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CORE JOBS · INTERVIEW QUESTIONS

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Sensors and Industrial Instrumentation Interview Questions

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Online, with links to the notes: **iaeacademy.in/study/sensors-instrumentation/interview-questions**

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Sensing principles and signal conditioning

1. What is the gauge factor of a strain gauge, and what values do metal and semiconductor gauges have?

The gauge factor is the fractional change in resistance per unit strain, $G = (\Delta R/R)/\varepsilon$. Metal foil gauges have a value near 2, from the change in length and cross-section plus a small change in resistivity. Semiconductor gauges reach values near 100, but they vary strongly with temperature and are less linear.

2. Why is an instrumentation amplifier used to read the output of a sensor bridge?

A bridge gives a small difference voltage sitting on a large voltage shared by both output terminals. An instrumentation amplifier amplifies only the difference, rejects the shared part (high common-mode rejection ratio) and has very high input impedance, so it does not load the bridge. One resistor sets its gain without upsetting the matched resistors that give that rejection.

3. A quarter bridge has one strain gauge of gauge factor 2.0 and three fixed resistors, each equal to the gauge's unstrained resistance, excited at 10 V. The gauge sees a strain of 1000 microstrain. Find the bridge output voltage.

The bridge output is about 5 mV, using the small-change approximation that holds when the resistance change is a tiny fraction of the nominal resistance of the gauge.

WORKING

1. $\Delta R/R = G\varepsilon = 2.0 \times 1000 \times 10^{-6} = 2 \times 10^{-3}$
2. For a quarter bridge with equal arms and a small change, $V_o \approx V_s\,(\Delta R/R)/4$
3. $V_o = 10 \times 2 \times 10^{-3}/4$
4. $V_o = 5 \times 10^{-3}$ V

Motion & force

4. Why can a piezoelectric force sensor not measure a steady load?

The sensor produces a charge, and that charge leaks away through the sensor's insulation and the amplifier's input resistance. Under a steady load the output decays with time constant RC, so the sensor works only above a lower cut-off frequency $f = 1/(2\pi RC)$. It suits dynamic and shock measurement, not static weighing.

5. An incremental encoder gives 1024 pulses per revolution. A counter records 6000 pulses in 0.5 s. Find the shaft speed in rpm.

The shaft turns at about 703 rpm, found by dividing the pulse rate by the pulses per revolution and converting revolutions per second to revolutions per minute.

WORKING

1. Pulse rate = 6000/0.5 = 12000 pulses/s
2. Speed = 12000/1024 = 11.72 rev/s
3. Speed in rpm = $11.72 \times 60 \approx 703$

6. What is the difference between a seismic accelerometer and a seismic vibrometer?

Both use a spring-mounted mass inside a case. An accelerometer works well below its natural frequency (frequency ratio much less than 1): the mass follows the case and the relative motion is proportional to acceleration. A vibrometer works well above its natural frequency (ratio much greater than 1), where the mass stays almost still and the relative motion equals the case displacement.

Pressure and flow measurement

7. How does a U-tube manometer measure pressure, and what limits its use?

It balances the pressure difference against the weight of a liquid column, $\Delta p = (\rho_m - \rho_f) g h$, where h is the height difference between the two legs, ρ_m is the manometer liquid's density and ρ_f the measured fluid's, negligible for a gas. It is simple and needs no calibration against another device. It suits only low pressures, since high ones need a very tall column, and it is hard to read remotely or use with fast changes.

8. An orifice-plate flowmeter indicates 30 m³/h when the differential pressure is 16 kPa. What flow does it indicate when the differential pressure is 25 kPa, for the same fluid?

The meter indicates 37.5 m³/h, because for a differential-pressure meter the flow rises with the square root of the differential pressure, not in direct proportion to it.

WORKING

1. For a differential-pressure meter, $Q \propto \sqrt{\Delta p}$
2. $Q_2 / Q_1 = \sqrt{25/16} = 1.25$
3. $Q_2 = 30 \times 1.25 = 37.5$ m³/h

9. What is the difference between a differential-pressure flowmeter and an electromagnetic flowmeter?

A differential-pressure meter puts a restriction such as an orifice plate in the pipe and infers flow from the pressure drop, so its output follows a square law and it causes a permanent pressure loss. An electromagnetic meter has no obstruction and gives an emf proportional to velocity, but it works only on liquids with some electrical conductivity.

Temperature measurement

10. Why does a thermocouple circuit need cold-junction compensation?

A thermocouple's emf depends on the temperature difference between its measuring junction and its reference junction, not on the measuring junction alone. The reference end is at the instrument, where room temperature changes. So the instrument either measures that temperature and adds the matching emf, or the reference is held at a fixed temperature.

11. What is the difference between an RTD and a thermistor?

An RTD is a metal element, usually platinum, whose resistance rises almost linearly with temperature over a wide range and stays stable. A typical thermistor is a semiconductor whose resistance falls steeply and non-linearly as temperature rises. It is much more sensitive but covers a narrower range and needs linearising.

12. A platinum RTD has a resistance of 100 Ω at 0 °C and a temperature coefficient of 0.00385 per °C. Using the linear relation, find the temperature when its resistance is 119.25 Ω.

The temperature is 50 °C, found by rearranging the linear RTD relation, which is a good approximation for platinum over a modest range of temperature around 0 °C.

WORKING

1. $R = R_0(1 + \alpha T)$
2. $119.25 = 100\,(1 + 0.00385\,T)$
3. $0.1925 = 0.00385\,T$
4. $T = 0.1925 / 0.00385 = 50$ °C

13. Why is a three-wire connection used for an RTD in a bridge?

The lead wires add resistance that changes with the cable's temperature, which would read as a false change in sensor temperature. In a three-wire connection, one lead sits in each of two adjacent bridge arms, so their resistances cancel when the arms are equal. The third lead carries almost no current, so it adds no error. A two-wire connection cannot do this.

Level, pH, conductivity and viscosity

14. An open tank holds oil of density 800 kg/m³ to a depth of 4 m. A pressure sensor at the bottom measures gauge pressure. Find the reading. Take $g = 9.81$ m/s².

The sensor at the bottom reads a gauge pressure of about 31.4 kPa, since the hydrostatic pressure depends only on the liquid density, gravity and the depth of the liquid.

WORKING

1. Hydrostatic pressure, $p = \rho g h$
2. $p = 800 \times 9.81 \times 4$
3. $p = 31392$ Pa ≈ 31.4 kPa

15. Why does a pH measurement with a glass electrode need an amplifier with very high input impedance?

The glass membrane has a very high resistance, from tens to hundreds of megaohms. Any current drawn by the measuring circuit drops voltage across that resistance, so the reading falls below the true electrode voltage. A high input impedance keeps the current negligible and the error small.

16. Why is alternating current used to excite a conductivity cell?

Direct current drives electrolysis and builds up polarisation layers at the electrodes, which changes the electrode surfaces and the measured resistance over time. Alternating current reverses the current before these effects build up, so the cell resistance, and hence the conductivity, stays steady and repeatable.

Instrument networks and the 4-20 mA transmitter

17. Why is a 4-20 mA current signal used instead of a voltage signal to send a measurement over a

long cable?

In a series loop the same current flows at every point, so cable resistance does not change the reading while the supply can still drive the loop. Current signals also resist picked-up noise. The 4 mA floor powers the transmitter and makes a broken wire (0 mA) easy to tell from a true zero reading.

18. A pressure transmitter has a range of 0 to 200 kPa and gives 4 to 20 mA, linearly. Find the loop current at 75 kPa.

The transmitter outputs 10 mA at 75 kPa, because the 16 mA span between 4 mA and 20 mA is shared out linearly across the 200 kPa pressure range.

WORKING

1. $I = 4 + 16\,(p/200)$ mA
2. $I = 4 + 16 \times 0.375$
3. $I = 4 + 6 = 10$ mA

19. What does HART add to a 4-20 mA loop, and how does it do it without disturbing the analog signal?

HART superimposes a digital signal on the same two wires, using frequency-shift keying with tones near 1200 Hz and 2200 Hz. The tones average to zero over time, so the 4-20 mA value is not disturbed. This carries configuration, diagnostics and extra process variables alongside the analog measurement.

Optical sources, detectors, interferometry and spectroscopy

20. What is the difference between an LED and a laser diode as a light source?

An LED emits by spontaneous recombination, giving light that is incoherent, spread over a wide band of wavelengths and emitted over a wide angle. A laser diode emits by stimulated emission above a threshold current, giving light that is coherent, of very narrow spectral width and in a narrow, well-directed beam.

21. Why does a silicon photodiode not respond to light of very long wavelength?

A photon frees a charge carrier only if its energy hc/λ exceeds the bandgap of the material. Silicon has a bandgap of about 1.12 eV, which gives a cut-off wavelength near 1.1 µm, so longer wavelengths pass without generating photocurrent.

22. How does an interferometer measure displacement?

A light beam is split, and one part reflects from a mirror attached to the moving object. When the beams recombine, they form fringes. Each half wavelength of mirror movement shifts the pattern by one fringe, so the displacement is $d = N\lambda/2$ for N counted fringes, in air of known refractive index.

23. Why does a UV-visible spectrophotometer measure absorbance, and when is it proportional to concentration?

Absorbance, $A = \log_{10}(I_0/I)$, is used because it grows in proportion to concentration and path length: $A = \varepsilon c l$. This linear law holds for monochromatic light and dilute solutions that do not react or change with concentration. At high concentration the response bends away from a straight line.

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