THE UNIVERSITY OF BRITISH COLUMBIA

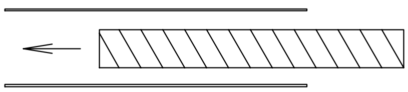
Science 1 Physics Assignment # 6:

CAPACITANCE, RESISTANCE & CIRCUITS

9 Feb. 2000 — finish during Reading Break

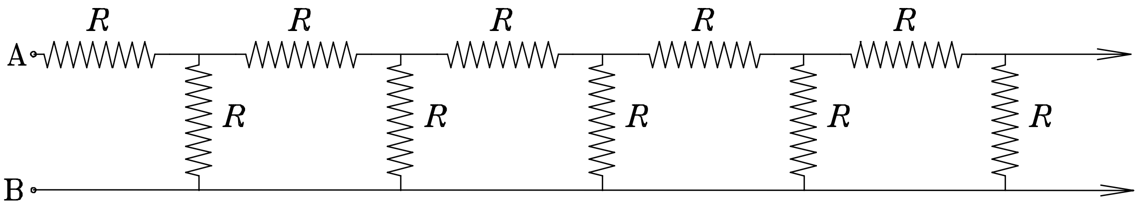
Tipler Ch. 22, problems **16, 24, 49** & **60**;

1. CAPACITOR WITH INSERT: Suppose we have a capacitor made of two large flat parallel plates of the same area A (and the same shape), separated by an air gap of width d. Its capacitance is C. Now we slip another planar conductor of width $d/2$ (and the same area and shape) between the plates so that it is centred halfway in between. What is the capacitance C' of the new system of three conductors, in terms of the capacitance C of the original pair and the other parameters given? (Neglect "edge effects" and any dielectric effect of air.)

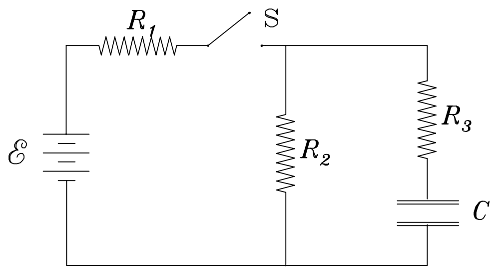


2. TRIUMF POWER USE: The electromagnet that generates the magnetic field for the world's largest cyclotron at TRIUMF has conductors made of aluminum ($\rho = 2.8\times10^{-8}$ Ωm) wound in a circle of radius 9.5 m. The conductor has a rectangular cross section (2.5 cm $\times$ 42 cm). There are 15 turns in the top half of the magnet and 15 in the bottom half, for a total length of 30 circumferences (the top and bottom coils are connected in series). If we apply 100 V to the coils, what current flows through it? How much power does this require to run?

3. DISTRIBUTED LOAD: A power transmission line (for instance) can be modelled as an array of discrete resistors such as that shown below. If the array continues indefinitely to the right, what is the effective resistance between A and B?



4. **RC CIRCUIT TIME-DEPENDENCE:** In the circuit shown, $\mathcal{E} = 1.2$ kV, $C = 6.5\ \mu$F and $R_1 = R_2 = R_3 = R = 0.73$ MΩ. With C completely uncharged, switch **S** is suddenly closed (at $t = 0$).



(a) Determine the currents through each resistor for $t = 0$ and $t = \infty$.

(b) Draw a qualitative graph of the potential difference V_2 across R_2 as a function of time from $t = 0$ and $t = \infty$.

(c) What are the numerical values of V_2 at $t = 0$ and $t = \infty$?

(d) Give the physical meaning of "$t = \infty$" in this case.

(e) Finally, write down expressions for the currents through R_1, R_2 and R_3 as functions of time, in terms of C and R.

. . . *and* Tipler Ch. 23, problems **9, 26, 39, 47, 52** & **61**.

Review: Gauss' Law

FIELD WITHIN A UNIFORM CHARGE DISTRIBUTION:

You have seen how to use Gauss' Law to derive the radial (r) dependence of the electric field $E(r > R)$ *outside* charge distributions of spherical, cylindrical or planar symmetry, where R is the distance the charge distribution extends from the centre of symmetry — the radius of a charged *sphere* or *cylinder*, or half the thickness of an infinite *slab* of charge, respectively. Use similar arguments to show that, for each of these cases (a sphere, cylinder or a slab of uniform charge density), the electric field $E(r < R)$ *inside* the charge distribution is given in terms of the field $E(R)$ *at the boundary* of the charge distribution by

$$E(r < R) = \left(\frac{r}{R}\right) E(R).$$