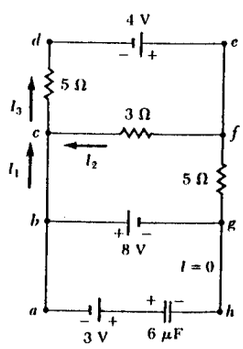
1. **(10%)** A rectangular bar has a length of (12.3 ± 0.2) cm, a width of (4.50 ± 0.10) cm, and a height of (6.75 ± 0.05) cm. (a) Find the sum of the length, the width, and the height of the bar, and the uncertainty in the calculated sum. (b) Also, find the volume of the bar and the uncertainty in the calculated volume.

2. **(20%)** State the following laws and explain with examples in a baseball game.
   (a) Newton's first law of motion
   (b) Newton's second law of motion
   (c) Newton's third law of motion
   (d) Newton's universal law of gravity
   (e) the law of conservation of energy

3. **(15%)** A steel railroad track has a length of 30 m when the temperature is 0°C. (a) What is its length on a hot day when the temperature is 40°C? (The linear thermal expansion coefficient of steel is 11×10^{-6} °C^{-1}.) (b) Suppose the two ends of the rail are rigidly clamped at 0°C so as to prevent expansion. Calculate the thermal stress set up in the rail if its temperature is raised to 40°C. (The Young's modulus of steel is 20×10^{10} N/m^2.) (c) If the rail has a cross-sectional area of 30 cm^2, calculate the force of compression in the rail in Newton.

4. **(15%)** The circuit on the right contains three resistors, three batteries, and one capacitor. (a) Under steady-state conditions, find the unknown currents, I_1, I_2, and I_3. (b) Find the voltage across the capacitor and the charge on the capacitor.



5. **(10%)** Explain the nature of light with the particle theory and the wave theory.

6. **(15%)** A 2-kg mass is attached to a massless spring of force constant k=25 N/m. The spring is stretched 0.4 m from its equilibrium position and released. (a) Find the total energy and frequency of oscillation according to classical calculations. (b) Assume that the energy is quantized. Find the quantum number, n, for the system. (c) How much energy would be carried away in a one-quantum energy change?

7. **(15%)** Compare and contrast electrical conductivity in insulators, semiconductors, and metals as to (a) their energy band structures, (b) the types of charge carriers including their concentrations and mobilities, (c) the temperature dependence.