R.N.G.P.I.T, Bardoli
Electrical Engineering Department

Subject: Electrical Machine-II

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- Experience: 13 Years.

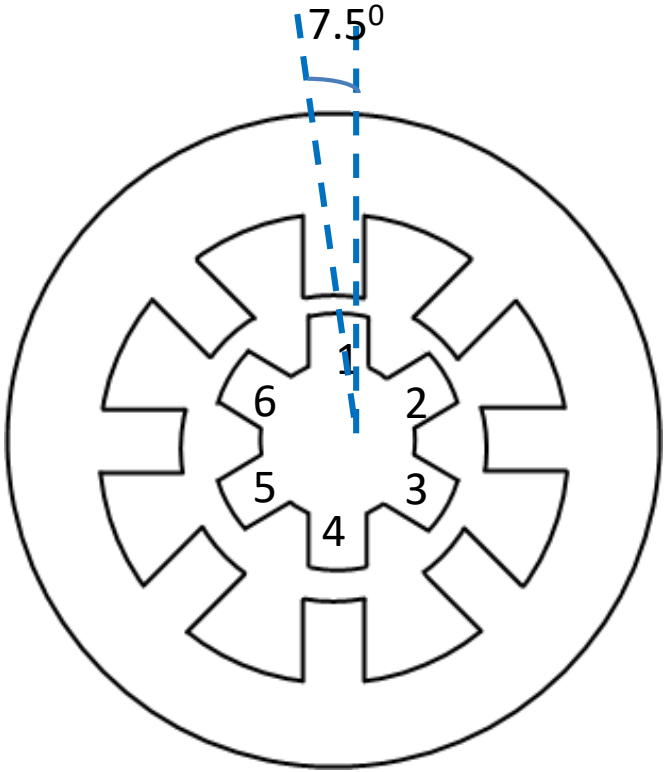
CH: Special Machine

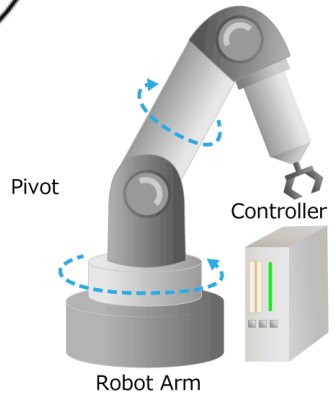
- This Lecture contain
  - Introduction of Stepper Motor
  - Types of Stator Motor
  - Theory of Permanent magnet stepper motor
  - Theory of variable reluctance stepper motor

  - By Dr. Shaikh Mohammed Suhel

- *Stepper Motor:*

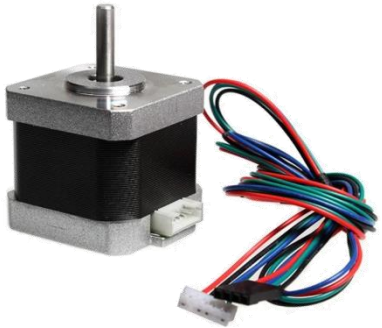
- *Stepper motors are electromagnetic incremental devices that convert electric pulses to shaft motion (rotation).*
- *These motors rotate a specific number of degrees as a respond to each input electric pulse.*
- *Typical types of stepper motors can rotate 2°, 2.5°, 5°, 7.5°, and 15° per input electrical pulse.*

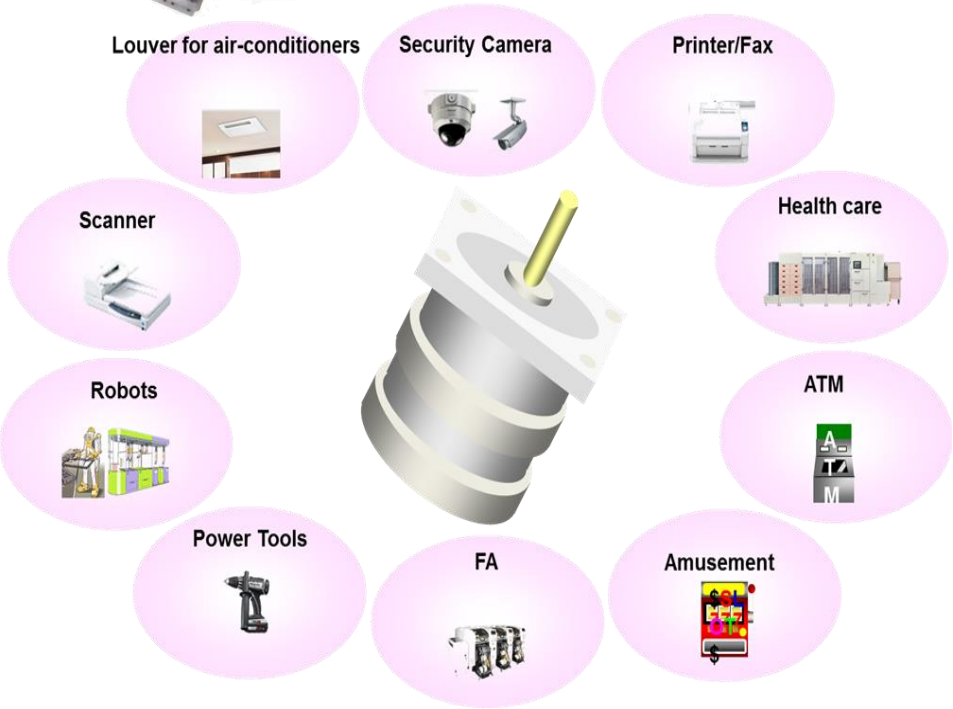




- Stepper Motor:

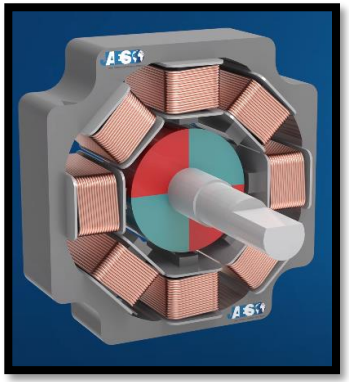
- Inherently position control without close loop control
- Control motors, robotics, printer , robotic arm, disk drive
- Use when power range is not very high

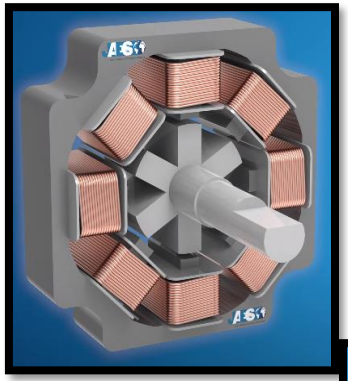


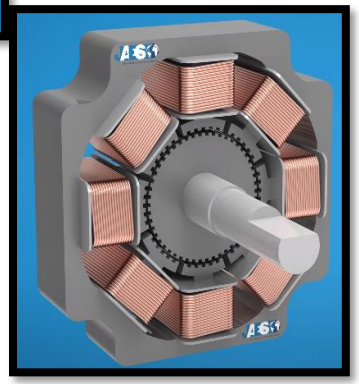


- Types of Stepper Motor:

- Permanent magnet stepper motor
- Variable reluctance stepper motor
- Hybrid synchronous stepper motor

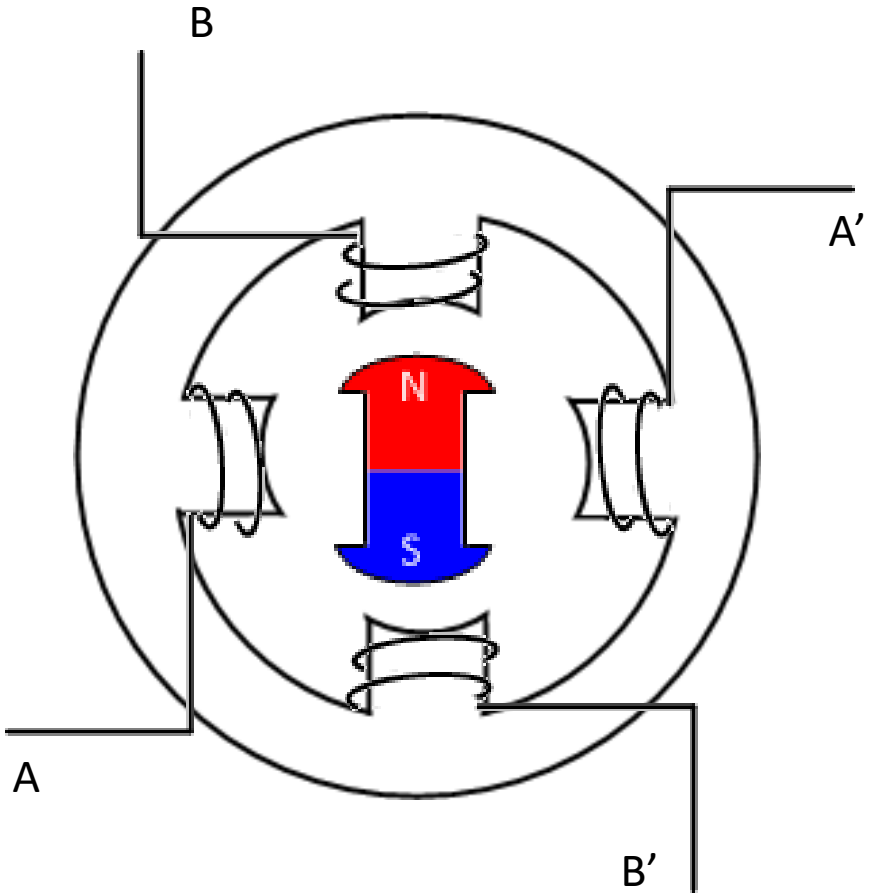






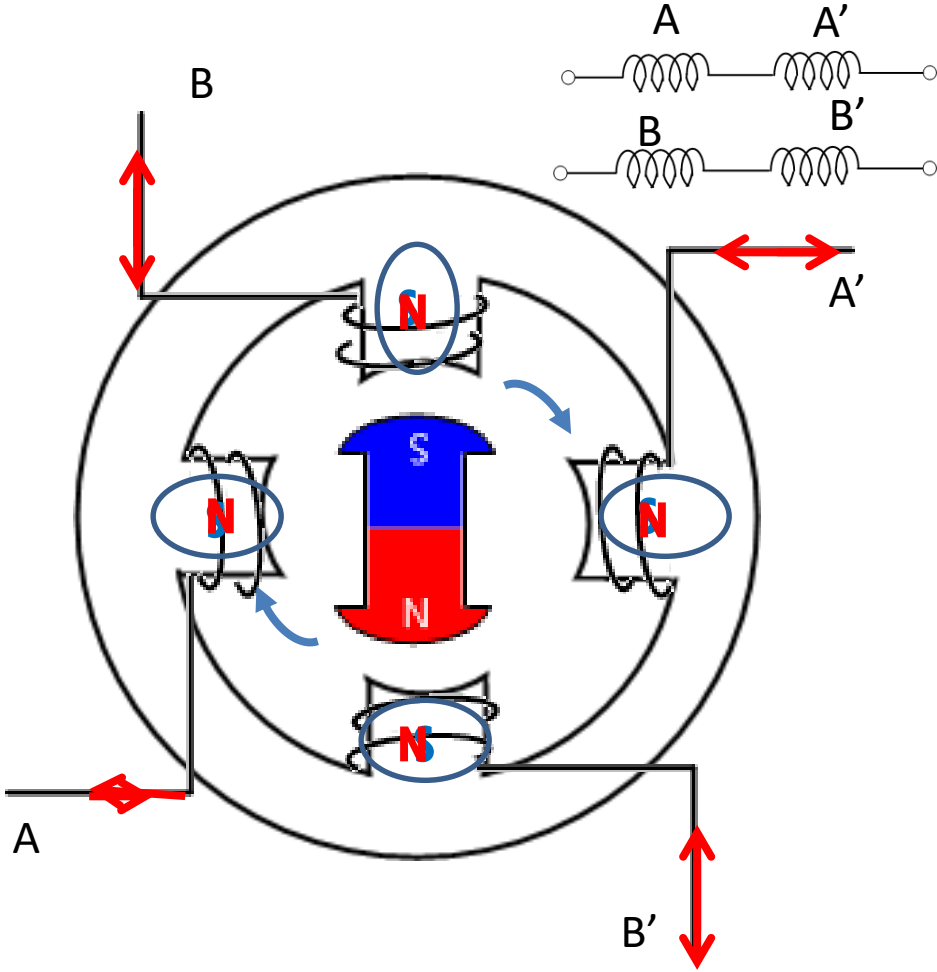
- Permanent magnet Stepper Motor:

- Stator phases=4
- Rotor Poles=2
- Permanent magnet rotor
- Here, winding is wound in such a way that when current is injected into the stator winding, S Pole is generated under that pole.



- Permanent magnet Stepper Motor:

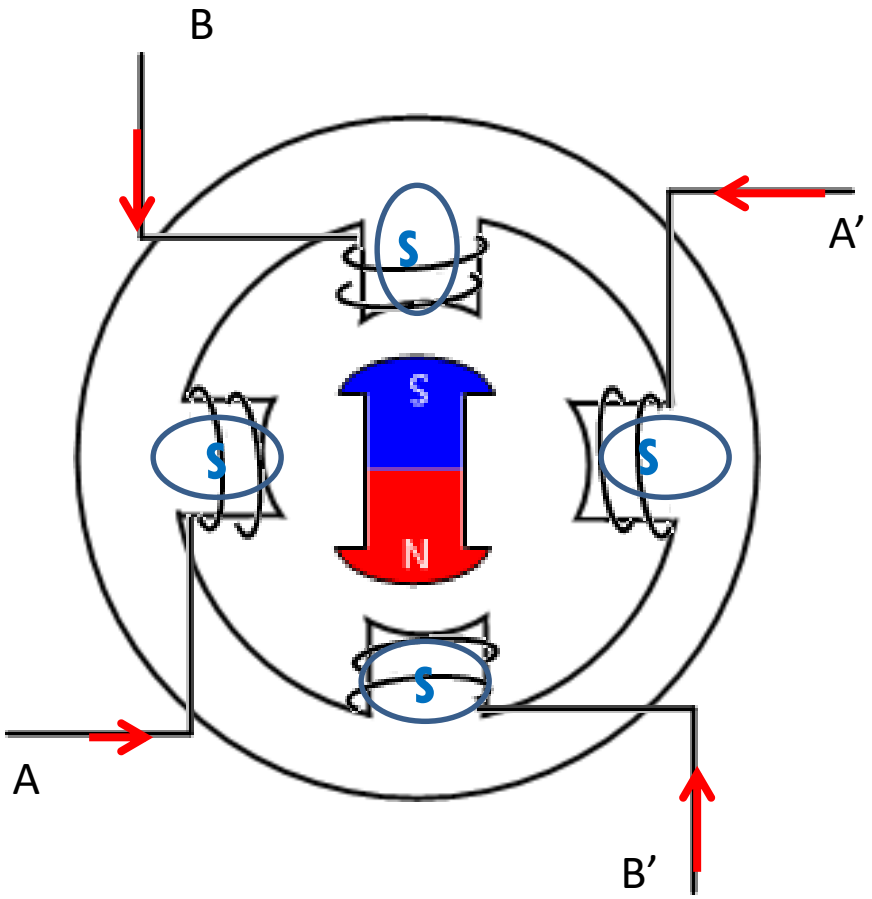
- Stator phases are excited sequentially
- Sequence of switching
- A
- B
- A’
- B’
- Step size=90 degree
- Anti clockwise rotation can be obtained by reversing the sequence.



- Permanent magnet Stepper Motor:

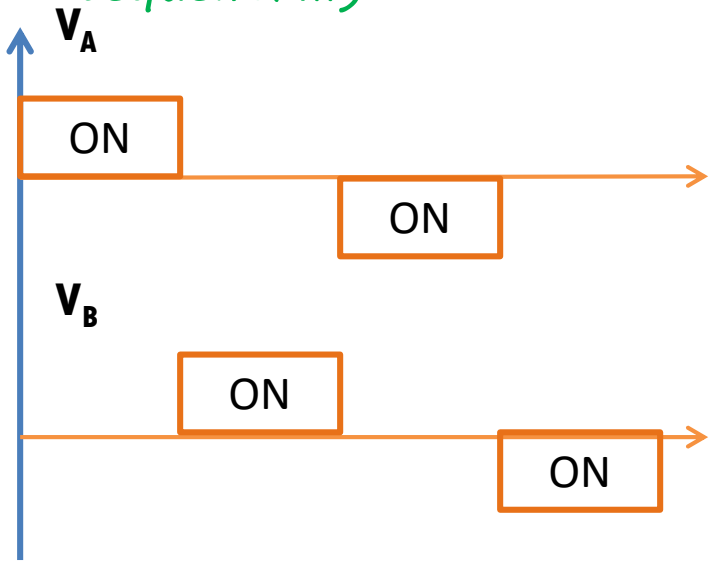
- Stator phases are excited sequentially

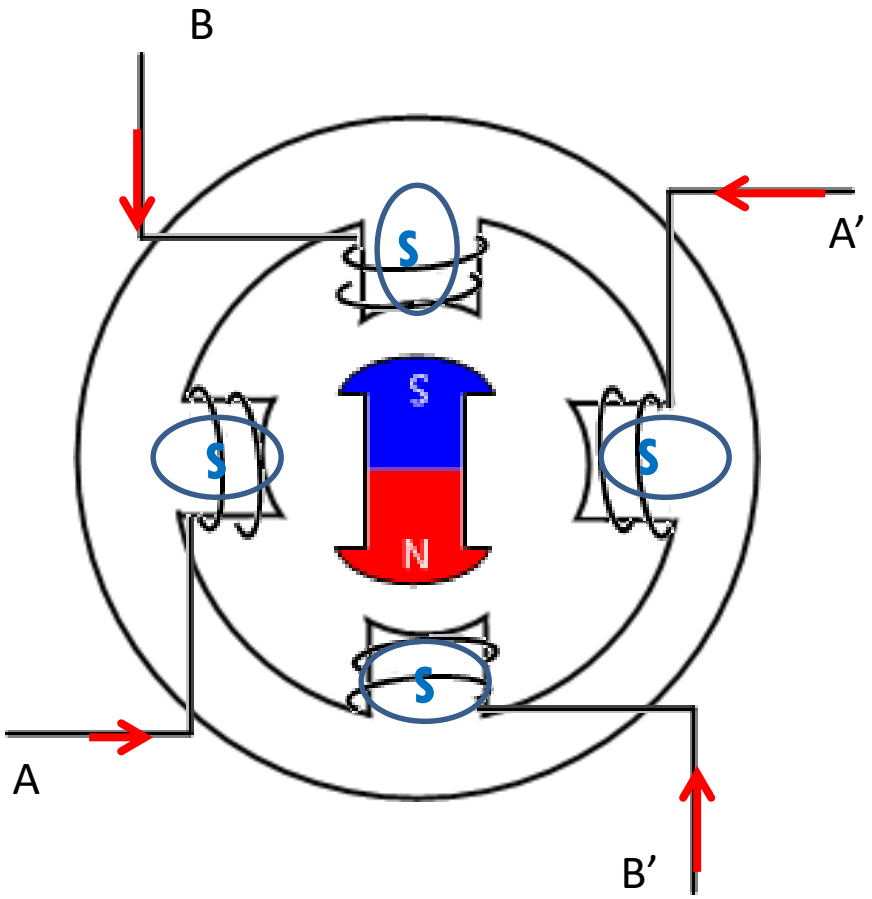
A	B	Position(δ)
1	0	0
0	1	90
-1	0	180
0	-1	270
1	0	360



- Permanent magnet Stepper Motor:

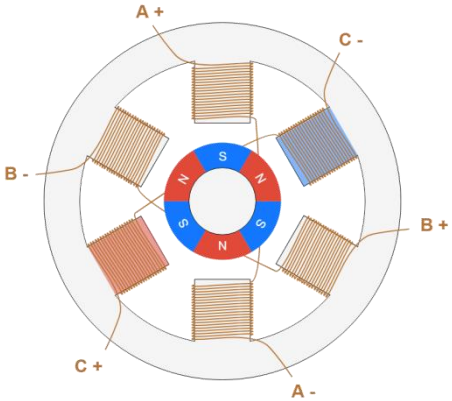
- Stator phases are excited sequentially

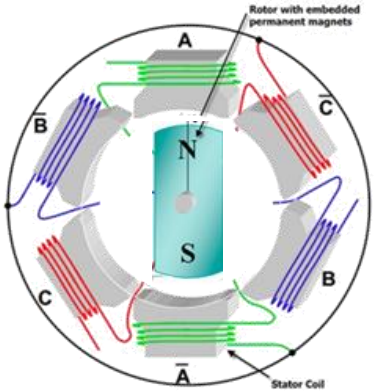




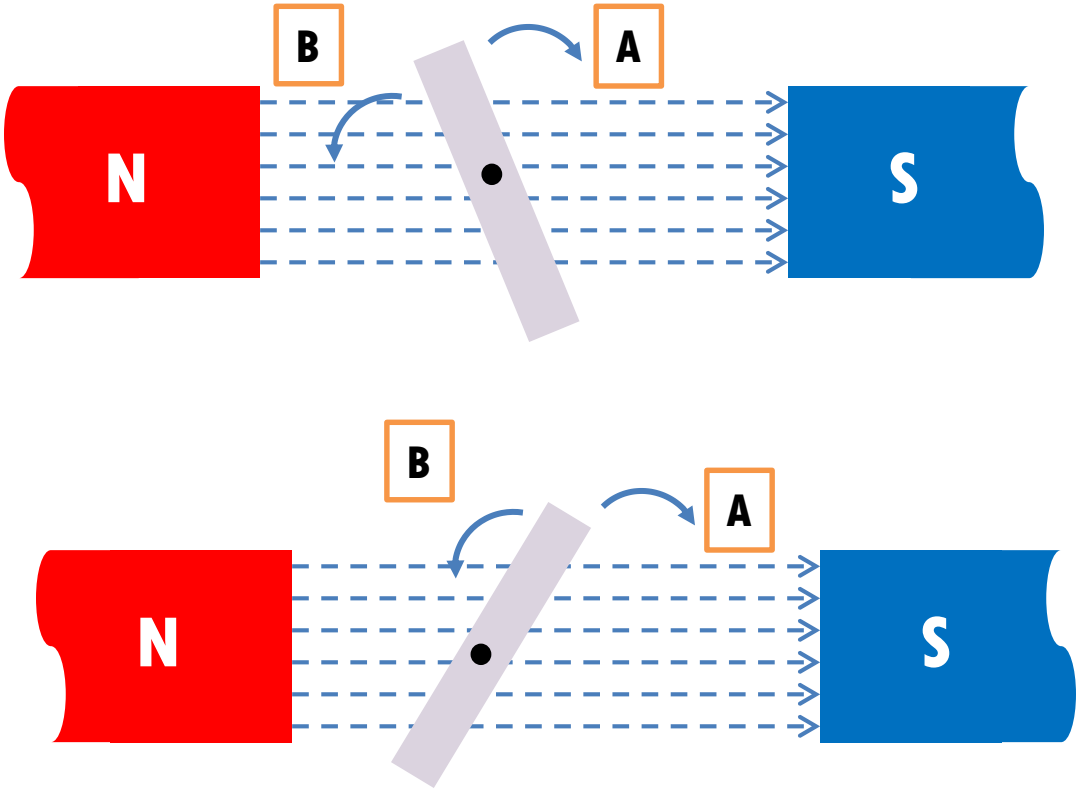
- Permanent magnet Stepper Motor:

- Step size can be increased by increasing number of Poles
- Permanent magnet rotor has mechanical constraint; range available in the market is 30-90 degree step size.
- Inertia of rotor is very large and hence poor speed response.
- Maximum step pulse rate is 300 pulses per second compared to 1200 pulses per second for variable reluctance stepper motors.
- Generate higher torque per ampere of stator currents than variable reluctance stepper motors.





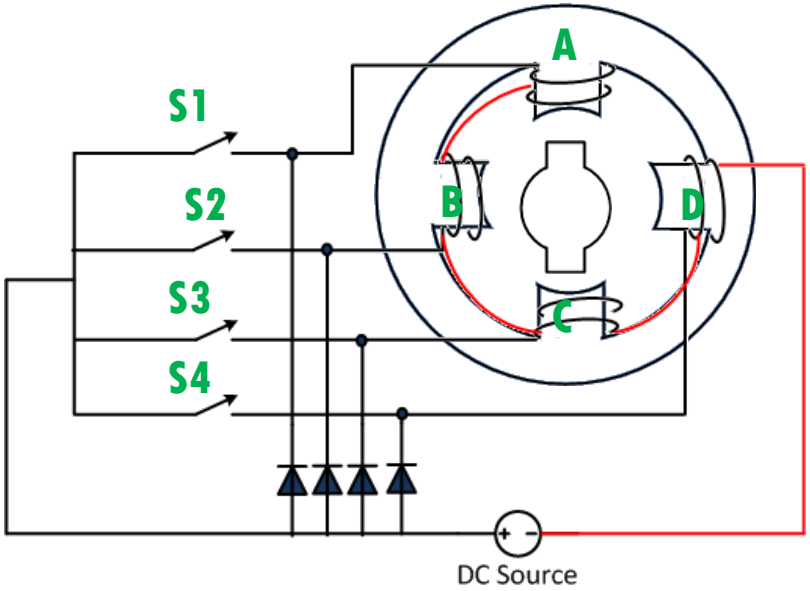
- Variable Reluctance Stepper Motor:



- Basic Variable reluctance Principle
- There is a tendency of the rotor to align along the minimum reluctance position

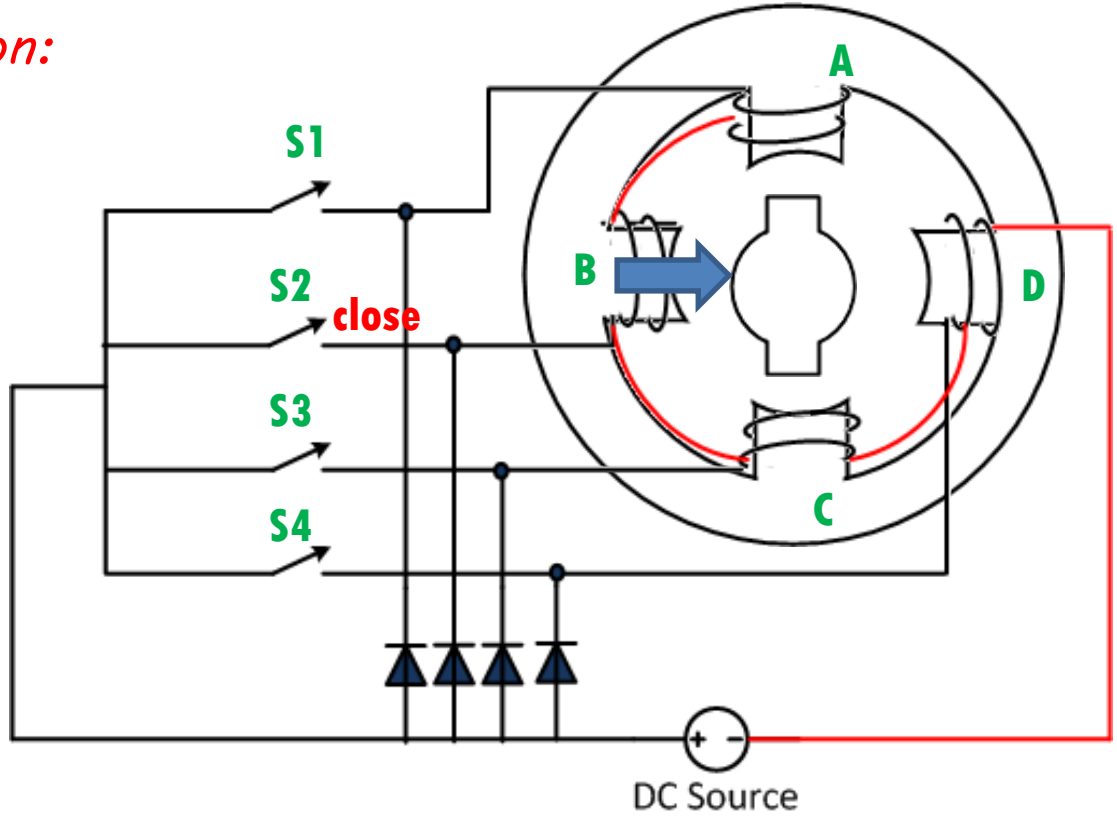
- ## Single Stack Variable Reluctance Stepper Motors:

- Fig. 1 presents the basic circuit configuration of a typical 4-phase, 2-pole, single-stack, variable reluctance stepper motor.
- The stator is made of a single stack of steel laminations with the phase windings wound around the stator poles. The rotor is made of stack of steel laminations without any windings.
- The main principle of operation depends on aligning one set only of stator and rotor poles by energizing the stator windings. Therefore, the number of poles in the stator and rotor windings has to be different.
- The stator windings are energized by a DC source in such a sequence to generate a resultant rotating air-gap field around the rotor in steps.
- The rotor is made of ferromagnetic material that provides a
- tendency to align the rotor axis along the direction of the resultant air-gap field. Therefore, the rotor tracks the motion of this stepped field.



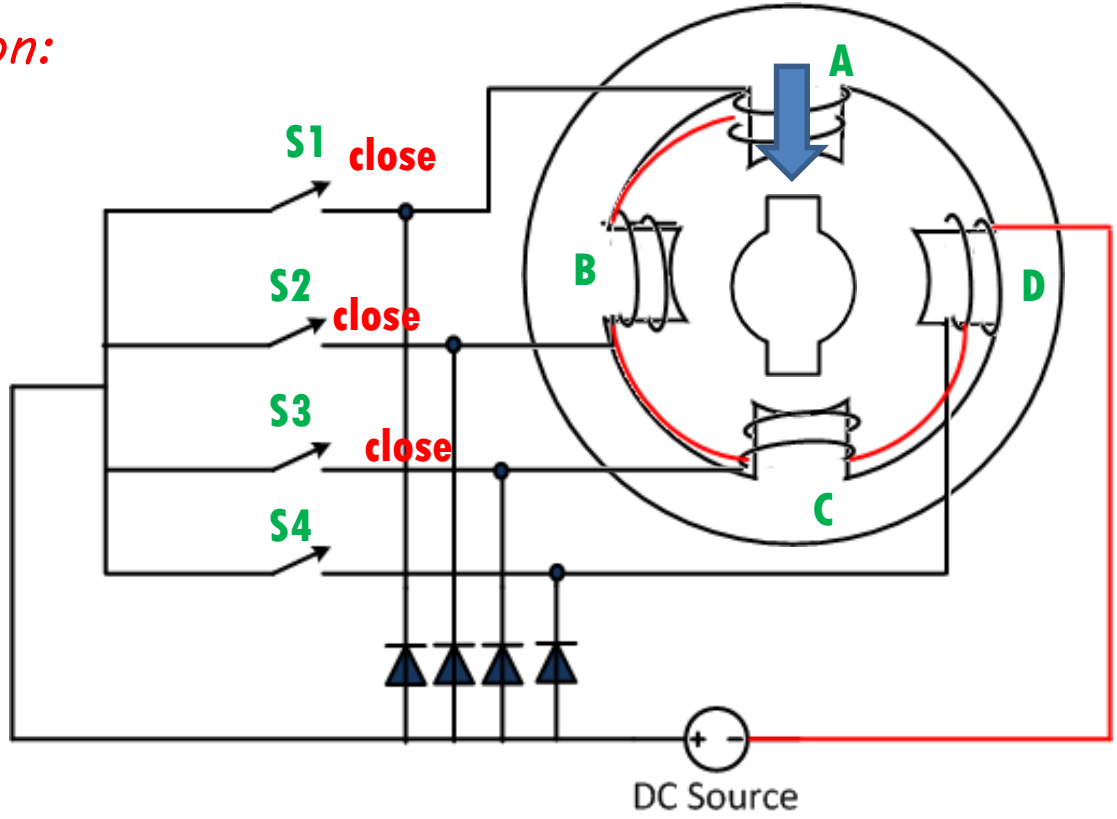
- *The switching Operation:*

- *Full Step, Anti-clockwise switching*
- *A, B , C, D , A*
- *Smooth transition*
- *Current shifts gradually from 'A' to 'B' so mmf also shifts gradually from 'A' to 'B'*



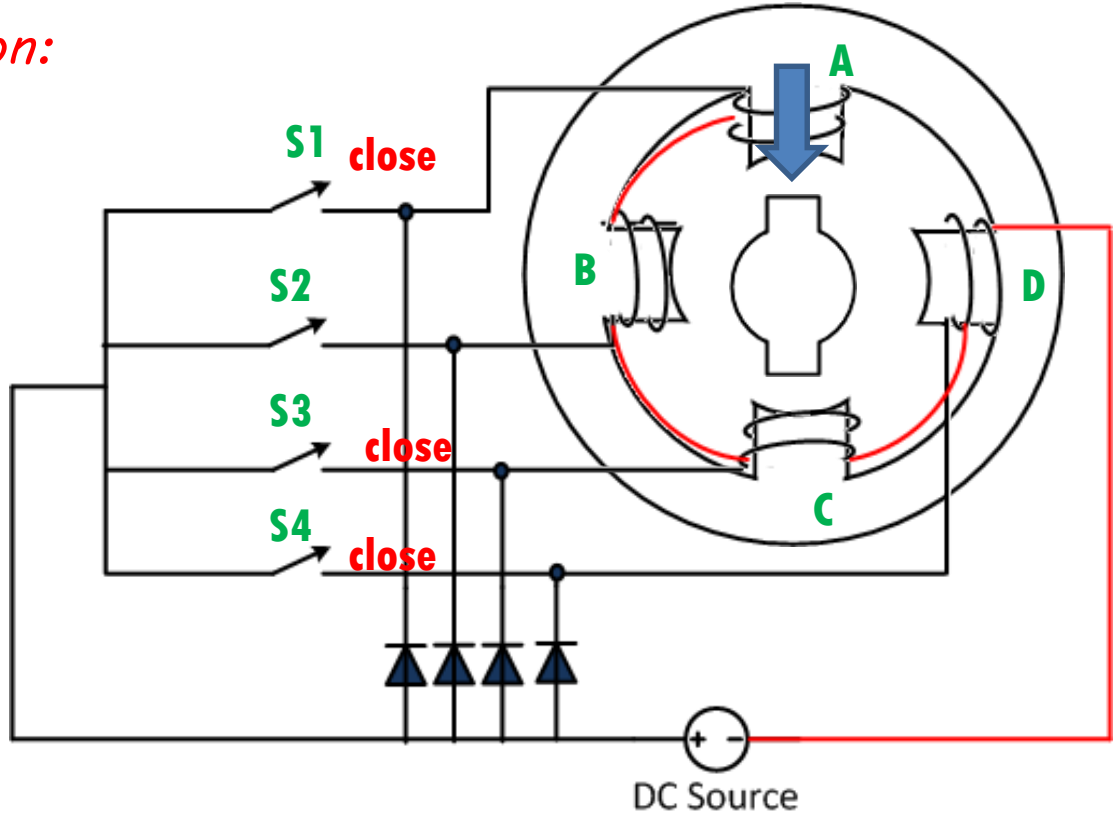
- *The switching Operation:*

- *Full Step, Operation jerky*
- *Micro steeping operation*
- *Two Phases are excited at the same time:*
- *For half stepping anti clock rotation:*
- *A, AB , B, BC, C, CD ,D, DA, A…*

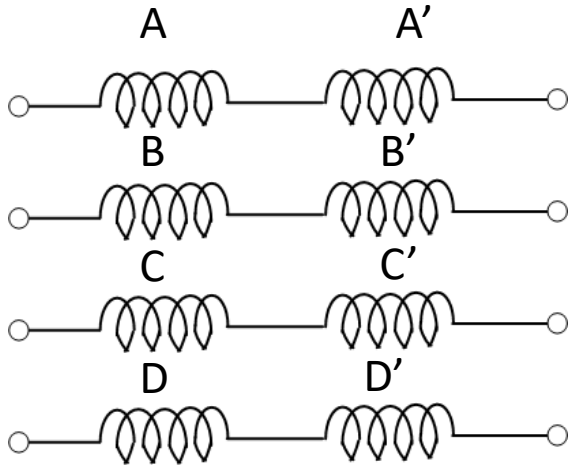


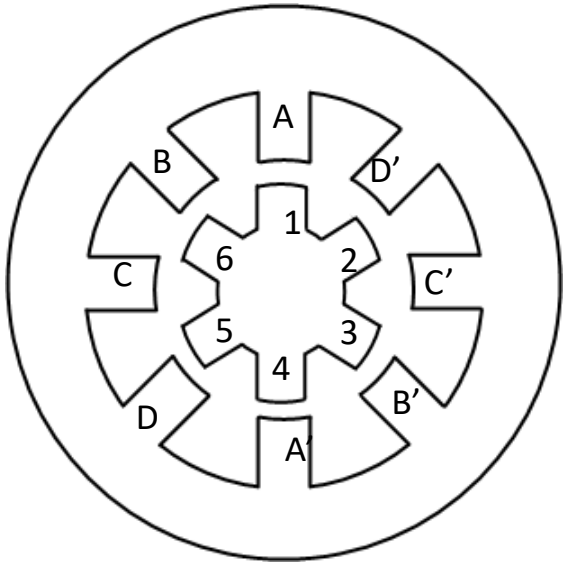
- *The switching Operation:*

- *For half stepping clockwise rotation:*
- *A, AD , D, DC, C, CB…*

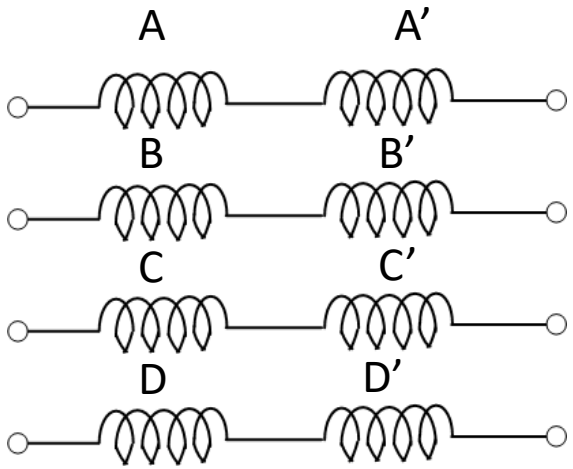


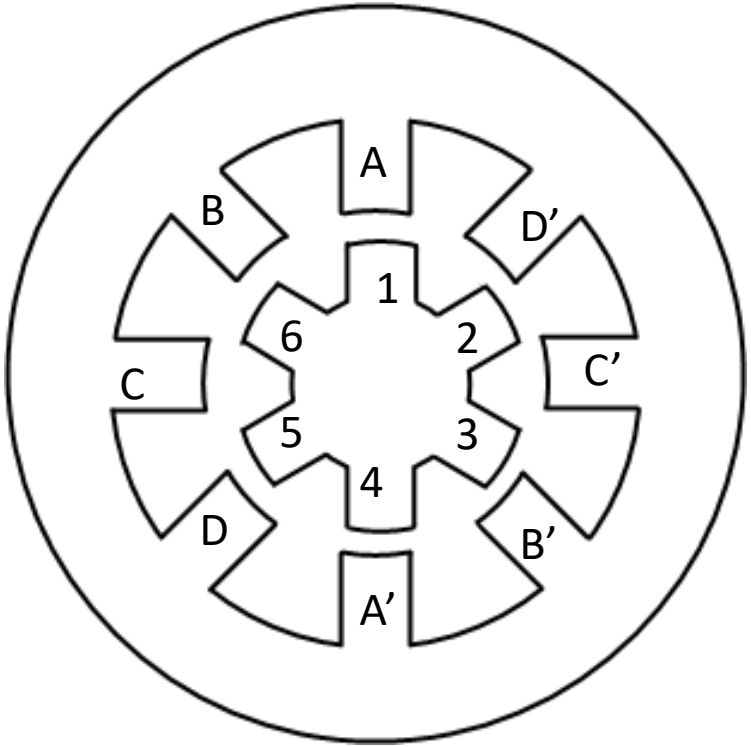
- Four Phase 8/6 pole Variable reluctance type stepper Motor
- Figure presents the circuit configuration and different operation modes for a 4-phase, 6- pole, single stack, variable reluctance stepper motor that rotate in a clockwise direction with a 30° step.



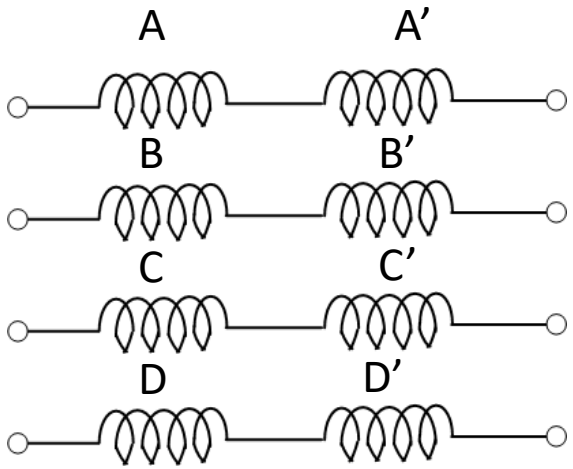


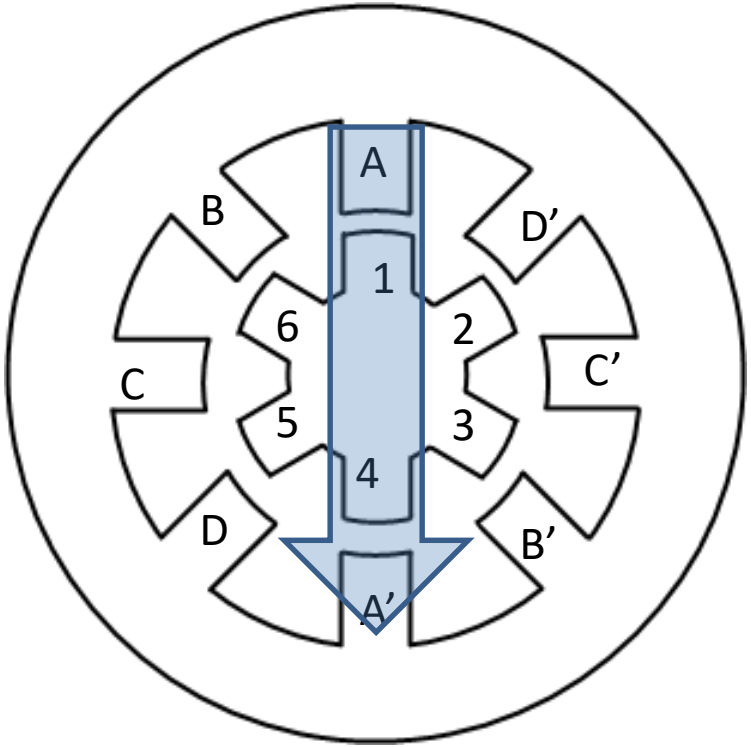
- Four Phase 8/6 pole Variable reluctance type stepper Motor





- Four Phase 8/6 pole Variable reluctance type stepper Motor





- Sequence of switching (Clock wise):
- A, B C, D, A...

- *Variable Reluctance stepper Motor:*

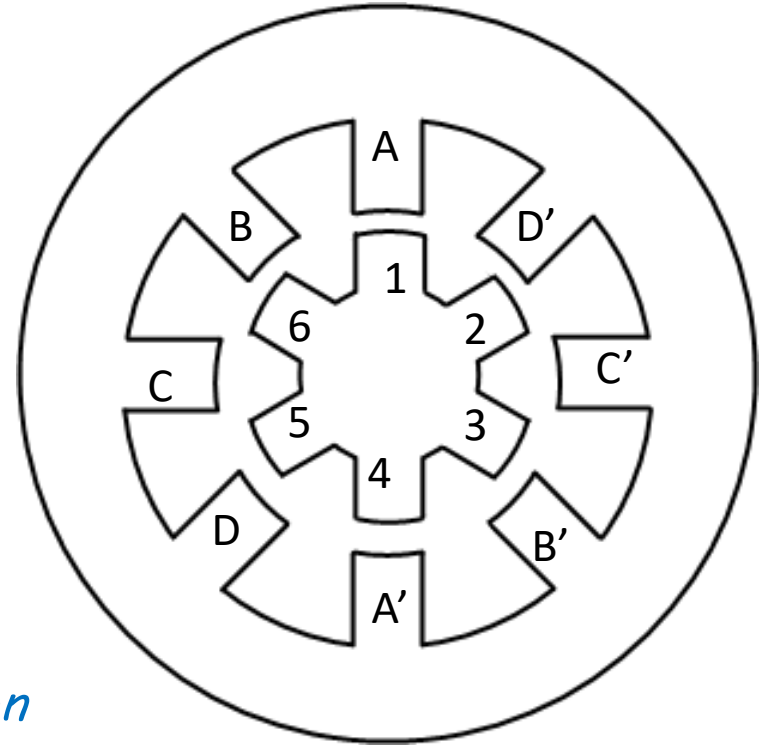
$$\text{stator pole pitch} = \frac{360}{8} = 45^0$$

$$\text{Rotor pole pitch} = \frac{360}{6} = 60^0$$

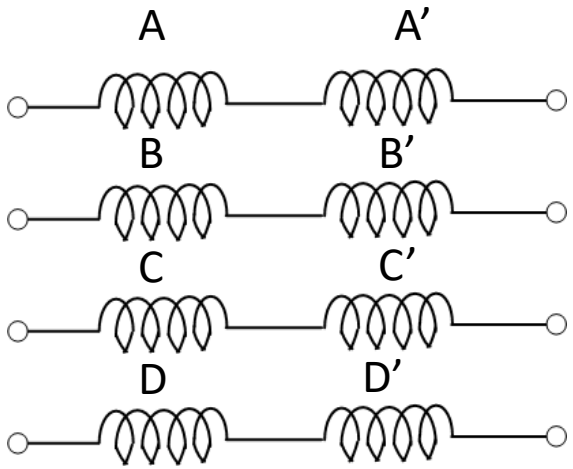
$$\text{Step size}(\beta) = \frac{|N_s - N_r|}{N_s \cdot N_r} \times 360^0 = 15^0$$

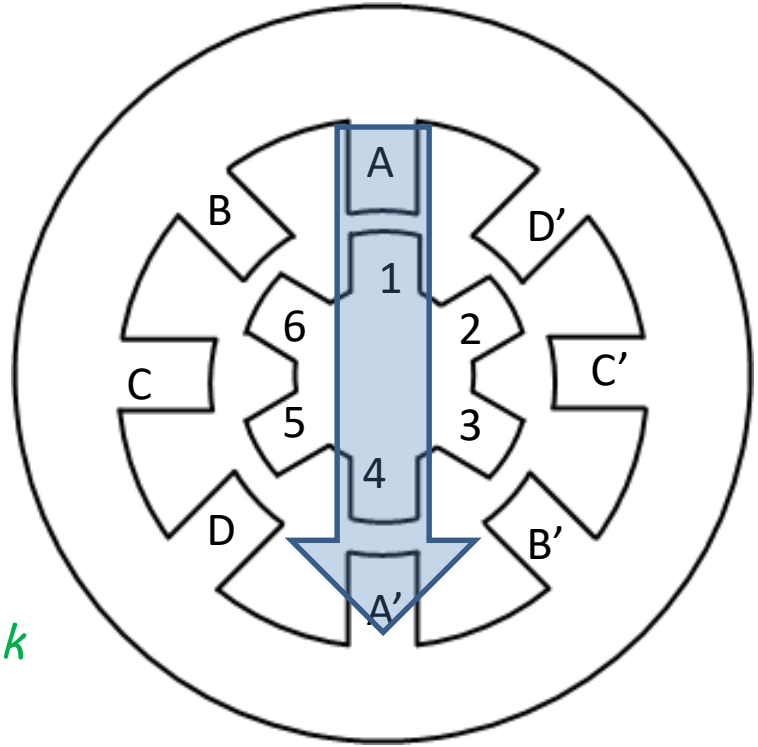
- *Micro stepping clockwise:*
- *A, AB, B, BC*

Note: In V·R· stepper motor direction of mmf doesn't matter



- Four Phase 8/6 pole Variable reluctance type stepper Motor





- Sequence of switching (Anti-Clock wise):
- A, D C, B, A...

Cycle	A	B	C	D	Position
1	1	0	0	0	0
	0	1	0	0	15
	0	0	1	0	30
	0	0	0	1	45
2	1	0	0	0	60
	0	1	0	0	75
	0	0	1	0	90
	0	0	0	1	105
3	:	:	:	:	:
	:	:	:	:	:

End

THANK YOU