MS-E2117 Risk analysis Holmberg

Examination 11.4.2019

Please write on each page clearly:

- MS-E2117 Risk analysis
- registration number, surname and official forenames
- degree programme and year of studies
- signature

One can use a scientific calculator in the examination, but not a graphical calculator

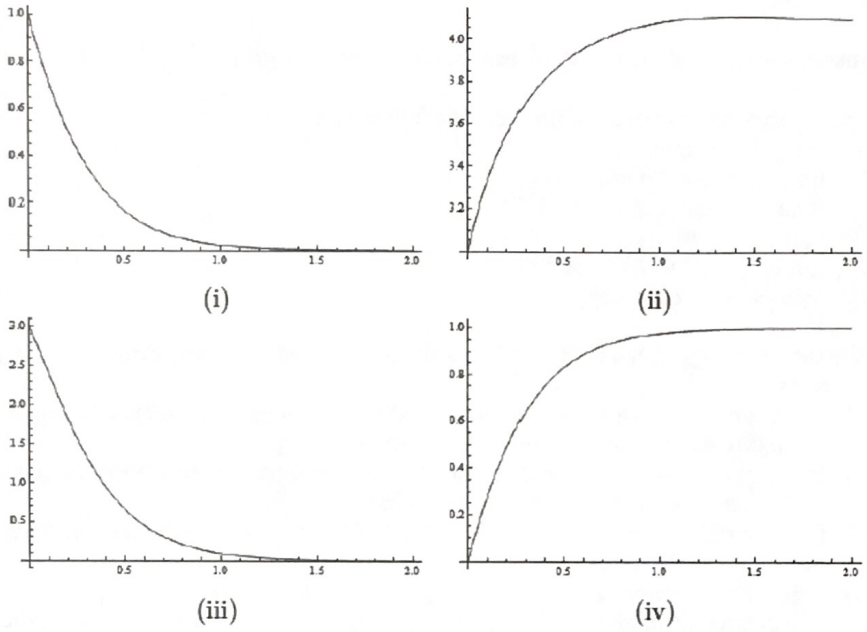
1. Please provide brief explanations for the following concepts:
   a) Risk achievement worth
   b) Homogeneous Poisson-process
   c) Binary decision diagram, BDD
   d) Risk aggregation
   e) ALARP (or ALARA) -principle
   f) Loss of life expectancy

2. Are the following statements true? Give a short and well-founded motivation for your answers.
   a) For a coherent system, duplication of individual components increases the system reliability more than the duplication of the whole system.
   b) In the block replacement policy, the expected number of components to be replaced is likely to be less than in the failure replacement policy.
   c) Positive risk messages typically increase confidence more than comparable negative messages would decrease it.
   d) The failure intensity function $\lambda(t)$ approaches infinity when $t \to \infty$.
   a) The mean unavailability of a repairable component is quantified by the formula U = MTTF/(MTTF +MTTR), where MTTF = mean time to failure, and MTTR = mean time to repair.
   b) Fussell-Vesely is not a meaningful risk measure in fault trees that contain only OR gates.

3. Consider a parallel system with components A, B and C. The failure probability of component C is 0.3 independent of components A and B. Components A and B have the same failure probability equal to 0.2. They are not independent, but the common cause failure is modelled by Beta factor model with parameter $\beta = 0.1$. Quantify the system reliability and the components Birnbaum importance measures.

4. These diagrams represent density function, cumulative probability distribution, risk hazard function and survival function of failure time.

   a) Which diagram represents which function? Justify your answer.
   b) Can the failure time be exponentially distributed? Justify your answer.
   c) What is the probability that the system fails after 0.6 time units given that it has function at 0.2? Approximate the probability with the accuracy of two decimals from the diagram.



5. A power plant requires both systems A and B working so that an initiating event I is mitigated. If A alone fails, consequence x occurs. If B alone fails, consequence $5x$ occurs. If both A and B fail, consequence $100x$ occurs.

   a) Draw the Event Tree representing the situation.
   b) If $A = m + n \cdot h$ and $B = k + m \cdot n$ are cut sets of systems A and B, define the minimal cut sets of the whole system based on the cut sets of A and B and the scenarios of the Event Tree.
   c) If the failure probabilities of components n, m, h and k are equal to 0.01, calculate the probability of all the scenarios in the Event Tree. The initiating event frequency is $f(I) = 0.1$ per year.
   d) Calculate and draw the risk profile of the power plant as a function of x.