**FUNDAMENTALS OF INDUSTRIAL HYGIENE, 6TH ED.**

**HOMEWORK #7**

**INDIVIDUAL MEASUREMENT OF ELECTRICITY**

**Name: KEY *49 pts. possible***

**EXERCISES:** Perform the calculations identified below. Show your work neatly and clearly in a manner similar to the examples provided above (i.e., write the formula and show steps of your calculations).

**Part I: Basic Electrical Units**

1a) Consider a short piece of insulated wire. Is there a current flowing in this wire? *(1 point)*

***No. There might be a few electrons moving about, but no organized flow and, thus, no current.***

1b) The two ends of the wire are connected together to form a complete circuit. Now is there a current flowing in the wire? *(1 point)*

***No. There is no voltage acting upon the electrons, so there is no flow, even though there is a complete circuit.***

***A wire is only a conductor . . . not a battery.***

1c) Given a 50-*amp* load and a conductor having 4.4-*ohm* resistance, what is the voltage? *(2 points)*

***V = I  R***

*V = 50  4.4*

***V = 220 volts***

1d) Given 440 *volts* and a conductor with 3.2-*ohm* resistance, what is the amperage? *(2 points)*

***I = V ÷ R***

*I = 440 ÷ 3.2*

***I = 137.5 amps***

1e) Given 120 *volts* and a 10-*amp* load, what is the resistance of the conductor? *(2 points)*

***R = V ÷ I***

*R = 120 ÷ 10*

***R = 12 ohms***

1f) A filament of a flashlight bulb has a resistance of 50 *ohms* and should be used with a current of 0.03 *amps*. What volt battery is needed? *(2 points)*

***V = I  R***

*V = 0.03  50*

***V = 1.5 volts***

1g) A 3-*volt* battery is used with a flashlight bulb having a resistance of 100 *ohms*. How much current is flowing when the bulb is lit? *(2 points)*

***I = V ÷ R***

*I = 3 ÷ 100*

***I = 0.03 amps***

1h) A 4.5-*volt* battery is used to produce a 0.3-*amp* current in a flashlight bulb. What is the resistance of the light bulb filament? *(2 points)*

***R = V ÷ I***

*R = 4.5 ÷ 0.3*

***R = 15 ohms***

**Part II: Units of Electrical Power and Energy**

Electric heaters are designed around high resistance conductors that convert electric energy into heat energy. If a 120-*volt* portable heater with a 10-*ohm* resistance is plugged in and turned on the highest setting.

2a) What is the current flowing through it? *(2 points)*

***I = V / R***

*I =* 120 *volts* / 10 *ohms*

***I =* 12 *amps***

2b) What is the power rating of this heater? *(2 points)*

***P = V2 / R******P = V  I***

*P =* 1202 *volts* / 10 *ohms* *P =* 120 *volts*  12 *amps*

*P =* 14400 *volts* / 10 *ohms* ***P =* 1440 w*atts***

***P =* 1440 *watts***

2c) How much energy is consumed if this heater is left on for 8 hours? *(2 points)*

***E = P  time***

*E =* 1440 *watts*  8 *hours*

***E =* 11520 *Wh* (11.5 *kWh*)**

A toaster operates at 120 *volts* and is rated at 800 *watts*.

2d) What is the resistance of the toaster element? *(2 points)*

***R = V2 / P***

*R =* 1202 *volts* / 800 *watts*

*R =* 14400 / 800

***R =* 18 *ohms***

2e) What is the current flowing through it? *(2 points)*

***I = V / R******I = P / V***

*I =* 120 *volts* */* 18 *ohms* *I =* 800 *watts /* 120 *volts*

***I =* 6.7 *amps******I = 6.7 amps***

Consider the following bathroom on a 120-*volt*, 20-*amp* circuit (i.e., the bathroom circuit is protected by a 20-*amp* breaker to prevent overheating of the wires and damage to fixtures). The homeowner enters the bathroom and turns on the 100-*watt* light, an 850-*watt* heater, and a 400-*watt* ventilation fan. After showering, the person plugs in an 1100-*watt* blow-dryer.

2f) Calculate the individual current (amperage) drawn by each item *(4 points)*

*I = P / V* *I = P / V* *I = P / V* *I = P / V*

*I =* 100 *watts*/120 *volts* *I =* 850 *watts*/120 *volts* *I =* 400 *watts*/120 *volts* *I =* 1100*watts* /120 *volts*

***I =* 0.83 *amps*** ***I =* 7.08 *amps******I =* 3.33 *amps*** ***I =* 9.17 *amps***

2g) Is the bathroom circuit overloaded? *(2 points)*

***Yes, barely.***

***Total = 20.4 amps***

**Part III: Electric Power Transmission**

Wanapum Dam on the Columbia River generates 1100 *MW* (1,100,000,000 watts) of power consisting of a current of 40,741 *amps* at 27,000 *volts*. As was seen in previous calculations, electric power is transmitted better (i.e., with less loss) if the size of the conductor is increased and if the voltage is higher. To transmit its load more efficiently, the power generated at Wanapum Dam is stepped-up to 230 *kV* (230,000 *volts*) before being sent down a 7.62-*cm* (3-*in*) ACSR overhead power line to Seattle 225 *km* (140 *mi*) away.

3a) What is the current (in *amps*) in the transmission lines? *(2 points)*

***I = P ÷ V***

*I = 1,100,000,000 watts ÷300volts*

***I = 4783 amps***

3b) What is the ratio of wraps between the primary coil and secondary coil in the step-up transformer?

 *(2 points)*

***II° voltage ÷ I° voltage = # turns in II° coil ÷ # turns in I° coil***

*230,000 volts ÷ 27,000 volts = # turns in II° coil ÷ # turns in I° coil*

***1 to 8.5 (8.5 to 1)***

3c) When the electric power arrives near its destination, it is routed through a sub-station where the voltage is stepped-down to 14,400 *volts* for local distribution. What is the ratio of wraps between the primary coil and secondary coil in the step-down transformer? *(2 points)*

***I° voltage ÷ II° voltage = # turns in I° coil ÷ # turns in II° coil***

*230,000 volts ÷ 14,400 volts = # turns in I° coil ÷ # turns in II° coil*

***16 to 1 (1 to 16)***

3d) Prior to being sent into a home, the electric power is again passed through a transformer (typically on a power pole adjacent to the home), where the voltage is stepped-down to 240 *volts*. What is the ratio of wraps between the primary coil and the secondary coil in the step-down transformer? *(2 points)*

***I° voltage ÷ II° voltage = # turns in I° coil ÷ # turns in II° coil***

*14,400 volts ÷ 240 volts = # turns in I° coil ÷ # turns in II° coil*

***60 to 1 (1 to 60)***

During a winter power outage, a homeowner connects a 6,000 *watt* generator and feeds 240 *volts* into their breaker panel.

3e) How many *amps* of current are flowing into the breaker panel? *(2 points)*

***I = P ÷ V***

*I = 6,000 watts ÷40volts*

***I = 25 amps***

In response to the power outage, linemen begin working to repair breaks in the power lines. Since the power is out in the neighborhood, the linemen assume there is no power in the lines they are handling. Unfortunately, the homeowner forgot to flip the main feed breaker when they hooked up the generator. As a result, power from the generator is back-feeding through the transformer outside the house and into these same power lines.

3f) What voltage are the workers exposed to? *(2 points)*

***ratio of I° to II° coils is 60 to 1***

***240 volts  60 = ~14,400 volts***

3g) What current are the workers exposed to? *(2 points)*

***ratio of I° to II° coils is 63.6 to 1***

***25 amps ÷ 60 = ~0.42 amps***

3h) Could this current be lethal to the linemen? Describe how. *(5 points)*

***Yes, it could well prove lethal.***

***At around 10 milliamperes, AC current passing through the arm of a person can cause powerful muscle contractions.***

***The victim is then unable to voluntarily control muscles and cannot release an electrified object.***

***A sustained shock from AC at 120 volts (60 Hz) is an especially dangerous source of ventricular fibrillation because it usually exceeds the let-go threshold, while not delivering enough initial energy to propel the person away from the source.***

***With voltages over 200-volts, dielectric breakdown of the skin occurs, lowering its impedance.***

***The voltage and current in the example are far high enough to induce ventricular fibrillation, which, if untreated, can be fatal.***

***In addition, potentially lethal consequences could involve falls from elevation.***