Name:_____

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2	
3	
4	
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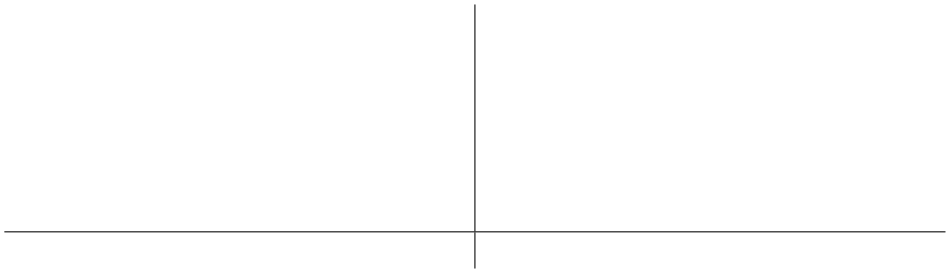
$\sum$	

EDISP 2012/2013 – Final exam1, **version A** 04.02.2013

If the space for answer is provided, try to write it there. Put your calculations in the provided space or on an additional sheet. Solve long problems on the additional sheet, marked with your name.

1. (6 p.) Let $x[n]$ be a signal obtained by sampling a continuous-time cosine wave of 5 Hz frequency with sampling period of 20 ms
   (a) Calculate the normalized frequency f_n of the $x[n]$.
   (b) Sketch the absolute value of DFT $X(k)$ for the transform size equal to $K = 3/f_n$.
   (c) Label the frequency axes carefully with index k and with θ_k values.



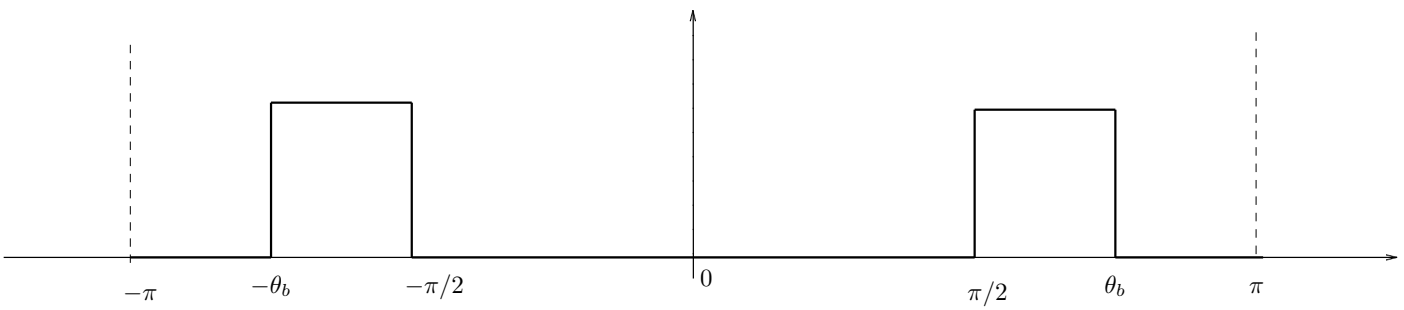
$f_n =$ .....
$K =$ .....
.....

2. (10 p.) A causal IIR filter is described by an equation

$$y(n) = -0.81y(n-2) + 0.1x(n)$$

   (a) Find the transfer function $H(z)$ of the filter: $H(z)=$ .....
   (b) Find zeros and poles of the filter: .....
   (c) Sketch the graph of a possible implementation of the filter *on additional sheet*
   (d) Find the output for a discrete input signal defined as $x(n) = cos(n\pi) + 2cos(n\frac{\pi}{2})$
   (e) Find the output for a discrete input signal defined as $x(n) = \delta(n-5)$

3. A causal bandpass FIR filter of the order 20 was designed from windowed Inverse Fourier Transform of the zero-phase ideal filter response (see figure). A rectangular window was used. Ideal filter passband was from $\pi/2$ to $\theta_b = \frac{3\pi}{4}$.
   (a) (2 p.) Fill missing words in the algorithm:
      i. The ideal impulse response was calculated by .....
      ii. It was made finite by .....
      iii. It was made causal by .....
   (b) (2 p.) Find the group delay $\tau(\theta)$. Answer: $\tau(\theta) =$.....
   (c) (2 p.) Sketch the *approximate* amplitude of frequency response of the resulting filter over the ideal response; make nonidealities visible and mark their extent with numerical values (e.g. width of the transition band)



4. (6 p.) If we calculate the instantaneous spectrum of a signal using a window of length K,

   (a) the frequency resolution is proportional to .....

   (b) the time resolution is proportional to .....

   (c) the rectangular window is good for .....
   because .....

   (d) but we use other window shapes when the important thing is .....

5. *"Tricky questions": present your reasoning for each answer, otherwise scores will be lower.*

   (a) (3 p.) A DT system is described as: $T(x[n]) = 8x[n]+8x^2[n+4]$
   ; is the system T
   - stable yes:☐ or no:☐ explain why: .....
   - causal yes:☐ or no:☐ explain why: .....
   - linear yes:☐ or no:☐ explain why: .....

   (b) (3 p.) What is the preferred way to deal with out-of-image pixel values when filtering images? (mark one box) make white:☐; make black:☐; use circular symmetry:☐; use mirror symmetry:☐
   Why?.....
   .....

   (c) *(5 p.)DCT can be calculated using FFT as a tool. Invent and describe step-by-step how to do it for a variant of DCT, defined as $X(k) = \sum_{k=0}^{N-1} x(n)cos(nk\frac{\pi}{N-1})$.

   (d) (3 p.) The inverse Fourier transform of limited energy signal is calculated by ☐ summation ☐ integration (choose answer, and explain why: .....)
   The integration/summation bounds are: from ☐ to ☐

   (e) (4 p.) What does a digital signal processor MAC instruction do?
   Answer: .....
   Why is this operation implemented as one instruction?
   Answer: .....

   (f) (2 p.) Calculate the $\mathcal{Z}$ transform of a signal $x[n] = \delta[n]-3\delta[n-1]+\delta[n+1]$

   Answer: .....

   (g) (4 p.) How many complex number multiplications do we need to compute a DFT of a finite-time signal of 2^{14} samples, using:
   - the definition formula? Answer: ☐ calculation: .....
   - the FFT method? Answer: ☐ calculation: .....

   (h) (3 p.) What is the maximum possible lenght of FIR filter response for a given input signal; filter order is 10.
   i. $x[n] = \delta[n-3]$ Answer: .....
   ii. $x[n] = u[n] - u[n-35]$ Answer: ☐ calculation: .....
   .....

   (i) (2 p.)When we design an IIR filter with high order, we decompose it into series of lower order sections. What is the typical section order? Answer:☐ .....

   (j) (2 p.) Which filter better removes "dead pixels" error from an image (mark one)?
   Median filter:☐; linear averaging filter:☐ Why? .....

$\Sigma = 59p$ $T = 90$ *min* Points over 50 are a bonus :-).