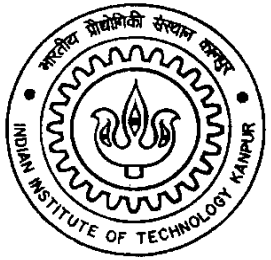
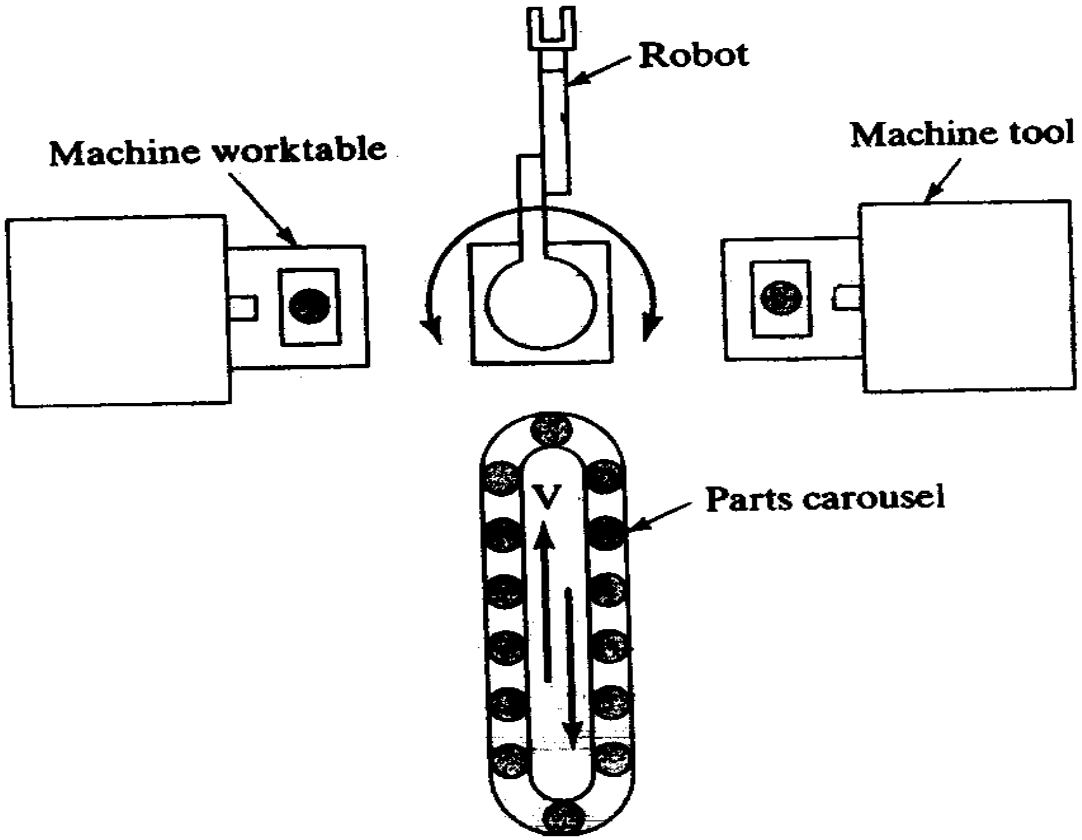
Robot Programming



Dr. Ashish Dutta
Professor, Dept. of Mechanical Engineering
IIT Kanpur, INDIA

A robot works with other machines



General structure of robot hardware

- Mechanical hardware : arms, motion transmission, gripper.
- Robot Control unit: robot controller, motors, sensors, power amplifiers, ADC/DAC.
- Central controller for interfacing robot with other machines etc.

Using a robot:

- **Teach pendent**: used to manually teach different points that are recorded in the robots memory. These points can then be played back. e.g. tasks requiring human skills e.g. welding, etc.

- **Program based control**:The desired task is written as a sequence of motions in a language such as VAL. These motions can then be played back.

Three generations of programming languages

- ***First generation:*** Simple commands for pick and place operations, with limited interaction with limit switches (ON/OFF), stops etc.

- ***Second generation:*** Interaction with the environment using force, touch, ADC/DAC, etc.

- ***Third generation:*** Intelligence capability to understand general commands e.g. ‘tighten a nut’

Examples of a few programming languages:

- **VAL** : Victors Assembly Language (1960). Developed by Unimation for the PUMA robot.
- **AML** : Developed by IBM for manufacturing automation systems (1960).
- **RPL** : based on FORTRAN Language (1960).

Basic commands in VAL II

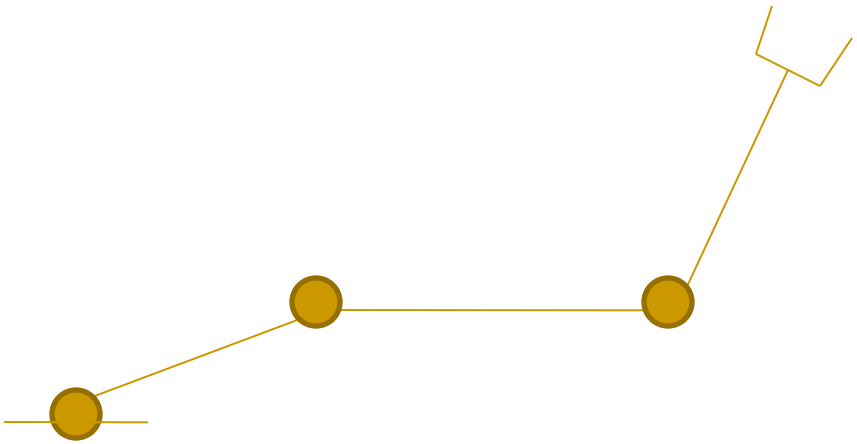
- **Constants, variables, data objects**
- **Motion control commands.**
- **Robot Hand control.**
- **Program control and input/output control.**

Variables, Motion Control

- POINT P1 = 3, 4, 5, 30, 45, 50
  (x, y, z, Θ, α, ɣ)
- MOVE P1
- MOVES P1
- DRAW 45, 56, 60
- APPRO P1 50 (along z axis)
- DEPART P1 50 (along z axis)
- APPROS or DEPARTS APPRO or DEPART

MOVE and MOVES

- Straight line motion between two points requires more energy ?



- Energy required is proportional to the number of joints that move to take the end effector from one point to another.

Hand Control

- **OPEN and CLOSE**
- **OPENI and CLOSEI**
- **CLOSEI 75 in VAL**

Speed control, Pause

- SPEED 60 IPS
- DEFINE PATH1=PATH(A1,A2,A3)
- **PAUSE Time (milli secs)**

In – line robot cell

Pick from conveyor and place on table

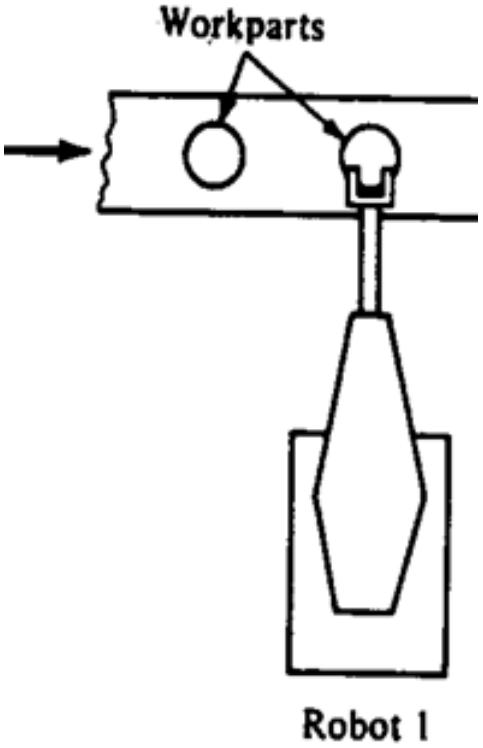
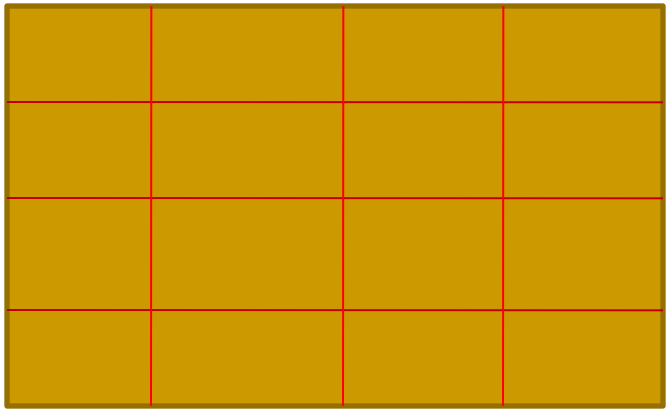
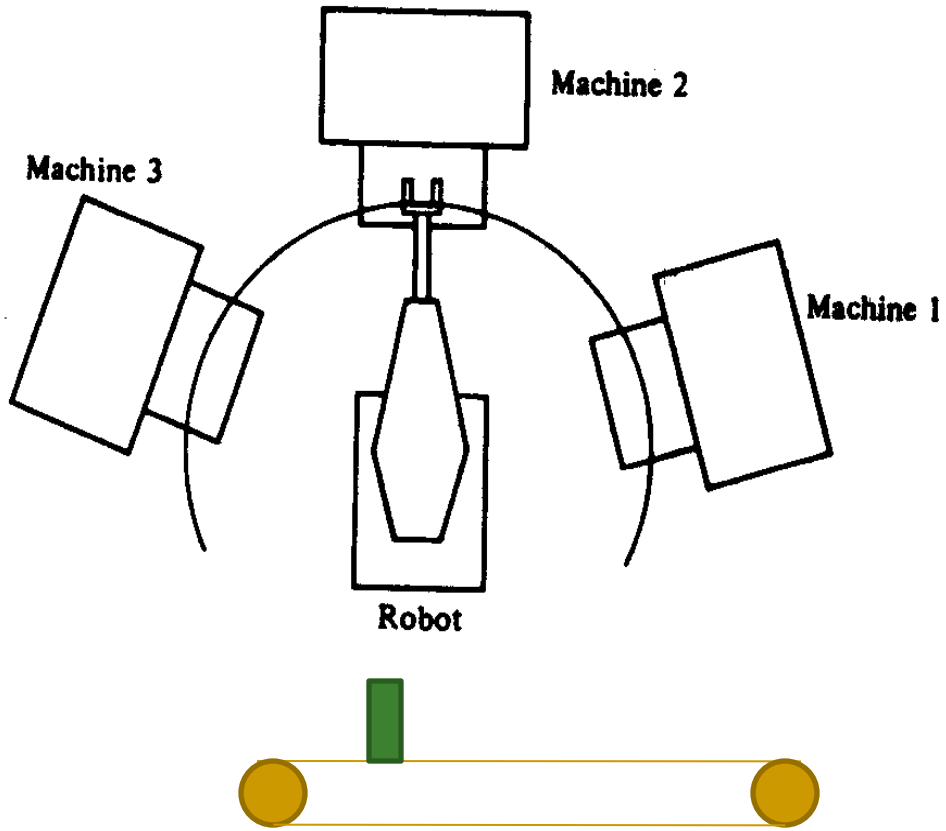


Table : Parts to be placed in each square : INDEXING



Robot centered cell – sequencing - dead lock



Simple ON/OFF sensors

- Proximity : ultrasonic, hall effect, conductive sensors.
- Limit switches.
- ON +5 V
- OFF 0 V

Program Control, Interlock Commands and

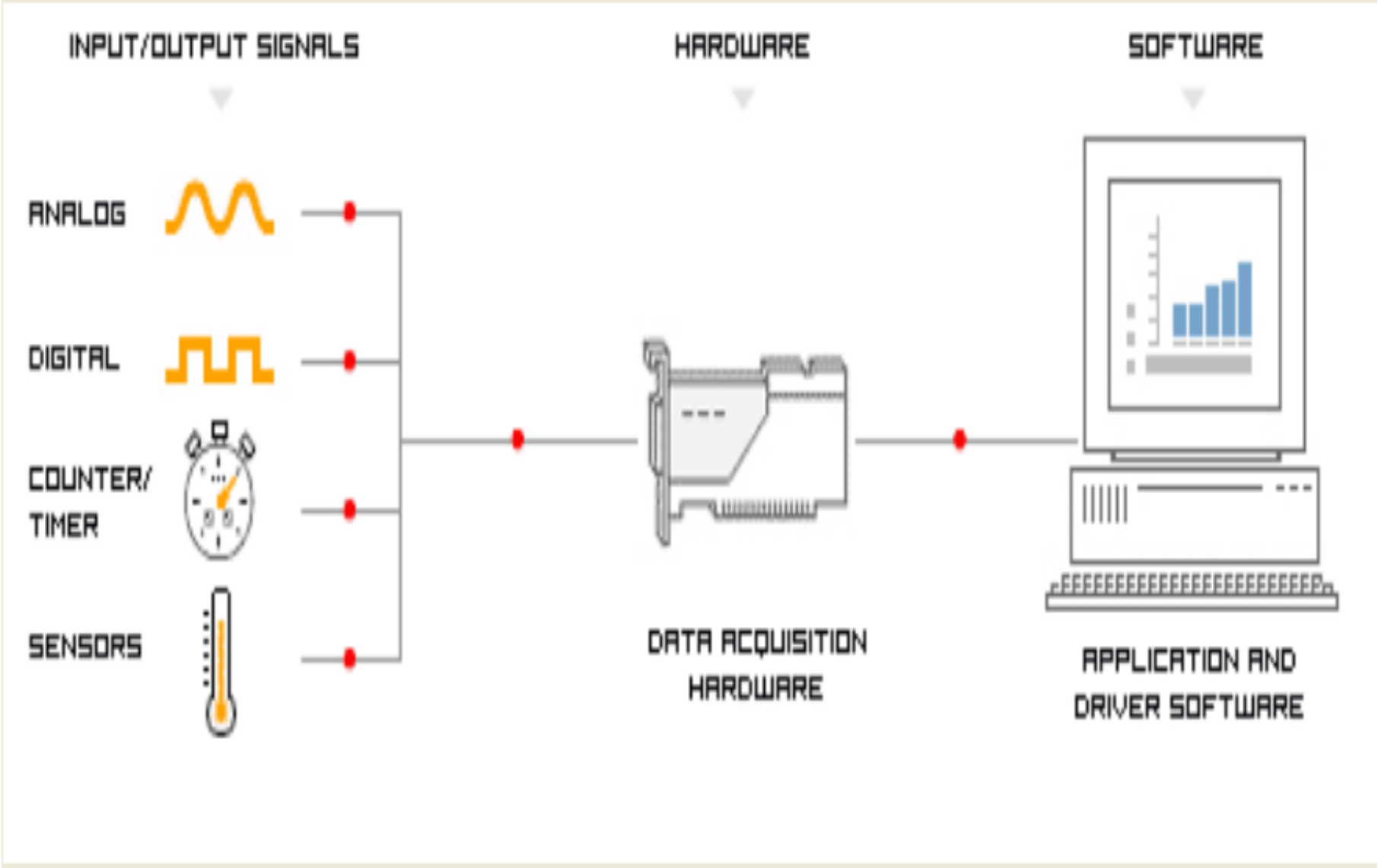
- GOTO 20
- GOSUB and RETURN
- IF THEN ELSE

- PAUSE
  PROCEED

ON/OFF Type communication based on high (+5V) / low (0V)signals

- SIGNAL 2,-3
- IFSIG 2,-3 THEN
- WAIT SIG (-1, 2)
- RESET turns off all external signals
- ON 2
- OFF 3
- RESET

What Is Data Acquisition?

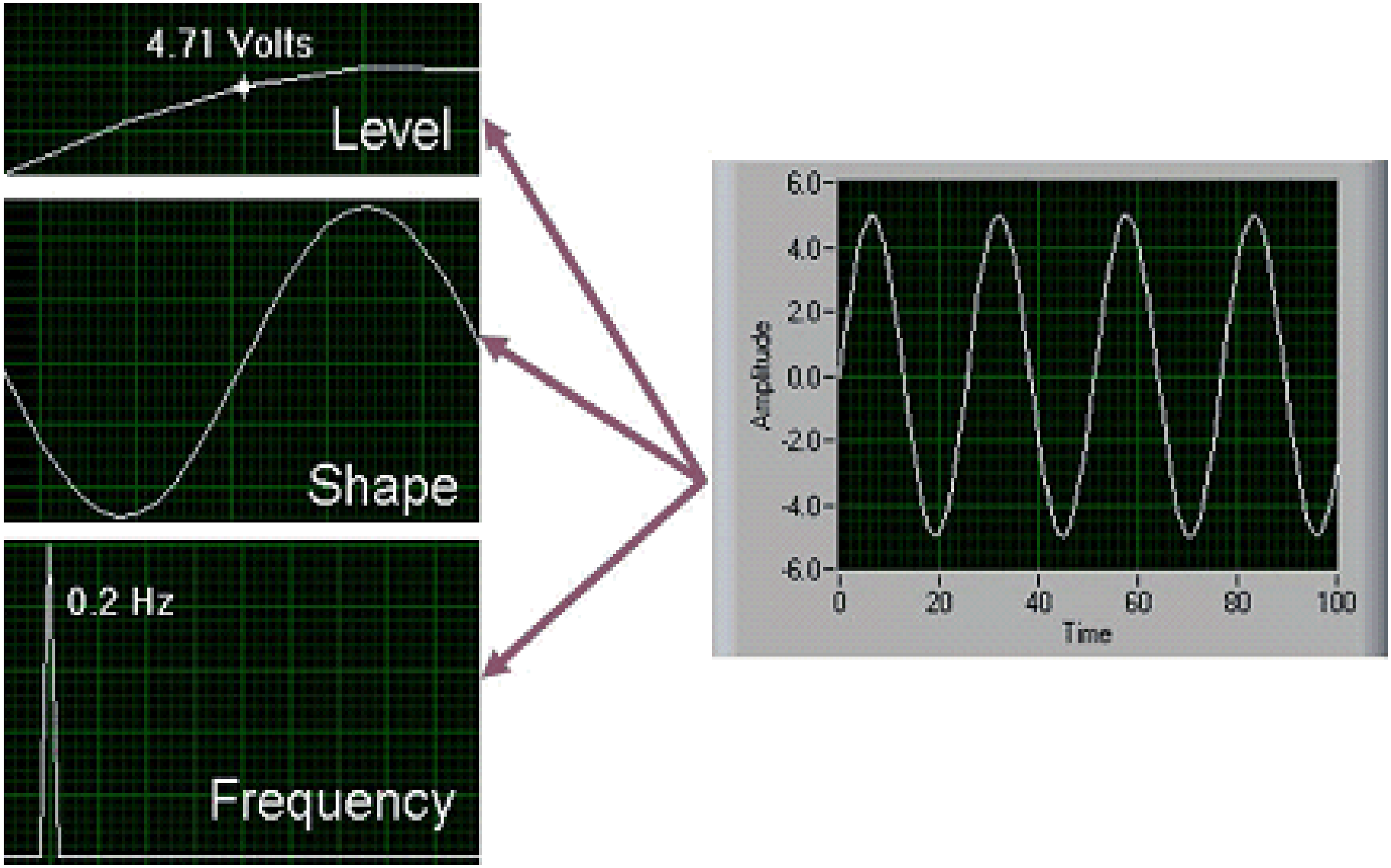


Analog Signals

- An analog signal is a continuous signal that can be at any value with respect to time.

  e.g. analog signals include voltage, temperature, pressure, sound, and load.

- The three primary characteristics of an analog signal include level, shape, and frequency.
  - level
  - shape
  - frequency



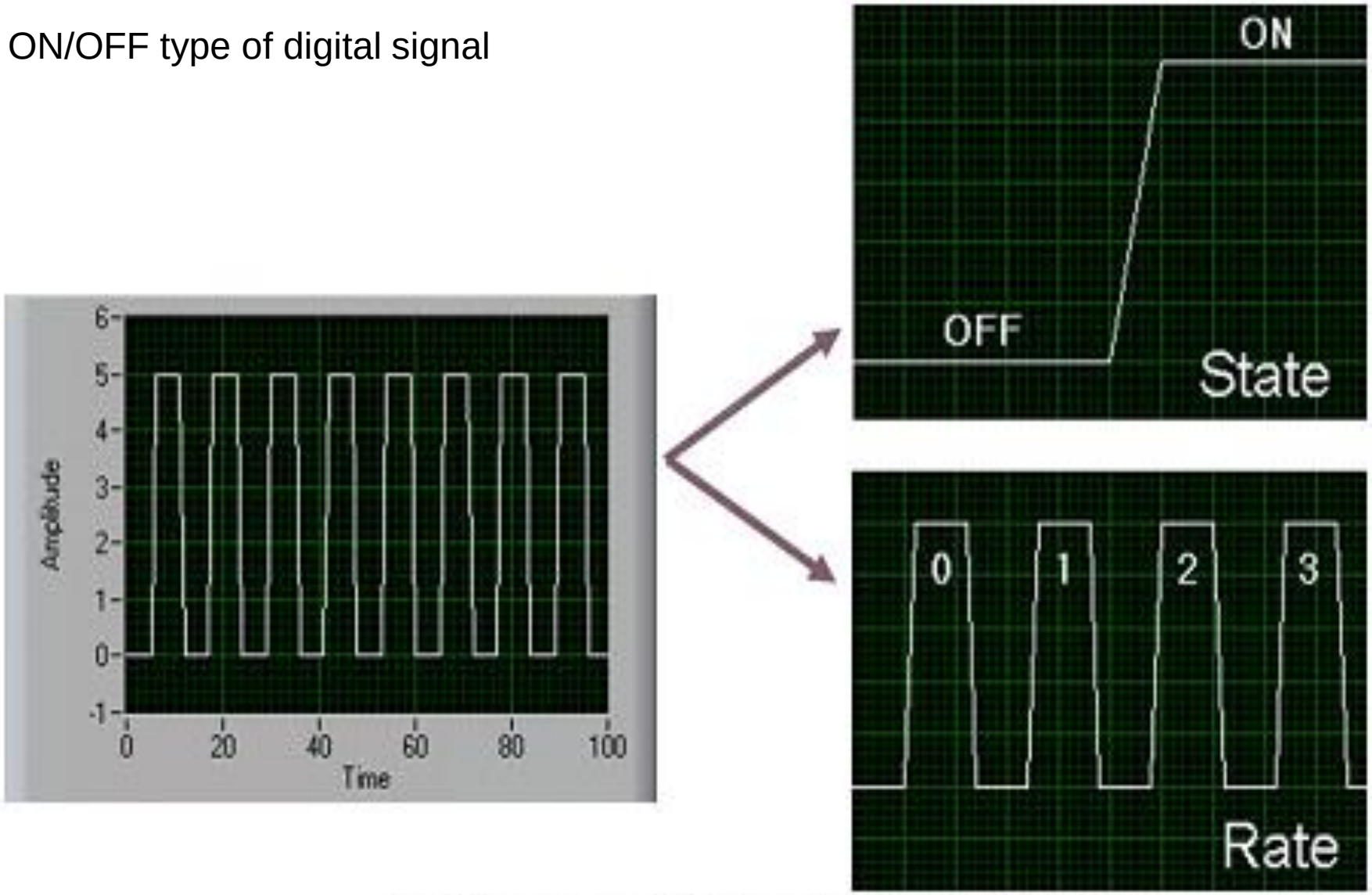
Primary Characteristics of an Analog Signal

Digital Signals

- An analogue signal sampled at a particulate frequency results in a digital signal.

- A digital signal has values only at certain instants of time (at which it is being sampled).

ON/OFF type of digital signal



Primary Characteristics of a Digital Signal

ADC / DAC

- ADC : Analogue to digital converters.

Temperature, force signal converted to digital signal for a computer to read.

- DAC : Digital to analogue converters.

Digital voltage converted to analogue voltage.

Robots use ADC to convert forces, distance, etc from analogue to digital value.

Input / output control

- IOPUT and IOGET

  SIGNAL

ADC / DAC

- ADC1= SENSOR 1

  DAC1= CONST

  DAC1= 3 + CONST

- VAR 1 = ADC (1)

Computation and operations

- SIN(A)
- COS(A)

- SQRT(A)
- EQ, NE, GT …

Using a robot:

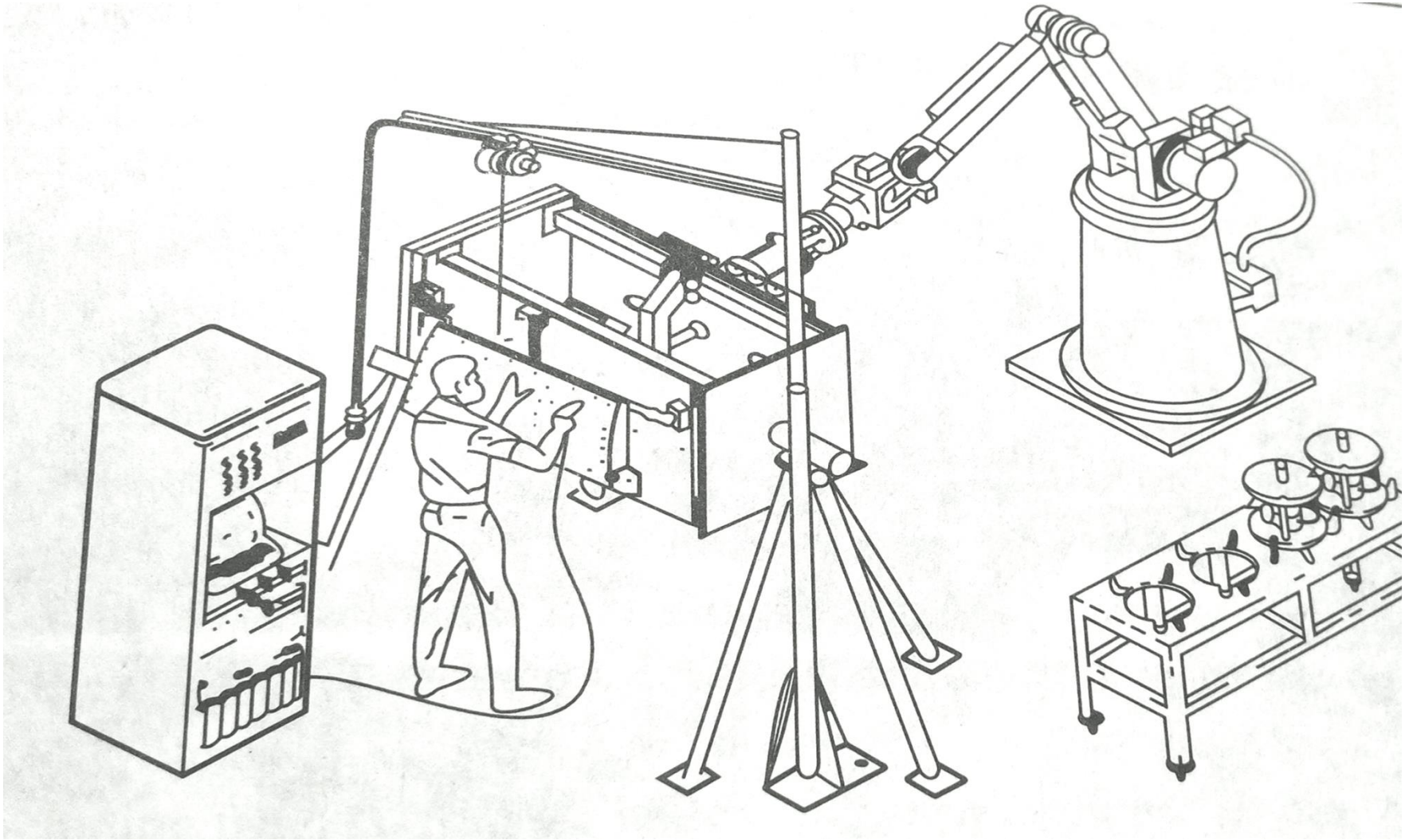
- **Teach pendent**: used to manually teach different points that are recorded in the robots memory. These points can then be played back. e.g. tasks requiring human skills e.g. welding, etc.

- **Program based control**:The desired task is written as a sequence of motions in a language such as VAL. These motions can then be played back.

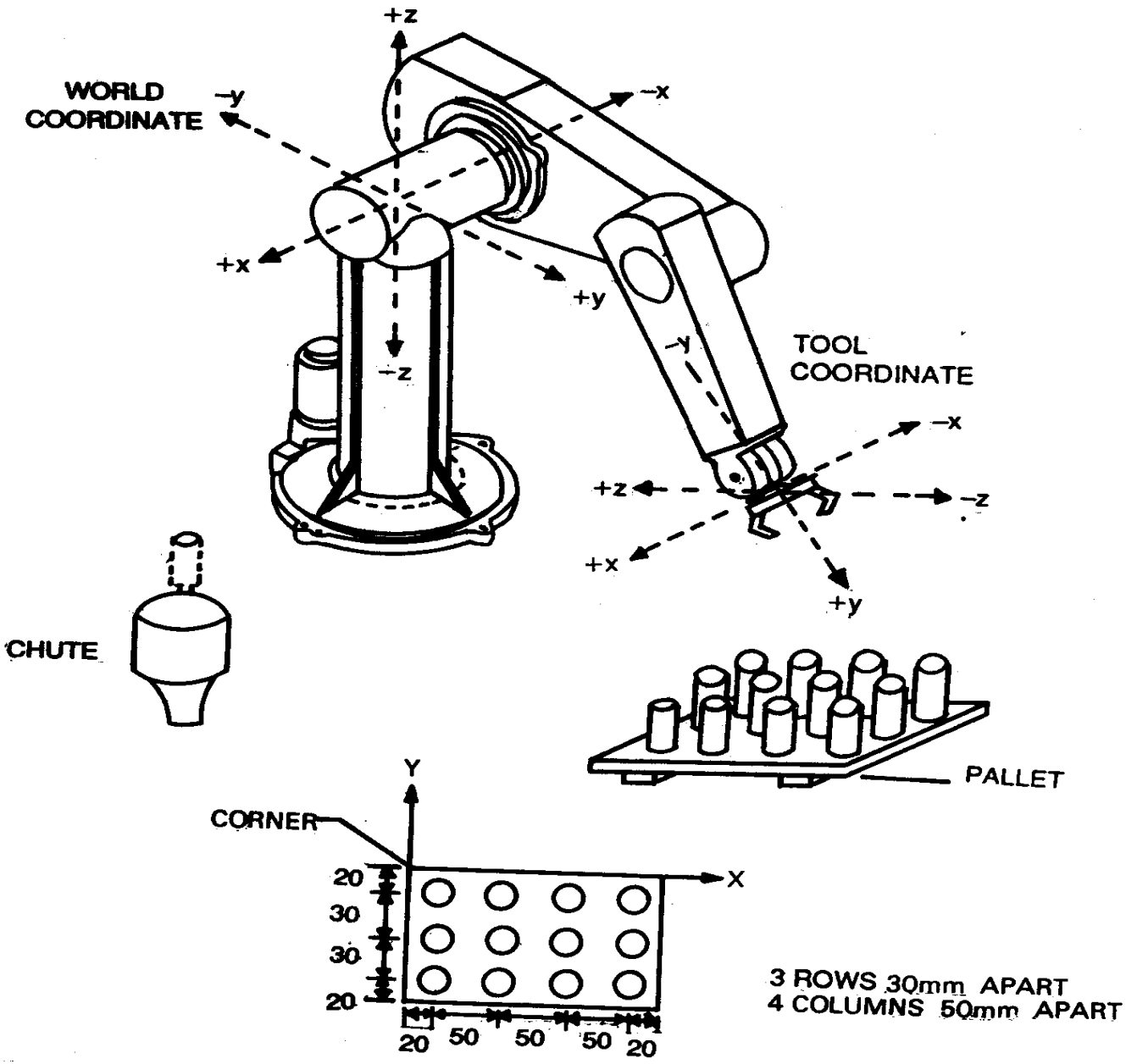
Computer integrated manufacturing

Industrial robots spot weld automobile bodies on an assembly line.

Lead through teaching



Program example



```
PROGRAM DEPALLET 1
REMARK CORNER AND CHUTE LOCATIONS ARE TAUGHT

SETI MAXCOL=4
SETI MAXROW=3
SETI ROW =1
SETI COLUMN=1
SET PICK =CORNER
SHIFT PICK BY 20.00,-20.00, 60.00
OPENI
10  MOVE PICK
    DRAW 0, 0, - 25.00
    CLOSEI
    DRAW 0, 0,  25.00
    MOVE CHUTE
    OPENI
    GOSUB PALLET
    IF ROW LE MAXROW THEN 10
END

PROGRAM PALLET
    SETI COLUMN = COLUMN + 1
    IF COLUMN GT MAXCOL THEN 20
    SHIFT PICK BY 50.00, 0.00, 0.00
    GO TO 10
20  SETI ROW =  ROW + 1
    IF ROW GT MAXROW THEN 30
    SHIFT PICK BY – 150.00, -30.00, 0.00
```

Program Contd.

```
    SETI COLUMN = 1
30  RETURN
```

In – line robot cell

Pick from conveyor and place on table

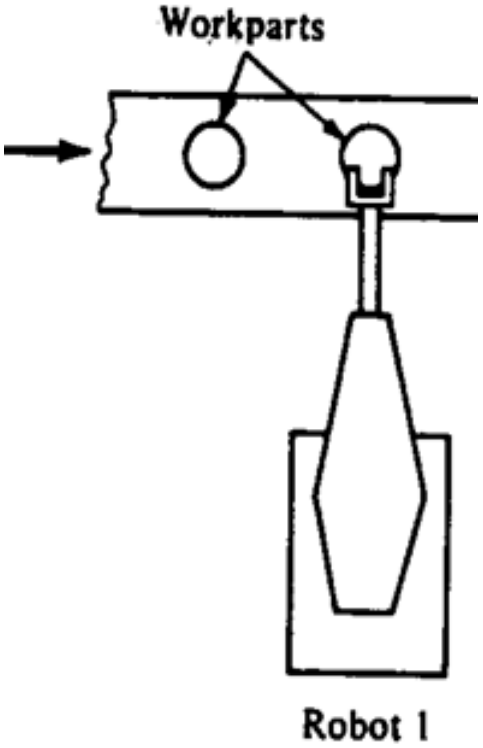
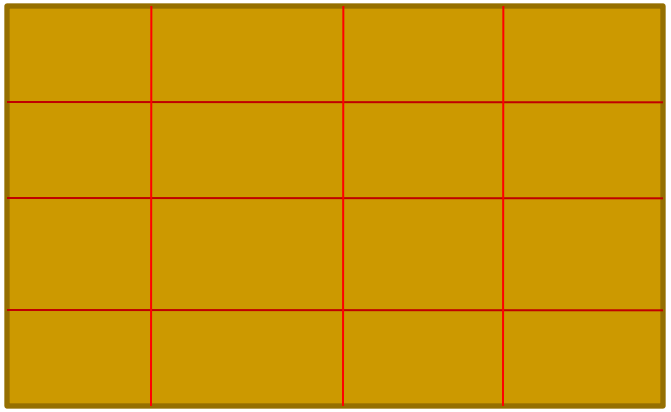
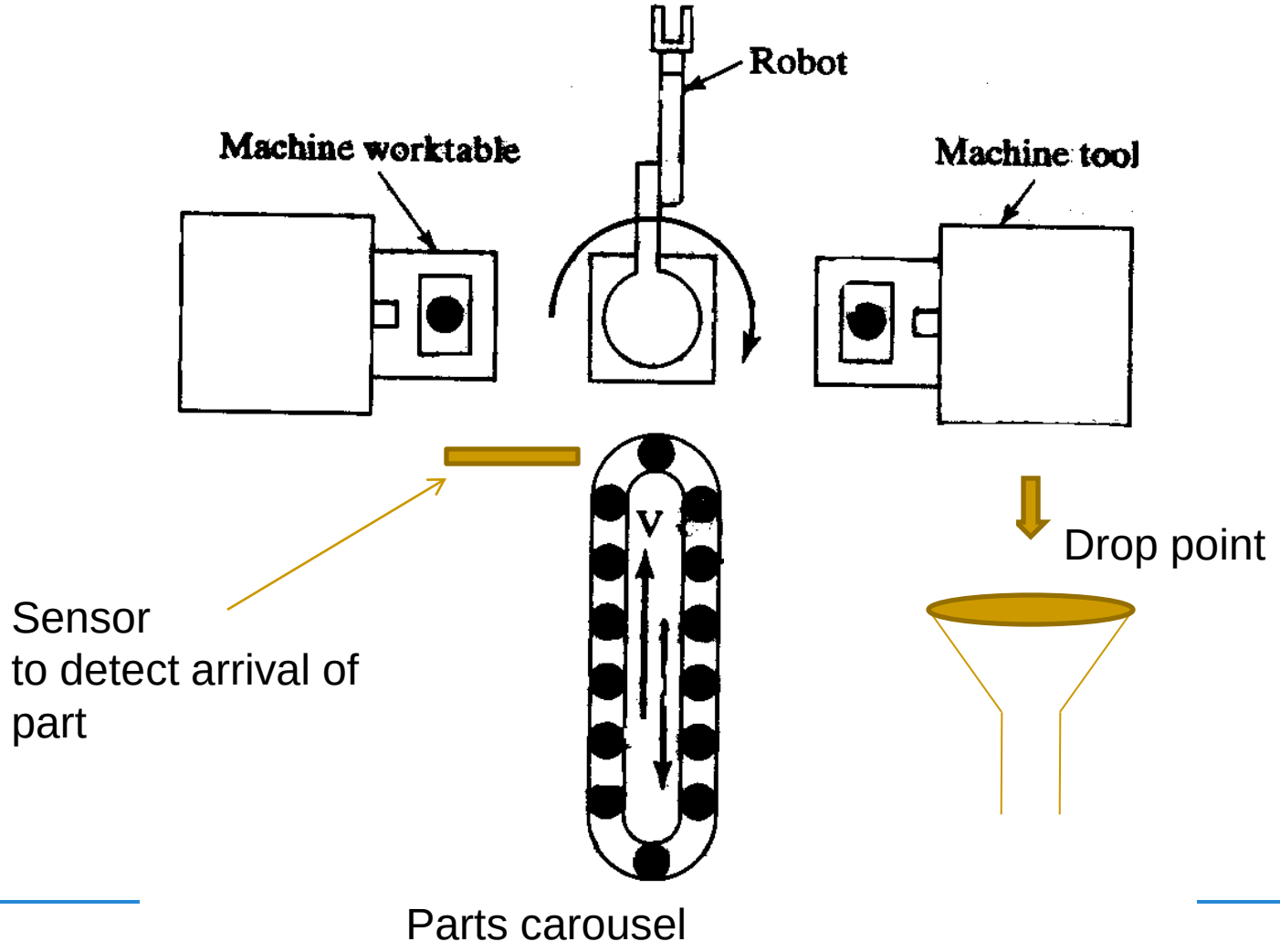


Table : Parts to be placed in each square : INDEXING



Flexible manufacturing cell



Write a program in VAL II for peg in hole robotic assembly.

Robot Specifications:

- **Resolution** : smallest unit the end effectors can be positioned. Control resolution.

- **Accuracy**: the closest the robot can position to a desired point. Accuracy = ½ resolution

- **Repeatability**: ability to position at a pre-taught point a large number of times.

Control resolution:

- 1 DOF prismatic robot having 12 bit storage memory and motion of 1 m .
- 12 bits = 2^12 = 4096 units
- Resolution is 1/4096 = 0.244 mm

END