Last name: First name:

EMARO1/ARIA1 – ARPRO-IRP Exam – 30 January 2018

Duration: 1 h 30 mn

Documents allowed: Val II/V+ printed notes

Answer the questions on the subject sheet. For multiple answer questions, tick the answer squares ❑ of correct answers with a tick mark ✔. There may be more than one correct answer. Not ticking a correct answer gives 0 points. **Ticking an incorrect answer is penalized** (negative points: -50%).

Statistics (10)

(2) What is the order of magnitude of the number of robots in operation in the world?	
(2) What is the order of magnitude of the number of robots sold yearly?	
(1) Order the robotics markets of the following geographical zones from largest to smallest.	Asia : Europe : America:
(1) Which is the country with the largest robotics market?	
(2) Give the two industrial branches which purchase the highest number of industrial robots per year.	
(1) What is the order of magnitude of the density of robots per 10 000 workers in the industry, in Europe?	
(1) What is the order of magnitude of the density of robots per 10 000 workers in the **automotive** industry, in Japan, where the density is highest ?	

Repeatability vs precision (10)

(1) A robot cannot exhibit good precision if it does have good repeatability.	True ❑ False ❑
(1) A robot which has excellent repeatability necessarily has good precision.	True ❑ False ❑
(1) To execute a typical pick and place task defined by pre-recorded locations, repeatability is necessary.	True ❑ False ❑
(1) To execute a typical pick and place task defined by pre-recorded locations, repeatability and precision are both necessary.	True ❑ False ❑
(1) What is the order of magnitude of the repeatability of the RX90 robot (in mm):	

(5) Use an **annotated** figure to define repeatability and precision.

Robot languages and programming (10)

(2) Give a concise definition of an end effector level language:	
(4) To program a depalletization task of an homogeneous pallet with a large number of objects: ° Recording a location for each object is technically impossible. ° Recording a location for each object is technically possible but not satisfactory. ° Recording a location for each object is satisfactory. ° A joint level language is preferable.	 True ❑ False ❑ True ❑ False ❑ True ❑ False ❑ True ❑ False ❑
(1) The Val II system (Puma robot) **does not include** an Inverse Geometric Model of the Puma robot.	True ❑ False ❑
(1) The V+ system (Puma robot) **includes** an Inverse Geometric Model of the RX90 robot.	True ❑ False ❑
(1) The V+ language is	Interpreted ❑ Compiled ❑
(1) V+ is an object level robot programming language	True ❑ False ❑

Robot motions and tasks (20)

Answers must be concise and clear. Space limitation is voluntary. Clarity and conciseness will be important evaluation criteria.

a. (2) Define a guarded motion.

b. (2) Define a repeatable task.

c. (2) Explain why task repeatability makes robotization easier.

d. (2) Name the two major weaknesses that make robots not so flexible. No justification is necessary. The relative importance of the two is not the concern of the question.

Reason 1:

Reason 2:

e. (2) What are the main reasons why spot welding of car bodies is not robotized by teaching welding locations at the production line.

f. (2) Assembly of small mechanical parts:

a. Is generally easy to robotize using locations recorded with a teach pendant....True ❑ False ❑

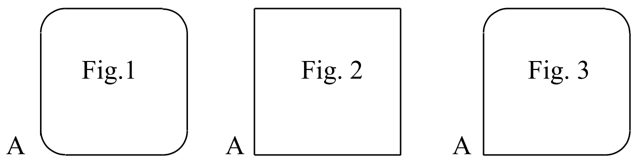
b. Often requires the use of sensors, for example force sensors..........................True ❑ False ❑

g. (2) A robot grasps objects which are localized by a computer vision system.
It is logical to use a robot with an end effector level language.............................True ❑ False ❑

h. (2) By default, it is better to always use straight line motions when programming a robot. Indeed, it's always best to know the path of the tool...True ❑ False ❑

i. (4) A, B, C and D are four coplanar locations forming a square, A being the lower left corner. The tool of the robot is a pen and, at points A...D the tool is perpendicular to and in contact with the plane. Instructions **`closei`**/**`openi`** respectively put the pen in write/no write mode. The robot executes the following instructions:

```
appro A , 100
moves A
closei
moves B
moves C
moves D
moves A
openi
```



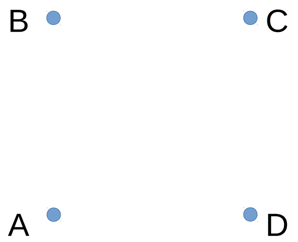
The robot draws figure 1. ❑

The robot draws figure 2. ❑

The robot draws figure 3. ❑

Now the pen is no longer controlled by **`closei`**/**`openi`** but by setting output 1 to write (**`signal`** `1`) and resetting it to stop writing (**`signal`** `-1`). Otherwise, the situation is the same as in the previous question. The robot executes the following instructions. Draw the result on the figure below.

```
appro A, 100
moves A
signal 1
moves B
moves C
moves D
moves A
signal -1
```

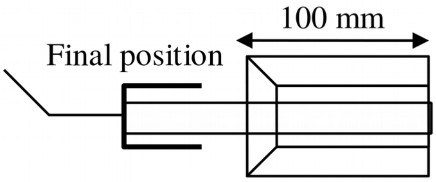


Programming in Val/V+ (35)

a. (5) Peg insertion.

A robot must insert a cylinder into a hole. The precision of the robot is such that the insertion can be performed without using any exteroceptive sensor: the **clearance** between object and hole is **small but sufficient**, if the program is correct. The location *object.inserted* corresponds to the final position shown on the figure below.

Write the Val instructions to insert the object, taking into account that :
- The robot initially is at a convenient location *wait.loc*, with the object already in the gripper.
- The robot must be put back to this location after completion of the task.



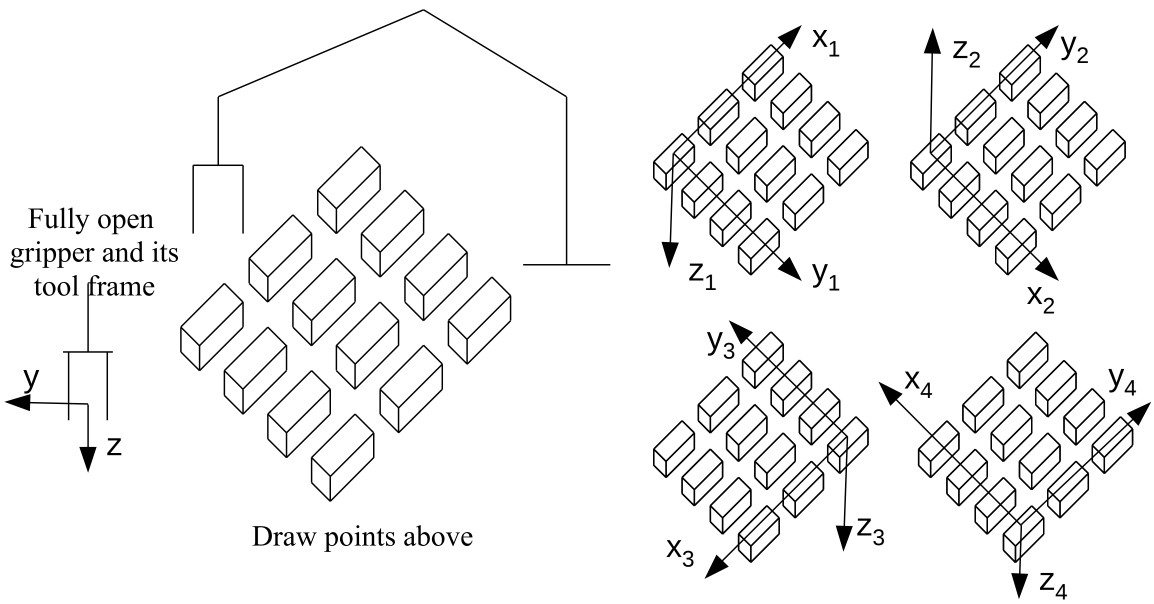
Robot at location *object.inserted*

Code:

b. (10) Frame definition

For the pallet and the gripper represented on the figure below, tick the pallet frames which are convenient to program the depalletizing task.

Frame R1..................❑
Frame R2..................❑
Frame R3..................❑
Frame R4..................❑



On the figure, indicate the points where you would put the tip of the pointer tool when teaching the robot the necessary locations to define a proper frame for the board. Give names to these points and write the names on the figure. If the orientation of the corresponding locations matter, draw them as triedrons, otherwise draw them as crosses.

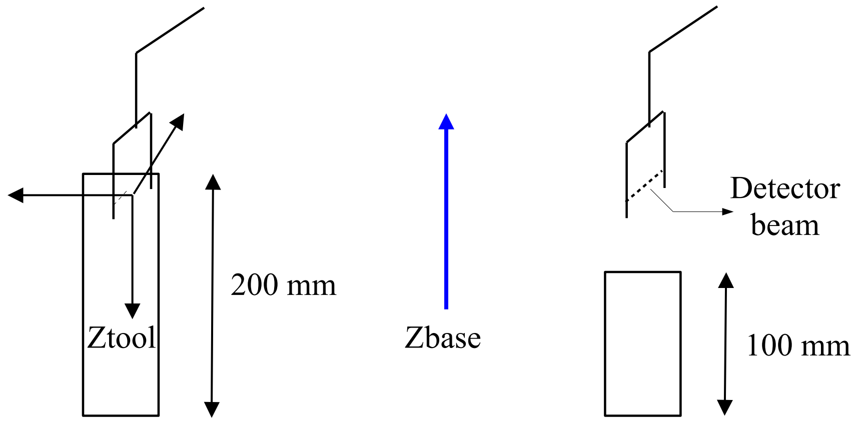
Give the Val II instruction to define the board frame. The frame name will be R1, R2, R3 or R4, depending on which one you choose to define.

Instruction to define the frame:

c. (10) Long/short object grasping (answer on exam sheet).

A robot is used to handle objects that can arrive at two different points. At each point, a switch detects the presence of an object. These switches are connected to inputs 1 and 2 respectively.

There are two types of objects, long and short. To distinguish between long and short objects, the robot uses a broken beam detector located in the fingers of its gripper. When an object is present, the robot moves to the corresponding known grasp location corresponding to a **long** object (there are two such locations). When at the location, the robot tests the state of the broken beam detector (input 3). If it is high (*i.e.* true), it means there is an object between the fingers of the gripper (the object is long), otherwise it means that nothing cuts the beam (the object is short). The figure below shows the two cases that can occur when the robot is at one of the grasp locations of a long object.



Beam connected to input 3 is broken by the long object: input 3 is true.

Beam connected to input 3 is not broken by the small object: input 3 is false.

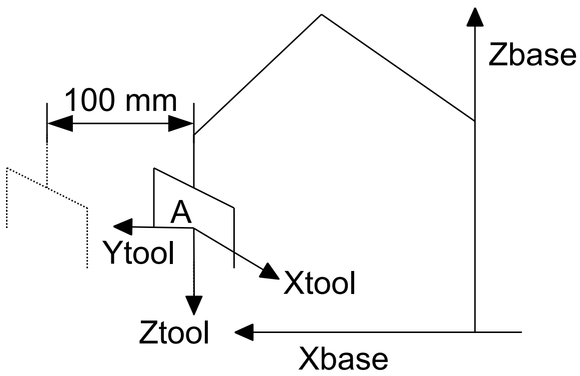
When an object is available, the robot takes it. Short objects are put at a given location, long objects at another location, both known. Objects are removed by another process, so drop locations are always vacant when needed.

There are a total of 5 known locations: two grasp locations **corresponding to long objects**, two drop locations (for short and long objects) and one wait location to which the robot moves at the end of the task. No other location is pre-defined.

- Write a program to handle one cycle of the task. Do not include any file loading command: the five known points are assumed to be in memory, with the names you decide to use.
- Give the command you would use to execute this task infinitely.

d. (10) Motions and compound transforms

A robot has its tool at Cartesian location A, as depicted in the figure. The goal is to move it to the location in dotted lines, located 100 mm in the direction pointed by the tool Y axis. Zbase is vertical and Ytool and Xbase coincide. Which instructions correctly perform the task?



`moves shift(``A` **`by`** `0,100,0)`	Correct ❑	Incorrect ❑
`moves shift(here by` `100,0,0)`	Correct ❑	Incorrect ❑
`move` `A:`**`shift(null by`** `0,100,0)`	Correct ❑	Incorrect ❑
`move here:shift(``A` **`by`** `100,0,0)`	Correct ❑	Incorrect ❑
`move here:shift(null by` `0,100,0)`	Correct ❑	Incorrect ❑