ELEMENTS OF ELECTRICAL ENGINEERING
Course Code : UE25EE141A/B

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ELEMENTS OF ELECTRICAL ENGINEERING

ELECTROMAGNETISM BASICS & B-H CURVE

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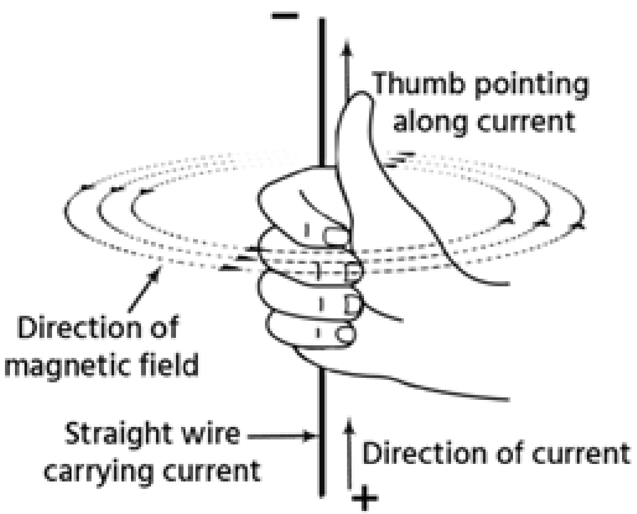
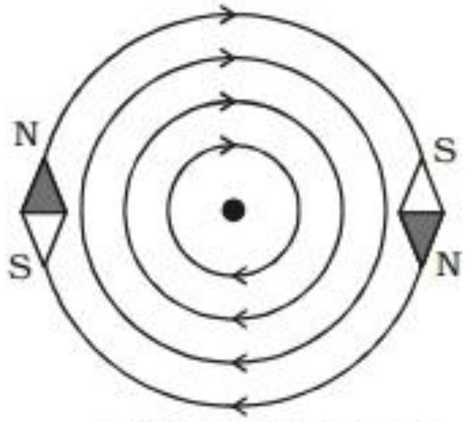
Magnetic Field Pattern Due To Straight Current-carrying Conductor

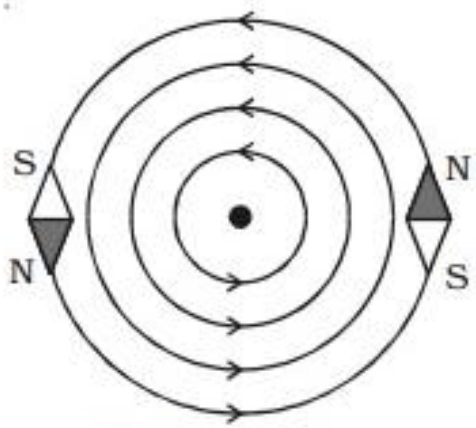
Whenever a conductor or coil carries current through it, a magnetic field is set up around it.

Direction of the magnetic field due to this current in the conductor or coil can be determined by **Right Hand Thumb Rule**





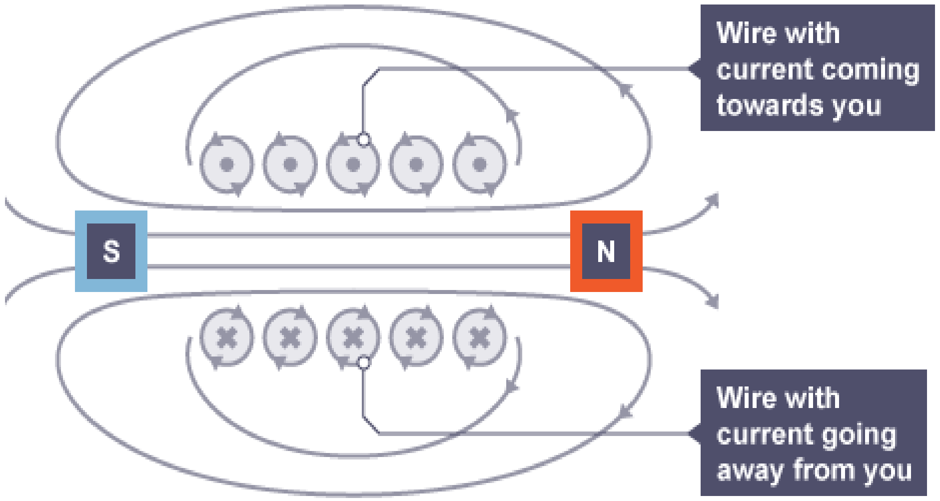
(a) Current inwards



(b) Current Outwards

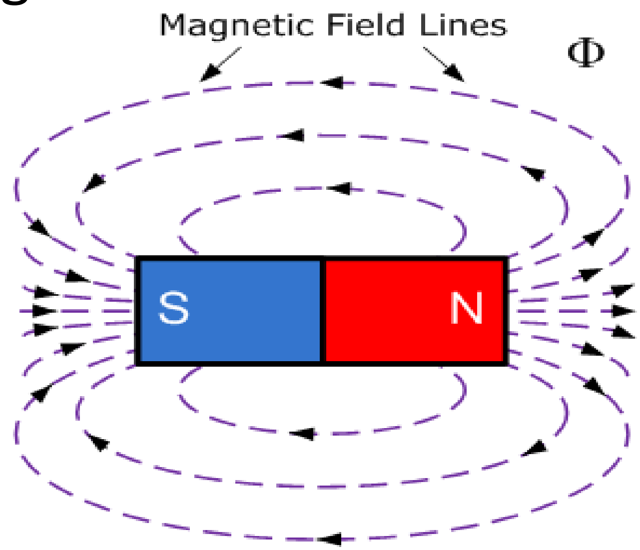
Magnetic Field Pattern Due To Circular Loop (Or Coil) Carrying Current

- A **coil of wire, or solenoid**, consists of a wire coiled up into a spiral shape.
- When an electric current flows, the shape of the magnetic field is very similar to the field of a bar magnet.
- The field inside a solenoid is strong and uniform.
- The small magnetic field caused by the current in each coil add together to make a stronger overall magnetic field.
- The north pole of the electromagnet can also be found by using your right hand.
- Point the fingers of your right hand in the same direction as the current is flowing in the coil.
- Your thumb points to the north pole of the electromagnet.



Magnetic Field:

The region around a magnetic material (or) a moving electric charge with in which the force of magnetism acts.



Magnetic Flux (ϕ):

The amount of magnetic field produced by magnetic source is called as magnetic flux. Its SI unit is Weber (Wb)

Magnetic Flux Density

- The magnetic flux density is defined as the amount of magnetic flux through a unit area placed perpendicular to the direction of magnetic field. It is a vector quantity, usually denoted by **B**.
- The SI unit of magnetic flux density is Tesla (T) or Weber per square meter.

$$\boldsymbol{B = \frac{\phi}{A}}$$

ϕ = magnetic flux (Wb)
B = magnetic flux density (T)
A = cross-sectional area (m^2)

Magneto Motive Force (MMF)

The magnetic pressure, which sets up the magnetic flux in a magnetic circuit is called Magneto Motive Force. The SI unit of MMF is Ampere-turn (AT) and denoted as **F**.

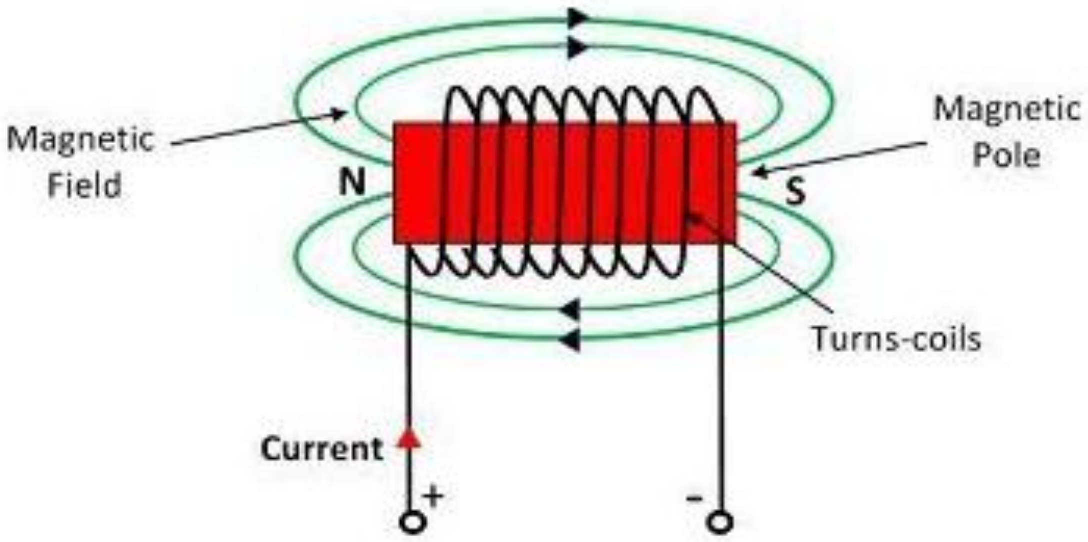
The MMF for the inductive coil shown in the figure below is expressed as

$$\boldsymbol{F = NI}$$

Where,

N – numbers of turns of the inductive coil

I – current



Magnetic Field Strength

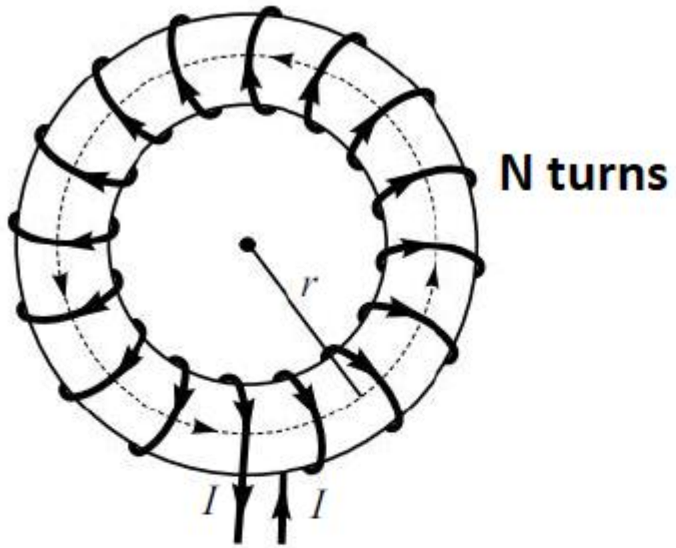
- Magnetic field strength is also called magnetic field intensity or Magnetizing force.
- It is represented as vector H and is defined as MMF per unit length of that magnetic path.
- Magnetic field strength is measured in ampere-turns per meter (AT/m)

$$\boldsymbol{H = \frac{NI}{l}}$$

Where,

NI is called as MMF,

l is the length of magnetic circuit in m.



Relation between B & H

- Magnetic field strength or field intensity (H) is the amount of magnetising force.
- Magnetic flux density (B) is the amount of magnetic flux induced in the given body due to the magnetising force.
- The relation between B & H is,

$$B = \mu H$$

Where μ is permeability,

$$\mu = \mu_0 \mu_r$$

Magnetic Reluctance

Magnetic reluctance (also known as reluctance, magnetic resistance, or a magnetic insulator) is defined as the opposition offered by a magnetic circuit to the production of magnetic flux (ϕ) and is denoted by S.

Reluctance is directly proportional to the length(l) of the magnetic circuit and inversely proportional to the area of the cross-section of the magnetic path(a) and permeability (μ) of the material.

Mathematically it can be expressed as

$$\boldsymbol{s = \frac{l}{\mu_0 \mu_r A}}$$

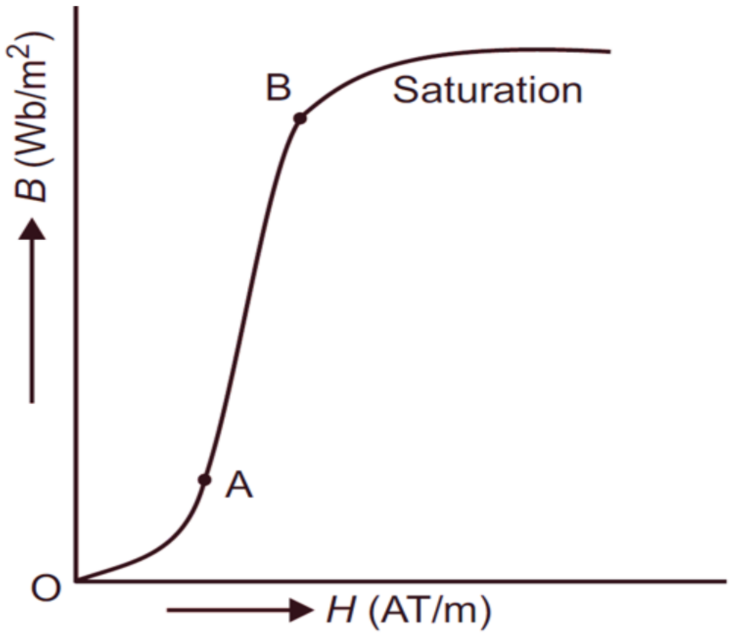
where, l = length of the magnetic path in meters
μ_0= permeability of free space (vacuum)
μ_r= relative permeability of a magnetic material
A= Cross sectional area in square meters (m^2)

B-H Curve

- The B-H curve or magnetisation curve is the graph plotted between magnetic flux density (B) and magnetising force (H).
- The B-H curve indicates the manner in which the magnetic flux density varies with the change in magnetising force.

Uses of B-H curve

- It is used to find out the saturation point of the magnetic materials, so it is useful for designing purpose.
- It is used to find out the permeability i.e. B/H of the material.

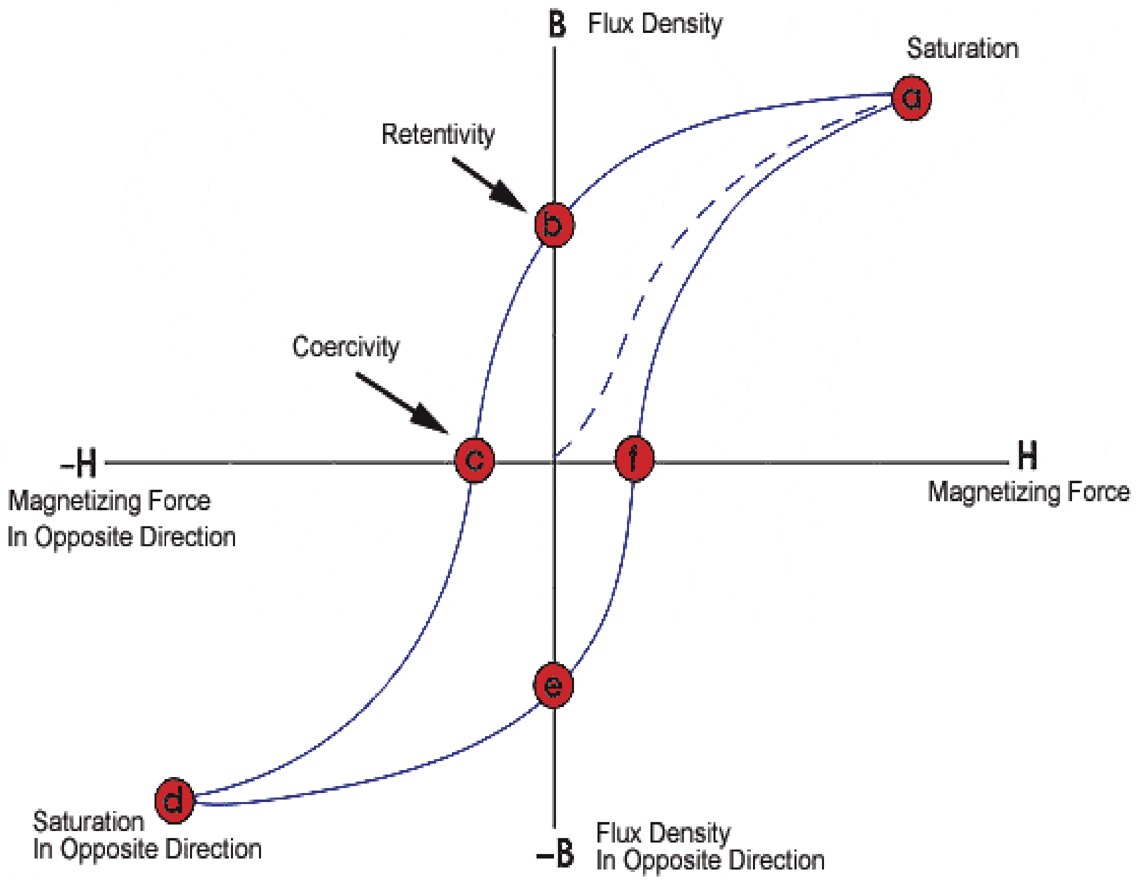


BH Curve

Hysteresis Loop

The hysteresis loop shows the relationship between the magnetic flux density and the magnetizing field strength. The loop is generated by measuring the magnetic flux coming out from the ferromagnetic substance while changing the external magnetizing field.

- The magnetic flux density (B) increases when the magnetic field strength(H) is increased from **0** (zero).
- With increasing the magnetic field there is an increase in the value of magnetism and finally reaches point **a** which is called saturation point where magnetic flux density is constant.

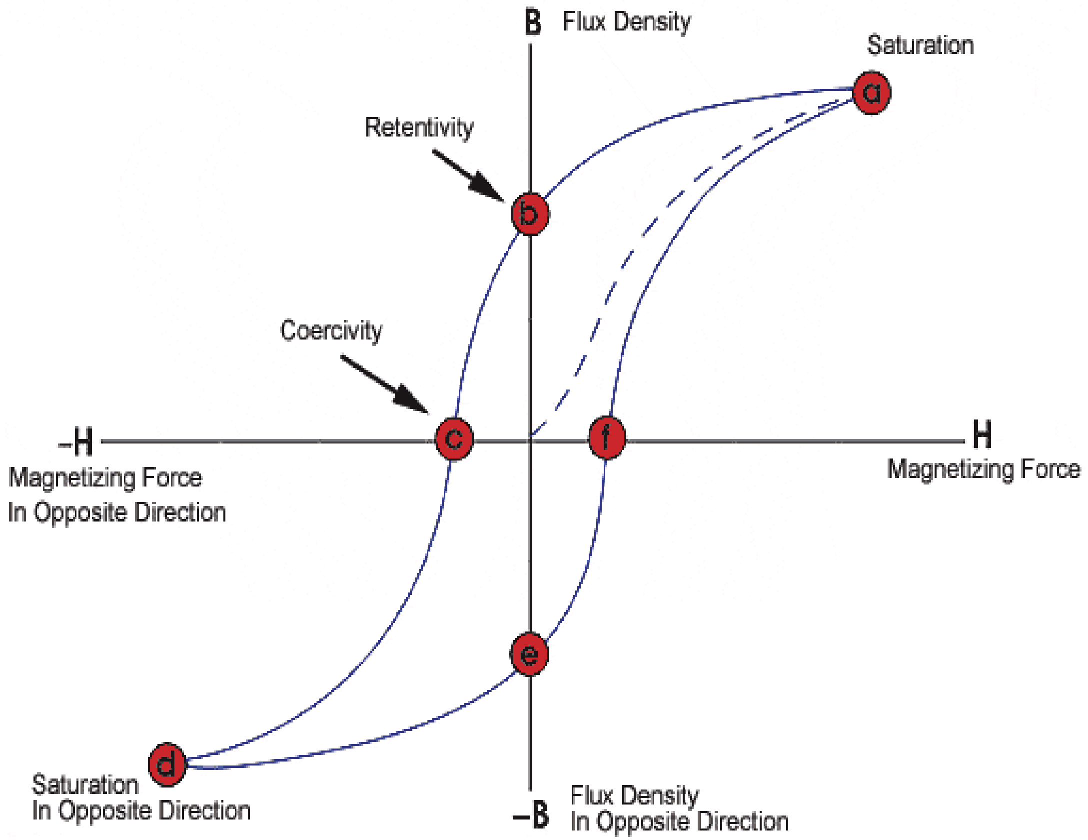


Hysteresis Loop

Hysteresis Loop

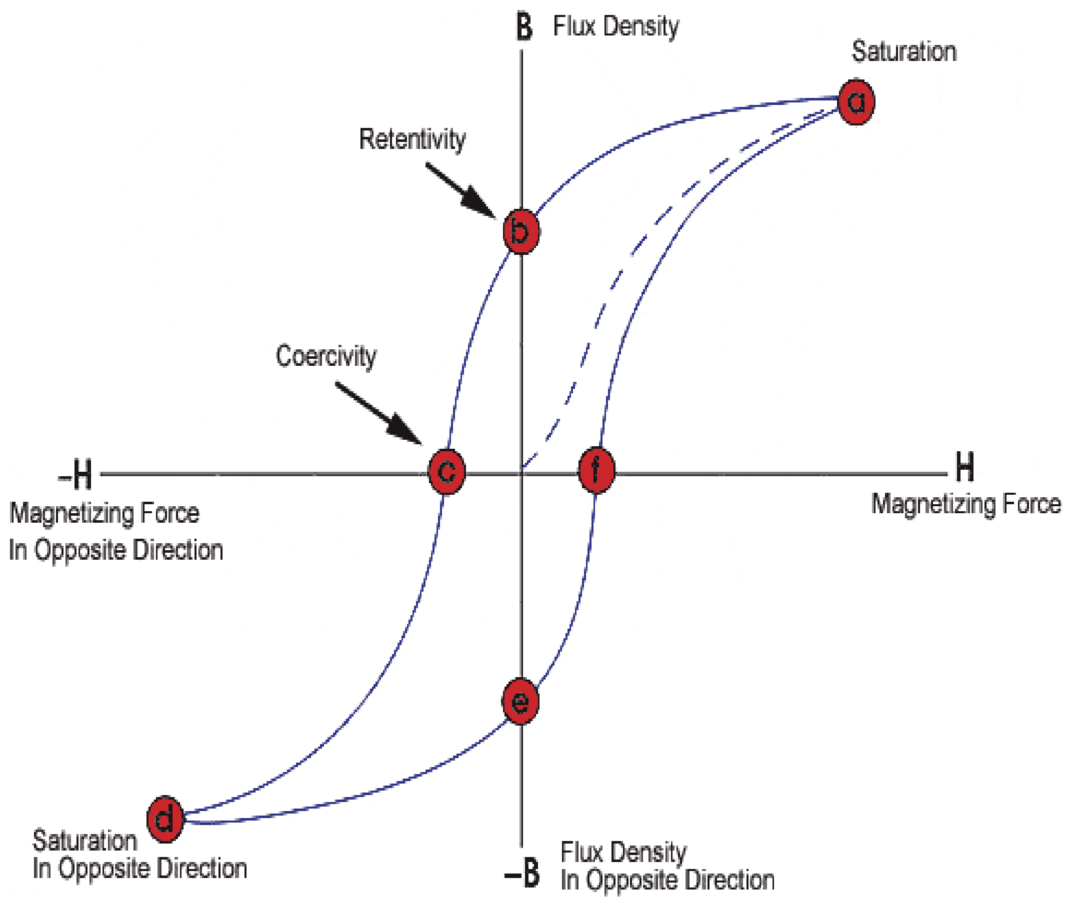
- With a decrease in the value of the magnetising field (H), there is a decrease in the value of magnetism (B). But at point b, when H is equal to zero, substance or material retains some amount of magnetism is called retentivity or residual magnetism.

- When there is a decrease in the magnetic field towards the negative side, magnetism also decreases. At point **c** the substance is completely demagnetized.



Hysteresis Loop

- The force required to remove the retentivity of the material is known as Coercive force (C).
- In the opposite direction, the cycle is continued where the saturation point is **d**, retentivity point is **e** and coercive force is **f**.
- Due to the forward and opposite direction process, the cycle is complete and this cycle is called the hysteresis loop.



Text Book & References

Text Book:

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2. "Basic Electrical Engineering", D. C. Kulshreshta, 2nd Edition, McGraw-Hill. 2019
3. "Special Electrical Machines" E G Janardanan, PHI Learning Pvt. Ltd., 2014

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1. "Engineering Circuit Analysis" William Hayt, Jack Kemmerly, Jamie Phillips and Steven Durbin, 10th Edition McGraw Hill, 2023

2. "Electrical and Electronic Technology" E. Hughes (Revised by J. Hiley, K. Brown & I.M Smith), 12th Edition, Pearson Education, 2016.

THANK YOU

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