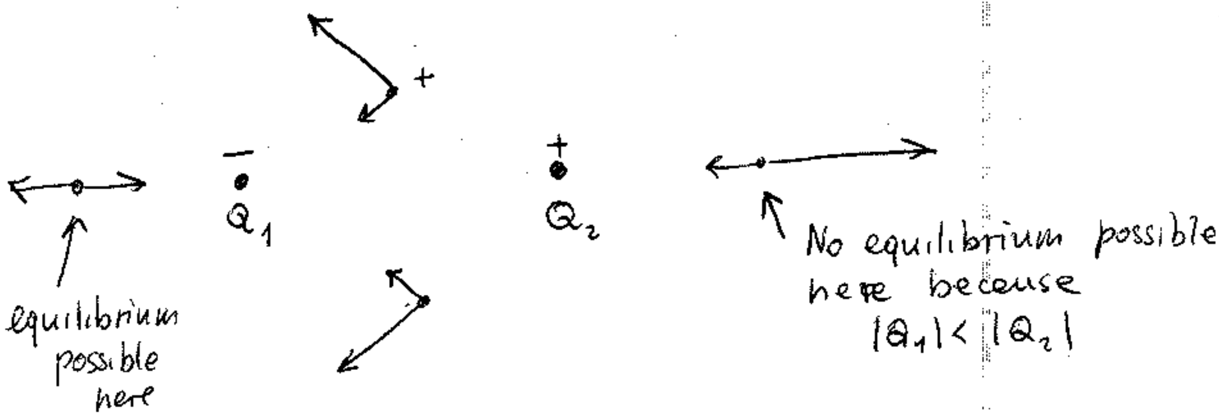
PHYSICS 3 FINAL
FALL 2004 TR SECTION

1 $\boxed{A}$



2 $\boxed{C}$ Consider spherical gaussian surface just inside shell – No field ⇒ No flux ⇒ Total enclosed charge is zero

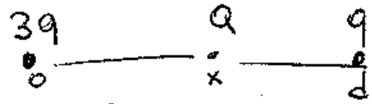
3 $\boxed{B}$ $\Phi = EA\cos 60° = 1000\,\frac{N}{C}\;100\;cm^2\;\frac{1}{2} = 5\;10^4\,\frac{N}{C}\,cm^2 = 5\,\frac{N}{C}\,m^2$

4 $\boxed{A}$ Ideal voltmeter has infinite resistance, therefore it measures the true EMF

5 $\boxed{A}$ $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{20\,\mu F} + \frac{1}{20\,\mu F} = \frac{1}{10\,\mu F}$ $\quad C = 10\,\mu F$

6 $\boxed{D}$ $I = V/R \quad P = I^2 R = \frac{V^2}{R^2} R = \frac{V^2}{R} = \frac{25}{10}\,W = 2.5\,W$

7 $\boxed{B}$



$$\frac{3qQ}{x^2} = \frac{qQ}{(d-x)^2}$$

$$(d-x)^2 = \tfrac{1}{3}x^2$$
$$d^2 - 2dx + x^2 = \tfrac{1}{3}x^2$$
$$\tfrac{2}{3}x^2 - 2dx + d^2 = 0$$

$$x = \frac{2d \pm \sqrt{4d^2 - 4\,\tfrac{2}{3}\,d^2}}{4/3}$$

$$x = \frac{3d}{4}\left[2 \pm \sqrt{4\left(1-\tfrac{2}{3}\right)}\right] = \frac{3d}{2}\left[1 \pm \sqrt{\tfrac{1}{3}}\right]$$

Need to take negative sign

$$x = \frac{3d}{2}\left[1 - \sqrt{\tfrac{1}{3}}\right] = 0.634\,d$$

8 $\boxed{C}$

$$\Delta f = \frac{V}{V-V_c} f - \frac{V}{V+V_c} f = \left(\frac{350}{315} - \frac{350}{385}\right) f$$
$$\Delta f = (1.111 - 0.909) f = 0.202\,f = 202\ \text{Hz}$$

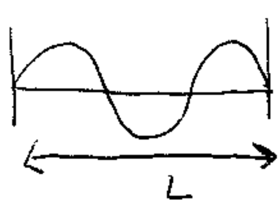
9 $\boxed{A}$

$R = \frac{\rho L}{A}$ Double diameter $\rightarrow$ resistance factor of 4 smaller $\frac{2\Omega}{4} = 0.5\,\Omega$

10 $\boxed{B}$

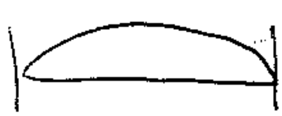
$$\Delta f = f_1 - f_2 = \frac{v}{\lambda_1} - \frac{v}{\lambda_2} = v\,\frac{\lambda_2 - \lambda_1}{\lambda_1 \lambda_2} = 336\ \frac{1}{42} = 8$$

11 $\boxed{D}$



$\lambda = \frac{2}{3}L \quad f = f' = 12\ \text{Hz}$

$v = \lambda f' = \frac{2}{3} L f'$



$\lambda = 2L$

$v = \frac{2}{3} L f' = \lambda f_0 = 2 f_0 L$

$f_0 = \frac{1}{3} f' = 4\ \text{Hz}$

12 $y = 4 \sin \frac{\pi}{2}(x - 400t)$

(a) $\boxed{A = 4m}$

(b) $y = A \sin(kx - \omega t) \longrightarrow k = \frac{\pi}{2} \frac{1}{m}$

But $k = \frac{2\pi}{\lambda} \rightarrow \frac{2\pi}{\lambda} = \frac{\pi}{2m} \rightarrow \boxed{\lambda = 4m}$

(c) $w = \frac{\pi}{2} 400 \frac{1}{sec} = 200\pi \frac{1}{sec}$

$v = \frac{w}{k} = 200\pi \frac{2}{\pi} \, m/sec = \boxed{400 \, m/sec}$

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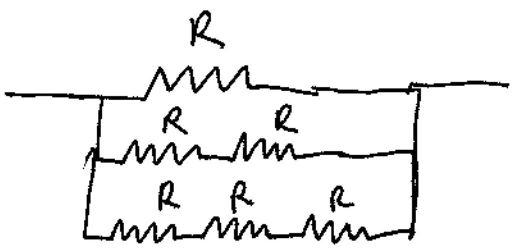

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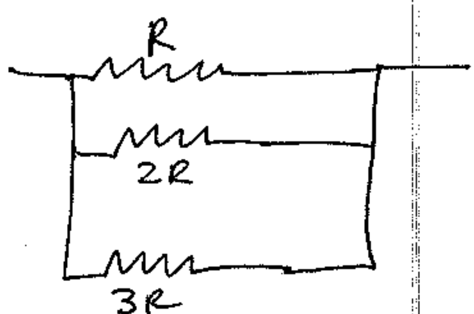


$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{2R} + \frac{1}{3R} = \frac{1}{R}\left(\frac{6+3+2}{6}\right) = \frac{11}{6R}$

$\boxed{R_{eq} = \frac{6}{11} R}$

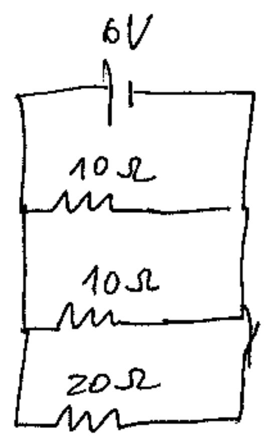
(14) $+\lambda$ at $x=0$ $\quad$ $-\lambda$ at $x=D$

Field due to wire at $x=0$ on the x-axis $E_x = \dfrac{\lambda}{2\pi\varepsilon_0 x}$

Field due to wire at $x=D$ on the x-axis $E_x = \dfrac{\lambda}{2\pi\varepsilon_0 (D-x)}$

Total field $E_x = \dfrac{\lambda}{2\pi\varepsilon_0}\left[\dfrac{1}{x} + \dfrac{1}{D-x}\right]$ $\quad$ $\boxed{E_x = \dfrac{\lambda}{2\pi\varepsilon_0}\,\dfrac{D}{x(D-x)}}$

(15) Redraw this circuit



(a) $\boxed{V = \mathcal{E} = 6V}$

(b) $I = \dfrac{\mathcal{E}}{R}$ $\quad$ $I = \dfrac{6}{20}A$

$\boxed{I = 0.3A}$

(c) $\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} = \left(\dfrac{1}{10} + \dfrac{1}{10} + \dfrac{1}{20}\right)\dfrac{1}{\Omega}$

$\dfrac{1}{R_{eq}} = \dfrac{2+2+1}{20}\,\dfrac{1}{\Omega}$ $\qquad$ $R_{eq} = 4\Omega$

$I = \dfrac{\mathcal{E}}{R_{eq}} = \dfrac{6V}{4\Omega}$ $\quad$ $\boxed{I = 1.5A}$

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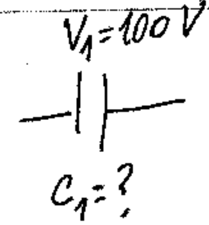
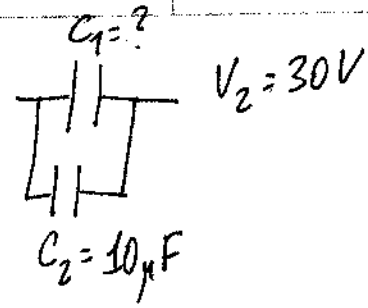




The charge is the same !

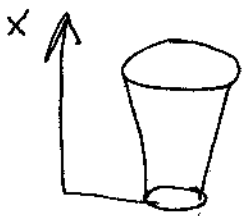
Before $Q = C_1 V_1$

After $Q = C_{eq} V_2 = (C_1 + C_2) V_2$

$$C_1 V_1 = C_1 V_2 + C_2 V_2 \qquad C_1 = C_2 \frac{V_2}{V_1 - V_2} = 10\,\mu F \;\frac{30}{70}$$

$$\boxed{C_1 = 4.3\,\mu F}$$

17 (a) Resistance of a disk, thickness dx : $dR = \rho \dfrac{dx}{\pi r^2(x)}$



$$r(x) = r_2 + \frac{r_1 - r_2}{h} x =$$

$$dR = \frac{\rho\, dx}{\pi \left(r_2 + \frac{r_1 - r_2}{h} x\right)^2} \qquad R = \int_0^h \frac{\rho}{\pi} \frac{dx}{\left(r_2 + \frac{r_1 - r_2}{h} x\right)^2}$$

$$\int \frac{dx}{(A + Bx)^2} = -\frac{1}{B} \frac{1}{A + Bx} \qquad \text{here, } A = r_2 \quad B = \frac{r_1 - r_2}{h}$$

$$R = \frac{\rho}{\pi} \frac{h}{r_1 - r_2} \left[-\frac{1}{r_1 + \frac{r_1 - r_2}{h} x} \right] = \frac{\rho}{\pi} \frac{h}{r_1 - r_2} \left[\frac{1}{r_2} - \frac{1}{r_1} \right] = \frac{\rho}{\pi} \frac{h}{r_1 - r_2} \frac{r_1 - r_2}{r_1 r_2}$$

$$\boxed{R = \frac{\rho}{\pi} \frac{h}{r_1 r_2}}$$

(b) If $r_1 = r_2 = r$ $R = \dfrac{\rho}{\pi} \dfrac{h}{r^2}$ as expected