Module 4 : Sensors and Controllers in robots

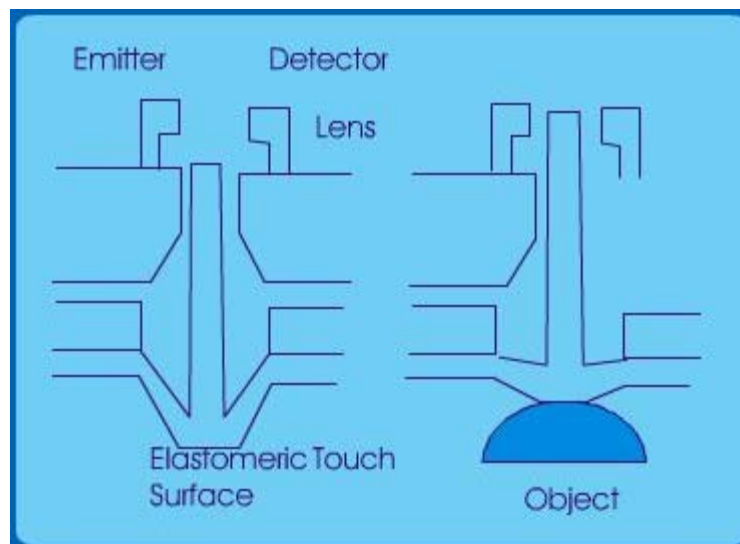**Lecture 11 : Tactile and slip sensors, measurement of forces**

Objectives

In this course you will learn the following

- Incremental Optical encoders

  1X Position decoding

  4X Position Quadrature decoding

- Velocity measurement – Tachs

  FVC using Incremental Encoders

  Software based Velocity estimation

- Acceleration sensing

- External State Sensing

- Tactile sensors

    - Proximity Rod based sensor

    - Photodetector based sensor

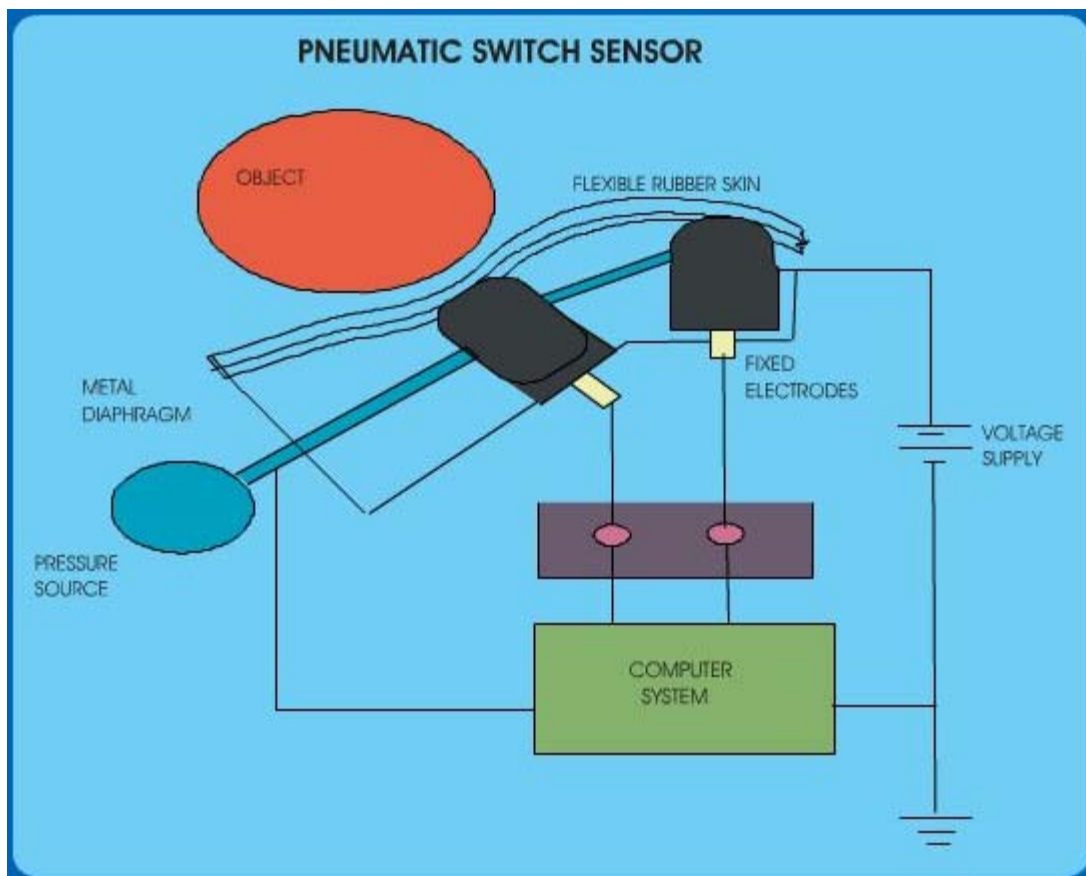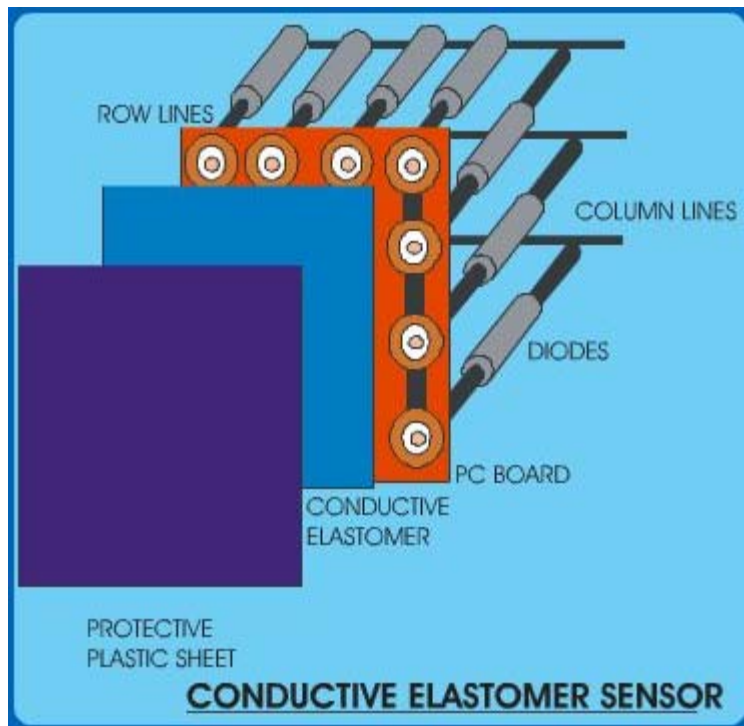   - Conductive elastomer based

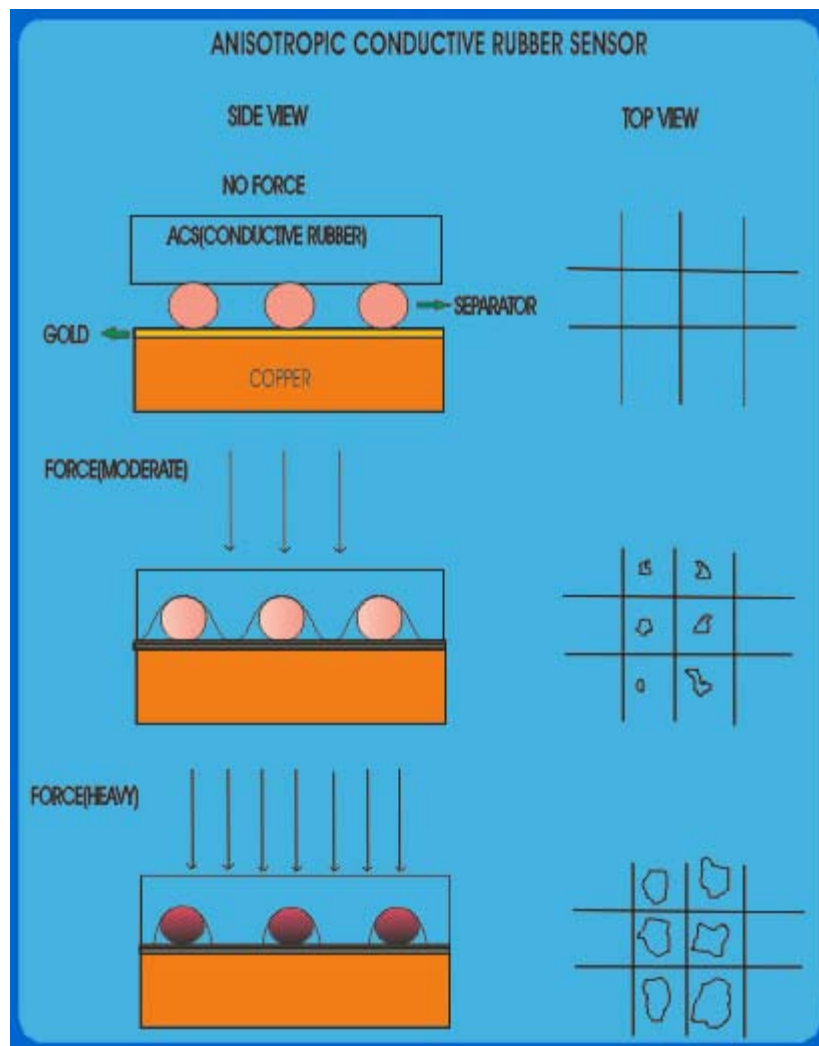### Photo-detector based sensor
8X8 array

Conductive Elastomer
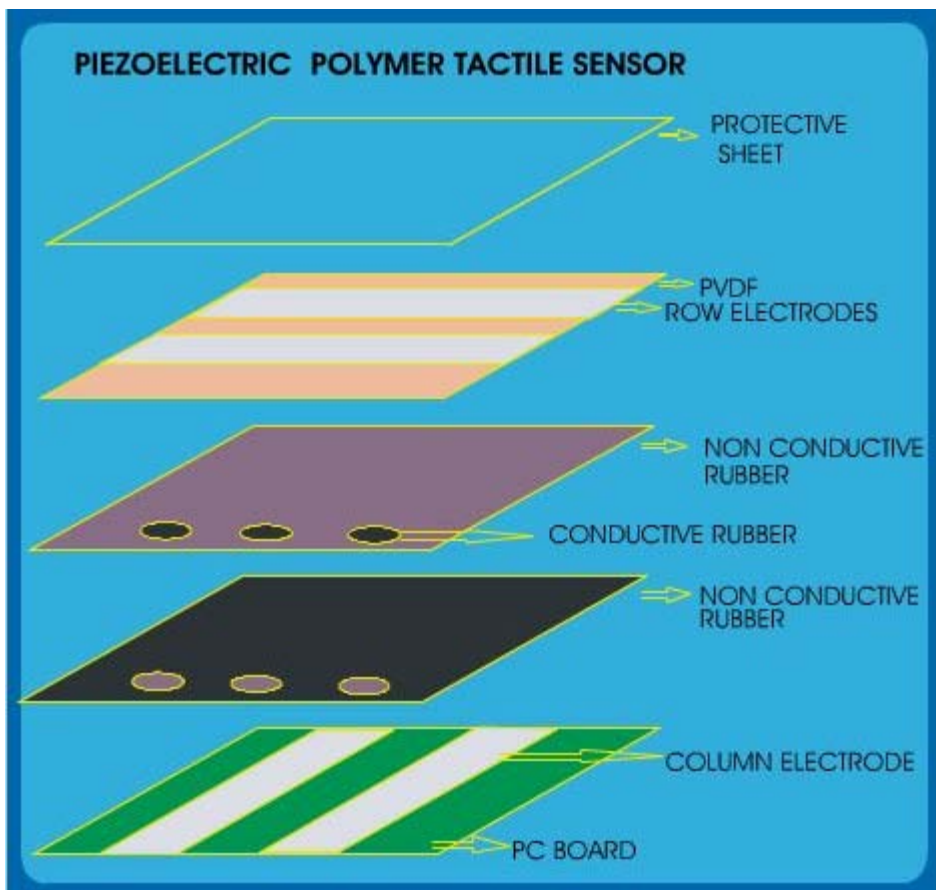Resistance changes with Pressure

nxm array

- n + m lines

CONDUCTIVE ELASTOMER SENSOR

ROW LINES

COLUMN LINES

DIODES

PC BOARD

CONDUCTIVE ELASTOMER

PROTECTIVE PLASTIC SHEET

PNEUMATIC SWITCH SENSOR

OBJECT

FLEXIBLE RUBBER SKIN

FIXED ELECTRODES

VOLTAGE SUPPLY

METAL DIAPHRAGM

PRESSURE SOURCE

COMPUTER SYSTEM

Rubber conduction perpendicular to copper tracks in PCB

ANISOTROPIC CONDUCTIVE RUBBER SENSOR

SIDE VIEW TOP VIEW

NO FORCE

ACS(CONDUCTIVE RUBBER)

SEPARATOR

GOLD

COPPER

FORCE(MODERATE)

FORCE(HEAVY)

Piezoelectric Polymer Tactile Sensor

- PVDF Film generate Potential difference when pressure is applied

- Effect small in thickness but large in-plane
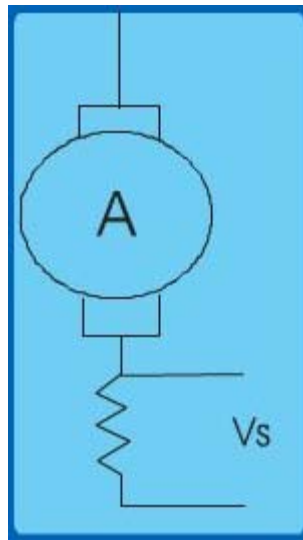
- Signal read before charge leaks
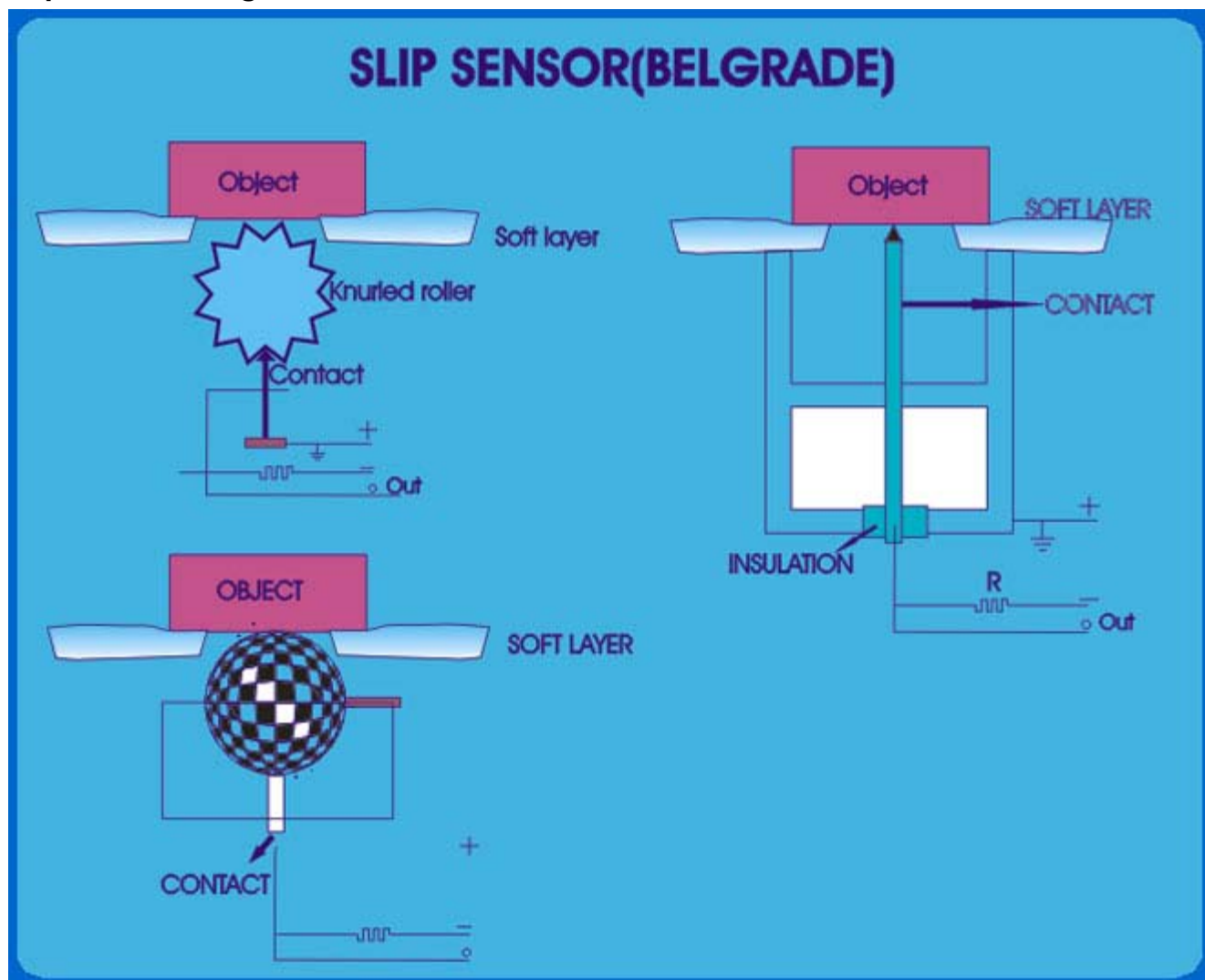
- T ~ a few seconds

Slip Sensor

- Slip motion causes forced vibrations in piezoelectric crystal

- Phonograph record P.U. tends to be sensitive to manipulator vibration periodic replacement of needle

    - Steel Ball end

    - Electromagnetic pickup

    - Oil damper

Force sensing

- I_a proportional to T (Torque)

- $F = T\eta / r = \eta \, K_t \, I_a/r$

- Grasping Strategy

    - Determine Min & Max Force that can be applied on a part

    - Use Min force to start with

    - Increase force if slip is detected subject to limit of max force / Displacement
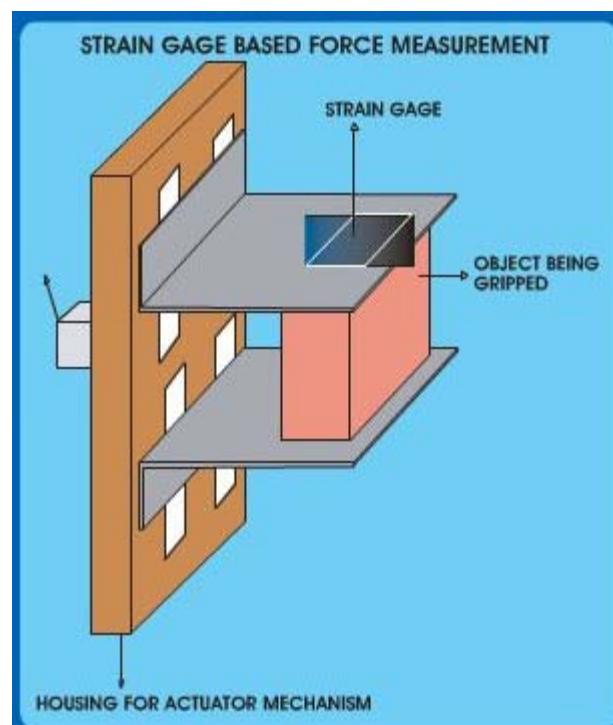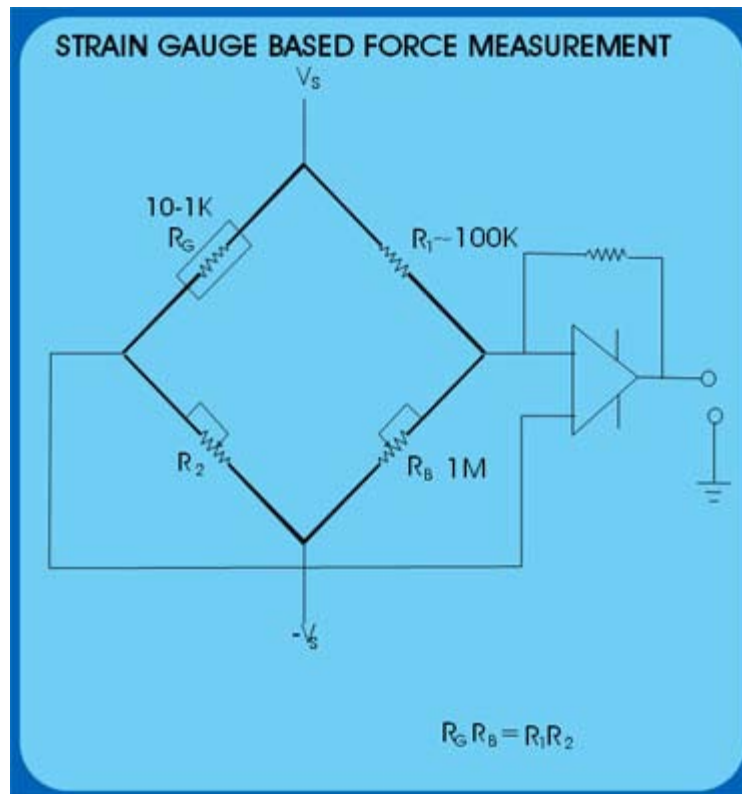
Slip sensor (Belgrade)
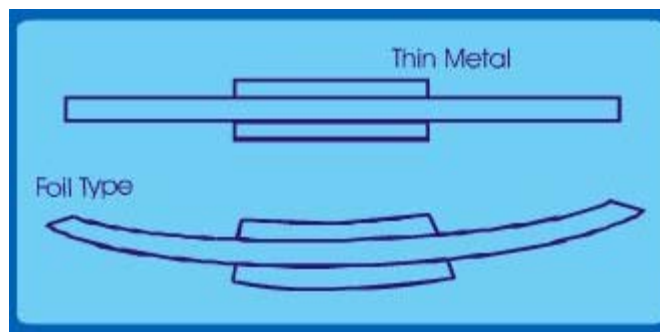

SLIP SENSOR(BELGRADE)

Object

Soft layer

Knurled roller

Contact

Out

OBJECT

SOFT LAYER

CONTACT

Object

SOFT LAYER

CONTACT

INSULATION

R

Out

Strain Gage based Force measurement

R = L / σ A

Other types, Thin Film Semiconductor

Thin Metal

Foil Type

STRAIN GAUGE BASED FORCE MEASUREMENT

V_S

10-1K
R_G

$R_1 \sim 100K$

R_2

R_B 1M

$-V_S$

$R_G R_B = R_1 R_2$

STRAIN GAGE BASED FORCE MEASUREMENT

STRAIN GAGE

OBJECT BEING GRIPPED

HOUSING FOR ACTUATOR MECHANISM

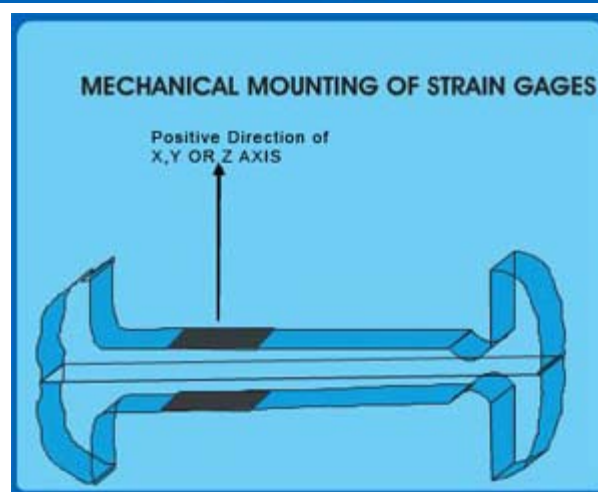**6-Axis Force/Moment Sensor**
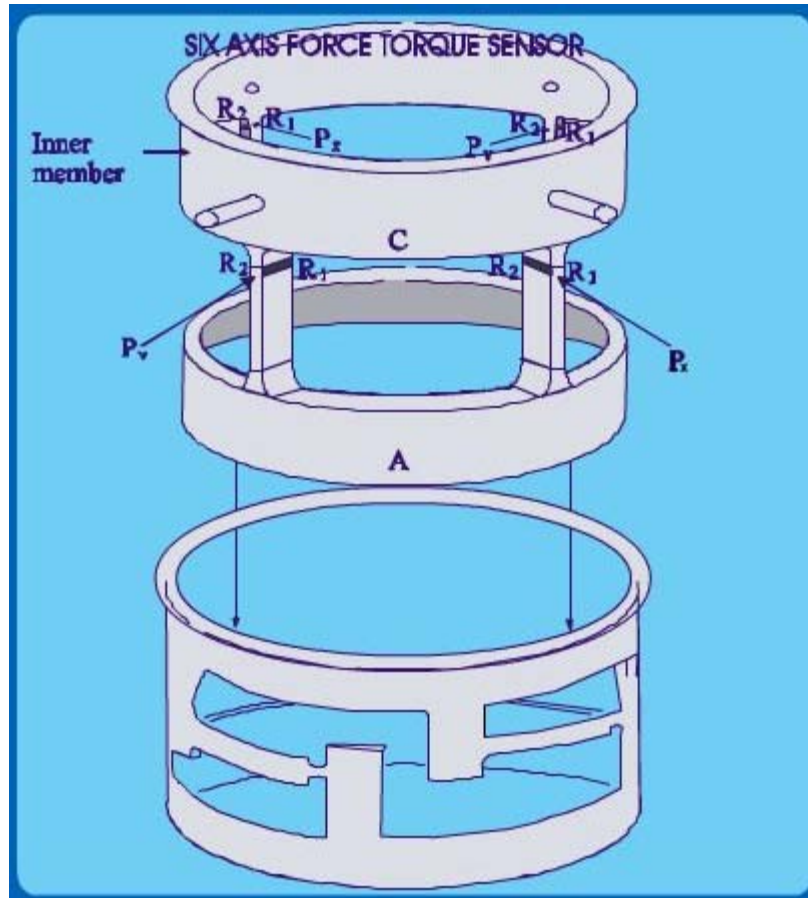
$$F_X \sim P_{Y+} + P_{Y-}$$
$$F_Y \sim P_{X+} + P_{X-}$$
$$F_Z \sim Q_{X+} + Q_{X-} + Q_{Y+} + Q_{Y-}$$
$$M_X \sim Q_{Y+} - Q_{Y-}$$
$$M_Y \sim Q_{X+} - Q_{X-}$$
$$M_Z \sim P_{X+} - P_{X-} - P_{Y+} + P_{Y-}$$

Recap

In this course you have learnt about

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FVC using Incremental Encoders
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- Acceleration sensing

- External State Sensing

- Tactile sensors

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    - Photodetector based sensor

    - Conductive elastomer based

Congratulations, you have finished Lecture 11. To view the next lecture select it from the left hand side menu of the page