

EXAM 2021-05-31 - Requires Respondus LockDown Browser

⚠ This is a preview of the published version of the quiz

Started: May 31 at 10:31am

Quiz Instructions

WRITTEN EXAM 2021 Information Transmission EITA30 (EIT100)

2021-05-31, 14:00-19:00

The exam consists of five problems with 10 points each (Question 1 -- Question 5). 20 of 50 points are required to pass.

Permitted aids: Computer running LockDown Browser, pen, empty A4 sheets, pocket calculator (without any programs, scripts or files stored) and the printed course formula collection (without any notes).

The environment: You must be in a separate room while taking the exam, without any contact with any other person. Your desk should be empty, except for the explicitly permitted aids listed above.

Contacting the supervisor: You can contact the exam supervisor using the Zoom app on your phone. This is the only time you are allowed to temporarily handle the phone during the ongoing exam, except for requests to go to the restroom.

Visits to restroom: If you need to visit the restroom during the exam, **wave to the camera or "raise your hand" or write in the chat in the Zoom app to let the exam supervisor know.** The supervisor will acknowledge that your request has been noticed (e.g. by show a thumbs-up), but in case it takes time to get an acknowledgement you can leave for the restroom after writing in the chat. Return to your exam workspace directly after.

Instructions:

- Write down your name and personal ID number (personnummer) at the top of each page.
- Each solution must be written on separate sheets (add page numbers to the sheets).
- Your solutions must clearly reveal your method of solution.
- Problems are *not* sorted in order of difficulty.
- For each problem (and sub-problem) **write down your answer in simple text format in the web interface**, in a way that it can be identified as **the same answer** as the one you have on

your solutions on paper (**indicate your answer clearly on paper - circle or underline**) that you scan and send in directly after you finish the exam:

- EXAMPLES (feel free to use whatever "notation" you want, as long as it is possible to compare them with your scanned answers):

$\alpha e^{-\beta|t|}$ may be written simply as, e.g., " $\alpha * \exp(-\beta * \text{abs}(t))$ " or, even better, (in LaTeX) " $\alpha e^{-\beta |t|}$ "

$\frac{A}{B+j\omega C}$ may be written simply as, e.g., " $A/(B+j*w*C)$ " or, even better, (in LaTeX) " $\frac{A}{B + j$

ωC) $\sin(\omega_0 t + \phi)$ may be written simply as, e.g., " $\sin(\omega_0 * t + \phi)$ " or, even better, (in LaTeX) " $\sin(\omega_0 t + \phi)$ "

- When you have finished, submit the text-format answers on the web page.

[NOTE: This can only be done once. Check carefully before submitting. Submission must be done before the exam time ends.]

- After submitting your answers on the web page, **close the Zoom app and use your mobile phone to scan your solutions** using a scanning app (to PDF format). Make sure that the name, personal ID number, and page number, are visible on each scanned page. **Send the PDF file (as an attached document, not a download link) to fredrik.tufvesson@eit.lth.se (<mailto:fredrik.tufvesson@eit.lth.se>) within 15 minutes** after finishing (submitting your answers) in the web interface.

[NOTE: The e-mailing of solutions MUST meet the 15 minute deadline after submitting your answers on the web page.]

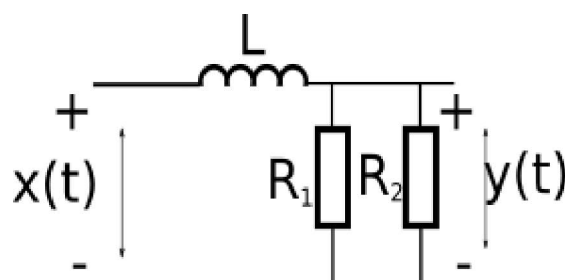
**BY STARTING THIS QUIZ
YOU ACKNOWLEDGE THAT YOU ARE AWARE OF,
AND WILL FOLLOW,
THE RULES DESCRIBED ABOVE!**

ANY VIOLATIONS WILL BE REPORTED TO
THE DISCIPLINARY BOARD OF LUND UNIVERSITY.

Question 1

10 pts

Consider this circuit, built up by two resistors, R_1 Ohm and R_2 Ohm, and an inductor, L Henry. The input signal is $x(t)$ Volt and the output signal $y(t)$ Volt.



Answer the following questions:

(a) Find the output $y(t)$ for the input $x(t) = 3(u(t) - u(t - 2))$ (3 p)

ANSWER (a): $y(t) =$

(b) What is the impulse response of the circuit? (2 p)

ANSWER (b): $h(t) =$

(c) What is the frequency function $H(f)$ of the circuit, expressed in inductance L and resistances R_1 and R_2 ? (3 p)

ANSWER (c): $H(f) =$

(d) Consider now another circuit where the input signal $x(t) = 2\sin(\omega t) + \cos^2(\omega t) + \ln(u(t))$ gives the output signal $y(t) = 4\sin(\omega t) + 2\cos^2(\omega t) + 2\ln(u(t))$. What is the impulse response of this circuit? (2 p)

ANSWER (d): $h(t) =$

Question 2

10 pts

Two microphones are used to analyze vibration noise from a milling machine and the two analog signals have bandwidths of 10 kHz and 100 kHz, respectively. The aim is to use digital wireless transmission at a frequency of 3.5 GHz for the microphone data using as little bandwidth as possible.

(a) How large is the quantization noise of the analog-to-digital converters if the analog-to-digital converters use 16 bits/sample? (2 p)

ANSWER (a): Quantization noise =

(b) What would the minimum bit rate be if we want to avoid reconstruction errors? (2 p)

ANSWER (b): Min bitrate =

(c) Assume that 16-QAM is used and that channel coding with a code rate of $R = 1/3$ is used. What is the smallest bandwidth that can be used (without creating intersymbol interference) for the transmission? Motivate your answer clearly. (6 p)

ANSWER (c): Min bandwidth =

Question 3

10 pts

Morse considered the length of the code words when encoding individual letters in an efficient manner. Below is how the first 5 letters are encoded ("long" is denoted as "-" and "short" is denoted as "."), their frequencies in English text and their relative frequencies when considering just those 5 letters. Do not forget to motivate your answers clearly so that one can follow the solution on paper.

letter	freq (%)	rel freq	Morse
a	8,4966	0,287	.-
b	2,0720	0,070	-...
c	4,5388	0,153	-.-
d	3,3844	0,114	-..
e	11,1607	0,376	.
sum	29,6525	1	

(a) Is Morse code a variable-length prefix-free code? Do not forget to motivate your answer. (1 p)

ANSWER (a): Yes/No .

(b) What is the average word length for Morse code if we use zero for "-" and one for "." and consider only those 5 letters and their relative frequencies? (2 p)

ANSWER (b): Average word length=

(c) What is the entropy of the source considering only those 5 letters and their relative frequencies? Do not forget to mention the unit. (2 p)

ANSWER (c): Entropy=

(d) What is the average word length using Huffman coding when considering only those 5 letters and their relative frequencies? (4 p)

ANSWER (d): Average word length=

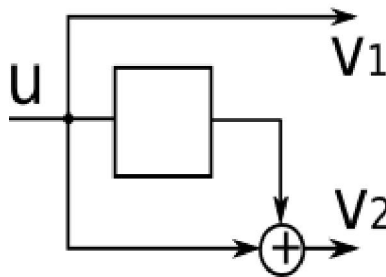
(e) Considering the above answers it could be thought that both Huffman coding and Morse coding are relatively good, but why would not the coding strategy in (b) work when applying it to full words? (1 p)

ANSWER (e): Motivation=

Question 4

10 pts

Consider the rate $R = 1/2$ convolutional encoder shown below. Answer the questions below, but remember that your answers on paper should be easy to follow, and show the solution step by step.



(a) How would the information sequence $u=0\ 1\ 1\ 0\ 0\ 0$ be encoded? For clarity, the last zero is a termination bit to enforce the zero state at the end. (3 p)

ANSWER (a): State the generated code sequence Out= .

(b) Use the Viterbi algorithm to decode the received sequence $r=11\ 11\ 11\ 11\ 01\ 00$ (4 p)

ANSWER (b): Information bits=

(c) How many error have occurred if the optimal path corresponds to the trans-

mitted code word? (1 p)

ANSWER (c): $n =$

(d) What is the free distance of this code? Motivate your answer. (2 p)

ANSWER (d): $d =$

Question 5

10 pts

Consider an RSA public key cryptosystem with the public parameters $n = 143$ and $e = 7$.

(a) Find the ciphertext corresponding to the plaintext $P=11$. Motivate your answer carefully (on paper), by showing all calculation steps in detail. (2 p)

ANSWER (a): $C =$

Find the plaintext P corresponding to the ciphertext $C = 47$. Motivate your answer carefully (on paper), by showing all calculation steps in detail. (8 p)

ANSWER (b): $P =$

No new data to save. Last checked at 10:35am

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