Question 6

$$SINR = 10log_{10}\frac{P_{rx}}{N}$$

$$SINR = P_{rx}[dBm] - N[dBm]$$

$$P_{rx}[dBm] = SINR + N[dBm]$$

$$P_{rx}[dBm] = 20 + (-80) = -60dBm$$

Question 7

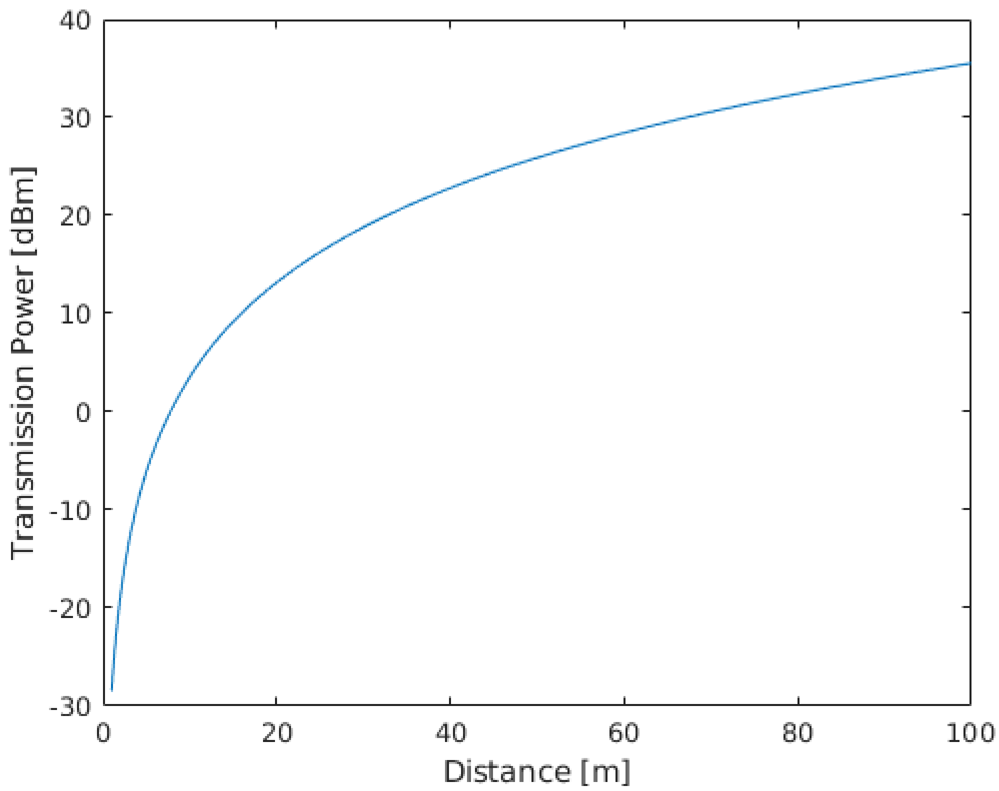
$$P_{rx,min}[dBm] = -60dBm$$

$$P_{tx,min}[dBm] + G_{tx}[dBi] + G_{rx}[dBi] + 20log_{10}(\frac{\lambda}{4\pi d_0}) + 10\gamma log_{10}\frac{d_0}{d} = -60dBm$$

$$P_{tx,min}[dBm] + 0 + 0 + 20log_{10}(\frac{\lambda}{4\pi d_0}) + 10\gamma log_{10}\frac{d_0}{d} = -60dBm$$

$$P_{tx,min}[dBm] = -60 - 20log_{10}(\frac{\lambda}{4\pi d_0}) - 10\gamma log_{10}\frac{d_0}{d}$$

```
c = physconst('LightSpeed');
f = 900 * 1e6;
Gamma = 3.2;
d0 = 1;
lambda = c / f;
power_f = @(d) -60 - 20*log10(lambda/(4*pi*d0)) - 10*Gamma*log10(d0./d);
d = 1:0.1:100;
ptx = power_f(d);
% plot the required transmission power as a function of the distance
% between a node and the BS.
plot(d, ptx);
ylabel('Transmission Power [dBm]')
xlabel('Distance [m]')
```



Question 8

```
d_node = 75;
p_tx_75 = power_f(d_node)
```

```
p_tx_75 = 31.5346
```

For the transmission power function, we can compute the minimum received power for a node at 75m needed to satisfy the BER requirement.

$P_{tx,75m} = P_{tx}(75m) = 31.53dBm > 10dBm$

We need more than 1 transmission for a message from a node at 75 m to reach the AP.

For a maximum transmission power of 10dBm, we can compute the max received distance from the function.

$$-60 - 20log_{10}(\frac{\lambda}{4\pi d_0}) - 10\gamma log_{10}\frac{d_0}{d} = 10$$

$$d_{10dBm,\ max} = 10^{\frac{7}{\gamma}+\frac{2}{\gamma}log_{10}\frac{\lambda}{4\pi}=15.93m}$$

$$N = \lceil\frac{75m}{d_{10dBm,\ max}}\rceil = 5$$

```
d_10dbm = 10^((7+2*log10(lambda/4/pi))/Gamma)
```

```
d_10dbm = 6.5910
```

```
n = ceil(75 / d_10dbm)
```

```
n = 12
ans = 15.9259
ans = 15.9259
```

Hence, we need 19 transmission.

Question 9

$t_{tx} = \frac{data}{data\ \ rate} = \frac{20 * 8bit}{3 \times 10^5 bit/s} = 5.33 \times 10^{-4} s$

$P_{tx}[dBm] = 10dBm \Leftrightarrow P_{tx} = 0.01W$

$E = P_{tx} t_{tx} N = 0.01W \times 5.33 \times 10^{-4} s \times 5 = 2.67 \times 10^{-5} J = 26 \mu J$

Question 10

From the engry consumption perspective, I would perfer option A (LoRaWAN). For the transimisson power - distance diagrams of LoRaWAN and 802.11ah. The LoRaWAN network requires less transmission power than the 802.11ah network at the same distance. From the above questions result, the LoRaWAN network has a large coverage distance than the 802.11ah network. A packet requires less transmissions to a BS/AP with a LoRaWAN network at the same distance, reducing transmission power. Hence, I would perfer option A.

Question 11

If the two network operate at 2.4 GHz, the path loss of a transmission is lower according to the equation. Nodes might use less transmission power than networks operates at 900 MHz. The leakage power and CPU dynamic power, however, will be increased when the network frequence is increased. Hence, if we want to reduce power consumption with increasing working frequence, we might also need to take care of other power components of the system.