Exercise 1: How much does a cable's resistance increase when the gauge size increases by 6? By 3? Hint: a wire's resistance is ~~inversely~~ proportional to its cross-sectional area.

$$\text{area} = \pi r^2 = \frac{\pi d^2}{4}$$

by 6:

$$\frac{d_2}{d_1} = \frac{1}{2}$$

$$\frac{a_2}{a_1} = \frac{1^2}{2^2} = \frac{1}{4}$$

$$\frac{r_2}{r_1} = \frac{\frac{1}{1}}{\frac{1}{4}} = 4$$
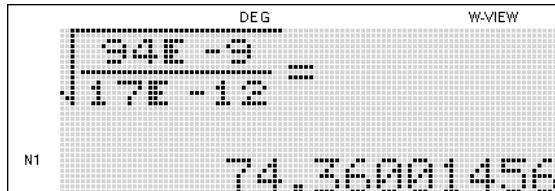
by 3:

$$\frac{d_2}{d_1} = \frac{1}{2^{(3/6)}} = \frac{1}{\sqrt{2}}$$

$$\frac{a_2}{a_1} = \frac{1}{2}$$

$$\frac{r_2}{r_1} = 2$$

Exercise 2: What is the characteristic impedance of a lossless cable with an inductance of 94 nH per foot and capacitance of 17pF/ft?

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

DEG   W-VIEW

94E-9
――――― =
17E-12

N1

74.36001456 Ω

Exercise 3: What is the characteristic impedance of UTP made
from 24-gauge wire with polyethylene insulation ($\varepsilon_r = 2.2$) of
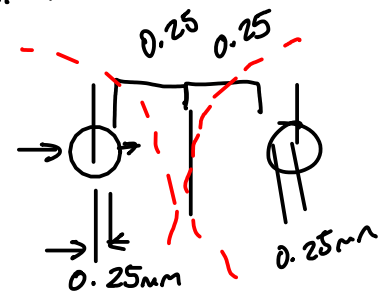0.25mm thickness?

$$D = 24\,ga = 0.5mm$$

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

$$S = ?$$


```
                    DEG                    W-VIEW
    120     2×1
  ─────── ln ───
   √2.2     0.5

N1                  112.1567361
```


total separation
$$= S = 0.25 + 0.25 + 0.25 + 0.25$$
$$= 1mm$$

$$Z_0 \approx 112\,\Omega$$

Exercise 4: What is the characteristic impedance of a co-ax
cable with a 0.8mm diameter center conductor, 3.5mm diam-
eter shield and foamed polyethylene between them that has a
dielectric constant of 1.5?

$$D = 3.5$$
$$d = 0.8$$
$$\varepsilon_r = 1.5$$

$$Z_0 = \frac{60}{\sqrt{\varepsilon_r}} \ln\left(\frac{D}{d}\right)$$

$$= \frac{60}{\sqrt{1.5}} \ln\left(\frac{3.5}{0.8}\right) = 72$$

```
                    DEG                    W-VIEW
    60      3.5
  ─────── ln ───
   √1.5     0.8

N1                  72.30435763
```

$$Z_0 = 50 \quad , 52$$
$$\left.\begin{array}{l} 70, \quad 72, \quad 75 \end{array}\right\} \text{common values for co-ax}$$
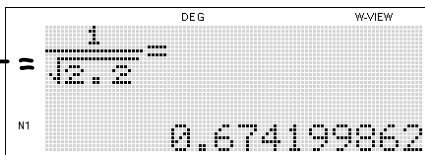
Exercise 5: An 800 MHz signal is output from a CATV amplifier at a power level of 10dBm. What power level would you expect at the other end of a 75m run of co-ax whose loss is specified as 24dB/100m at 800 MHz?

$$loss = \frac{24\, dB}{100M.} \cdot 75m = 24 \cdot \frac{3}{4} = 18\, dB \quad \underline{loss.}$$

? $P_{out} = P_{in} - loss = 10 - 18 = -8\, dBm.$

10 dBm

75m
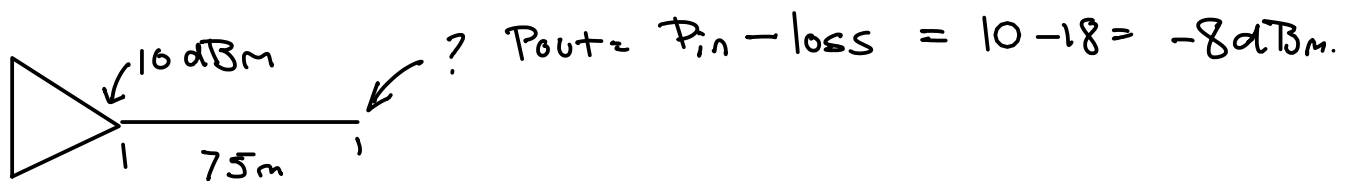
Exercise 6: What is the velocity factor for a cable with polyethylene insulation ($\varepsilon_r = 2.2$)? How long would it take for a signal to propagate 100m? For a cable with air dielectric?

$$VF = \frac{1}{\sqrt{\varepsilon_r}} = \frac{1}{\sqrt{2.2}} = \frac{1}{\sqrt{2.2}}$$

```
                        DEG              W-VIEW
              1
          ─────────
           √2.2

N1
                    0.674199862
```

$$v = \frac{d}{t}$$

$$c = 3 \times 10^8 \, m/s$$

$$t = \frac{d}{v} = \frac{d}{VF \cdot c} = \frac{100}{0.66 \cdot 3 \times 10^8} \approx \frac{10^2}{2 \times 10^8} = 0.5\mu s.$$

$$= \frac{1}{2} \times 10^2 \cdot 10^{-8} = \frac{1}{2} \times 10^{-6}$$

$$t = \frac{100\, m}{300 m/\mu s} = 0.33\mu s.$$

Exercise 7: If the optical signal wavelength is 1330nm what is the frequency? Note that the wavelength is specified in free space, not in the fiber.

$$v = \frac{d}{t}$$

$$c = \lambda f$$

$$f = \frac{c}{\lambda} = \frac{3 \times 10^8}{1.33 \times 10^{-6}} \approx 2 \times 10^{14}$$

$$200 \times 10^{12} = 200 THz$$

Exercise 8: A point-to-point link uses a transmit power of 1 Watt, transmit and receive antennas with gains of 20dB and operates at 3 GHz. How much power is received by a receiver 300m away?

$$c = \frac{d}{t}$$

$$t = \frac{1}{f}$$

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

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{3 \times 10^9}$$

$$= 0.1 \, m.$$

$$= 1 \cdot 100 \cdot 100 \cdot \left(\frac{0.1}{4\pi \, 300} \right)^2$$

$$20 \, dB = 10 \log G_T$$

$$G_T = 10^{\frac{20}{10}} = 100$$

$$= 10^4 \; \frac{10^{-2}}{(36)^2 10^4} = 7 \mu W$$

$$G_R = G_T$$

$$7 \mu W$$

Exercise 9: Rank each of twisted-pair, co-ax, optical fiber and free space media according to cost of the medium, cost of the interface, media size and immunity to interference.

cost

	media	interface	media size	immunity interference
T.P.	M	L	M-L	M
Co-ax	H	M	M-H	M-H
F.O.	M/H	H	L	H
wireless	L	H	—	L

H
M
L