Notes:

- Part A is “closed book”. It will be distributed only on paper and must be completed on paper. You must return part A before proceeding with parts B-C.
- Parts B and C are open-book, open-laptop, open-Internet. You can consult any course material during the exam and you can browse the Web. Parts B and C should be submitted using the “Submit” button (as a single zip file).
- You are not allowed to share information with anyone during the exam except with the lecturer.

Part A. Foundational Knowledge (20 points)

Distributed separately on paper

Part B. Process Modelling and Analysis (20 points)

This part consists of two tasks, which are independent (you can do one without doing the other and there are no dependencies between them).

Task B1. [5 points]

We consider a simplified process for handling a Request for Quote (RFQ) for custom-made metal products at a company called MetalWorks. The process model is given in Figure 1. The process model shows the processing times of tasks and a branching probability. There are two sales engineers dedicated to this process and one production engineer. The sales engineers can dedicate up to 32 hours per week to this process (each), while the production manager can dedicate up to 18 hours per week to this process. Metalworks receives six RFQs per week. The sales engineer usually handle one RFQ from start to end in a single go. In other words, once sales engineer starts handling an order, they work on it (and do not work on anything else) until they send the quote back to the customer. Sales engineers and production engineers only work during working hours.

Calculate the cycle time of this process in working hours. Please explain how did you analyse this problem and show the arithmetic expressions you used to calculate your result. If you use a queuing theory tool, you should include a screenshot with the inputs you gave to the tool and the outputs.
Task B2. [15 points]

Model the following order-to-delivery process using BPMN. You should follow the modelling conventions given in the lecture. You do not need to draw a value chain. It is possible that this process cannot be modelled without using subprocesses. If you need to use sub-process diagrams, you should use them.

A Build-to-order (BTO) process – also known as a Make-to-order process – is an “order-to-delivery” process where the products to be sold are manufactured on the basis of a confirmed purchase order. In other words, the manufacturer does not maintain any ready-to-ship products in their stock. Instead, the products are manufactured “on demand”, when the customer orders them. This approach is used in the context of customized products, such as metallurgical products, where customers often submit orders for products with very specific requirements.

We consider a BTO process at a company called MetalWorks. The process starts when MetalWorks receives a Purchase Order (PO) from one of its customers. This PO is called the “customer PO”. The customer PO may contain one or multiple line items. Each line item refers to a different product.

Upon receiving a customer PO, a Sales Engineer checks the PO to determine if all the line items in the order can be produced within the timeframes indicated in the PO. As a result of this check, the Sales Engineer may either confirm the customer PO or ask the customer to revise the terms of the PO. In some extreme cases, the Sales Engineer
may reject the PO, but this happens very rarely. If the customer is asked to revise the PO, the BTO process remains on “stand-by” until the customer submits a revised PO. The Sales Engineer will then check the revised PO and either accept it, reject it, or ask again the customer to make further changes.

Once a PO is confirmed, the Sales Engineer creates one “work order” for each line item in the customer PO. In other words, one customer PO gives place to multiple work orders (one per line item). The work order is a document that allows employees at MetalWorks to keep track of the manufacturing of a product requested by a customer.

In order to manufacture a product, multiple raw materials are typically required. Some of these raw materials are maintained in stock in the warehouse of MetalWorks, but others need to be sourced (i.e. purchased) from one or multiple suppliers.

Accordingly, each work order is examined by a Production Engineer. During this examination, the Production Engineer determines which raw materials are required in order to fulfil the work order. The Production Engineer annotates the work order with a list of required raw materials. Each raw material listed in the work order is then checked by a Procurement Officer. The Procurement Officer determines whether the required raw material is available in stock, or it has to be ordered. If the raw material has to be ordered, the Procurement Officer selects a suitable supplier for the raw material and sends a PO to the selected supplier. This “PO for a raw material” is called a “material PO”, and it is different from the initial “customer PO”. A “material PO” is a PO sent by MetalWorks to one of its suppliers, whereas a “customer PO” is a PO received by MetalWorks from one of its customers.

Once all materials required to fulfil a work order have been received from the corresponding suppliers, the production can start. The responsibility for the production of a work order is assigned to the same Production Engineer who previously examined the work order. The Production Engineer is responsible for scheduling the production. Once the product has been manufactured, it is checked by a Quality Inspector. Sometimes, the Quality Inspector finds a defect in the product and reports it to the Production Engineer. The Production Engineer then decides whether: (i) the product should undergo a minor fix; or (ii) the product should be discarded and manufactured all over again, which means that new work orders need to be created, new raw materials need to be ordered, and so on.

Once the production of a product has completed, the sales engineer schedules the shipment of the final product. There is no need to wait until all the line items in a customer PO are ready before scheduling the shipment. As soon as a product is ready (i.e. as soon as one line item is ready), it can be shipped.

**Part C. Process Mining (10 points)**

Using Disco, answer the questions listed below using the following event log pertaining to a process for managing road traffic fines: [http://tinyurl.com/y7rr7ay4](http://tinyurl.com/y7rr7ay4)

1. **[3 points]** In how many cases the fine was paid AND a penalty was added? What is the mean cycle time for those cases? How many of those cases have an amount greater than or equal to 1000 euros?

2. **[3 points]** In how many cases the fine was given to a vehicle of class A? What is the mean cycle time for those cases where this has happened? How many of those cases have an amount greater than or equal to 1000 euros?
3. [2 points] In how many cases the amount of the fine is greater than 40 and lower than 50? What is the most frequent activity in those cases?

4. [2 points] What is the most frequent “dismissal” value for cases that were appealed to the judge. How many cases have this dismissal value?

*Important: It is not enough to write the answer to each question. You need to explain the steps you followed in Disco to obtain your answer.*