**Instrumentation and Measurements**



# Instrument Types and Performance Characteristics

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# Instrument types

❑ Active and passive instruments

❑ Null-type and deflection-type instruments

❑ Analogue and digital instruments

❑ Indicating instruments and instruments with a signal output
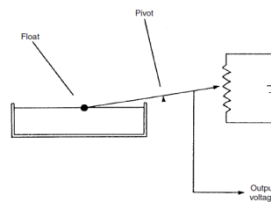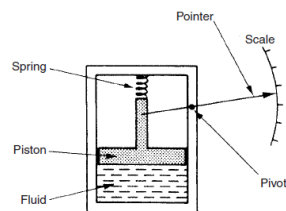
❑ Smart and non-smart instruments

# Active and passive instruments

❑ *In passive instruments, the output is entirely produced by the quantity being measured*.

❑ The pressure-measuring device shown is an example of a passive instrument.

❑ *In active instruments, the quantity being measured simply modulates the magnitude of some external power source*.

❑ In the float-type petrol tank level indicator, the change in petrol level moves a potentiometer arm, and the output signal consists of a proportion of the external voltage source applied across the two ends of the potentiometer.
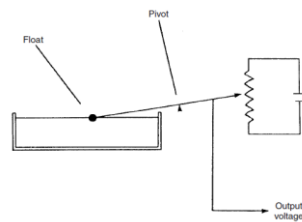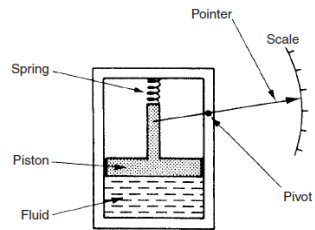
## Active and passive instruments: **Resolution**

❑ With the simple pressure gauge shown, the amount of movement made by the pointer for a particular pressure change is closely defined by the nature of the instrument.

❑ In an active instrument, however, adjustment of the magnitude of the external energy input allows much greater control over measurement resolution.

❑ Whilst the scope for improving measurement resolution is much greater

## Active and passive instruments: **Cost**

❑ Passive instruments are normally of a more simple construction than active ones and are therefore cheaper to manufacture.

❑ Therefore, choice between active and passive instruments for a particular application involves carefully balancing the measurement resolution requirements against cost.
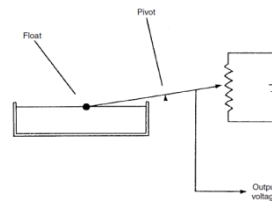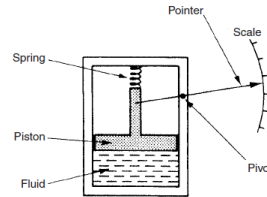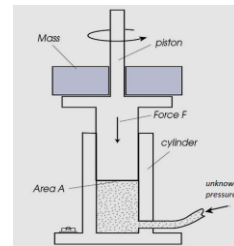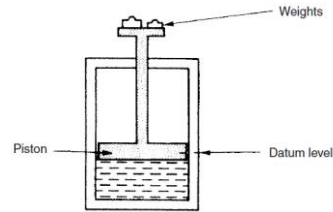


## **Null-type and deflection-type instruments**

❑ In deflection type instruments, the value of the quantity being measured is displayed in terms of the amount movement of a pointer.

❑ The pressure-measuring device shown is an example of a deflection type instrument.
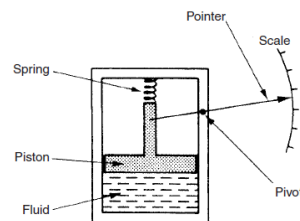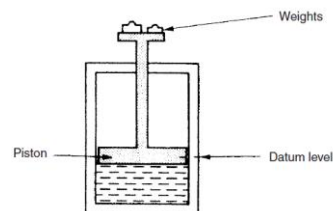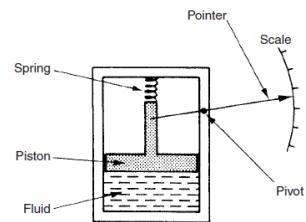
## Null-type and deflection-type instruments

❑ An alternative type of pressure gauge is the deadweight gauge which is a null-type instrument.

❑ Here, weights are put on top of the piston until the downward force balances the fluid pressure.

❑ Weights are added until the piston reaches a datum level, known as the null point.

❑ Pressure measurement is made in terms of the value of the weights needed to reach this null position.

## Null-type and deflection-type instruments: Accuracy

❑ The accuracy of the deflection type pressure measurement instrument depends on the linearity and calibration of the spring, whilst for the second it relies on the calibration of the weights.

❑ As calibration of weights is much easier than careful choice and calibration of a linear-characteristic spring, this means that the second type of instrument will normally be the more accurate.

❑ This is in accordance with the general rule that null-type instruments are more accurate than deflection types.

## Null-type and deflection-type instruments:
### **Usage**

❑ In terms of usage, the deflection type instrument is clearly more convenient. It is far simpler to read the position of a pointer against a scale than to add and subtract weights until a null point is reached.

❑ A deflection-type instrument is therefore the one that would normally be used in the workplace.

❑ However, for calibration duties, the null-type instrument is preferable because of its superior accuracy.

❑ The extra effort required to use such an instrument is perfectly acceptable in this case because of the infrequent nature of calibration operations.
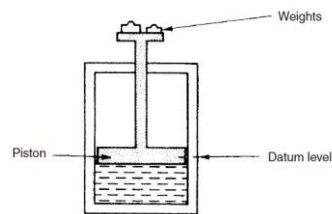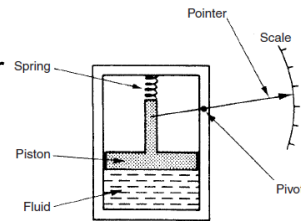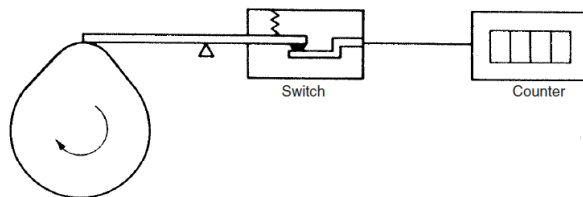
# **Analogue and digital instruments**

❑ An analogue instrument gives an output that varies continuously as the quantity being measured changes.

❑ The output can have an infinite number of values within the range that the instrument is designed to measure.

❑ The deflection-type of pressure gauge is an example of an analogue instrument.

❑ As the input value changes, the pointer moves with a smooth continuous motion.

❑ Whilst the pointer can therefore be in an infinite number of positions within its range of movement, the number of different positions that the eye can discriminate between is strictly limited, this discrimination being dependent upon how large the scale is and how finely it is divided.
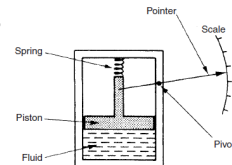
# Analogue and digital instruments

❑ A digital instrument has an output that varies in discrete steps and so can only have a finite number of values.

❑ The rev counter is an example of a digital instrument. A cam is attached to the revolving body whose motion is being measured, and on each revolution the cam opens and closes a switch.

❑ The switching operations are counted by an electronic counter.

❑ This system can only count whole revolutions and cannot discriminate any motion that is less than a full revolution



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## Analogue and digital instruments: **Computer Interface**

❑ An instrument whose output is in digital form is when there is a need to be interfaced to a control computer. Analogue instruments must be interfaced by an analogue-to-digital (A/D) converter.

❑ A/D converter adds a significant cost to the system. Additionally, a finite time is involved in the process of converting an analogue signal to a digital quantity, and this time can be critical in the control of fast processes where the accuracy of control depends on the speed of the controlling computer.

❑ Degrading the speed of operation of the control computer by imposing a requirement for A/D conversion thus impairs the accuracy by which the process is controlled.
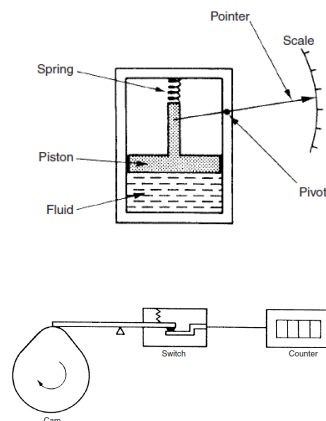
## Indicating instruments and instruments with a signal output

❑ Signal-type output instruments

  ❑ Instruments used as part of automatic control systems.

  ❑ Usually, the measurement signal involved is an electrical voltage, but it can take other forms in some systems such as an electrical current, an optical signal or a pneumatic signal.

❑ Indicating instruments

  ❑ Includes all null-type instruments and most passive ones.

  ❑ Indicators can also be further divided into those that have an analogue output and those that have a digital display.

## Smart and non-smart instruments

❑Self calibration capability

❑Self-diagnosis of faults

❑Compensation for random errors

❑Adjustment for measurement non-linearities

# Challenge

Carry out the following for an instrument of your choice

❑ Describe the measuring mechanism in the instrument with a simple sketch

❑ Specify the components of the instrument including the sensor, variable conversion element, signal processing, transmission and display.

❑ Categorize the instrument according to weather it is (i) active or passive, (ii) null or deflection type, (iii) analog or digital, (iv) indicating or with signal output, (v) smart or non-smart.