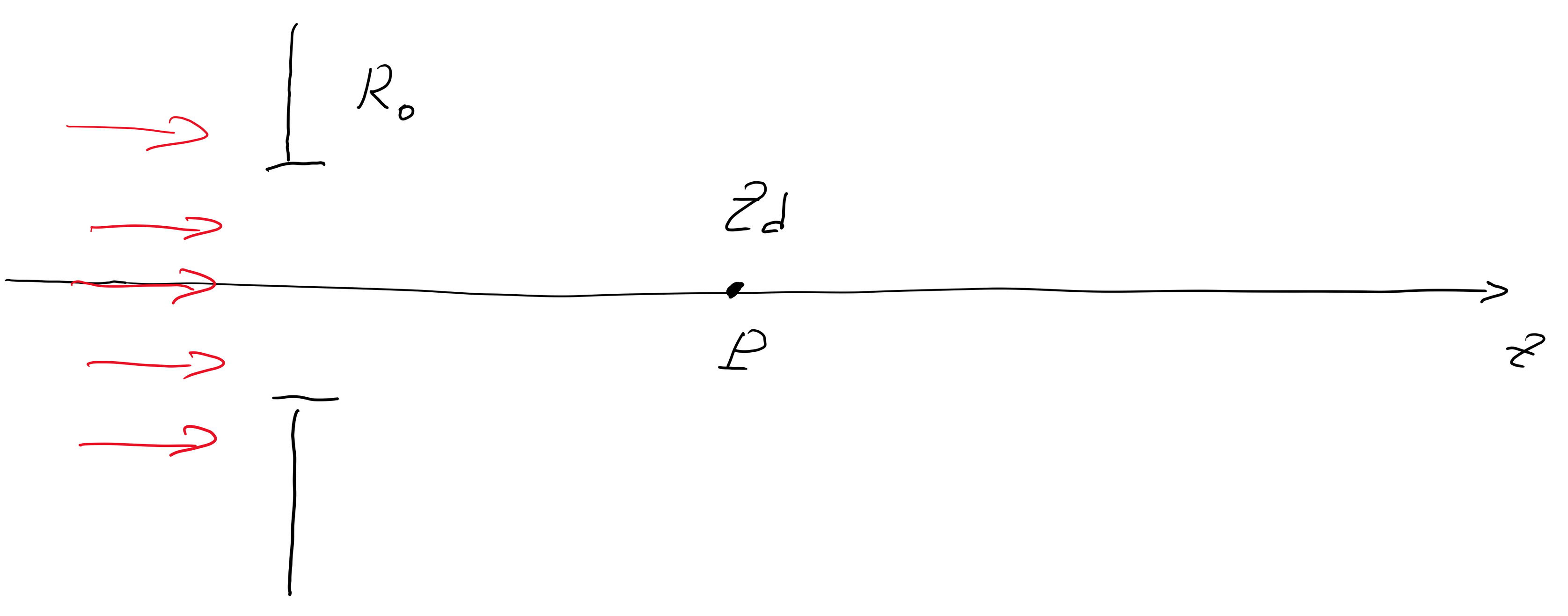
Classification of diffraction effects

Let's take round hole with R_0 radius with incoming plane wave.



For radius of n Fresnel zone:

$$R_n = \sqrt{\frac{r r_0}{r + r_0} n \lambda} \qquad \text{Since } r_0 \to \infty,\ n = 1,\ r = z$$

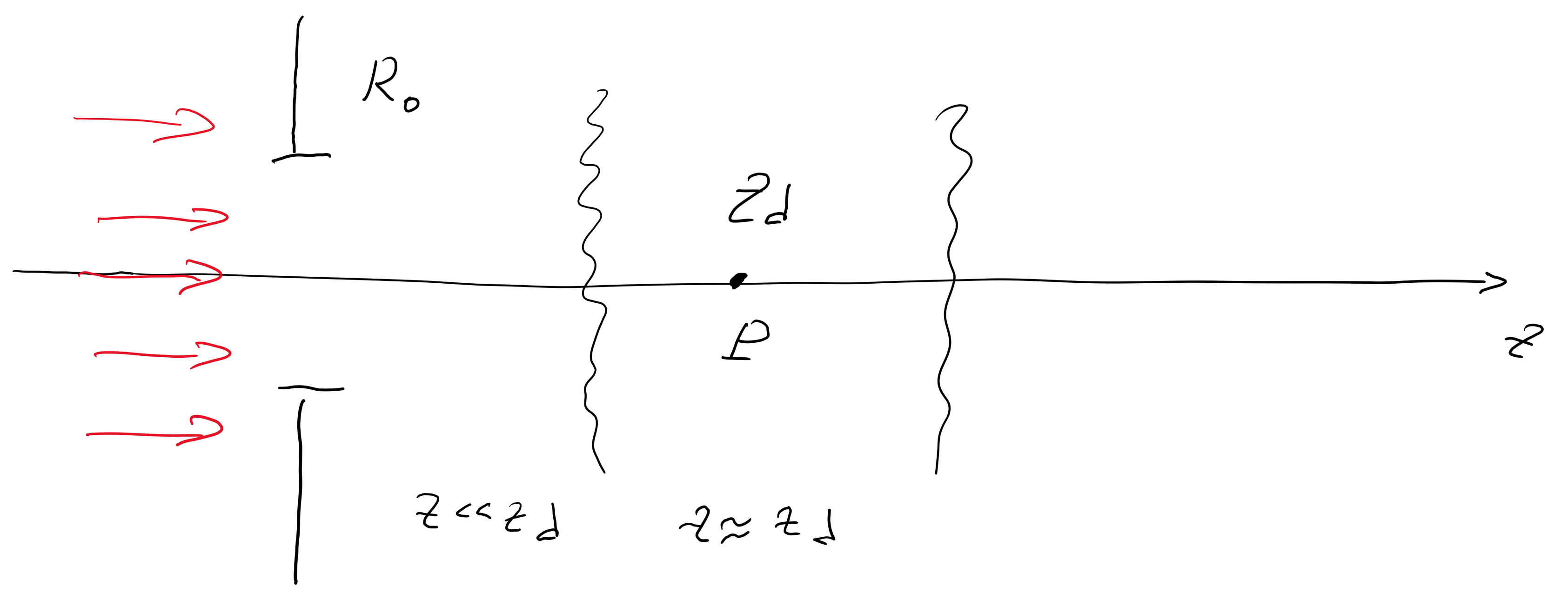
$$R_1 = \sqrt{z \lambda}$$

Let's assign z_d, distance at which the hole will open only 1st Fresnel zone.

$$z_d \Rightarrow R_1 = R_0 \Rightarrow z_d = \frac{R_0^2}{\lambda}$$

Now, the space behind the hole can be divided into several areas.

① $z \ll z_d$



$$R_1 = \sqrt{z\lambda} \ll \sqrt{z_d \lambda} = R_0$$

$$\Downarrow$$

$$R_1 \ll R_0$$

In this area the hole opens many different Fresnel's zones. It means vector $\bar{E}_0$ will not change much, its amplitude

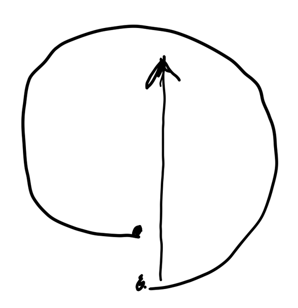
This area called the area of geometrical optics.

② $z \approx z_d$

$$R_1 = \sqrt{z\lambda} \approx \sqrt{z_d \lambda} = R_0$$

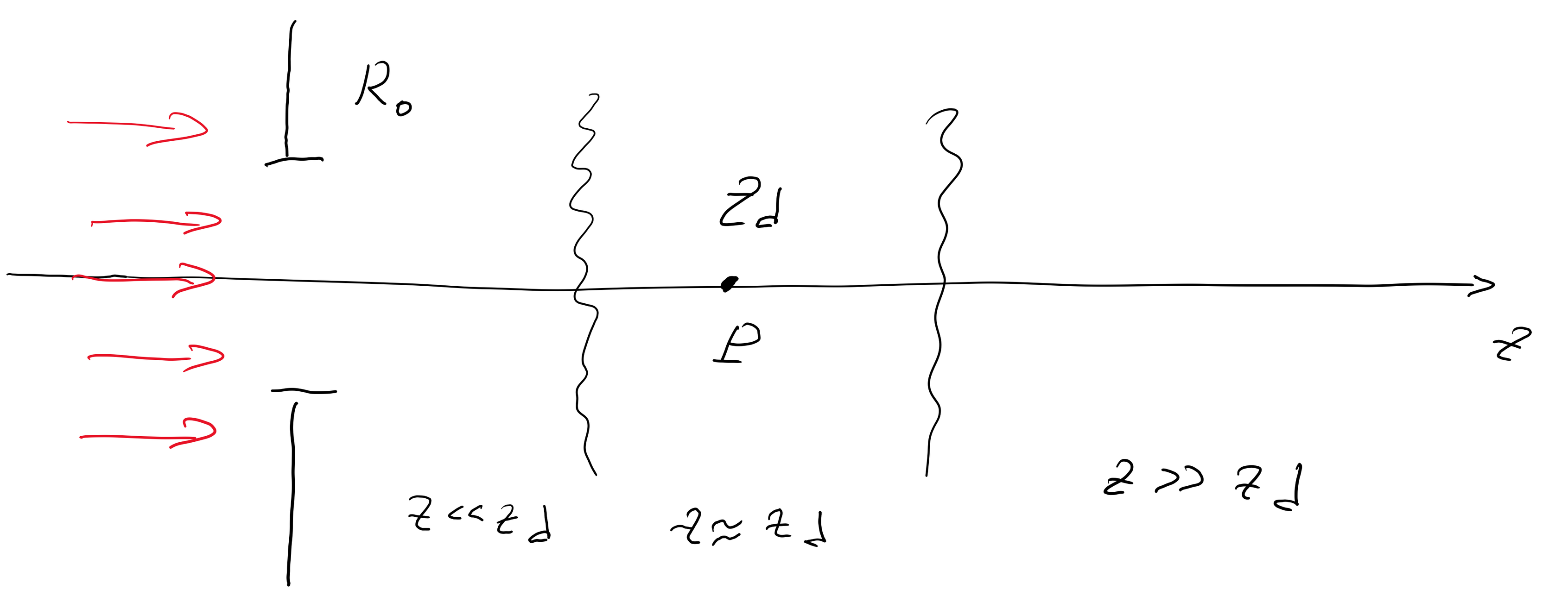
$$R_1 \approx R_0$$

It means the hole will open few first Fresnel's zones.



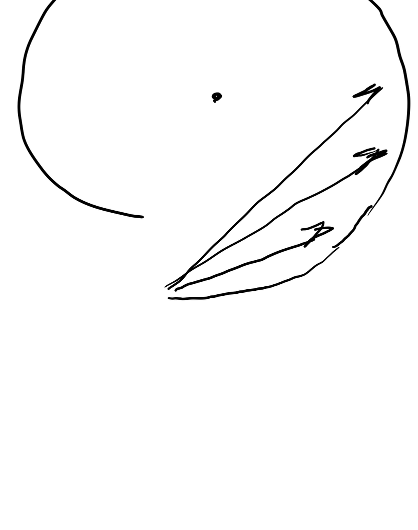
Amplitude will change depending on z. This is area of Fresnel diffraction.

③ $z \gg z_d$



In this case $R_1 \gg R_0$.
It means the hole is opening very small portion of first Fresnel zone.

This area is Fraunhofer diffraction.



Hence, we have