The University Centre in Svalbard

Exam
AT-327 & AT-827 Arctic Offshore Engineering
Friday 1st of December 2017, hours: 09.00-13.00

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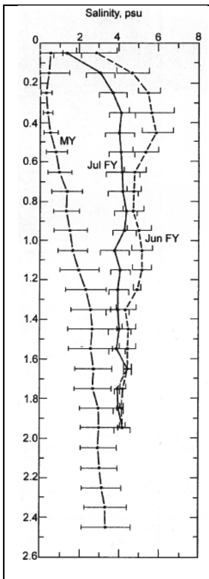
Permitted aids: Dictionary between English and mother tongue. Approved particular simple calculator. This set of problems consists of 4 pages. Four problem sets are presented; you must answer all 4 problem sets. You must answer the problem sets in one of the following languages: Norwegian, English, Danish or Swedish.
In case of obvious mistakes or omissions in the problem sets, make your own assumptions.

Problem Set 1 (20 %)

The ice cover:



a) Describe the characteristics of the different forms of sea ice: 1) Pancake ice, 2) Brash ice, 3) Cake ice, 4) Floe, 5) Fast ice.

b) Describe the characteristics of the different ice types: 1) New ice, 2) Nilas, 3) Young ice, 4) First-year ice, 5) Old ice.

c) The figure on the left-hand side displays three typical vertical salinity profiles of first-year ice (FY) in June (Jun FY), in July (Jul FY), and multi-year ice (MY). The horizontal scale unit is psu (‰), while the unit on the vertical scale is depth from the surface in metres. Explain the process leading to these typical salinity profiles?

d) The typical salinity profile of relatively young first-year ice is said to have a “C-shape”. Explain the process behind that?

Problem Set 2 (25 %)

Resources and Reserves:

a) There are three levels of certainty, namely P90, P50, and P10 that are often associated with probabilistic (stochastic) method of reserves evaluation.

   1) Give a short definition to these categories of hydrocarbon reserves

   2) What method is most commonly used for stochastic evaluation of resources and reserves

b) There are 5 necessary conditions that should be met in order to find petroleum.

Define these necessary conditions.

c) Assume that in a given area the following probabilities are given for each of the 5 necessary conditions to find petroleum:

P1=[0.80, 0.90]
P2=[0.90, 0.94]
P3=[0.90, 0.96]
P4=[0.70, 0.80]
P5=[0.20, 0.35]
(These evaluations are expressed in interval numbers, where numbers in square brackets denote minimum and maximum estimate, respectively).

Estimate a total probability of finding petroleum in this region based on the following evaluation methods:

1) Deterministic approach (use the middle points of the given interval numbers)
2) Fuzzy approach (assume that each probability can be described by a symmetrical fuzzy number
3) Interval calculus

Compare the obtained results and the most likely values.

Problem Set 3 (30 %)

Probabilistic ice load calculations:

a) Formulate six main steps of Monte Carlo simulation technique and explain how it works.

b) Define the main difference between probabilistic and deterministic approaches? Explain briefly what the meaning of semi-probabilistic approach is?

c) Give definitions of the cumulative distribution function (CDF) and probability density function (pdf)? Explain their physical sense, units, and interdependence?

d) Describe (formulate pdf, CDF and show their plots) uniformly distributed variable in the segment [a,b]? Define discrete distribution and suggest where it can be applied for ice loads estimations?

e) Explain the concept of probability of exceedance used in design philosophy. Define exceedance distribution function (EDF). Assume that two kinds of ice hazard events, A and B, are expected during operation of the structure. The probability of exceedance of their loads on a structure is shown below in Figure 1. Using that figure:

1) Find load values of abnormal level ice event (ALIE) of different ice hazard actions A and B?
2) Which ice event A or B is more frequent to provide a certain load?

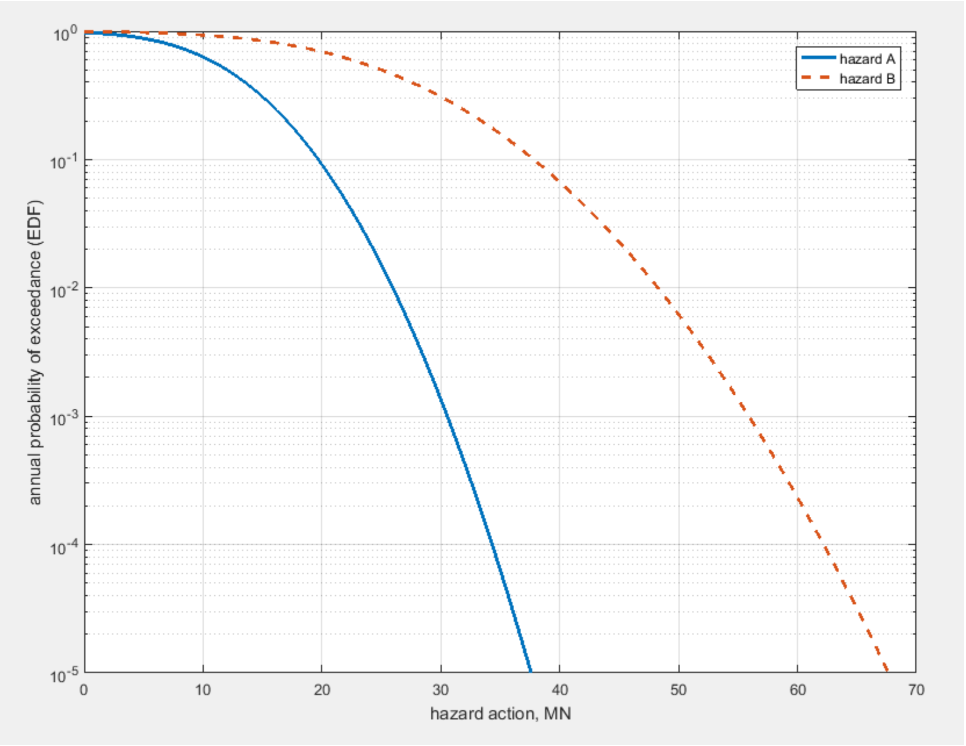


Figure 1. Annual probability of exceedance of two different ice hazards actions A and B.

Problem Set 4 (25 %)

Marine icing:

a) Explain shortly the difference between “thermally limited” and “mass limited scenarios”?
b) What is the freezing temperature of the water in the Baltic Sea which has a salinity of 0.8 %?
c) Consider the design of a vessel for Arctic conditions. Calculate the minimal power of heating required to keep the window of the vessel free from ice. The window is 1 m high and 2 m wide. Assume severe conditions, an air temperature of -15 °C, wind speed of 20 m/s and humidity of 80%. The sea spray flux to the window is unlimited but the spray temperature is equal to the freezing temperature (-2 °C) when the spray arrives to the window. The Nusselt number for any surface of the vessel is defined by $Nu = 0.03\mathrm{Re}^{0.8}$. The vessel is 15 m wide and 150 m long. Argument the choice of characteristic size for the heat transfer calculations.

Some equations for Problem Set 4:

$$h = \frac{Nuk_a}{D}$$ is the convective heat transfer coefficient

$$k_a = 0.024\frac{W}{m \cdot K}$$ is the thermal conductivity of air

$$\mathrm{Re} = \frac{V \cdot D}{\nu}$$, V is the wind speed, D is the characteristic linear size of the vessel.

$$\nu = 10^{-5}\frac{m^2}{s}$$ is the kinematic viscosity of air

$$S_b = \alpha T_f \ , \ 0°C > T_f > -8.2°C, \alpha = -0.0182[°\mathrm{C}]^{-1}$$

Evaporative heat flux:

$$Q_e = C \cdot h\left(e_v\left(T_f\right) - r_H \cdot e_v\left(T_a\right)\right);\ C{=}0.017\,\frac{\mathrm{K}}{\mathrm{Pa}}$$

$$e_v\left(T\right) = \ 611.2\left[\mathrm{Pa}\right] exp\left(\frac{17.67T}{T+243.5}\right),\ T \text{ in } \left[{}^{0}\mathrm{C}\right],\ e_v \text{ in } \left[\mathrm{Pa}\right]$$

r_H - relative humidity of air