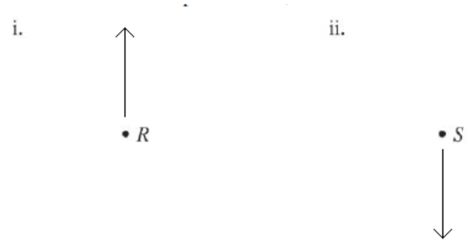
2017 AP Physics C Electricity and Magnetism Free Response Answers

1a.



1b.i.

$Q_{enc} = \varepsilon_0 \cdot \Phi_E$

$\rho A h = \varepsilon_0 \cdot \Phi_E$

$\Phi_E = \frac{\rho_0 Ah}{\varepsilon_0}$

1b.ii.

$Q_{enc} = \varepsilon_0 \cdot \Phi_E$

$\rho_0 A(2z) = \varepsilon_0 \cdot \Phi_E = \varepsilon_0 \cdot E \cdot (2A)$

$E = \frac{\rho_0 z}{\varepsilon_0}$

1c.i.

$z_0 < 0$. The electric field of the metal plate is upwards/positive. The electric field of the charged slab must then be downwards/negative. Similar to point S in question 1a, this point must be below zero. (By the way, this is a confusingly-worded question)

1c.ii.

$0 = E_{plates} + E_{slab}$

$0 = \frac{\sigma_{plates}}{\varepsilon_0} + \frac{\rho_0 z}{\varepsilon_0}$

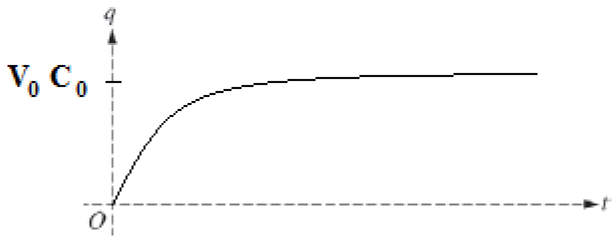
$0 = 2 \text{ x } 10^{-6} + 1 \text{ x } 10^{-3} \cdot z$

$z = -0.002\text{m}$

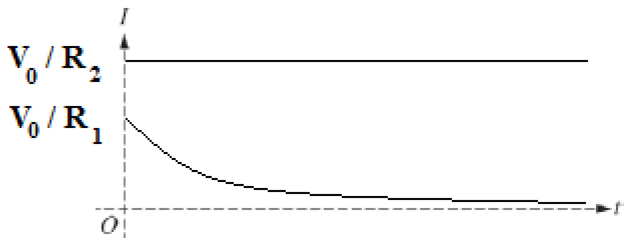
1d.

$\Delta V = -\int \frac{\sigma_{plates}}{\varepsilon_0} + \frac{\rho_0 z}{\varepsilon_0} \cdot dz = \frac{-1}{\varepsilon_0} \int_0^{0.005} (2x10^{-6} + 1x10^{-3} \cdot z) \cdot dz = -2542\text{V}$

2a.



2b.



2c.

$\Delta t_C < \Delta t_D$. The time it takes to charge or discharge is proportional to RC. For Δt_C, this equals (150)(80), but for Δt_D, this equals (150 + 100)(80).

2d.i.

$V_{capacitor} = V_0 = 1.5V$

$-1.5V = -(I)(250\Omega)$

$I = 0.006A$

2.d.ii.

Decreasing. As the capacitor discharges, the voltage across the capacitor decreases. By the loop rule, the voltages across the resistors must also decrease. By Ohm's law, this implies the current is decreasing.

2e.i.

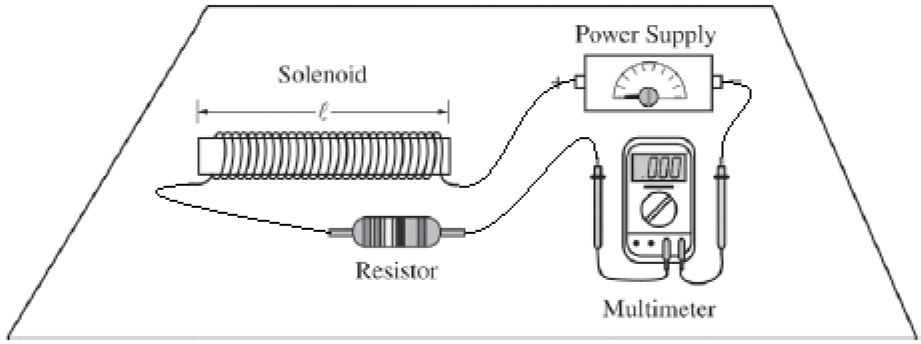
$U = ½CV^2 = ½(0.00008)(1.5^2) = 0.00009J$

2e.ii.

$E \sim R$ because $P = -I^2R$

$E = (0.00009J)(\frac{150}{250}) = 0.000054J$

3a.i.



3a.ii.

Leftward

3a.iii.

Point B. This is where the magnetic field would be strongest; it is, on average, closest to the current-carrying wire segments.

3b.

Solenoid 1 because it is closer to an ideal solenoid, having a higher number of turns per length.

3c.i.

$\mu_0 = \frac{B}{\frac{NI}{l}}$ = slope = $1.15 \times 10^{-6}\ \frac{T \cdot m}{A}$

3c.ii.

% error = $\frac{4\pi - 11.5}{4\pi}$ = 8.5%

3d.i.

A given current will always produce a weaker-than-expected magnetic field because the solenoid is not an ideal solenoid. There will always be an "edge effect" unless the solenoid is infinitely long.

3d.ii.

The absence of a resistor leads quickly to a very high current which would likely burn-out the fuse in the multimeter, causing it to cease functioning.