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

**HOMEWORK #4**

**INDIVIDUAL MEASUREMENT OF SOUND**

**Name: KEY *73 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, define each variable in the formula, show steps of your calculations).

**Part I: Calculation of Sound Power Level**

Calculate the sound power level (*W0*) (in *dB*) for each of the following sound powers (*W*): 10, 20, 40, and 80 watts.

***10 watts*** *(5 points)*

Formula:

where: ***W = sound power (in watts)***

 ***W0 = reference power (10-12 watts)***

 ***log10 = a logarithm to the base 10***

Calculations:

***20 watts*** *(5 points)*

Formula:

where: ***W = sound power (in watts)***

 ***W0 = reference power (10-12 watts)***

 ***log10 = a logarithm to the base 10***

Calculations:

***40 watts*** *(5 points)*

Formula:

where: ***W = sound power (in watts)***

 ***W0 = reference power (10-12 watts)***

 ***log10 = a logarithm to the base 10***

Calculations:

***80 watts*** *(5 points)*

Formula:

where: ***W = sound power (in watts)***

 ***W0 = reference power (10-12 watts)***

 ***log10 = a logarithm to the base 10***

Calculations:

Notice that each of the values given represents a doubling in power output from the previous value (e.g., 10, 20, 40, 80).

What is the relationship in sound power levels (*LW*) and decibels (*dB*) based on your calculations?

*When the sound power is doubled, the sound power level increases by* ***3*** *dB.**(1 point)*

**Part II: Calculation of Sound Pressure Level**

Calculate the sound pressure level (*Lp*) (in *dB*) for each of the following sound pressures: 2000, 4000, 8000, and 16000 *μPa*.

***2000 μPa*** *(4 points)*

Formula:

where: ***p = measured Root-Mean-Square (RMS) sound pressure (in μPa)***

 ***p0 = reference RMS sound pressure (20 μPa)***

Calculations:

***4000 μPa*** *(4 points)*

Formula:

where: ***p = measured Root-Mean-Square (RMS) sound pressure (in μPa)***

 ***p0 = reference RMS sound pressure (20 μPa)***

Calculations:

***8000 μPa*** *(4 points)*

Formula:

where: ***p = measured Root-Mean-Square (RMS) sound pressure (in μPa)***

 ***p0 = reference RMS sound pressure (20 μPa)***

Calculations:

***16000 μPa*** *(4 points)*

Formula:

where: ***p = measured Root-Mean-Square (RMS) sound pressure (in μPa)***

 ***p0 = reference RMS sound pressure (20 μPa)***

Calculations:

Notice that each of the values given represents a doubling from the previous value (e.g., 2000, 4000, 8000, 16000).

What is the relationship in sound pressure levels (*L0*) and decibels (*dB*) based on your calculations?

*When the sound pressure is doubled, the sound pressure level increases by* ***6*** *dB.**(1 point)*

**Part III: Calculation of Sound Intensity Level**

Given a source radiating a sound pressure level of 96 *dB* measured at a distance of 2 meters from the source, calculate the sound pressure level (*Lp*) (in *dB*) at each of the following distances from the source: 5, 10, 20, and 40 meters.

***5 m*** *(5 points)*

Formula:

where: ***LP1 = sound pressure level at location of first measurement (in dB)***

 ***r1 = location of first measurement (in meters)***

 ***r2 = location of second measurement (in meters)***

Calculations:

***10 m*** *(5 points)*

Formula:

where: ***LP1 = sound pressure level at location of first measurement (in dB)***

 ***r1 = location of first measurement (in meters)***

 ***r2 = location of second measurement (in meters)***

Calculations:

***20 m*** *(5 points)*

Formula:

where: ***LP1 = sound pressure level at location of first measurement (in dB)***

 ***r1 = location of first measurement (in meters)***

 ***r2 = location of second measurement (in meters)***

Calculations:

***40 m*** *(5 points)*

Formula:

where: ***LP1 = sound pressure level at location of first measurement (in dB)***

 ***r1 = location of first measurement (in meters)***

 ***r2 = location of second measurement (in meters)***

Calculations:

Notice that each of the values given represents a doubling from the previous value (e.g., 5, 10, 20, 40).

What is the relationship between distance from the source and decibels (*dB*) based on your calculations?

*When the distance from a sound source is doubled, the sound pressure is decreased by* ***6*** *dB.**(1 pt.)*

**Part IVa: Assessing Multiple Sound Power Emissions**

A workplace has three pieces of equipment in operation each of which individually radiates sound power levels of *LW1* = 87 *dB*, *LW2* = 112 *dB*, and *LW3* = 93 *dB*.

What is the resultant combined sound power level *LW(total)* (in *dB*) if all three devices operate concurrently?

Formula: *(1 point)*

 or

1) Calculation of the individual sound powers (*W1, W2, and W3*) of the devices.*(3 points)*

 ***5.01  108 1.58  1011 1.99  109***

2) Addition of the individual sound powers (*W1 + W2 + W3*) of the devices.*(1 point)*

 ***1.61  1011***

3) Use of the new ‘combined sound power’ value to calculate the resultant sound power output (in *dB*).

*(2 points)*

Formula:

Calculation:

 ***dB***

**Part IVb: Assessing Multiple Sound Pressure Emissions**

When measured in isolation from the same location, the sound pressure level of each of three noise sources are: *LP1* = 83 *dB*; *LP2* = 96 *dB*; and *LP3* = 68 *dB*.

What will the sound pressure level (*LP(total)*) be if all three sources run simultaneously?

Formula: *(1 point)*

 or

1) Calculation of individual sound pressures (*P1, P2, and P3*) of the devices. *(3 points)*

 ***2.00  108 3.98  109 6.31  106***

2) Addition of the individual sound pressures (*P1 + P2 + P3*) of the devices.*(1 point)*

 ***4.19  109***

3) Use of the new ‘combined sound pressure’ value to calculate the resultant sound pressure output (in *dB*).*(2 points)*

Formula:

Calculation: