MEC-E1030 - Random Loads and Processes L, 19.09.2016-21.10.2016

Exam, 25.10.2016, Otakaari 5, S4, 08:00-11:00 Jani Romanoff

Question 1. Deterministic vs. Stochastic Loads

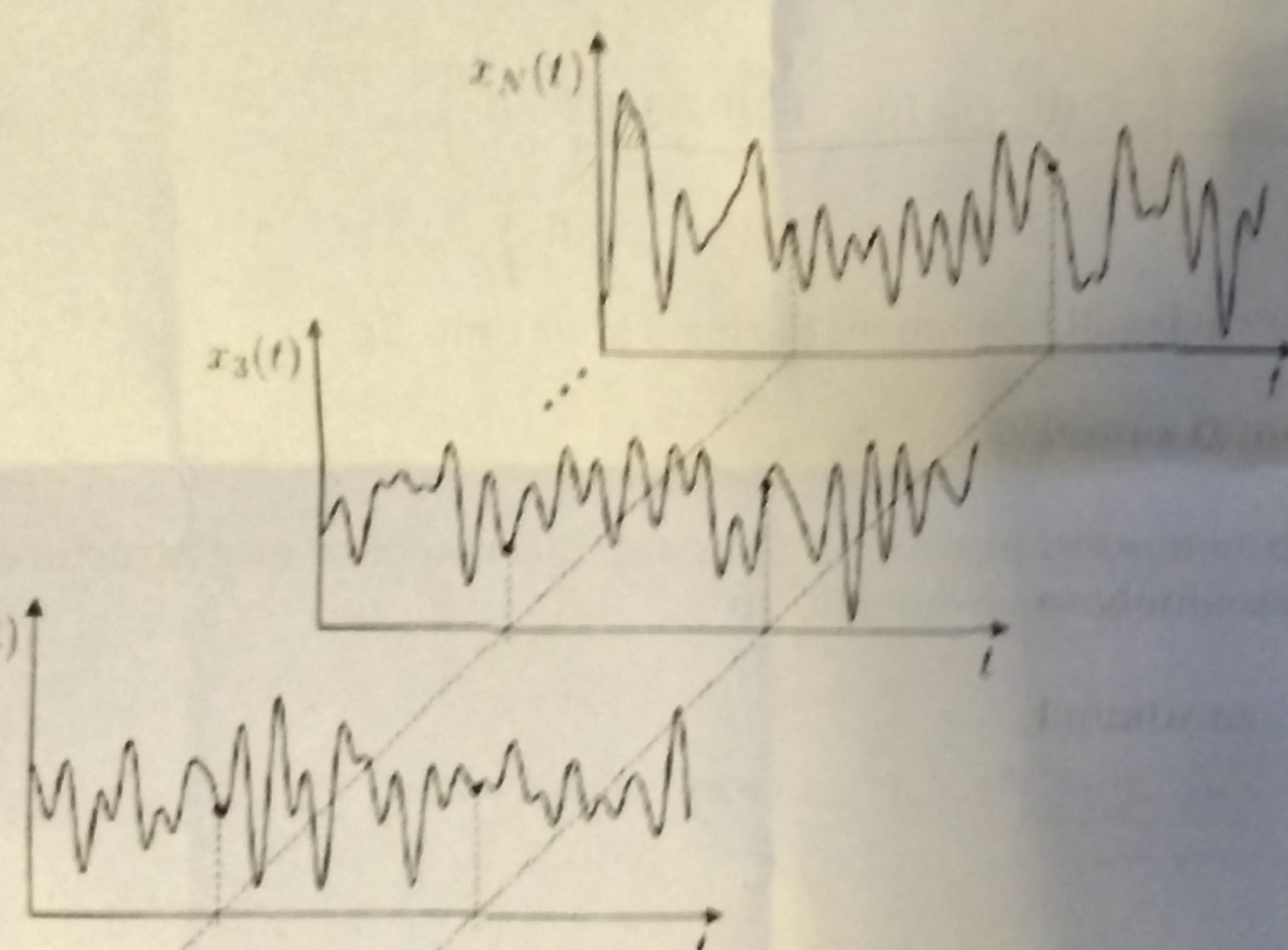
A. Explain the difference between deterministic and stochastic loads. **2p**

B. What is needed to define the response of random load and the probability of exceeding certain reference value (e.g. stress)? **2p**

C. How are the continuous probability distributions connected (e.g. Weibull, Rayleight, Gaussian)? **2p**

Question 2. Mathematics of Random Process

A. What does stationary, ergodic process mean? Use attached figure to explain this. **2p**



B. Long-term response is known to be broad-banded and non-Gaussian. What measures you could use to make it narrow-banded and Gaussian? What mathematical criteria you can use to assess the success of this process? **2p**

C. Describe the to process to calculate the time average and standard deviation for random signal and resulting probability distributions? What affects the results? **2p**

Question 3. Environmental Loads

A. *Describe how the random load in your application case [1] (project work) forms (physical process). What are the random and static parts of the load in your application case and associated time spans?* **2p**

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[1] *If you do not have one, describe ocean waves.*

B. What is the scatter diagram? How is it associated with the load spectra? **2p**

C. What is the link between spectrum and probability? What assumptions need to be valid that the link can be derived based on mathematics? **2p**

Moments

Question 4. Deterministic vs. Stochastic Loads

A. What does quasi-static response mean in terms of natural frequency of the system? What is the benefit we obtain for design with this assumption? **2p**

B. How can you obtain Rayleigh distribution for peak values of a Gaussian process? Explain the steps and assumptions made? **2p**

C. The wave spectrum [m²/s] and response amplitude operator [ton²/m²] of the bending moment of the ship is given as:

$$\omega_{RAO} = \{\ 0.3\ \ 0.4\ \ 0.5\ \ 0.6\ \ 0.7\ \},$$

$$S_{wave} = \{\ 2\cdot10^1\ \ 4\cdot10^1\ \ 3\cdot10^1\ \ 3\cdot10^1\ \ 0\ \}$$

$$RAO = \{\ 0\ \ 2\cdot10^9\ \ 4\cdot10^9\ \ 3\cdot10^9\ \ 0\ \}$$

Calculate maximum bending moment during 3 hour time. **2p**

Bonus Question. Big Picture

Draw and explain the big picture of assessing the response of a structure to random excitation due to environment. **2p**

Equations

$$n = \frac{T}{2\pi}\sqrt{\frac{m_2}{m_0}} \qquad S_{yy}(\omega) = |H(\omega)|^2 S_{xx}(\omega) \qquad R = k\int_0^\infty S(\omega)d\omega, k = 2 \text{ or } 8$$

$$\overline{\omega}_1 = \frac{m_1}{m_0} = \frac{\int_0^\infty \omega S(\omega)d\omega}{\int_0^\infty S(\omega)d\omega} \qquad \hat{z} = \sqrt{\ln\frac{n}{\alpha}}\sqrt{R} \qquad m_k = \int_0^\infty \omega^k S(\omega)d\omega$$