COMPUTER SCIENCE

Computer Organization and Architecture

Secondary Memory & IO Interface

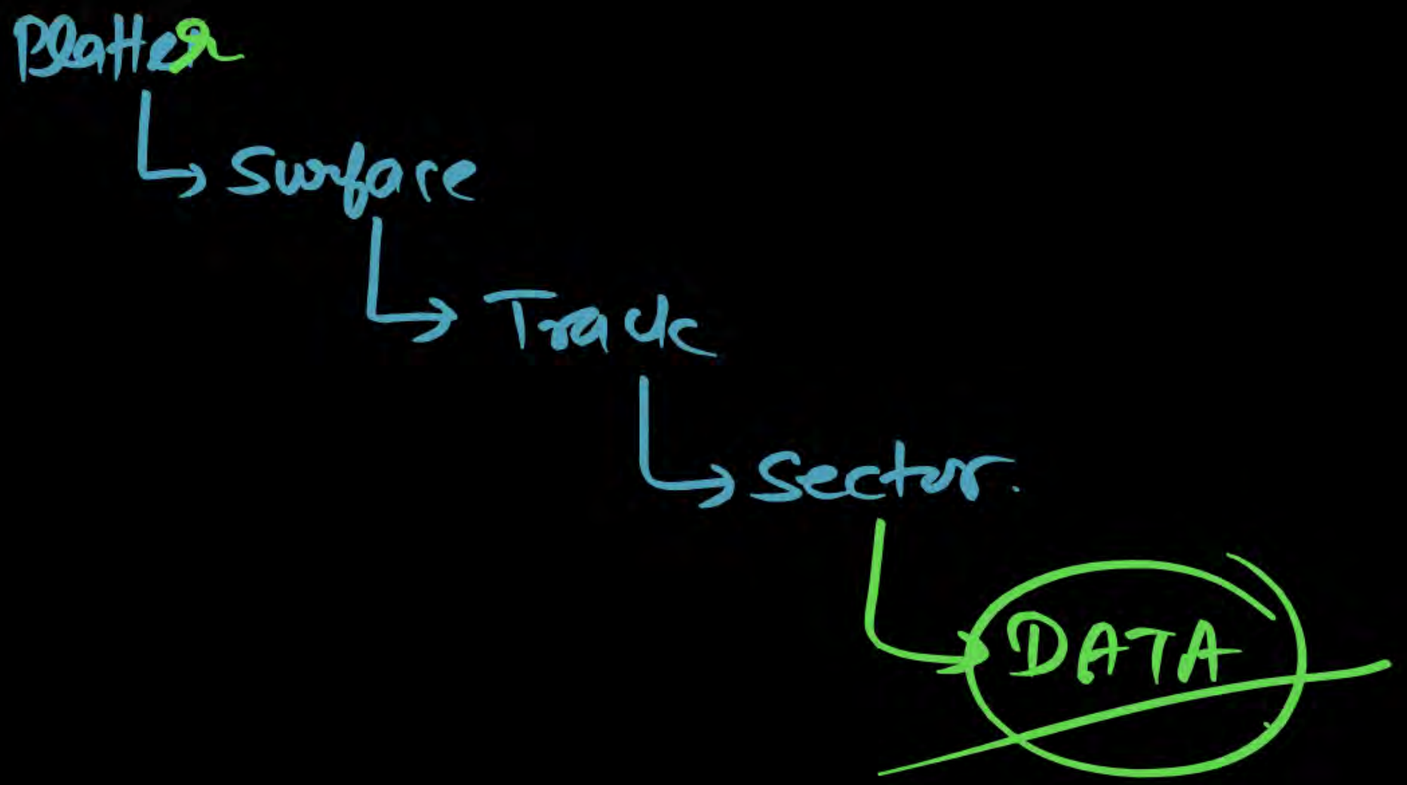
Lecture_03

Vijay Agarwal sir

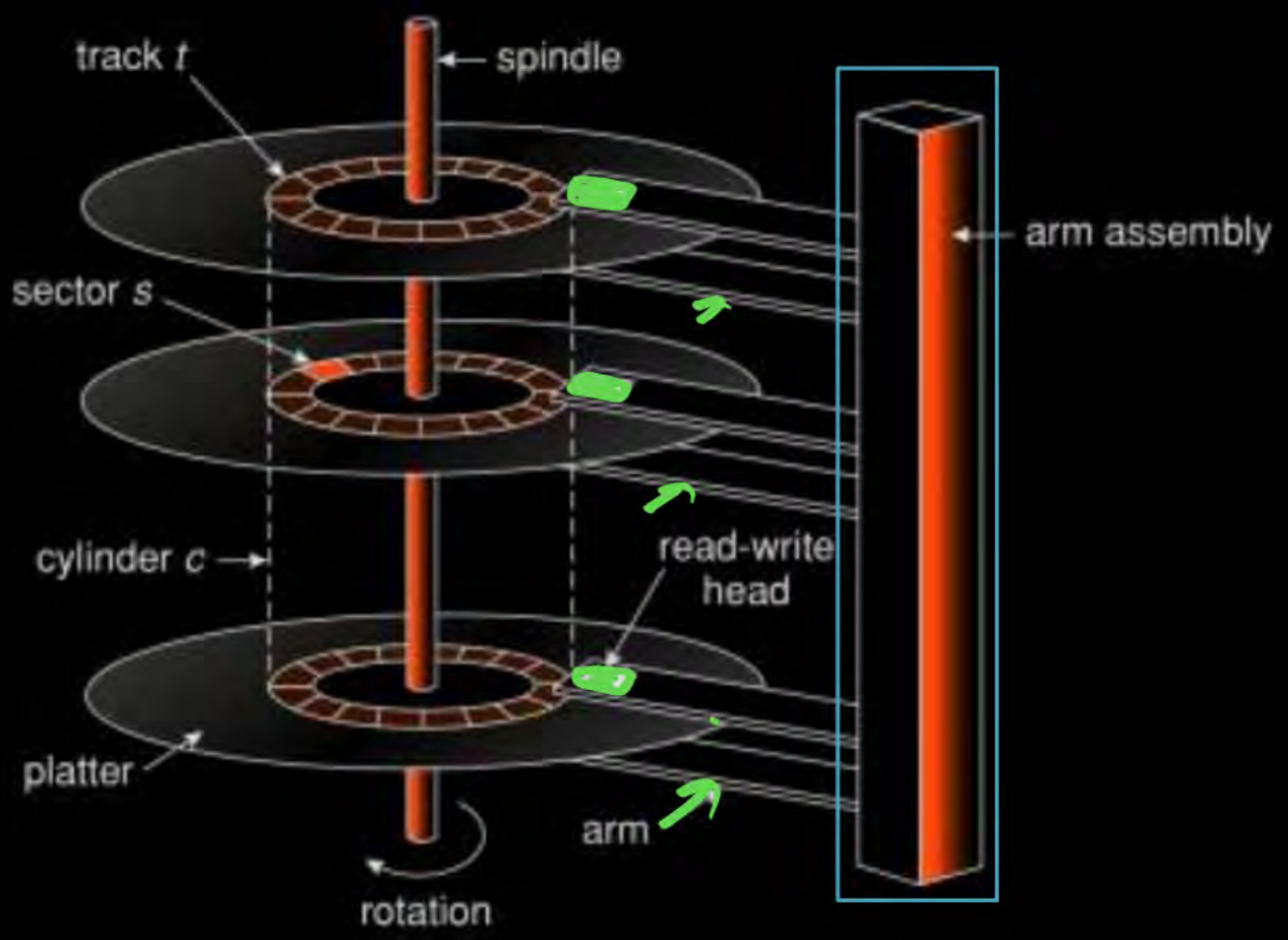
01 Disk Addressing

02 IO Organization

- Disk Concept Capacity.
- Disk Access time
  - S.T
  - R.T
  - D.T.T
- & Data transfer Rate


Platter
Surface
Track
Sector
DATA

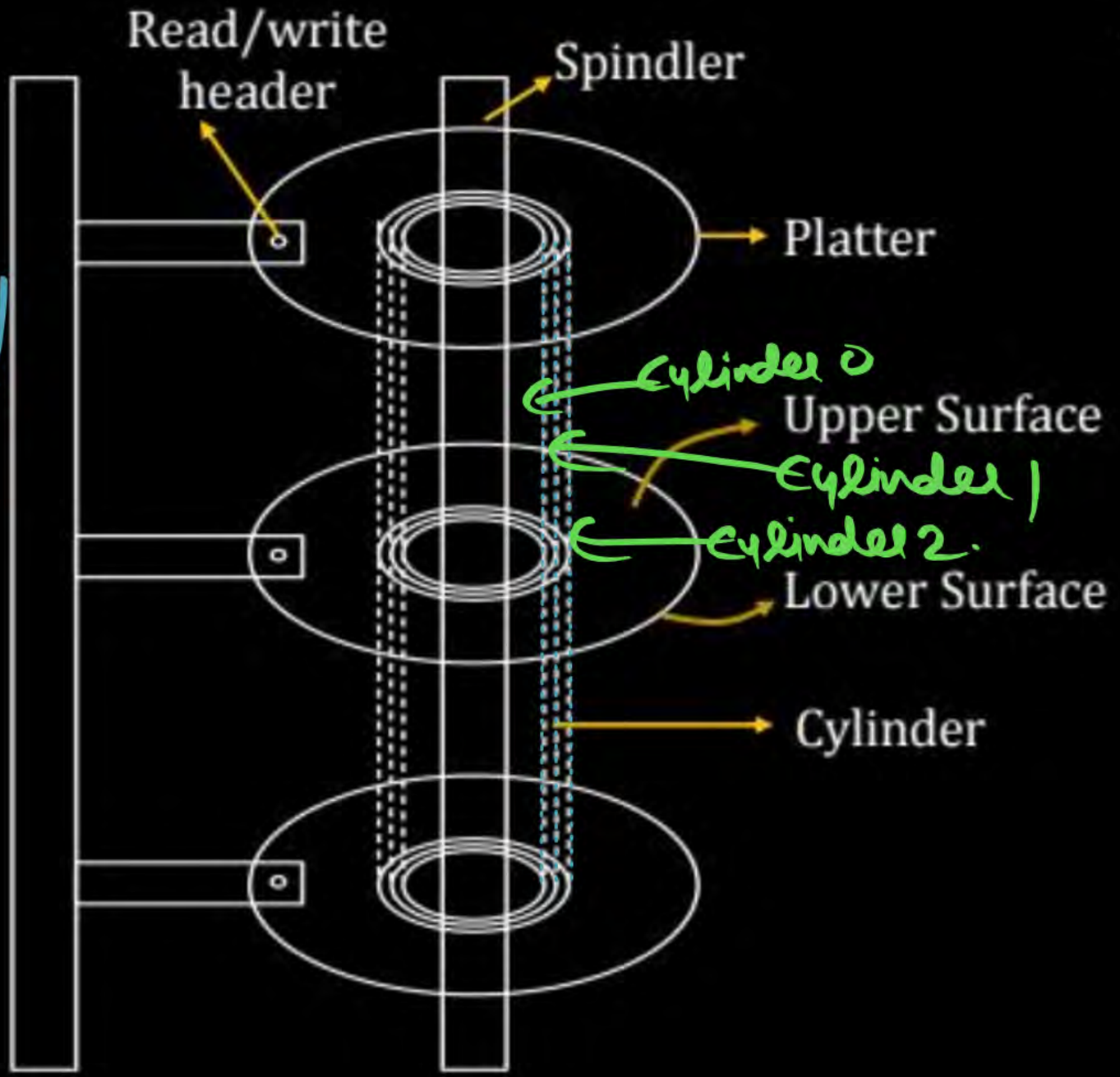
Moving - Head Disk Mechanism



Disk - structure

File Size = 1GB / 2GB / GB's

1 Track Size = 32MB.



Magnetic disks provide the bulk of secondary storage for modern computer systems. Conceptually, disks are relatively simple.

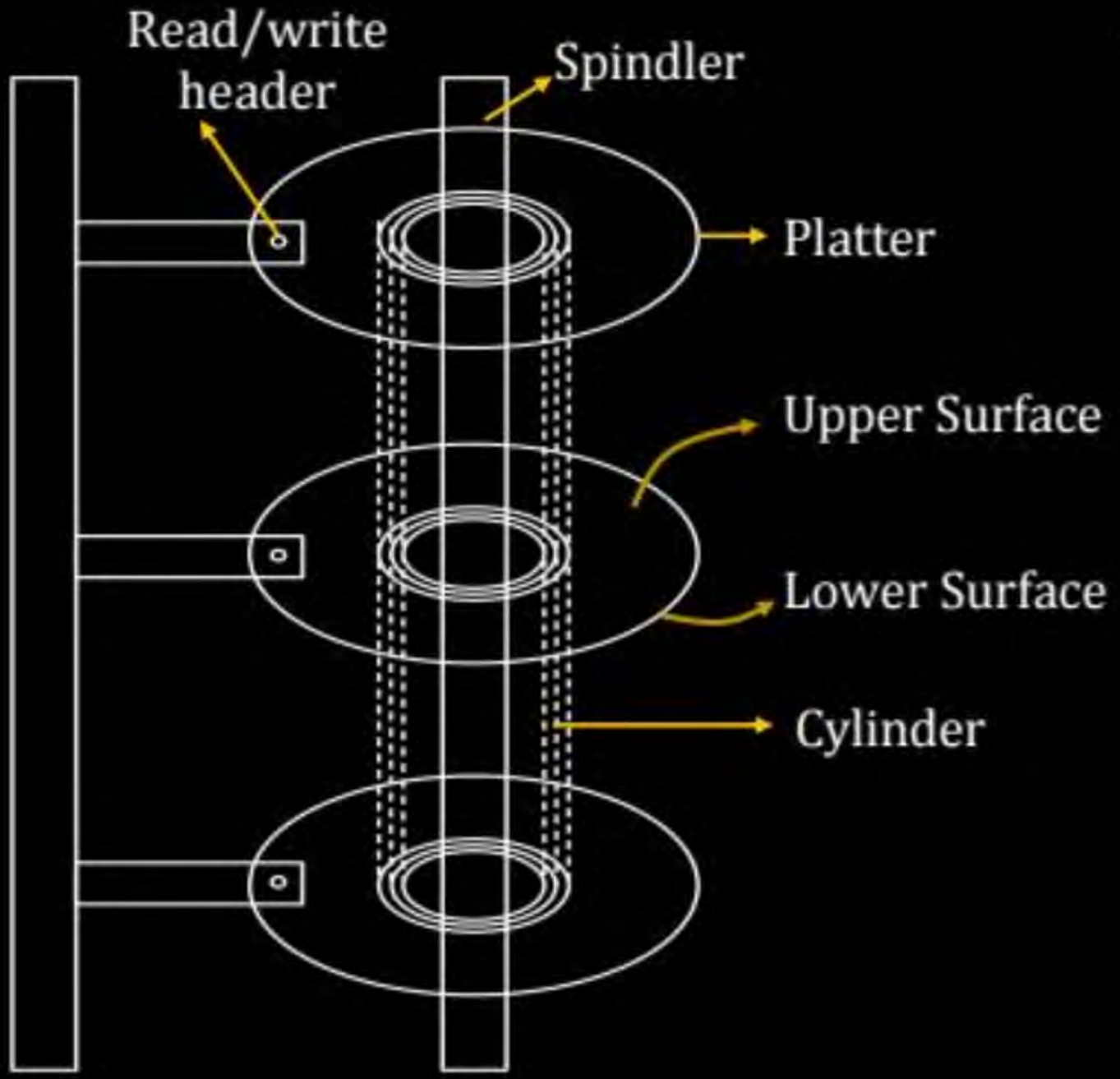
Each disk platter has a flat circular shape, like a CD. Common platter diameters range from 1.8 to 3.5 inches.

The two surfaces of a platter are covered with a magnetic heads are attached to a disk arm that moves all the heads as a unit.

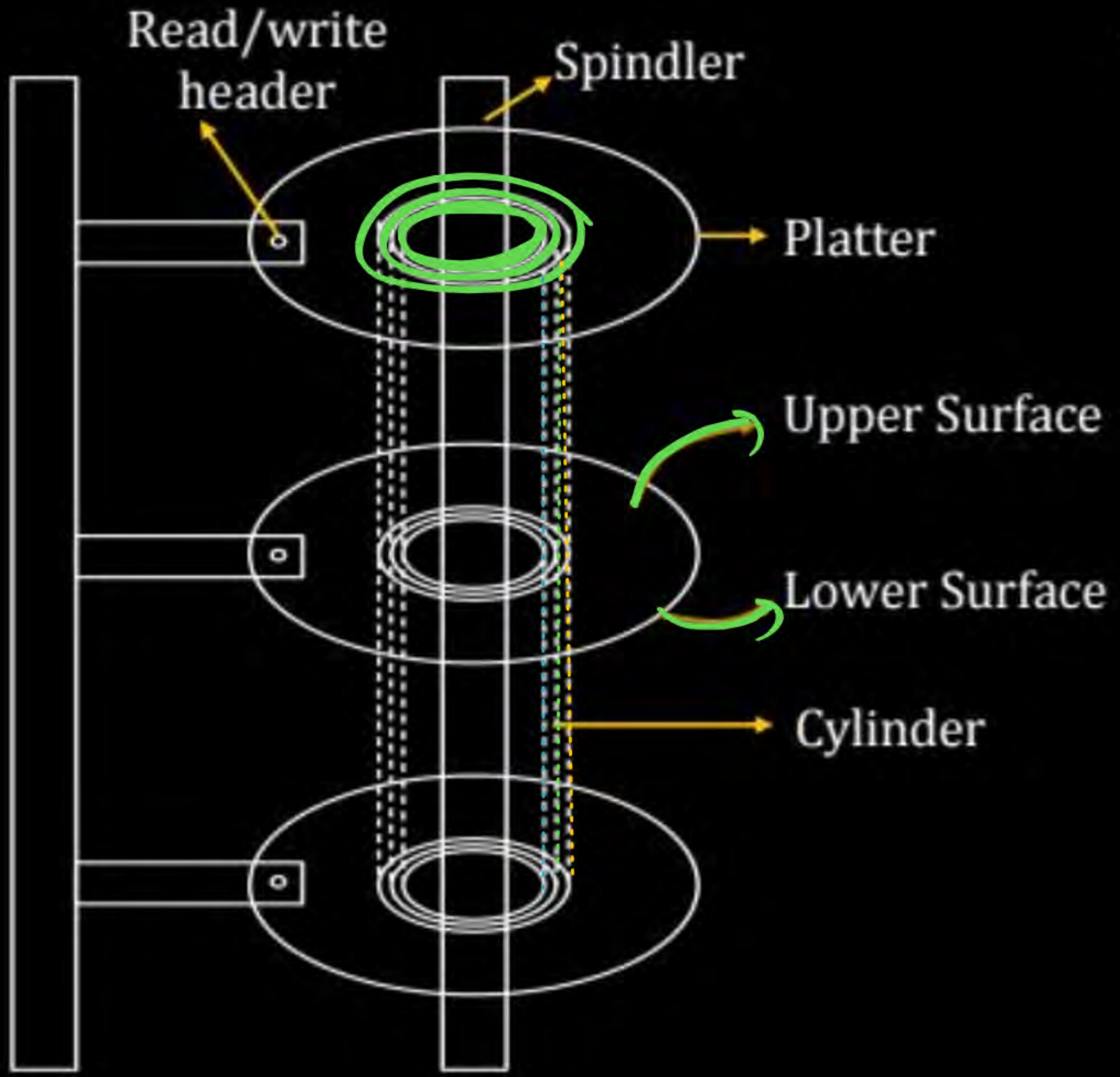
The surface of a platter logically divided into circular tracks, which are subdivided into sectors.

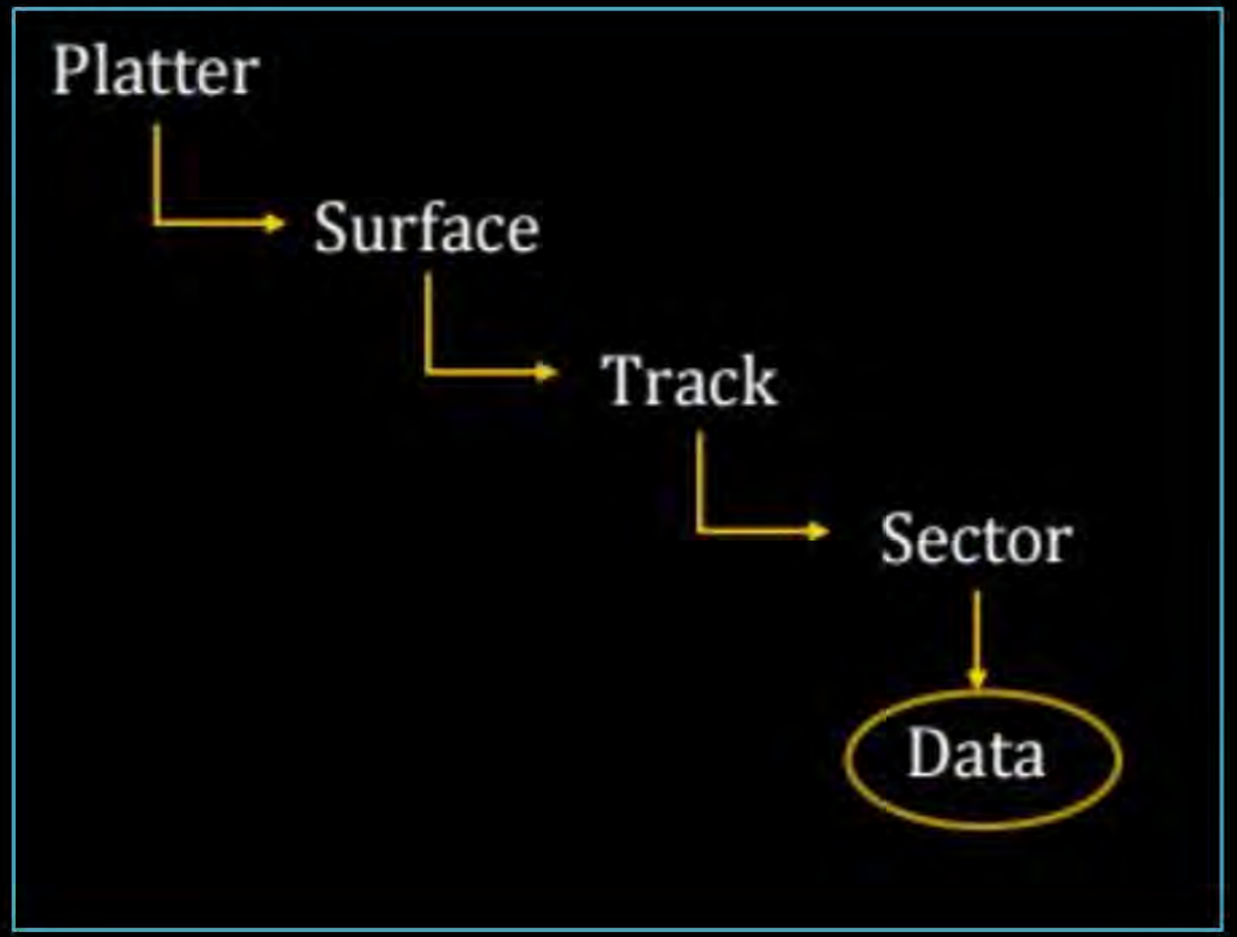
The set of tracks that are at one arm position makes up a cylinder. There may be thousand of concentric cylinders in a disk drive, and each track may contain hundreds of sectors. The storage capacity of common disk drives is measured in gigabytes.

Disk - structure

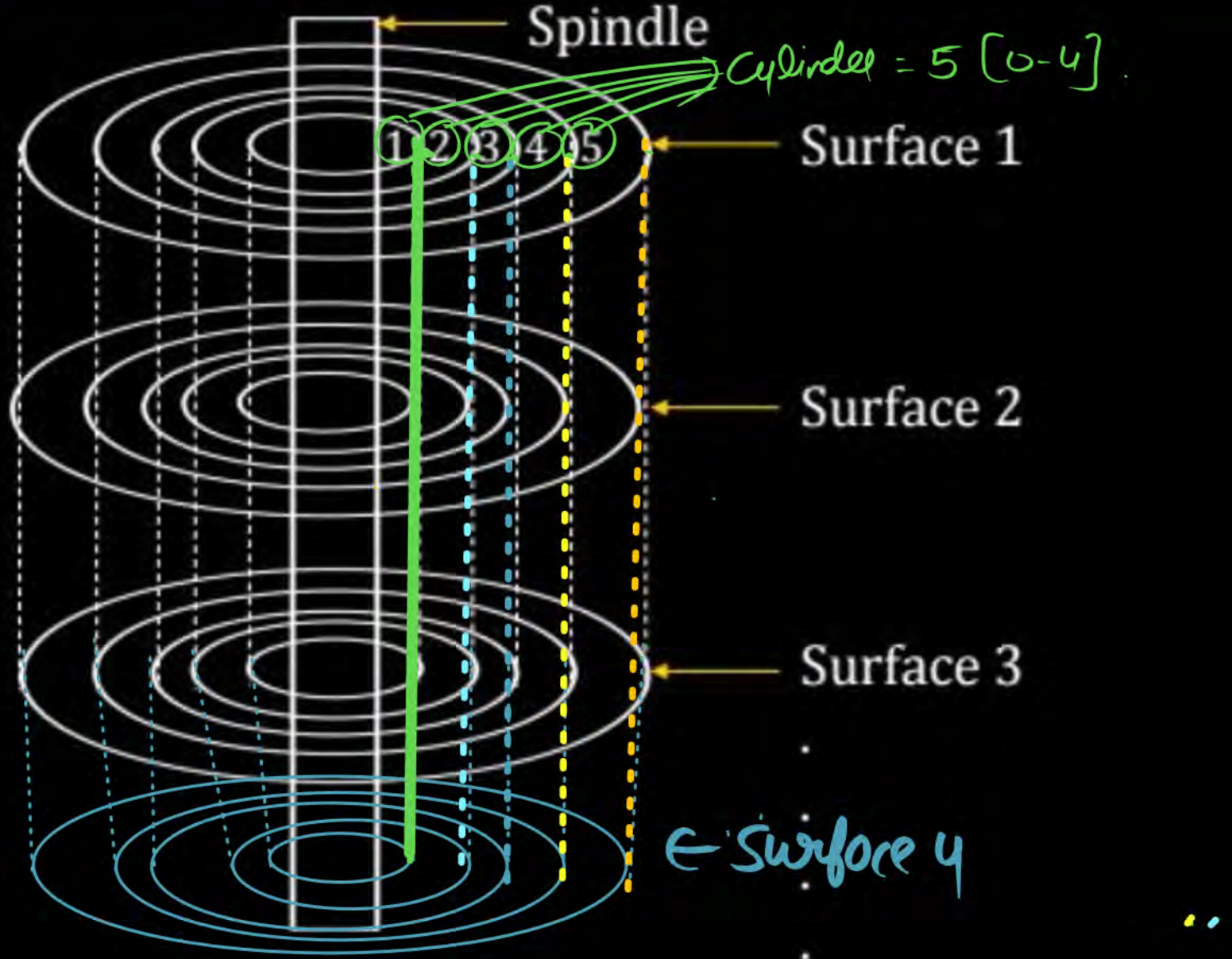


Disk - structure




Platter
Surface
Track
Sector
Data

Same track number in all the surface will form a cylinder.



WHY cylinder ?

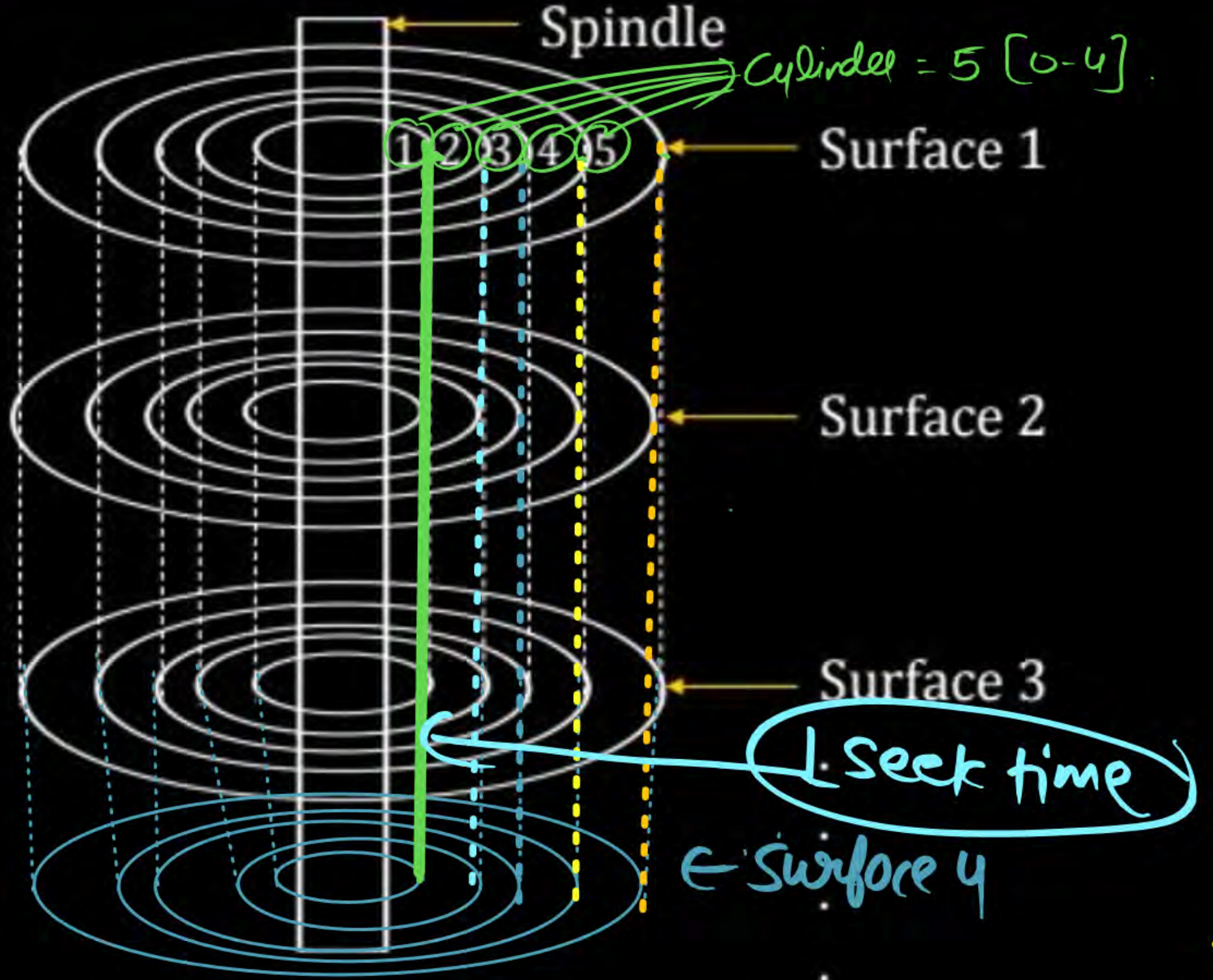
Q) WHY Cylinder ? (Advantage of the Cylinder). ?

Soln) Assume we have a very Large file Size (in GB) & 1 Track Size is 32 MB.

If we Store a file on a Disk then We Can Store 32MB on One Track then we have to go Next track of the Same Surface So storing Data So we have to Suffer Unnecessary very High Seek latency (time).

Soln) So we Store the Data Cylinder Wise. Bz we know Each Surface R/W Head Point to Same address at a time.

Same track number in all the surface will form a cylinder.



So first we Store (track '0' of Surface 0)

1000 platter

2X1000 = 2000 Surface

track 0 1

track 0 2

.. .. 3

.. .. 4

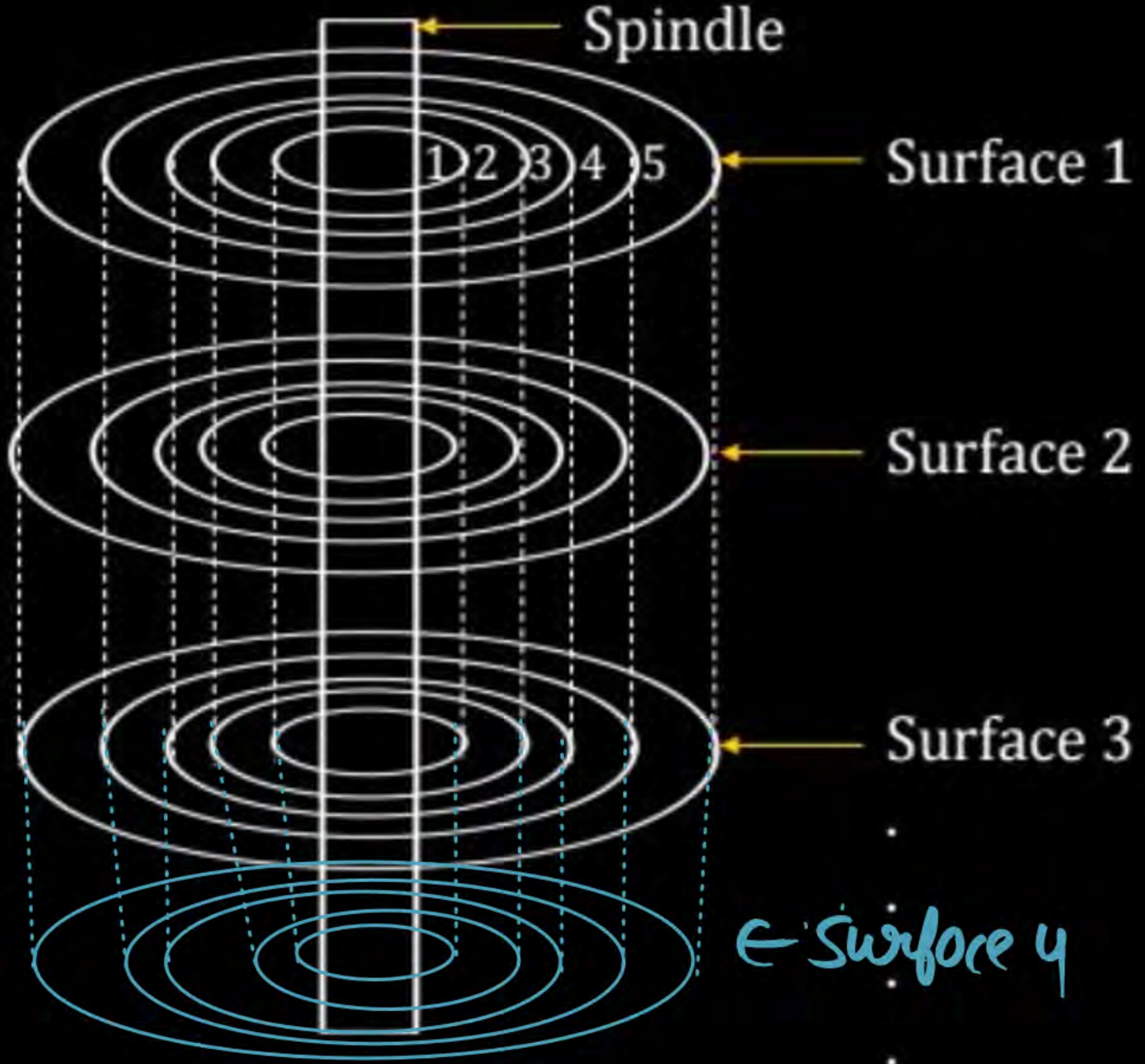
track 0 of Surface 2000

) 1 Seek time (Latency)

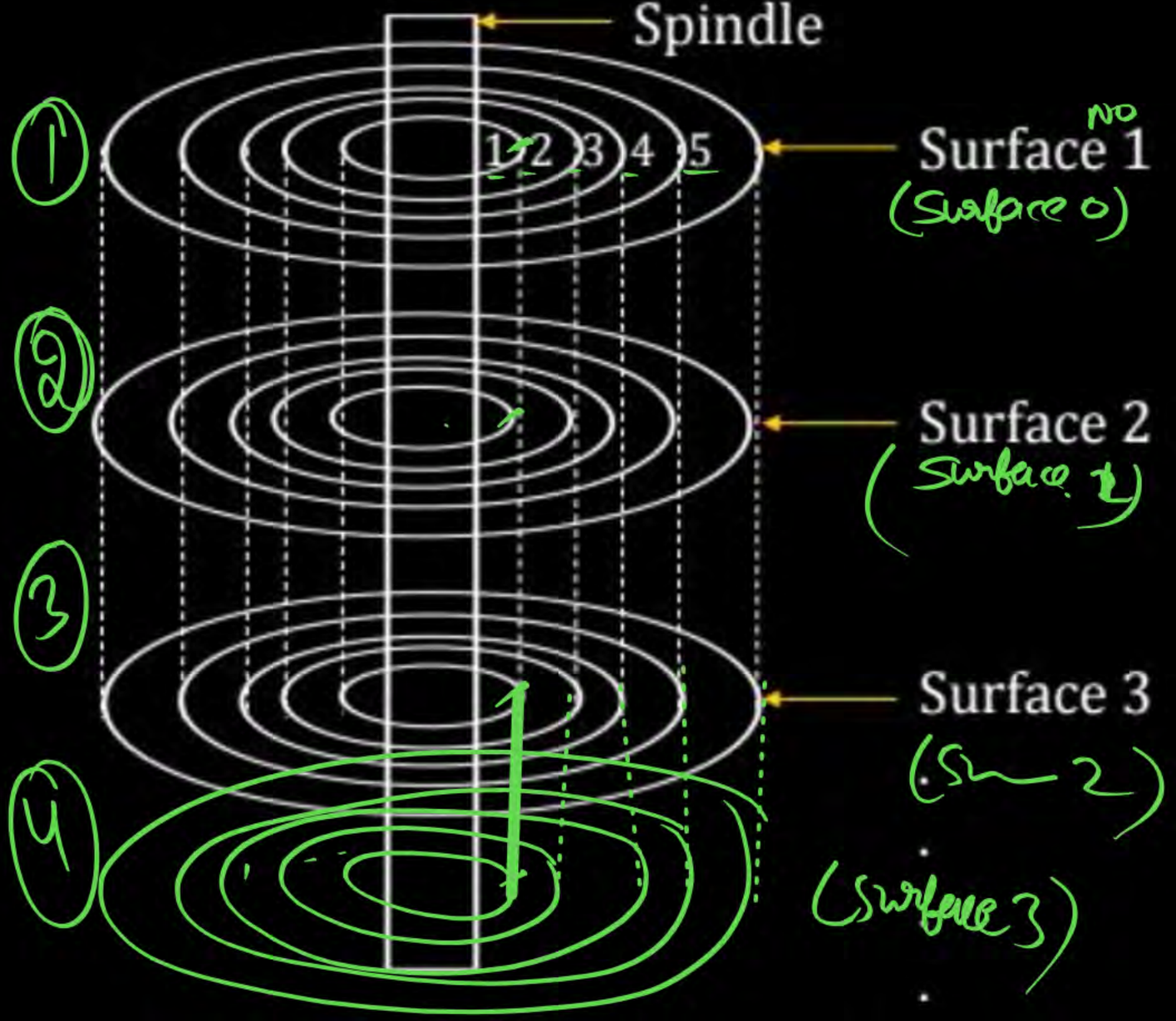
With the Help of cylinder we Can Store 2000 Track Data in One Seek time.

2000 Surface of or track '0' Data Stored in 1 Seek time.

Same track number in all the surface will form a cylinder.



Same track number in all the surface will form a cylinder.



Number of Platter =2

#Surface = 4

Number of Surface =4

Number of track Per Surface =5 (0-4)

Number of Cylinder = 5 (0-4)

Number of Sector Per track =8

Number of Sector Per Cylinder= 4X8 = 32

Platter = 2

Surface = 2 × 2 = 4 Surface [0 to 3].

Number of track Per Surface = 5

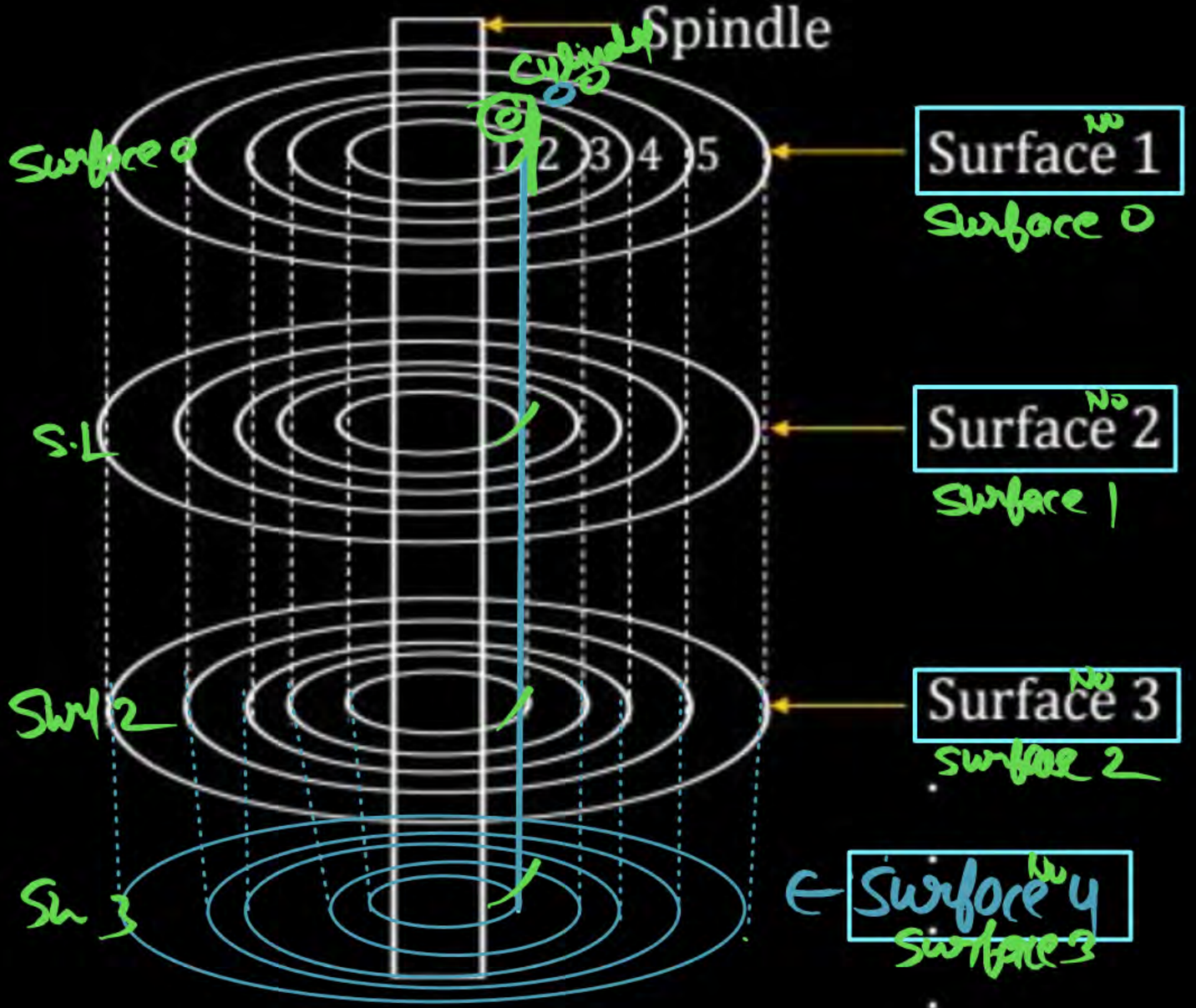
Number of cylinder = 5 [0 to 4].

Number of Sector Per track = 8.

Number of Sector Per cylinder = 4 × 8

= 32 sector/cylinder

Same track number in all the surface will form a cylinder.



Cylinder 0

Surface 0 : Track 0 = 8 Sector

Surface 1 : Track : 0 ⇒ 8 sector

Surface 2 : Track 0 ⇒ 8 Sector

Surface 3 : Track 0 = 8 Sector

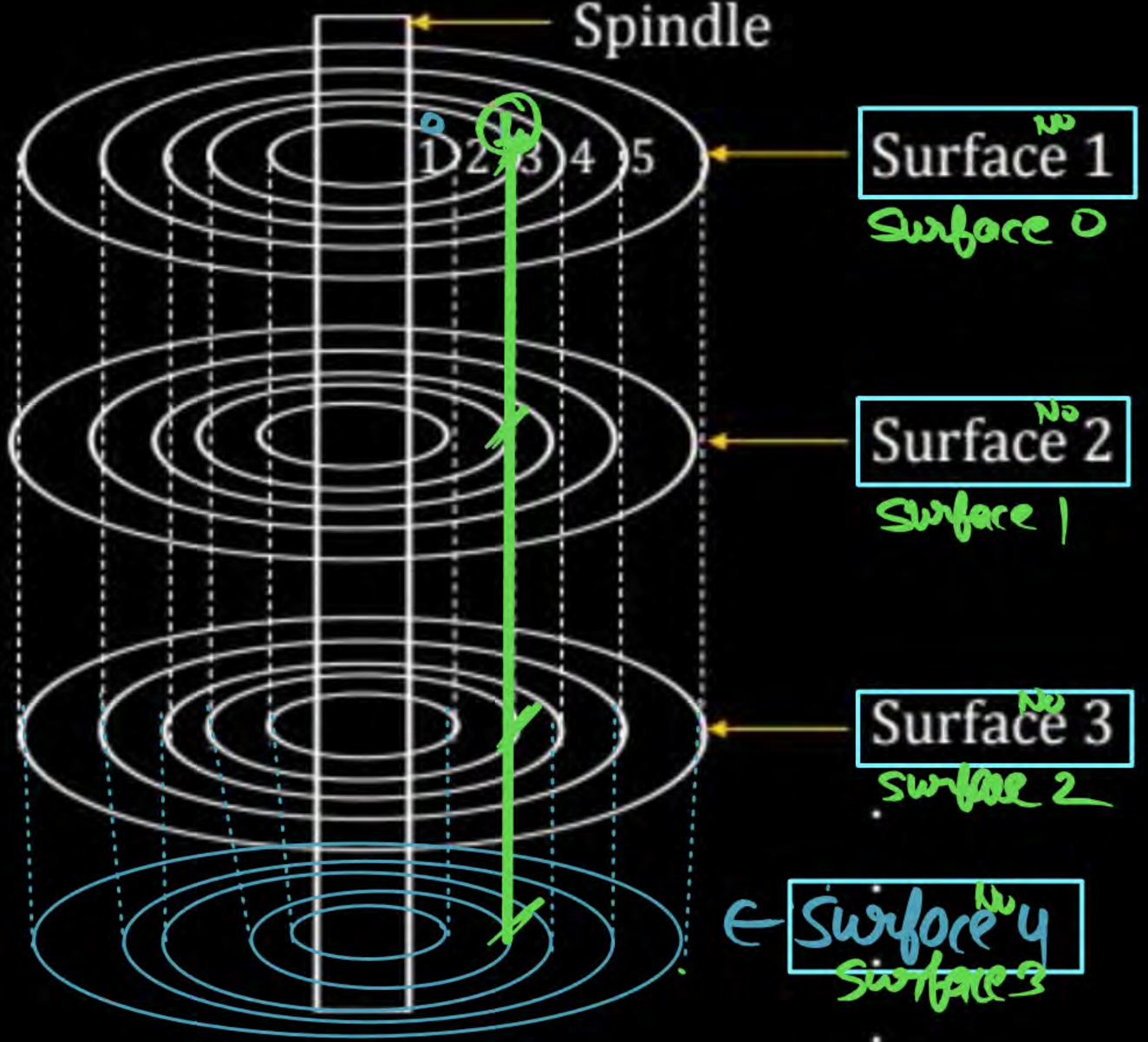
#Sector per Cylinder = 4 X 8

= 32 Sector per cylinder

#Sector per Cylinder = #Surface X #Sector per Track.

4 X 8 = 32 S/c.

Same track number in all the surface will form a cylinder.



Cylinder 1

Surface 0 : Track 1 = 8 Sector

Surface 1 : Track 1 ⇒ 8 sector

Surface 2 : Track 1 ⇒ 8 Sector

Surface 3 : Track 1 = 8 Sector

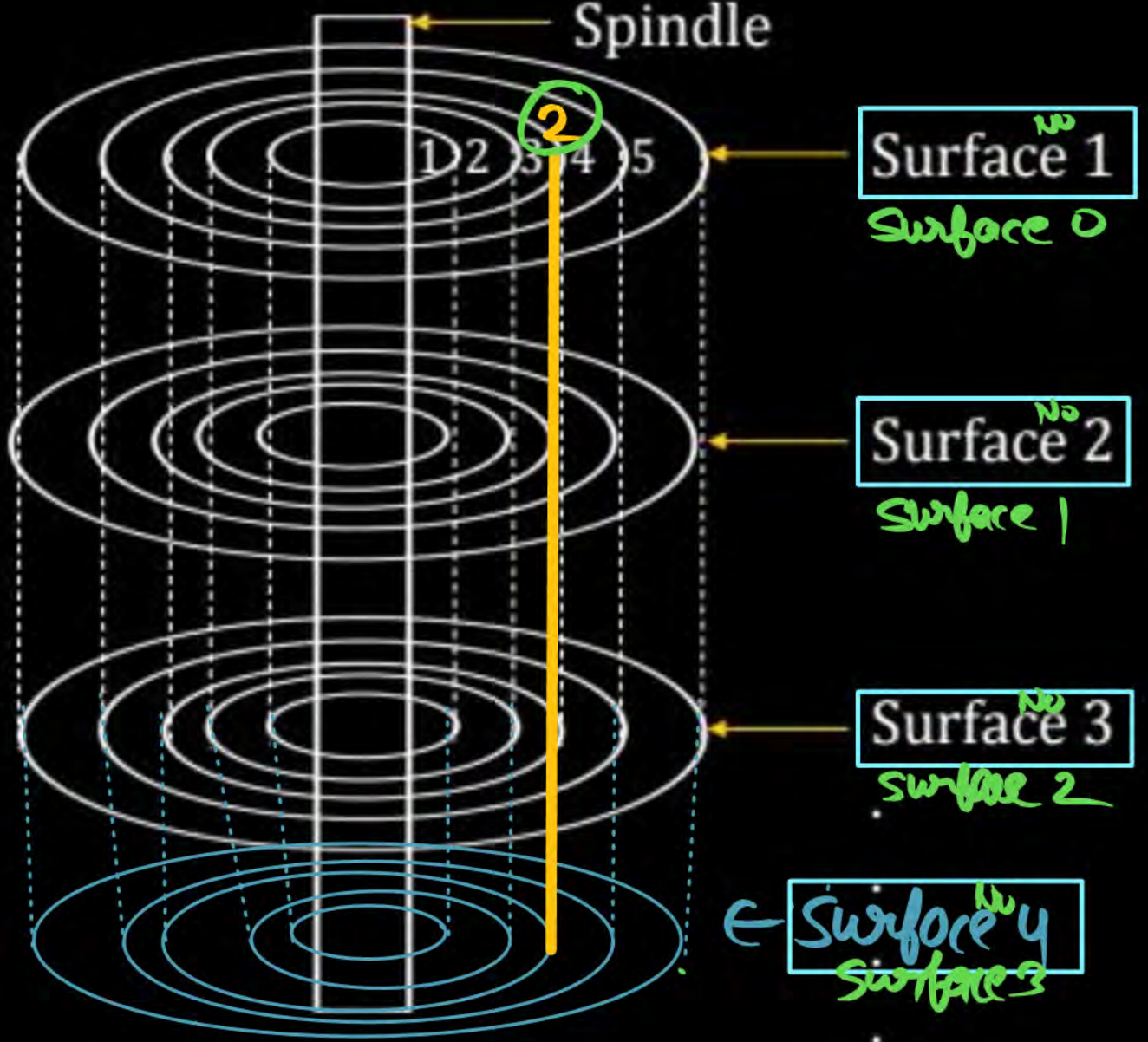
#Sector per Cylinder = 4 X 8

= 32 Sector per cylinder

#Sector per Cylinder = #Surface X #Sector per Track.

4 X 8 = 32 S/c.

Same track number in all the surface will form a cylinder.



Cylinder 2.

Surface 0 : Track 2 = 8 Sector

Surface 1 : Track 2 ⇒ 8 sector

Surface 2 : Track 2 ⇒ 8 Sector

Surface 3 : Track 2 = 8 Sector

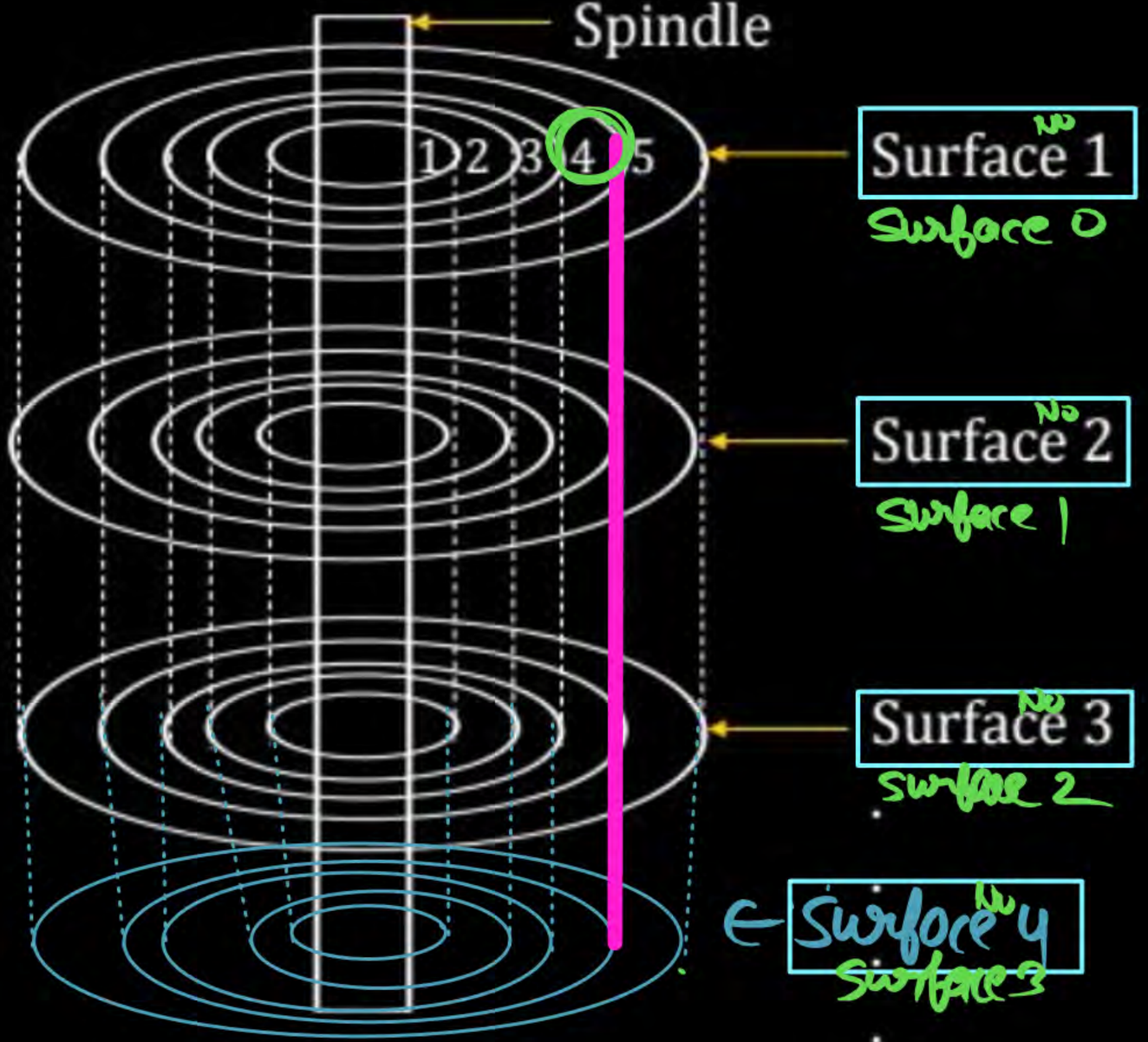
#Sector per Cylinder = 4 X 8

= 32 Sector per cylinder

#Sector per Cylinder = #Surface X #Sector per Track.

4 X 8 = 32 S/c.

Same track number in all the surface will form a cylinder.



Cylinder: 3

Surface 0 : Track 3 = 8 Sector

Surface 1 : Track 3 ⇒ 8 sector

Surface 2 : Track 3 ⇒ 8 Sector

Surface 3 : Track 3 = 8 Sector

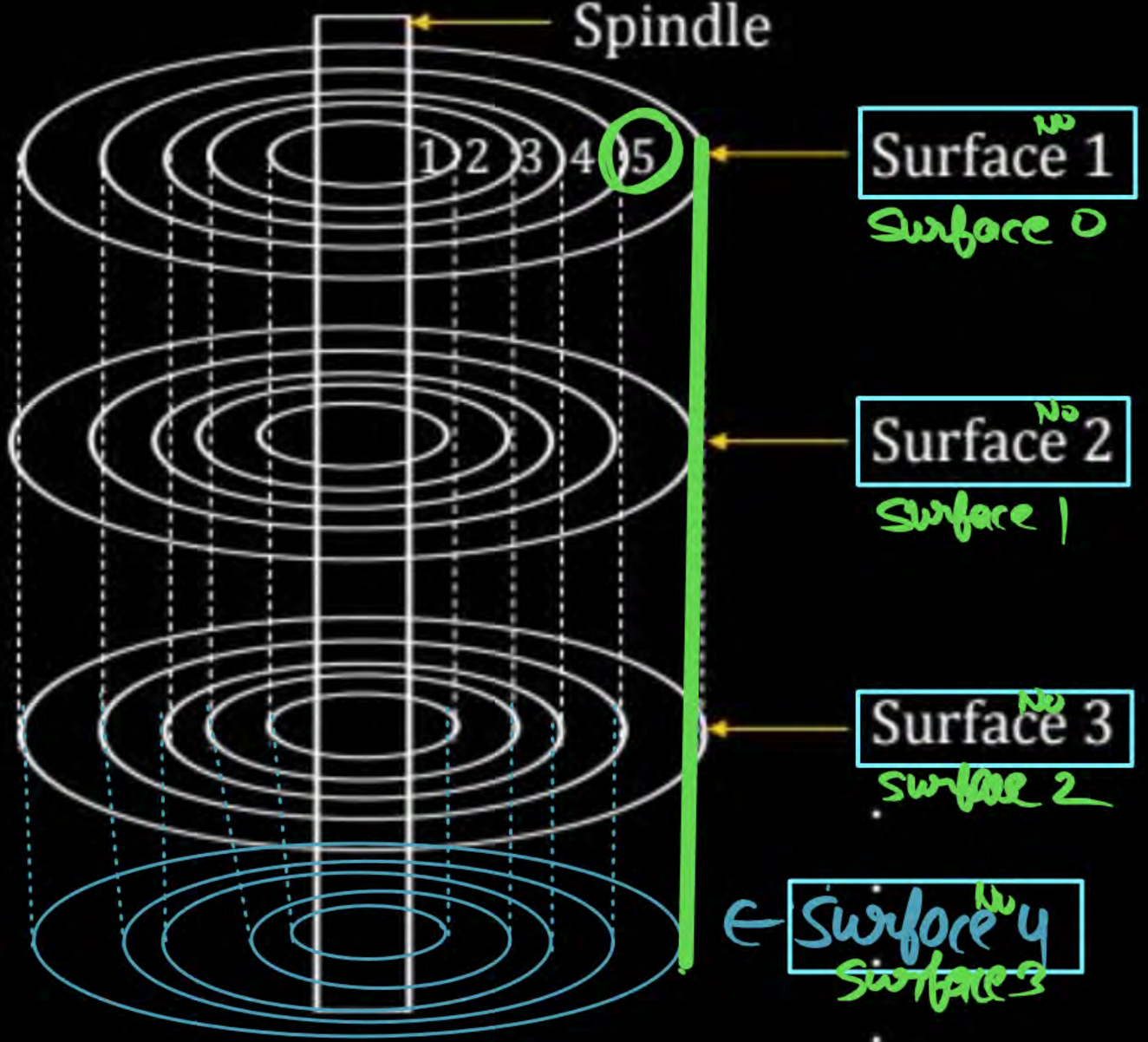
#Sector per Cylinder = 4 X 8

= 32 Sector per cylinder

#Sector per Cylinder = #Surface X #Sector per Track.

4 X 8 = 32 S/c.

Same track number in all the surface will form a cylinder.



Cylinder : 4

Surface 0 : Track 4 = 8 Sector

Surface 1 : Track 4 ⇒ 8 sector

Surface 2 : Track 4 ⇒ 8 Sector

Surface 3 : Track 4 = 8 Sector

#Sector per Cylinder = 4 X 8

= 32 Sector per cylinder

#Sector per Cylinder = #Surface X #Sector per Track.

4 X 8 = 32 S/c.

In this example Each track Contain 8 Sector.

this is for Ist Cylinder [Cylinder 0]

Note

first we traversed [Cross] all Sector of track 0 (Ist track) of Surface 0.

then we traversed [Cross] all Sector of track 0 of Surface 1

then we traversed [Cross] all Sector of track 0 of Surface 2.

then we traversed [Cross] all Sector of track 0 of Surface 3.

In this example Each track Contain 8 Sector.

this is for 2nd Cylinder [Cylinder 1]

Note

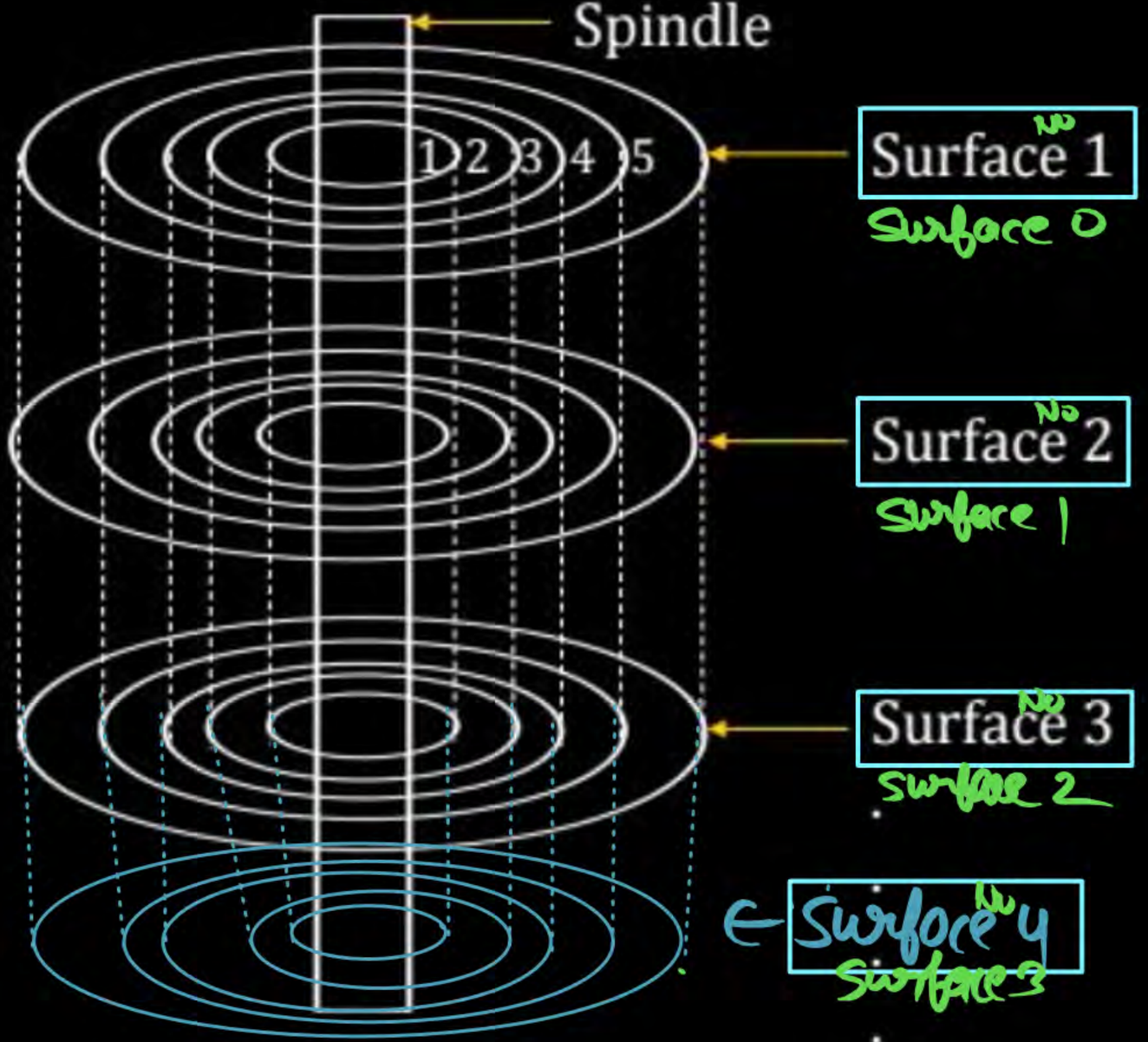
first we traversed [cross] all Sector of track 1 (1st track) of Surface 0.

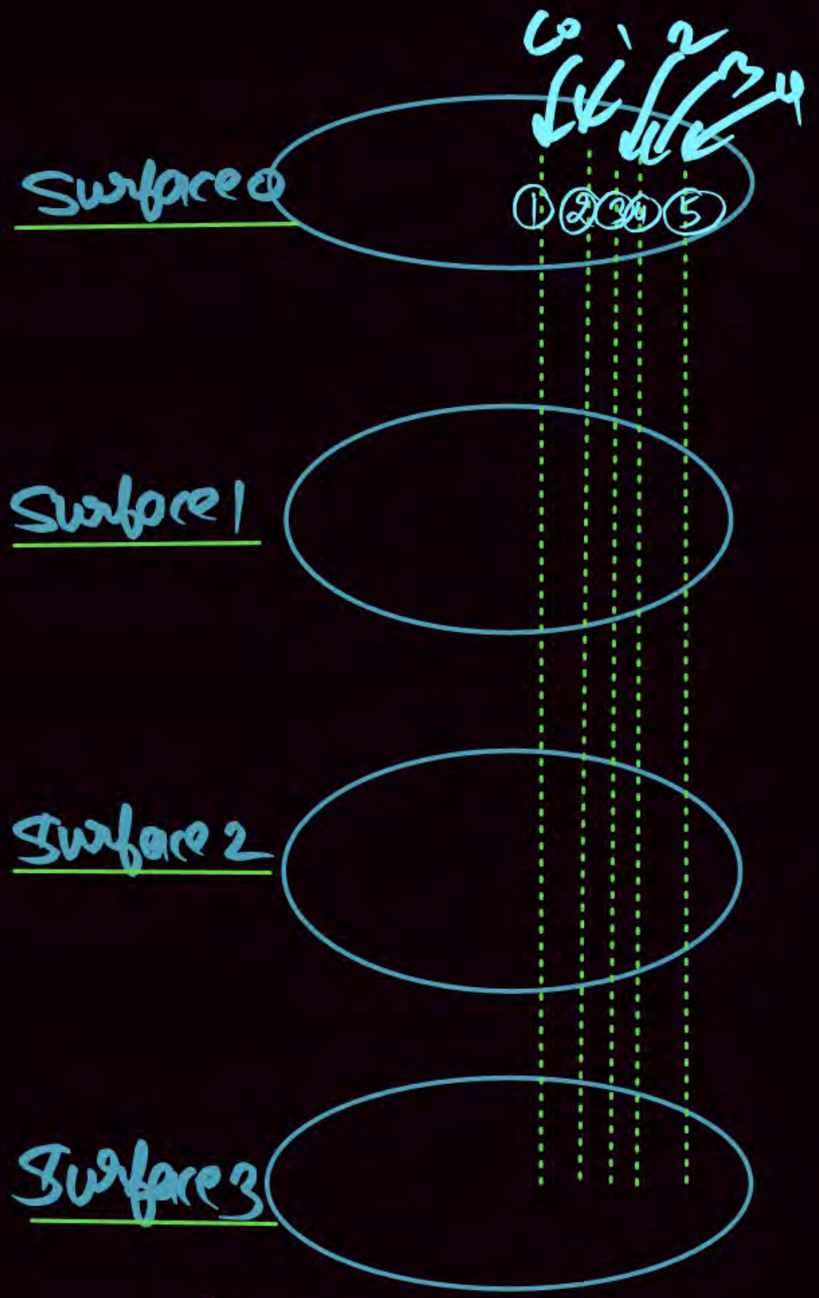
then we traversed [cross] all Sector of track 1 of Surface 1

then we traversed [cross] all Sector of track 1 of Surface 2.

then we traversed [cross] all Sector of track 1 of Surface 3.

Same track number in all the surface will form a cylinder.





2 Platter ⇒ 4 Surface

Track Per Surface = 5

Sector Per track = 8

Sol^n

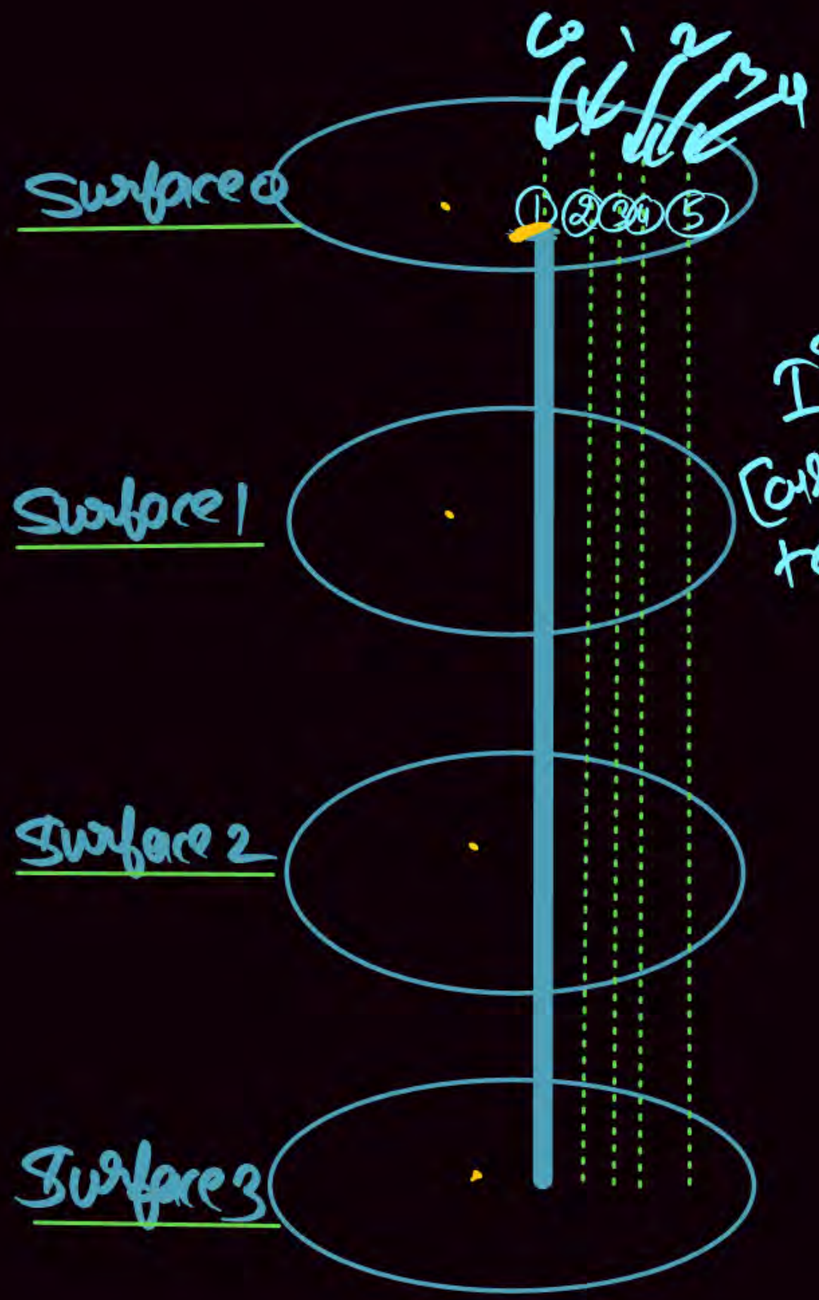
cylinder = 5 [0-4]

Sector Per track = 8

Sector Per cylinder = # Surface × # Sector Per track

⇒ 4 × 8

= 32 Sector Per Cylinder.



I^st Cylinder [Cylinder '0' traversed].

I^st Cylinder: Cylinder Number 0.

Step 1: Surface Number 0 (I^st Surface) track No 0 (I^st track) all 8 sector are traversed [crossed]

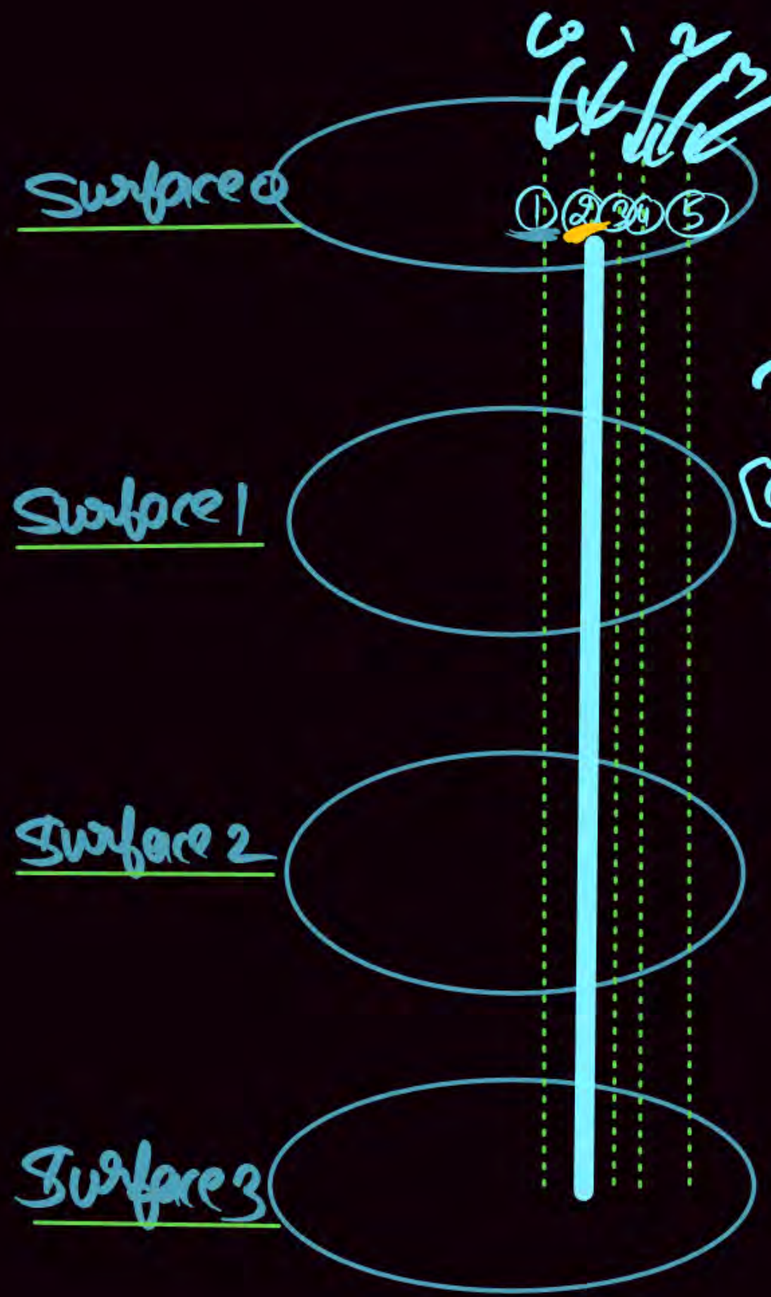
Step 2: Surface Number 1 (II^nd Surface) track No 0 (I^st track) all 8 sector are traversed [crossed]

Step 3: Surface Number 2 (III^rd Surface) track Number 0 (I^st track) all 8 sector are traversed [crossed]

Step 4 Surface Number 3 (4^th Surface) track Number 0 (I^st track) all 8 sectors are traversed [crossed]

Now Move to Next Cylinder.

2nd Cylinder (cylinder 1)



2nd Cylinder (Cylinder 1 traversed)

2nd Cylinder : Cylinder Number '1'

Step1 : Surface Number 0 (I st Surface) track No 1 (2nd track), all 8 sector are traversed [Crossed]

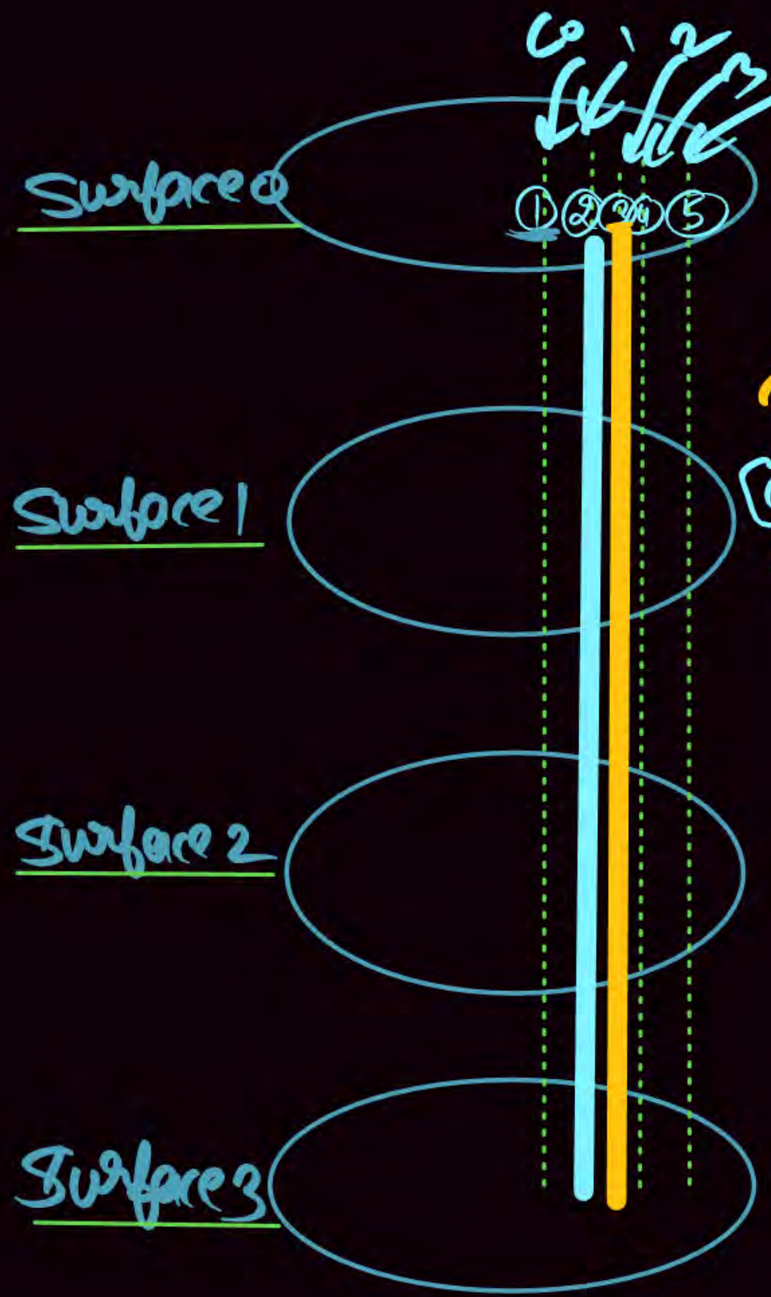
Step2 : Surface Number 1 (II nd Surface) track No 1 (2nd track) all 8 sector are traversed [Crossed]

Step3 : Surface Number 2 (III rd Surface) track Number 1 (2nd track) all 8 sector are traversed [Crossed]

Step4 Surface Number 3 (4th Surface) track Numbe 1 (2nd track) all 8 sectors are traversed [Crossed]

Now Move to the Next cylinder.

3rd cylinder (cylinder no 2).



3rd Cylinder : Cylinder Number : 2

Step 1 : Surface Number 0 (I st Surface) track No 2 (3rd track) all 8 sector are traversed [Crossed]

Step 2 : Surface Number 1 (II nd Surface) track No 2 (3rd track) all 8 sector are traversed [Crossed]

Step 3 : Surface Number 2 (III rd Surface) track Number 2 (3rd track) all 8 sector are traversed [Crossed]

Step 4 Surface Number 3 (4th Surface) track Number 2 (3rd track) all 8 sectors are traversed [Crossed]

& so on.

Addressing

<c, h, s>

① 0th cylinder

<C, h, S>.

(0th Sector of 0th surface of 0th cylinder)

<0,0,0> :	0th sector
<0,0,1> :	1st Sector
<0,0,2>	2nd Sector
<0,0,3>	3rd Sector
<0,0,4>	4th Sector
<0,0,5>	5th Sector
<0,0,6>	6th Sector
<0,0,7>	7th Sector

8 Sector of Surface 0 of Cylinder 0

1st Surface: <0,1,0> 8th Sector

#Sector/track: 8

#Surface = 4

#Track Per Surface = 5

#Cylinder = 5 [0-4]

#Surface = 4 [0-3]

#Sector/track = 8 [0 to 7]

#Sector Per Cylinder = 32.

① 0th cylinder <C, h, S>.

(0th Sector of 0th surface of 0th cylinder)

<0, 1, 0> : 8th sector

<0, 1, 1> : 9th Sector

<0, 1, 2> 10th Sector

<0, 1, 3> 11th Sector

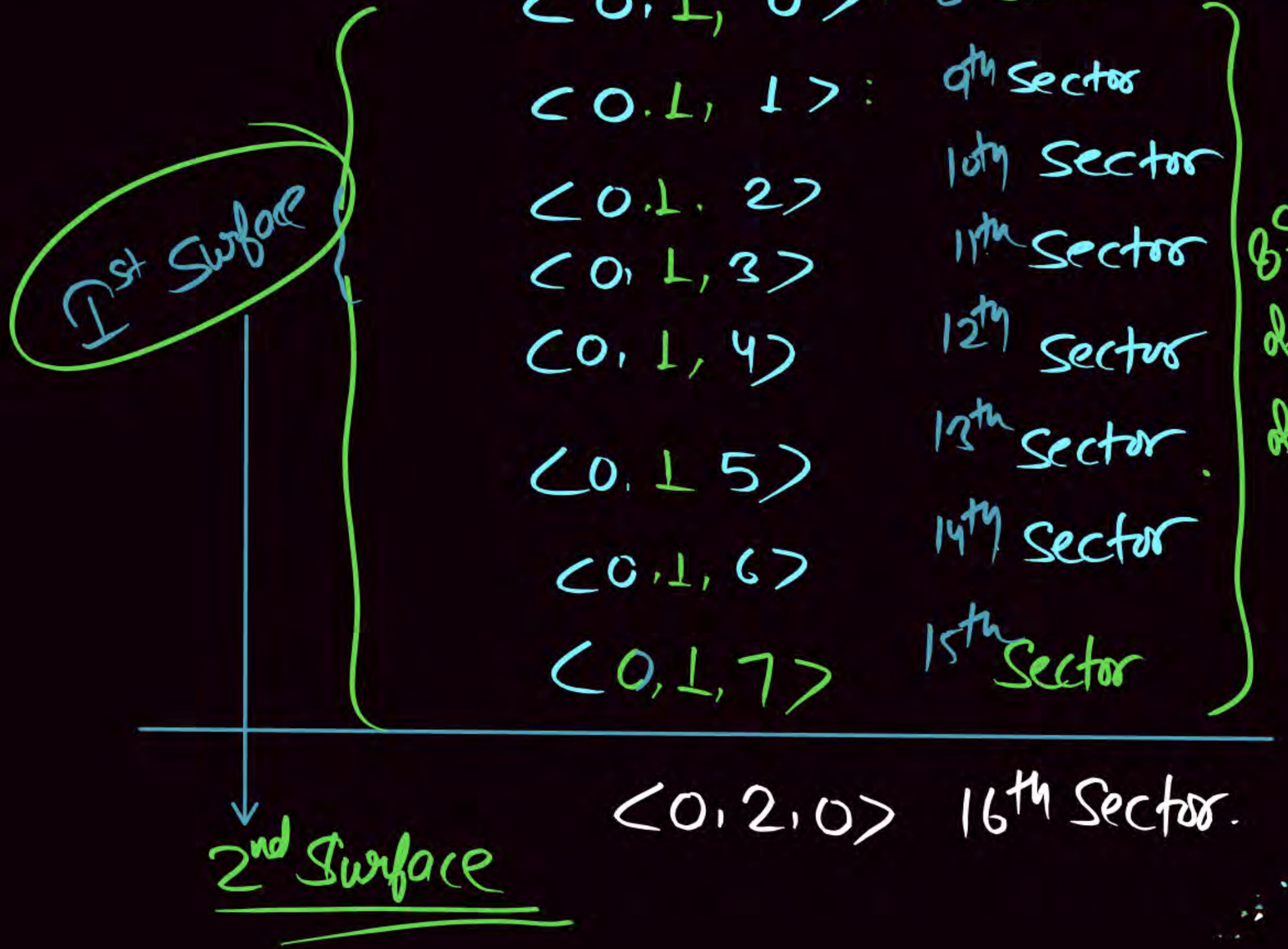
<0, 1, 4> 12th Sector

<0, 1, 5> 13th Sector

<0, 1, 6> 14th Sector

<0, 1, 7> 15th Sector

8 Sector of Surface 0 of cylinder 0



<0, 2, 0> 16th Sector.

#Sector/track: 8

Surface = 4

Track per Surface = 5

cylinder = 5 [0-4]

Surface = 4 [0-3]

Sector/track = 8 [0 to 7]

Sector per cylinder = 32.

① 0th cylinder

<C, h, S>.

(0th sector of 0th surface of 0th cylinder)

<0, 2, 0> : 16th sector

<0, 2, 1> : 17th sector

<0, 2, 2> : 18th sector

<0, 2, 3> : 19th sector

<0, 2, 4> : 20th sector

<0, 2, 5> : 21st sector

<0, 2, 6> : 22nd sector

<0, 2, 7> : 23rd sector

8 sector of surface 2 of cylinder 0

Now 3rd Surface <0, 3, 0> 24th Sector.

Sector/track : 8

Surface = 4

Track per Surface = 5

Cylinder = 5 [0 - 4]

Surface = 4 [0 - 3]

Sector/track = 8 [0 to 7]

Sector per Cylinder = 32.

① 0th cylinder <C, h, S>.

(0th Sector of 0th surface of 0th cylinder)

<0, 3, 0> : 24th Sector

<0 3, 1> : 25th Sector

<0 3, 2> 26th Sector

<0, 3, 3> 27th Sector

<0, 3, 4> 28th Sector

<0, 3, 5> 29th Sector

<0, 3, 6> 30th Sector

<0, 3, 7> 31st Sector

3rd Surface

8 Sector of Surface 0 of cylinder 0

#Sector/track: 8

Surface = 4

Track Per Surface = 5

cylinder = 5 [0 - 4]

Surface = 4 [0 - 3]

Sector/track = 8 [0 to 7]

Sector Per Cylinder = 32.

Now One Complete Cylinder Traversed [32 Sector].

All 32 sector Stored in 4 Surface of cylinder NO '0'

Now we move to the Next cylinder.

2nd Cylinder (cylinder No 1)

Now cylinder L.

(II) Cylinder 1

0th Surface.

<1, 0, 0> 32th sector

<1, 0, 1>

⋮

<1, 0, 7> 39th Sector

} 8 sector

1st Surface

<1, 1, 0> 40th Sector

<1, 1, 7> 47th Sector

} 8 Sector

2nd Surface

<1, 2, 0> 48th Sector

<1, 2, 7> 55th sector

} 8 Surface

3rd Surface

<1, 3, 0 56th Sector>

<1, 3, 7> 63th Sector

} 8 Sector.

All 32 sector Stored in 4 Surface of cylinder No 1

Now we move to the Next cylinder.

3rd cylinder (cylinder No 2).

3rd cylinder

Now Cylinder No 2.

(2, - - -)

(III) Cylinder 2:

0th Surface

<2,0,0> 64th sector

<2,0,1>

<2,0,7> 71st sector

} 8 sector.

1st Surface

<2,1,0> 72nd sector

<2,1,7> 79th sector

} 8 Sector

IInd Surface

<2,2,0> 80th sector

<2,2,7> 87th sector

} 8 Surface

IIIrd Surface

<2,3,0> 88th sector

<2,3,7> 95th sector

} 8 Sector.

All 32 sector Stored in 4 Surface of cylinder No 2

Now we move to the Next cylinder.

4th cylinder (cylinder No 3)

4th cylinder

Now

Cylinder No 3

(3, - - -)

(IV) Cylinder 3

0th Surface

<3, 0, 0> 96th sector

<3, 0, 1>

⋮

<3, 0, 7> 103th Sector

} 8 sector.

1st Surface

<3, 1, 0> 104th Sector

<3, 1, 7> 111th Sector

} 8 Sector

IInd Surface

<3, 2, 0> 112th Sector

<3, 2, 7> 119th sector

} 8 Surface

IIIrd Surface

<3, 3, 0> 120 Sector

<3, 3, 7> 127th Sector

} 8 Sector.

All 32 sector Stored in 4 Surface of cylinder No 3)

Now we move to the Next cylinder.

5th Cylinder (cylinder No 4

5th Cylinder

Now Cylinder No 4

<4, - - - >

(V) Cylinder 4

0th Surface

<4, 0, 0>
<4, 0, 1>
<4, 0, 7>

128th sector
135th sector

8 sector.

1st Surface

<4, 1, 0>
<4, 1, 7>

136th sector
143rd sector

8 Sector

IInd Surface

<4, 2, 0>
<4, 2, 7>

144th sector
151st sector

8 Surface

IIIrd Surface

<4, 3, 0>
<4, 3, 7>

152nd sector
159th sector

8 Sector.

#Sector/track: 8

#Surface = 4

#Track per Surface = 5

#Cylinder = 5 [0-4]

#Surface = 4 [0-3]

#Sector/track = 8 [0 to 7]

#Sector per Cylinder = 32.

Total Sector in all cylind = 5 × 32 = 160

Now One Complete Cylinder Traversed [32 Sectors].

In this manner we store Total 160 Sector
Which Stored in (32 Sector per Cylinder X 5 Cylinder)

I^st cylinder : <0,0,0> ... <0,0,7>

<0,1,0> <0,1,7>

<0,2,0> <0,2,7>

<0,3,0> <0,3,7>

<0,0,0> } 32 sectors <0,3,7>

II^nd cylinder <1,0,0> to <1,0,7>

<1,1,0> to <1,1,7>

<1,2,0> to <1,2,7>

<1,3,0> to <1,3,7>

<1,0,0> <1,3,7>

III^rd cylinder : <2,0,0> to <2,3,7> } 32 sector

4^th cylinder = <3,0,0> to <3,3,7> } 32 sector

5^th cylinder = <4,0,0> to <4,3,7> } 32 sector.

<0, 0, 0> Sector Number '0'

<4, 3, 7> Sector Number 159 (160th Sector).

Q1 What is Sector No of <4, 3, 7>

<C, h, S>.

Surface = 4
track Per Surface = 5
Sector Per track = 8.

Sector

(i) To Cross 4 cylinder (0, 1, 2, 3) $\Rightarrow 4 \times 4 \times 8 = 128$ 1 cylinder = 4×8 = 32 sector/cylinder!

(ii) To Cross 3 Surface (0, 1, 2) $= 3 \times 8 = 24$

(iii) To Cross 7th Surface (0, to 6)

$= 7$

159 Ans

(Q.2) What is Sector No of <4, 2, 37.

<C, h, S>.
C → cylinder, h → surface, S → sector.

#Sector Traversed

(i) To cross 4 cylinder [0,1,2,3] = 4 X 4 X 8 = 128

(ii) To cross 2 surface [0,1] = 2 X 8 = 16

(iii) To cross 3 sector (0,1,2) = 3

3

147 Ans

#Surface = 4
#track Per Surface = 5
#Sector Per track = 8.

1 Cylinder = #Surface X # Sector Per track

⇒ 4 X 8

1 cylinder = 32 sector/cylinder.

128
16
3
147

Q.3 What is Sector No of <3, 3, 7>

<C, h, S>
C → cylinder, h → surface, S → sector.

#Sector Traversed

(i) To cross 3 cylinder (0,1,2) = 3 × 4 × 8 = 96

(ii) To cross 3 surface (0,1,2) = 3 × 8 = 24

(iii) To cross 7 sector (0 to 6) = 7 = 7

127 Ans

∴

#Surface = 4
#track Per Surface = 5
#Sector Per track = 8.

1 Cylinder = #Surface × # sector per track

⇒ 4 × 8

1 cylinder = 32 sector/cylinder.

(Q.4) What is Sector No of <1, 3, 4>.

#Surface = 4
#track Per Surface = 5
#Sector Per track = 8.
#cylinder = 5 (0 to 4)
1 Cylinder = #Surface × # Sector Per track
⇒ 4 × 8
1 Cylinder = 32 sector / cylinder.

<C, h, S>.
C → cylinder, h → surface, S → sector.

#Sector Traversed

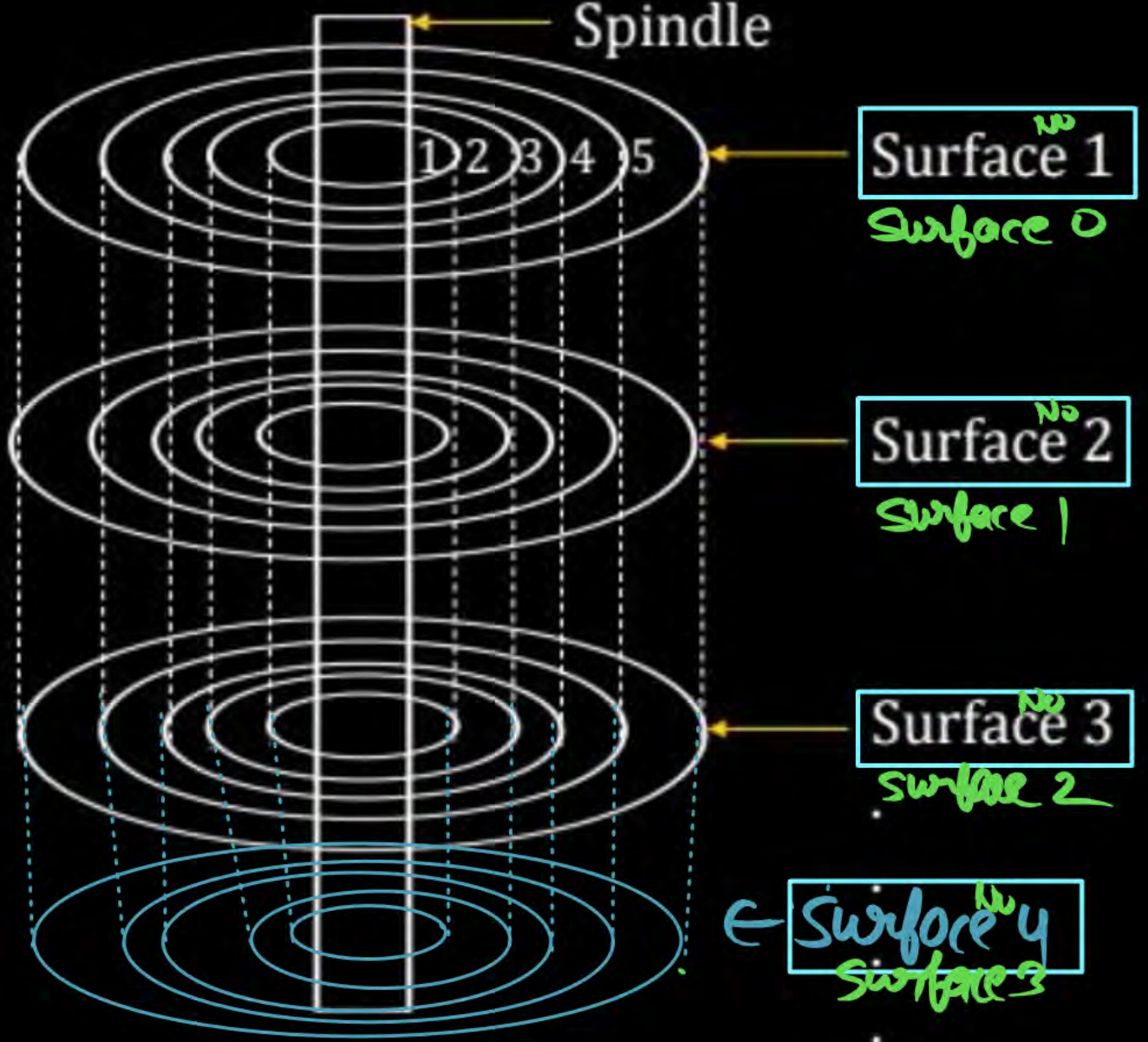
(i) To cross 1 cylinder [0] = 1 × 4 × 8 = 32

(ii) To cross 3 surface [0, 1, 2] = 3 × 8 = 24

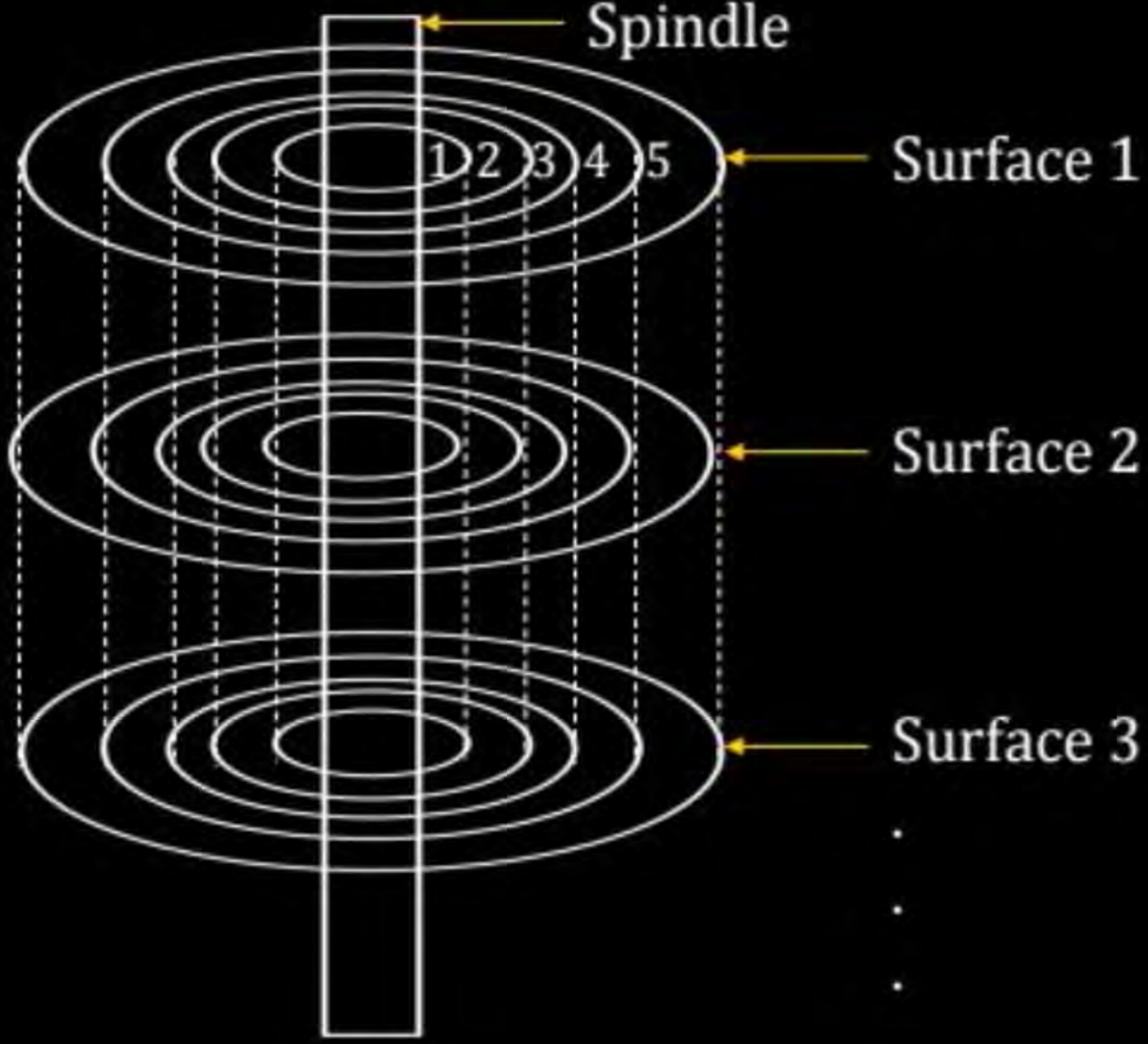
(iii) To cross 4 sector (0 to 3) = 4

60 Ans

Same track number in all the surface will form a cylinder.



Same track number in all the surface will form a cylinder.



Number of Platter =2

Number of Surface =4

Number of track Per Surface =5

Number of Cylinder =5

Number of Sector Per track =8

Number of Sector Per Cylinder=32

Common Data for next two questions:

A hard disk has 63 sectors per track, 10 platters each with 2 recording surfaces and 1000 cylinders. The address of a sector is given as a triple ⟨c,h,s⟩, where c is the cylinder number, h is the surface number and s is the sector number. Thus, the 0^{th} sector is addressed as⟨0,0,0⟩, the 1^{st} sector as ⟨0,0,1⟩, and so on.

⟨c,h,s⟩

⟨400,16,29⟩

1000 cylinder

#Surface = 10×2 = 20 Surface

#sector/track = 63 sector/track

#Sector per Cylinder = 20×63

= 1260 sector/cylinder

$\langle 400, 16, 19 \rangle$

#Surface = 20

#Sector/track = 63

#Sector/cylinder = 20 × 63

= 1260 sector per cylinder.

(i) To Cross 400 cylinder (0 to 399) = $400 \times 20 \times 63$

= 504,000

(ii) To cross 16 Surface (0 to 15) = $16 \times 63 = 1008$

(iii) To cross 29 Sector (0 to 28) = 29 = 29

505037.

MCQ

The address ⟨400,16,29⟩ corresponds to sector number:

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A 505035

B 505036

C 505037

D 505038

$\langle 400, 16, 19 \rangle$

#Surface = 20

#Sector/track = 63

#Sector/cylinder = 20 × 63

= 1260 sectors per cylinder.

(i) To Crosss 400 cylinder (0 to 399) = 400 × 20 × 63

= 504,000

(ii) To cross 16 Surface (0 to 15) = 16 × 63 = 1008

(iii) To cross 29 Sector (0 to 28) = 29 = 29

505037

Alternate Method

formula.

<C, h, S>

C: cylinder, h: surface, S: sector

$$\text{Sector Number} = S + ST * h + ST * TC * C$$

$$\text{Sector Number} = S + ST * h + SC * C \quad \text{(OR)}$$

ST: #sector per track

TC: #track per cylinder (#surface)

SC: #sector per cylinder

↳ $ST * TC$

<C, h, S> = <400, 16, 29>

ST: #sector per track = 63

TC: #track per cylinder = 2 * 10 = 20 (tc: #surface)

SC = #sector per cylinder = 63 × 20 = 1260

$$\text{Sector Number} = 29 + 63 \times 16 + 63 \times 20 \times 400$$

$$= 505037$$

(or) Sector Number $= S + ST * h + SC * C$

$\Rightarrow 29 + 63 \times 16 + 1260 \times 400$

$= 505037$ Ans

Now Reverse Sector No is given then Calculate the address.

MCQ

The address of 1039th sector is

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A ⟨0,15,31⟩

B ⟨0,16,30⟩

C ⟨0,16,31⟩

D ⟨0,17,31⟩

⟨0 + 15*63 + 31⟩ = 976

⟨0 + 16*63 + 30⟩ = 1038

⟨0 + 16*63 + 31⟩ = 1039

⟨0 + 17*63 + 31⟩ = 1102.

Sector / track = 63

surface = 20

Sector per cylinder = 63 × 20

= 1260 sector in per cylinder

Here 1039 sector so its available in very first cylinder.

$$C = \left\lfloor \frac{\text{Given Sector No}}{\text{Total \#Sector Per Cylinder}} \right\rfloor$$

1039th Sector

#ST = 63

#SC = 1260

$$C = \left\lfloor \frac{1039}{1260} \right\rfloor = 0 \quad (1^{st} \text{ cylinder})$$

$$h = (1039 \,\%\, 1260)/63 \Rightarrow \left\lfloor 1039/63 \right\rfloor = 16 \text{ Surface}$$

How much sector Remaining

$$= 1039 - 16 * 63$$

$$\Rightarrow 1039 - 1008$$

$$= 31$$

$\therefore$ C0, 16, 31

<C, h, S>.

$$C_{[\text{Cylinder Number}]} = \left\lfloor \frac{\text{Given Sector}}{\#\text{Sector Per Cylinder}} \right\rfloor$$

$$h_{(\text{Surface Number})} = \left\lfloor \frac{(\text{Given Sector} \,\%\, \#\text{Sector Per Cylinder})}{\#\text{Total Sector Per track}} \right\rfloor$$

y

$h = x$

Sector Number $y - x * \#\text{Sector}$

Q) In the Previous Question Data what is the Sector Address of 4734. ?

$$c = \left\lfloor \frac{4734}{1260} \right\rfloor = 3$$

$c = 3$

$< 3,$

$c=0 \Rightarrow 1260$
$c=1 \Rightarrow 1260$
$c=2 = 1260$
3780 Sector

$$h = (4734 \% 1260) / 63 = \underbrace{954}_{y} / 63 = \underbrace{15}_{x}$$

$< 3,$

$< 3, 15,$

$y - x * \#Sector$

Sector Number $= 954 - 15 * 63 = 9$

$< 3, 15, 9 >$ Ans

$\therefore$

Q) In the Previous Question Data what is the Sector Address of 5433 ?

$C = \left\lfloor \frac{5433}{1260} \right\rfloor = \lfloor 4.3 \rfloor \Rightarrow \boxed{C=4} < 4,$

$h = \left(5433 \,\%\, 1260 \right) / 63 = \left\lfloor \frac{393}{63} \right\rfloor = 6 \quad (y)$

$< 4, 6,$

$y - x*$

Sector Number $= 393 - 6*63$

$= 15.$

$\boxed{<4,6,15>}$ Ans

C=0 ⇒ 1260
C=1 ⇒ 1260
C=2 = 1260
C=3 = 1260
5040

Now C=4

cylinder in the disk = # track, in the surface

Track capacity = # sector tracks * # Bytes / sector

Cylinder capacity = # surface in the disk * track capacity

Disk capacity = # cylinder in the disk * cylinder capacity

To access the data from the hard disk different adjustments are required in the hard disk so, the associative adjust latencies are -

(1) Seek time

(2) Rotational time

(3) transfer time

THANK YOU!