THE UNIVERSITY OF ZAMBIA

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COURSE : MEC 3102

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Q 1 Explain what is meant by:

Give examples of each and discuss the relative merits of these two classes of instruments.

(a) Active instruments

The quantity to be measured activates some external power in-put source which in turn produces the out-put.

(b) Passive instruments

These are instruments where the output is entirely produced by the quantity being measured.

For active instruments, an additional external energy in-put source is required, these instruments are complicated to design due to there complexity (requiring a larger number of elements). Active instruments provide high resolution and the resolution can be adjusted by the magnitude of the external energy in-put. Examples of these instruments are electronic weighing scale, blood pressure monitor, float tank petrol level indicator.

On the other hand, passive instruments require no external energy in-put source to function, these instruments are very simple to design because they are less complicated and the resolution is less and can not be easily be adjusted. Examples of the instruments are the spring balance, pressure gauge, thermocouple and a light dependent resistor.

Q 2 What are the three categories of systematic errors in the instrument and explain in detail.

There are 3 categories of systematic errors, these are:

- Instrumental error: This is the error of the measuring instrument itself or the difference between the actual value and the measured value by the instrument these errors can be due to overstretching of the spring, spring tension etc. These errors can be avoided by calibrating the instrument against standard, applying correctional error.
- Environmental error: These are errors that are due to the environment in which the instrument is being used. These errors can be corrected by moderating the temperature to prevent some components from expanding, sealing some components of the instrument in case of humid conditions and use of magnetic shields.
- Observational error: These are errors introduced by the observer usually parallax error where the observer reads scales at an angle sometimes the observer makes approximations which might be wrong.

Q 3 i) Briefly define and explain the following static characteristics of measuring instruments;

(a) Accuracy: This is simply the degree of agreeance of the measured value with the actual value or a standard.

(b) Resolution: This is an increase in the input to increase the clarity and / or sharpness of a measurement or observation.

(c) Sensitivity: This shows the ability to detect any slight change in a quantity being measured by an instrument. Can be given by Sensitivity = $\frac{infinitesmal\ change\ in\ output}{infintesmal\ change\ in\ input} = \frac{\Delta qo}{\Delta qi}$

(d) Linearity: this is the ability to reproduce the input characteristics symmetrically and linearly.

ii. Define and explain the types of static errors possible in an instrument.

There are three types of static errors, these are

i) Gross errors/ human errors: These errors are wholly caused by humans, they cannot be eliminated completely but can be minimized.
ii) Systematic errors: Just as mentioned in Q 2 above.
iii) Random errors: Reasons for these errors are not known, they occur after all systematic errors have been accounted for, they can be avoided by taking several readings and use of mathematics (statistical) method to best approximation of the true value.'

Q 4

i. Explain the difference between accuracy and precision in an instrument.

Accuracy is the degree of closeness of measured values with the actual true value of a particular quantity while precision is the reproducibility or agreeance of a certain group of values taken to measure something.

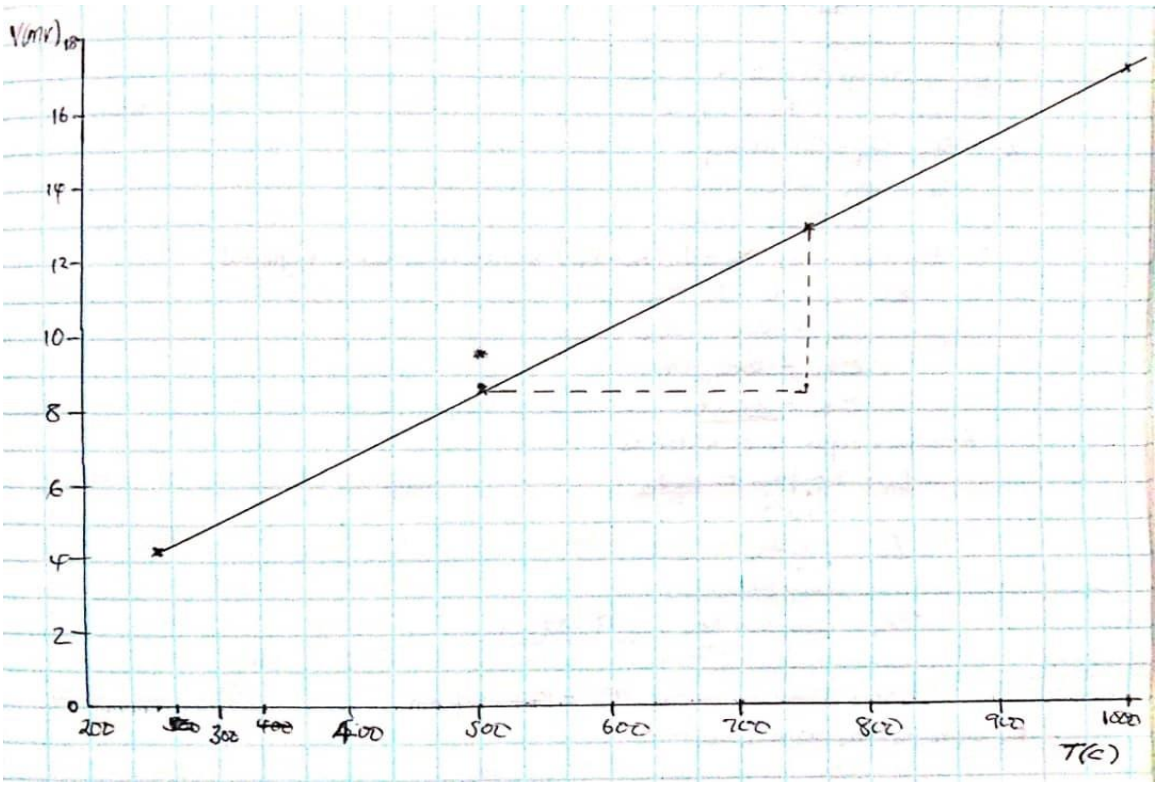
ii. Discuss in detail the various dynamic characteristics of a measuring system.

The various dynamic characteristics are:

- ✓ Speed of response: This is simply the time a machine or instrument has to detect any slight change in the quantity being measured or examined. A good example of an instrument that need a good speed of response is a thermometer or speedometer.
- ✓ Measuring lag: This is the delay of response of an instrument in capturing a change in measurement of a quantity. Measuring lag is in two type, the first being, the retardation type where response of the measurement system starts as soon as there is a change in measured quantity. The second type is Time delay lag where the response of the measurement system begins after a dead time after the application of input.
- ✓ Fidelity: is the degree to which a measurement system indicates changes in the measurand quantity without dynamic error.
- ✓ Dynamic error: is the difference between the true value of the quantity changing with time & the value indicated by the measurement system if no static error is assumed. It is also called measurement error.

Q 5 A tungsten/5% rhenium-tungsten/26% rhenium thermocouple has an output e.m.f. as shown in the following table when it is hot (measuring) junction is at the temperatures shown. Determine the sensitivity of measurement for the thermocouple in mV/^{0}C

mV	**4.37**	**8.74**	**13.11**	**17.48**
^{0}C	**250**	**500**	**750**	**1000**



Sensitivity $= \frac{v(mv)3 - v(mV)2}{0c3 - 0c2}$

$= \frac{13.11 - 8.74}{750 - 500}$

$= \frac{4.37}{250}$

Sensitivity $= 0.01748$ mV/^{0}C