

72

$I_{\text{max}} = 4 \text{ A}, T = 0.02 \text{ s}, R = 4 \Omega, \epsilon = ?$

$I = 4 \sin\left(\frac{2\pi}{0.02} t\right), \epsilon = IR = 4 \sin\left(\frac{2\pi}{0.02} \times \frac{5}{600}\right) \times 4$

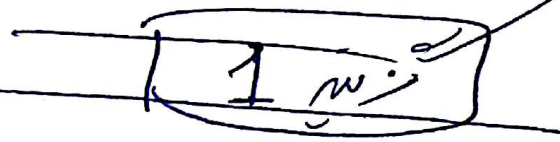
$\Rightarrow \epsilon = 4 \sin\left(\frac{200\pi}{2} \times \frac{5}{600}\right) \times 4$

$\Rightarrow \epsilon = 4 \times \frac{1}{2} \times 4^2$

$\epsilon = 8 \text{ V}$ / 4 نمره

73] $B = \frac{\mu_0 NI}{L} \Rightarrow N = \frac{BL}{\mu_0 I} = \frac{(1.8 \times 10^{-4}) \times (50 \times 10^{-2})}{(12 \times 10^{-7})(1.5)}$

$N = \frac{1.8 \times 5 \times 10^{-5}}{12 \times 1.5 \times 10^{-7}} = \frac{9}{18} \times 10^{+2} = 0.5 \times 10^{+2} = 5 \times 10^1 = 50$ عدد



74] کثرت 3 عدد

75] به شماره ارتفاع 1 و به شماره ارتفاع 2

دست 2 عدد 1 عدد