1. A Cube of Resistors

Suppose we have a “cube” of resistors (12 resistors total) all of the same resistance $R$ connected as in the figure to the left. Find the equivalent resistance between the two diagonally opposite corners (points $a$ and $b$ in the figure) in terms of $R$. (8 pts) *Hint: Use symmetry.*
The neutron is a particle with zero net charge. However, it has a nonzero magnetic moment with magnitude equal to $9.66 \times 10^{-27} \text{A} \cdot \text{m}^2$. This can be explained by the internal structure of the neutron. The neutron is composed of three fundamental particles called quarks: an “up” ($u$) quark of charge $+2e/3$, and two “down” ($d$) quarks, each with charge $-e/3$. If the quarks are in motion, they can produce nonzero magnetic moment. As a very simple classical model, suppose the $u$ quark moves in a counter-clockwise circular path, and the two $d$ quarks move in a clockwise circular path, all with the same radius $r$ and speed $v$.

Note: To really model the neutron requires a strongly interacting quantum field theory known as Quantum Chromo-Dynamics, or QCD. Needless to say, this topic is slightly too advanced for us to get into here.

a) Determine the current due to the circulation of the $u$ quark, as well as the current due to each of the $d$ quarks (in terms of $e$, $r$ and $v$). (4 pts)

b) Determine the magnitude of the magnetic moment of the three quark system (in terms of $e$, $r$ and $v$. (4 pts)

c) Assuming that $r = 1.20 \times 10^{-15}$, determine the speed the quarks must be moving at to produce the magnetic moment of the neutron. (4 pts)