Q1- A cell phone broadcasts 800 MHz signal. If it is operated from the space between two massive radio-wave absorbing buildings with 15 m space between them, what is the angular width of the electromagnetic wave after it emerges from between the buildings?

Here the space between the buildings is behaving like a slit and it produces diffraction of radio waves.

The angular width of the central maximum in a single slit diffraction is given by

$\theta = 2\lambda/d$

Here λ is the wavelength and d is the width of the slit.

As we know

$c = n\lambda$ where c is the wave velocity and n is the frequency hence

$\lambda = c/n = 3*10^8/800*10^6 = 3/8$ meter (EM waves have speed of light)

Now the angular width of the central maximum is

$\theta = 2\lambda/d$ where d is the width of the slit.

Or $\theta = 2*(3/8)/15 = 0.05$ radian $= 2.86^0$

Q2- How far behind the pinhole should the viewing screen be placed to photograph a circular diffraction pattern with central maxima of diameter of 1.0 cm, if the wavelength of the light used is 633 nm and the diameter of the pinhole is 0.12 mm.

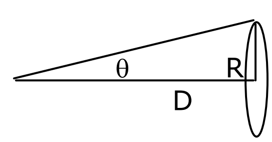
The central maximum is extended from center to the first minimum, angler position of which is given by

$\sin\theta = 1.22*\lambda/d$ where d is the diameter of aperture.

Now if the radius of the first minimum is R (=1.0/2 = 0.5 cm) on the screen at distance D then

$\tan\theta = R/D$ and $\sin\theta = \dfrac{R}{\sqrt{R^2+D^2}}$ hence

$$\frac{R}{\sqrt{R^2+D^2}} = 1.22*\lambda/d$$



Squaring the equation we get

$R^2 + D^2 = (Rd/1.22*\lambda)^2$

Or $D^2 = (Rd/1.22*\lambda)^2 - R^2$

$$D = R\sqrt{\left(\frac{d}{1.22\lambda}\right)^2 - 1} = 0.5*\sqrt{\left(\frac{0.12*10^{-3}}{1.22*633*10^{-9}}\right)^2 - 1} = 0.5*\sqrt{(155.38)^2 - 1} = 77.69 \text{ m}$$