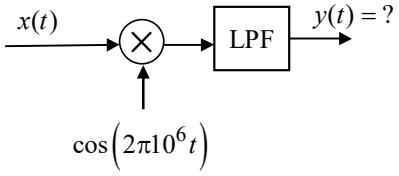
# Assignment #1

**Due:** Sep. 20, Wed. 8:30, SMD 224 (beginning of the tutorial). Hard copy only, no email submissions. *Late entries will not be accepted!*

This assignment is a refresher of ELG3175/3126. Please consult your notes/textbooks for those courses. Our current textbook also provides a wealth of information (as well as other reference books do).

1) Find a time-domain expression $x(t)$ for a conventionally AM-modulated signal with the following parameters: the carrier amplitude $A_c = 10$, the carrier frequency $f_c = 1$ MHz, the message $m(t) = 5\cos(2\pi Ft)$, where $F$ = 10 kHz is the message frequency, the modulation index $M = 0.5$. Answer the following questions:
   - what is the power of the modulated signal?
   - sketch its spectrum as it appears on a spectrum analyzer; indicate the key points and they values
   - sketch this modulated signal as it appears on an oscilloscope
   - what is its bandwidth?

2) Consider $x(t)$ from the previous question. Assume it is the input to the system below, where LPF is an ideal low-pass filter with cut-off frequency of 20 kHz. Find its output $y(t)$.




3) You have to design a base-band communication system for digital data transmission at rate = 1 Mb/s, using BPSK modulation and a raised-cosine pulse with roll-off factor $\alpha = 1$.
   - what is the minimum required bandwidth?
   - how the answer would change if QPSK modulation is used instead?
   - how the answer to 1st question would change if a bandpass (radio) system is needed using DSB-SC ?

4) The source is producing symbols at rate = $10^6$ symbols/s; each symbol is taken from the 4-symbol alphabet (set) $\{s_1, s_2, s_3, s_4\}$ with the corresponding probabilities:

$$p_1 = \frac{1}{2}, p_2 = \frac{1}{4}, p_3 = \frac{1}{8} = p_4$$

   - how much disk space (in bytes) do you need to store 1 hour of the output of this source using the best possible compression? Hint: the source entropy is the key to this question as it measures the amount of information produced by the source; consult your ELG3175 textbook for that.
   - how the answer would change if no compression is used at all? Explain the difference, if any.

5) Find the probability density function (PDF) of $\cos\phi$ if $\phi$ is uniformly distributed in the interval $[0, 2\pi]$. Sketch it. Can you give an intuitive explanation for the shape of this PDF?

6) Find the PDF of $x - y$ if random variables $x$ and $y$ are independent of each other, each of Gaussian distribution with mean $= 1$ and standard deviation $= 1$ and 2 respectively. Find $\text{Prob}\{x < 1, y < 1\}$.

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Please read appropriate chapters of the textbook first, study all the examples, attempt to do them with the closed book.

Remember the learning efficiency pyramid!

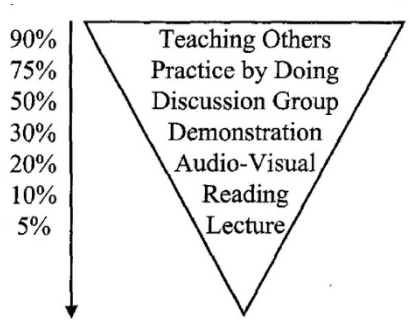


**Figure 1. The Learning Pyramid, adapted from David Sousa, *How the Brain Learns*, Reston, VA, The National Association of Secondary School Principals, 1995, ISBN 0-88210-301-6.**

Please include in your solutions all the intermediate results and their numerical values (if applicable). **Detailed solutions with explanations are required**, not just the final answers/equations; **all symbols used must be defined**, including units used (e.g. f = frequency [Hz], L = path loss [dB]). Missing explanations, symbol definitions/units will be penalized. Your answers should demonstrate the full extent of your knowledge and the latter will determine your marks.

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**Plagiarism** (i.e. "cut-and-paste" from a student to a student, other forms of "borrowing" the material for the assignment) is absolutely unacceptable and will be penalized. Each student is expected to submit his own solutions. If two (or more) identical or almost identical sets of solutions are found, each student involved receives 0 (zero) for that particular assignment. If this happens twice, the students involved receive 0 (zero) for the entire assignment component of the course in the marking scheme and the case will be send to the Dean's office for further investigation.