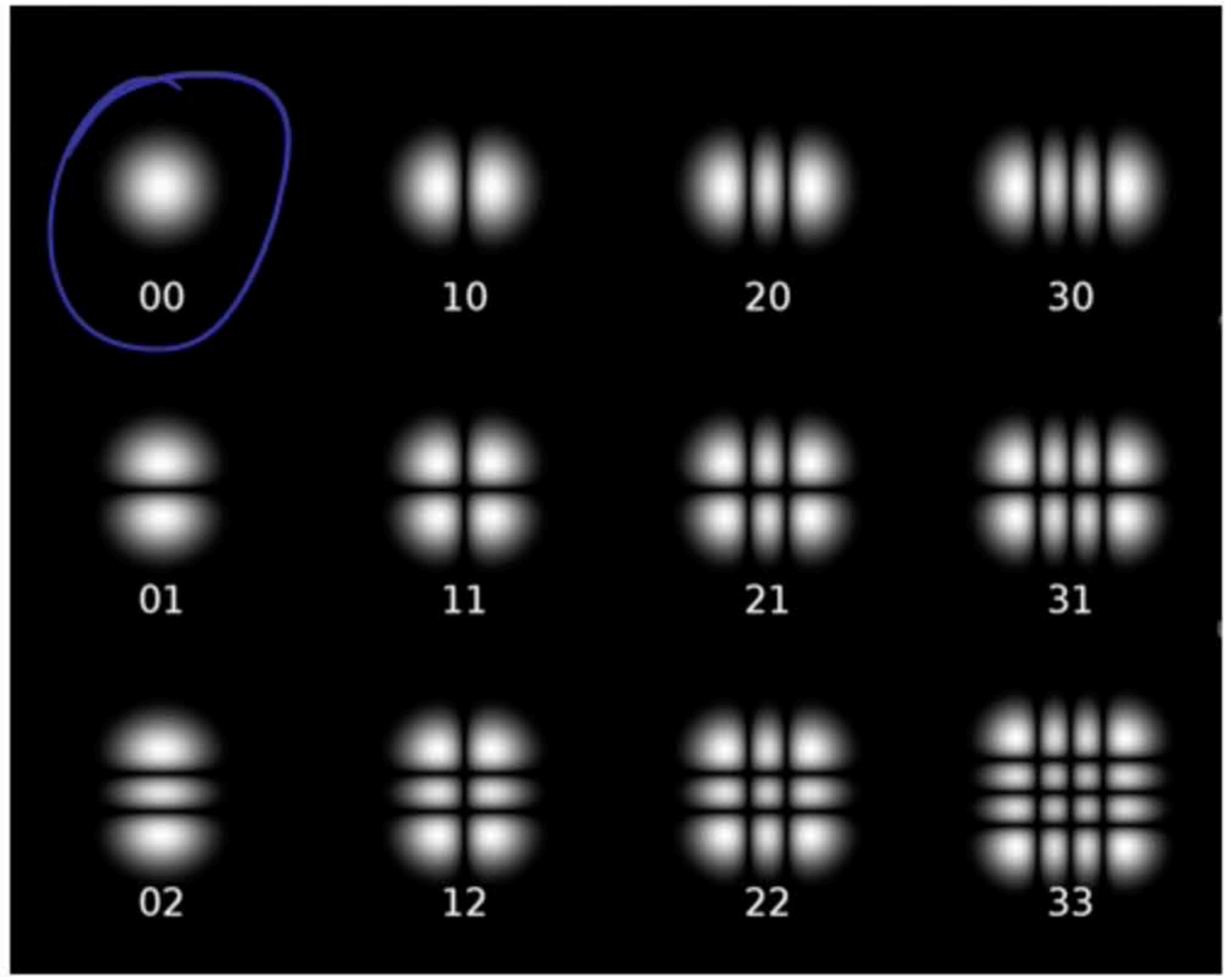
$$\nabla^2 \vec{E} + k^2 \vec{E} = 0$$

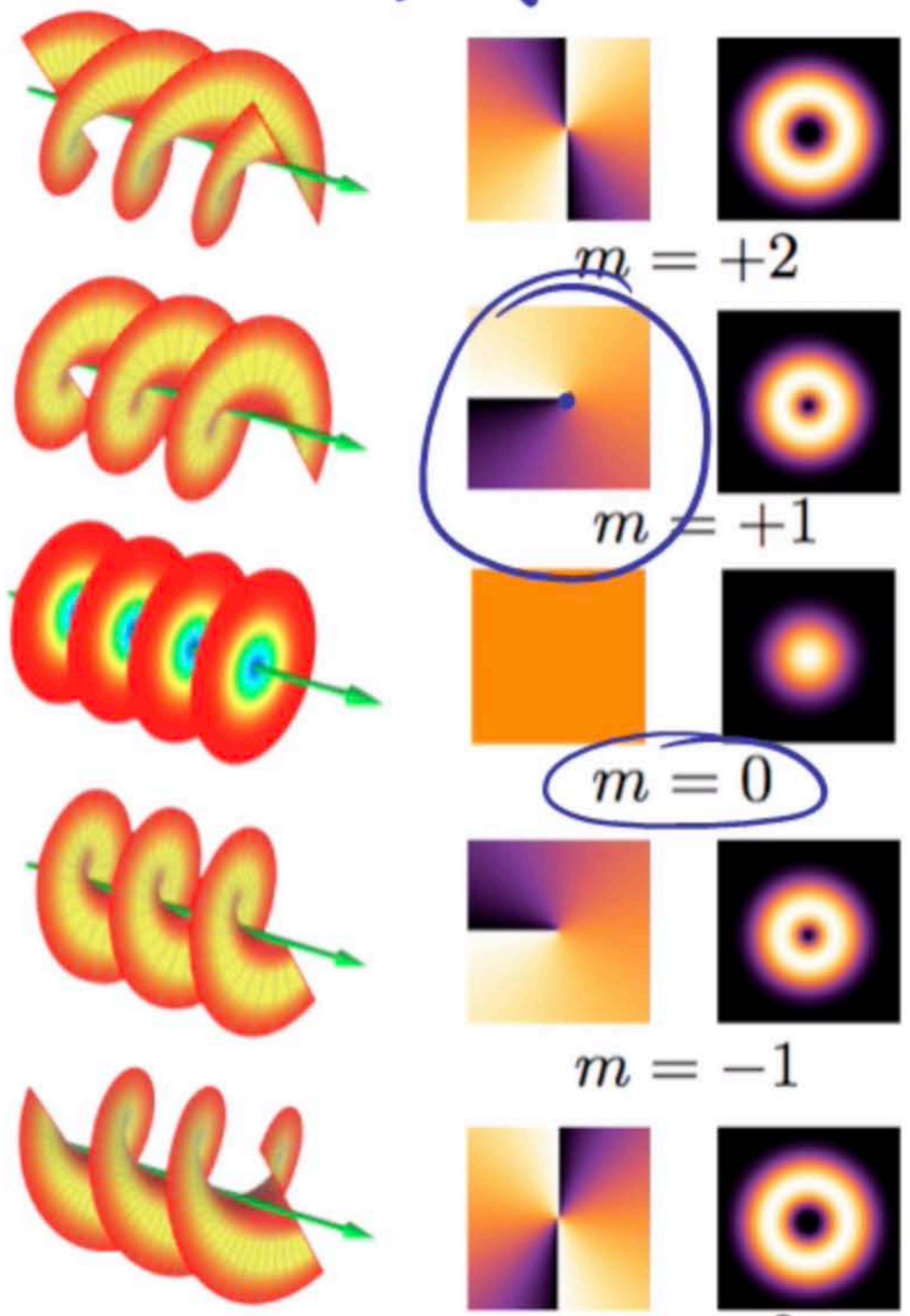
Cartesian

Cylindrical

Hermite - Gaussian



Laguarre Gaussian



Problems on Photon Optics:

Example 1(a):

$\lambda_0 = 0.2\,\mu m$

$\boxed{\text{CW laser}} \xrightarrow{1\,nW} \boxed{\text{Detector}}$

What is the rate @ which photons fall on the detector? (photon flux)

Photon flux, $\phi = \dfrac{\bar{n}}{T}$ → mean number of photons

Mean # of photons, $\bar{n} = \dfrac{E}{h\bar{\nu}} = \dfrac{P.T}{h\nu}$

At $\lambda = 1\,\mu m$,

$E = 1.24\,eV$

At $\lambda = 0.2\,\mu m$

$E = 6.2\,eV$

$= 6.2 \times 1.6 \times 10^{-19}$

$\simeq 10^{-18}\,J$

$$\phi = \frac{P}{h\nu} = \frac{10^{-9}}{10^{-18}}$$

$= 10^{9}$ photons/sec

(or) 1 photon/ns

Example 1b: Laser-assisted cataract surgery

Pulsed laser emitting 100 fs pulses @ $\lambda = 1.06\,\mu m$

You need 1 J/cm² energy density

What is the corresponding photon flux density?

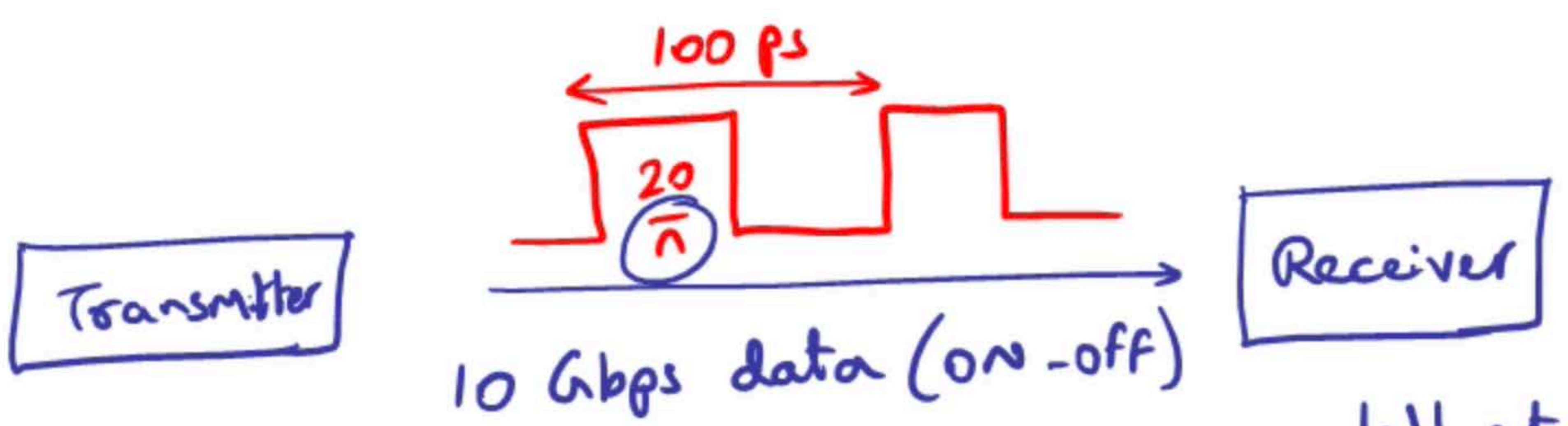
Photon flux density. $\phi(r) = \frac{\Phi}{A}$ $\quad \Phi = \frac{\bar{n}}{T}$

$= \frac{\bar{n}/T}{A} = \frac{1}{T} \cdot \frac{E}{A \cdot h\nu}$ $\rightarrow$ $\frac{1\ J/cm^2}{1.24 \times 1.6 \times 10^{-19}\ J}$

$= 0.5 \times 10^{19}$ photons/cm²

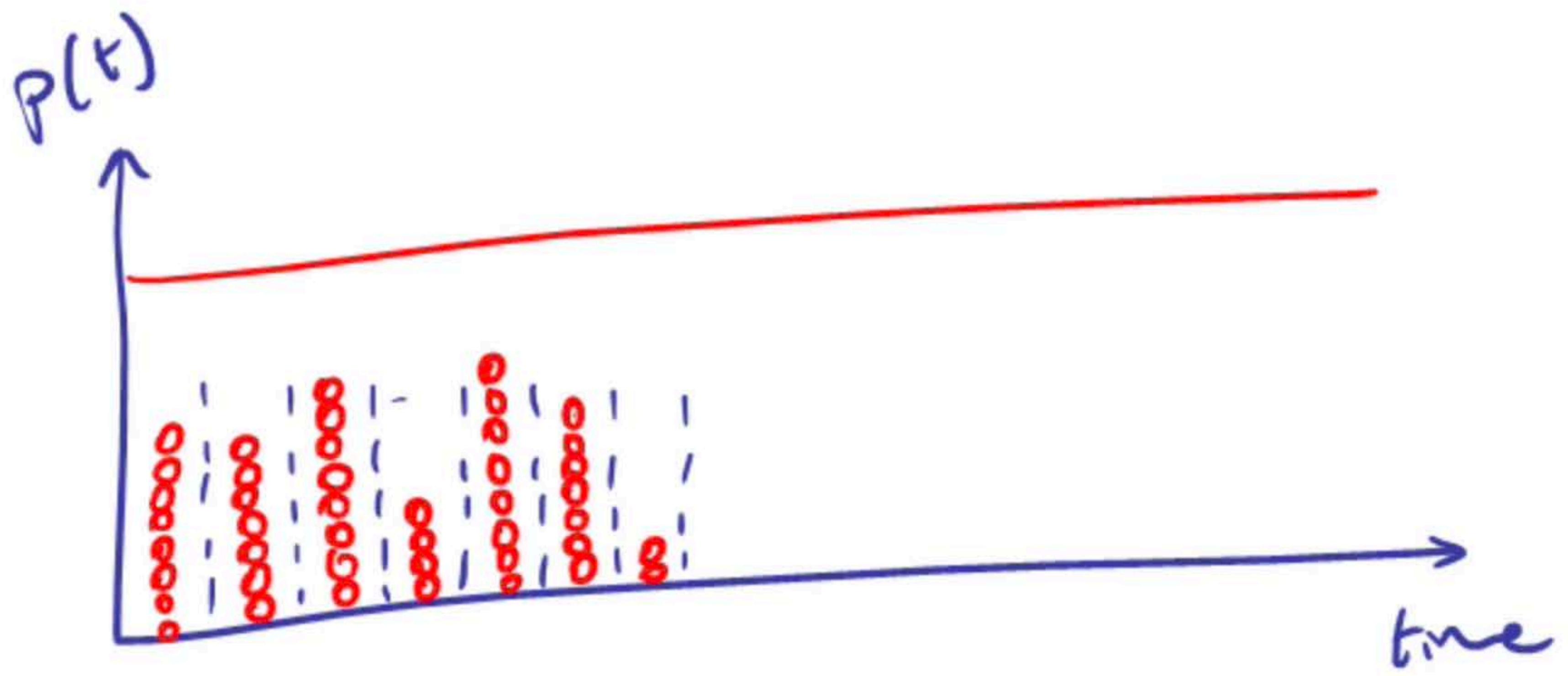
$= \frac{0.5 \times 10^{19}}{100 \times 10^{-15}} = \underline{0.5 \times 10^{32}}$ photons/s-cm²

Example 2 :

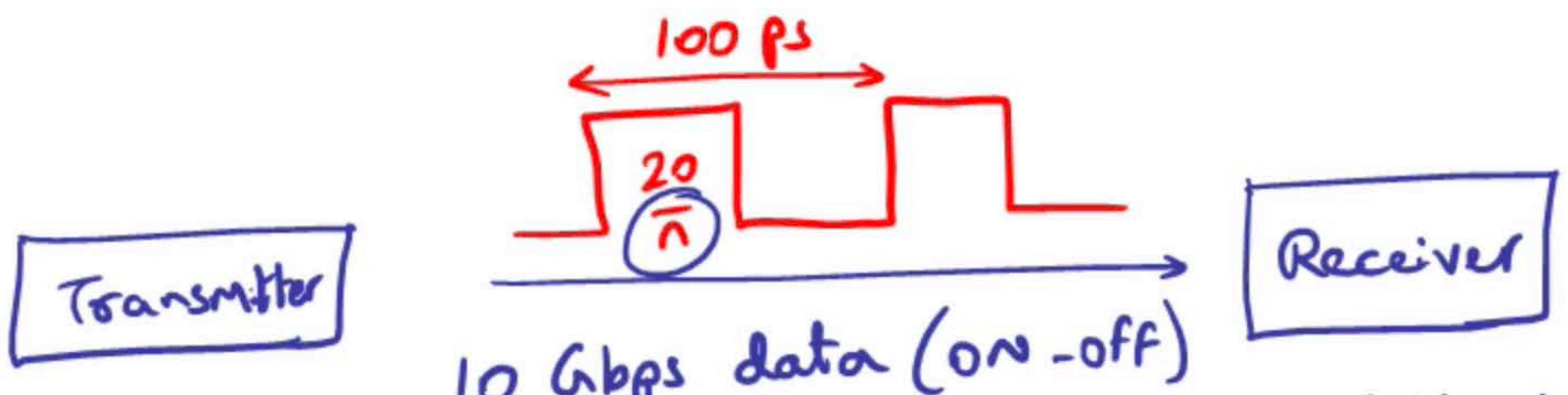


BER $\sim 10^{-9}$

What is the probability of finding zero photons in '1' bit ?

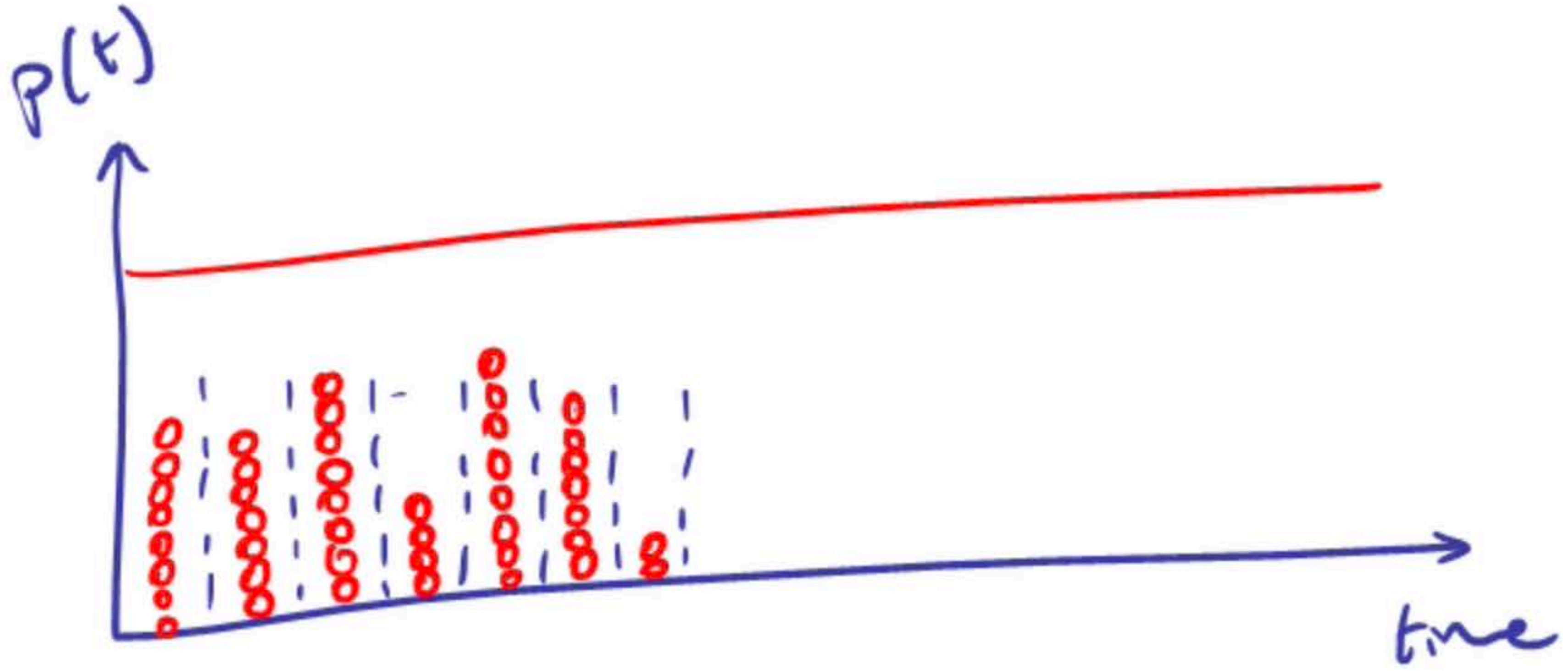


Example 2 :



BER $\sim 10^{-9}$

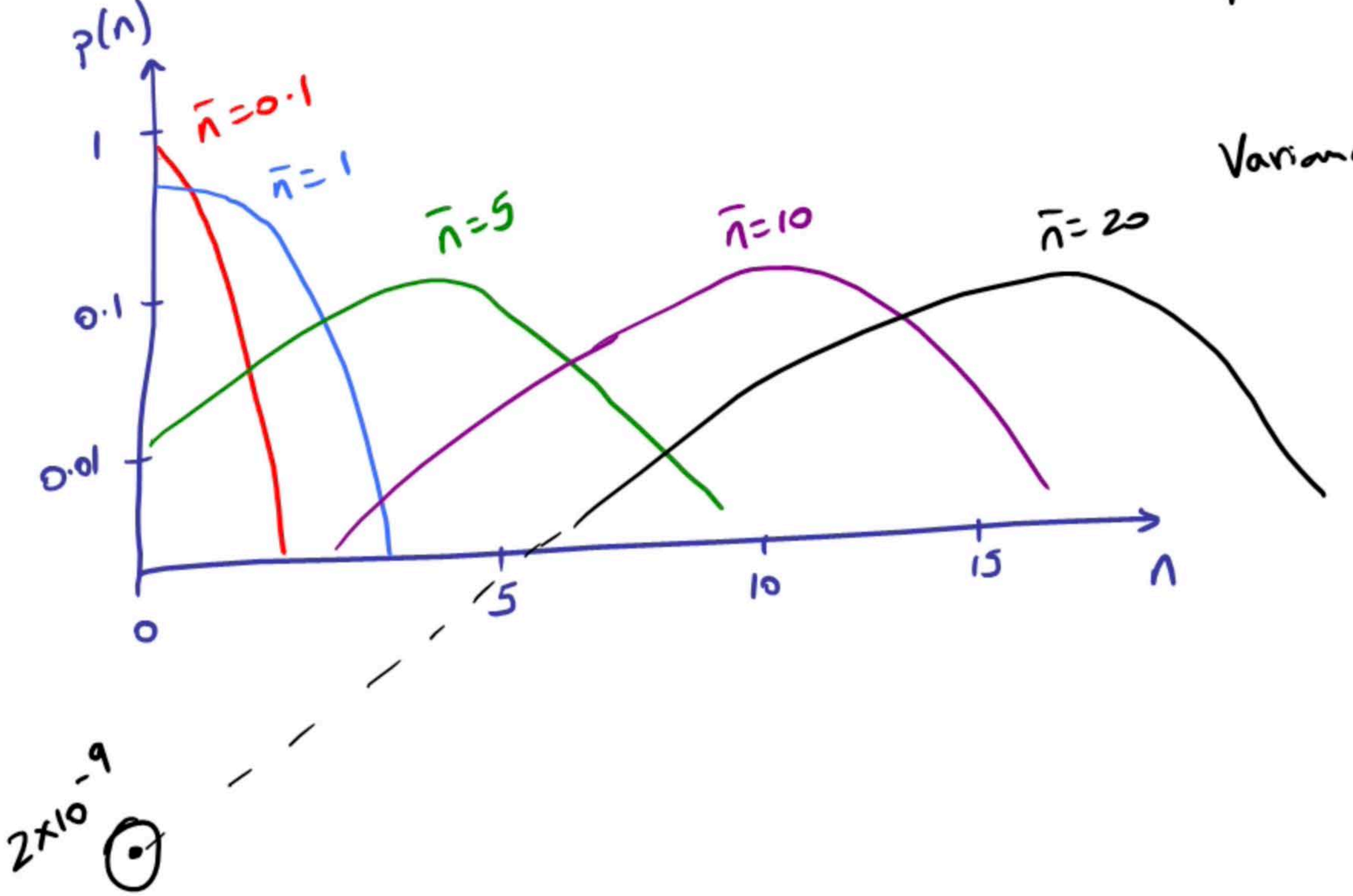
What is the probability of finding zero photons in '1' bit ?



Poisson arrival statistics

Probability of finding 'n' photons within time interval 'T' $\Big\}$ $p(n) = \dfrac{(\bar{n})^{n} \exp(-\bar{n})}{n!}$

$$p(n) = \frac{(\bar{n})^n \exp(-\bar{n})}{n!}$$



Mean, $\bar{n} = \sum_{n=0}^{\infty} n \cdot p(n)$

Variance, $\sigma_n^2 = \sum_{n=0}^{\infty} (n-\bar{n})^2 p(n)$

$= \bar{n}$ (Mean)

$$\mathrm{SNR} = \frac{(\mathrm{Mean})^2}{\mathrm{Variance}} = \bar{n}$$