

Open: one 8.5x11 page both sides only
Multiple choice 1 point each

Name KEY

1) Cone heater resistances measured with the resistance meter were less than resistances computed using current and voltage readings because

- a) meters tend to read low on the resistance scale.
- b) DC resistance is less than AC resistance.
- c) of resistance of the conductors leading to the cone heater
- d) resistance of metal goes up as temperature increases.

2) A voltmeter placed in series with a load will

- a) cause a short circuit, but no damage to meter.
- b) read correctly the voltage across the load.
- c) shut off almost all current to the load.
- d) cause a short circuit and ruin the meter.
- e) read correctly the voltage across the load

3) When the Fluke meter reads OL on the ohms function,

- a) resistance is infinite
- b) resistance is zero
- c) leads are reversed
- d) meter battery is dead

4) Analysis of an electrical load shows a power factor of 1.1.

- a) this load has more inductive reactance than capacitive reactance.
- b) this load has more capacitive reactance than inductive reactance.
- c) resistance load on the circuit exceeds the sum of capacitive and inductive load.
- d) there has been an error in meters, meter reading, or calculations.

5) Power factor improvement

- a) significantly reduces power usage of a motor.
- b) significantly increases power usage of a motor.
- c) does not change power usage of motor.
- d) a, b, or c depending on original power factor.

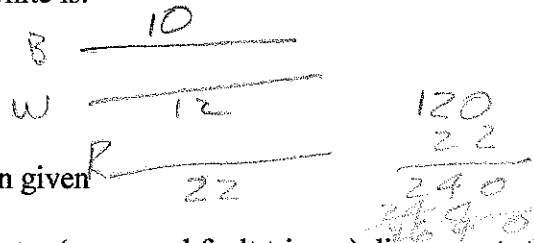
6) Negative instantaneous power in an AC circuit

- a) means energy stored in a reactive load component is flowing from the load to the generator.
- b) is impossible.
- c) means that resistive load components are adjusted to lower voltage by passing stored energy back to the generator.
- d) occurs only at power factors less than 0.5.

700 7
300 5
700 7
600 7
500 8
400 2
300 2
200 6
100 1
470

7) A 3-wire 120/240 volt branch circuit has only 120-volt resistive loads connected. Currents measured: Black: 10 amps White: 12 amps The wattage of the load connected between red and white is:

- a) 1440 watts
- b) 1200 watts
- c) 240 watts
- d) 2640 watts
- e) can't tell from information given



8) A ground fault circuit interrupter (or ground fault tripper) disconnects the circuit

- a) when a detector senses that current is flowing toward the load in both the black and white wires at the same time.
- b) when the current in the black wire exceeds a certain amperage for a certain time.
- c) when a detector senses a larger current in black (hot) than in white (neutral).
- d) when a detector senses a current in the wrong direction in the white (neutral).

9) A GFI will NOT protect a person who contacts

- a) red conductor and earth
- b) black conductor and earth
- c) black conductor and neutral conductor

10) A wild phase is present on this type of service:

- a) wye
- b) delta
- c) both wye and delta
- d) neither wye nor delta

11) A voltage of 208 Volts is measured between two wires on a 3-phase wye load, connected to a 3-phase wye service. This is a

- a) line voltage
- b) phase voltage
- c) both phase and line
- d) neither phase or line
- e) can't tell from info given

12) Phase voltage and line voltage on a 3-phase system

- a) are always equal
- b) are never equal
- c) are equal on a wye system
- d) are equal on a delta system

13) A 240-volt load is connected between black and red on a 120/240-V service.

- e) this will cause a short circuit
- f) the load will not operate
- g) the load is unsafe because no neutral is connected
- h) the load will operate normally

14) Ampacity determines wire size for

- a. very short distances
- b. very long distances
- c. heavy loads
- d. aluminum conductors
- e. branch circuits
- f. circuits

15) A three-way switch (S3) is actually a:

- a. SPST
- b. SPDT
- c. DPST
- d. DPDT

16) In order to switch a light from 4 locations, these switches are needed:

- a. 2-S, 2-S3
- b. 2-S3, 2-S4
- c. 4-S4
- d. 1-S4, 3-S3

17) A cable designated as 3 wire with ground contains these conductors:

- a. black, red, white, green, or bare
- b. black, white, green, bare
- c. black, red, green, bare
- d. red, white, green, bare
- e. black, red, white

18) The diameter of a rod having a cross-sectional area of 10,000 circular mils is

- a. 100 in.
- b. 0.1 mil
- c. 1000 mils
- d. 0.1 in.

(100) 10000

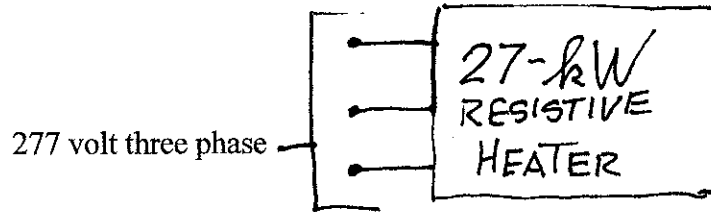
19) This type conductor is suitable for direct burial

- a. USE
- b. SE
- c. AC
- d. TW
- e. NM
- f. NMC
- g. DB

20) A copper conductor and an aluminum conductor have the same diameter.

- a. ampacity of each is the same
- b. ampacity of copper conductor is larger
- c. ampacity of aluminum conductor is larger
- d. we cannot decide on ampacity because length is not stated

21. (27)



5

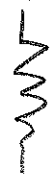
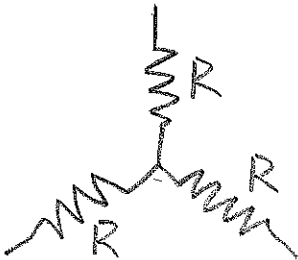
(a) Compute line current

$$27000 = \sqrt{3} I_L (277) (1)$$

$$I_L = 56.3 \text{ A}$$

11

(b) If the heater is configured as three resistors in a wye, what is the resistance of each resistor?



$$9 \text{ kW}$$

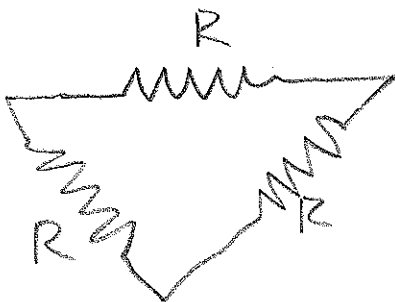
$$\frac{277}{\sqrt{3}} = 160 \text{ V}$$

$$I = \frac{9000}{160} = 56.3 \text{ A}$$

$$R = \frac{160}{56.3} = \boxed{2.84 \Omega}$$

11

(c) If the heater is configured as three resistors in a delta, what is the resistance of each resistor?



$$I = \frac{9000}{277} = 32.49$$

$$R = \frac{277}{32.49} = \boxed{8.53 \Omega}$$

22. (26) A branch circuit is to be run from a 240 volt panel to a 110-amp load 200 feet away. The conductor is to be aluminum and is to be run overhead. A 3 % design voltage drop is to be used in the design.

a) What conductor or cable type should be used? **TRIPLEX**

4 b) What conductor is needed considering ampacity? **AWG-1**

6 c) What conductor is needed considering voltage drop?

$$CM = \frac{(1.6)(22)(110)(220)}{(0.3)(240)} = 118,311 CM$$

AWG-00 133100 CM

e. Write the order for the conductor.

4 **220FT ALUMINUM TRIPLEX SIZE AWG-00**

6 d) With the conductor from e in place, what is the exact voltage available at the load with the load on?

WR 18311
-3 X 2-3

$$VD = \frac{(1.6)(22)(110)(220)}{133100} = 6.4$$

$$\begin{array}{r} 240.0 \\ - 6.4 \\ \hline 233.6 V \end{array}$$

2 e) What voltage is available at the end of the circuit with the load disconnected?

240

4 f) How much power does the conductor use with the load connected?

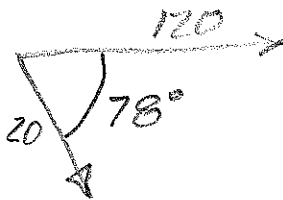
$$P = IE = (110)(6.4) = 704W$$

23. (27) A motor connected to a 120-volt, 60 Hz power source draws 20 amps and uses 500 watts.

a) Draw a phasor diagram referencing on voltage and specifying the phase angle.

3

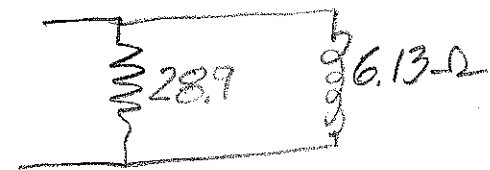
$$\cos \theta = \frac{500}{(120)(20)} = 0.208$$

$$\theta = 78^\circ$$


b) Calculate values of circuit components which will model this motor as a parallel R-L circuit.

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$$R = \frac{120}{20 \cos 78} = 28.9 \Omega$$

$$X_L = \frac{120}{20 \sin 78} = 6.13 \Omega$$


c) A 530 microfarad capacitor is placed in parallel with this motor. Calculate the current to the capacitor-motor combination and express in polar form.

10

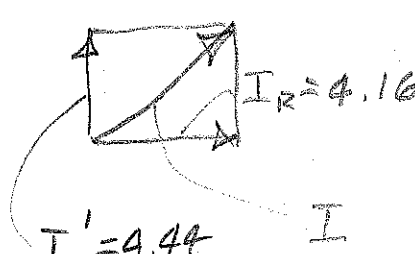
$$X_C = \frac{1}{2\pi(60)(530 \times 10^{-6})} = 5.00 \Omega$$

$$I_C = \frac{120}{5.00} = 24.00$$

$$I_L = 20 \sin 78 = 19.56$$

$$I_C' = 4.44$$

$$I_R = 4.16$$

$$I = 6.08 \angle 46.9$$


$$\tan \theta = \frac{4.44}{4.16}$$

$$\theta = 46.9^\circ$$

$$I \cos 46.9 = 4.16$$

$$I = 6.08$$

$I = 6.08 \angle 46.9$

d) Compute the power used by the motor-capacitor combination.

4

$$P = (6.08)(120) \cos 46.9 = 500W$$

TABLE 5.3 Properties of conductors

Size	Area, cmil	Usual Number of Strands	Diameter each Strand, in.	Copper		Aluminum	
				Weight lb/1000 ft	Resistance ohms/1000 ft	Weight lb/1000 ft	Resistance ohms/1000 ft
AWG**							
14	4110	1	0.064	12.5	3.07	3.78	5.06
12	6530	1	0.081	19.8	1.93	6.01	3.18
10	10380	1	0.102	31.43	1.21	9.556	2.00
8	16510	1	0.128	49.98	0.764	15.20	1.26
6	26240	7	0.061	79.44	0.491	24.15	0.808
4	41740	7	0.077	126.3	0.308	38.41	0.508
3	52620	7	0.087	159.3	0.245	48.43	0.403
2	66360	7	0.097	205	0.194	62.3	0.319
1	83690	19	0.066	259	0.154	78.6	0.253
0	105600	19	0.074	326	0.122	99.1	0.201
00	133100	19	0.084	411	0.0967	125	0.159
000	167800	19	0.094	518	0.0766	157	0.126
0000	211600	19	0.106	653	0.0608	199	0.100
kcmil***							
250	250000	37	0.082	772	0.0515	235	0.0847
300	300000	37	0.090	925	0.0429	282	0.0707
350	350000	37	0.097	1080	0.0367	328	0.0605
400	400000	37	0.104	1236	0.0321	375	0.0529
500	500000	37	0.116	1542	0.0258	469	0.0424
600	600000	61	0.099	1850	0.0214	563	0.0353
700	700000	61	0.107	2160	0.0184	657	0.0303
750	750000	61	0.111	2316	0.0171	704	0.0282
800	800000	61	0.114	2469	0.0161	751	0.0265
900	900000	61	0.122	2780	0.0143	845	0.0235
1000	1000000	61	0.128	3086	0.0129	938	0.0212

* DC resistance at 75°C.
 ** American Wire Gage numerical designation.
 *** kcmil = thousands of circular mils.

Conductor Design Principles

TABLE 5.8 Minimum aluminum conductor sizes for (AWG or kcmil) 230-

Load in Amps	Amperage, Circuit											
	In Air-Cable or Conduit		Direct Burial		Underground		Overhead in Air		Single		Bunch or Quad	
	NM	UF	NM	UF	NM	UF	NM	UF	USE	USE	USE	USE
5	12	12	12	12	12	12	12	12	8	8	8	12
7	12	12	12	12	12	12	12	12	8	8	8	12
10	12	12	12	12	12	12	12	12	8	8	8	12
15	12	12	12	12	12	12	12	12	8	8	8	12
20	10	10	10	10	10	10	10	10	8	8	8	12
25	10	10	10	10	10	10	10	10	8	8	8	12
30	8	8	8	8	8	8	8	8	8	8	8	10
35	6	6	6	6	6	6	6	6	8	8	8	10
40	6	6	6	6	6	6	6	6	8	8	8	10
45	4	4	4	4	4	4	4	4	6	6	6	10
50	4	4	4	4	4	4	4	4	6	6	6	8
60	3	3	3	3	3	3	3	3	4	4	4	8
70	2	2	2	2	2	2	2	2	3	3	3	8
80	1	1	1	1	1	1	1	1	2	2	2	6
90	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	2	2	2	6
100	1/0	1	1	1	1	1	1	1	1	1	1	6
115	2/0	1/0	1	1	1	1	1	1	1/0	1/0	1	6
130	3/0	2/0	1/0	1/0	1/0	1/0	1/0	1/0	2/0	2/0	1/0	4
150	4/0	3/0	2/0	2/0	2/0	2/0	2/0	2/0	3/0	3/0	2/0	4
175		4/0	3/0	3/0	3/0	3/0	3/0	3/0	4/0	4/0	3/0	4
200		5/0	4/0	4/0	4/0	4/0	4/0	4/0	5/0	5/0	4/0	4
225		300	250	250	250	250	250	250	300	300	250	3
250		350	300	300	300	300	300	300	350	350	300	3
275		500	350	350	350	350	350	350	500	500	300	2
300		500	500	400	400	400	400	400	500	500	350	2
325		600	500	500	500	500	500	500	600	600	400	1
350		700	500	500	500	500	500	500	700	700	500	1
375		700	600	600	600	600	600	600	700	700	500	1
400		900	700	700	700	700	700	700	900	900	600	1

Source: Hiatt (2000); reprinted with permission.
 *Single conductors in overhead branch circuits must be at least AWG-12 copper or AWG-8 aluminum or AWG 6 aluminum (NEC articles 225-6 (a) and 230-23).
 **UF not permitted in sizes larger than AWG-4/0.
 NM not permitted in sizes larger than AWG-2.
 NM cannot be used in agricultural environments defined by NEC article 547.
 In most applications, equipment will be rated at 60°C. Therefore, conductor ampacity must be