AE 363 - Exam 1

1. The maximum instantaneous voltage to ground occurring on a 120/240 v single phase system is about:
   A. 240 V
   B. 120 V
   C. this depends on the type of meter used.
   D. 370 V
   E. 0 V
   F. 84.6 V
   G. 115 V

2. In an AC circuit, power is used by
   A. resistances
   B. capacitances
   C. inductances
   D. all of the above
   E. (a) & (b)
   F. (a) & (c)
   G. (b) & (c)

3. When an extra series load is added to a series circuit,
   A. voltages across and currents through other loads are not changed.
   B. voltages change, but currents remain the same.
   C. currents change, but voltages remain the same.
   D. voltages across and currents through other loads change.

4. A voltmeter placed in series with a load will
   A. cause a short circuit but no damage to the meter
   B. read correctly the voltage across the load
   C. shutoff almost all current to the load
   D. cause a short circuit and ruin the meter
   E. read correctly the voltage across the load
5. The resistance of an instrument fuse is measured to be 4.1 MΩ. This fuse is:
   A. good
   B. weak, but usable
   C. blown
   D. can't tell from this information

6. 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.

7. 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.

8. 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.

9. How long will it take a 4kW load to use 12 kWh of energy?
   A. 3 hour
   B. 1/3 hour
   C. 36 minutes
   D. 3.6 hours
   E. none of the above

   \[
   (4\text{ kW}) \times (T \text{ h}) = 12 \text{ kWh}
   \]
   \[
   T = 3 \text{ h}
   \]

10. Which of the following loads can be assumed to operate at power factor of 1?
    A. transformer welder
    B. fluorescent lamp
    C. toaster
    D. capacitor start induction run motor

11. 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
12. A person can usually survive a shock of 100 mA if
A. contact is through the two hands
B. the power source is high-voltage AC
C. the time duration of the shock is very short
D. skin is dry at contact point

13. Severity of an electrical shock depends on
A. magnitude of current.
B. duration of shock.
C. route through body.
D. all of the above.
E. a & b
F. a & c

14. A watthour meter has a Kh factor of 3 on the nameplate. With a test load connected through it, 10 revolutions of the disk take 300 seconds. Compute the load wattage.

\[
\text{Load wattage} = \frac{3 \times 10^3}{300} = 1000 \text{ W} = 1 \text{ kW}
\]

15. If a 240-volt load has no connection to neutral,
A. the load will work, but not very well
B. the load will not operate
C. this violates code
D. the load works normally

16. If two equal-wattage 120-volt light bulbs are placed in series across 240 volts,
A. they will both operate normally
B. one will burn out in a short time and open the circuit
C. they will both light, but light output will be greatly reduced
D. both will light, but the bulb nearer the source of electrons (negative terminal) will be brighter

17. Voltage drop determines wire size for:
A. very short distances
B. very long distances
C. heavy loads
D. branch circuits
E. aluminum conductors
18. 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

19) (30) A branch circuit consisting of AWG-6 copper THHN conductors are run in a conduit from a 240-V panel a distance of 50 ft (including 10% extra) to a 110-A load.

a) Does this conductor meet the ampacity requirement?  \( \times \)

b) What is the smallest conductor size that can be used in order to meet the ampacity requirement?

AWG-2

c) Compute the voltage across the load with the load turned on, assuming the AWG-6 copper conductor is installed.

\[
CM = \frac{22(110)(50)}{26.240} = \frac{240.00}{4.61} \quad \frac{235.39}{1000} = 0.491
\]

\[
VD = \frac{22(110)(50)}{26.240} = 4.61V
\]

\[
P = 110(4.61) = 507W
\]

\[
P = (110)(5.40) = 594W
\]

d) Compute the power used by the conductor with the load turned on.

e) What is the voltage at the load end of the circuit with the load turned off? (Breakers are still on.)

240V

f) If the load is resistive and is rated at 240V, by how many watts does the load power decrease because of voltage drop in the conductors?

\[
R = \frac{240}{110} = 2.182 \Omega
\]

\[
P = \frac{E^2}{R} = \frac{(240)^2}{2.182} = 26,397 \text{ W}
\]

\[
P_1 = \frac{(240)^2}{2.182} = 26,397 \text{ W}
\]

\[
P_2 = \frac{(2354)^2}{2.182} = 25,396 \text{ W}
\]

\[
1,001 \text{ W}
\]
A single-phase motor is drawing 30A and 4000W when connected to a 240-V, 60-Hz power supply.

a) Sketch a phasor diagram for the motor referenced on voltage. Show phase angle.

\[ 4000 = 240(30) \cos \theta \quad \theta = 56.3^\circ \]

b) Compute values of \( R \) and \( X_L \) which model this motor as a parallel \( R \)-\( X_L \) circuit.

\[ R = \frac{240}{30 \cos 56.3} = 14.4 \Omega \]
\[ X_L = \frac{240}{30 \sin 56.3} = 9.61 \]
\[ 16.65 \]

c) Sketch a phasor diagram of the motor referenced on current. Show the phase angle.

d) Compute values of \( R \) and \( X_L \) which will model the motor as a series \( R \)-\( X_L \) circuit.

\[ R = \frac{240 \cos 56.3}{30} = 4.44 \Omega \]
\[ X_L = \frac{240 \sin 56.3}{30} = 6.66 \]

e) A 400 \( \mu \)F capacitor is installed in parallel with the motor. Compute the current drawn by the motor-capacitor combination and express in polar notation.

\[ X_C = \frac{1}{2 \pi (60)(400 \times 10^{-6})} = 6.63 \Omega \]
\[ \tan \theta = \frac{13.14}{16.65} \]
\[ \theta = 38.28^\circ \]
\[ I = \frac{38.28}{16.65} = 2.12 \]

f) Compute the power used by \( R \) in part d). Use your computed value of \( R \) in your calculation.

\[ P = I^2R = (30)^2(4.44) = 3996 \leq 4000W \]

g) Compute the power used by \( R \) in part b). Use your computed value of \( R \) in your calculation.

\[ P = I^2R = (16.65)^2(14.4) = 3992 \leq 4000W \]
21 (12) Draw a branch circuit extending from the circuit breaker to a lamp. The lamp is to be switched from two locations between the circuit breaker and the lamp. Show all wire colors.
### Table 5.3 Properties of Conductors

<table>
<thead>
<tr>
<th>AWG**</th>
<th>Area cmil</th>
<th>Number of Strands</th>
<th>Diameter each Strand in</th>
<th>Weight lb/1000 ft</th>
<th>Resistance ohms/1000 ft</th>
<th>Copper Weight lb/1000 ft</th>
<th>Copper Resistance ohms/1000 ft</th>
<th>Aluminum Weight lb/1000 ft</th>
<th>Aluminum Resistance ohms/1000 ft</th>
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<td>1</td>
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<tr>
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<td>0.194</td>
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<td>0.106</td>
<td>653</td>
<td>0.0608</td>
<td>199</td>
<td>0.100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 Gauge numerical designation.
*** kcmil = thousands of circular mils.

Numbers run from 40 to 0000. These gage numbers are like names and have no relation to the wire size. The AWG gages commonly used in electrical wiring are listed (14 through 0000). The corresponding diameters are listed in column 4. The AWG system applies only to non-ferrous metals.

The cross-sectional area in circular mils is listed for each wire size in column 2. Notice that for sizes larger than 0000, the size listed is the cross-sectional area in kcmil (thousands of circular mils). Conductors larger than AWG-8 are usually made up of several strands, rather than one solid cylinder, so that the conductor can be easily and repeatedly bent without breaking. The number of wires (strands) is listed in column 3 of Table 5.3. When the conductor is stranded, the area listed is the sum of the areas of the strands. Conductors smaller than AWG-6 may also be available in stranded form.

**Example 5.3**

What is the area of a conductor made up of 37 strands of 0.0900-in.-diameter wire?

\[
\frac{0.0900\text{ in.} \cdot \frac{\text{mil}}{0.001\text{ in.}}} = 90\text{ mil}
\]

\[
A = (90\text{ mil})^2 = 8100\text{ cmil}
\]

This is the area of each strand. \[
\frac{\text{cmil}}{\text{strand}} \frac{8100}{37\text{ strand}} = 299,700\text{ cmil}
\]

\[
\approx 300,000\text{ cmil} = 300\text{ kcmil}
\]

**Circuit Conductor Design**

In choosing conductors for specific applications, it is necessary to consider three factors:

- Environment in which the conductor will be placed.
- Amperage capacity (ampacity) of the conductor.
- Voltage drop.

Environment determines the type of insulation needed. Conductor size might be determined by any
## TABLE 5.7 Minimum copper conductor sizes (AWG or mcm) for 230–240 V single-phase branch circuits

<table>
<thead>
<tr>
<th>Load in NM'' THHN, THW, SE''</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amps</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>10</td>
</tr>
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<tr>
<td>80</td>
</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

### 2.4 Voltage Drop Criterion

| Length of Run in Feet | 25 | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | 275 | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 650 | 700 | 750 | 800 |
|------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|

*Source: Hiatt (2000); reprinted with permission.

*Single conductors in overhead branch circuits must be at least AWG-12 copper or AWG-8 aluminum for spans up to 50 ft. For service conductors and for branch circuit spans greater than 50 ft, conductors must be at least AWG-8 copper or AWG-6 aluminum (NESC 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.