Assignment 1 Solutions

Question 1

As an example, if 1234 is the decimal number we can convert it to binary by subtracting successively-smaller powers of 2:

```
1234 - 1024 = 210
 210 - 128 = 82
  82 - 64 = 18
  18 - 16 = 2
   2 - 2 = 0
```

so 1234_{10} (base 10) is $2^{10} + 2^7 + 2^6 + 2^4 + 2^1$ or 0000 0100 1101 0010 (base 2). This is in MS to LS bit order (network order).

To convert to hexadecimal, each group of 4 bits is converted to a hexadecimal number resulting in the value 0x04D2.

If the two bytes were swapped to little-endian order the value would be 0xD204. If the bits in each byte were also swapped the bits would be 0100 1011 followed by 0010 0000 which is 0x4B20.

Unless your student number ends in 1234 your answer would, of course, be different.

Question 2

The Unicode code point (the index in the Unicode code table) of the character CANADIAN SYLLABICS PAA (ᐹ) is found on page 4 of http://www.unicode.org/charts/PDF/U1400.pdf as 0x1439.

Question 3

The Chinese character for "Rice" (the grain) is "米" with Unicode value (code point) U+7C73. Converting this to binary we get:

0111 1100 0111 0011

which must be encoded using the third line. According to this row in the table the binary number is split into the three fields with 4, 6, and 6 bits each:

zzzz = 0111
yyyyyy = 11 0001
xxxxxx = 11 0011

then by inserting these fields into the corresponding fields in the table we get the binary value:

1110 0111 1011 0001 1011 0011

which is the three-byte value 0xE7B1B3. Therefore:

- it takes three bytes to represent the character 米
- the byte values are 0xE7, 0xB1 and 0xB3

Question 4

Since the diameter of 24-gauge wire is approximately 0.5 mm, the diameter of 14-gauge wire is given by:

$$D = 0.5 \times 2^{\frac{(24-14)}{6}} = 0.5 \times 2^{1.67} = 1.6 \text{ mm}$$

The characteristic impedance of a twisted pair cable is given by:

$$Z_0 \approx \frac{120}{\sqrt{\epsilon_r}} \ln\left(\frac{2S}{D}\right)$$

so we can solve for the conductor spacing S:

$$S \approx \frac{D}{2} \exp\left(Z_0 \frac{\sqrt{\epsilon_r}}{120}\right)$$

For polyethylene insulation $\epsilon_r = 2.2$ and we require $Z_0 = 80\ \Omega$ so the conductor spacing is:

$$S \approx \frac{1.6}{2} \exp\left(80 \frac{\sqrt{2.2}}{120}\right) = 2.1 \text{ mm}$$

S is the distance between the centers of the conductors which is equal to twice the thicknesses of the insulation (call it T) plus twice the wire radius (which is the wire diameter, D). Thus $S = 2T + D$. So the insulation thickness is: $T = (S - D)/2 = (2.1 - 1.6)/2 = 0.27$ mm[1]

[1] You have to use more than two significant digits in your calcuations in order to get an accurate numerical result because the two quantities being subtracted have about the same same value.

Using the equations:

$$\frac{c}{\sqrt{\epsilon_r}} = \frac{1}{\sqrt{LC}}$$

where c is the velocity of light (3×10^8 m/s) and L and C are the cable inductance and capacitance per meter, and

$$Z_0 = \sqrt{\frac{L}{C}}$$

we can solve for C as:

$$C = \frac{\sqrt{\epsilon_r}}{cZ_0} \text{ F/m}$$

using the values for Z_0 and ϵ_r above, we find $C = 62$ pF/m.

Question 5

The propagation delay through the cable, assuming a velocity factor 0.66 is:

$$d/v = 50/(0.66 \times 3 \times 10^8) = 250 \text{ ns}$$

At a frequency of 3 MHz this delay would result in a phase shift of:

$$2\pi f \tau \text{ rad.} = 360° \times 3 \times 10^6 \times 250 \times 10^{-9} = 270°$$

Since the question did not state the type of dielectric, other values for velocity of propagation $\leq 3 \times 10^8$ are acceptable. For air dielectric the phase shift would be $180°$.

Question 6

The received signal level for a LOS link is given by the Friis equation:

$$P_R = P_T G_T G_R \left(\frac{\lambda}{4\pi d}\right)^2$$

or if all gains are in dB and the transmit power is in dBW (or dBm),

$$P_R = P_T + G_T + G_R + 20\log\left(\frac{\lambda}{4\pi d}\right)$$

where $P_T = 50\text{ kW} = 10\log(50 \times 10^3) = 47$ dBW, $G_T = 12$, $G_R = 0$, $\lambda = c/f = 3 \times 10^8/644 \times 10^6 = 0.465$ m and $d = 12 \times 10^3$. The result is:

$$P_R = 47 + 12 + 0 + 20\log\left(\frac{0.465}{4\pi \times 12 \times 10^3}\right) = -51 \text{ dBW}$$