Threshold Condition :- (Resonator).

$$2nL = m\lambda$$

$$L = \frac{m\lambda}{2n}$$

Waves in the resonator are standing waves. Cavity is not in nm. We can multiply some length element to $m\lambda$ to have a length having resonance freq which is then amplify.

→ Small variation in length disturbing the cavity.

• For creating laser must follow some conditions.

Laser are of two types.

1) Continous Wave laser ($< \omega$).

2) Pulsed Laser.

↳ no. of photons (in continuous path) entering

or

↘ Reception rate (in one second how much pulse pass

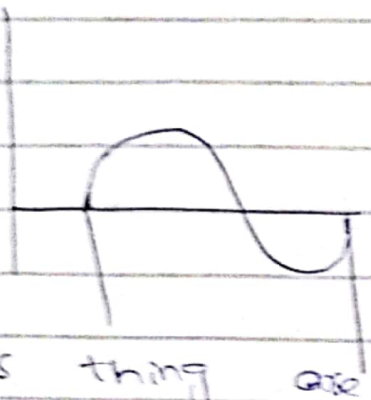
For 10 pulses 10 Hz

200 " 200 Hz

1000 " 1000 Hz

we can't distinguish b/c continous pulse but its not actually continous but repetation is very high so it is continous.

→ Every pulse has its own pulse duration which is in ns



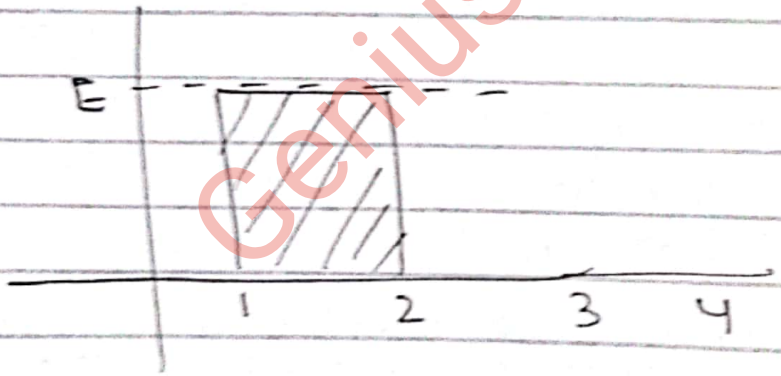
This thing are important in both laser power
→ (i) average power (ii) peak power

* Continuous wave laser → average power

Power = E/t (J/s) = W

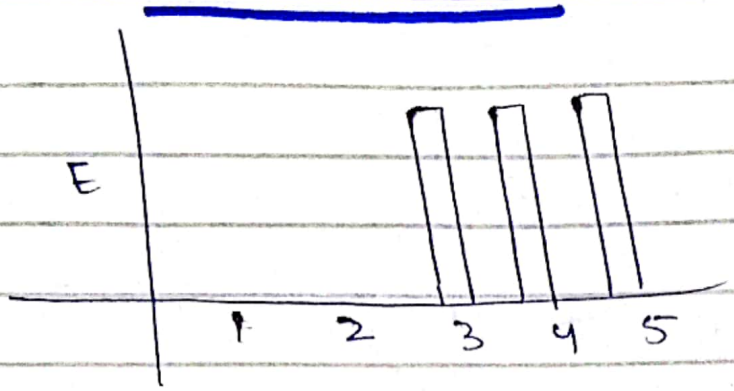
Pulse laser → average + peak both present

Now we have continuous wave laser



Power average = E/t

* Pulse laser → peak power.



and this pulse repeat at specific time period.

$P_{average} = E/T$ energy delivered during this time period T

$P_{peak} = E/\Delta T$

Continous wave laser has less power as compared to pulse laser, pulse laser has high power

both have same energies (CW, PL)

$E = P_{avg} \times T$

$E = P_{peak} \times \Delta t$

$P_{avg} \times T = P_{peak} \times \Delta t$

$$\frac{P_{avg}}{P_{peak}} = \frac{\Delta t}{T}$$

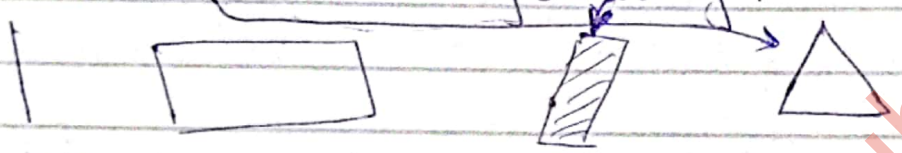
→ only cycle Relation b/w P_{avg} and P_{peak} → Duty cycle

So we can Control the output of laser:-

Resonator → Active medium → apply pumping source.

Specific intensity pulse is generated in cavity to control out put pulse (to deliver max energy is less duration) We apply methods.

Prism or gratting.



We can turn the laser at specific length (in grating). {by rotating prism or grating}

→ Pasive Devices (As we can't control them externally) {e.g prism, gratting}.

→ Active Devices → which can't be controlled externally (has its own rotating material).

- Pulse duration decrease and we can have high energy in three methods.

Methods:-

1) ■ Q switching :- "is a technique for obtaining highly ~~generated~~ energetic short laser pulses."

Q switching → just like a shutter.

Q = $2\pi\nu$ $\frac{\text{energy stored in mode}}{\text{energy loss in per second in a mode}}$

$E(t)$ at 't'
E_0 at $t=0$.

loss in energy

$$-\frac{dE}{dt} \propto E(t)$$

$$-dE/dt = c\,E(t)$$

$$E(t) = \frac{E_0}{e}$$

$$E(t) = \frac{E_0}{e} = E_0 \exp(-et).$$

$$t_c = 1/e$$

$$E_0(t) = E_0 \exp(-t/t_c)$$

$$\frac{dE}{dt} = E_0 \exp(-t/t_c)(-1/t_c)$$

$$-\frac{dE}{dt} = 1/t_c \exp(-t/t_c)$$

$$t_c = \frac{E_0 \exp(-t/t_c)}{-dE/dt}$$

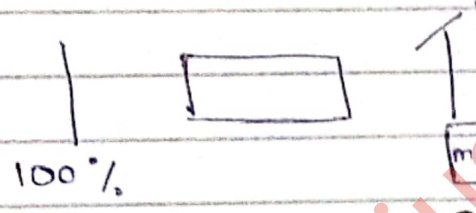
$$Q = 2\pi\nu t_c = \omega t_c = \frac{\omega}{\Delta\omega} = \frac{\nu}{\Delta\nu}$$

Quality factor.

$$\boxed{Q = \frac{\nu}{\Delta\nu}} \rightarrow \text{Quality factor of laser.}$$

Q-switching ma quality factor kyun ha (use) When we introduce shutter. Shutter remove quality factor decrease so losses increase and when we put shutter again quality factor increase and losses decrease.

(i) Mechanical Q-switching (Rotating mirror).



RPM differ in case of 1000 or more than 10000

→ Active medium

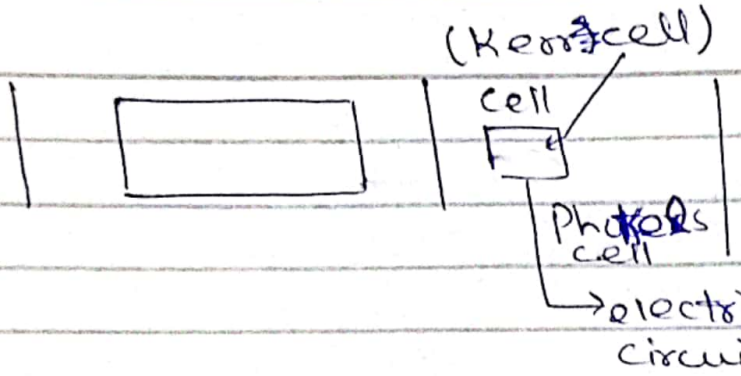
* every motor has its own rotations per minute (RPM)

100% mirror or concave mirror parallel (pulse laser) output pe laser generate.

* milli second laser $\xrightarrow{\text{can be taken as}}$ micro second laser

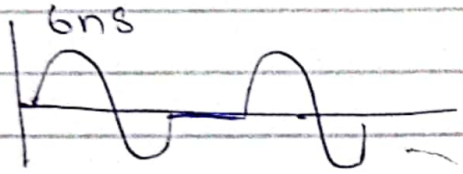
at very small pulse.

Electro-optic Q-switching.



1) Mechanical Q-switching
Active medium
2) Electro-optic Q-switching.
3) Acusto-optic Q-switching.
4) Saturable Absorber.
↳ passive medium.

↳ linearly polarized passed in cell so it can convert it into orthognally polarized light.



* Pulse duration depends. Suppose 6ns. own pulse duration than freq high not obtained due to small difference in time.

- if duration is less we can't achive repetation rate.

Q-switching basically obtain nano-second pulse duration.

According to laser system cell is used

→ Ruby laser Pokar cell. used Q switching first time