APPENDIX E
Workplace Scenarios

Three workplace scenarios were generated by the Conference working groups of employers, mathematics educators, and STEM instructors representing each of the Conference domains: biotechnology, information and communication technology, and manufacturing technology.

CONTENTS

Biotechnology Workplace Scenario

ELISA
(Enzyme-Linked ImmunoSorbent Assay)

Background

Quantitative assays, such as the Enzyme-Linked ImmunoSorbent Assay (ELISA), are designed to measure the amount of a specific molecule present in a sample. Antibodies are the key component of the ELISA. Millions of different antibodies are available to the research community. Each antibody will only recognize and detect a specific target. The target detected by an antibody is known as its antigen. The flexibility and specificity of these assays allow scientists track molecules that would be otherwise difficult to trace. Medical practitioners commonly diagnose disorders by using ELISAs to detect pathogens or discreet substances in blood or other body fluids.

The following scenario concerns an ELISA that is used to determine the level of parathyroid hormone (PTH) in blood samples. In patients suffering from parathyroid disorder, parathyroid glands produce too much PTH, resulting to a calcium imbalance which may lead to bone loss and kidney malfunction. This disorder can be treated surgically by removing one or more of the parathyroid glands. It is critical that a person be diagnosed correctly: a person whose hormone levels are normal should not be mistakenly subjected to surgery and a person whose hormone levels are abnormal should not be left untreated.

Typically, an ELISA is performed in a 96-well plate (Figure 1). A 96-well plate is a plastic holder that contains 96 tiny test tubes, called “wells.” The plastic used to manufacture the plate is designed so that antibodies and other proteins stick to it tightly. For the PTH ELISA, antibodies against PTH (the antigen) are manufactured by specialized companies. These antibody molecules are coated onto the bottom surfaces of the wells. A single well that is coated with antibody against PTH is illustrated in Figure 2A. When an assay is performed, wells are filled with samples prepared from patients’ blood. If PTH is present in a sample, it binds to the antibodies on the bottom of the wells. Once the PTH has bound, the wells are rinsed with washing solution. PTH complexed with antibody will remain stuck to the bottom of the well while other substances are washed away, Figure 2B. At this point, the PTH-antibody complex is invisible. To allow for PTH-antibody complex detection, a substance is added which will form a color only in the presence of the PTH-antibody complex. The more PTH in the well, the more intense the color that develops, Figure 2C. Finally, the plate is put into an instrument called a *plate reader*, which detects and quantifies how much color is present in each well.

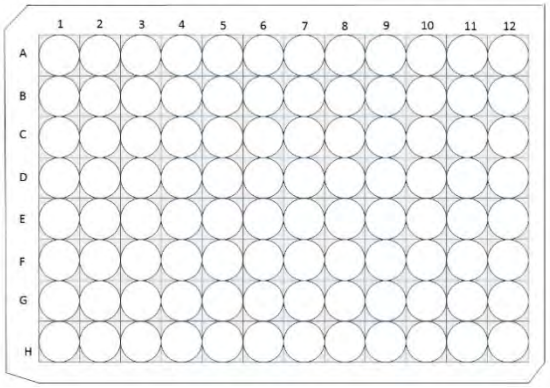

Figure 1. Top View of a 96-Well Plate

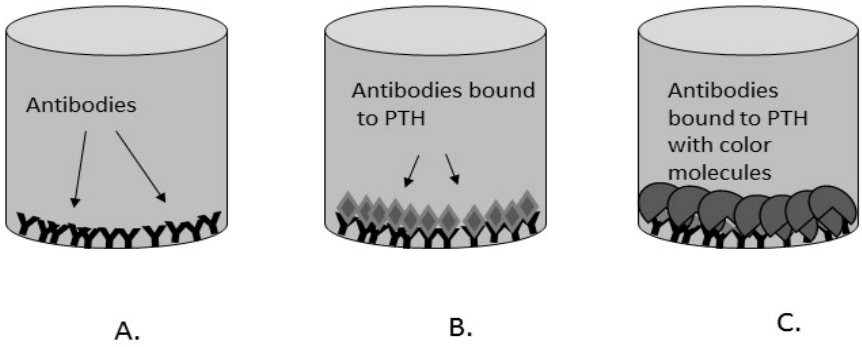

Figure 2. ELISA

2A. Closer view of a single well from a 96-well plate that has been coated with antibody against the PTH hormone
2B. The antigen, PTH, which was present in a sample has bound specifically to the coated antibody
2C. A series of steps were performed resulting in a colored deposit

Recall that this PTH ELISA is *quantitative*, which means it detects not only the presence of PTH, but also *how much* of it is present. It is necessary to understand the concept of a standard curve in order to understand the conduct of a quantitative ELISA. A standard curve is a graph of the relationship between the amount or concentration of a material of interest and the response of an assay. To construct a standard curve for an ELISA assay, the following steps are performed:

Step 1: A series of standards with known levels of the material of interest (in this case, PTH) are prepared by dissolving the material in a water-based solution.
Step 2: A specific volume of each standard is added to its own well of the 96-well plate.
Step 3: The PTH in each standard binds to the antibody that was previously coated on the bottom of the well.
Step 4: The wells are washed to remove extraneous materials, leaving behind the antibody-standard complex.
Step 5: Steps are performed to make the complex colored.

Step 6: The 96-well plate is put into the plate reader, which provides a reading for each well. This reading is proportional to the amount of color in that well. The greater the amount of PTH in the standard, the greater the amount of color is produced and the higher the reading.

Step 7: The resulting readings are plotted on a graph with the concentration of PTH on the X axis and the instrument's reading on the Y axis.

Step 8: The points are connected into a line. This line shows the relationship between the quantity of PTH present and the response of the plate reader. Based on this relationship, it is possible to determine the concentration of PTH in patient samples.

In addition to the standards described above, it is also important to have *controls t*hat indicate whether or not the assay is working properly. *Positive* (**+**) *controls* contain a known level of the material of interest; *negative* (**-**) *controls* contain no such material. If the assay is working properly, it will provide correct values for the positive controls and will not detect any substance of interest in the negative controls. Hence, in this PTH assay, the positive controls contain known levels of hormone; the negative controls, no hormone.

Scenario Example 1

Figure 3 shows a diagram of an ELISA plate that is set up to conduct a PTH ELISA of samples from 3 patients:

- Columns 1 and 2 contain the standards that are used to create the standard curve. Each standard was prepared in duplicate (twice). Thus, the standards in column 1 and column 2 are of the same concentration.
- Columns 3 and 4 contain **+** control samples in replicate. (The negative control is considered to be the same as the first standard, which contains no PTH.)
- Columns 5 and 6 contain patient samples, also in replicate.

	1	2	3	4	5	6	7	8	9	10	11	12
A	Standard 0 ρg/mL	Standard 0 ρg/mL	+ Control 1 30 ρg/mL	+ Control 1 30 ρg/mL	Patient 1	Patient 1 Replicate						
B	Standard 20 ρg/mL	Standard 20 ρg/mL	+ Control 1 60 ρg/mL	+ Control 1 60 ρg/mL	Patient 2	Patient 2 Replicate						
C	Standard 40 ρg/mL	Standard 40 ρg/mL	Control 2 100 ρg/mL	Control 2 100 ρg/mL	Patient 3	Patient 3 Replicate						
D	Standard 80 ρg/mL	Standard 80 ρg/mL										
E	Standard 100 ρg/mL	Standard 100 ρg/mL										
F	Standard 200 ρg/mL	Standard 200 ρg/mL										
G												
H												

Figure 3. Arrangement of Standards, Samples, and Controls in a 96-Well Plate

The assay is performed, and the plate is put into the plate reader. The measured value for each well is shown in Figure 4. The units of measurement are called *AU* (absorbance units). For our purposes, it is not important to discuss the derivation of these units.

	1	2	3	4	5	6	7	8	9	10	11	12
A	0.004	0.001	0.239	0.242	0.550	0.546						
B	0.161	0.153	0.481	0.479	1.344	1.400						
C	0.310	0.311	0.801	0.799	0.037	0.028						
D	0.623	0.626										
E	0.785	0.783										
F	1.569	1.566										
G												
H												

Figure 4. Plate Reader Values for the Standards, Samples, and Controls in the 96-Well Plate Illustrated in Figure 3

The task is to analyze these results. To do so, perform the following steps.

Step 1. Construct a standard curve based on the values for the standards:

- Average the two plate reader values for each standard.
- Prepare a graph with the value of the standard on the X axis and the average plate reader measurements on the Y axis.
- Do the points appear to lie on a single line? If they form a line, connect them into a line. This is the standard curve. If the points appear scattered, consult a supervisor.
- Be sure to label the axes and give the graph a title.

Step 2. Evaluate the results for the positive and negative controls:

- Use the replicate standard with 0 ρg/mL of PTH as the negative control. Average the replicate readings.
- Average the replicate values for the **+** controls.
- Use the standard curve to determine the concentration of PTH in the **+** controls.

The values for the controls should make sense, that is, the plate reader value for the 0 ρg/mL should be zero. Note, however, that there is some noise in readings and the value may be close to, but not exactly, zero. Similarly, the values for the three **+** controls must lie in a particular range. Assume that makers of this ELISA kit specify that the value for the negative control must be in the range of 0 – 3 ρg/mL. The value for the first **+** control must be in the range of 27-33 ρg/mL, the second **+** control must be in the range of 57-63 ρg/mL, and the third **+** control must be in the range of 97-103 ρg/mL.

If the positive and negative controls do not lie in the specified range, DO NOT PROCEED with patient sample analysis but consult your supervisor.

Step 3. If the **+** and **–** controls values are in the specified ranges, then evaluate the patient samples:

- Average the replicate values.
- Use the standard curve to determine the PTH value in each patient sample. Assume that it has been determined, based on previous analysis of many patients, that the normal range for PTH values in this ELISA should be between 23 and 90 ρg/mL.
- Based on this information, evaluate whether each patient's values are in the normal range.

Scenario Example 2

Figures 5 and 6 provide another example with more patient samples. Analyze these results as was previously described.

	1	2	3	4	5	6	7	8	9	10	11	12
A	Standard 0 ρg/mL	Standard 0 ρg/mL	+ Control 1 25 ρg/mL	+ Control 1 25 ρg/mL	Patient 4	Patient 4 Replicate						
B	Standard 30 ρg/mL	Standard 30 ρg/mL	+ Control 1 50 ρg/mL	+ Control 1 50 ρg/mL	Patient 5	Patient 5 Replicate						
C	Standard 50 ρg/mL	Standard 50 ρg/mL	Control 2 100 ρg/mL	Control 2 100 ρg/mL	Patient 6	Patient 6 Replicate						
D	Standard 80 ρg/mL	Standard 80 ρg/mL										
E	Standard 100 ρg/mL	Standard 100 ρg/mL										
F	Standard 200 ρg/mL	Standard 200 ρg/mL										
G												
H												

Figure 5. Scenario Example 2: Arrangement of Standards, Samples, and Controls in a 96-Well Plate

	1	2	3	4	5	6	7	8	9	10	11	12
A	0.002	0.004	0.988	0.978	0.601	0.603						
B	0.901	0.906	1.505	1.500	1.450	1.440						
C	1.503	1.499	1.861	1.782	2.103	2.098						
D	2.403	2.402										
E	2.891	2.789										
F	2.931	3.102										
G												
H												

Figure 6. Plate Reader Values for the Standards, Samples, and Controls in the 96-Well Plate Illustrated in Figure 5

Answers to Scenario Example 1

	1	2	**Average of values in columns 1 and 2. These values are used to construct the standard curve.**	3	4	**Average of values in columns 3 and 4**	5	6	**Average of values in columns 5 and 6**
A	0.004	0.001	**0.003**	0.239	0.242	**0.241**	0.550	0.546	**0.548**
B	0.161	0.153	**0.157**	0.481	0.479	**0.480**	1.344	1.400	**1.372**
C	0.310	0.311	**0.311**	0.801	0.799	**0.800**	0.037	0.028	**0.325**
D	0.623	0.626	**0.625**						
E	0.785	0.783	**0.784**						
F	1.569	1.566	**1.568**						

Figure 7. Averaged Values for the Replicates Using the Plate Reader Measurements Shown in Figure 4

The averages of columns 1 and 2 are used to construct the standard curve shown in Figure 8 below. The averages of columns 3 and 4 are the controls used to evaluate whether the assay was working properly. The averages of columns 5 and 6 are the patient samples.

Figure 8 shows the standard curve for this scenario: the points all lie close to a best fit line. The line is straight and does not plateau. The line runs through zero. So, the points appear to form a reasonable standard curve.

It is possible to determine the concentration of PTH in the controls and the patient samples in two ways:

1. The concentrations can be read off the graph, as illustrated in Figure 8. A line is drawn from the sample's average plate reader value on the Y axis to the best fit line. For the first **+** control, that averaged value is 0.480 AU. Then another line is drawn from the intersection with the best fit line to the X axis, as shown. The result is 62 ρg/mL. For the 100 ρg/mL control, a similar procedure yields a value of 102 ρg/mL.

2. Alternatively, the equation for the trend line on the graph can be calculated or read from Excel and the values for Y can be plugged into the equation. We can then solve for X, which is the concentration of PTH. It is sometimes difficult to read values precisely off a graph, so the algebraic method may be more accurate.

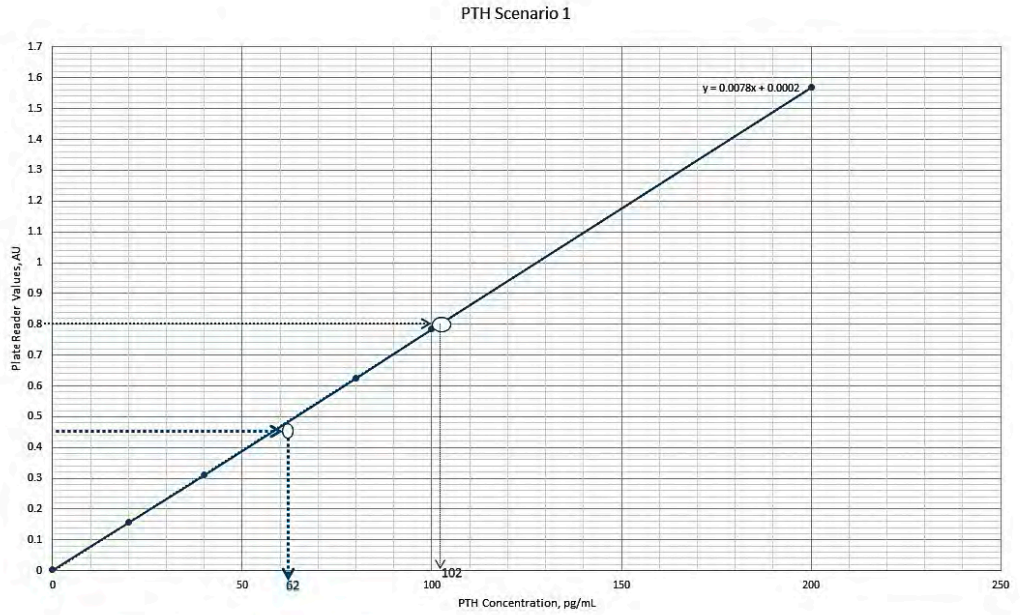

Figure 8. Results from Scenario Example 1

Excel was used to graph the best fit line for the standard curve data. (Before graphing, the values of each of the two replicates were averaged.) The best fit line was then used to find the values for the positive controls.

Algebraic Method:

The equation for the best fit line from Excel is Y = 0.0078X + 0.0002

Plugging in the average plate reader value for the 30 pg/mL **+** control, that is 0.241 AU, yields:

0.241 = 0.0078X + 0.0002

X=30.87 pg/mL

Plugging in the average plate reader value for the 60 pg/mL **+** control, that is 0.480 AU, yields:

0.480 = 0.0078X + 0.0002

X = 61.51 pg/mL

Plugging in the average plate reader value for the 100 pg/mL **+** control, that is 0.800 AU, yields:

0.800 = 0.0078X + 0.0002

X = 102.53 pg/mL

Analysis of controls: The values for the positive controls were calculated using both a graphical and algebraic method. The results of the two methods are consistent. All three **+** controls are within the specified range required. Therefore, it is possible to continue with analysis of the patient samples.

The replicates are averaged as shown in Figure 7, and the PTH concentration is calculated, in this case using the algebraic method:

Patient 1: *0.548 = 0.0078X + 0.0002*

X = 70.23 ρg/mL

Patient 2: *1.372 = 0.0078X + 0.0002*

X =175.64 ρg/mL

Patient 3: *0.325 = 0.0078X + 0.0002*

X = 41.64 ρg/mL

Based on these results, the PTH level of patient 2 appears to be abnormal. Further medical follow-up would likely be recommended for this patient. The other two patient PTH levels are in the normal range.

Answers to Scenario Example 2

1	2	**Average of values in columns 1 and 2. These values are used to construct the standard curve.**	3	4	**Average of values in columns 3 and 4**	5	6	**Average of values in columns 5 and 6**
0.002	0.004	**0.003**	0.988	0.978	**0.983**	0.601	0.603	**0.602**
0.901	0.906	**0.904**	1.505	1.500	**1.503**	1.450	1.440	**1.445**
1.503	1.499	**1.551**	1.861	1.782	**1.822**	2.103	2.098	**2.101**
2.403	2.402	**2.403**						
2.891	2.789	**2.840**						
2.931	3.102	**3.017**						

Figure 9. Averaged Values for the Replicates Using the Plate Reader Measurements Shown in Figure 4

The averages of columns 1 and 2 are used to construct the standard curve shown in Figure 9. The averages of columns 3 and 4 are the controls used to evaluate whether the assay was working properly. The averages of columns 5 and 6 are the patient samples.

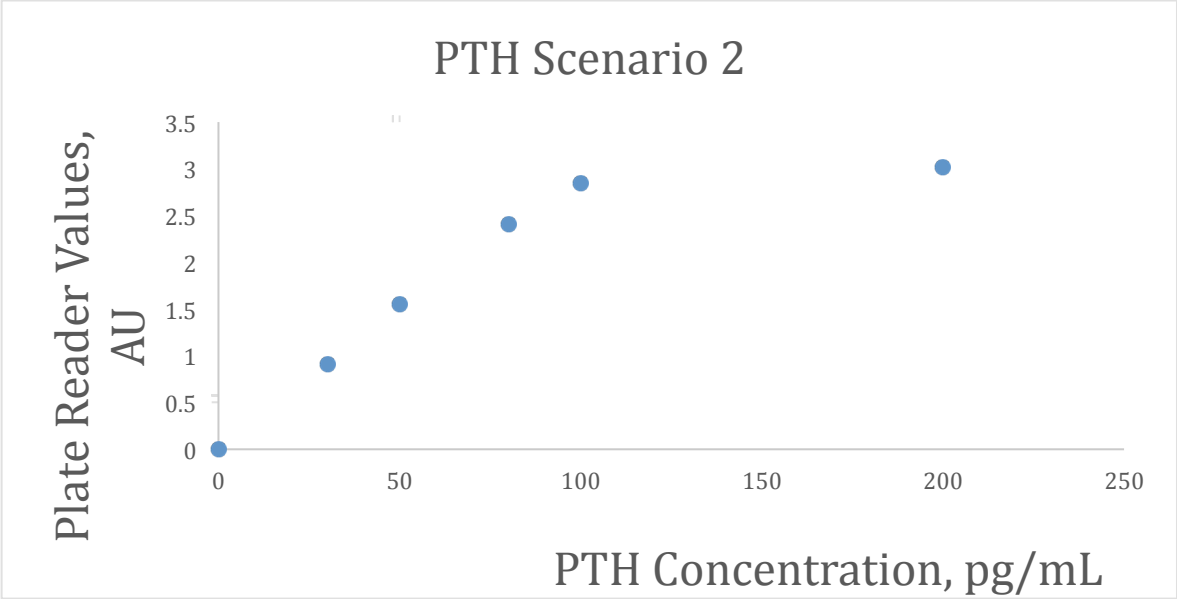

Figure 10. Results from Scenario Example 2

EXCEL was used to graph the best fit line for the standard curve data. (Before graphing, the values of each of the two replicates were averaged.) Observe that the graph plateaus at higher concentrations.

The standard curve plateaus at higher PTH concentrations.* There are various reasons why this might occur, but, whatever the reason, the results of this assay are not valid. Observe that the second **+** control, 100 ρg/mL, should have yielded a reading twice that of the 50 ρg/mL **+** control. It does not, for reasons that are unclear. We know that if the standard curve and the controls do not provide the right results, then the assay is invalid. Do not bother to evaluate the patient samples. In a workplace, the analyst might consult with a supervisor.

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* There are situations where assays are known to be inaccurate at higher and/or lower levels of analyzed material. In these cases, the reporting range of the standard curve might be reduced to exclude the areas of inaccuracy. The positive controls would be used to establish the accurate, reporting range. In such cases, patient samples that yield values outside the reporting range would need to be retested or tested using another method.

Information and Communication Technology Workplace Scenario

Tech Park Managed Wireless LAN Infrastructure

PART 1 - General

A. The Tech Park Group is seeking proposals for the development and installation of a centrally managed wireless local area network (LAN) system to support office computers, guest computers, laboratory equipment, and wireless mobile devices.
B. Blueprints with building specifications will be provided.
C. Proposals are due no later than 5 days from opening this RFP.
D. No proposals will be accepted after the due date and time specified. No changes will be allowed to any proposal without penalty.
E. Questions may be directed to the Tech Park manager.

PART 2 - Summary of Work

Design, install, set up, and test a fully functioning managed wireless LAN to the owner's specifications:

A. A site survey that includes locations, signal strength, and RF channels for dual band access points (APs)
B. Wireless access points to support data connectivity for 100% coverage within the building and limited or no connectivity outside the building
C. Provision and installation of all equipment for a complete and operational system per project drawings and specifications
D. Network equipment that follows the requirements of the specifications and drawings and all current revisions of the 802.11n standard
E. A platform that will assist in the management, configuration, and maintenance of the wireless LAN
F. A system that supports roaming between APs. It is critical that roaming not complicate deployment or troubleshooting, compromise security, or necessitate multiple client logins and authentications
G. A system that supports WPA2-Personal and AES
H. A system that works with all client types

PART 3 - Site Survey

A. Plot the location of each AP to cover the room with the least number of devices.
B. All access points shall be properly labeled (AP-1, AP-2, AP-3, etc.).
C. All stations inside the building MUST have a RSSI of 0dBm through -50dBm (Fair rating).
D. All rooms need to accommodate no more than 30 users, except the auditorium, which must accommodate at least 60 users.
E. Using the formulas provided, determine the total gain required to cover the area.
F. Set the channel of each AP so it does not interfere with another AP.

G. Provide a document showing:
    1. The location of each AP
    2. Total transmitter gain
    3. Signal strength at each radius
    4. Transmitter channel

PART 4 - Setup, Identification, and Administration

Using your site survey document, locate and set up each access point with the following:

A. Location
    1. Choose the appropriate type of AP
    2. Choose the appropriate type of antenna
    3. Place in the room

B. Setup
    1. AP location/name (as appropriate)
    2. AP external (Internet) IP network:197.30.56.32 255.255.255.224 (APs get the first available addresses)
    3. AP external (Internet) default gateway address: 197.30.56.62
    4. AP external (Internet) DNS address: 151.164.1.7
    5. AP internal (private NAT) IP address: 192.168.15.1 255.255.255.0 (internal default gateway)
    6. All 100 devices to connect starting at IP: 192.168.15.25
    7. Enable DHCP

C. Wireless
    1. Allow N devices only (both 2.4 and 5 GHZ bands)
    2. AP channel (as appropriate) using standard 20 MHz channel width only
    3. SSID: ATEP
    4. Disable SSID broadcasting
    5. Standard WAP2-Personal AES passphrase/key: ATEP-Acce$$
    6. Enable AP Isolation

D. Security
    1. Enable stateful inspection (**dynamic packet filtering)**
    2. Allow FTP and TCP port 80 to be forwarded in and out of the router

E. Administration:
    1. Change the router password to ATEP123
    2. Allow only HTTPS to access the router via wireless
    3. Do not allow remote management

F. Confirm connectivity

PART 5 - Testing

A. All equipment shall be tested for proper operation and be fully functional on completion.
B. When setup is complete, press the Test configuration button.
C. Fix any problems found

PART 6 - Wireless Location Mapping

A. Use the building blueprint and the different radius maps to find the locations of the access points.
B. Each AP can accommodate 30 users.
C. Using the RF Math Formula document, find the RSSI at each radius taking into account any possible interference:
   - All outside walls are made of reinforced concrete with a brick face (25 dBm).
   - Inside walls around the Science Lab are made of reinforced concrete (22 dBm).
   - Other interior walls are made of wood and drywall (5 dBm).
   - Inside line-of-sight access with limited obstructions (2 dBm).
D. You will need to adjust both the 2.4 GHz and 5 GHz.
E. Using the power loss (RSSI) formula, find the signal strength at each radius:
   - Set the transmitter power
   - Set the transmitter gain
   - Set the wavelength
   - Set the interference (n)

   Note: The receiver gain and the receiver sensitivity are set and cannot be changed.

   Note: Receive levels (RSSI) must be less than -50dBm to meet specifications.
F. Set the channels so they do not interfere with other APs.
G. Complete the following chart for each access point:
   - APs location
   - APs total transmitter power
   - APs transmitter channel
   - RSSI inside the room (line-of-sight)
   - RSSI inside the building (outside room through interior wall)
   - RSSI outside building (outside exterior walls)

Access Point Chart

AP Number_____ Location:_____

APs IP Address: _____

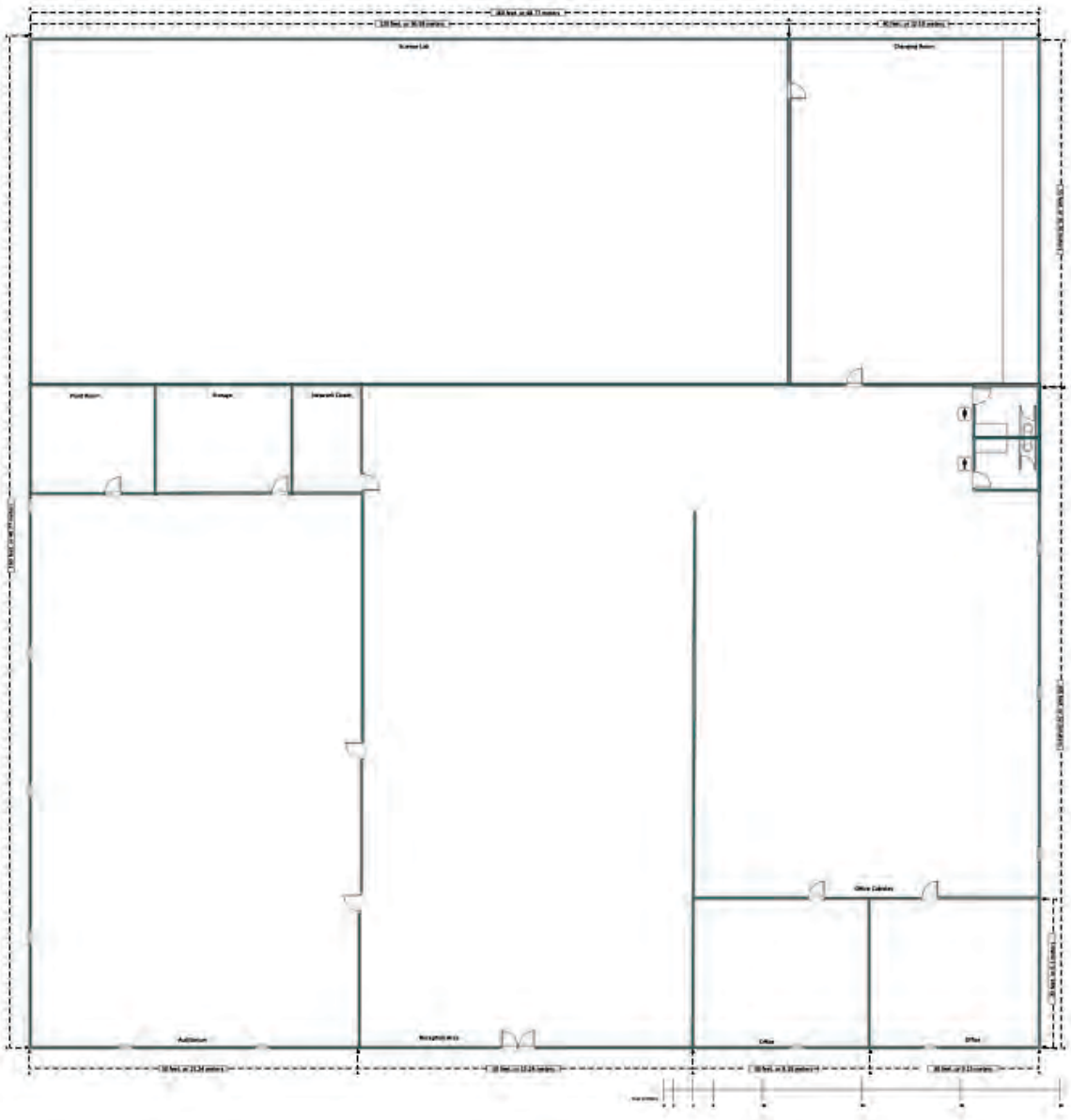
2.4GHz Total Transmitter Power: _____ Channel: _____

Inside Room	**Outside Room**	**Outside Building**
1m	1m	1m
3m	3m	3m
5m	5m	5m
10m	10m	10m
20m	20m	20m
30m	30m	30m
40m	40m	40m

5 GHz Total Transmitter Power: _____Channel:_____

Inside Room	**Outside Room**	**Outside Building**
1m	1m	1m
3m	3m	3m
5m	5m	5m
10m	10m	10m
20m	20m	20m
30m	30m	30m
40m	40m	40m

Floor Layout



Reference Materials

$$RSSI(P_R) = P_T + G_T + G_R - (20log_{10}\left(\frac{\lambda}{4\pi}\right) - 10n(10log_{10}d)))$$

Constant of 3

$\lambda = c/(f * 1000000000)$

Frequency	Wavelength
2.4 GHz	0.125
5 GHz	0.06

Path Loss (dB) *n*

Material	Loss
Free Space or Cubical	2dB
Drywall	4dB
Window or Glass Door	3dB
Metal Door	8dB
Brick, Concrete or Block	15dB
Reinforced Concrete	22dB

Formula Key	
P_T	Power at the Transmitter (dBm) (Intentional Radiator)
P_R	Power at the Receiver (dBm)
G_T	Antenna Gain of the Transmitter (dBi)
G_R	Antenna Gain of the Receiver (dBi)
c	The Speed of Light (299,792,458 meters per second)
f	Frequency of RF (2.4GHz or 5 GHz)
λ	Wavelength (speed of light/frequency)
d	Distance (Meters)
π	Pie – Ratio of a Circle's Circumference to its Diameter (approximately 3.14)
r	Radius (Meters)

Signal Strength	RSSI	Bandwidth
Excellent 100%	0 thru -15	54 Mb
Good 75%	-16 thru -30	54 Mb
Fair 50%	-31 thur -50	48 Mb
Poor 25%	-51 thur -70	24 Mb
Minimal 10%	-71 thur -89	11 Mb
Over Limit	Over -89	0 Mb

Math Formulas

Link Loss Budget (RSSI)

Transmitter Gain (dBm)

#N/A

Maximum of 36dBm or 4watts

Total Power (EIRP)

#N/A

Antenna Gain (dBm)

#N/A

Receiver Gain (dBi) Constant

3

Wavelength (M)

#N/A

Distance (M)

10

n Obstructions

Receiver Sensitivity

-89

Receiver Power (dBm)

#N/A	1m
#N/A	3m
#N/A	5m
#N/A	10m
#N/A	20m
#N/A	30m
#N/A	40m
#N/A	50m
#N/A	60m
#N/A	70m
#N/A	80m

SNR (0 - 120dB)

Path Loss (dB)

#N/A

Link Margin (dB)

#N/A

Power Loss Formulas

$$P_R = P_T + G_T + G_R + L$$

Typical Throughput Rates

Signal Strength*	RSSI*	Throughput*
Excellent 100%	0 – -15	54 Mbps
Good 90%	-16 – -30	54 Mbps
Fair 50%	-31 – -50	24 Mbps
Poor 25%	-51 – -70	11 Mbps
Minimal 10%	-71 – -89	5 Mbps
Over Limit	>-89	Signal Lost

*Estimates Only

$$SNR = 20 \log_{10}(2^n)$$

$$L = 20 \log\left(\frac{\lambda}{4\pi}\right) - (10n(\log_{10} d))$$

$$P_T + G_T - Receiver\ Sensativity - PathLoss$$

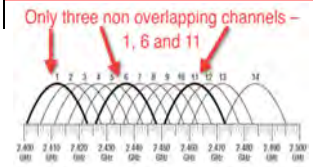
Radio Frequency Obstructions

Type of Barrier	Interference Potential
Open Space	None (0-2dB*)
Wood (Walls, Doors)	Low (4dB*)
Dry Wall	Low (4dB*)
Office Partition	Low (3dB*)
Glass	Low (3dB*)
Cinder Block	Medium (10dB*)
Bricks	Medium (12dB*)
Marble	Medium (12dB*)
Concrete	High (15dB*)
Ceramic Tile	High (13dB*)
Metal	Very high (18dB*)
Mirrors	Very high (20dB*)
Elevators	Very high (22dB*)
Reinforced Concrete	Very high (22dB*)

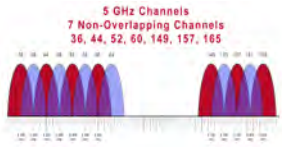
* Approximate values

Channels

2.4 GHz: 1, 6, 11



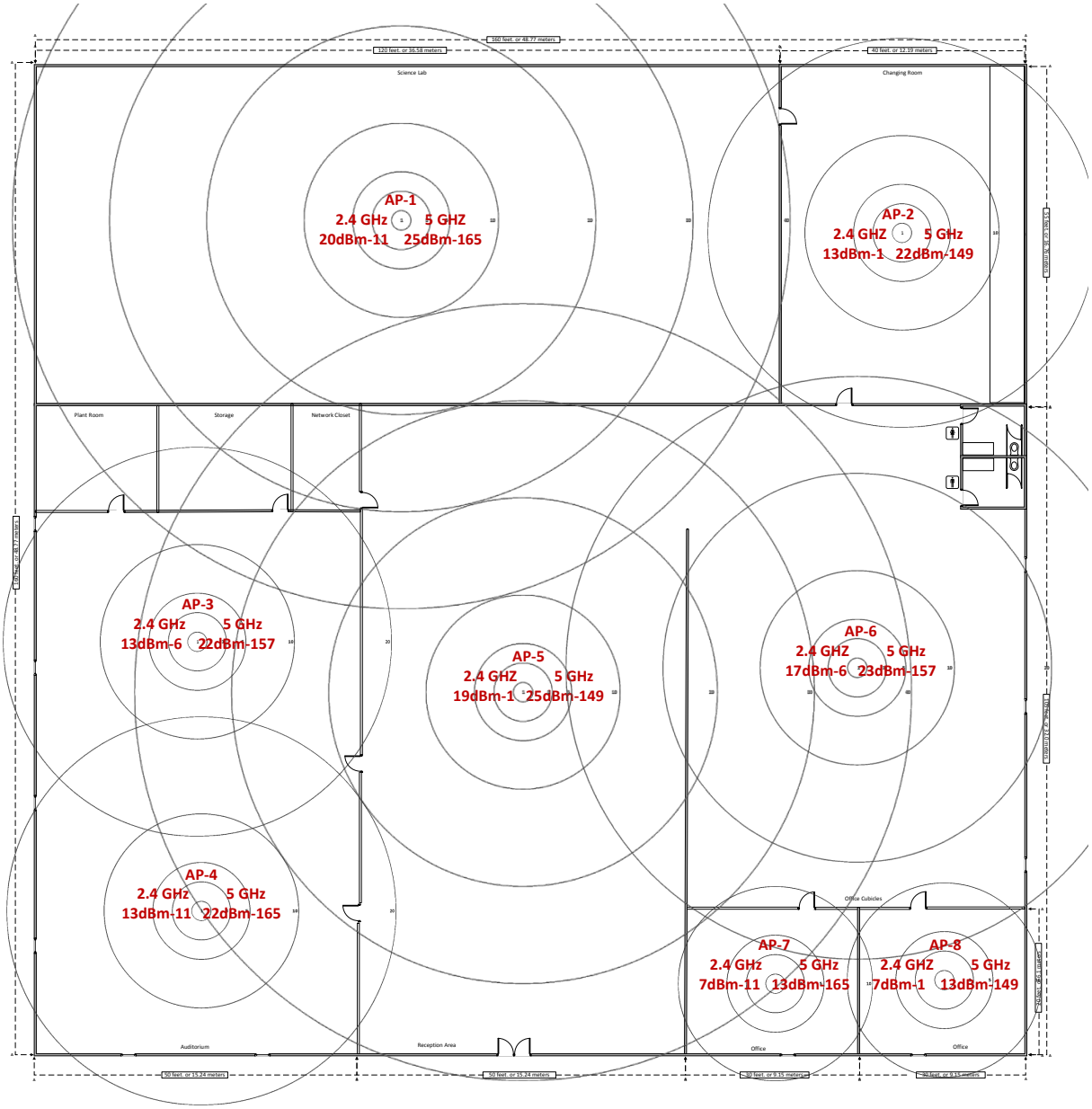
5 GHZ: 36, 44, 52, 60, 149, 157, 165



Formula Key

P_T	Power at the Transmitter (dBm) (Intentional Radiator)
P_R	Power at the Receiver (dBm)
G_T	Antenna Gain of the Transmitter (dBi)
G_R	Antenna Gain of the Receiver (dBi)
c	The Speed of Light (299,792,458 meters per second)
f	Frequency of RF (2.4GHz or 5 GHz)
λ	Wavelength (speed of light/frequency)
d	Distance (Meters)
π	Pi – Ratio of a Circle's Circumference to its Diameter (approximately 3.14)
r	Radius (Meters)
A	Area of Coverage (Meters)
n	Indicates the degree of loss as normally encountered in that environment
L	Path loss between two isotropic antennas in free space (dB)

Access Point Locations



Manufacturing Technology Workplace Scenario

Bid for an MPH Manufacturing Order

CBI is a leading full-service cut-to-size metal service company providing rectangular blocks for use in machining aluminum parts. CBI orders 4 feet by 12 feet rectangular aluminum plates 2 inches thick from a mill and cuts them into rectangular blocks according to customer specifications, to be subsequently milled into products for the aerospace industry. Your job as a technical sales representative is to develop bids for orders from companies like Boeing.

The Task

Develop a bid for an order to produce the blocks requested by MPH Manufacturing with the following finished dimensions:*

4 blocks	10¼" x 46½"
6 blocks	6" x 13"
16 blocks	11⅛" x 17"
3 blocks	3.7" x 14½"

- The plate costs $2.60 per pound. The density of aluminum is 3 gm/(cm^3).
- In order to reduce the machine and labor time turning a saw blade, each cut must go straight across the remaining plate.
- Each cut removes ¼" from the plate.
- Scrap pieces measuring 4 sq. ft. or more can be put into reserve; the customer must pay a restocking fee of $0.70 per pound.
- If the scrap pieces are less than 4 sq. ft., the material goes into the scrap bin, and the customer is charged for the waste.
- CBI charges 22% of all costs except the restocking fee to cover labor expenses, overhead, and profit.

Prepare a bid that gives CBI the best chance to obtain the order over other bids. The bid should be documented with the cost calculations and a diagram of the layout of the blocks on the plate.

* These figures are slightly revised by omitting a few pieces from the actual order.