ECE1150 ASSIGNMENT3

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```
%please ignore this block
answer = @(num,unit) fprintf("<strong> ANSWER: %s [%s] </strong>\n",mat2str(num),unit);
question = @() eval("clearvars -except answer question");
```

Q1

- Optical fiber typically used for long-distance communication.
- Backbone, high-speed internet access
- Local networks are also using optical fiber
- Optical fiber is thin strand of glass that guides light (glass is a good conductor of light, not heavy; can carry large volumes of data over long distances)
- Data transmitted using light from lasers or light emitting diodes
- Extremely fast data rates (Hundreds of terabytes per second possible)

Q2

Twisted Pair

- Low in capacity
- High in noise susceptibility

Coax

- Good in capacity
- Lower in noise susceptibility

Multi-mode Fiber

- High in capacity
- Very low in noise susceptibility

Single-mode Fiber

- Highest in capacity
- Very low in noise susceptibility

The capacity increases as the noise susceptibility improves.

Q3

Destinations are far away -> Loss of signal power as it travels from transmitter to receiver (energy gets scattered in many directions, energy is absorbed.)

The signal gets weaker and loses more fidelity when distance increases.

Wired channel has linear attenuations, but wireless channel has exponential attenuations.

Q4

Long Waves

- Wavelength: >10m
- Frequency: <10e7Hz
- Applications: Broadcasting

Radio Waves

- Wavelength: 1m~10m
- Frequency: 10e8~10e9
- Applications: TV, FM, AM

Microwaves

- Wavelength: 1mm~10cm
- Frequency: 10e9Hz~10e11Hz
- Applications: Wi-Fi, cellular, satellites

Infrared Rays

- Wavelength: 10um~1mm
- Frequency: 10e12Hz~10e14Hz
- Applications: Lasers, Epilation

Visible Lights

- Wavelength: 400nm~700nm
- Frequency: 10e14Hz~10e15HZ
- Applications: Surgery, CD players

Ultraviolet Rays

- Wavelength: 10nm~100nm
- Frequency: 10e15Hz~10e16Hz
- Applications: Killing bacteria, Phototherapy

X-Rays

- Wavelength: 0.1nm~10nm
- Frequency: 10e17Hz~10e19HZ
- Applications: Fracture checking, Cancer Detection

Q5A

```
question();
p_t = 85;%[W] power level
p_t_dbm = 10*log10(p_t);%[dBm] power level
answer(p_t_dbm,"dBm");
```

ANSWER: 19.2941892571429 [dBm]

Q5B

```
a_db = 12*10;%[dB] total attenuation
p_r_dbm = p_t_dbm-a_db;%[dBm] received power
answer(p_r_dbm,"dBm");
```

ANSWER: -100.705810742857 [dBm]

Q5C

```
s_dbm = -75;%[dBm] sensitivity
detect = p_r_dbm >= s_dbm;
answer(detect,"");
```

ANSWER: false []

Q5D

```
n_dbm = -65;%[dbm] noise
n = 10^(n_dbm/10)/1000;%[W] noise
p_r = 10^(p_r_dbm/10)/1000;%[W] received power
snr_db = 10*log10(p_r/n);%[dB] signal-to-noise ratio
answer(snr_db,"dB");
```

ANSWER: -35.7058107428571 [dB]

Q6

```
question();
b = 8e3;%[Hz] bandwidth
snr_db = 82;%[db] signal-to-noise ratio
snr = 10^(snr_db/10);%[] signal-to-noise ratio
c = b*log2(snr);%[bits/s] channel capacity
answer(c,"bits/s");
```

ANSWER: 217918.483024611 [bits/s]

Q7

```
question();
c = 36e6;%[bits/s] channel capacity
b = 9e6;%[Hz] bandwidth
snr = 2^(c/b)-1;%[] signal-to-noise ratio
snr_db = 10*log10(snr);%[dB] signal-to-noise ratio
answer(snr_db,"dB");
```

ANSWER: 11.7609125905568 [dB]

Q8A

```
question();
p_tx = 85;%[W] transmit power
D_tx = 180e-2;%[m] diameter of transmit antenna
D_rx = 270e-2;%[m] diameter of receive antenna
r = 50000e3;%[m] distance between transmitter and receiver
f = 12.2e9;%[Hz] frequency
c_0 = 299792458;%[m/s] speed of light
lambda = c_0/f;%[]
eta = 0.6;%[] aperture efficiency
p_tx_dbm = 10*log10(p_tx/1e-3);%[dBm] transmit power
A_tx = 10*log(eta*(pi*D_tx/lambda)^2);%[dB] transmit antenna gain
A_rx = 10*log(eta*(pi*D_rx/lambda)^2);%[dB] receive antenna gain
freeSpaceLoss = 10*log((4*pi*r/lambda)^2);%[dB] free space loss
p_rx_dbm = p_tx_dbm-freeSpaceLoss+10*log10(A_tx*A_rx);%[dBm] received power
answer(p_rx_dbm,"dBm");
```

ANSWER: -389.359315216702 [dBm]

Q8B

```
question();
f = 13e9;%[Hz] frequency
c_0 = 299792458;%[m/s] speed of light
lambda = c_0/f;%[]
D_tx = 1.5;%[m] diameter of transmit antenna
D_rx = 2.5;%[m] diameter of receive antenna
eta = 0.47;%[] aperture efficiency
p_rx_dbm = -70;%[dBm] received power
A_tx = 10*log(eta*(pi*D_tx/lambda)^2);%[dB] transmit antenna gain
A_rx = 10*log(eta*(pi*D_rx/lambda)^2);%[dB] receive antenna gain
p_tx_dbm = p_rx_dbm-10*log10(A_tx*A_rx);%[dBm] transmitted power
answer(p_tx_dbm,"dBm");
```

ANSWER: -110.326342475737 [dBm]

**This answer assumes no free space loss, since this value is not given in Q8B.

Q9

```
r = (30^2+40^2)^0.5;%[m] distance between transmitter and receiver
p_tx = 1e-3;%[W] transmit power
p_tx_dbm = 10*log10(p_tx/1e-3);%[dBm] transmit power
f = 2.7e9;%[Hz] frequency
n = 5;%[] path loss exponent
pathLoss_db = 20*log(f)+10*n*log(r)+(-147.56);%[dB] path loss
p_rx_dbm = p_tx_dbm-pathLoss_db;%[dBm] received power
sensitivity = -95%[dBm] sensitivity
```

```
sensitivity = -95
```

```
answer(p_rx_dbm>=sensitivity,"");
```

```
ANSWER: false []
```

```
%ignore this block
export("submission.mlx","submission.pdf");
```