Massachusetts Institute of Technology - Physics Department

Physics - 8.02 **Assignment #7** April 5, 2002.

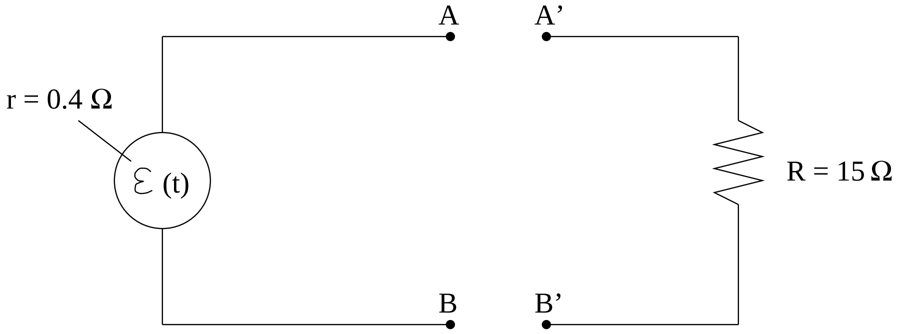
We strongly recommend that you read about a topic before it is covered in lectures.

Lecture Date	**Topics Covered**	**Reading from Giancoli**
#23 Mon 4/8	Review Exam 2.	
Wed 4/10	**Exam 2** covering assignments 4, 5 & 6, and all material covered in the reading assignments and in lectures through Mon 4/1 **(last names A-K in 26-100, L-Z in Walker)**	
#24 Fri 4/12	Transformers - Car Coils RC Circuits	Sect. 26-4, 26-5 & 29-6
#25 Wed 4/17	Driven LRC circuits - Resonance Metal Detectors (beach/airport)	Chapter 31 through Sect. 31- 6 *Lecture Supplement*

Due before 4 PM, Wednesday, April 17 in 4–339B.

Problem 7.1
Ideal transformer.
Giancoli 29-42.

Problem 7.2
A transformer for impedance matching.
The generator in the diagram has an internal resistance r of $0.4\,\Omega$ and produces an EMF between the points A and B of $\mathcal{E}(t) = 150\cos(\omega t)$ (in volts), with $\frac{\omega}{2\pi} = 50\,\text{Hz}$.



(a) If the load resistor $R = 15\,\Omega$ (with A connected to A', and B to B'), what average power will be delivered to the load?

The maximum power is delivered to a load when the load "impedance" (in this case the resistance R) is equal to the generator impedance (resistance r). In our case, $R >> r$. However, the load and generator impedances can be matched by connecting a transformer between the terminals AB (primary side of the transformer with N_1 windings) and A'B' (secondary side of the transformer with N_2 windings).

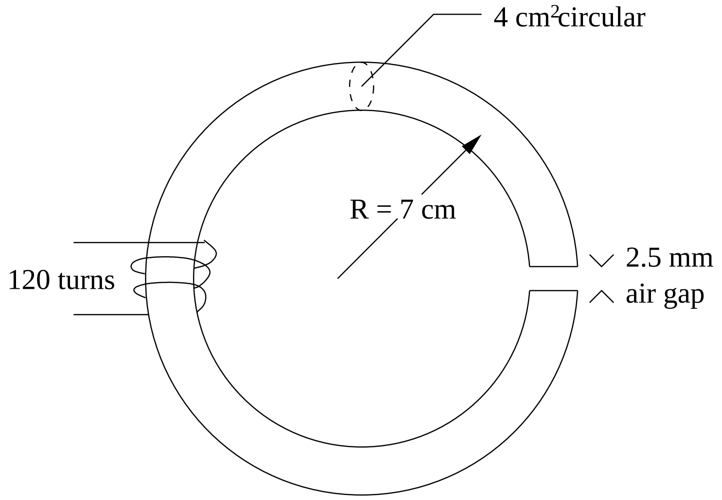
(b) What should the ratio $\frac{N_1}{N_2}$ be for an ideal transformer so that there will be a maximum transfer of power to the load R?

(c) How much power is then delivered to the load?

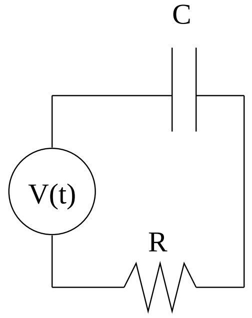
Problem 7.3
RC circuit.
Giancoli 26-45.

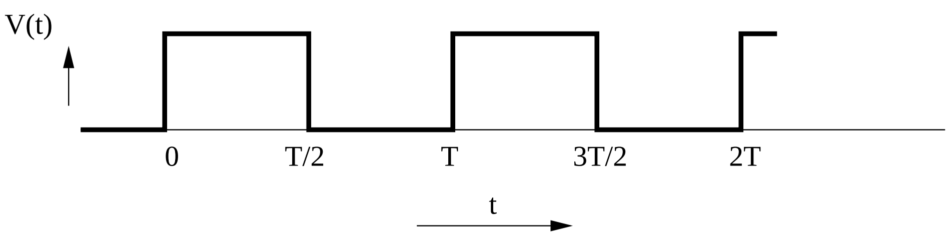
Problem 7.4
RC circuit.
Giancoli 26-46.

Problem 7.5
Electromagnet with small air gap.
An electromagnet has a steel core ($\kappa_M \approx 2500$) with an approximately circular cross sectional area of $4\,\mathrm{cm}^2$. The radius of the magnet is 7 cm; there is a small air gap of only 2.5 mm (see sketch). The current through the magnet's 120-turn coil is 15 A. What will the magnetic field strength be (approximately) inside the air gap?



Problem 7.6
RC Circuit.
A series RC circuit (see left diagram below) is driven by a periodic square wave voltage $V(t)$ with a period $T = 0.3\,\mathrm{sec}$ (see right diagram). $V(t) = 0\ V$ for $t < 0$; after $t = 0$, the voltage alternates between 15 V and 0 V; $R = 40\,\Omega$, $C = 150\,\mu\mathrm{F}$. We will call the voltages across the capacitor and the resistor $V_C(t)$ and $V_R(t)$, respectively.





(a) Calculate the current $I(t)$ in the circuit, the voltage $V_C(t)$, and the power delivered by the driving source as a function of time for the first full period ($0 < t < T$).

(b) Sketch in ***one graph*** $V(t)$, $V_C(t)$, and $V_R(t)$ in the time interval $0 < t < 2T$.

(c) How much energy is dissipated in the resistor during one period?
Hint: $RC << T$, thus $e^{(-T/2RC)} << 1$.

Recitations.

There are 28 recitation sections (see the 8.02 Website). If *for any reason* you want to change section, please see Maria Springer in 4-352.