SkillsUSA
2010 Contest Projects

Industrial Motor Control

Click the “Print this Section” button above to automatically print the specifications for this contest. Make sure your printer is turned on before pressing the button.

Skills Process/Mixing Equipment Control Problem (2010)

Skill's has hired your company to wire a control circuit for Process/Mixing Equipment.

The equipment consists of a tank for mixing three liquids (liquids "A", "B" and "C" will be controlled by solenoid valves). A mixer paddle to mix the three liquids. A drain solenoid valve and pump to empty the tank.

Conditions:

1. A stop/start station will control power to the process.
2. The tank is empty with the low level float switch closed and the high level float switch open (this is one switch with two contacts and will operate together).

Customer Requirements: (Work description)

The operator must have control to stop and start the operation with a green indicator light signaling when the process has power. The operator must be able to monitor the process: a red indicator light when the mixing motor is ON and a green indicating light when the drain valve is open and the drain pump is ON.

Sequence of Operation:

The operator will engage the start button on the stop/start station. At this point the operation is automatic.

a. Liquid "A", "B" and "C" will start to flow
b. Liquid "A" and "B" will stop flowing after a predetermined time period
c. The Mixer will come on after Liquids "A" and "B" stop flowing
d. Liquid "C" will continue to flow until the tank is filled – the mixer will turn off when the tank is full
e. A full tank will open the drain valve and start the drain pump
f. The tank will continue to empty its contents until the low level switch is activated – the drain valve will close and the drain pump will stop and the cycle will start over.

Material List (2010)

Qty.	Description
1	Large Enclosure - 24" X 18"
1	Push Buttons Oiltight 1NC (red)
1	Push Buttons Oiltight 1NO (push to test – green)
1	Pilot light Oiltight (green)
1	Pilot light Oiltight (red)
1	Limit Switch CH E50SA 1NO/1NC
1	Motor Starter Open (CH C306GN3)
1	Motor Starter Enclosed (CHECN0511AAA)
1	Motor Starter Aux Blocks C-H C320KGT15 Top-2NO/2NC
2	Relay - 4PDT - D2PR4A
2	Relay Sockets - 4PDT - DP2PA4
1	Timing Relay/w/socket CH TRNP240AC
20′	EMT ½"
2	EMT ½" Box connectors
7′	MC cable – 14-4 /w/ ground
2	MC Cable box connectors – ½" straight
1	MC Cable box connectors – ½" 90 degree
3	MC Cable 1-hole straps
1′	Metal Flex ½"
2	Metal Flex ½" Box connector straight
5′	Liquid Tight ½"
10	Liquid Tight ½", Box connector straight
2	Liquid Tight ½", Box connector 90 degree
5	½" HW, 1-hole strap
6	Oct. Box, 4" x 1 1/2"
6	Lamp holders
6	Lamps
15′	14 awg THHN – Black
25′	14 awg THHN – White
20′	14 awg THHN – Red
15′	14 awg THHN – Green
1	Power cord with cord grip
25	#10 x ¾" Sheet metal screw
2	# 8 x 1 1/2" Sheet metal screw
1	Ground Bar 10 or greater holes
Misc.	Wire nuts, tape, marker book, tie-wraps, ground screws/clips
1	Terminal strip – 10 blocks (din rail mounted – replaceable blocks)

SPECIFICATIONS: Skill's 2010 – Process/Mixing Equipment

1. The work area consists of a 4' x 8' sheet of plywood. All AFF measurements will be from the bottom of the plywood.

2. All work will be done using the 2008 NEC.

3. Installation must utilize minimum materials while still meeting all requirements.

4. All box and device mounting dimensions will be to the center of the box or device unless otherwise specified.

5. Power will be supplied by cord set attached to the large enclosure.

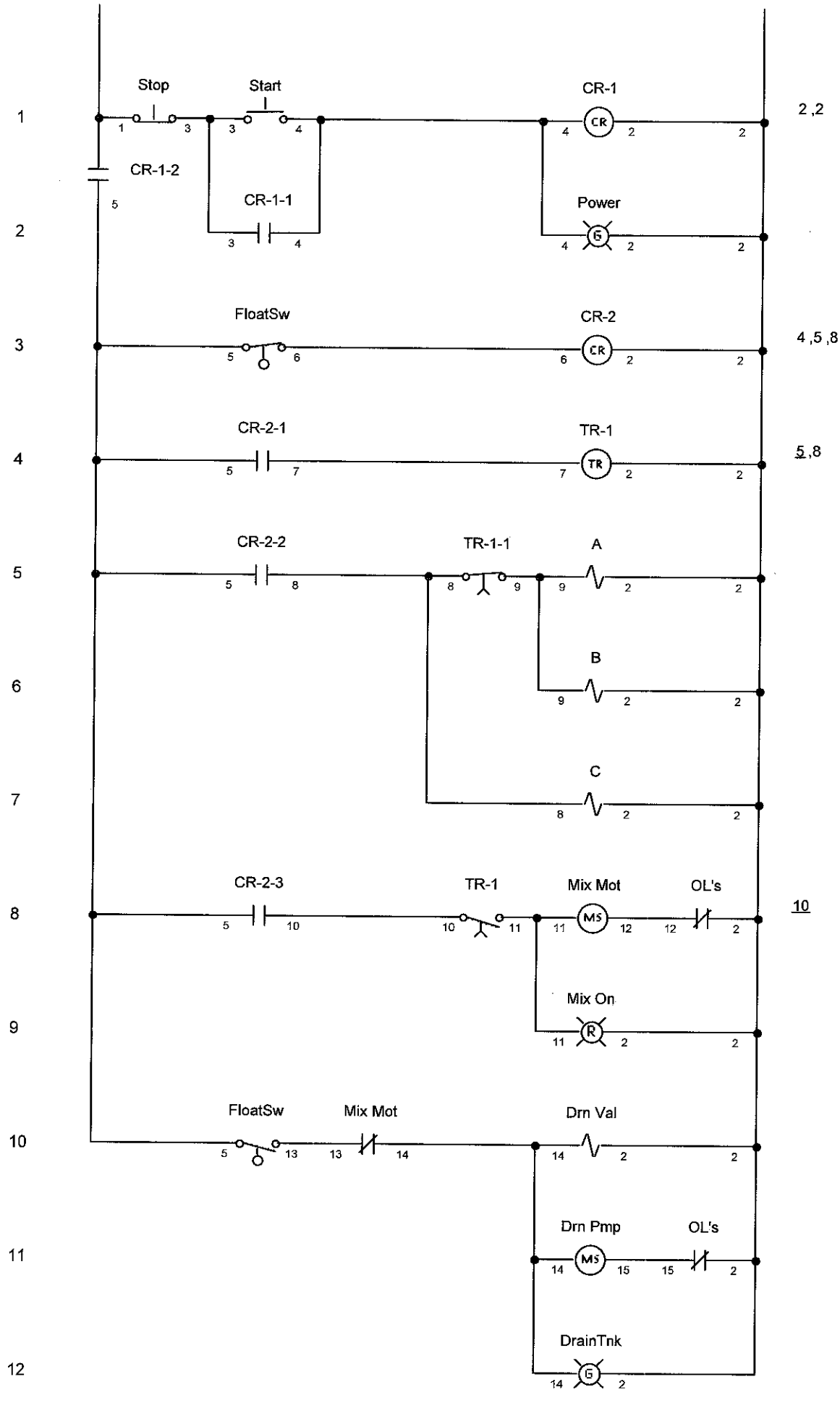
6. Porcelain light fixtures and lamps will be used to simulate all motors and solenoids The lamp indicating the "Mixer" is mounted 27" AFF and 12" from the left edge of board. The lamp indicating the "Drain Pump" is mounted 18" AFF and 12" from the left edge of board. A lamp mounted 42" AFF and 24" from right edge of the board to the right side of the box will simulated the solenoid for liquid "A". A lamp mounted 27" AFF and 24" from the right edge of the board to the right side of the box will simulate the solenoid for liquid "B". A lamp mounted 18" AFF and 24" from the right edge of the board to the right side of the box will simulate the solenoid for liquid "C". (Use liquid-tight flexible non-metallic conduit for the above.) A lamp mounted 60" AFF and 6" from the right edge of the board will simulate the solenoid for the drain valve. (EMT will be used for this solenoid.)

7. The Float Switch is a limit switch. The Float Switch will be mounted 3' AFF to the bottom of the switch and 6" from right edge board to the right side of the limit switch. Use MC cable for the limit switch. The switch will be mounted so the long side is parallel to the floor.

8. The "Mixer" starter will be mounted in the control enclosure. The "Drain Pump" starter will be mounted 3' AFF to the bottom. (Use flexible metal conduit between the large enclosure and the starter.)

   The motors in Item 8 (simulated by porcelain light fixtures) will be wired with black wire for the current carrying conductor and white wire for the neutral. The neutral will not be broken (i.e. it will feed through the starter).

9. The job is not complete until the Job Work Sheet is filed out.


1
2
3
4
5
6
7
8
9
10
11
12
Stop
Start
CR-1
CR-1-2
CR-1-1
Power
FloatSw
CR-2
CR-2-1
TR-1
CR-2-2
TR-1-1
A
B
C
CR-2-3
TR-1
Mix Mot
OL's
Mix On
FloatSw
Mix Mot
Drn Val
Drn Pmp
OL's
DrainTnk
2 ,2
4 ,5 ,8
5 ,8
10

Work Sheet **Contestant Number** _____

Page No._____ **Date:**_____

Customer Name: 2010 Industrial Motor Control Competition **Work Station**_____
Address: Bartle Hall
Kansas City, Missouri 64105
Phone: None

Work Description:_____
_____
_____

Quantity	Item Description	Unit Cost	Total Cost	
	Total Additional Materials from Attached Pages			
	Total Materials			

Arrived on Job Site:	Departed Job Site:

Labor to Be Billed	Name	Hours (Regular)	Hours (Overtime)

I hereby acknowledge satisfactory completion of work as described.

Work approved by:_____ **Date:**_____

Continuation Sheet

Page ___ of ___ **Job Number_____**

Quantity	Item Description	Unit Cost	Total Cost	
	Total This Page			

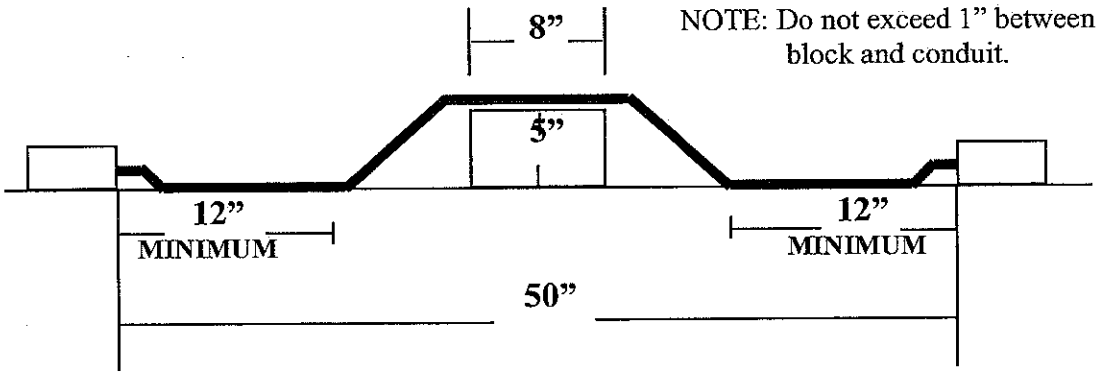
Continuation Sheet

Page ___ of ___ **Job Number_____**

Quantity	Item Description	Unit Cost	Total Cost	
	Total This Page			

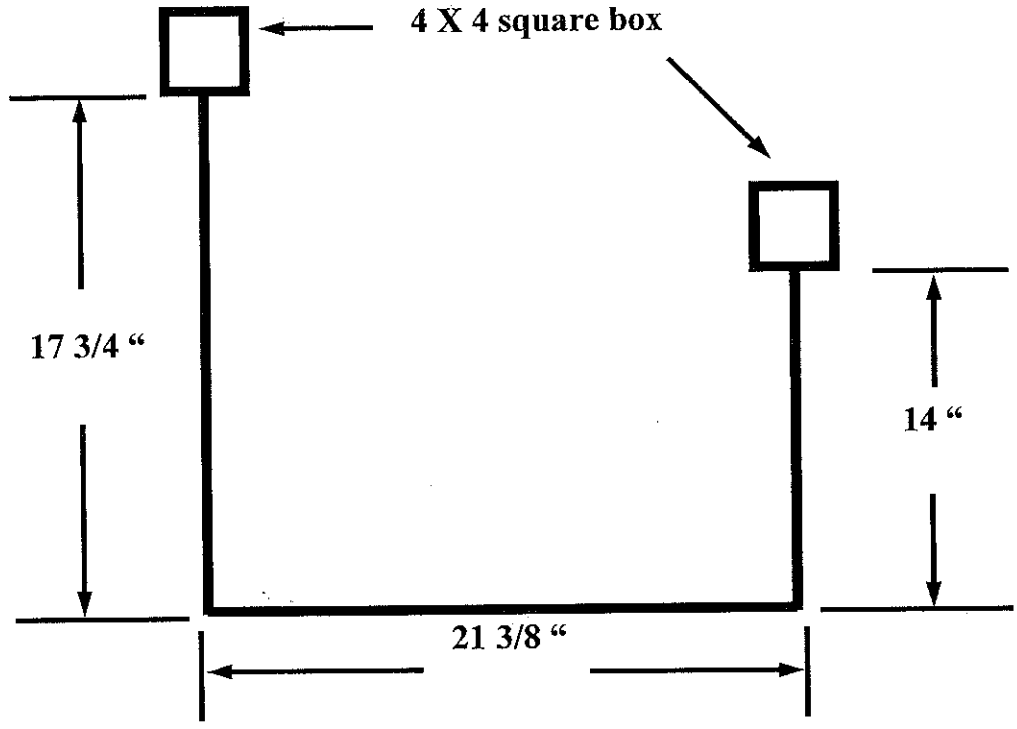
CONDUIT ASSIGNMENT

1. **Make each conduit bend from the measurements shown.**
2. **Offsets are required at all boxes.**
3. **Label your conduit and place at the edge of your work station.**
4. **You may use a 4" square box to get the box measurements.**
5. **All measurements - within 1/8"**



CONDUIT ASSIGNMENT

1. **Make each conduit bend from the measurements shown.**
2. **Offsets are required at all boxes.**
3. **Label your conduit and place at the edge of your work station.**
4. **You may use a 4" square box to get the box measurements.**
5. **All measurements - within 1/8"**



Skills USA 2010 Motor Control Test

Student # _____

For the first 12 questions, draw the appropriate electrical symbol that represents each term.

1 _____ Normally closed push button

2 _____ Normally open push button

3 _____ Normally open pressure switch

4 _____ Normally closed flow switch

5 _____ Normally open float switch

6 _____ Normally closed limit switch

7 _____ Normally open held closed limit switch

8 _____ Normally open temperature switch

9 _____ Normally open to close: delay on energize

10 _____ Normally closed to open: delay on energize

11 _____ **Normally open to open: delay on de-energize**

12 _____ **Normally closed to close: delay on de-energize**

For the remaining questions, write the letter representing the correct answer on the line following the question number.

13 _____ **Conductors sizes are expressed in American Wire Gage (AWG) or _____.**

a. inches
b. circular mils
c. square inches
d. AWG

14 _____ **The *NEC* requires that electrical work be _____**

a. installed in a neat and workmanlike manner
b. installed under the supervision of a qualified person
c. completed before being inspected
d. all of these

15 _____ **Determine the allowable ampacity of six current carrying No. 8 THW copper conductors installed in EMT with an ambient temperature of 30°C**

a. 40A
b. 45A
c. 50A
d. 55A

16 _____ **The auxiliary contact used to maintain a circuit to the coil of a relay when the start button is released is known as the**

a. holding contact
b. maintaining contact
c. sealing contact
d. all of these

17 _____ **Conductor ampacity must be de-rated when more than ___ current-carrying conductors are grouped together in a raceway or cable**

a. two
b. three
c. four
d. six

18 _____ **The rating of a branch circuit shall be determined by the rating of the _____ .**

a. ampacity of the largest device connected to the circuit
b. average of the ampacity of all devices
c. branch-circuit over-current devices
d. ampacity of the branch-circuit conductors according to Table 310.16

19 _____ **Resistance values for conductors to be used when calculating voltage drop are given in ___**

a. Table 310.15
b. Table 310.16
c. Table 400.5
d. Table 8 of Chapter 9

20 _____ **A *continuous load* is one that is expected to operate ___**

a. for three hours or more
b. daily
c. at peak connected load
d. none of these

21 _____ **Illumination shall be provided for all working spaces about service equipment, switchboards, panel-boards, and motor control centers**

a. Over 600V
b. Using automatic means of control
c. Rated 1,200A or more
d. Located indoors

22 _____ **The *NEC is* _____ .**

a. Intended to be a design manual
b. meant to be used as an instruction guide for untrained persons
c. for the practical safeguarding of persons and property from hazards arising from the use of electricity
d. published by the Bureau of Standards

23 _____ **Which of the following is not a standard size fuses of inverse time circuit breaker?**

a. 45A
b. 70A
c. 75A
d. 80A

24 _____ **For general motor applications, the motor branch-circuit short-circuit protection device shall be sized based on the _____ values**

a. motor name plate
b. NEMA standard
c. *NEC* Table
d. factory manual

25 _____ **The motor _____ currents listed in Table 430.247 through 430.250 shall be used to determine the ampacities of motor circuit conductors and short-circuit and ground-fault protection devices.**

a. nameplate
b. full-load
c. power factor
d. service factor

26 _____ **The current in ampears a conductor can carry continuously, where the temperature will not be raised in excess of the conductor's insulation temperature rating is called its _____ .**

a. short-circuit rating
b. ground-fault rating
c. ampacity
d. all of these

27 _____ **Motors shall be located so that adequate _____ is provided and so that maintenance, such as lubrication of bearings and replacement of brushes, can be readily accomplished.**

a. space
b. ventilation
c. protection
d. all of these

28 _____ **For stationary motors of 2 HP or less and 300V or less on a ac circuits, the controller is permitted to be an ac-rated general-use snap switch where the motor full-load current rating is not more than ___ percent of the rating of the switch**

a. 80
b. 50
c. 75
d. 125

29 _____ **In determining the highest rated motor for the purposes of 430.24, the highest rated motor shall be based on the rated full-load current as selected _____ .**

a. from the motor nameplate
b. from Tables 430.247 through 430.250
c. from taking the horsepower times 746 watts
d. using the largest horsepower motor

30 _____ **Branch-circuit conductors supplying a single continuous-duty motor shall have an ampacity not less than _____ rating**

a. 125 percent of the motor's nameplate current
b. 125 percent of the motor's full-load current as determined by 430.6(A)(1)
c. 125 percent of the motor's locked-rotor current
d. 80 percent of the motor's full -load current

31 _____ **The total opposition to current flow in an ac circuit is expressed in ohms is called**

a. resistance
b. reluctance
c. conductance
d. impedance

32 _____ **Feeder tap conductors supplying motor circuits, with an ampacity at least one-third that of the feeder, shall not exceed _____ in length.**

a. 10 ft
b. 15 ft
c. 20 ft
d. 25 ft

33 _____ **Overload devices are intended to protect motors, motor control apparatus, and motor branch-circuit conductors against _____ .**

a. excessive heating due to motor loads
b. excessive heating due to failure to start
c. short circuits and ground faults
d. a and b

34 _____ **Motors with a nameplate service factor (SF) rating of 1.15 or more must have the overload protection device sized at no more than ___ percent of the motor nameplate current rating**

a. 100
b. 115
c. 125
d. 135

35 _____ **If a dual-element fuse is used for overload protection, what size fuse is required for a 30 hp, 460V, three phase synchronous motor, with a temperature rise of 38°C ?**

a. 20 A
b. 30 A
c. 25 A
d. 40 A

36 _____ **Unless overload protection is provided by other approved means, the minimum number of overload units required for a three-phase ac motor is _____ .**

a. one
b. two
c. three
d. any of these

37 _____ **The maximum rating or setting of an inverse time breaker used as the motor branch-circuit short-circuit and ground-fault protective device for a single-phase motor is _____ percent of the full-load current given in Table 430.52**

a. 125
b. 175
c. 250
d. 300

38 _____ ***NEC* 310.3 requires that conductors 8 AWG and larger must be ___ when installed in a raceway**

a. grounded
b. bonded
c. stranded
d. none of these

39 _____ **The internal diameter of a 1" trade size EMT is _____ .**

a. 1" b. .824"
c. .96" d. 1.049"

40 _____ **Only wiring methods recognized as _____ are included in the *NEC* code.**

a. expensive b. efficient
c. suitable d. all of these

41 _____ **_____ is a term indicating that there is an intentional delay in the tripping action of the circuit breaker, which decreases as the magnitude of the current increases**

a. Adverse time b. Inverse time
c. Time delay d. Timed unit

42 _____ **The branch-circuit conductors supplying a motor that draws 40 amperes must have an ampacity not less than:**

a. 40 A b. 50 A
c. 60 A d. 70 A

43 _____ **If no other information is given, a motor that draws 100 amperes must be protected by an overload device rated at not more than:**

a. 115 A b. 125
c. 140 d. 150

44 _____ **The conductors between the final over-current device protecting the circuit and the (outlets) are known as ____ conductors.**

a. feeder b. branch-circuit
c. home run d. none of these

45 _____ **The conductors of a feeder supplying two (2) continuous duty motors, one 7 1/2 hp, 240 volts dc, and one rated 10 hp 240 volts dc shall have a current rating not less then:**

a. 56 A b. 74 A
c. 77 A d. 84 A

46 _____ **An electric heater is rated 10 kW @ 277 volts. What is the kW output of this heater if it is connected to a 240 volt source?**

a. 5 KW
b. 7.5 KW
c. 8.7 KW
d. 10 KW

47 _____ **In a 3-wire, 3-phase ac system feeding a motor, with one conductor grounded, where must fuses for motor overload protection be inserted in the circuit?**

a. A fuse must be inserted in each ungrounded conductor and also in the grounded conductor
b. No fuses are required for motor overload protection
c. A fuse must be inserted only in each ungrounded conductor
d. None of these are correct

48 _____ **A power factor correction capacitor connected on the load side of the overload device of a motor reduces the line current by 20%. If the full-load current of the motor is 100 amperes, the setting of an overload device in the circuit is based on a current of:**

a. 80 A
b. 100 A
c. 125 A
d. 135 A

49 _____ **A feeder supplying fixed load(s) shall have a protective device with a rating or setting _____ branch-circuit short-circuit and ground-fault protective device for any motor in the group, plus the sum of the full-load currents of the motors of the group**

a. not greater than the largest rating or setting of the
b. 125 percent of the largest rating of the
c. equal to the largest rating of any
d. none of these

50 _____ **A pneumatic timer operates on the principle of**

a. the decay of a magnetic field in a coil
b. an RC time constant
c. air entering a bellows through an orifice
d. a crystal oscillator

SkillsUSA™
CHAMPIONSHIPS

2010

Industrial Motor Control

Math Test

Secondary _____

Postsecondary _____

Contestant Number _____

PERFORM THE FOLLOWING OPERATIONS

1. $618 + 59 + 274 + 446 =$ _____ **2.** $742 - 366 =$ _____ **3.** $640 \times 58 =$ _____

4. A new type of light fixture will be installed in a machine shop. The new fixtures must be installed for every 121 ft^2 of floor space. If the machine shop has 3388 ft^2, determine the number of light fixtures required _____

SOLVE AND REDUCE TO LOWEST TERMS

5. $17\frac{5}{6} + 4\frac{2}{3} =$ _____ **6.** $17\frac{3}{4} - 6\frac{7}{8} =$ _____ **7.** $4\frac{4}{5} \times 3\frac{1}{3} =$ _____

8. An electrician can bend and install lengths of conduit at a rate of 8¼ per hour. Calculate the length of time it takes the electrician to install 75 lengths of conduit. _____

PERFORM THE FOLLOWING OPERATIONS

9. A maintenance technician measures 8.361′ of wire between the disconnect panel and the control panel, 1.8′ from the top to the bottom of the control panel, 5.73′ from the panel to the 3ϕ motor box, and 0.477′ in the 3ϕ motor box. How many feet of wire are required to run the 3ϕ motor? _____

10. 29.24 gal. – 22.464 gal. = _____ **11.** $0.75\ g \times 1.6\ g \times 0.437\ g =$ _____

12. $\frac{120E}{7.5R} =$ _____

SIGNED NUMBERS

13. $6 - (-4.9) =$ _____ **14.** $-18.5 - (-11.2) =$ _____

SOLVE THE FOLLOWING

15. $(6 \times 10^4) \times (5 \times 10^2) =$ _____ **16.** $(12 \times 10^{-3}) \times (4 \times 10^{-8}) =$ _____

ORDER OF OPERATIONS

17. $\frac{21}{7} - 6(20 - 8 \times 2) =$ _____ **18.** $\left(\sqrt{25} + 3\right) - \left(3^3 + \frac{16}{4}\right) =$ _____

SOLVE FOR THE UNKNOWN

19. $26 - 2a = 8 + a$ $a =$ _____

20. $3x - 17 = 28 - x$ $x =$ _____

21. $\frac{15Y}{3} - 8 = 27$ $Y =$ _____

22. In an electrical circuit where $E = I \times R$, the circuit has two (2) loads in series. Load #1 causes a voltage drop of 32 V, and Load #2 causes a voltage drop of 64 V. The total resistance of the circuit is 48 Ω. What is the current in the circuit? _____

USE THE RIGHT TRIANGLE LAWS FOR THE FOLLOWING PROBLEMS

23. If angle A (∠ A) = 53°, then ∠ C = _____.

24. If line BC = 25′ and line AC = 26′, then line AB = _____.

25. If ∠ A = 45° and line AC = 26′, then ∠ C = _____, and line BC = _____.