Mathematical modeling of Linear Acceleration by using Magnetic Strips

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Abstract

Permanent Magnets are known from thousands of years and this human eagerness to utilize magnetic force for useful work. Magnets have north and south poles, similar pole always repel and opposite poles attract to each other. Magnetic Strips are made of thousands of tiny magnets in similar arrangement in the form of long strip. In this article magnetic force behavior of magnetic strips over water surface in two different cases has been discussed. A linear acceleration is generated along the magnetic strip which is responsible for the motion of movable disk in both directions only by changing the inclination angle, and in second case the continuous force on the internal disk which makes the disk rotating over the water surface. Experimental result is explained by using mathematical modelling.

Introduction

Magnetism is basically a non-contact force. It is the core of attraction and repulsion without having to touch the object they are attraction or repulsion. Accordingly, herein below I represent the model elucidating the study based on above theory. There is no gravitational force interference if water used as floating medium.

Magnetic Force Vs Electrostatic Force:

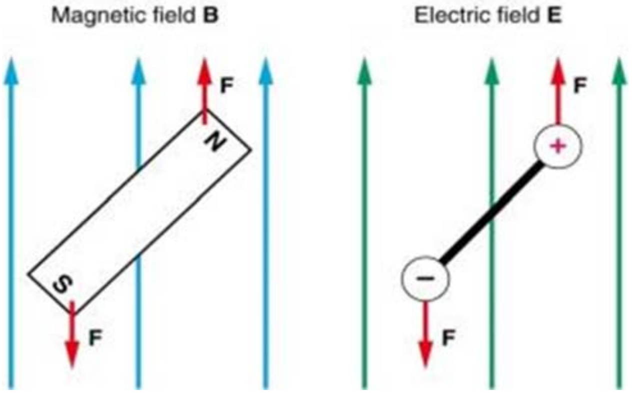


Figure 1: Magnetic force direction

Magnetic force direction is calculated by assuming North Pole behaviors in magnetic field similar as positive charge behavior in electrostatic field as shown in Figure 1.

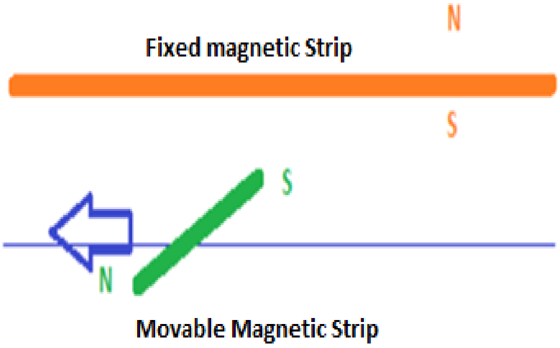


Figure 2: Magnetic force direction on movable strip

When a movable magnetic strip placed at an angle in the field of fixed magnetic strip, it will feel a force in the arrow direction as shown in figure 2.

Magnetic Strips:

Different types of magnetic strips are available in the market.

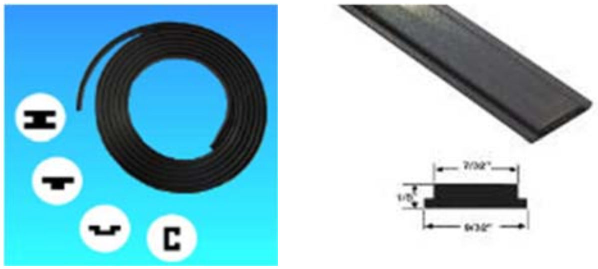
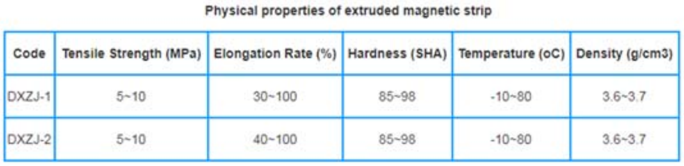


Figure 3: Types of magnetic Strips

In this experiment T-shape of magnetic strip are used

Figure 4: Types of magnetic Strips used in the experiment

Examples of physical properties of magnetic strips are given below table.



Physical properties of extruded magnetic strip

Code	Tensile Strength (MPa)	Elongation Rate (%)	Hardness (SHA)	Temperature (oC)	Density (g/cm3)
DXZJ-1	5~10	30~100	85~98	-10~80	3.6~3.7
DXZJ-2	5~10	40~100	85~98	-10~80	3.6~3.7

Polarity of Magnetic Strips:

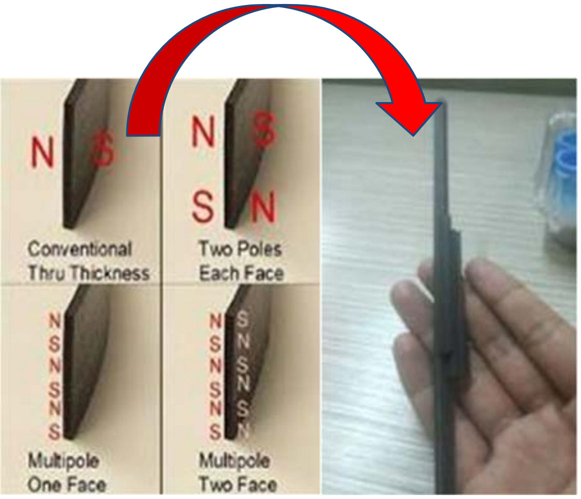


Figure 5: Magnetic Strips Polarities

In this study as shown above conventional through thickness type of magnetic strip is used. Magnetic strips have magnetic poles on each surface.

Method:

Liner acceleration over water surface has been shown with two experiments.

Figure 6: Magnetic strips arrangements in first experiment

In first experiment a long magnetic strips used, which have thousands of poles on each edge. When a small magnetic strip is placed over water surface inside the disk, disk moves along the long magnetic strip as the water surface is efficient to detect a minute magnetic force in slow motion as shown Fig.6.

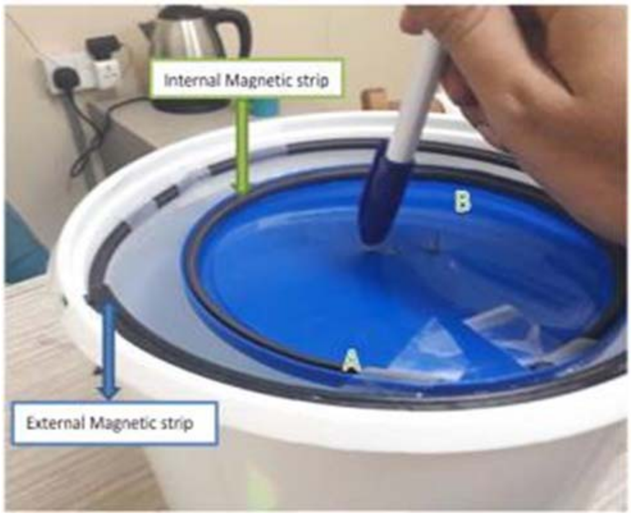


Figure 7: Magnetic strips arrangements in second experiment

In second experiment external magnetic strip is fixed with the outer circular bucket containing water and the internal magnetic strip is tied to the inner circular disk placed over the water surface as shown in Figure7. The continuous rotation of internal disk is by maintaining the fixed distance between two disks either point ‘A’ or ‘B’. If fixed distance is set at point ‘A’ the internal disk rotate clockwise and if the fixed distance is set at point ‘B’ the internal disk rotate anticlockwise.

Result:

Experiment 1:

The direction of force on small disk changes with change of orientation of small magnet inside disk over water surface. Small disk moves left to right in figure 8.1, Figure 8.2, Figure 8.3. If only angle of small magnetic strip changed to 180 Degree and others all parameter are constant, small magnetic strips inside disk will move left to right direction as shown in Figure 8.4, Figure 8.5, and Figure 8.6.

Figure 8.1: small magnetic strip start moving left to right

Figure 8.2: small magnetic strip moving left to right

Figure 8.3: small magnetic strip moving towards right end

Figure 8.4: small magnetic strip start from right to left

Figure 8.5: small magnetic strip moves from right to left

Figure 8.6: small magnetic strip moves from right toward left end

Experiment 2: Linear acceleration on the periphery of inner magnetic strip ring due to repulsion forces. If we maintain the fixed distance either at Point 'A' it start rotate in anticlockwise direction as shown in Figure 9.1, Figure 9.2, Figure 9.3, Figure 9.4. If the fixed distance maintained by external (by hand) during rotation of inner ring it will continuous rotate in clockwise direction.

Anti-Clockwise rotation:

Figure 9.1 : Rotation due fixed distance maintain at Point 'A'

Figure 9.2 : Rotation due fixed distance maintain at Point 'A'

Figure 9.3: Rotation due fixed distance maintain at Point 'A'

Figure 9.4: Rotation due fixed distance maintain at Point 'A'

Clockwise Rotation:

Figure 9.5: Rotation due fixed distance maintain at Point 'B'

Figure 9.6 : Rotation due fixed distance maintain at Point ‘B’

Figure 9.7: Rotation due fixed distance maintain at Point ‘B’

Figure 9.8: Rotation due fixed distance maintain at Point ‘B’

Mathematical modeling:

Mathematical model is derived on the bases of below assumption –

Assumption:

1. Outer ring magnet strip only North Pole considered, S pole will also have some effect will not affect the direction of net force.
2. Force due to others segment will be canceled each other due to symmetrical magnet strip both side.
3. Magnetic field of magnetic strip assume uniform along its whole length
4. Measurement of force unit during curve plotting considered 1, to analyze the shape of curve only.

Equivalent Diagram for experiment 1:
Thickness of magnetic strip considered 2b, which is placed at a distance d.

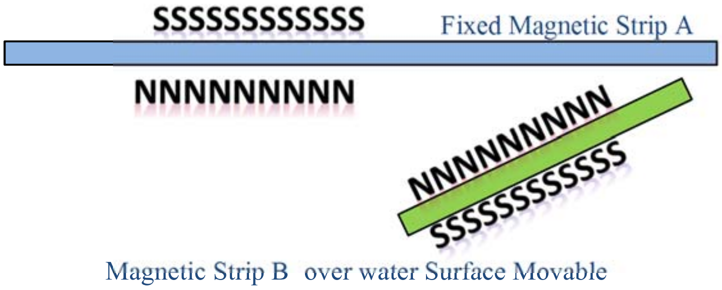


Figure 10.0: Fixed magnetic strip aligned to movable strip over water surface

Point P_0 - represent the North Pole of magnetic strip A, P1 South pole and P2 North pole of Magnetic strip B.

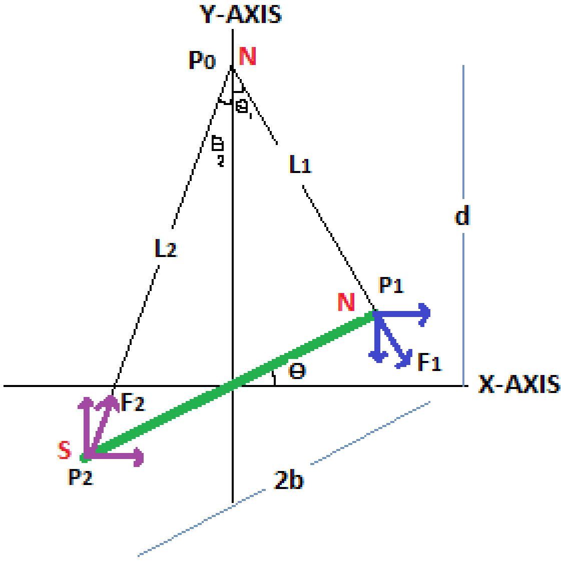


Figure 10.1: Axial force distribution due to point magnet pole (N) assuming at point P_0

Net force in X-direction:

$F_x = F_1 \sin\Theta_1 + F_2 \sin\Theta_2$ ………………………….. (1)

Net force in Y-direction:

$F_y = F_1 \cos\Theta_1 - F2 \cos\Theta_2$ ………………………….. (2)

Where $F_1 = K\, p^2 / L_1^2$ and $F2 = K\, p^2 / L_2^2$ (by using Gilbert model of magnetism)
Where $K = \mu_0/4\pi$ and p is field strength of magnetic pole

L_1 and L_2 can be calculated by trigonometry relationship as below –

$L_1 = \sqrt{\{b^2 \cos^2\Theta + (d - b \sin \Theta)^2\}}$ and
$L_2 = \sqrt{\{b^2 \cos^2\Theta + (d + b \sin \Theta)^2\}}$

By putting these values in Equation (1) and Equation (2)

$F_x = Kp^2 b \cos\Theta[\, 1/\{b^2 \cos^2\Theta + (d - b \sin \Theta)^2\}^{3/2} + 1/\, \{b^2 \cos^2\Theta + (d + b \sin \Theta)^2\}^{3/2}\,]$ ………(3)

$F_y = Kp^2 b \cos\Theta[\, (d - b \sin\Theta)/\{b^2 \cos^2\Theta + (d - b \sin \Theta)^2\}^{3/2} - (d + b \sin\Theta)/\, \{b^2 \cos^2\Theta + (d + b \sin \Theta)^2\}^{3/2}\,]$ ………(4)

X-direction force will accelerate the magnetic strip in forward or back word direction depends on the angles
Y- Direction force will be compensated automatically or by hand as shown in experiment 2.

Force behavior with Angles of movable strips:

Net forces in X-direction and Y-direction plotted with inclination angle Θ.

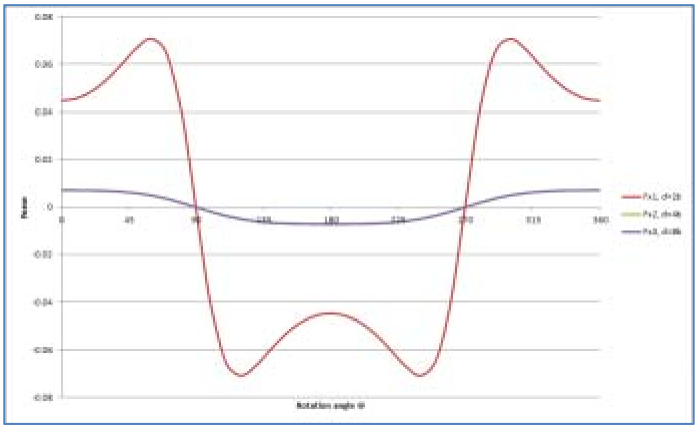


Figure 10.2: Force Vs angle Θ for d= 2b, d=4b and d=8b

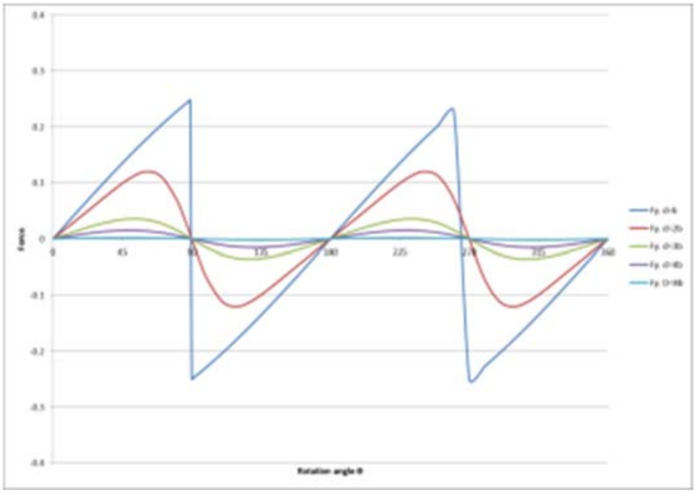


Figure 10.3: Force Vs angle Θ for d= 2b, d=2b, d=3b and d=4b

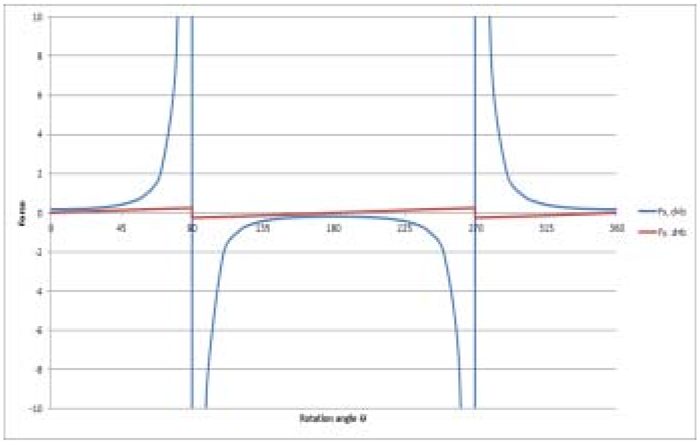


Figure 10.4: Force Vs angle Θ for d= b

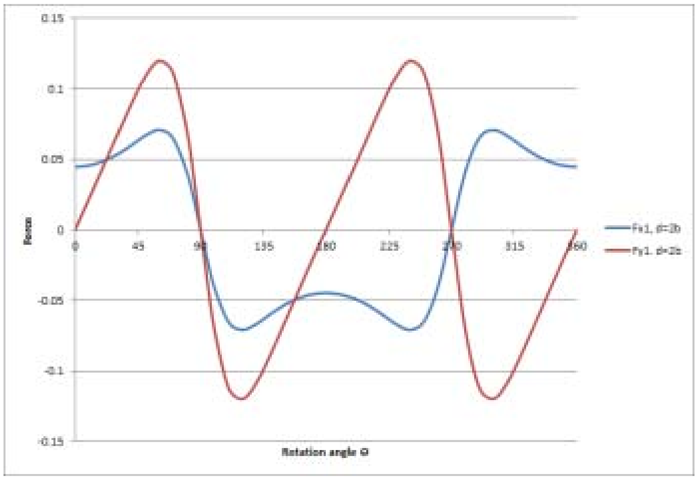


Figure 10.5: Force Vs angle Θ for d= 2b

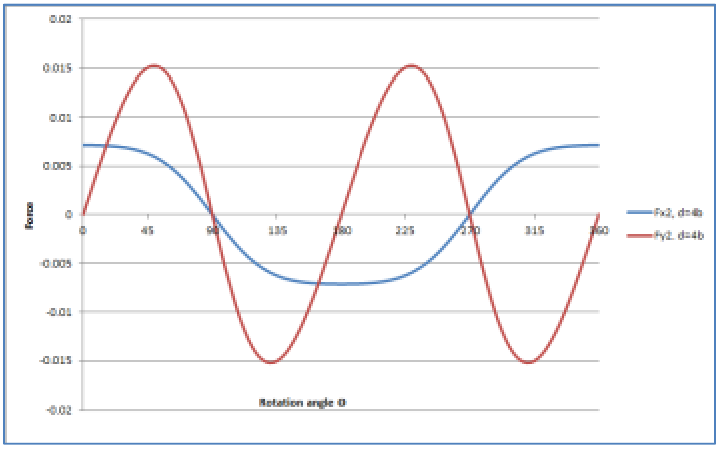


Figure 10.6: Force Vs angle Θ for d= 4b

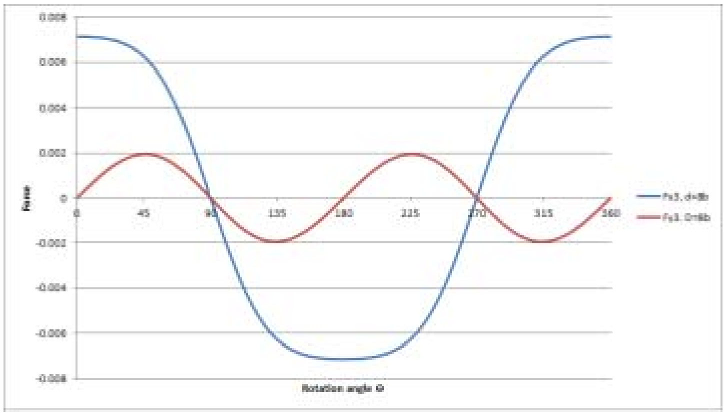


Figure 10.7: Force Vs angle Θ for d= 8b

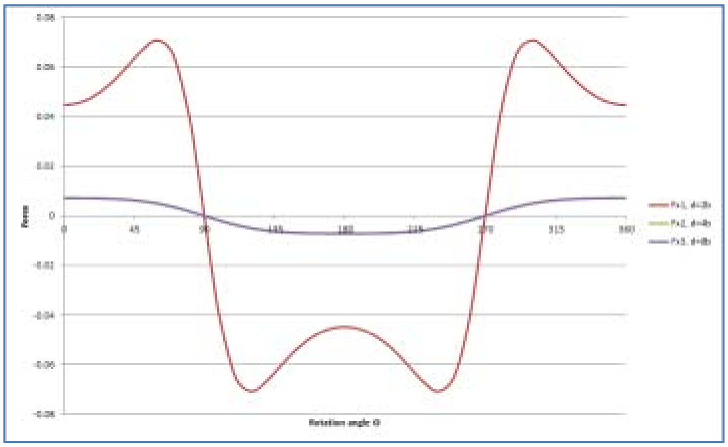


Figure 10.8: Force Vs angle Θ for d= 2b, d=4b and d=8b

Equivalent diagram of rotating disk over water Surface:

By Equivalent angle Θ all position can be easily explain and verified by experimental result.

Assumption: Outer ring magnet strip only North Pole considered, S pole will also have some effect will not affect the direction of net force. Force due to others segment will be canceled each other due to symmetrical magnet strip both side.

Ring R1 is tied to inner surface of bucket full of water. Moving disk having ring R2 fixed on its periphery over water surface can be replaced and equivalent magnet having 2b thickness and inclined with an angle to Θ if moved along the point A, B, C and D. The Ring R2 feels a net force in tangential direction which generates torque in the disk over water surface.

If disk moves in A direction by hand Fy force is compensated by hand its will rotates in clockwise direction as shown in Figure 11.1. If the disk moves by hand in direction to B it will rotates in anticlockwise direction as shown in figure 11.2.

There will be no rotation if the disk moves in direction of C or D as shown in figure 11.3 and figure 11.4

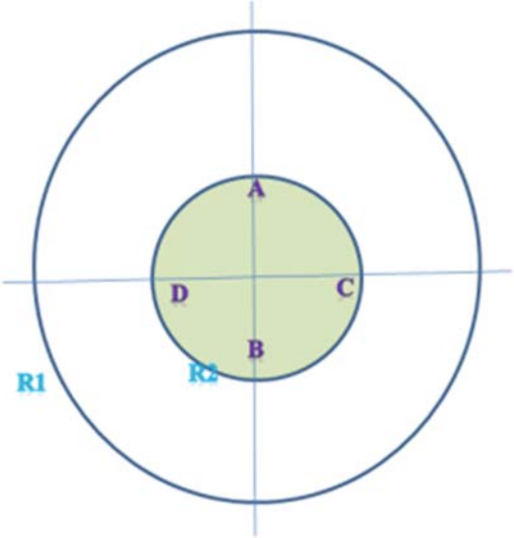


Figure 11.0: Ring R1 and Ring R2 both are concentric

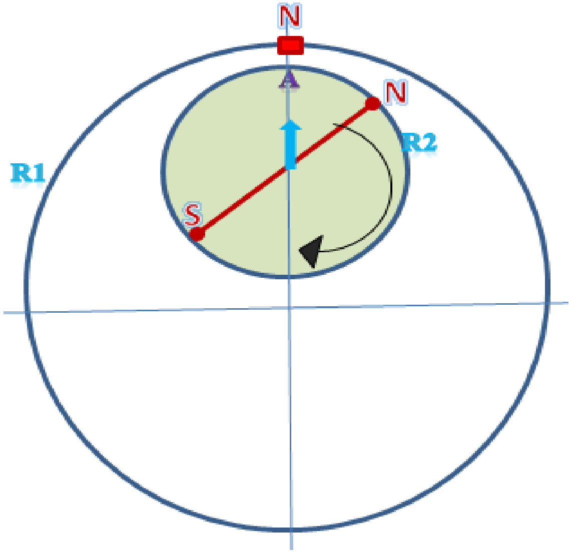


Figure 11.1: Ring R1 are fixed and Ring R2 move towards A, Equivalent angle Θ=45^{0}, start rotating in clockwise direction

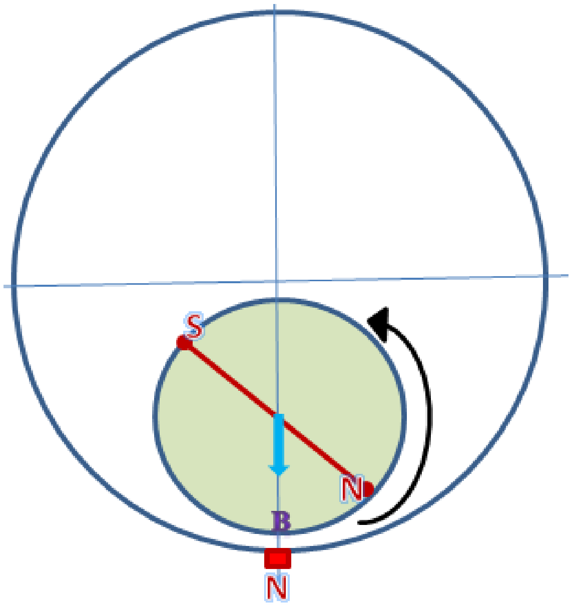


Figure 11.2: Ring R1 are fixed and Ring R2 move towards B, Equivalent angle Θ= -45^{0}, start rotating in anti-clockwise direction

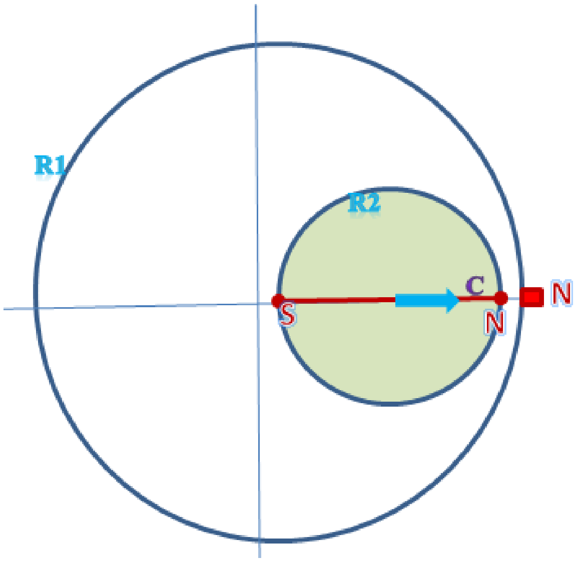


Figure 11.3: Ring R1 are fixed and Ring R2 move towards C, Equivalent angle Θ=90^{0}, No rotation

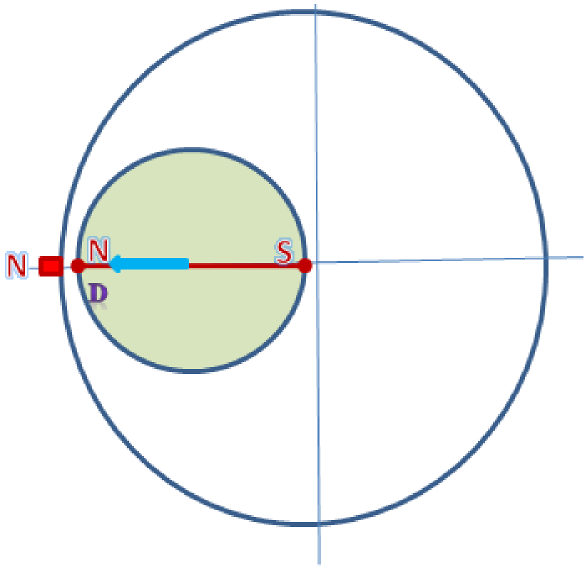


Figure 11.4: Ring R1 are fixed and Ring R2 move towards D, Equivalent angle Θ=-90^{0}, No rotation

Conclusion:

A linear acceleration is generated along the magnetic strip in first case which is responsible for the motion of the small disk in both directions only by changing the inclination angle, and in second case the continuous force on the internal disk which makes the disk rotating over the water surface. Rotating motion is possible without hand (external) support by fixing the distance mechanically. The force behavior in both experiment are explained by using mathematical model. In Figure 10.7 where Fx is greater that Fy , this conditioned can be used as output work done by Fx will be greater that input work done to maintain the fixed distance between two points.

Computer simulation of Magnetic field and comparison of experimental force with the calculated forces are under development.

Reference:

1. Baliyan S.K (2017) Linear acceleration over water surface by using magnetic strips: presented in international conference on Magnetism and magnetic materials held at London during Oct 09-10, 2017.
2. Baliyan. S.K (2003) Revolutionary Current, Published by Faraday Lab Ltd. in New Energy Technologies”, Russia
3. Rubber Magnet Strip http://www.rubber-magnet.com/rubber-magnet-strip.htm
4. Flexible Magnetic Strips https://www.rochestermagnet.com/flexible-magnets/flexible-magnetic-strip
5. Magnetic Field and Magnetic Interaction http://onlinephys.haplosciences.com/magnetism.html
6. Force between magnets https://en.wikipedia.org/wiki/Force_between_magnets