Solution

Final Exam, PHYS-2038-002, Spring 2017

Prob. 1

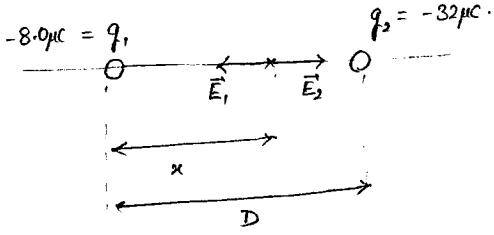
$|\vec{E}_1| = |\vec{E}_2|$

$\frac{k|q_1|}{x^2} = \frac{k|q_2|}{(D-x)^2}$

$\frac{8.0}{x^2} = \frac{32}{(D-x)^2}$

$D - x = \pm 2x$

$x = \frac{D}{(1 \pm 2)} = +\frac{D}{3}$ or $-D$ → not consistent with $x > 0$.



Answer: $x = \frac{D}{3} = \frac{10.0\,cm}{3} = 3.3\,cm.$

Prob. 2

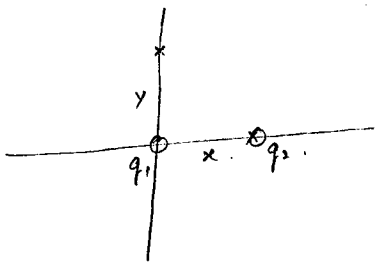
$U_i = \frac{k q_1 q_2}{x} = -\frac{8.99\times10^9 \times 6.0\times10^{-8} \times 2.0\times10^{-8}}{3.0\times10^{-2}}$

$= -3.60\times10^{-4}\ J$

$U_f = \frac{k q_1 q_2}{y} = -\frac{8.99\times10^9 \times 6.0\times10^{-8} \times 2.0\times10^{-8}}{4.0\times10^{-2}}$

$= -2.70\times10^{-4}\ J$

$U_f - U_i = -2.70\times10^{-4} - (-3.60\times10^{-4}) = +9.0\times10^{-5}\ J$



Prob. 3

$C_A = C_B$

$U_A = \frac{Q_A^2}{2C_A}$

$U_B = \frac{Q_B^2}{2C_B}$

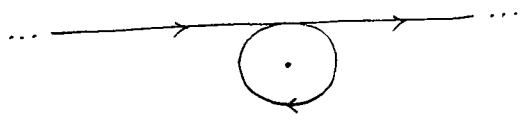
$\frac{U_A}{U_B} = \frac{Q_A^2}{Q_B^2}$

$Q_A = \sqrt{\frac{U_A}{U_B}}\ Q_B$

$= \sqrt{\frac{16\times10^{-3}}{4\times10^{-3}}}\ 1.0\,\mu C = 2.0\,\mu C$

Prob. 4

$$B = B_{\text{infinite wire}} + B_{\text{circle}}$$



$$= \frac{\mu_0 I}{2\pi a} + \frac{\mu_0 I}{2a}$$

$$= \frac{\mu_0 I}{2\pi a}\left(1+\pi\right) = \frac{\cancel{4\pi}^{2} \times 10^{-7} \times 2.0}{\cancel{2\pi} \times 0.100}\left(1+\pi\right) = 1.7 \times 10^{-5}\ \text{T}$$

direction: into the page.

Prob. 5

$$V = N\left(\frac{\Delta B}{\Delta t}\right) A$$

$$= 50\left(\frac{(2-0)\ \text{T}}{(2-0)\ \text{s}}\right) 25 \times 10^{-4}\ \text{m}^2 = 0.13\ \text{V}$$

$$I = \frac{V}{R} = \frac{0.13}{100.0} = 1.3 \times 10^{-3}\ \text{A} = 1.3\ \text{mA}.$$

Prob. 6

$$4.4\ \text{light-years} = 4.4\ \text{light-year}\ \frac{c \times 1\ \text{year}}{1\ \text{light-year}}$$

$$= 4.4 \times \left(3.0 \times 10^{8}\ \frac{\text{m}}{\cancel{\text{s}}}\right) \times \left(365 \times 24 \times 60 \times 60\ \cancel{\text{s}}\right)$$

$$= 4.2 \times 10^{16}\ \text{m}$$

Prob. 7

(d) Virtual, upright, and the same size as you.

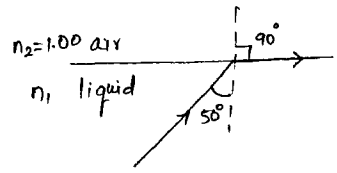
Prob. 8

$$n_1 \sin\theta_c = n_2 \underbrace{\sin 90}_{=1}$$

$$\frac{c}{v_1}\sin\theta_c = n_2$$

$$v_1 = c\,\frac{\sin\theta_c}{n_2} = 3.0\times10^8\ \frac{m}{s}\ \frac{\sin 50}{1.00}$$

$$= 2.3\times10^8\ \frac{m}{s}$$



Prob. 9

(a) $R = 2f = 20.0\text{cm}$

(b) $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

$\frac{1}{+5.0} + \frac{1}{d_i} = \frac{1}{+10} \Rightarrow d_i = -10.0\text{cm}$

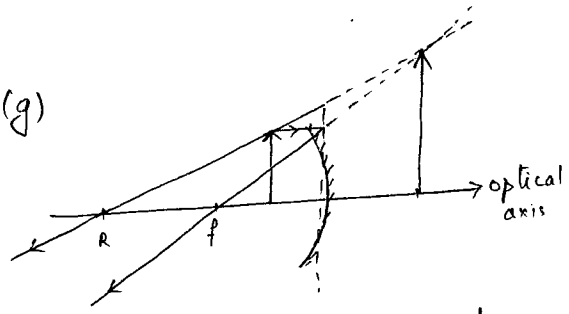
(c) $m = -\frac{d_i}{d_o} = -\frac{(-10.0\text{cm})}{5.0\text{cm}} = +2.0$

(d) virtual

(e) upright

(f) $h_i = m h_o$
$= +2.0\times1.0\text{cm}$
$= +2.0\text{cm}$

(g)



Prob. 10

(a) $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

$\frac{1}{+20} + \frac{1}{d_i} = \frac{1}{+10} \Rightarrow d_i = +20.0\text{cm}$

(b) $m = -\frac{d_i}{d_o} = -\frac{20.0\text{cm}}{20.0\text{cm}} = -1.0$

(c) real

(d) Inverted

(e) $h_i = m h_o = -1.0\times1.0\text{cm}$
$= -1.0\text{cm}$

(f)