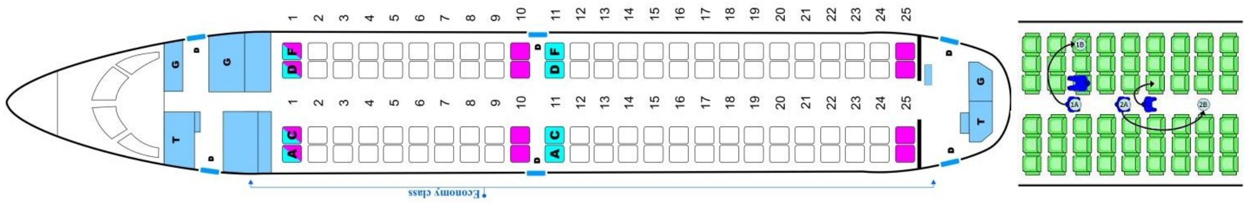
Statistical Methods Exercises 4 Autumn 2020

Return your solutions by 12.00 Finnish time on Thursday 8.10.2020 to Moodle course page: `https://moodle.helsinki.fi/course/view.php?id=30207`

1. **Monte Carlo (MC) method**. The boarding of passengers on an airplane is a classical MC simulation. Let's examine the boarding of an Embraer E190 (see picture below). The seat rows are at 1 m distance from each other and the distance from the gate to the first seat row is 25 m. Assume that the plane is 100 % full, that people are randomly seated and that their walking speed is exactly 0.5 m/s (same for all passengers). The distance between two passengers in the boarding queue is at least 0.5 m at all times.

   Include in your simulation "aisle interference", depicted by "2A $\rightarrow$ 2B", i.e. passengers cannot get through to their seat because somebody is putting his/her luggage in the luggage storage above the seats and/or getting seated (assume it to take 30 s). Another effect to account for is "seat interference", depicted by "1A $\rightarrow$ 1B", i.e. that a passenger cannot get seated in his/her own window seat since somebody else is already seated in the aisle seat. Assume such a swap to take 15 s.



   (i) Simulate 100 random boardings; the passengers start off standing in the boarding queue at the gate in random order, with randomly assigned seats, with the above mentioned 0.5 m distance between two adjacent passengers. Give as result the average and standard deviation of the total boarding time (time between the first passenger in queue starting to walk from the gate to the last passenger being seated). Please remember also to include the code of your simulation.

   Hint: Describe area from gate to back of plane as an array where each element describes 0.5 m length of space and make the simulation in time steps of 1 s. Start by moving the first passenger in the queue to first position in array, then try move the second passenger in the queue, then third etc... until the last. Always check that the passenger can move (= no other passenger in the position in the array to which passenger wants to move). Once passenger is at position where he/she should be seated keep him/her in that position the time required by the passenger to put luggage in luggage compartment and get seated. If a passenger is seated at window, check whether aisle seat already occupied, and if so, keep passenger in that position the additional time required to cover the swap. Keep track of number of seated passangers and where they are seated. Stop simulation when all passengers are seated. *Exercise gives max 12 points instead of usual 6.*

2. **Test statistic**. In a time-of-flight (TOF) detector, the time a charged particle takes to traverse the detector ($= t_{entrance} - t_{exit}$) is measured and used for separating different types of particles having the same momentum using their rest mass differences (special relativity applied). Suppose a test statistic w built from the TOF measurements follows a Gaussian distribution centered at 0.0(3.0) for pions(kaons), with a standard deviation, $\sigma = 1.0$ for both hypotheses. Suppose kaons are selected by requiring $w > 2.0$.

   (i) What is the kaon selection efficiency when requiring $w > 2.0$?

   (ii) What is the probability that a pion will be accepted as a kaon when requiring $w > 2.0$?

   (iii) Suppose a sample of particles consists of 95 % pions and 5 % kaons. What is the purity of the kaon sample selected by $w > 2.0$?

   (iv) Design a kaon selection for the same sample that gives real kaons in at least 4 cases out of 5. What will be the requirement on w ?

   Obtain cumulative Gaussian distribution values from table books or computer programs e.g. by searching for "Gaussian applet" in Google.