Name____

Physics 111 Quiz #4, January 30, 2019

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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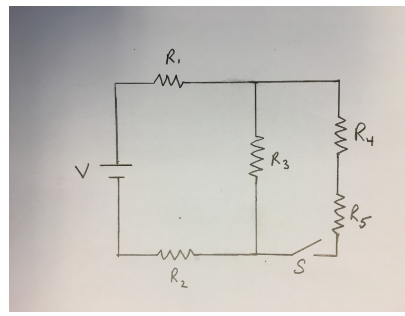
A circuit is constructed using five resistors each with resistance 100Ω connected to a $15V$ battery. The switch S is used to put in or take out resistors R_4 and R_5 from the circuit. Unless otherwise specified, assume that the switch S is closed.



1. What is the total current produced by the battery?

R_4 and R_5 are in series: $R_{45} = R_4 + R_5 = 100\Omega + 100\Omega = 200\Omega$

R_3 and R_{45} are in parallel: $\frac{1}{R_{345}} = \frac{1}{R_3} + \frac{1}{R_{45}} = \frac{1}{100\Omega} + \frac{1}{200\Omega} = \frac{3}{200\Omega} \rightarrow R_{345} = \frac{200}{3}\Omega = 66.7\Omega$

R_1, R_2, and R_{345} are in series: $R_{eq} = R_{12345} = R_1 + R_2 + R_{345} = 100\Omega + 100\Omega + 66.7\Omega = 266.7\Omega$

The total current is: $I_{total} = \frac{V}{R_{eq}} = \frac{15V}{266.7\Omega} = 0.0563A = 56.3mA$

2. What is the potential difference across resistor R_4?

$$V - V_{R_1} - V_{R_{345}} - V_{R_2} = 0$$
$$\rightarrow V_{R_{345}} = V - V_{R_1} - V_{R_2} = V - I_{total}\left(R_1 + R_2\right) = 15V - 0.0563A \times 200 = 3.74V$$
$$\rightarrow V_{R_{345}} = V_{R_3} = V_{R_{45}}$$
$$\rightarrow V_{R_{45}} = V_{R_4} + V_{R_5} = 2V_{R_4} \Rightarrow V_{R_4} = \frac{V_{R_{45}}}{2} = \frac{3.74V}{2} = 1.87V$$

3. What is the current through resistor R_3?

$$V_{R_{345}} = V_{R_3} = I_3 R_3 \rightarrow I_3 = \frac{V_{R_{345}}}{R_3} = \frac{3.74V}{100\Omega} = 0.0374A = 37.4mA$$

4. What is the total power produced by the battery?

$$P = I_{total}V = I_{total}^2 R_{eq} = \frac{V^2}{R_{eq}} = \left(0.0563A\right)^2 266.7\Omega = 0.845W = 845mW$$

5. What happens to the current through resistor R_3 when the switch S is opened?

a. The current through resistor R_3 increases because the equivalent circuit resistance increases.

b. The current through resistor R_3 increases because the equivalent circuit resistance decreases.

c. The current through resistor R_3 decreases because the equivalent circuit resistance increases.

d. The current through resistor R_3 decreases because the equivalent circuit resistance decreases.

e. The current through resistor R_3 remains the same because the battery has a constant voltage.

Physics 111 Equation Sheet

Electric Forces, Fields and Potentials

$$\vec{F} = k\frac{Q_1Q_2}{r^2}\hat{r}$$
$$\vec{E} = \frac{\vec{F}}{q}$$
$$\vec{E}_Q = k\frac{Q}{r^2}\hat{r}$$
$$PE = k\frac{Q_1Q_2}{r}$$
$$V(r) = k\frac{Q}{r}$$
$$E_x = -\frac{\Delta V}{\Delta x}$$
$$W = -q\Delta V_{f,i}$$

Magnetic Forces and Fields

$$F = qvB\sin\theta$$
$$F = IlB\sin\theta$$
$$\tau = NIAB\sin\theta = \mu B\sin\theta$$
$$PE = -\mu B\cos\theta$$
$$B = \frac{\mu_0 I}{2\pi r}$$
$$\varepsilon_{induced} = -N\frac{\Delta\phi_B}{\Delta t} = -N\frac{\Delta(BA\cos\theta)}{\Delta t}$$

Constants

$$g = 9.8\tfrac{m}{s^2}$$
$$1e = 1.6\times10^{-19}C$$
$$k = \frac{1}{4\pi\varepsilon_o} = 9\times10^9\tfrac{Nm^2}{C^2}$$
$$\varepsilon_o = 8.85\times10^{-12}\tfrac{C^2}{Nm^2}$$
$$1eV = 1.6\times10^{-19}J$$
$$\mu_o = 4\pi\times10^{-7}\tfrac{Tm}{A}$$
$$c = 3\times10^8\tfrac{m}{s}$$
$$h = 6.63\times10^{-34}Js$$
$$m_e = 9.11\times10^{-31}kg = \frac{0.511MeV}{c^2}$$
$$m_p = 1.67\times10^{-27}kg = \frac{937.1MeV}{c^2}$$
$$m_n = 1.69\times10^{-27}kg = \frac{948.3MeV}{c^2}$$
$$1amu = 1.66\times10^{-27}kg = \frac{931.5MeV}{c^2}$$
$$N_A = 6.02\times10^{23}$$
$$Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B\pm\sqrt{B^2-4AC}}{2A}$$

Electric Circuits

$$I = \frac{\Delta Q}{\Delta t}$$
$$V = IR = I\left(\frac{\rho L}{A}\right)$$
$$R_{series} = \sum_{i=1}^{N}R_i$$
$$\frac{1}{R_{parallel}} = \sum_{i=1}^{N}\frac{1}{R_i}$$
$$P = IV = I^2R = \frac{V^2}{R}$$
$$Q = CV = \left(\frac{\kappa\varepsilon_0 A}{d}\right)V = (\kappa C_0)V$$
$$PE = \tfrac{1}{2}QV = \tfrac{1}{2}CV^2 = \frac{Q^2}{2C}$$
$$Q_{\text{charge}}(t) = Q_{\max}\left(1-e^{-\frac{t}{RC}}\right)$$
$$Q_{\text{discharge}}(t) = Q_{\max}e^{-\frac{t}{RC}}$$
$$C_{parallel} = \sum_{i=1}^{N}C_i$$
$$\frac{1}{C_{series}} = \sum_{i=1}^{N}\frac{1}{C_i}$$

Light as a Particle & Relativity

$$E = hf = \frac{hc}{\lambda} = pc$$
$$KE_{\max} = hf - \phi = eV_{stop}$$
$$\Delta\lambda = \frac{h}{m_e c}(1-\cos\phi)$$
$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$
$$p = \gamma mv$$
$$E_{total} = KE + E_{rest} = \gamma mc^2$$
$$E_{total}^2 = p^2c^2 + m^2c^4$$
$$E_{rest} = mc^2$$
$$KE = (\gamma-1)mc^2$$

Geometry

$Circles:\quad C = 2\pi r = \pi D \qquad A = \pi r^2$

$Triangles:\quad A = \tfrac{1}{2}bh$

$Spheres:\quad A = 4\pi r^2 \qquad V = \tfrac{4}{3}\pi r^3$

Light as a Wave

$$c = f\lambda = \frac{1}{\sqrt{\varepsilon_o\mu_o}}$$
$$S(t) = \frac{energy}{time\times area} = c\varepsilon_o E^2(t) = c\frac{B^2(t)}{\mu_0}$$
$$I = S_{avg} = \tfrac{1}{2}c\varepsilon_o E_{\max}^2 = c\frac{B_{\max}^2}{2\mu_0}$$
$$P = \frac{S}{c} = \frac{Force}{Area}$$
$$S = S_o\cos^2\theta$$
$$v = \frac{1}{\sqrt{\varepsilon\mu}} = \frac{c}{n}$$
$$\theta_{inc} = \theta_{refl}$$
$$n_1\sin\theta_1 = n_2\sin\theta_2$$
$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$
$$M = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$
$$M_{total} = \prod_{i=1}^{N}M_i$$
$$S_{out} = S_{in}e^{-\sum_i \mu_i x_i}$$
$$HU = \frac{\mu_w - \mu_m}{\mu_w}$$

Nuclear Physics

$$E_{binding} = (Zm_p + Nm_n - m_{rest})c^2$$
$$\frac{\Delta N}{\Delta t} = -\lambda N_o \rightarrow N(t) = N_o e^{-\lambda t}$$
$$A(t) = A_o e^{-\lambda t}$$
$$m(t) = m_o e^{-\lambda t}$$
$$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

Misc. Physics 110 Formulae

$$\vec{F} = \frac{\Delta\vec{p}}{\Delta t} = \frac{\Delta(m\vec{v})}{\Delta t} = m\vec{a}$$
$$\vec{F} = -k\vec{y}$$
$$\vec{F}_C = m\frac{v^2}{R}\hat{r}$$
$$W = \Delta KE = \tfrac{1}{2}m\left(v_f^2 - v_i^2\right) = -\Delta PE$$
$$PE_{gravity} = mgy$$
$$PE_{spring} = \tfrac{1}{2}ky^2$$
$$|\vec{A}| = \sqrt{A_x^2 + A_y^2}$$
$$\phi = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$
$$\vec{v}_f = \vec{v}_i + \vec{a}t$$
$$v_f^2 = v_i^2 + 2a\Delta x$$
$$\vec{x}_f = \vec{x}_i + \vec{v}_i t + \tfrac{1}{2}\vec{a}t^2$$