Physics 1B - Quiz 3 (12 Feb 2007)

Formulas

The force on charge q_1 from charge q_2 is $\vec{F}_{12} = k_e \frac{q_1 q_2}{r_{12}^2}\hat{r}_{12}$, where the direction vector $\hat{r}_{12}$ points from q_2 to q_1 and the proportionality constant is $k_e = 8.99 \times 10^9\ Nm^2/C^2$.

Note that the permittivity of free space is $\varepsilon_0 \equiv \frac{1}{4\pi k_e} = 8.85 \times 10^{-12}\ C^2/(Nm^2) = 8.85 \times 10^{-12}\ A^2 s^4/(kg\ m^3)$.

Note that the unit of elemental electronic change is $e^- = -1.62 \times 10^{-19} C$.

The force on a test charge q_0 induced by an electric field, denoted $\vec{E}$, is $\vec{F} = q_0 \vec{E}$.

The electric flux through a surface is $\Phi_e \equiv \sum_{All\ Surfaces} EA_\perp = \sum_{All\ Surfaces} EA\cos\theta$, where $A_\perp = A\ cos\theta$ is the component of the area whose normal lies parallel to the electric field..

Gauss' Law relates the net flux through a closed surface to the net charge enclosed by the surface, *i.e.*, $\Phi_e = 4\ \pi\ k_e\ Q_{Total}$.

The electric field produced by a point charge q at the origin, *i.e.*, $\vec{r} = 0$, is $\vec{E} = k_e \frac{q}{r^2}\hat{r}$ where $\hat{r}$ is the radius vector in spherical coordinates.

The electric field produced by a line charge, with charge per unit length λ, is $\vec{E} = 2k_e \frac{\lambda}{r}\hat{r}$, where the line is defined to lie along the $\hat{z}$ axis and $\hat{r}$ is the radius vector in cylindrical coordinates.

The electric field produced by a surface charge, with charge per unit area σ, is $\vec{E} = 2\pi k_e \sigma\ \hat{n}$, where the surface lies in the $\hat{x}$-$\hat{y}$ plane and $\hat{z}$ corresponds to the normal to the $\hat{x}$-$\hat{y}$ plane in Cartesian coordinates.

Work-Energy Theorem: $W = \Delta KE + \Delta PE$

Electric potential: $\Delta V = -E\ \Delta x\ cos\ \theta$, where $\Delta V = \frac{\Delta PE}{Q}$

$V = k_e \frac{q}{r}$ a distance r away from a point charge q.

Current: $I = \frac{\Delta Q}{\Delta t}$ or $I = n\ e\ v_D\ A$

Capacitance: $Q = C\ \Delta V$ where $C = \frac{\kappa}{4\pi k_e}\frac{A}{d}$ for parallel plates and κ is the dielectric constant

$I = C\frac{\Delta V}{\Delta t}$

Energy Stored = $\frac{1}{2}Q\ \Delta V = \frac{1}{2}C\ (\Delta V)^2 = \frac{1}{2C}Q^2$

Resistance: $V = I\,R$ where $R = \rho \frac{l}{A}$ and ρ is the resistivity in Ohm-m.

	Series	Parallel
Capacitors	$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$	$C_{eq} = C_1 + C_2 + C_3 + \cdots$
Resistors	$R_{eq} = R_1 + R_2 + R_3 + \cdots$	$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$

Power Dissipated = $IV = I^2R = V^2/R$

Kirchoff's Laws: 1) Sum of voltage drops around any loop is zero, *i.e.*, gains = losses

2) Sum of current flow into a node is zero, *i.e.*, total current in = total current out

Finally! The Quiz

1. For current flow in a resistor, which statement is true?
A. The acceleration of the charge carrier is proportional to the voltage drop across the resistor
B. The velocity of the charge carriers is proportional to the voltage drop
C. The velocity of the charge carriers is a constant that depends solely on the type of material
D. The velocity of the charge carriers is a constant that depends solely on the temperature
E. The velocity of the charge carriers is a constant that depends solely on the geometry

2. A 1.50 V battery is connected across a 4 F capacitor, as shown below in figure 1. What is the energy stored in the capacitor subsequent to removal of the battery?
A. 6.0 J
B. 4.5 J
C. zero
D. 6.0 W
E. 4.5 W

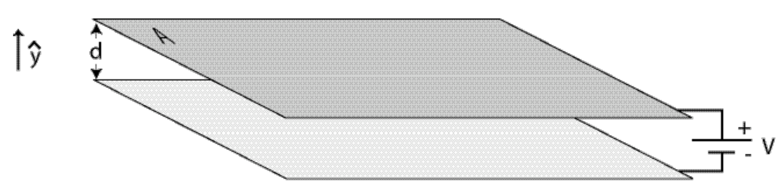

Figure 1

3. The resistivity of cytoplasm, the solution inside of a cell, is 100 Ω cm. What is the resistance of a cylinder of cytoplasm that is 1.0 mm long and 2.0 μm in diameter? Mind the units!
A. $3.2x10^8$ Ω
B. $3.1x10^{-15}$ Ω
C. $3.2x10^3$ Ω
D. $8.0x10^7$ Ω
E. $8.0x10^3$ Ω

4. A room heater operates at 220 Volts and consumes 2000 W of power. How much current does the heater draw?
A. 1.1×10^{-1} A
B. 4.1×10^{-3} A
C. 3.0 A
D. 9.1 A
E. 4.4×10^{5} A

5. In bacterial photosynthesis, the absorption of one photon causes a *pair* of electrons to move across the membrane. Under high light levels, *pairs* of *electrons* cross once every 100 μs. What is the current?
A. 1.6×10^{-21} A
B. 3.2×10^{-21} A
C. 2.0 A
D. 1.6×10^{-15} A
E. 3.2×10^{-15} A

6. A battery supplies current to a circuit with 3 resistors, as shown below in figure 2. What is the correct expression for the total current I?
A. V/R
B. V/(2R)
C. 2V/R
D. 5V/4R
E. 3V/R

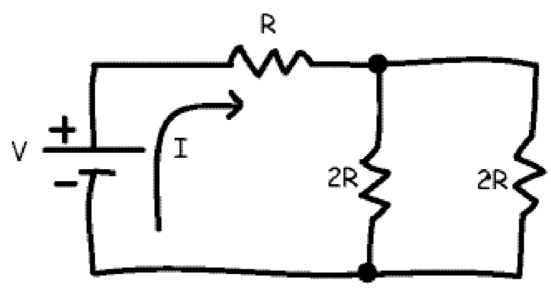

Figure 2

7. Find the equivalent resistance between points A and B for the circuit shown below in figure 3.
A. 50 Ω
B. 3.0×10^{-2} Ω
C. 112 Ω
D. 71 Ω
E. 3.8 Ω

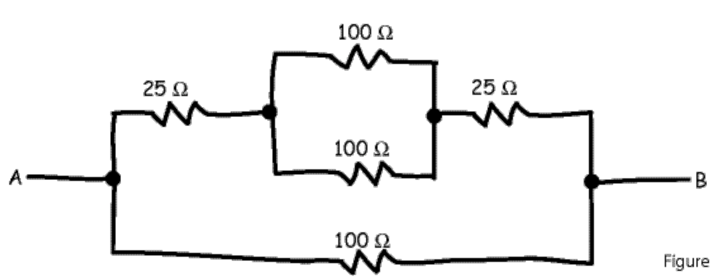

Figure 3

8. A battery supplies current to a circuit with 4 resistors, as shown below in figure 4. What is the correct expression for the potential V_1? Hint – you do not need to keep track of V_2 to find V_1.
A. 1/3 V_B
B. 1/2 V_B
C. 2/3 V_B
D. 4/5 V_B
E. 2 V_B

9. What is the correct expression for the potential V_2 in Figure 4? Think carefully before you start!
A. 1/5 V_B
B. 1/4 V_B
C. 1/3 V_B
D. 1/2 V_B
E. 2/5 V_B

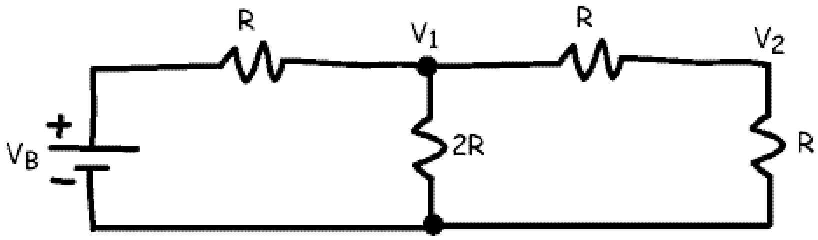

Figure 4

10. In a real battery with interval resistance, as shown below in figure 5, the voltage drop across an external load resistor is
A. always less than the open circuit voltage, $V_{battery}$
B. equal to the open circuit voltage
C. unconstrained
D. zero
E. always greater than the open circuit voltage

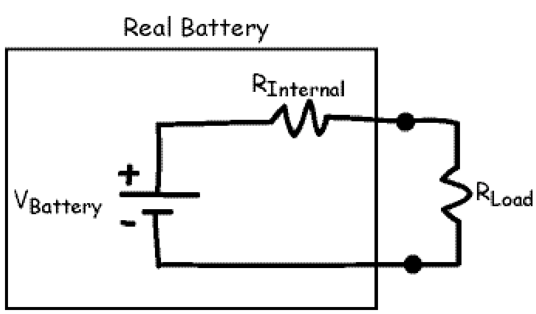

Figure 5