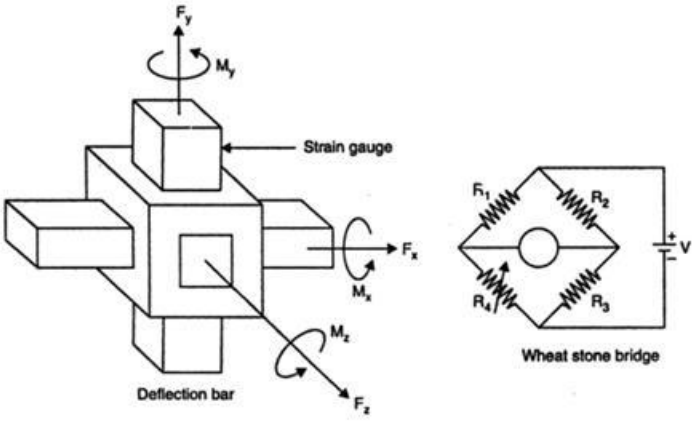
FORCE AND TORQUE SENSORS:

Force sensors are instruments that transform various mechanical force such as weight, compression, torque, strain, stress or pressure in to electrical signal.

The following figure shows the wrist force sensor which measure the force and torque induced on the wrist of the robotic manipulator. They can also be used to measure the joint forces. Force /torque sensor works on the principle of strain Gauge.



Principle of strain gauge.

When a force is applied to a strain gauge it may stretch or compress changing the resistance of the gauge. The resistance change is converted into measure able electrical output. When the gauge stretches resistance increases when the gauge compress resistance decreases.

The construction of the sensor has a disc housing and a deflection bar; the strain gauge is mounted on the six faces of the deflection bar. The force on the wrist is converted in to measure able displacement at the wrist.

A wheat stone bridge shows the arrangement of the resistors and galvanometers. The galvanometer shows zero when no force is exerted. when the force is exerted the resistance of any one of the arms vary which leads to current flow showing the needle movement in galvanometer. The chance in resistance is given by,

$$\frac{R_1}{R_4} = \frac{R_2}{R_3}$$

Specifications for force sensors:

- Linearity between response and applied force
- Low hysteresis and internal friction for restoring the original position
- Compact design to avoid collision with other objects.

Two types of encoders are used to measure the speed

- LINEAR ENCODER TO MEASURE LINEAR SPEED

The light source emits a focused beam of light.

As the linear scale moves, the light beam passes over the alternating transparent and opaque sections of the scale. The photodetector receives the light (or lack thereof) and converts it into a series of electrical pulses. These pulses are processed and interpreted by a controller or display to provide a precise measurement of the linear displacement

- INCREMENTAL ENCODER TO MEASURE ROTATIONAL SPEED.

An integrated light source, typically an infrared LED or a laser, illuminates the code disk. The disk is etched with a pattern of transparent and opaque lines, arranged in concentric tracks for rotary encoders. A photosensitive sensor is positioned on the opposite side of the disk (or the same side for reflective encoders). As the disk rotates, the lines alternately block and transmit the light. The sensor converts these variations in light intensity into electrical pulses.

Both the encoder convert motion in to electrical signal.

The force torque sensor has 3 forces and 3 moments acting at the center, Therefore the force balanced equation is

$F=CW$

Where, F is the external force,

C -matrix relating external force

W -Strain gauge reading.