OPTICAL ENCODER :- (Sensor).

* which gives output as a digital form / pulses. based on the light transmission property.

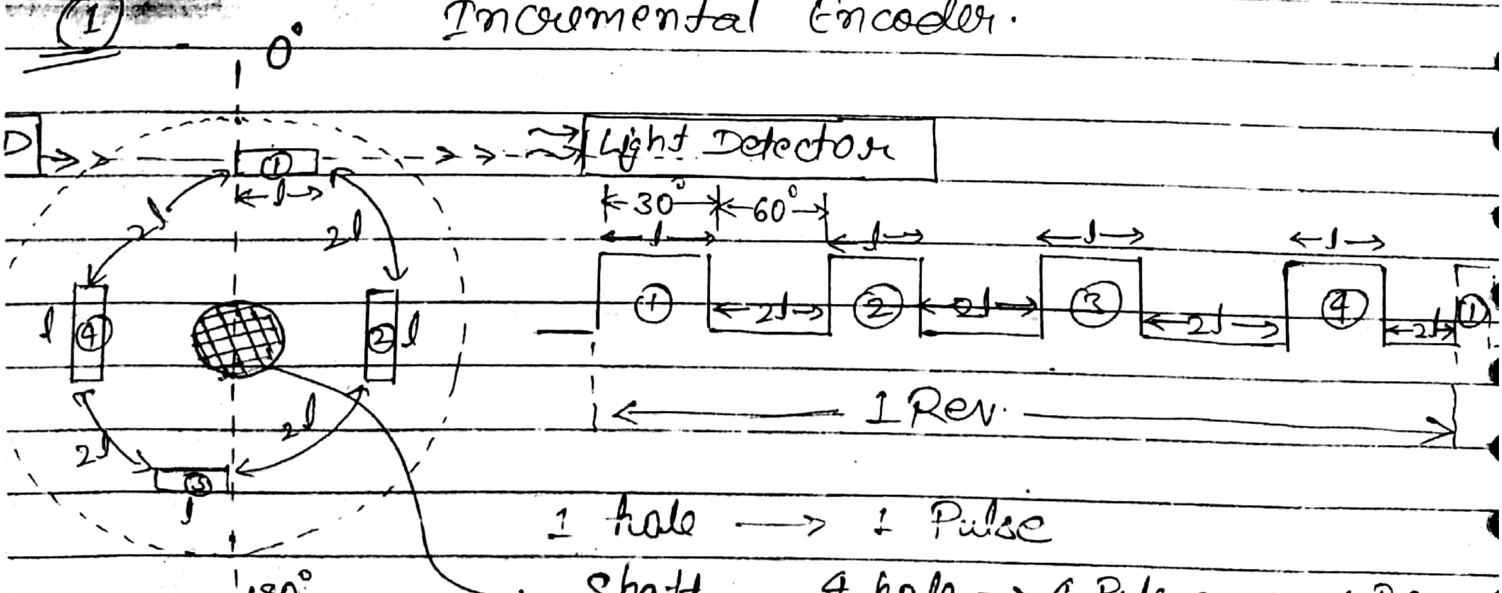
It is a device which generates digital pulses based on the light transmission property.
optical encoders are used to measure angular displacement (θ) as well as linear displacement (x).

Optical Encoders are divided into 2 types :-

1. Incremental Type Encoder
2. Absolute Type Encoder.

for measurement → Sensor.

1. Incremental Encoder.



1 hole → 1 Pulse

4 hole → 4 Pulses → 1 Rev.

Resolution → $\frac{360°}{4} = 90°$

It generates equally spaced pulses, corresponding to the angular displacement of the shaft.
Incremental Encoders are divided into 2 types :-

① Single - Track Incremental Encoder.
② Multi - Track Incremental Encoder.

① Single - Track Incremental Encoder :-

It consist a disk on which equal length holes are placed at equal distance as shown below.

$12\,l \longrightarrow 360^\circ \longrightarrow 1$ Rev

$1\,l \longrightarrow \frac{360^\circ}{12} = 30^\circ$

→ Resolution $= 30^\circ$

Resolution $= 3l$; if $l = 1$ mm

$= 3$ mm

Note:

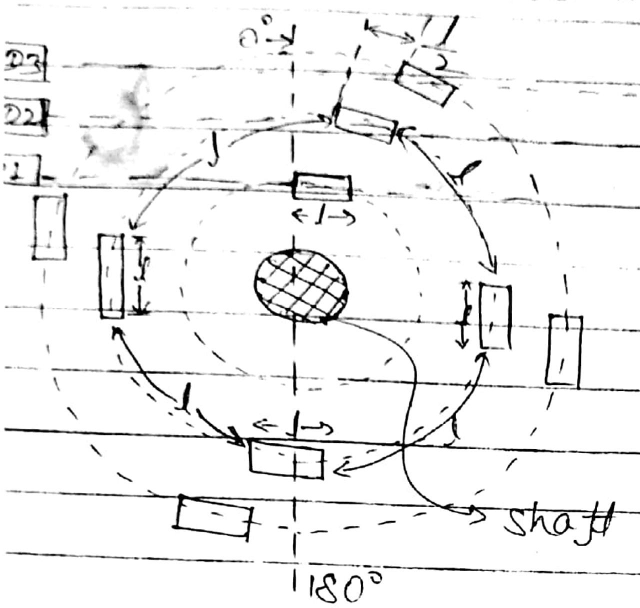
If the disc consist of N holes then the resolution is equals to

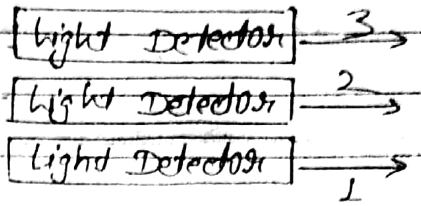
$$\boxed{\text{Resolution} = \frac{360^\circ}{N}}$$

Note: we can measure the shaft speed by using single - Track Incremental Encoder but we can't ~~measure~~ find the dirn of the shaft rotation (when no. is not given)

To find the dirn of shaft rotation we generally prefer Multi - Track Incremental Encoder

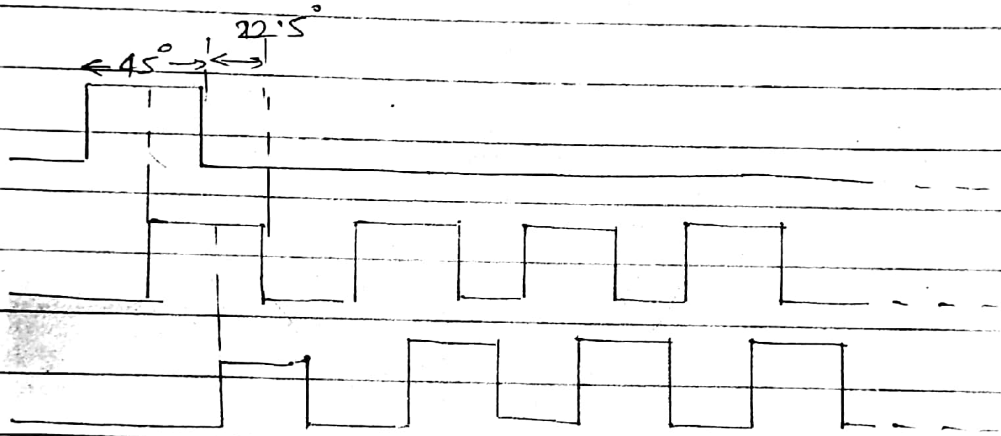
3 Track Incremental Encoder





$8 \longrightarrow 360°$

$1 \longrightarrow \frac{360}{8} = 45°$



As shown in the fig,

If the shaft rotates in ACW then pulses from Detector 2 ~~LEDs~~ leads pulses from Detector 3

If the shaft rotates in C.W dirn then pulses from Detector 3 leads the pulses from detector 2.

Digital Logic :-

	θ	D_1	D_2	D_3	θ	D_1	D_2	D_3
...tion .5°	0°+	1	0	0	67.5°+	0	0	1
	22.5°+	1	1	0	90°+	0	0	0
	45°+	0	1	1	112.5°+	0	1	0

360°

Absolute Type Encoder :-

These encoders are used to measure the <u>angular displacement</u> θ accurately compared to the <u>Incremental type</u> Encoders.
Absolute Encoders generates <u>Binary</u> output based on the angular position of the shaft.

~~Single-Track Absolute Encoder~~ :-

Binary Logic :-

Binary Logic
- → Single bit (b_0) → 0|1
- → Two bit ($b_1 \xrightarrow{} 0|1$ $b_0 \xrightarrow{} 0|1$)
- → Three bit ($b_2 \xrightarrow{} 0|1$ $b_1 \xrightarrow{} 0|1$ $b_0 \xrightarrow{} 0|1$)
- → N bit (b_{n-1} b_{n-2} ---- b_0)

MSB → Most Significant Binary

LSB → Least Significant Binary

b_{n-1} → MSB, b_0 → LSB

$\Downarrow$

2^N - Levels

Max^m Decimal Display $= 2^N - 1$.

Single bit logic (b_0)

$D = b_0 \cdot 2^0$

D	b_0
0	0.

Two bit Logic ($b_1 b_0$)

$D = b_1 2^1 + b_0 2^0$

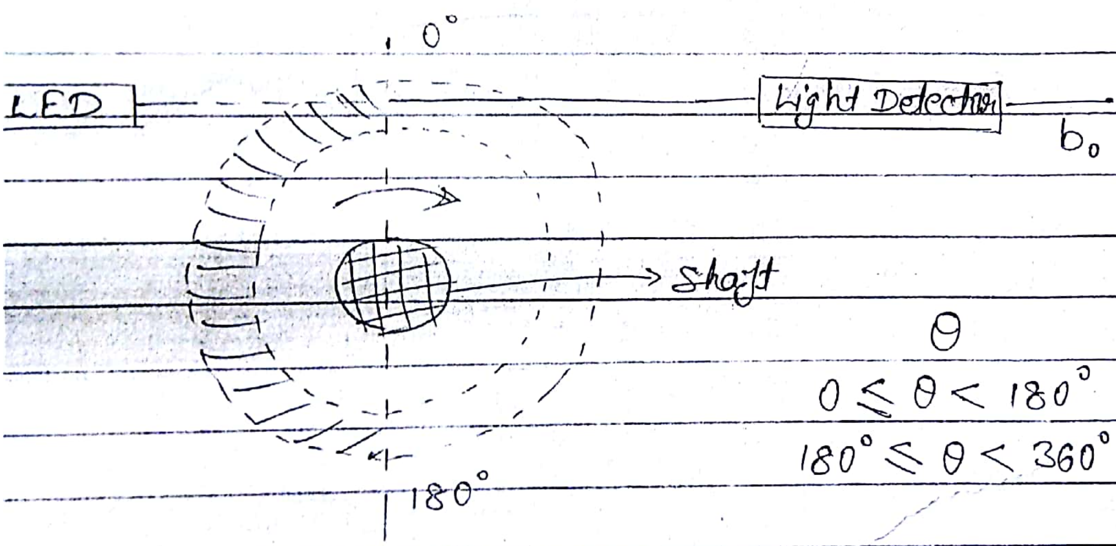
D	b_1	b_0
0	0	0
1	0	1
2	1	0
3	1	1

Three bit Logic ($b_2 b_1 b_0$)

$D = b_2 2^2 + b_1 2^1 + b_0 2^0$

D	b_2	b_1	b_0
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

Single - Track Absolute Encoder :-



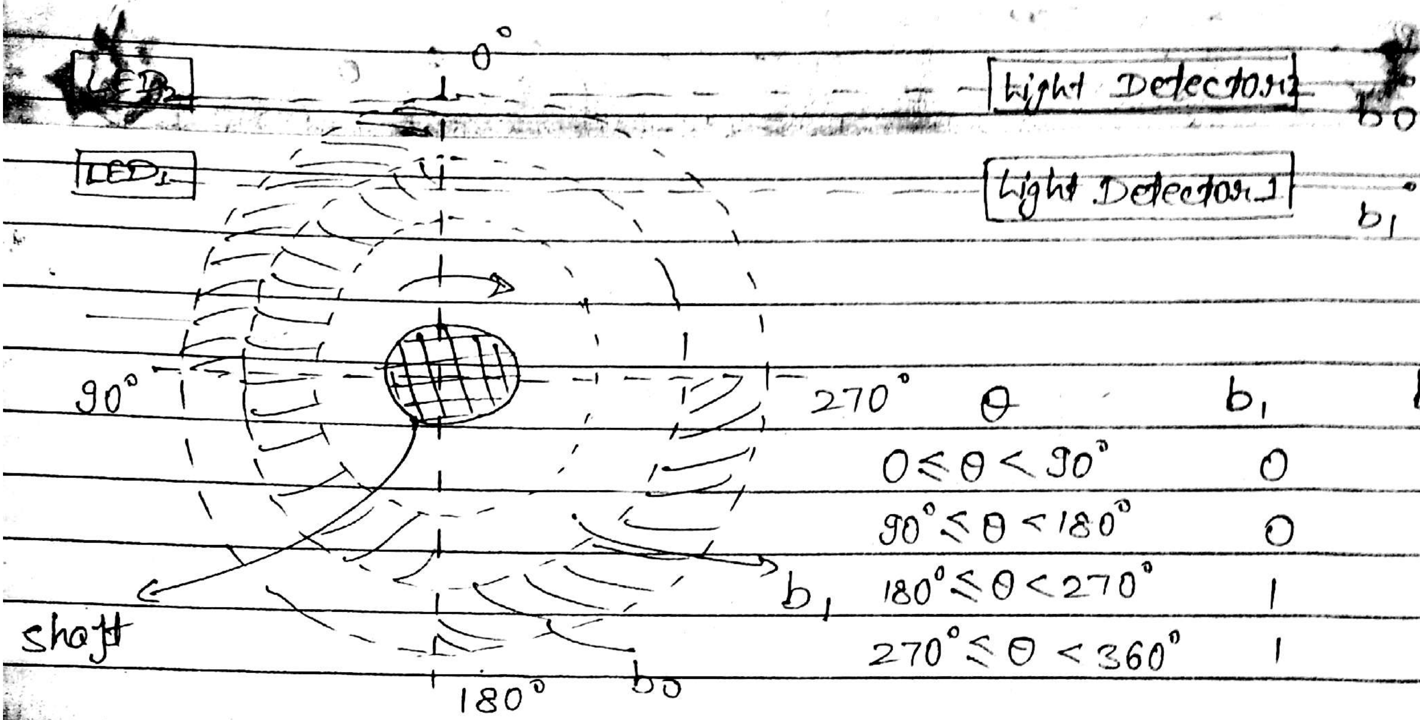
θ	b_0
$0 \leq \theta < 180^\circ$	0
$180^\circ \leq \theta < 360^\circ$	1

$$\text{Resolution} = \frac{360^\circ}{2^1} = 180^\circ$$

$$\Rightarrow \text{Resolution} = \frac{360^\circ}{2^N}$$

N – No of tracks

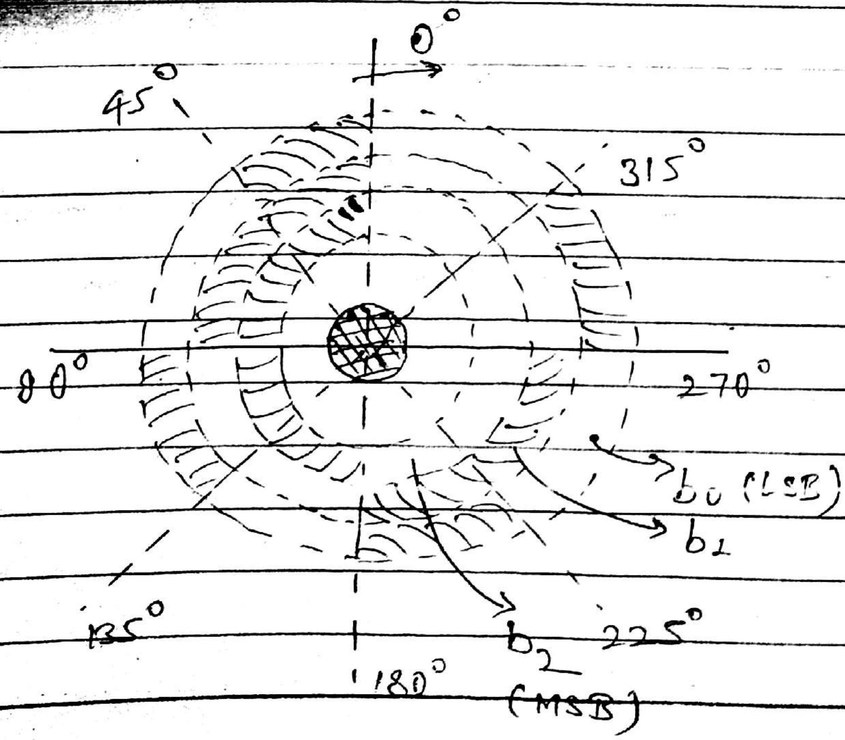
Two - Track



θ	b_1	b_0
$0 \le \theta < 90°$	0	0
$90° \le \theta < 180°$	0	1
$180° \le \theta < 270°$	1	0
$270° \le \theta < 360°$	1	1

$$\text{Resolution} = \frac{360°}{2^2} = 90°$$

Three - Track.



θ	b_2	b_1	b_0
$0 \le \theta < 45°$	0	0	0
$45° \le \theta < 90°$	0	0	1
$90° \le \theta < 135°$	0	1	0
$135° \le \theta < 180°$	0	1	1
$180° \le \theta < 225°$	1	0	0
$225° \le \theta < 270°$	1	0	1
$270° \le \theta < 315°$	1	1	0
$315° \le \theta < 360°$	1	1	1

$\{b_7 \quad b_6 \quad b_5 \quad b_4 \quad b_3 \quad b_2 \quad b_1 \quad b_0\} \rightarrow$ 8 bits $\rightarrow$ 1 word

8 Track → Resolution $= \frac{360°}{2^8} = \frac{360°}{256} = 1.40$

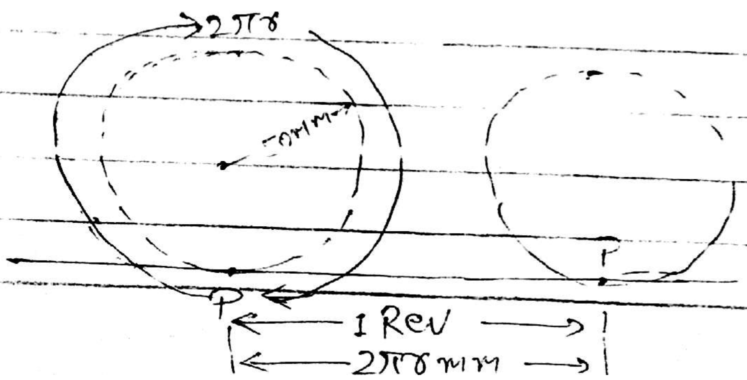
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1
0	0	0	0	0	0	1	0

Note :- For a N-track absolute encoder ~~rose~~

$$\boxed{\text{Resolution} = \frac{360°}{2^N}}$$

(8) A shaft encoder is to be used with 50 mm radius tracking wheel to monitor linear displacement. If the encoder produces 256 pulses / revolution, what will be the no. of pulses produced for a linear displacement of 200 mm?

Ans :->



1 Rev → 360° → 2πr mm → 256 Pulses

⇒ 2 × 3.14 × 50 mm

⇒ 314 mm → 256 Pulses

⇒ 200 mm → ≈ 163 Pulses.

GATE 2007

Q) A shaft encoder which is attached to a wheel ~~as~~ ~~the~~ has a sensitivity of 500 pulses / rev. A digital pulse counter connected to the shaft indicated 5500 pulses in 1 sec. The speed of the shaft in rpm is ___?___

Solⁿ: ⇒

500 pulses → 1 rev

5500 " → 11 rev

11 rev → 1 sec

660 rev ← 60 sec (1 min)

Shaft Speed = 660 rpm.

Q) A stepper motor which is rotating at 200 steps/rev, which is subjected to a input pulse rate of 1000 pulses/sec. If a 3-track absolute optical encoder is attached to the shaft then the binary display just after 1.25 secs is ___?___

1 Pulse = 1 rev.

200 steps → 1 rev

200 Pulses → 1 rev

1000 Pulses → 1 sec

$1\ sec^+ \rightarrow 5\ rev^+ \rightarrow 5 \times 360°^+$

↓

0 0 0

$1.25\ sec^+ \rightarrow 6.25\ Rev^+ \rightarrow 6.25 \times 360°$

↓

$(6 + 0.25) \times 360°$

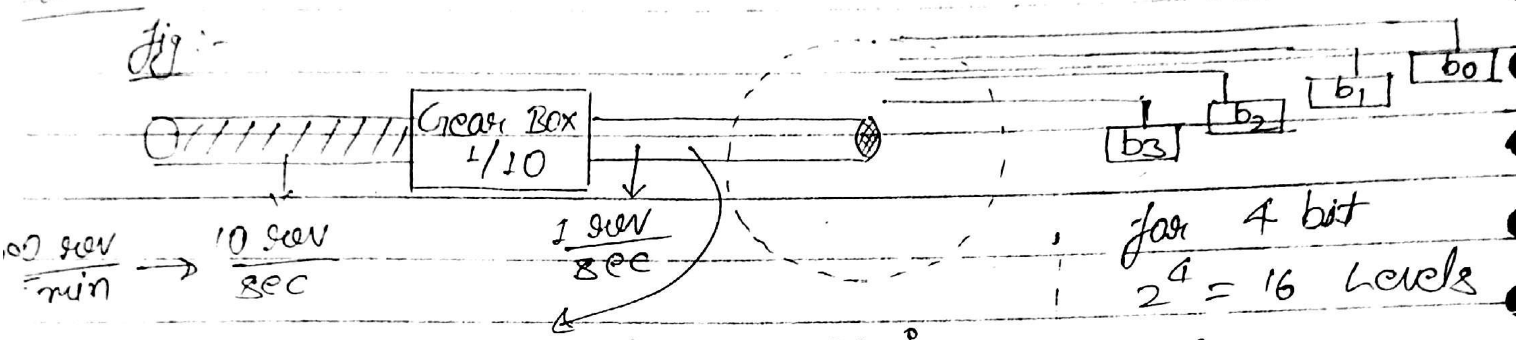
$6 \times 360° + 0.25 \times 360°$

0 1 0 ← $0° + 90° = 90°$

(8) A shaft, which is rotating at a speed of 600 rpm is connected to a gear box of ratio 1/10. Find the binary display indicated at the output side of the absolute encoder just after 0.25 sec is ______

Sol^n:→

fig:-



for 4 bit
$2^4 = 16$ Levels

$$1\ sec \longrightarrow 1\ rev \longrightarrow 360^\circ$$
$$0.25\ sec^+ \longrightarrow 0.25\ rev^+ \longrightarrow 90^{\circ +}$$

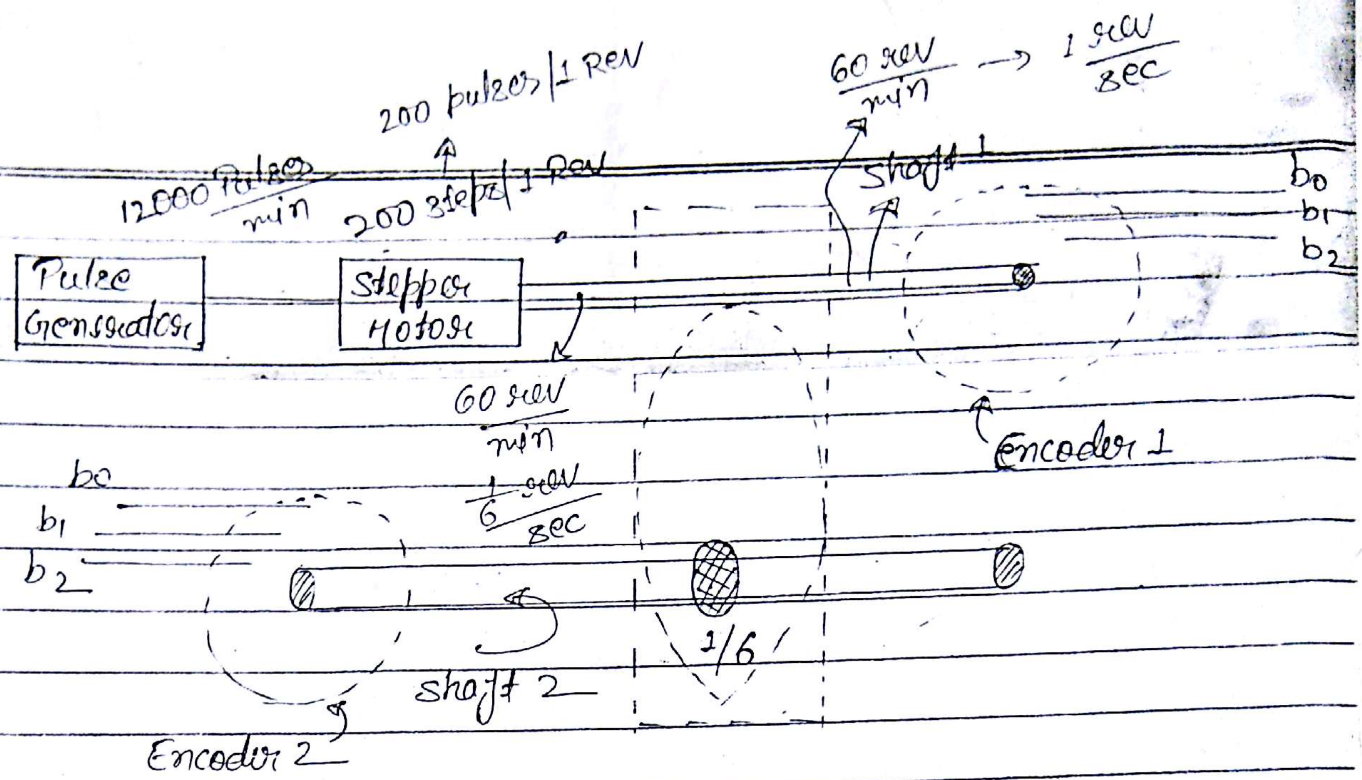
$\frac{360^\circ}{16} = 22.5^\circ$ (Resolution)

θ	b_3	b_2	b_1	b_0
$0 \le \theta \le 22.5^\circ$	0	0	0	0
$22.5^\circ \le \theta < 45^\circ$	0	0	0	1
$45^\circ \le \theta \le 67.5^\circ$	0	0	1	0
$67.5^\circ \le \theta < 90^\circ$	0	0	1	1
$90^\circ \le \theta < 112.5^\circ$	0	1	0	0

→ Ans.

(8) A stepper motor, which has a sensitivity of 200 ~~set~~ steps/rev is supplied pulses from pulse generator at a rate of 12000 pulses/min. If the stepper motor shaft is attached to a 3 track-absolute optical encoder and a gear ratio of 1/6 as shown in the fig. Shaft-2 ~~to~~ is passed through a gear and connected to 2nd encoder as shown in the fig.

(i) Find the min. time required for for the encoders to show the same binary display after the 1st sec?



t	Shaft 1	Shaft 2
@ 1 sec$^+$	⇒ 1 Rev$^+$	⇒ $\frac{1}{6}$ Rev$^+$
	⇒ 360°	⇒ 60°$^+$
	⇒ 000	⇒ 001
@ 1.125 sec$^+$	⇒ 1.125 Rev$^+$	⇒ 1.125 ($\frac{1}{6}$ Rev$^+$)
	⇒ 1.125 × 360°$^+$	⇒ 1.125 × 60°$^+$
	⇒ 405°$^+$	⇒ 67.5°$^+$
	⇒ 001	001

	shaft 1	Shaft 2
@ 1sec$^+$	360°$^+$	60°$^+$
	000	001
@ 1.125 sec$^+$	→ +45°$^+$	67.5°
	405°$^+$	001
	001	

∴ After 1st sec → 0.125 sec required.

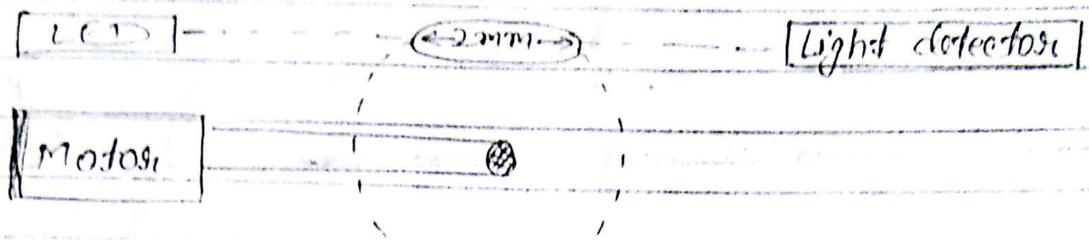
GATE 2009

(8) A measurement system for the rotational speed of the motor is as shown in the fig. The system consist of a disc attached to motor shaft, which is running at 120 rpm. If the dia. of the circular hole is 2 mm as shown in the fig and the dia of the total disc is 200 mm. Then find the %ge of duration light passes through the hole in 1 rev.

Soln:-

$$\%\text{ of duration Light Passes} = \frac{2\,mm}{\pi d\,mm} \times 100$$

$$= 0.318\ \%$$


LCD
2mm
Light detector
Motor