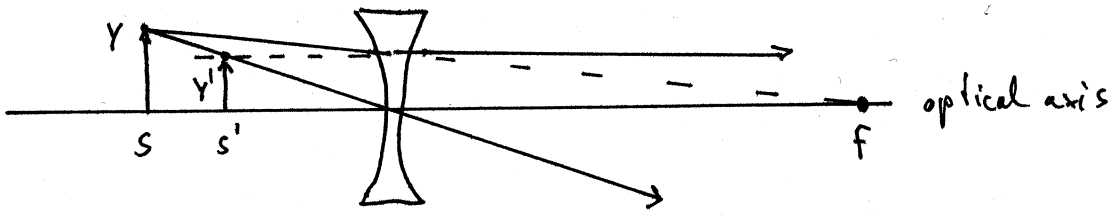
Solutions Final Exam PHY2049 Dec. 5th, 2003

1. up, out, ~~out~~ in, no force

2. a) $\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \rightarrow f = -48\,cm$ diverging

b) $y' = y \cdot \left(-\frac{s'}{s}\right) = 0.26\,cm$ erect

c)



3. a) Left loop: $14 - I_1 - 2(I_1 - I_2) = 0$

Top loop: $-2\cdot(I - I_1) + I_2 + I_1 = 0$

Bottom loop: $-(I - I_1 + I_2) + 2(I_1 - I_2) - I_2 = 0$

$\rightarrow I = 10\,A \quad I_1 = I_{R_1} = 6\,A \quad I_2 = I_{R_3} = 2\,A$

$I_{R_2} = I - I_1 = 4\,A \quad I_{R_4} = I_1 - I_2 = 4\,A \quad I_{R_5} = I - I_1 + I_2 = 6\,A$

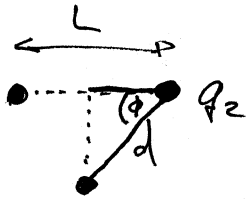
b) $V_{ab} = V_b - V_a = R_5 \cdot I_{R_5} = 6\,V$

c) $R_{eq} = \frac{V}{I} = 1.4\,\Omega$

4. a) $q_1 > 0 \quad q_2 > 0 \quad q_3 < 0$

b) $|\vec{F}|_{13} = k\frac{q_1 q_3}{d^2} = |\vec{F}_{23}| = k\frac{q_2 \cdot q_3}{d^2} = 9\cdot 10^9 \frac{Nm^2}{C^2} \frac{(6\cdot 10^{-6} C)^2}{1m^2}$

$= \underline{0.324\,N} = F_0$ (not the total force!)



$\cos\phi = \frac{L}{2d}$

Total force: $F_{total} = 2 \cdot F_0 \cdot \sin\phi$ where ~~with~~

with L = distance between q_1 and q_2

$\Rightarrow F_{total} = 0.648\,N \cdot \sin\phi$ with $\phi = \arccos\frac{L}{2m}$

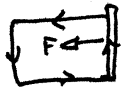
c) $U = k\cdot\frac{q_1 q_3}{d} + k\frac{q_2 q_3}{d} = -2\cdot 9\cdot 10^9 \frac{Nm^2}{C^2}\frac{(6\cdot 10^{-6} C)^2}{1m} = \underline{-0.648\,J}$

d) $|F_{34}| = k\frac{q_3 q_4}{x^2} = 2\cdot F_0 \cdot \sin\phi \Rightarrow x = \sqrt{\frac{k\cdot q_3 q_4}{2F_0\cdot\sin\phi}} = \frac{1m}{\sqrt{\sin\phi}}$

q_4 is located $x = \frac{1m}{\sqrt{\sin\phi}}$ below q_3

5. a) $\mathcal{E} = v \cdot B \cdot L = 3V$

b) up, counterclockwise

c) $\dot{A} > 0$, hence the induced emf will oppose its cause (Lenz's law)
$\dot{\phi} > 0$ or 

Lorentz Force F acting on induced current reduces Flux.

d) $F = I L B = \frac{\mathcal{E}}{R} L B = 0.8 N$ to the right

6. Gauss' law. a) $\phi = 0$

b) $\phi = \frac{q_2}{\varepsilon_0} = -678 \frac{Nm^2}{C}$

c) $\phi = \frac{q_1 + q_2}{\varepsilon_0} = -226 \frac{Nm^2}{C}$

7. a) $C = \varepsilon_0 \frac{A}{d} = 4.425 \cdot 10^{-10} F$

b) $U = \frac{1}{2} \frac{1}{C} Q^2 = 1.13 \cdot 10^{-5} J$

c) Electric energy is stored in the electric field

d) $V = \frac{Q}{C} = 226V$

e) $V = E d \rightarrow E = \frac{V}{d} = 1.13 \cdot 10^5 \frac{N}{C}$