

# BTC Instrumentation and Control Technology

## Certification prep exam

This is a multiple-choice exam. Books and hand-written notes are allowed, as well as a scientific calculator. However, you may not reference old exams, course assignments, or other printed materials.

You are to choose the *best* answer for each question. This means there may be more than one answer which could be considered correct, but there will definitely be *one* answer that is better than all others.

It is strongly recommended that you do not change an answer unless you are absolutely sure it needs to be changed. If you feel unsure, leave your initial answer, because it is probably right.

A wrong answer counts the same as an unanswered question, so it pays to guess if you do not know the answer to a question.

This exam is an overview of concepts spanning the entire two-year stretch of the Instrumentation and Control Technology program. Unless you are just finishing the final quarter of this program, you will no doubt find some sections of the exam unfamiliar. Do not be concerned about this – simply do your best to answer all the questions.

The second page of this exam is a bubble-type answer sheet. When the exam time begins, you are to detach this sheet from the rest of the exam, write your name on this sheet, and also mark the quarters you have studied (**F**, **W**, **S** ; Fall, Winter, and Spring) in the Instrumentation and Control Technology program.



**Question 1 – Industrial safety**

The purpose of a lock-out/tag-out procedure is to:

- (A) Improve productivity on the job
- (B) Secure harmful energy sources to prevent injury
- (C) Slow down work so technicians are less stressed
- (D) Save money
- (E) Identify personal items to avoid theft

**Question 2 – Industrial safety**

The purpose of CPR is to:

- (A) Maintain oxygenated blood circulation
- (B) Stabilize body temperature to avoid hypothermia
- (C) Build upper body strength
- (D) Dislodge blood clots within the victim's lungs
- (E) Prevent infection resulting from open wounds

**Question 3 – Industrial safety**

The *very first* thing you should do if you are the first to witness or discover an accident on the job site is to:

- (A) Go find at least one co-worker to help you so you can work as a team
- (B) Go to the scene and help the person(s) injured
- (C) Find and fill out the necessary forms to document the incident
- (D) Activate the emergency response system (equivalent to dialing "911")
- (E) Contact your supervisor to report the incident

**Question 4 – Industrial safety**

The purpose of a cartridge-style respirator is to:

- (A) Reduce the concentration of particulates in the air you breathe
- (B) Provide a pure oxygen breathing environment where there is insufficient oxygen in the air
- (C) Enhance your personal appearance for maximum social appeal
- (D) Convert exhaled carbon dioxide back into oxygen for re-breathing
- (E) Reduce noxious odors in the air you breathe

**Question 5 – Industrial safety**

*Shock* is defined as an abnormal condition of the body where:

- (A) A broken bone has penetrated the skin
- (B) The lungs are unable to process oxygen properly
- (C) The muscles in the body have “frozen” and will not move
- (D) The heart stops beating normally, and “quivers” instead
- (E) There is insufficient blood delivered to the body’s cells

**Question 6 – Industrial safety**

A *confined space* is deemed ready for employee entry when:

- (A) A company safety inspector has certified it
- (B) The unit operations foreman declares it ready
- (C) An engineer has completed the necessary calculations
- (D) Your supervisor assigns you to the job
- (E) An independent inspection agency has completed their survey

**Question 7 – Industrial safety**

One of the common signs of a heart attack is:

- (A) A sharp pain in the lower area of the spine
- (B) Loss of bowel control
- (C) A feeling of numbness in the legs
- (D) Discomfort in the chest and/or upper body
- (E) A general feeling of restlessness and anxiety

**Question 8 – Industrial safety**

*Heat stroke* is often indicated by the following symptoms:

- (A) A sudden affinity for country-western music
- (B) Dizziness, vomiting, cold skin, profuse sweating
- (C) Cold and clammy skin, thirst, vomiting, confusion
- (D) Hot and dry skin, inability to drink, vomiting, confusion
- (E) Blue-colored skin, extreme hunger, feelings of anxiety, thirst

**Question 9 – Industrial safety**

*Arc blast* is caused by:

- (A) Poor contact within electrical wire splices
- (B) Radio frequency emissions from high-power transmitters
- (C) Discharge of high electrical current through open air
- (D) Failure to lock-out and tag-out electrical breakers
- (E) Ionization of gases near high-voltage electrical conductors

**Question 10 – Industrial safety**

Current measurements are more dangerous to make with a multimeter than voltage measurements because:

- (A) You must use both hands to take the measurement
- (B) Most multimeters are unfused
- (C) The resulting magnetic fields may be very strong
- (D) The circuit must be broken (opened)
- (E) A fuse protects the voltage measurement ranges, but not current

**Question 11 – Algebra**

Manipulate the following equation to solve for  $x$ :

$$y = \frac{x}{ab}$$

- (A)  $x = \frac{y}{ab}$
- (B)  $x = aby$
- (C)  $x = \frac{ay}{b}$
- (D)  $x = \frac{a}{by}$
- (E)  $x = \frac{ab}{y}$

**Question 12 – Algebra**

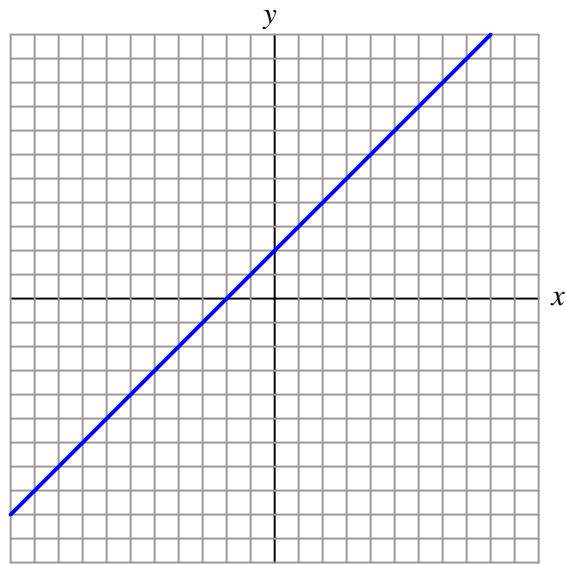
Manipulate the following equation to solve for  $x$ :

$$a = \sqrt{bx^2}$$

- (A)  $x = \frac{a}{\sqrt{b}}$
- (B)  $x = \sqrt{ab}$
- (C)  $x = \sqrt{\frac{a}{b}}$
- (D)  $x = \left(\frac{a}{b}\right)^2$
- (E)  $x = \frac{a^2}{b}$

**Question 13 – Algebra**

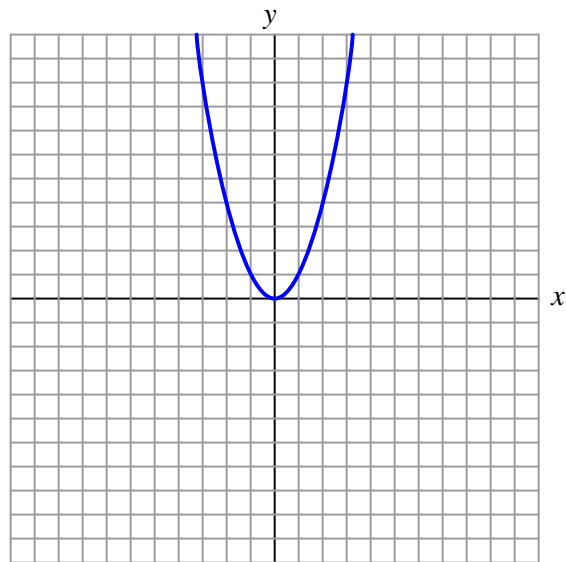
Which of the following equations describes this graph?



- (A)  $y = 3x$
- (B)  $y = 3x + 2x$
- (C)  $y = x + 2$
- (D)  $y = 2 - x$
- (E)  $y = -2x$

**Question 14 – Algebra**

Which of the following equations describes this graph?



- (A)  $y = \sqrt{x}$
- (B)  $y = x^2$
- (C)  $y = 2x$
- (D)  $y = \sqrt[3]{x}$
- (E)  $y = x^{-2}$



**Question 15 – Algebra**

Solve for both  $x$  and  $y$  in this simultaneous system of equations:

$$x + 3y = -1$$

$$4x - y = 9$$

- (A)  $x = 2 ; y = 1$
- (B)  $x = 2 ; y = -1$
- (C)  $x = 1 ; y = 2$
- (D)  $x = -2 ; y = 1$
- (E)  $x = -1 ; y = 2$

**Question 16 – Algebra**

Which of the following ratios is equivalent to the ratio 25:300 ?

- (A) 1:12
- (B) 15:4
- (C) 15:1
- (D) 17:5
- (E) 5:17

**Question 17 – Algebra**

Simplify the following expression as much as possible:

$$\left(\frac{a^4b^{-2}c}{ab^2}\right)\left(\frac{x^2y^2c^2}{a^2b^3}\right)$$

- (A)  $a^{-1}b^7c^2x^2y^2$
- (B)  $(ab)^4c^3(xy)^4$
- (C)  $a\sqrt{b^5}c^3x^4y^4$
- (D)  $ab^{-7}c^3x^2y^2$
- (E)  $a^2b^{-3}c^2x^2y^2$

**Question 18 – Algebra**

Select the equivalent expression:

$$\frac{1}{\sqrt{x^3}}$$

- (A)  $-\sqrt{x^3}$
- (B)  $x^{3/2}$
- (C)  $x^{-3/2}$
- (D)  $x^{2/3}$
- (E)  $2x^{-1/3}$

**Question 19 – Algebra**

Calculate 27% of 340.

- (A) 88.8
- (B) 91.8
- (C) 12.6
- (D) 79.4
- (E) 81.0

**Question 20 – Algebra**

Factor the following polynomial expression:

$$x^2 - x - 12$$

- (A)  $(x + 2)(x - 6)$
- (B)  $(x + 4)(x - 3)$
- (C)  $(x + 3)(x - 4)$
- (D)  $(x + 1)(x - 12)$
- (E)  $(x + 12)(x - 1)$

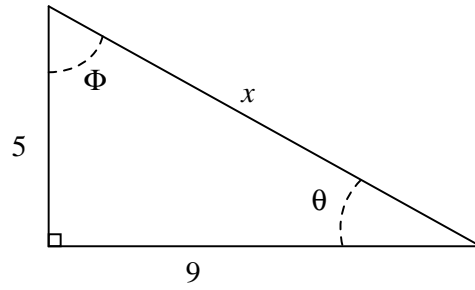
**Question 21 – Trigonometry**

The *sine* function is defined as ratio of side lengths,

- (A) Hypotenuse divided by adjacent
- (B) Opposite divided by hypotenuse
- (C) Opposite divided by adjacent
- (D) Adjacent divided by hypotenuse
- (E) Adjacent divided by opposite

**Question 22 – Trigonometry**

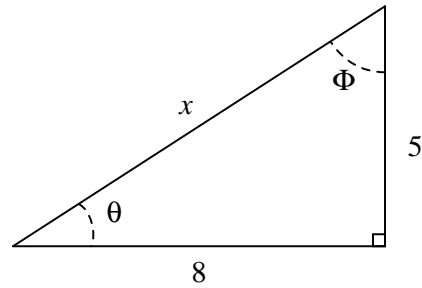
Calculate the length of side  $x$  in this right triangle:



- (A) 10.3
- (B) 10.8
- (C) 9.43
- (D) 3.74
- (E) 4.00

**Question 23 – Trigonometry**

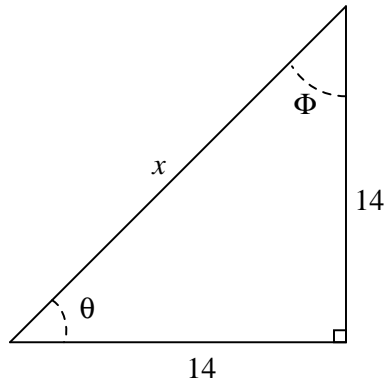
Calculate the angle  $\Phi$  in this right triangle:



- (A)  $38.68^\circ$
- (B)  $51.32^\circ$
- (C)  $64.44^\circ$
- (D)  $57.99^\circ$
- (E)  $1.012^\circ$

**Question 24 – Trigonometry**

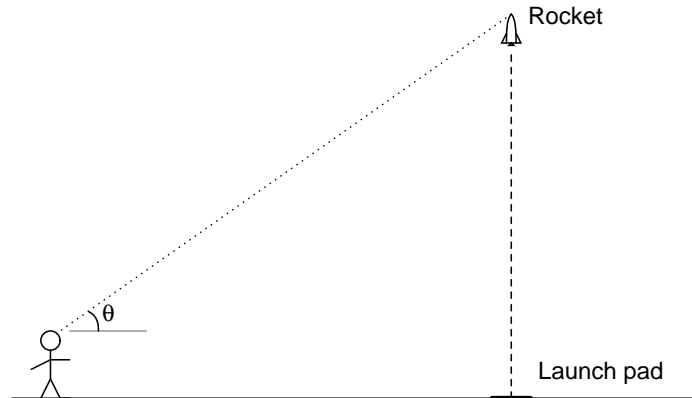
Calculate the angle  $\theta$  in this right triangle:



- (A)  $19.80^\circ$
- (B)  $50^\circ$
- (C)  $45^\circ$
- (D)  $14^\circ$
- (E)  $\frac{\pi}{4}^\circ$

**Question 25 – Trigonometry**

A model rocket enthusiast wants to approximately measure the peak altitude of her rocket by measuring the angle from horizontal ( $\theta$ ) sighting the rocket at its apogee and the distance from the launch pad to the point of observation. Which trigonometric function will she need to use in order to calculate the rocket's height?



- (A) Tangent
- (B) Cosine
- (C) Cosecant
- (D) Sine
- (E) Secant

**Question 26 – Trigonometry**

Add these two complex numbers and express the sum in polar notation:

$$(5 - j3) + (-8 - j10)$$

- (A)  $14.765 \angle 28.3^\circ$
- (B)  $14.765 \angle 61.7^\circ$
- (C)  $-3 + j13$
- (D)  $13.342 \angle -103^\circ$
- (E)  $18.385 \angle -45^\circ$

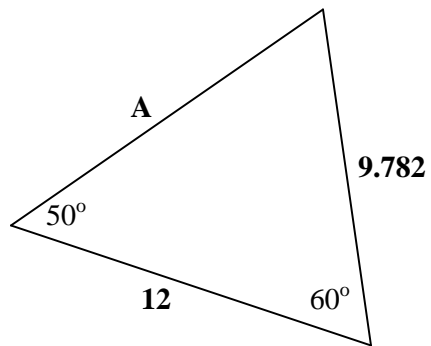
**Question 27 – Trigonometry**

Complex numbers are used in AC circuit analysis primarily to represent:

- (A) Frequency
- (B) Amplitude and phase shift
- (C) Power
- (D) Bandwidth and harmonic content
- (E) Gain and attenuation factors

**Question 28 – Trigonometry**

Calculate the length of side **A** in this non-right triangle:



- (A) 12
- (B) 18.67
- (C) 11.06
- (D) 12.77
- (E) 15.48

**Question 29 – Trigonometry**

Convert an angle of 75 degrees into radians:

- (A) 1.571 radians
- (B) 1.309 radians
- (C) 0.7854 radians
- (D) 1.178 radians
- (E) 3.142 radians

**Question 30 – Trigonometry**

If the cosine of angle  $\theta$  is equal to 0.5, and the length of the *opposite* side is 20 meters, calculate the length of the hypotenuse.

- (A) 20.01 meters
- (B) 40 meters
- (C) 17.32 meters
- (D) 23.09 meters
- (E) 44.72 meters

**Question 31 – Chemistry and physics**

An atom of Lead (Pb) has an atomic number of 82, and an atomic mass of 207. How many neutrons does the nucleus of one Lead atom contain?

- (A) 289
- (B) 82
- (C) 125
- (D) 110
- (E) 207



**Question 32 – Chemistry and physics**

An *alkaline* solution has a pH value . . .

- (A) at least 11
- (B) greater than 6
- (C) greater than 7
- (D) less than 6
- (E) less than 7

**Question 33 – Chemistry and physics**

A *catalyst* is a substance that . . .

- (A) moderates the velocities of neutrons in a fission reaction
- (B) accelerates a chemical reaction without being consumed
- (C) buffers an alkaline solution for a more stable pH value
- (D) polarizes light so that the waves are oriented in one plane
- (E) dissolves in water to form an ionic solution

**Question 34 – Chemistry and physics**

Use the *Ideal Gas Law* to calculate the volume of an ideal gas sample containing 1 mole of gas at 20 degrees C and at a pressure of 2 atmospheres.

- (A) 1.687 liters
- (B) 11.21 liters
- (C) 12.03 liters
- (D) 0.821 liters
- (E) 178.5 liters

**Question 35 – Chemistry and physics**

A chemical reaction that requires a net input of energy is called:

- (A) Spontaneous
- (B) Catalytic
- (C) Endothermic
- (D) Ectomorphic
- (E) Equipotential

**Question 36 – Chemistry and physics**

Calculate the kinetic energy of an object moving at a speed of 15 meters per second, having a mass of 40 kilograms.

- (A) 9,000 joules
- (B) 600 joules
- (C) 300 joules
- (D) 4,500 joules
- (E) 12,000 joules

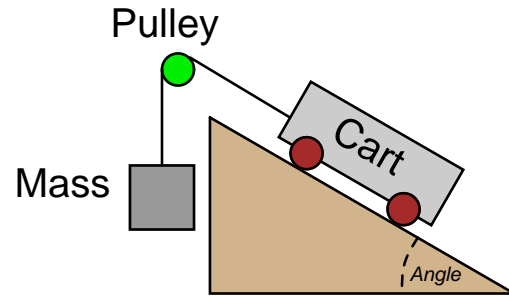
**Question 37 – Chemistry and physics**

Calculate the gravitational potential energy of a 50 kilogram mass lifted 24 meters vertically above the ground.

- (A) 11,760 joules
- (B) 14,400 joules
- (C) 1,200 joules
- (D) 5,880 joules
- (E) 600 joules

**Question 38 – Chemistry and physics**

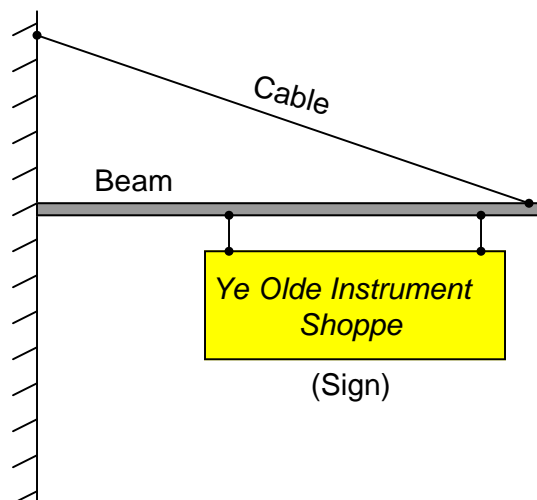
Calculate the angle of the incline necessary so that the cart (on wheels) and the suspended mass precisely balance one another in this cable-and-pulley system. The mass is 450 kg and the cart is 1370 kg:



- (A)  $23.21^\circ$
- (B)  $15.08^\circ$
- (C)  $70.82^\circ$
- (D)  $19.18^\circ$
- (E)  $18.18^\circ$

**Question 39 – Chemistry and physics**

The tension in the cable holding up the sign is . . .



- (A) less than the weight of the sign
- (B) always changing with temperature
- (C) equal to the weight of the sign
- (D) greater than the weight of the sign
- (E) a negative quantity

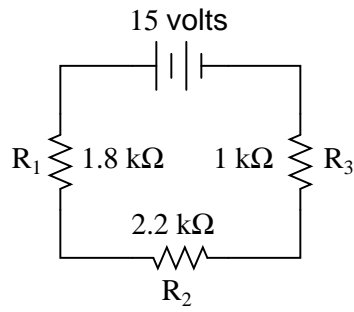
**Question 40 – Chemistry and physics**

The *latent heat of vaporization* for water is . . .

- (A) less than the specific heat
- (B) greater than the melting point
- (C) less than the latent heat of fusion
- (D) greater than the latent heat of fusion
- (E) equal to the latent heat of fusion

**Question 41 – DC circuit theory**

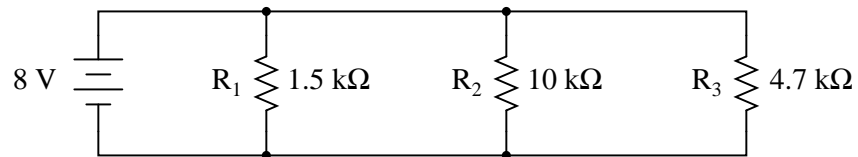
Determine the voltage dropped across resistor  $R_3$  in this circuit:



- (A) 7.5 volts
- (B) 3.0 volts
- (C) 6.6 volts
- (D) 15 volts
- (E) 5.4 volts

**Question 42 – DC circuit theory**

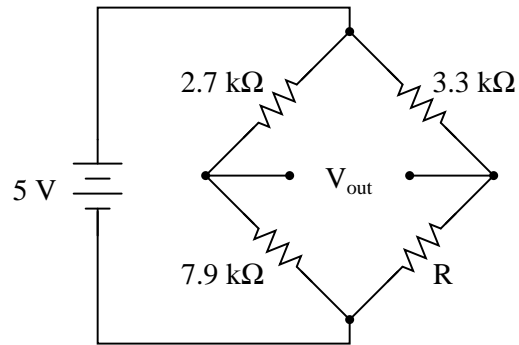
Calculate total current in this circuit:



- (A) 8.000 mA
- (B) 7.835 mA
- (C) 8.168 mA
- (D) 493.8  $\mu\text{A}$
- (E) 5.333 mA

**Question 43 – DC circuit theory**

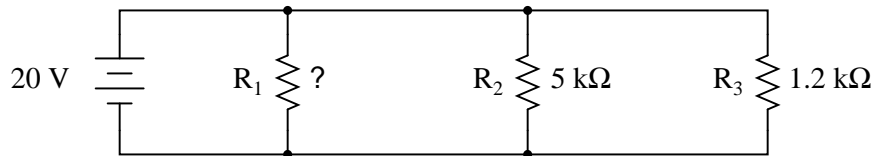
Calculate the necessary resistor value ( $R$ ) to balance this bridge circuit:



- (A) 7.299 k $\Omega$
- (B) 6.464 k $\Omega$
- (C) 9.656 k $\Omega$
- (D) 8.501 k $\Omega$
- (E) 5.830 k $\Omega$

**Question 44 – DC circuit theory**

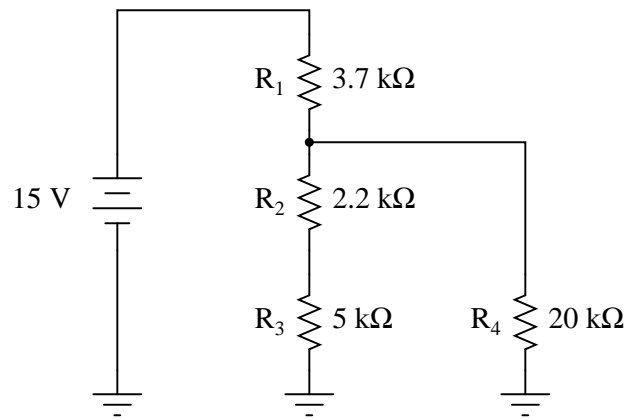
Calculate the necessary resistor size for  $R_1$  to make the total circuit current equal to 30 milliamps:



- (A) 2.143 k $\Omega$
- (B) 1.500 k $\Omega$
- (C) 967.7  $\Omega$
- (D) 666.7  $\Omega$
- (E) 310.0  $\Omega$

**Question 45 – DC circuit theory**

Calculate the current through resistor  $R_4$  in this circuit:



- (A) 1.226 mA
- (B) 441.5  $\mu$ A
- (C) 1.668 mA
- (D) 4.054 mA
- (E) 8.994 mA

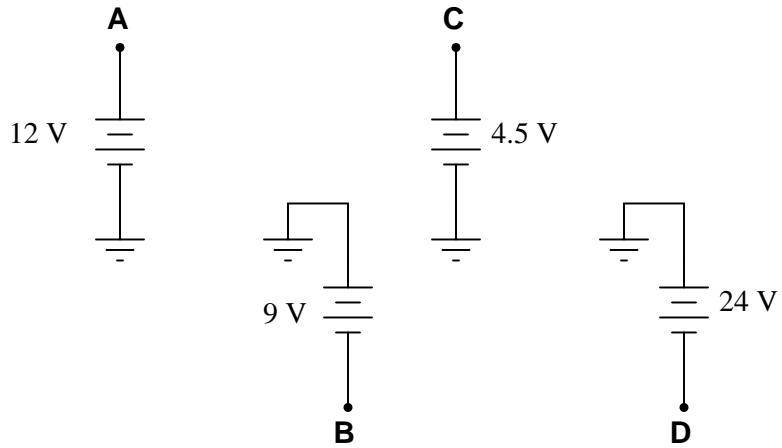
**Question 46 – DC circuit theory**

Voltages and currents in an RC or LR time-constant circuit will settle to within 1% of their final value(s) in how many time constants?

- (A) 10
- (B) 3
- (C) 5
- (D) 2
- (E) 4

**Question 47 – DC circuit theory**

How much voltage will a DMM register if connected with the red test lead on point **B** and the black test lead on point **D**?

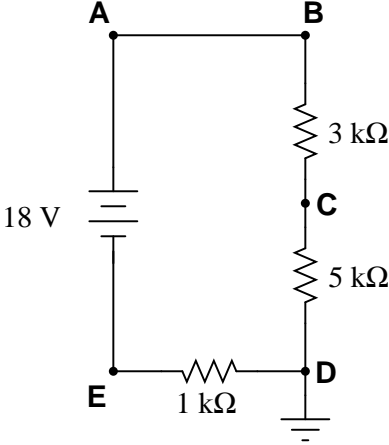


- (A) +15 volts
- (B) -33 volts
- (C) +33 volts
- (D) -9 volts
- (E) -15 volts



**Question 48 – DC circuit theory**

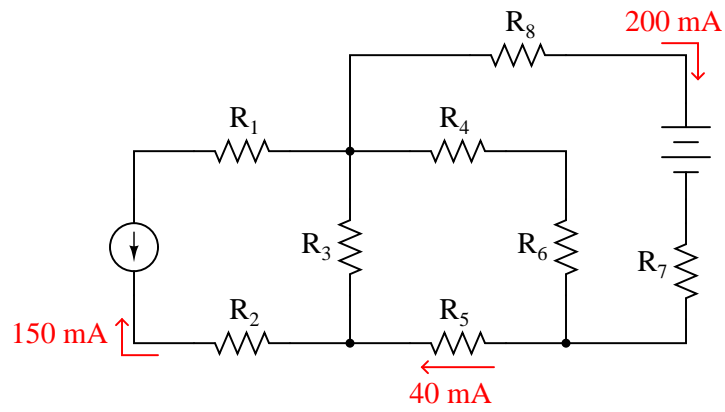
Calculate the voltage between test point **B** and ground in this circuit:



- (A) 20 volts
- (B) 18 volts
- (C) 2 volts
- (D) 6 volts
- (E) 16 volts

**Question 49 – DC circuit theory**

Determine the magnitude and direction of current through resistor  $R_4$  in this circuit:

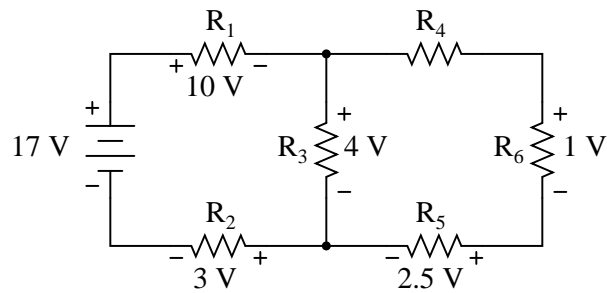


*Note: all current arrows point in the direction of electron flow!*

- (A)  $240\text{ mA} \rightarrow$  (left to right)
- (B)  $160\text{ mA} \leftarrow$  (right to left)
- (C)  $200\text{ mA} \rightarrow$  (left to right)
- (D)  $240\text{ mA} \leftarrow$  (right to left)
- (E)  $160\text{ mA} \rightarrow$  (left to right)

**Question 50 – DC circuit theory**

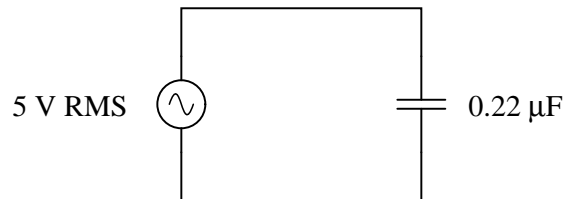
Determine the magnitude and polarity of the voltage across resistor  $R_4$  in this circuit:



- (A) - 1.0 volt + (negative on left, positive on right)
- (B) - 7.0 volts + (negative on left, positive on right)
- (C) + 0.5 volts - (positive on left, negative on right)
- (D) - 3.5 volts + (negative on left, positive on right)
- (E) + 4.0 volts - (positive on left, negative on right)

**Question 51 – AC circuit theory**

What will happen to the current in this circuit as frequency *increases*?



- (A) Current will remain the same
- (B) Cannot tell – not enough information given
- (C) Current will decrease
- (D) Current will decrease to a minimum and then increase
- (E) Current will increase

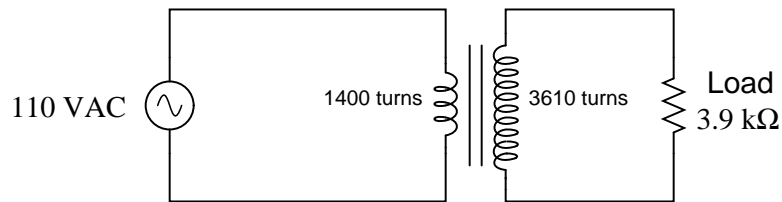
**Question 52 – AC circuit theory**

*Resonance* is defined as a condition in an AC circuit when:

- (A) no more magnetic flux may be forced into an iron core
- (B) opposition to electric current varies with frequency
- (C) voltage and current waveforms are exactly  $90^\circ$  out of phase
- (D) electrons are able to “tunnel” across an energy gap
- (E) complementary reactances are equal and opposite

**Question 53 – AC circuit theory**

Calculate the source and load currents in this transformer circuit:



- (A)  $I_{source} = 77.22 \text{ mA}$      $I_{load} = 283.6 \text{ mA}$
- (B)  $I_{source} = 187.5 \text{ mA}$      $I_{load} = 72.73 \text{ mA}$
- (C)  $I_{source} = 186.5 \text{ mA}$      $I_{load} = 72.53 \text{ mA}$
- (D)  $I_{source} = 164.2 \text{ mA}$      $I_{load} = 63.66 \text{ mA}$
- (E)  $I_{source} = 72.53 \text{ mA}$      $I_{load} = 186.5 \text{ mA}$

**Question 54 – AC circuit theory**

The function on an oscilloscope that “locks in” waveforms so that they do not scroll horizontally across the screen is called the \_\_\_\_\_.

- (A) Horizontal sync
- (B) Timebase
- (C) Beam finder
- (D) Trigger
- (E) Cursor

**Question 55 – AC circuit theory**

A voltage gain of 25 (expressed as a unitless ratio) may also be expressed as \_\_\_\_\_ decibels (dB).

- (A) 17.78
- (B) 7.959
- (C) 64.38
- (D) 13.98
- (E) 27.96

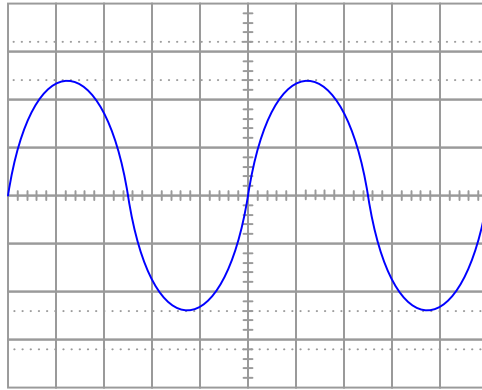
**Question 56 – AC circuit theory**

In an AC circuit where current lags voltage by  $35^\circ$ , the power factor is:

- (A) 0.707
- (B) 0.574
- (C) 0.700
- (D) 1.414
- (E) 0.819

**Question 57 – AC circuit theory**

Determine the frequency of this waveform shown on an oscilloscope screen:

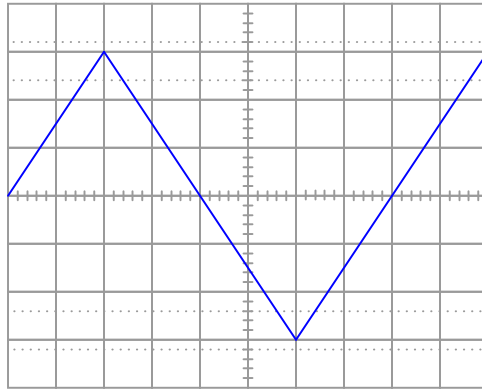


Vertical sensitivity = 2 volts/div  
1:1 probe DC coupling  
Timebase = 0.5 ms/div

- (A) 250 Hz
- (B) 0.4 Hz
- (C) 10 kHz
- (D) 10 Hz
- (E) 400 Hz

**Question 58 – AC circuit theory**

Calculate the RMS value of this triangle wave, as shown by the oscilloscope:



Vertical sensitivity = 10 volts/div  
1:1 probe DC coupling  
Timebase = 5  $\mu$ s/div

- (A) 17.31 volts
- (B) 30 volts
- (C) 3.2 volts
- (D) 21.21 volts
- (E) 32 volts

**Question 59 – AC circuit theory**

If a communications cable has a *characteristic impedance* of 75 ohms, this means:

- (A) The cable's end-to-end resistance is 75 ohms
- (B) The cable's conductor-to-conductor resistance is 75 ohms
- (C) The cable should be terminated with a resistance equal to 37.5 ohms
- (D) The cable's conductor resistance is 75 ohms per mile of length
- (E) The cable appears to a pulse signal as a 75 ohm load

**Question 60 – AC circuit theory**

A *low pass filter* is a circuit that performs the following function:

- (A) Modifies the shape of an AC wave
- (B) Blocks low-frequency signals from passing through
- (C) Passes only the negative (low) portions of an AC wave
- (D) Blocks high-frequency signals from passing through
- (E) Attenuates low-frequency signals

**Question 61 – Electric power and motor controls**

The heating element used in an industrial electric boiler is rated at 15 kW, at 480 volts, 3 phase. Calculate the current drawn by each line of this 3-phase heater.

- (A) 18.48 amps
- (B) 31.25 amps
- (C) 32.00 amps
- (D) 18.04 amps
- (E) 10.42 amps

**Question 62 – Electric power and motor controls**

3-phase electrical systems are favored over single-phase systems for power distribution because:

- (A) It would be expensive to convert everything to single phase
- (B) 3-phase systems are easier to understand
- (C) Single-phase electric motors are more rugged
- (D) More power may be transmitted using less copper (wire)
- (E) 3-phase power is easier to step voltage up and down



**Question 63 – Electric power and motor controls**

An AC *induction motor* works on the principle of:

- (A) The Lorentz force
- (B) A rotating magnetic field
- (C) Voltage stepped up through mutual induction
- (D) Magnetic hysteresis
- (E) Magnetostriction converting magnetism to force

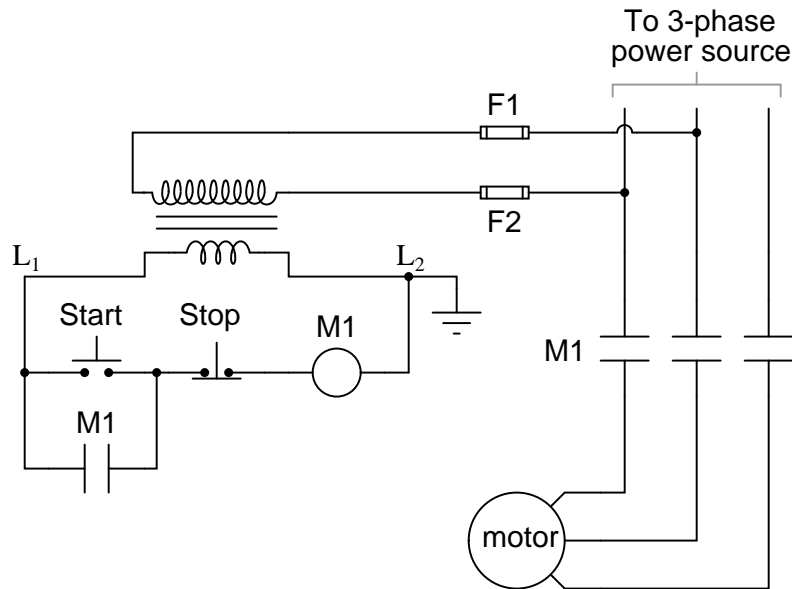
**Question 64 – Electric power and motor controls**

*Variable frequency drives*, or *VFDs*, are popular in industry for electric motor control because:

- (A) They increase the available horsepower from a motor
- (B) They cost less than an across-the-line starter
- (C) They potentially save energy
- (D) They make the motor run quieter
- (E) They increase the available torque from a motor

**Question 65 – Electric power and motor controls**

The “M1” contact in the low-voltage control circuit serves the purpose of:



- (A) Protecting the motor from overcurrent conditions
- (B) Ensuring the motor will stop even if the “stop” switch fails
- (C) Providing a fail-safe state for the motor
- (D) Indicating when the motor is running
- (E) Latching the motor in the “run” state

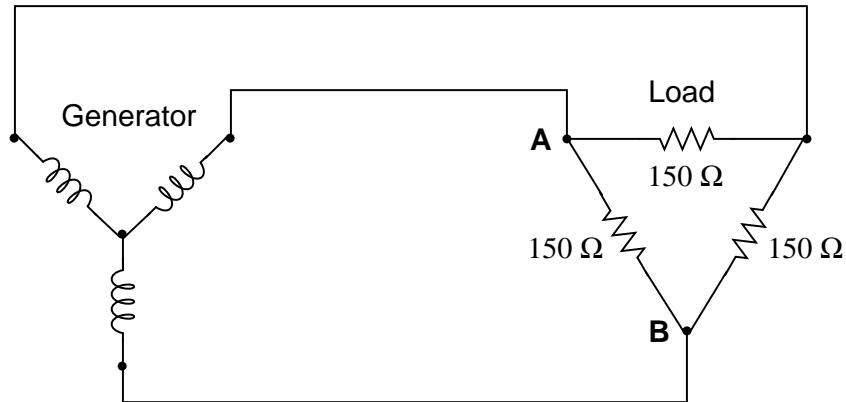
**Question 66 – Electric power and motor controls**

*Overload heaters and overload contacts* work together to:

- (A) Protect the motor against mild overcurrent conditions
- (B) Protect the motor against mechanical overloading
- (C) Protect the motor against massive overcurrent conditions
- (D) Protect the motor against lubrication failures
- (E) Protect the power lines against overcurrent conditions

**Question 67 – Electric power and motor controls**

Calculate the amount of voltage between points **A** and **B** in this balanced three-phase circuit, assuming a generator phase voltage of 4160 volts:



- (A) 27.73 V
- (B) 2.080 kV
- (C) 4.160 kV
- (D) 7.205 kV
- (E) 48.04 V

**Question 68 – Electric power and motor controls**

A single-phase AC electric motor draws 54.7 amps while being powered by a 240 volt source. Assuming perfect power factor (1.0) and an efficiency of 87%, calculate the mechanical horsepower output by this motor.

- (A) 20.24 hp
- (B) 17.18 hp
- (C) 14.95 hp
- (D) 15.32 hp
- (E) 17.60 hp

**Question 69 – Electric power and motor controls**

A *synchronous* motor differs from an *induction* motor by the fact that . . .

- (A) it operates on DC instead of AC
- (B) it uses fewer poles
- (C) it must be properly “timed”
- (D) its speed is constant
- (E) it uses brushes

**Question 70 – Electric power and motor controls**

DC motors are used in industry where . . .

- (A) the motor must tolerate constant vibration
- (B) superior low-speed torque is needed
- (C) low maintenance is necessary
- (D) the motor’s speed must remain constant
- (E) explosive gases may be present

**Question 71 – Semiconductor circuit theory**

*P-type* semiconductor materials are made to be that way due to \_\_\_\_\_ doping.

- (A) intrinsic
- (B) nonvalent
- (C) pentavalent
- (D) extrinsic
- (E) trivalent

**Question 72 – Semiconductor circuit theory**

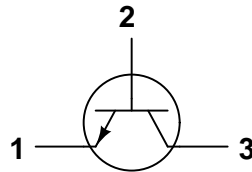
Identify the labels used to describe the left- and right-hand leads on this diode (respectively):



- (A) Anion and cation
- (B) Cation and anion
- (C) Cathode and anode
- (D) Anode and cathode
- (E) Pentode and tetrode

**Question 73 – Semiconductor circuit theory**

Identify the terminals of this transistor:



- (A) 1 = Drain ; 2 = Gate ; 3 = Source
- (B) 1 = Emitter ; 2 = Base ; 3 = Collector
- (C) 1 = Source ; 2 = Gate ; 3 = Drain
- (D) 1 = Gate ; 2 = Emitter ; 3 = Drain
- (E) 1 = Collector ; 2 = Base ; 3 = Emitter

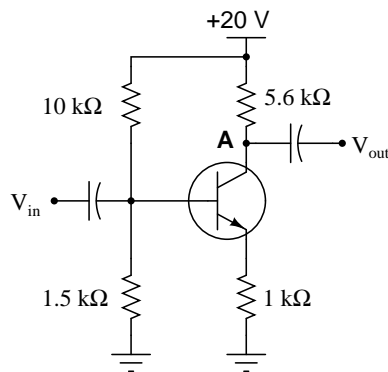
**Question 74 – Semiconductor circuit theory**

A *Hall Effect* device is a component typically used to . . .

- (A) measure an electrical resistance
- (B) detect vibration in machinery
- (C) suppress transient voltages
- (D) switch current on and off
- (E) measure magnetic field strength

**Question 75 – Semiconductor circuit theory**

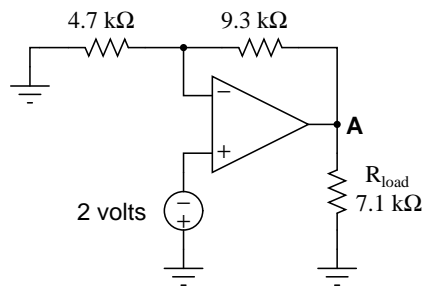
Estimate the amount of voltage between point **A** and ground in this transistor amplifier circuit under quiescent conditions. Assume an ideal silicon transistor:



- (A) 14.4 volts
- (B) 2.61 volts
- (C) 9.31 volts
- (D) 1.91 volts
- (E) 19.3 volts

**Question 76 – Semiconductor circuit theory**

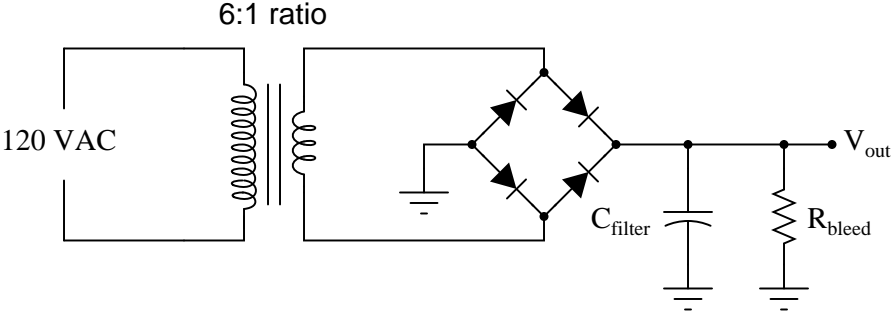
Calculate the voltage between point **A** and ground in this operational amplifier circuit:



- (A) -2.00 volts
- (B) -2.58 volts
- (C) +2.58 volts
- (D) -5.96 volts
- (E) +3.96 volts

**Question 77 – Semiconductor circuit theory**

Estimate the DC output voltage of this power supply circuit, when unloaded. Assume the use of silicon rectifying diodes:

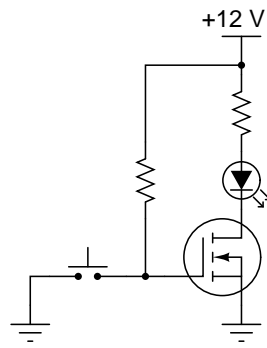


- (A) 42.4 volts
- (B) 18.6 volts
- (C) 19.3 volts
- (D) 20.0 volts
- (E) 26.9 volts



**Question 78 – Semiconductor circuit theory**

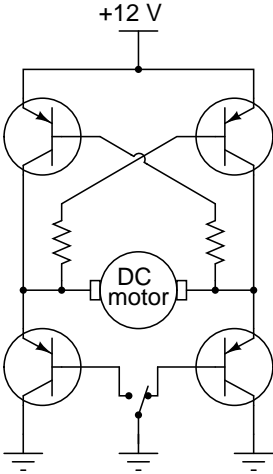
When the pushbutton switch is actuated, the LED will:



- (A) turn on
- (B) turn off
- (C) burn up
- (D) blink on and off
- (E) become dim

**Question 79 – Semiconductor circuit theory**

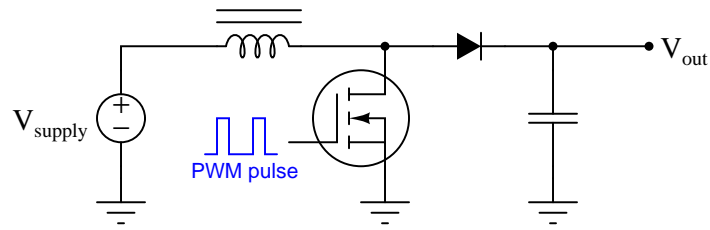
The following circuit is typically used to:



- (A) control motor speed
- (B) control motor torque
- (C) change motor direction
- (D) limit motor current
- (E) control motor frequency

### Question 80 – Semiconductor circuit theory

Identify the function of this DC-DC converter circuit:



- (A) Boost or Buck voltage ; same output polarity as input
- (B) Boost voltage ; same output polarity as input
- (C) Buck voltage ; same output polarity as input
- (D) Boost voltage ; inverted output polarity
- (E) Buck voltage ; inverted output polarity

### Question 81 – Digital circuit theory

Convert the decimal number 45,688 into binary.

- (A) 1000011100101011
- (B) 1010110011000010
- (C) 1110111000011011
- (D) 1011001001111000
- (E) 1001101011001110

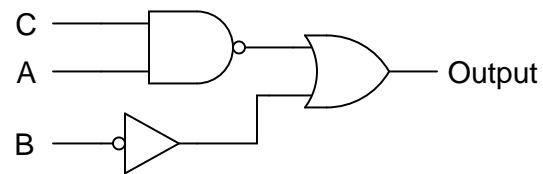
**Question 82 – Digital circuit theory**

The two's complement of the binary number 11001111 is:

- (A) 11010000
- (B) 11110011
- (C) 00110000
- (D) 11110100
- (E) 00110001

**Question 83 – Digital circuit theory**

The Boolean representation of this digital logic gate circuit is:



- (A)  $\overline{B} \overline{A} + C$
- (B)  $\overline{B} + \overline{A} \overline{C}$
- (C)  $\overline{B} + \overline{A} \overline{C}$
- (D)  $\overline{B + \overline{A} \overline{C}}$
- (E)  $\overline{B + \overline{A} \overline{C}}$

**Question 84 – Digital circuit theory**

The Boolean representation of this truth table is:

A	B	C	Output
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

- (A)  $A\bar{C}$
- (B)  $B$
- (C)  $\bar{A}\bar{B}C$
- (D)  $B\bar{C}$
- (E)  $AB + \bar{C}$

**Question 85 – Digital circuit theory**

The *reset* state of a flip-flop circuit is defined as:

- (A)  $Q = 1$  and  $\bar{Q} = 0$
- (B)  $Q = 1$  and  $\bar{Q} = 1$
- (C) Clock = falling edge
- (D)  $Q = 0$  and  $\bar{Q} = 1$
- (E)  $Q = 0$  and  $\bar{Q} = 0$

**Question 86 – Digital circuit theory**

Switch *debouncing* is a technique used for the purpose of:

- (A) Filtering noise
- (B) Extending the operating life of a switch
- (C) Eliminating false switching events
- (D) Canceling the effects of vibration
- (E) Reducing switch contact arcing

**Question 87 – Digital circuit theory**

In an electronic circuit schematic,  $V_{EE}$  represents:

- (A) The negative power supply rail of a field-effect transistor circuit
- (B) The positive power supply rail of a field-effect transistor circuit
- (C) The positive power supply rail of a bipolar transistor circuit
- (D) The positive power supply rail of an ECL transistor circuit
- (E) The negative power supply rail of a bipolar transistor circuit

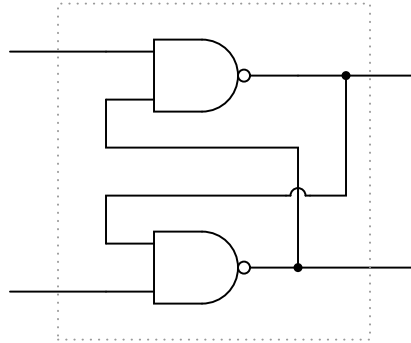
**Question 88 – Digital circuit theory**

*ASCII* is a digital code used for:

- (A) Representing alphanumeric characters
- (B) Code breaking
- (C) Detecting and correcting data errors
- (D) Organizing data stored on a hard disk
- (E) Describing angular position on a rotary encoder

**Question 89 – Digital circuit theory**

The following digital circuit is commonly known as a \_\_\_\_\_



- (A) gate
- (B) counter
- (C) register
- (D) latch
- (E) one-shot

**Question 90 – Digital circuit theory**

A digital logic gate equipped with a *tri-state* output is able to:

- (A) Share an output line with another gate
- (B) Latch an input state for later use
- (C) Produce an intermediate voltage state
- (D) Switch faster than a regular gate
- (E) Operate with three times less power

**Question 91 – Basic control theory**

A basic control loop will consist of:

- (A) signal converter, resistor, knob, and control valve
- (B) transducer, valve packing, hex-head wrench, and tubing
- (C) transmitter, controller, I/P transducer, and control valve
- (D) resistor, capacitor, terminal block, and battery
- (E) control valve, microprocessor, terminal block, and cables

**Question 92 – Basic control theory**

In order for a control loop to work well under a wide range of conditions, it must possess:

- (A) Calibration drift
- (B) Hysteresis
- (C) A very expensive transmitter
- (D) Proper documentation
- (E) Negative feedback

**Question 93 – Basic control theory**

Which of the following is not a “final control element”?

- (A) A pressure transmitter
- (B) An electric motor
- (C) A heating element
- (D) A control valve
- (E) A servo



**Question 94 – Basic control theory**

The purpose of a “shield” wire on an instrument signal cable is to:

- (A) Hold a steadier setpoint value
- (B) Ensure technician safety
- (C) Minimize the possibility of sparking
- (D) Protect the cable from corrosion
- (E) Minimize electrical noise

**Question 95 – Basic control theory**

The most common analog signal standard for industrial process instruments is:

- (A) 10 to 50 milliamps DC
- (B) 0 to 5 amps AC
- (C) 0 to 10 volts
- (D) 0 to 20 milliamps
- (E) 4 to 20 milliamps DC

**Question 96 – Basic control theory**

In a process controller, “output” refers to:

- (A) The target value for the measured variable
- (B) The DC supply power to the transmitter
- (C) The maximum value for the low-alarm point
- (D) The command signal to the control valve
- (E) The production quota for each work day

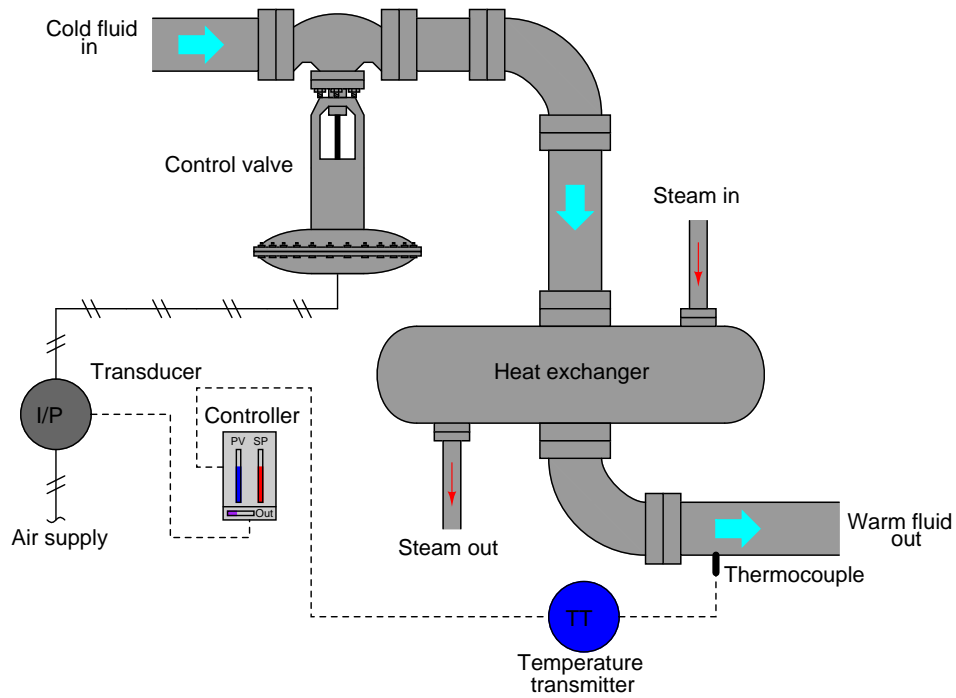
**Question 97 – Basic control theory**

Identify which of the following is an example of a “primary sensing element”:

- (A) I/P transducer
- (B) Instrument signal cable
- (C) Control valve
- (D) Diaphragm
- (E) Digital controller

### Question 98 – Basic control theory

Identify the controller's proper action in the event that the thermocouple suddenly detects a *drop* in process temperature:



- (A) Re-calibrate the temperature transmitter
- (B) Move the control valve further open
- (C) Completely open the control valve
- (D) Move the control valve further closed
- (E) Hold the control valve's position steady

**Question 99 – Basic control theory**

In a home heating system, room temperature is the:

- (A) Process variable
- (B) Setpoint
- (C) Inferred variable
- (D) Manipulated variable
- (E) Error variable

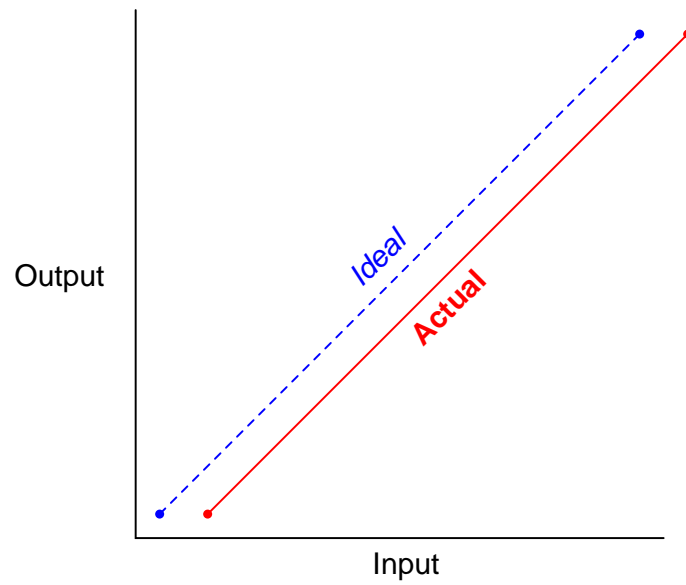
**Question 100 – Basic control theory**

When a process controller is in the “automatic” mode,

- (A) The output responds to changes in the process variable
- (B) The control valve will fail closed
- (C) The process variable cannot deviate from setpoint
- (D) The controller will automatically generate alarms
- (E) The control valve will fail open

**Question 101 – Calibration principles**

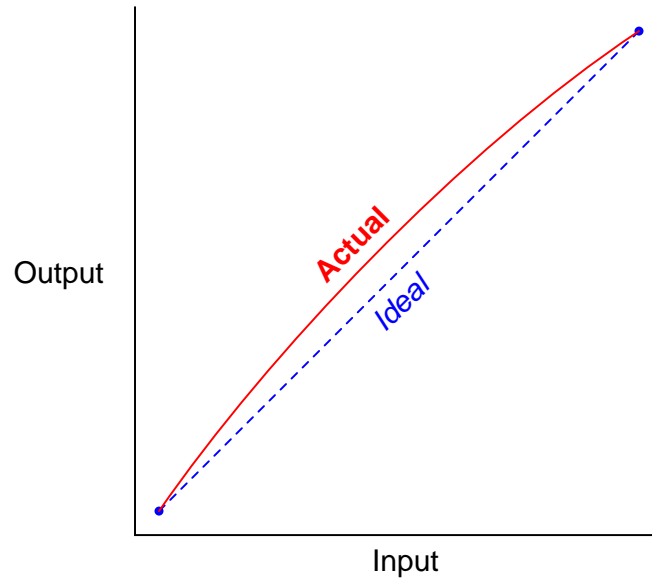
Identify the type of instrument calibration error(s) shown in this graph:



- (A) Hysteresis error
- (B) Linearity error
- (C) Both zero and span errors
- (D) Span error
- (E) Zero error

**Question 102 – Calibration principles**

Identify the type of instrument calibration error(s) shown in this graph:



- (A) Span error
- (B) Hysteresis error
- (C) Zero error
- (D) Both zero and span errors
- (E) Linearity error

**Question 103 – Calibration principles**

When calibrating an instrument, you may detect the presence of hysteresis error by:

- (A) Comparing the instrument against a known standard that is free from any hysteresis
- (B) Comparing accuracy at certain points both going up and down the calibration scale
- (C) Measuring error before and after turning the “deadband” adjustment screw
- (D) Checking for calibration drift at certain points over long periods of time
- (E) Shaking the instrument and listening for the rattling sound of loose parts

**Question 104 – Calibration principles**

A technician calibrating a mechanical (bourdon tube) pressure gauge is gradually increasing pressure with a deadweight tester and checking the gauge's indication at several points. After checking one calibration point, the technician accidentally applies too much pressure and "overshoots" the next calibration point. To obtain the best response from the pressure gauge, the technician should:

- (A) Reduce pressure well below the intended calibration point and then increase pressure again
- (B) Abort the test and get a new pressure gauge
- (C) Carefully reduce pressure down to the intended calibration point, approaching it from the opposite direction
- (D) Completely vent pressure from the gauge and re-check all calibration points from zero upwards again
- (E) Apply full pressure to the gauge and then check all calibration points in descending order

**Question 105 – Calibration principles**

Which of the following adjustments is usually adjusted *first* in an instrument requiring calibration?

- (A) Deadband
- (B) Span
- (C) Hysteresis
- (D) Zero
- (E) Linearity

**Question 106 – Calibration principles**

An error tolerance of  $\pm 0.4\%$  is \_\_\_\_\_ for a 4-20 mA instrument signal.

- (A)  $\pm 0.04$  mA
- (B)  $\pm 0.08$  mA
- (C)  $\pm 0.064$  mA
- (D)  $\pm 0.4$  mA
- (E)  $\pm 0.46$  mA

**Question 107 – Calibration principles**

A pressure transmitter has a calibrated measurement range of 200 to 300 PSIG, and an output range of 4-20 mA. What is the expected output if the input pressure is 235 PSIG?

- (A) 1.6 mA
- (B) 16.5 mA
- (C) 5.6 mA
- (D) 9.6 mA
- (E) 12.5 mA

**Question 108 – Calibration principles**

A pH transmitter has a calibrated range of 5 to 9 pH, with a 4-20 mA output. What is the pH measurement if the transmitter's output is equal to 17.3 mA?

- (A) 4.156 pH
- (B) 6.599 pH
- (C) 8.325 pH
- (D) 8.460 pH
- (E) 7.481 pH

**Question 109 – Calibration principles**

The purpose of documenting an “As Found” calibration in addition to documenting the “As Left” calibration for an instrument is to:

- (A) Ensure perfect accuracy
- (B) Eliminate instrument hysteresis
- (C) Help others locate the instrument
- (D) Measure calibration drift
- (E) Speed up the calibration



**Question 110 – Calibration principles**

A “smart” transmitter is one that:

- (A) Communicates using Foundation Fieldbus
- (B) Calibrates itself
- (C) Also plays MP3 music files
- (D) Has multiple process sensors
- (E) Has a microprocessor built inside

**Question 111 – Pressure measurement**

Convert a pressure measurement of 20 PSIA into units of inches water column (gauge)

- (A) 1321 "H<sub>2</sub>O
- (B) 510.1 "H<sub>2</sub>O
- (C) 701.2 "H<sub>2</sub>O
- (D) 146.7 "H<sub>2</sub>O
- (E) 960.5 "H<sub>2</sub>O

**Question 112 – Pressure measurement**

Which of the following is *not* a type of pressure sensing element?

- (A) Bellows
- (B) Bourdon tube
- (C) Manometer
- (D) Orifice plate
- (E) Diaphragm

**Question 113 – Pressure measurement**

If a force of 3400 pounds is applied to a circular piston 2 inches in diameter, calculate the fluid pressure working against the piston.

- (A) 344.5 PSI
- (B) 270.6 PSI
- (C) 850 PSI
- (D) 1082.3 PSI
- (E) 1700 PSI

**Question 114 – Pressure measurement**

Another word for “pressure” is:

- (A) pH
- (B) Flow
- (C) Density
- (D) Force
- (E) Head

**Question 115 – Pressure measurement**

If the pressure applied to the “low” side of a  $\Delta P$  transmitter increases while the pressure applied to the “high” side remains steady, the transmitter output should:

- (A) Fail low
- (B) Remain the same
- (C) Increase
- (D) Decrease
- (E) Fail high

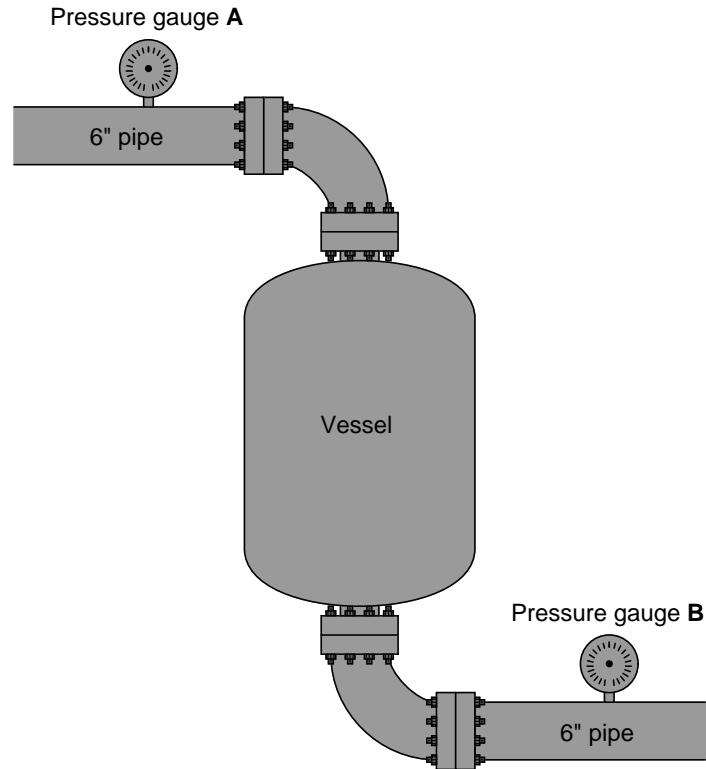
**Question 116 – Pressure measurement**

Identify the proper sequence of valve actions for a three-valve manifold and bleed when taking a differential pressure transmitter out of service:

- (A) Open bleed, close one block valve, open equalizing valve, close other block valve
- (B) Open equalizing valve, close both block valves (simultaneously), open bleed
- (C) Close one block valve, open equalizing valve, close other block valve, open bleed
- (D) Close one block valve, open bleed, close other block valve, open equalizing valve
- (E) Open equalizing valve, open bleed, close both block valves (simultaneously)

**Question 117 – Pressure measurement**

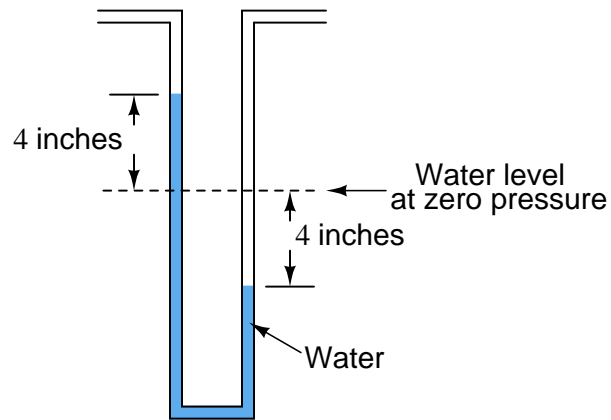
Assuming the pipes and vessel are completely filled with slow-moving water, how will the two pressure gauges' indications compare?



- (A) Both gauges will register exactly the same pressure
- (B) Gauge **A** will register less pressure than gauge **B**
- (C) Gauge **B** will register less pressure than gauge **A**
- (D) Gauge **A** will register a more erratic pressure than gauge **B**
- (E) Gauge **B** will register a more erratic pressure than gauge **A**

**Question 118 – Pressure measurement**

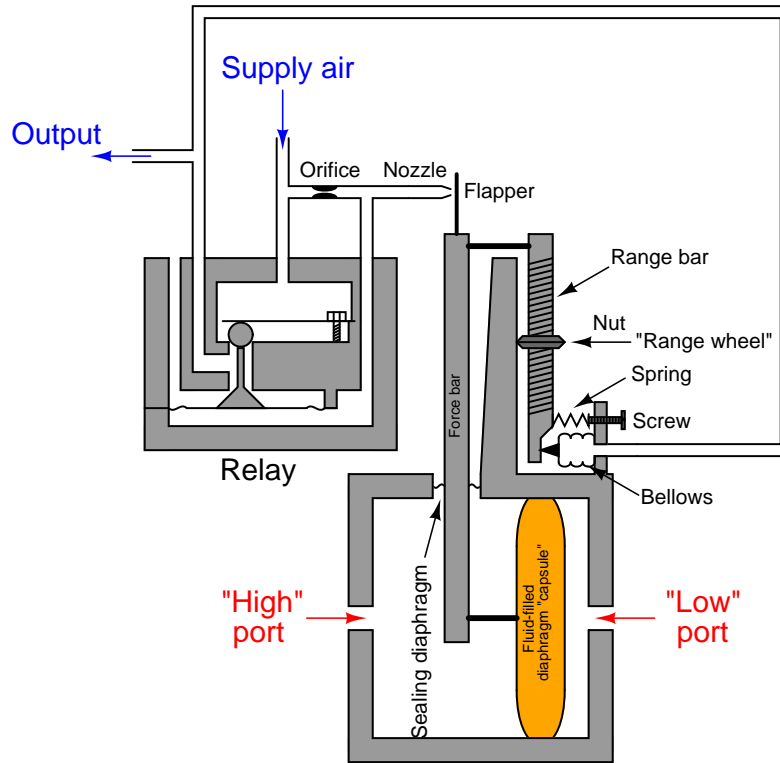
How much differential pressure does this manometer indicate?



- (A) 8.00 "W.C.
- (B) 745 torr
- (C) 4.00 "W.C.
- (D) 3.929 "W.C.
- (E) 0.272 "W.C.

### Question 119 – Pressure measurement

Suppose the following pneumatic  $\Delta P$  transmitter (same working principle as the Foxboro models 13 and 15) was calibrated to a range of 0 to 250 inches water column:

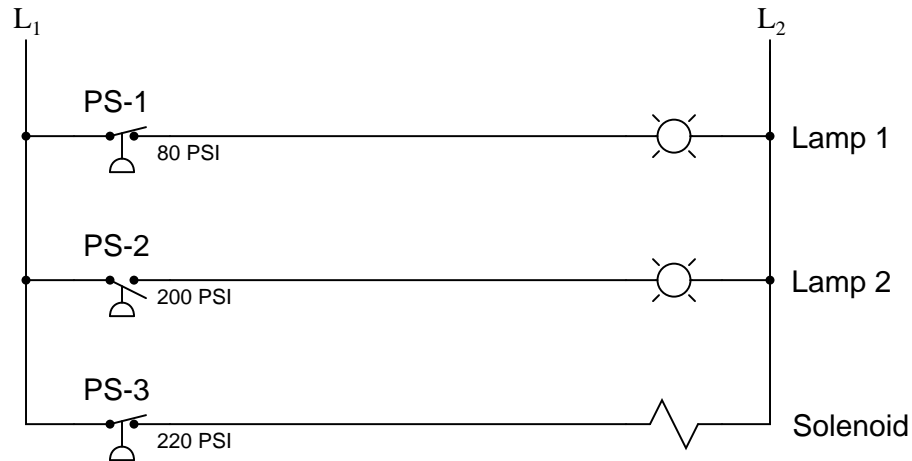


What would have to be done to it to re-calibrate it for a new range of 100 to 350 inches water column?

- (A) Turn the screw (located near the bellows)
- (B) Bend the flapper (next to the nozzle)
- (C) Turn the range wheel nut (located in the middle of the range bar)
- (D) Re-size the orifice (located between air supply and nozzle)
- (E) Replace the diaphragm capsule with one of a different size

### Question 120 – Pressure measurement

The following circuit shows three pressure switches that all measure the same process pressure, but activate different electrical loads:



Determine the statuses of these loads at a pressure pressure of 210 PSI.

- (A) Lamp 1 on, Lamp 2 off, Solenoid on
- (B) Lamp 1 off, Lamp 2 on, Solenoid off
- (C) Lamp 1 on, Lamp 2 off, Solenoid off
- (D) Lamp 1 on, Lamp 2 on, Solenoid on
- (E) Lamp 1 off, Lamp 2 on, Solenoid on

### Question 121 – Level measurement

Suppose a storage vessel holds a liquid of unpredictable density. Identify which level measurement technology will *not* maintain accurate measurement of liquid height in the vessel as the liquid density changes:

- (A) Differential pressure transmitter
- (B) Guided-wave radar
- (C) Ultrasonic
- (D) Float and tape
- (E) Sightglass

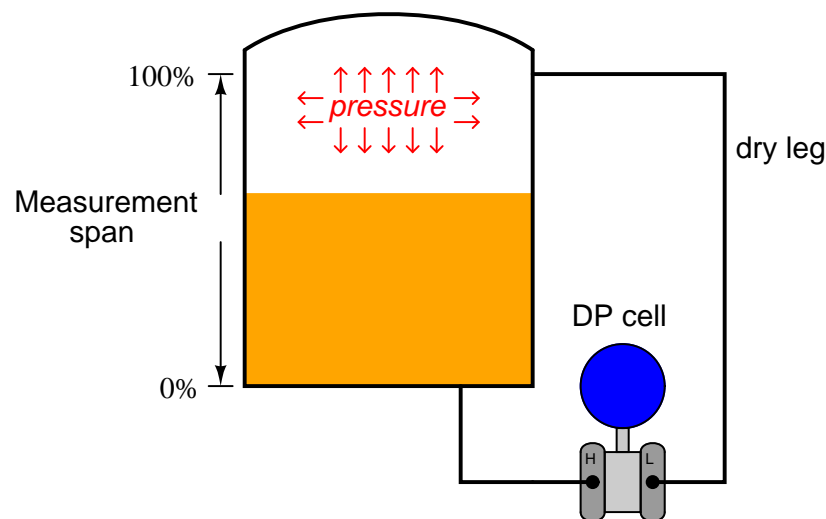
**Question 122 – Level measurement**

The main advantage of a “dip tube” or “bubbler” system for level measurement is that:

- (A) It isolates the pressure transmitter from the process fluid
- (B) It always elevates and never suppresses the calibration range
- (C) It is less expensive to operate than a direct-connected transmitter
- (D) It compensates for changes in liquid density
- (E) It can measure both solid and liquid levels

**Question 123 – Level measurement**

If the specific gravity of the liquid inside the vessel increases, what aspects of the transmitter’s calibration will we need to change in order to maintain accurate liquid level measurement?



- (A) We will need to change the transmitter’s *LRV* and *linearity*
- (B) We will need to change the transmitter’s *linearity* and *span*
- (C) We will need to change the transmitter’s *LRV* and *URV*
- (D) We will need to change the transmitter’s *linearity* and *zero*
- (E) We will need to change the transmitter from linear to square-root characterization, and adjust the *zero*



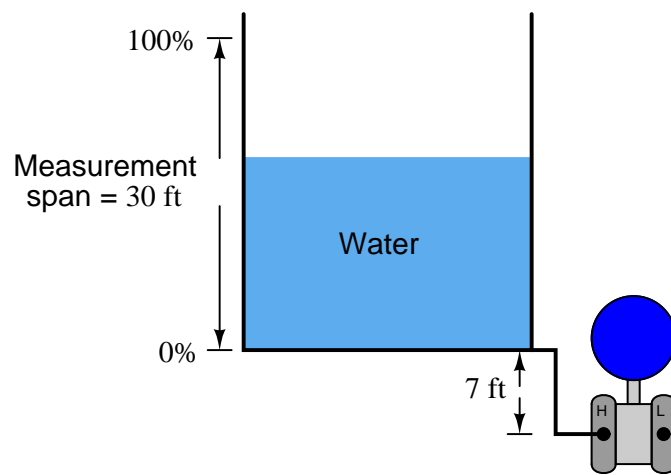
**Question 124 – Level measurement**

A displacer-type level transmitter has a cylindrical displacer 30 inches long and 2.5 inches in diameter. When fully submerged in a petroleum fuel ( $G_f = 0.82$ ), how much buoyant force will the displacer generate?

- (A) 5.320 pounds
- (B) 6.488 pounds
- (C) 4.363 pounds
- (D) 17.45 pounds
- (E) 2.792 pounds

**Question 125 – Level measurement**

Calculate the LRV and URV for this  $\Delta P$ -based liquid level measurement system:



- (A) LRV = 0 "H<sub>2</sub>O ; URV = 444 "H<sub>2</sub>O
- (B) LRV = 84 "H<sub>2</sub>O ; URV = 444 "H<sub>2</sub>O
- (C) LRV = 7 "H<sub>2</sub>O ; URV = 37 "H<sub>2</sub>O
- (D) LRV = 444 "H<sub>2</sub>O ; URV = 0 "H<sub>2</sub>O
- (E) LRV = 0 "H<sub>2</sub>O ; URV = 360 "H<sub>2</sub>O

**Question 126 – Level measurement**

A d/p cell used to measure liquid level has a “suppressed zero.” This means:

- (A) The transmitter is located above the 0% liquid level mark
- (B) The transmitter uses filter circuits to suppress noise to a zero level
- (C) The liquid is less dense than water
- (D) The transmitter is located below the 0% liquid level mark
- (E) The elevation of the vessel is below sea level

**Question 127 – Level measurement**

Which of the following level-measurement technologies *cannot* be adapted to measure solid (powder) level in a vessel?

- (A) Displacer
- (B) Float and tape
- (C) Radar
- (D) Ultrasonic
- (E) Load cell

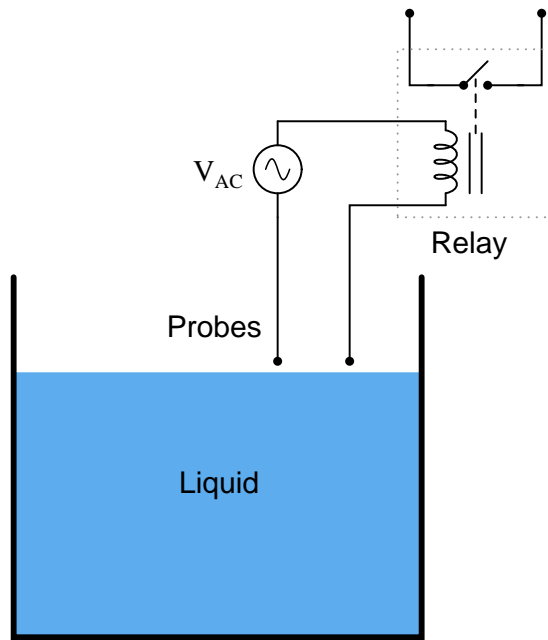
**Question 128 – Level measurement**

A guided-wave radar transmitter is able to measure liquid interface levels based on differences of \_\_\_\_\_ between the two liquids.

- (A) Ionization potential
- (B) Density
- (C) Speed of light
- (D) Temperature
- (E) Dielectric constant

**Question 129 – Level measurement**

The following liquid level switch will only function with liquids that are \_\_\_\_\_.



- (A) Electrically conductive
- (B) Denser than water
- (C) Absolutely pure (i.e. not a solution)
- (D) In a state of laminar flow
- (E) Optically transparent

**Question 130 – Level measurement**

Calculate the hydrostatic pressure at the bottom of a vessel holding 17 vertical feet of liquid with a density of 55 lb/ft<sup>3</sup>.

- (A) 33.8 PSI
- (B) 8.36 PSI
- (C) 21.2 PSI
- (D) 6.49 PSI
- (E) 5.90 PSI

**Question 131 – Temperature measurement**

Identify the thermocouple type with the highest temperature limit from those listed here:

- (A) Type J
- (B) Type K
- (C) Type S
- (D) Type T
- (E) Type E

**Question 132 – Temperature measurement**

The negative lead of a thermocouple is always colored:

- (A) Blue
- (B) Yellow
- (C) Red
- (D) White
- (E) Black

**Question 133 – Temperature measurement**

The most rugged temperature sensing element listed here is a/an:

- (A) Thermocouple
- (B) Orifice plate
- (C) RTD
- (D) Filled bulb
- (E) Fire eye

**Question 134 – Temperature measurement**

Convert a temperature measurement of  $250^{\circ}\text{C}$  into Kelvin.

- (A) 523.2 K
- (B) -209.7 K
- (C) 709.7 K
- (D) -23.2 K
- (E) 23.2 K

**Question 135 – Temperature measurement**

When the reference junction is the same temperature as the measurement junction in a thermocouple circuit, the output voltage (measured by the sensing instrument) is:

- (A) Zero
- (B) Reverse polarity
- (C) Noisy
- (D) AC instead of DC
- (E) Unreliable

**Question 136 – Temperature measurement**

A “thermowell” is a:

- (A) Heat sink
- (B) Small vessel for holding liquids at high temperature
- (C) Protective tube for a temperature sensing element
- (D) Temperature sensing device
- (E) Safety relief device for high pressure

**Question 137 – Temperature measurement**

*Reference junction compensation* is necessary in thermocouple-based temperature instruments because:

- (A) Copper extension wire has a tendency to corrode
- (B) Thermocouples are inherently nonlinear
- (C) The reference junction generates a temperature-dependent voltage
- (D) The junction's electrical resistance varies with temperature
- (E) Electrical noise may interfere with the measurement otherwise

**Question 138 – Temperature measurement**

*Latent heat* is:

- (A) The heat required to raise the temperature of a substance
- (B) The amount of heat energy present in ambient conditions
- (C) The potential energy residing in a sample of unburnt fuel
- (D) The heat released when a gas suddenly decreases pressure
- (E) The heat required to make a substance change phase

**Question 139 – Temperature measurement**

Thermocouple *extension wire* may be readily distinguished from regular thermocouple-grade wire by:

- (A) Different metal types
- (B) Outer sheath color
- (C) Special markings on the wire's insulation
- (D) Thickness
- (E) Flexibility (stranded instead of solid)

**Question 140 – Temperature measurement**

A *type J* thermocouple is made of the following metals:

- (A) Aluminum and Tungsten
- (B) Iron and Constantan
- (C) Platinum and Platinum/Rhodium alloy
- (D) Copper and Constantan
- (E) Chromel and Alumel

**Question 141 – Flow measurement**

Which of the following flow-measuring elements is inherently linear and requires no signal characterization (e.g. square-root extraction) anywhere in the loop?

- (A) Target
- (B) Venturi
- (C) Orifice plate
- (D) Pitot tube
- (E) Turbine

**Question 142 – Flow measurement**

Bernoulli's Equation is a mathematical expression of:

- (A) The ratio of kinetic to viscous forces in a flow stream
- (B) Friction loss as fluid moves through a rough pipe
- (C) Potential and kinetic energies in a flow stream
- (D) Fluid density and compressibility in a restriction
- (E) Vertical height and pressure for a static fluid

**Question 143 – Flow measurement**

As an incompressible fluid moves through a restriction,

- (A) Velocity decreases and pressure increases
- (B) Velocity increases and pressure increases
- (C) Velocity increases and pressure remains the same
- (D) Velocity increases and pressure decreases
- (E) Velocity decreases and pressure remains the same

**Question 144 – Flow measurement**

A flag flapping in the breeze illustrates what type of dynamic fluid effect?

- (A) Cavitation
- (B) Vortex shedding
- (C) Transitional flow
- (D) Coriolis effect
- (E) Laminar flow

**Question 145 – Flow measurement**

For accurate operation, orifice plate flowmeters require:

- (A) Laminar flow
- (B) Fully-developed turbulent flow
- (C) Swirls and eddies in the flow stream
- (D) Transitional flow
- (E) Plug flow



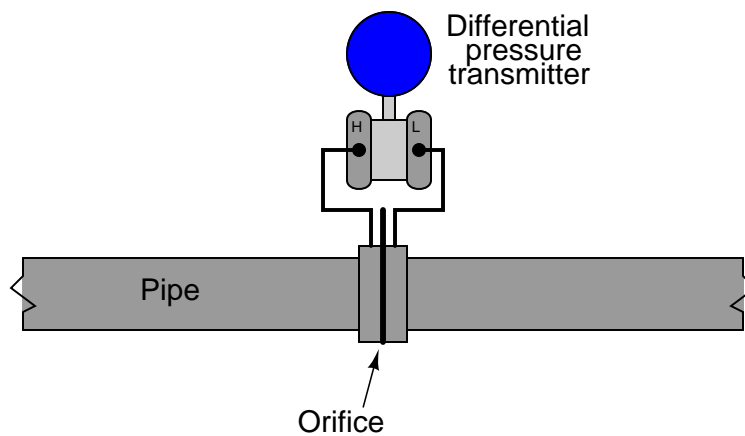
**Question 146 – Flow measurement**

A magnetic flowmeter will not properly measure the flow rate of:

- (A) Dirty water
- (B) Milk
- (C) Oil
- (D) Caustic
- (E) Acid

**Question 147 – Flow measurement**

Based on the relative positions of transmitter and orifice plate, this flow-measuring installation is suitable for:



- (A) Slurry flow
- (B) Water or oil flow
- (C) Gas flow
- (D) Steam flow
- (E) Laminar flow

**Question 148 – Flow measurement**

The purpose for providing ample straight-pipe lengths before and after a flowmeter is to:

- (A) Dampen pipe vibrations generated near elbows
- (B) Stabilize the flow profile within the flowmeter
- (C) Amplify the coriolis effect for better rangeability
- (D) Prevent cavitation
- (E) Minimize choking under high-flow conditions

**Question 149 – Flow measurement**

A  $\Delta P$  transmitter calibrated for a range of 0 to 100 "H<sub>2</sub>O measures liquid flow through an orifice plate from 0 to 1200 GPH. Calculate the new calibration range for the transmitter if we desire to decrease the flow measurement range to 0 to 700 GPH, using the same orifice plate.

- (A) 0 to 34.03 "H<sub>2</sub>O
- (B) 0 to 76.38 "H<sub>2</sub>O
- (C) 0 to 171.4 "H<sub>2</sub>O
- (D) 0 to 293.9 "H<sub>2</sub>O
- (E) 0 to 58.33 "H<sub>2</sub>O

**Question 150 – Flow measurement**

Identify which of the following flowmeters inherently measures *mass* flow rate:

- (A) Thermal
- (B) Magnetic
- (D) Flow nozzle
- (D) Vortex
- (E) Venturi tube

**Question 151 – Analytical measurement**

The pH of a liquid solution is a measure of:

- (A) Dissolved salt content
- (B) Hydrogen ion activity
- (C) Hydroxyl ion molarity
- (D) Electrical conductivity
- (E) Sodium ion molarity

**Question 152 – Analytical measurement**

A pH value less than 7.0 means that the solution is:

- (A) Conductive
- (B) Caustic
- (C) Hot
- (D) Acidic
- (E) Alkaline

**Question 153 – Analytical measurement**

The *Nernst equation* relates:

- (A) Reagent dosage to change in pH
- (B) O<sub>2</sub> concentration to latent heat
- (C) Relative ion concentration to voltage
- (D) Conductivity to fluid flow rate
- (E) Partial vapor pressure to fluid density

**Question 154 – Analytical measurement**

*Buffer solutions* are used with pH probes for the purpose of:

- (A) Cleaning
- (B) Linearization
- (C) Purging embedded sodium ions
- (D) Electrode inspection
- (E) Calibration

**Question 155 – Analytical measurement**

Flue gas *oxygen* measurement (“O<sub>2</sub> trim”) is important in combustion control systems for the purpose of:

- (A) Reducing sulphur emissions
- (B) Safer shut-downs
- (C) Faster start-ups
- (D) Reducing NO<sub>x</sub> emissions
- (E) Minimizing burner noise

**Question 156 – Analytical measurement**

An aqueous solution has a hydrogen ion concentration of 0.0015 *M*. Calculate the pH of this solution.

- (A) 1.824 pH
- (B) 11.18 pH
- (C) 2.292 pH
- (D) 2.824 pH
- (E) 2.897 pH

**Question 157 – Analytical measurement**

A *chromatograph* separates and distinguishes different molecule types in a fluid stream by:

- (A) Emitted light spectra
- (B) Atomic mass (weighing)
- (C) Electric charge
- (D) Adsorption time-delay
- (E) Reverse osmosis

**Question 158 – Analytical measurement**

An *electrodeless*, or *toroidal*, conductivity probe enjoys the following advantage over electrode-type conductivity probes:

- (A) Smaller size
- (B) Lower cost
- (C) Immunity to temperature changes
- (D) Resists fouling
- (E) Greater sensitivity

**Question 159 – Analytical measurement**

*ORP* measurement is often used in processes where:

- (A) Pigments are added to a solution to control color
- (B) Precise temperature control is critical
- (C) The addition of an oxidant must be controlled
- (D) The octane value of a liquid fuel is important
- (E) Conductivity of the liquid is negligible

**Question 160 – Analytical measurement**

According to the *Nernst equation*, the voltage developed by the electrodes will \_\_\_\_\_ when temperature increases, all other factors remaining the same.

- (A) Approach zero
- (C) Decrease
- (D) Fluctuate
- (B) Remain the same
- (E) Increase

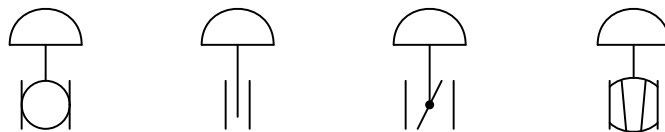
**Question 161 – Control valves**

When a control valve is installed in a process with where the differential pressure (drop) across the valve decreases with increasing flow, the best trim characteristic to choose for the valve would be:

- (A) Ported
- (B) Quick-opening
- (C) Equal percentage
- (D) Linear
- (E) Anti-cavitation

**Question 162 – Control valves**

The correct identities of the four control valve types shown below are (in order from left to right):



- (A) Plug, Slide, Rotary, Ball
- (B) Globe, Butterfly, Disc, Ball
- (C) Ball, Gate, Butterfly, Plug
- (D) Diaphragm, Gate, Disc, Globe
- (E) Ball, Disc, Butterfly, Globe

**Question 163 – Control valves**

An air-to-open control valve assembly may be formed with which of these actuator/valve body combinations?

- (A) Reverse-acting actuator, direct-acting valve body
- (B) Direct-acting actuator, direct-acting valve body
- (C) Direct-acting actuator, reverse-acting valve body
- (D) A or C
- (E) B or C

**Question 164 – Control valves**

Calculate the necessary  $C_v$  rating for a liquid service control valve, given a pressure drop of 24 PSID, a specific gravity of 1.3, and a maximum flow rate of 140 GPM. Assume there will be no flashing or choked flow through the valve.

- (A) 0.1319
- (B) 32.58
- (C) 7.583
- (D) 2585
- (E) 601.5

**Question 165 – Control valves**

The main purpose of a control valve *positioner* is to:

- (A) Alter the fail-safe status of the valve
- (B) Improve the precision of the valve
- (C) Alter the characterization of the valve
- (D) Increase transmitter accuracy
- (E) Eliminate cavitation in the valve

**Question 166 – Control valves**

The purpose of valve *packing* is to:

- (A) Help reduce cavitation in the valve trim
- (B) Increase stiction
- (C) Cushion the valve against harm during shipment
- (D) Seal process fluid from escaping past the stem
- (E) Lubricate the valve trim

**Question 167 – Control valves**

The definition of *split range* control valves implies that they are . . .

- (A) designed to be easily disassembled.
- (B) easily re-ranged for different characteristics.
- (C) equipped with quick-acting positioners.
- (D) only used in sets of three.
- (E) calibrated with complementary ranges.

**Question 168 – Control valves**

*Dual-ported* globe valves typically enjoy the following advantage over *single-ported* globe valves:

- (A) Less actuating force required
- (B) Longer service life
- (C) Easier disassembly and maintenance
- (D) Tighter shut-off
- (E) Greater temperature range



**Question 169 – Control valves**

*Cavitation* in a control valve is caused by:

- (A) process noise
- (B) vibration in the piping
- (C) the Von Karman effect
- (D) a laminar flow regime
- (E) pressure recovery

**Question 170 – Control valves**

The proper “fail safe” status of a control valve should always be dictated by:

- (A) economic savings
- (B) the configuration of the positioner
- (C) the controller’s tuning
- (D) the controller’s action (direct or reverse)
- (E) the nature of the process

**Question 171 – PID control and tuning**

Derivative control action is typically used when controlling \_\_\_\_\_, but rarely used when controlling \_\_\_\_\_.

- (A) Temperature, Flow
- (B) Flow, Level
- (C) pH, Temperature
- (D) Level, Temperature
- (E) Level, Flow

**Question 172 – PID control and tuning**

\_\_\_\_\_ processes always require some degree of \_\_\_\_\_ control action to achieve setpoint.

- (A) Integrating, Derivative
- (B) Integrating, Feedforward
- (C) Self-regulating, Proportional
- (D) Runaway, Linear
- (E) Self-regulating, Integral

**Question 173 – PID control and tuning**

The reciprocal of *proportional band* is called:

- (A) Reset
- (B) Percent
- (C) Minutes per repeat
- (D) Rate
- (E) Gain

**Question 174 – PID control and tuning**

“Quarter-wave damping” may be described as:

- (A) a condition of good control where PV approaches SP without overshoot
- (B) a condition of poor control where oscillations continue at constant amplitude
- (C) a condition of poor control where the transmitter is damped by 25%
- (D) a condition of good control where oscillations quickly subside
- (E) a condition of excellent control where there are no oscillations

**Question 175 – PID control and tuning**

Reset control action is often expressed in units of:

- (A) percent
- (B) seconds per rate
- (C) minutes
- (D) time constant ratio (unitless)
- (E) repeats per minute

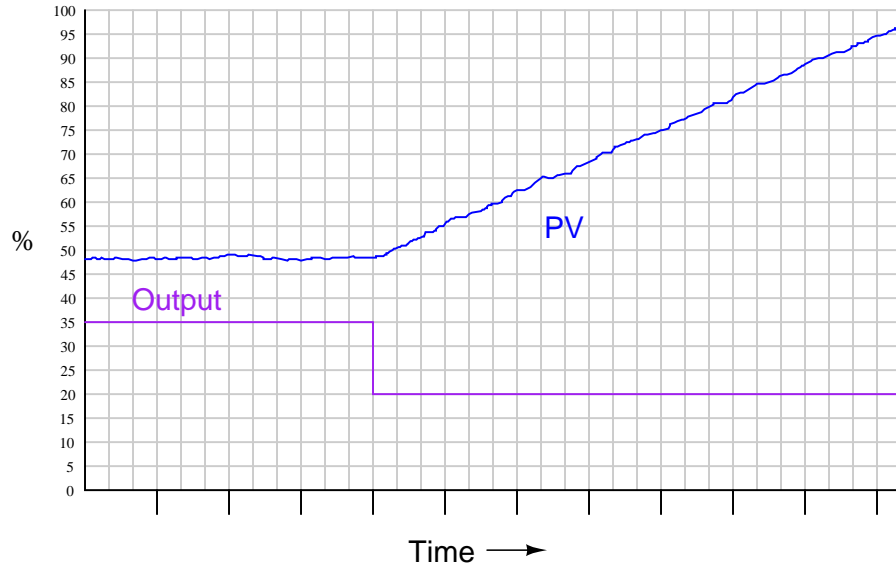
**Question 176 – PID control and tuning**

A proportional band setting of 175% is equivalent to a gain setting of \_\_\_\_\_.

- (A) 175
- (B) 0.756
- (C) 1.32
- (D) 0.571
- (E) 1.75

### Question 177 – PID control and tuning

The open-loop response of a process is shown in the following trend. What sort of process is indicated by this behavior?



- (A) Integrating
- (B) Proportional
- (C) Linear
- (D) Direct-acting
- (E) Self-regulating

### Question 178 – PID control and tuning

A condition where integral control action drives the output of a controller into saturation is called:

- (A) self-bias
- (B) wind-up
- (C) repeat
- (D) noise
- (E) offset

**Question 179 – PID control and tuning**

Fast, self-regulating processes typically respond well to aggressive \_\_\_\_\_ control action.

- (A) Nonlinear
- (B) Derivative
- (C) Proportional
- (D) Reset
- (E) Gain

**Question 180 – PID control and tuning**

Process variable *filtering* should be used:

- (A) to dampen noise
- (B) only on integrating processes
- (C) to improve response time
- (D) only on self-regulating processes
- (E) never

**Question 181 – Control strategies**

*Cascade* control is characterized by:

- (A) a special relay or function block to compensate for nonlinear process gain
- (B) one controller providing a setpoint for another controller
- (C) the presence of a “dead time” relay or function block
- (D) two controllers whose outputs are selected either by high or low value
- (E) the presence of a “lead/lag” relay or function block

**Question 182 – Control strategies**

*Adaptive gain* is used for controlling \_\_\_\_\_ processes.

- (A) Time-variant
- (B) Nonlinear
- (C) Dead time
- (D) Fast
- (E) Integrating

**Question 183 – Control strategies**

The three “elements” in a three-element boiler feedwater control system are:

- (A) Feedwater flow, water conductivity, and steam flow
- (B) Steam flow, drum level, and feedwater flow
- (C) Turbidity, feedwater flow, and temperature
- (D) Drum temperature, firing rate, and feedwater flow
- (E) Drum level, water pH, and drum temperature

**Question 184 – Control strategies**

The purpose of *feedforward* control is to:

- (A) eliminate the need for feedback control in a process
- (B) reduce the effect of load variation on the process variable
- (C) save energy
- (D) reduce the effect of process variable noise on stability
- (E) compensate for dead time and lag time in a process

**Question 185 – Control strategies**

In a *feedback* control system, the controller gets its input from the \_\_\_\_\_.

- (A) Load variable
- (B) Manipulated variable
- (C) Inferred variable
- (D) Controlled variable
- (E) Dynamic variable

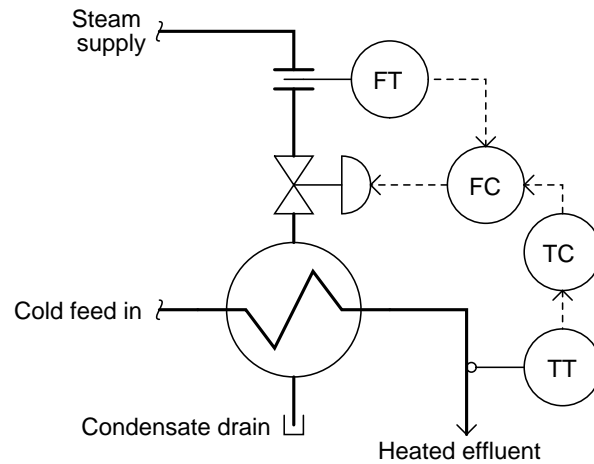
**Question 186 – Control strategies**

*Ratio* control is where:

- (A) one variable is controlled in proportion to another
- (B) a “wild flow” variable sets the gain of the controller
- (C) fuel must be precisely rationed for economy
- (D) process data is communicated in a digital format
- (E) the rate of one variable must remain fixed over time

**Question 187 – Control strategies**

The following P&ID shows a/an \_\_\_\_\_ control strategy:



- (A) Adaptive gain
- (B) Ratio
- (C) Model predictive
- (D) Cascade
- (E) Feedforward

**Question 188 – Control strategies**

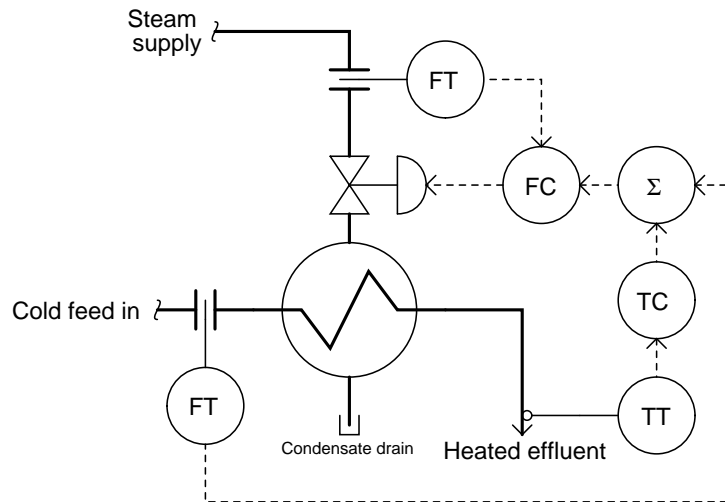
The *primary* controller in a cascade control system must always be tuned:

- (A) faster than the secondary
- (B) using the Ziegler-Nichols method
- (C) with the same parameters as the master
- (D) with greater filtering than the secondary
- (E) after the secondary is tuned



**Question 189 – Control strategies**

The following P&ID shows a/an \_\_\_\_\_ control strategy:



- (A) Ratio
- (B) Cascade
- (C) Override
- (D) Feedforward with trim
- (E) Two-element

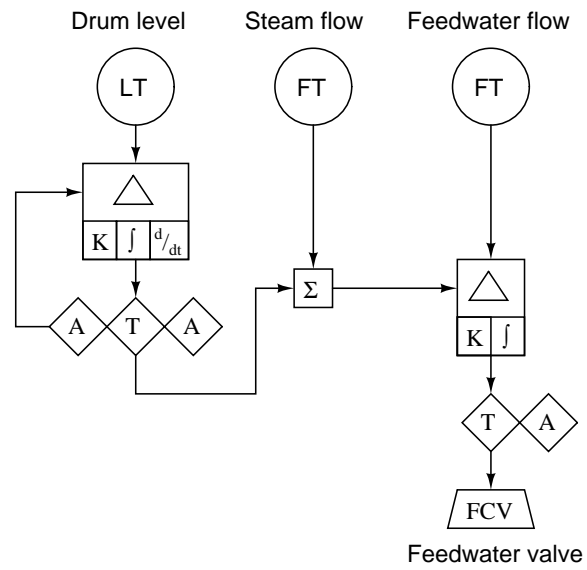
**Question 190 – Control strategies**

*Lead/lag compensation*, sometimes called “dynamic compensation,” is commonly used to:

- (A) improve stability by changing controller gain over time
- (B) filter noise from the process variable signal in a feedforward system
- (C) overcome dead time by duplicating the process lags on the setpoint signal
- (D) equalize load and manipulated variable lags in a feedforward system
- (E) prevent integral windup by placing limits on the manipulated variable signal

**Question 191 – Instrumentation diagrams**

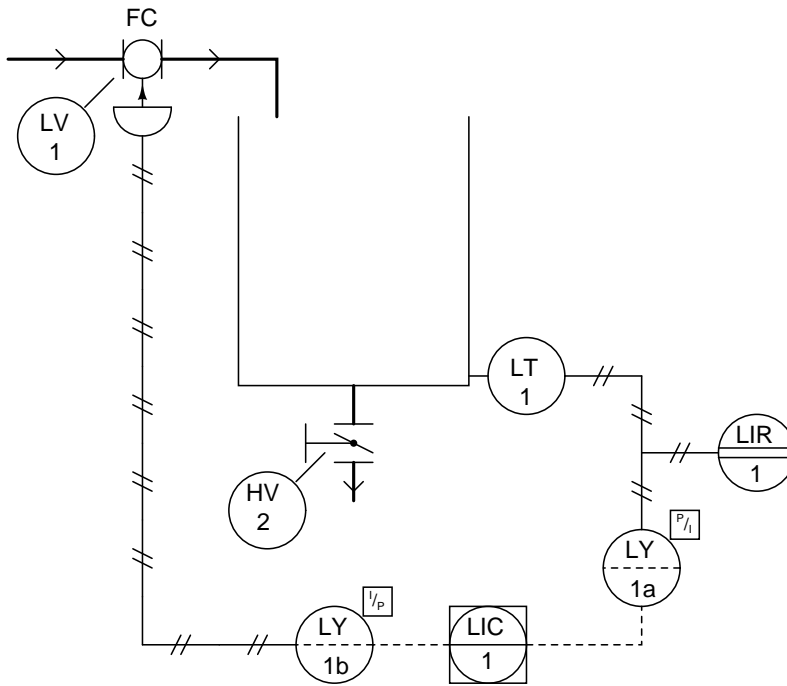
Identify what type of diagram this is:



- (A) Wiring diagram
- (B) Isometric drawing
- (C) SAMA diagram
- (D) P&ID
- (E) Loop diagram

**Question 192 – Instrumentation diagrams**

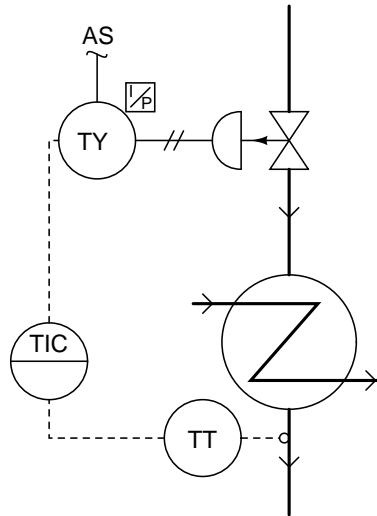
Identify what type of diagram this is:



- (A) Wiring diagram
- (B) Isometric drawing
- (C) Loop diagram
- (D) P&ID
- (E) SAMA diagram

**Question 193 – Instrumentation diagrams**

According to this diagram, the controller is \_\_\_\_\_, and it is located \_\_\_\_\_:



- (A) Pneumatic, in the field (process) area
- (B) Pneumatic, on the front of a secondary control panel
- (C) Pneumatic, on the front of the main control panel
- (D) Electronic, behind the main control panel
- (E) Electronic, on the front of the main control panel

**Question 194 – Instrumentation diagrams**

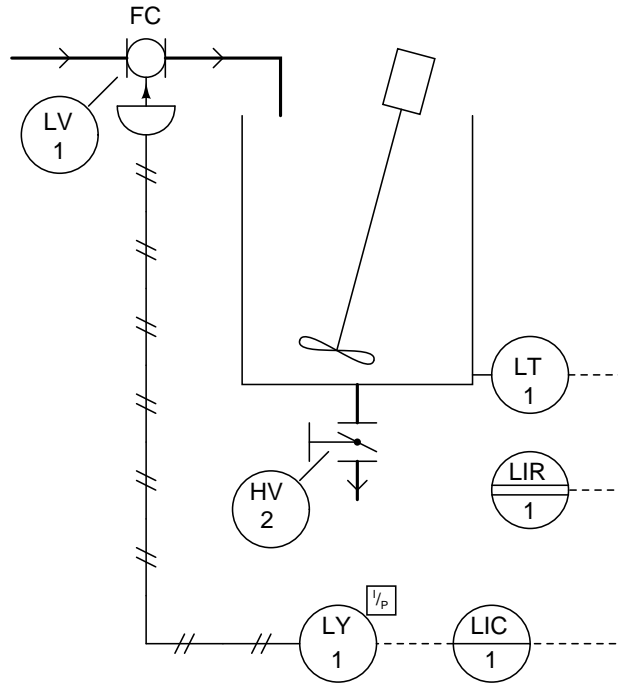
Identify the following instrumentation (P&ID and loop diagram) line types, from left to right:



- (A) pneumatic, electric, capillary, hydraulic
- (B) electric, pneumatic, digital network, filled system
- (C) pneumatic, electric, hydraulic, mechanical link
- (D) electric (on/off), electric (analog), pneumatic, digital network
- (E) pneumatic, mechanical link, hydraulic, capillary

**Question 195 – Instrumentation diagrams**

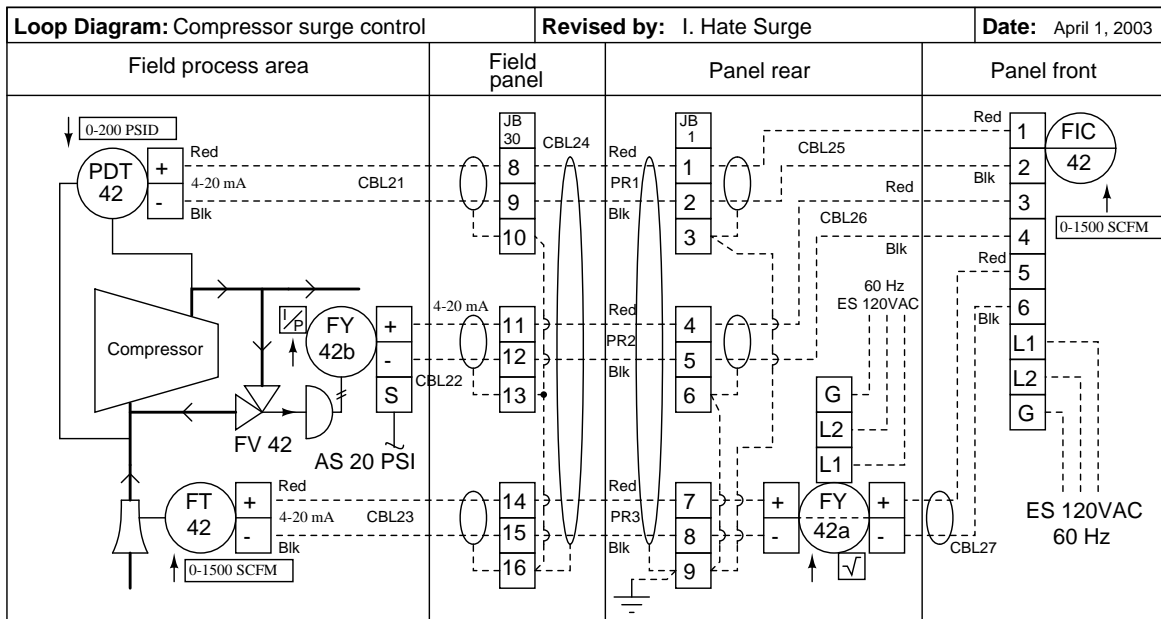
If the pneumatic tube in this diagram were to suddenly break in two pieces, what would be the effect on the process variable?



- (A) It would remain the same
- (B) It would decrease
- (C) It would become noisier
- (D) It would become less noisy
- (E) It would increase

### Question 196 – Instrumentation diagrams

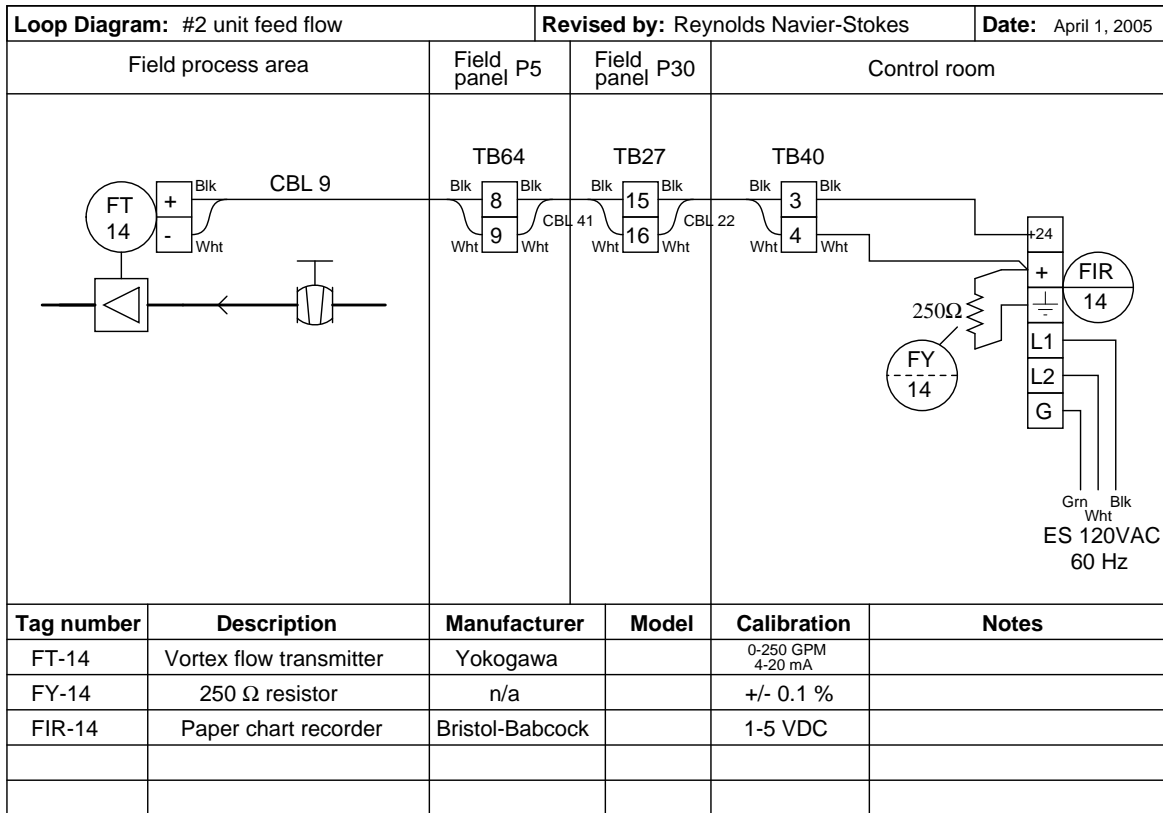
If the gas flow through FT-42 is 1200 SCFM, how much electric current is going through cable 23 and through cable 27?



- (A)  $I_{CBL23} = 14.2 \text{ mA}$  ,  $I_{CBL27} = 14.2 \text{ mA}$
- (B)  $I_{CBL23} = 16.8 \text{ mA}$  ,  $I_{CBL27} = 16.8 \text{ mA}$
- (C)  $I_{CBL23} = 16.8 \text{ mA}$  ,  $I_{CBL27} = 18.3 \text{ mA}$
- (D)  $I_{CBL23} = 16.8 \text{ mA}$  ,  $I_{CBL27} = 14.2 \text{ mA}$
- (E)  $I_{CBL23} = 14.2 \text{ mA}$  ,  $I_{CBL27} = 16.8 \text{ mA}$

### Question 197 – Instrumentation diagrams

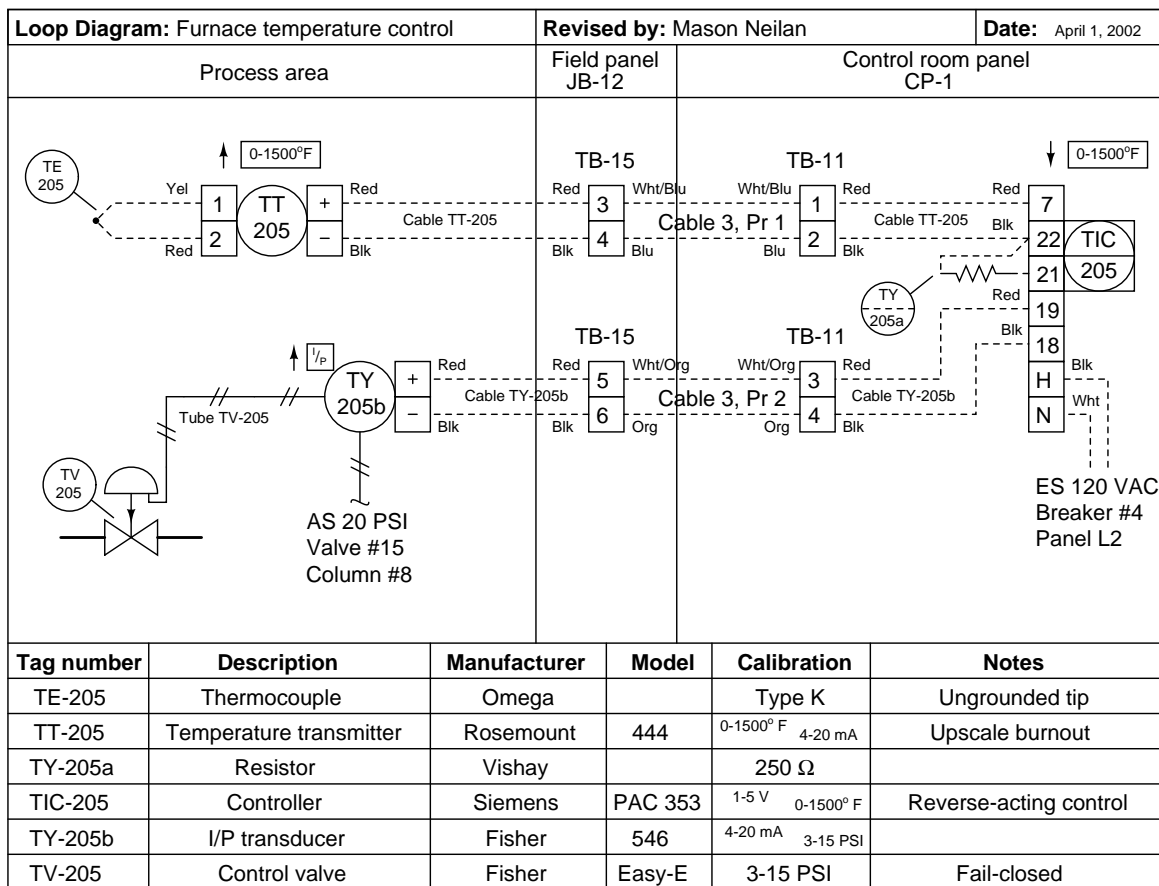
Calculate the voltage between terminals 15 and 16 of TB27 when the measured flow rate is 106 GPM. Assume a loop power supply voltage of exactly 24.00 volts, and negligible wire resistance:



- (A) 26.70 volts
- (B) 22.28 volts
- (C) 21.30 volts
- (D) 24.00 volts
- (E) 2.696 volts

### Question 198 – Instrumentation diagrams

If the thermocouple fails open, what will happen?

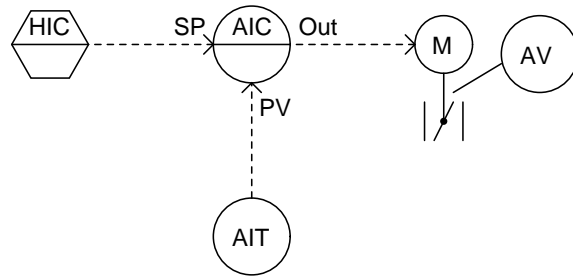


- (A) Valve TV-205 will hold position, stabilizing the process
- (B) Valve TV-205 will close shut, making the process warm up
- (C) Valve TV-205 will close shut, making the process cool down
- (D) Valve TV-205 will open wide, making the process cool down
- (E) Valve TV-205 will open wide, making the process warm up



**Question 199 – Instrumentation diagrams**

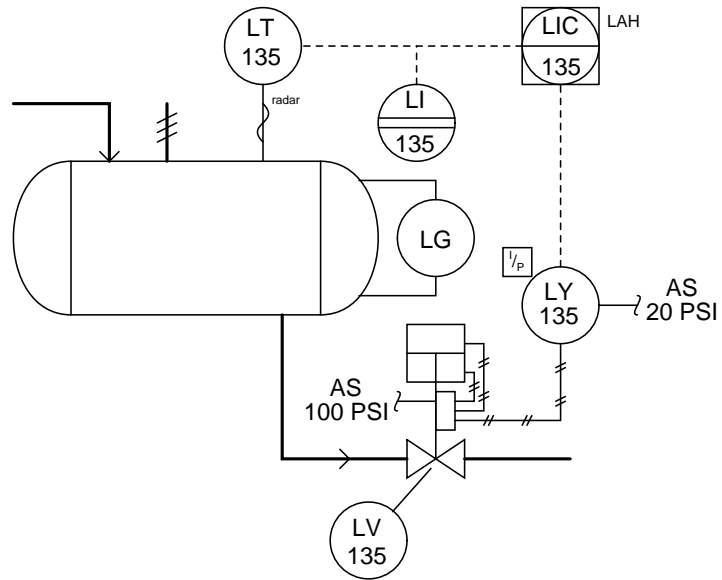
What kind of device provides the setpoint for the analytical indicating controller in this diagram?



- (A) A computer
- (B) A mathematical relay
- (C) Another panel-mounted controller
- (D) A programmable logic controller (PLC)
- (E) A pneumatic hand station

### Question 200 – Instrumentation diagrams

What sort of alarm function is provided by the controller in this diagram?



- (A) Low-flow alarm
- (B) High-temperature alarm
- (C) Low-level alarm
- (D) High-flow alarm
- (E) High-level alarm

### Question 201 – Programmable logic controllers

The acronym *PLC* stands for:

- (A) Pressure Load Control
- (B) Programmable Logic Controller
- (C) Pneumatic Logic Capstan
- (D) PID Loop Controller
- (E) Pressure Loss Chamber

**Question 202 – Programmable logic controllers**

*Ladder logic* programming consists primarily of:

- (A) Virtual relay contacts and coils
- (B) Logic gate symbols with connecting lines
- (C) Function blocks with connecting lines
- (D) Text-based code
- (E) Hieroglyphics

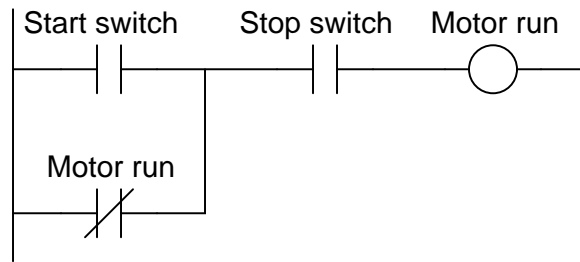
**Question 203 – Programmable logic controllers**

In a PLC, the *scan time* refers to the amount of time in which . . .

- (A) the technician enters the program
- (B) timers and counters are indexed by
- (C) one “rung” of ladder logic takes to complete
- (D) the entire program takes to execute
- (E) transmitted data communications must finish

**Question 204 – Programmable logic controllers**

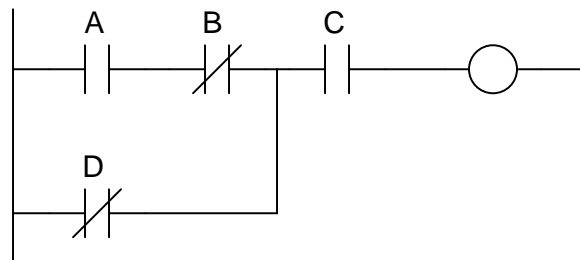
Identify the problem in this motor control PLC program:



- (A) Coil
- (B) Start contact
- (C) Seal-in contact
- (D) Stop contact
- (E) Power source

**Question 205 – Programmable logic controllers**

The Boolean representation of this PLC program is:



- (A)  $A\bar{B}C + \bar{D}$
- (B)  $C + (A + \bar{B})\bar{D}$
- (C)  $\bar{C} + D(\bar{A} + B)$
- (D)  $A\bar{B}C + B\bar{D}$
- (E)  $C(A\bar{B} + \bar{D})$

**Question 206 – Programmable logic controllers**

The difference between *online* and *offline* PLC programming is . . .

- (A) whether the PLC is running or stopped
- (B) whether the programming PC has internet connectivity
- (C) the type of programming cable used
- (D) where the edited program resides
- (E) the type of programmer used

**Question 207 – Programmable logic controllers**

In PLC programming, a *retentive* function is one that:

- (A) Defaults to the “on” state
- (B) Comes last in the program
- (C) Defaults to the “off” state
- (D) Cannot be edited or deleted
- (E) Is not reset after a power cycle

**Question 208 – Programmable logic controllers**

What is the largest integer number that a PLC counter function can reach if it uses a 16 bit register?

- (A) 32,768
- (B) 65,535
- (C) 65,536
- (D) 65,537
- (E) 32,767

**Question 209 – Programmable logic controllers**

An *OR* function implemented in ladder logic uses:

- (A) Normally-closed contacts in series
- (B) Normally-open contacts in series
- (C) A single normally-closed contact
- (D) Normally-open contacts in parallel
- (E) Normally-closed contacts in parallel

**Question 210 – Programmable logic controllers**

A good application for a *timed interrupt* in a PLC program would be:

- (A) A communications function block
- (B) A PID function block
- (C) A math function block
- (D) A motor start/stop rung
- (E) A “watchdog” timer

**Question 211 – Digital control systems**

The acronym *DCS* stands for:

- (A) DeltaV Console Services
- (B) Distributive Control System
- (C) Direct Cascade Sequencing
- (D) Differential Concentration Switch
- (E) Digital Control System

**Question 212 – Digital control systems**

Many digital control systems utilize *Ethernet* as a communications network, because . . .

- (A) no terminating resistors are necessary
- (B) speed is not affected by traffic
- (C) it is a wireless network standard
- (D) it is fully deterministic
- (E) it is robust and inexpensive

**Question 213 – Digital control systems**

*Resolution* refers to \_\_\_\_\_ in the analog-to-digital conversion portion of a digital control system.

- (A) the analog signal range
- (B) how determined the designer was
- (C) the number of active bits
- (D) the speed of analog signal sampling
- (E) the probability of hardware failure

**Question 214 – Digital control systems**

*Parity bits* are used for the purpose of \_\_\_\_\_ in digital systems.

- (A) power monitoring
- (B) error detection
- (C) symmetry generation
- (D) diagnostic monitoring
- (E) time-stamping data

**Question 215 – Digital control systems**

A typical use for an *integer* variable in a digital control system is:

- (A) Representing single switch status
- (B) Representing power supply voltage
- (C) Counting discrete events
- (D) Trigonometric math operations
- (E) Exponential math operations

**Question 216 – Digital control systems**

TIA/EIA-485 (formerly known as RS-485) is a digital communication standard with the following traits:

- (A) Single-ended voltage signaling, multidrop
- (B) Frequency Shift Key (FSK) signaling, superimposed on analog 4-20 mA
- (C) Manchester encoding, multidrop
- (D) Mark-and-space signaling, point-to-point
- (E) Differential voltage signaling, multipoint

**Question 217 – Digital control systems**

FOUNDATION Fieldbus is unique in that:

- (A) It has always been the leading fieldbus standard
- (B) Data communication is entirely deterministic
- (C) Power and data share the same wires
- (D) Diagnostic data is communicated as well as process data
- (E) Control algorithms may reside in the field devices



**Question 218 – Digital control systems**

A *watchdog timer* is a device or a programmed routine used for what purpose in a digital control system?

- (A) To interrupt normal program flow and address an immediate need
- (B) To check for errors in data communications
- (C) To provide time delays for critical functions
- (D) To monitor the operation of the microprocessor
- (E) To signal the start of a new program cycle

**Question 219 – Digital control systems**

Digital control systems are generally superior to analog control systems, but they are always worse with regard to:

- (A) Speed
- (B) Diagnostics
- (C) User-friendliness
- (D) Flexibility
- (E) Noise immunity

**Question 220 – Digital control systems**

A *triple modular redundant* (TMR) digital control system would be typically used for what purpose?

- (A) To save energy (compared to other control systems)
- (B) To control a potentially dangerous process
- (C) To increase response speed for fast processes
- (D) To save money (compared to other control systems)
- (E) To minimize routine maintenance requirements

## Answers

---

Answer 1

(B) Secure harmful energy sources to prevent injury

---

Answer 2

(A) Maintain oxygenated blood circulation

---

Answer 3

(D) Activate the emergency response system (equivalent to dialing “911”)

---

Answer 4

(A) Reduce the concentration of particulates in the air you breathe

---

Answer 5

(E) There is insufficient blood delivered to the body’s cells

---

Answer 6

(A) A company safety inspector has certified it

---

Answer 7

(D) Discomfort in the chest and/or upper body

---

Answer 8

(D) Hot and dry skin, inability to drink, vomiting, confusion

---

Answer 9

(C) A discharge of high electrical current through open air

---

Answer 10

(D) The circuit must be broken (opened)

---

Answer 11

(B)  $x = aby$

---

Answer 12

(A)  $x = \frac{a}{\sqrt{b}}$

---

Answer 13

(C)  $y = x + 2$

---

Answer 14

(B)  $y = x^2$

---

Answer 15

(B)  $x = 2 ; y = -1$

---

Answer 16

(A) 1:12

---

---

Answer 17

(D)  $ab^{-7}c^3x^2y^2$

---

Answer 18

(C)  $x^{-3/2}$

---

Answer 19

(B) 91.8

---

Answer 20

(C)  $(x + 3)(x - 4)$

---

Answer 21

(B) Opposite divided by hypotenuse

---

Answer 22

(A) 10.3

---

Answer 23

(D)  $57.99^\circ$

---

Answer 24

(C)  $45^\circ$

---

Answer 25

(A) Tangent

---

Answer 26

(D)  $13.342 \angle -103^\circ$

---

Answer 27

(B) Amplitude and phase shift

---

Answer 28

(C) 11.06

---

Answer 29

(B) 1.309 radians

---

Answer 30

(D) 23.09 meters

---

Answer 31

(C) 125

---

Answer 32

(C) greater than 7

---

---

Answer 33

(B) accelerates a chemical reaction without being consumed

---

Answer 34

(C) 12.03 liters

---

Answer 35

(C) Endothermic

---

Answer 36

(D) 4,500 joules

---

Answer 37

(A) 11,760 joules

---

Answer 38

(D) 19.18°

---

Answer 39

(D) greater than the weight of the sign

---

Answer 40

(D) greater than the latent heat of fusion

---

Answer 41

(B) 3.0 volts

---

Answer 42

(B) 7.835 mA

---

Answer 43

(C) 9.656 k $\Omega$

---

Answer 44

(A) 2.143 k $\Omega$

---

Answer 45

(B) 441.5  $\mu$ A

---

Answer 46

(C) 5

---

Answer 47

(A) +15 volts

---

Answer 48

(E) 16 volts

---

---

Answer 49

(B) 160 mA ← (right to left)

---

Answer 50

(C) + 0.5 volts - (positive on left, negative on right)

---

Answer 51

(E) Current will increase

---

Answer 52

(E) complementary reactances become equal and opposite

---

Answer 53

(B)  $I_{source} = 187.5 \text{ mA}$     $I_{load} = 72.73 \text{ mA}$

---

Answer 54

(D) Trigger

---

Answer 55

(E) 27.96 dB

---

Answer 56

(E) 0.819

---

Answer 57

(E) 400 Hz

---

Answer 58

(A) 17.31 volts

---

Answer 59

(E) The cable appears to a pulse signal as a 75 ohm load

---

Answer 60

(D) Blocks high-frequency signals from passing through

---

Answer 61

(D) 18.04 amps

---

Answer 62

(D) More power may be transmitted using less copper (wire)

---

Answer 63

(B) A rotating magnetic field

---

Answer 64

(C) They potentially save energy

---

---

Answer 65

(E) Latching the motor in the “run” state

---

Answer 66

(A) Protect the motor against mild overcurrent conditions

---

Answer 67

(D) 7.205 kV

---

Answer 68

(D) 15.32 hp

---

Answer 69

(D) its speed is constant

---

Answer 70

(B) superior low-speed torque is needed

---

Answer 71

(E) trivalent

---

Answer 72

(C) Cathode and anode

---

Answer 73

(B) 1 = Emitter ; 2 = Base ; 3 = Collector

---

Answer 74

(E) measure magnetic field strength

---

Answer 75

(C) 9.31 volts

---

Answer 76

(D) -5.96 volts

---

Answer 77

(E) 26.9 volts

---

Answer 78

(B) turn off

---

Answer 79

(C) change motor direction

---

Answer 80

(B) Boost voltage ; same output polarity as input

---

---

Answer 81

(D) 1011001001111000

---

Answer 82

(E) 00110001

---

Answer 83

(C)  $\overline{B} + \overline{AC}$

---

Answer 84

(D)  $B\overline{C}$

---

Answer 85

(D)  $Q = 0$  and  $\overline{Q} = 1$

---

Answer 86

(C) Eliminating false switching events

---

Answer 87

(E) The negative power supply rail of a bipolar transistor circuit

---

Answer 88

(A) Representing alphanumeric characters

---

Answer 89

(D) latch

---

Answer 90

(A) Share an output line with another gate

---

Answer 91

(C) transmitter, controller, I/P transducer, and control valve

---

Answer 92

(E) Negative feedback

---

Answer 93

(A) A pressure transmitter

---

Answer 94

(E) Minimize electrical noise

---

Answer 95

(E) 4 to 20 milliamps DC

---

Answer 96

(D) The command signal to the control valve

---

---

Answer 97

(D) Diaphragm

---

Answer 98

(D) Move the control valve further closed

---

Answer 99

(A) Process variable

---

Answer 100

(A) The output responds to changes in the process variable

---

Answer 101

(E) Zero error

---

Answer 102

(E) Linearity error

---

Answer 103

(B) Comparing accuracy at certain points both going up and down the calibration scale

---

Answer 104

(A) Reduce pressure well below the intended calibration point and then increase pressure again

---

Answer 105

(D) Zero

---

Answer 106

(C) +/- 0.064 mA

---

Answer 107

(D) 9.6 mA

---

Answer 108

(C) 8.325 pH

---

Answer 109

(D) Measure calibration drift

---

Answer 110

(E) Has a microprocessor built inside

---

Answer 111

(D) 146.7 "H<sub>2</sub>O

---

Answer 112

(D) Orifice plate

---



---

Answer 113

(D) 1082.3 PSI

---

Answer 114

(E) Head

---

Answer 115

(D) Decrease

---

Answer 116

(C) Close one block valve, open equalizing valve, close other block valve, open bleed

---

Answer 117

(B) Gauge **A** will register less pressure than gauge **B**

---

Answer 118

(A) 8.00 "W.C.

---

Answer 119

(A) Turn the screw (located near the bellows)

---

Answer 120

(E) Lamp 1 off, Lamp 2 on, Solenoid on

---

Answer 121

(A) Differential pressure transmitter

---

Answer 122

(A) It isolates the pressure transmitter from the process fluid

---

Answer 123

(C) We will need to change the transmitter's *LRV* and *URV*

---

Answer 124

(C) 4.363 pounds

---

Answer 125

(B)  $LRV = 84 \text{ "H}_2\text{O}$  ;  $URV = 444 \text{ "H}_2\text{O}$

---

Answer 126

(D) The transmitter is located below the 0% liquid level mark

---

Answer 127

(A) Displacer

---

Answer 128

(E) Dielectric constant

---

---

Answer 129

(A) Electrically conductive

---

Answer 130

(D) 6.49 PSI

---

Answer 131

(C) Type S

---

Answer 132

(C) Red

---

Answer 133

(A) Thermocouple

---

Answer 134

(A) 523.2 K

---

Answer 135

(A) Zero

---

Answer 136

(C) Protective tube for a temperature sensing element

---

Answer 137

(C) The reference junction generates a temperature-dependent voltage

---

Answer 138

(E) The heat required to make a substance change phase

---

Answer 139

(B) Outer sheath color

---

Answer 140

(B) Iron and Constantan

---

Answer 141

(E) Turbine

---

Answer 142

(C) Potential and kinetic energies in a flow stream

---

Answer 143

(D) Velocity increases and pressure decreases

---

Answer 144

(B) Vortex shedding

---

Answer 145

(B) Fully-developed turbulent flow

---

Answer 146

(C) Oil

---

Answer 147

(C) Gas flow

---

Answer 148

(B) Stabilize the flow profile within the flowmeter

---

Answer 149

(A) 0 to 34.03 "H<sub>2</sub>O

---

Answer 150

(A) Thermal

---

Answer 151

(B) Hydrogen ion activity

---

Answer 152

(D) Acidic

---

Answer 153

(C) Relative ion concentration to voltage

---

Answer 154

(E) Calibration

---

Answer 155

(D) Reducing NO<sub>x</sub> emissions

---

Answer 156

(D) 2.824 pH

---

Answer 157

(D) Adsorption time-delay

---

Answer 158

(D) Resists fouling

---

Answer 159

(C) The addition of an oxidant must be controlled

---

Answer 160

(E) Increase

---

---

Answer 161

(C) Equal percentage

---

Answer 162

(C) Ball, Gate, Butterfly, Plug

---

Answer 163

(D) A or C

---

Answer 164

(B) 32.58

---

Answer 165

(B) Improve the precision of the valve

---

Answer 166

(D) Seal process fluid from escaping past the stem

---

Answer 167

(E) calibrated with complementary ranges.

---

Answer 168

(A) Less actuating force required

---

Answer 169

(E) pressure recovery

---

Answer 170

(E) the nature of the process

---

Answer 171

(A) Temperature, Flow

---

Answer 172

(E) Self-regulating, Integral

---

Answer 173

(E) Gain

---

Answer 174

(D) a condition of good control where oscillations quickly subside

---

Answer 175

(E) repeats per minute

---

Answer 176

(D) 0.571

---

---

Answer 177

(A) Integrating

---

Answer 178

(B) wind-up

---

Answer 179

(D) Reset

---

Answer 180

(A) to dampen noise

---

Answer 181

(B) one controller providing a setpoint for another controller

---

Answer 182

(B) Nonlinear

---

Answer 183

(B) Steam flow, drum level, and feedwater flow

---

Answer 184

(B) reduce the effect of load variation on the process variable

---

Answer 185

(D) Controlled variable

---

Answer 186

(A) one variable is controlled in proportion to another

---

Answer 187

(D) Cascade

---

Answer 188

(E) after the secondary is tuned

---

Answer 189

(D) Feedforward with trim

---

Answer 190

(D) equalize load and manipulated variable lags in a feedforward system

---

Answer 191

(C) SAMA diagram

---

Answer 192

(D) P&ID

---

---

Answer 193

(E) Electronic, on the front of the main control panel

---

Answer 194

(A) pneumatic, electric, capillary, hydraulic

---

Answer 195

(B) It would decrease

---

Answer 196

(E)  $I_{CBL23} = 14.2 \text{ mA}$  ,  $I_{CBL27} = 16.8 \text{ mA}$

---

Answer 197

(C) 21.30 volts

---

Answer 198

(C) Valve TV-205 will close shut, making the process cool down

---

Answer 199

(A) A computer

---

Answer 200

(E) High-level alarm

---

Answer 201

(B) Programmable Logic Controller

---

Answer 202

(A) Virtual relay contacts and coils

---

Answer 203

(D) the entire program takes to execute

---

Answer 204

(C) Seal-in contact

---

Answer 205

(E)  $C(\overline{AB} + \overline{D})$

---

Answer 206

(D) where the edited program resides

---

Answer 207

(E) Is not reset after a power cycle

---

Answer 208

(B) 65,535

---

---

Answer 209

**(D)** Normally-open contacts in parallel

---

Answer 210

**(B)** A PID function block

---

Answer 211

**(B)** Distributive Control System

---

Answer 212

**(E)** it is robust and inexpensive

---

Answer 213

**(C)** the number of active bits

---

Answer 214

**(B)** error detection

---

Answer 215

**(C)** Counting discrete events

---

Answer 216

**(E)** Differential voltage signaling, multipoint

---

Answer 217

**(E)** Control algorithms may reside in the field devices

---

Answer 218

**(D)** To monitor the operation of the microprocessor

---

Answer 219

**(A)** Speed

---

Answer 220

**(B)** To control a potentially dangerous process

---