**QUESTION 1: GENERIC TOPICS (30 points)**

(a) List the seven types of waste initially recognized by Toyota. (**6 points**).

(b) A production system can protect itself against variability by applying buffers. (i) Mention the 3 different kinds of buffer in a production system (3 points); (ii) For each kind of buffer, give an example of the variability that is handled (3 points) (**6 points**).

(c) For each of the following flow enhancing mechanisms, name a technique that can be used to design it: (1) product layout, (2) small lot production, (3) short setups, (4) low inventory, (5) synchronized production. (**6 points**).

(d) What are the main advantages and disadvantages of respectively the Shortest Processing Time priority rule and the Earliest Due Date priority rule? (**6 points**).

(e) What are respectively the main advantages and main disadvantages of scheduling over the use of priority rules? (**6 points**).

**QUESTION 2: LINE BALANCING (35 points)**

(a) Is a synchronized production line typically used in a product layout or in a process layout? (**3 points**).

(b) Under which circumstances would you advise a synchronized production line as opposed to pull production? (**6 points**).

*Case description for question 2c/2d/2e*
Because there is not much time between the PPQC exam and the resit, the grades need to be published within 5 working days of 8 hours. Six people are involved in grading the exams (numbers between brackets indicate the hours they are potentially available on working days from Thursday to Wednesday): Anouk (32), Kevin (28), Sharmaine (36), Jeanine (14), Lisa (29), and Wout (30). Each question is a separate task that can be assigned to one of the assessors. Because each main question starts on a separate sheet the sequence in which the main questions (1, 2, 3) are graded is not important (please make sure you did indeed start main question 2 on a new sheet!). The sequence in which the questions are graded, however, is important; the sequence should follow the lettering (a, b, c, etc.). Furthermore, because question 2c, 2d, and 2e are related, they need to be assessed by the same person. The same holds for questions 3d and 3e.

(c) Design a balanced line using either the Rank Positional Weight technique demonstrated during the lecture, or using the technique as described in the book of Nicolas. Use the following task times for assessing each question (in seconds): 1a: 60, 1b: 60, 1c: 80, 1d: 80, 1e: 80, 2a: 60, 2b: 60, 2c: 120, 2d: 30, 2e: 60, 3a: 60, 3b: 60, 3c: 90, 3d: 120, 3e: 120. Assume that 300 exams need to be graded. (**14 points**).

(d) Should your proposed line be a paced line or an unpaced line? Why? (**4 points**).

(e) Would you advise us to use your proposed line? Why (or why not)? (**8 points**).

**QUESTION 3: CELLULAR MANUFACTURING (35 points)**

(a) Mention four different reasons why, according to Nicolas, small Focused Factories tend to be more efficient than large ones. (**5 points**).

(b) Draw in 3 pictures examples of the flow of production of respectively (i) a focused flow line, (ii) a workcell, (iii) a focused workcenter. (**4 points**).

(c) According to Nicolas, adopting work cells requires a shift to empowerment of shop floor workers. Explain what the effect of this is on respectively (i) the shop floor workers themselves and (ii) on the supervisors. (**5 points**).

*Case description for question 3d/3e*
The company “Latem” produces the following products for off-road vehicles: steel and aluminum tire carriers, steel brush guards (also called bullbars), differential covers (steel plates to protect the undercarriage of a car), and roll cages (steel frames built in the passenger compartment of a car to protect its occupants from being injured in an accident, particularly in the event of a roll-over). Currently the production process is organized in a process layout. For the tire carriers, first tubes are cut in the cutting department, after which they are subsequently bent in the bending department and welded in the welding department. There are essentially two welding departments: one for steel and one for aluminum. Most steel-welders cannot weld aluminum, but aluminum-welders are able to weld steel. The brush guards follow the same steps as the tire carriers, except that they don’t need to be welded. The differential covers are cut into the correct shape in the cutting department and subsequently bended in the bending department. For the roll cages, first tubes are cut (cutting department) and bended (bending department). Then holes are drilled in the tubes after which they are screwed together. These last two operations are performed in the assembly department. For very large cars, an extra tube is welded in the roll cage. The company aims to be flexible and promotes itself as a generic metal working company. However, in the past few years especially brush guards and aluminum tire carriers have become important products with much continuity.

(d) Perform the binary ordering technique on the production structure described above. (**12 points**).

(e) Propose an appropriate group structure based on the outcome of the binary ordering technique and the case description. Explain your proposal. (**9 points**).