

PHY 2049
Summer 2007
Midterm II solutions

1. A 60-watt light bulb carries a current of 0.5 A. The total charge passing through it in one hour is: **1800C**

The charge is determined by the current $I = dq/dt$; $q = I t = 0.5 \times 3600 = 1800 \text{ C}$

2. Five cylindrical wires are made of the same material. Their lengths and radii are

wire 1: length l , radius r	$R_1 = \rho l/A$	$A = \pi r^2$
wire 2: length $l/4$, radius $r/2$	$R_2 = R_1$	
wire 3: length $l/2$, radius $r/2$	$R_3 = 2R_1$	
wire 4: length l , radius $r/2$	$R_4 = 4R_1$	
wire 5: length $5l$, radius $2r$	$R_5 = 5R_1/4$	

Rank the wires according to their resistances, least to greatest. **1 and 2 tie, then 5, 3, 4**

3. Two conductors are made of the same material and have the same length. Conductor A is a solid wire of diameter 1m. Conductor B is a hollow tube of inside diameter 1m and outside diameter 2m. The ratio of their resistance, R_A/R_B , is: **3**

The material area in the hollow tube is $A_B = \pi(r_2^2 - r_1^2) = 3A_A$. They are from the same material and are of the same length.

4. Electrons are going around a circle in a counterclockwise direction as shown. At the center of the circle they produce a magnetic field that is into the page.

Remember that if the electrons are going counterclockwise, the current is going clockwise and the field is into the page.

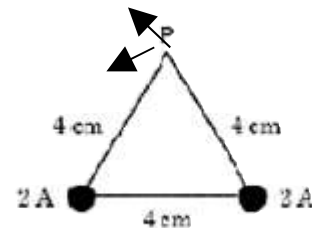
5. Two long straight wires are parallel and carry current in the same direction. The currents are 8.0 and 12A and the wires are separated by 0.40 cm. The magnetic field in tesla at a point midway between the wires is **0.4 mT**.

$$B = \frac{\mu_o}{2\pi r} [8 - 12] = 2 \times 10^{-7} \frac{4}{2 \times 10^{-3}} = 4 \times 10^{-4} T$$

6. Two long straight wires pierce the plane of the paper at vertices of an equilateral triangle as shown. They each carry 2A, out of the paper. The magnetic Field at the third vertex (P) has magnitude (in T): $1.7 \times 10^{-5} T$

The direction of magnetic field is perpendicular to the line joining the wire to the point of observation. The two fields are equal in magnitude. When added as vectors, their horizontal components add and the verticals cancel. The horizontals are pointing in $-x$ directions and have the magnitude:

$$|B| = 2 \frac{\mu_o}{2\pi} \frac{2}{.04} \cos 30 = 1.73 \times 10^{-5} T$$



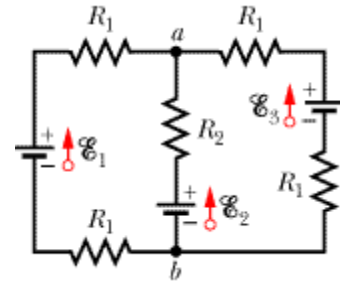
7. Nine identical wires, each of diameter d and length L , are connected in parallel. The combination has the same resistance as a single similar wire of length L but whose diameter is: $3d$

Equivalent resistance of 9 wires in parallel = $R/9$. where $R = \rho l/A$, where l is the length. Since area $A \sim r^2$, it follows that $R \rightarrow 3R$ would do the job.

8. The current in the 5.0Ω resistor in the circuit shown is: calculated as follows. The parallel combination of 6 and 12Ω gives us 4Ω . Thus there are two 8Ω resistors in parallel = one 4Ω . The current out of battery is 3A. It splits equally into $1.5A$, the current going through the 5Ω piece.
9. A proton (charge e), traveling perpendicular to a magnetic Field, experiences the same force as an alpha particle (charge $2e$) which is also traveling perpendicular to the same Field. The ratio of their speeds, $v_{\text{proton}}/v_{\text{alpha}}$, is: 2

$$q_{\text{proton}} v_{\text{proton}} B = q_{\text{alpha}} v_{\text{alpha}} B \rightarrow v_{\text{proton}}/v_{\text{alpha}} = q_{\text{alpha}}/q_{\text{proton}} = 2$$

10. In the Figure, the resistances are $R_1 = 1.5\Omega$, $R_2 = 2.3\Omega$, and the ideal batteries have emfs $E_1 = 2.0\text{ V}$, and $E_2 = E_3 = 3\text{ V}$. What is the current through the branch containing the battery E_3 ?



The current directions are as shown.

$$i_1 + i_2 + i_3 = 0$$

Outside loop: $2 - 3i_1 + 3i_3 - 3 = 0$ or $i_1 = i_3 - 1/3$

Right hand loop: $3 - 2.3i_2 + 3i_3 - 3 = 0 \rightarrow i_2 = 3i_3/2.3$

Substitute in the current equation to get $i_3 = 2.3/3 \times 7.6 = 0.101\text{ A}$

11. In the figure, a current $i = 25\text{ A}$ is set up in a long hairpin conductor formed by bending a wire into a semicircle of radius $R = 1.0\text{ mm}$. (Take the positive direction of the z axis to be out of the page.) What is the magnitude and direction of B at a ? $+0.0129\text{ T}$.

At a , $B = \frac{\mu_0 i}{4\pi R} [\pi + 2] = 0.012854\text{ T}$

