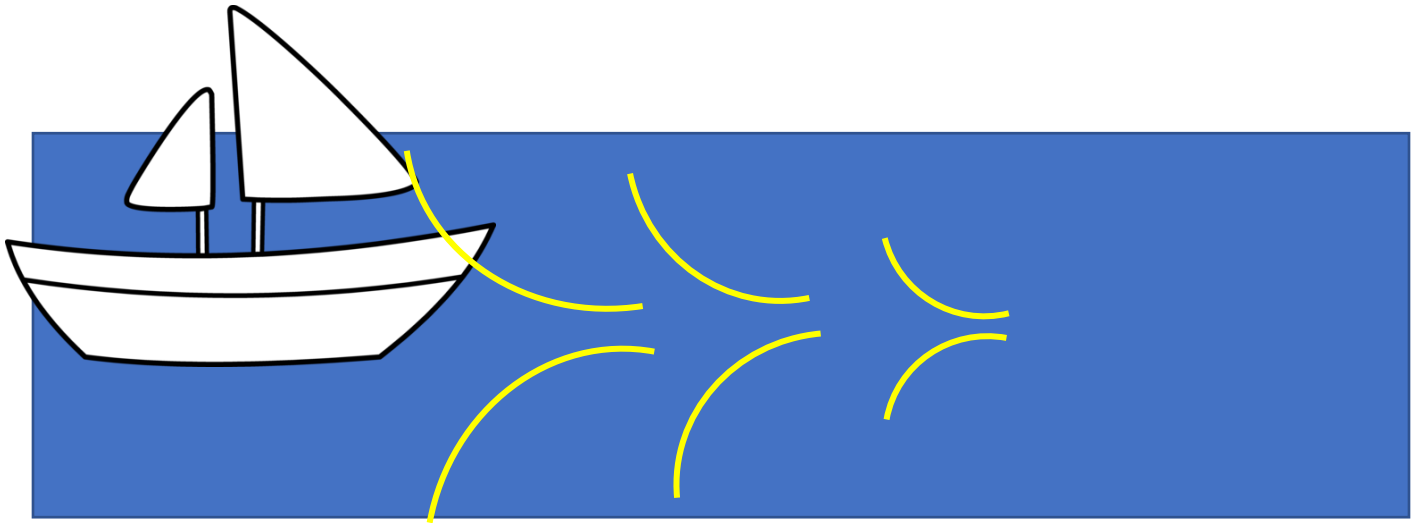
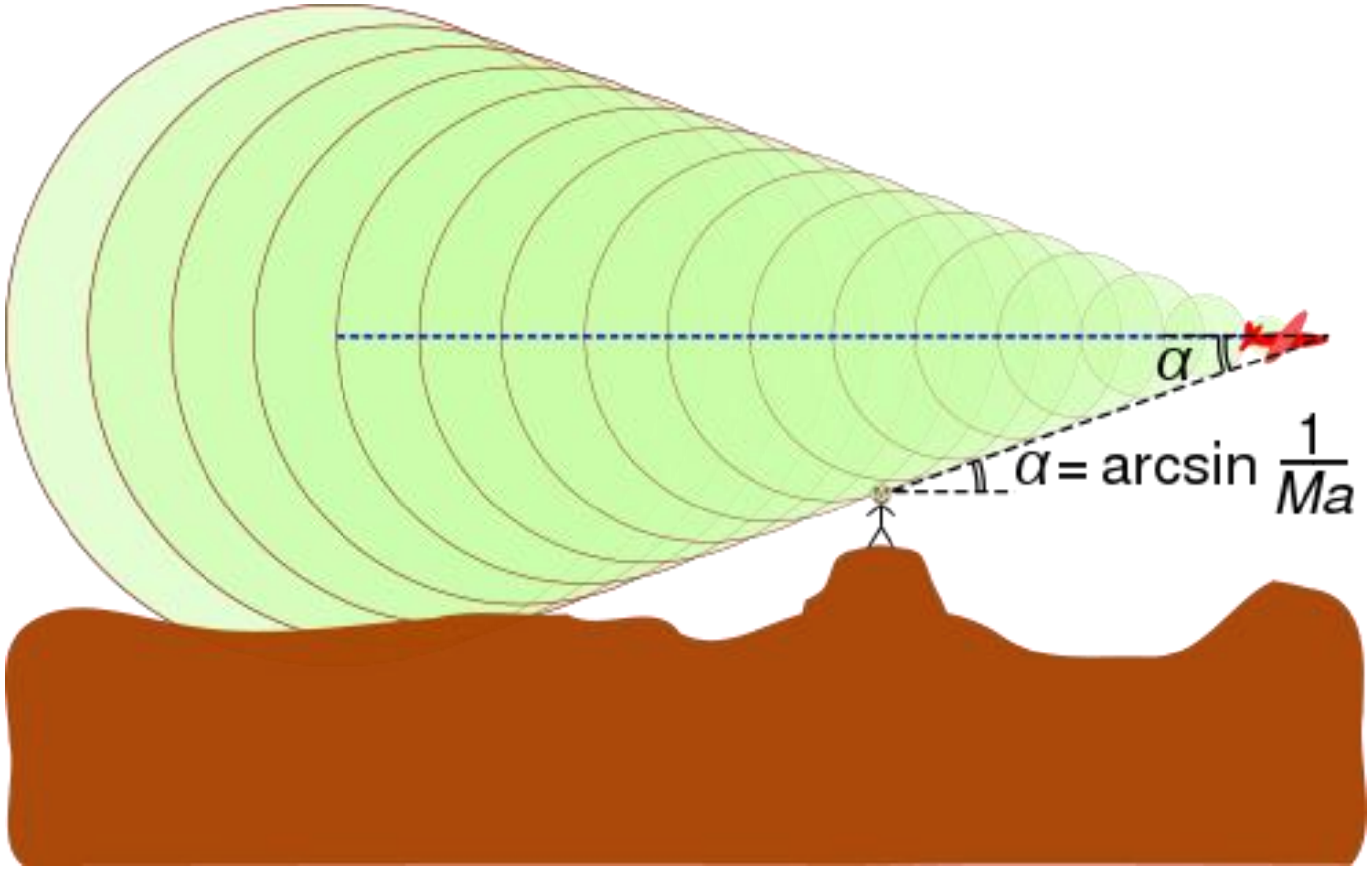
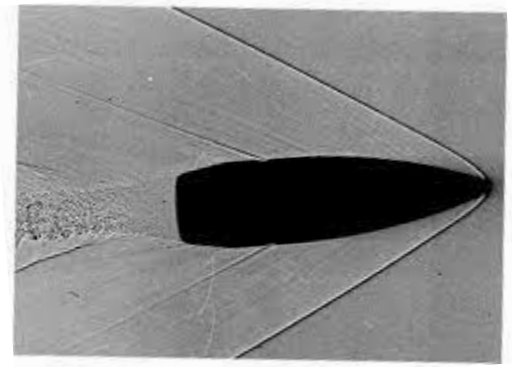
6. Ship wakes

Presenter:Giorgi papidze

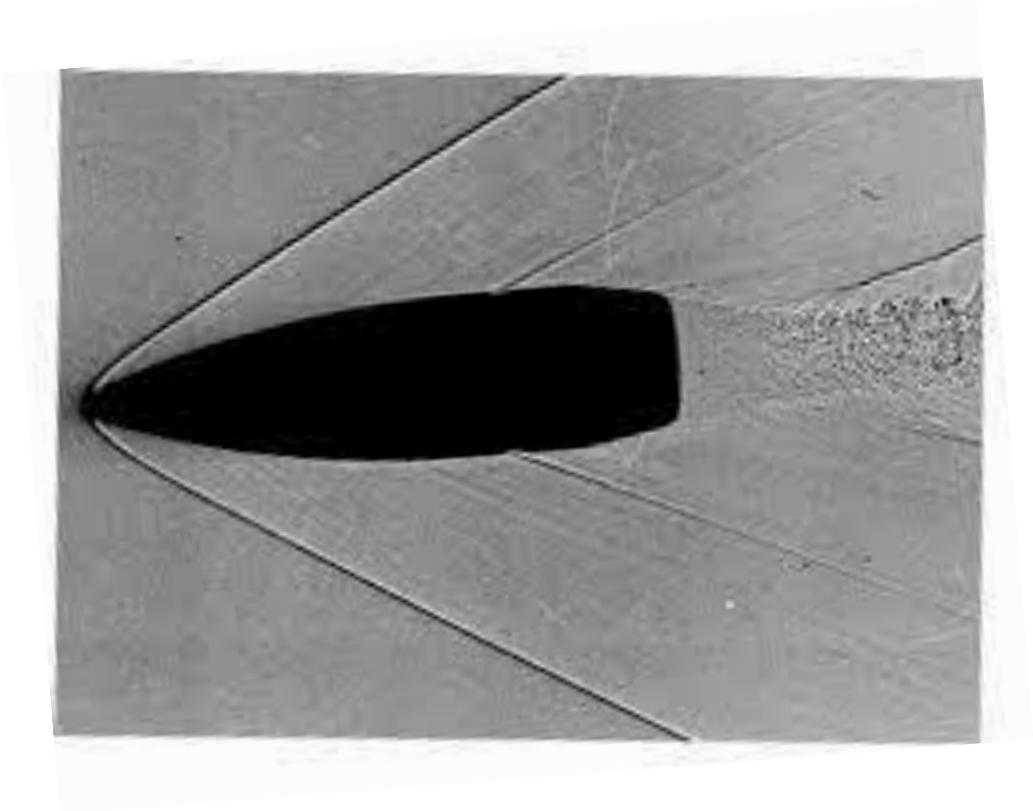
The wave pattern produced by a ship moving on the water is visually similar to a Mach cone and depends on various parameters. Investigate the effect..

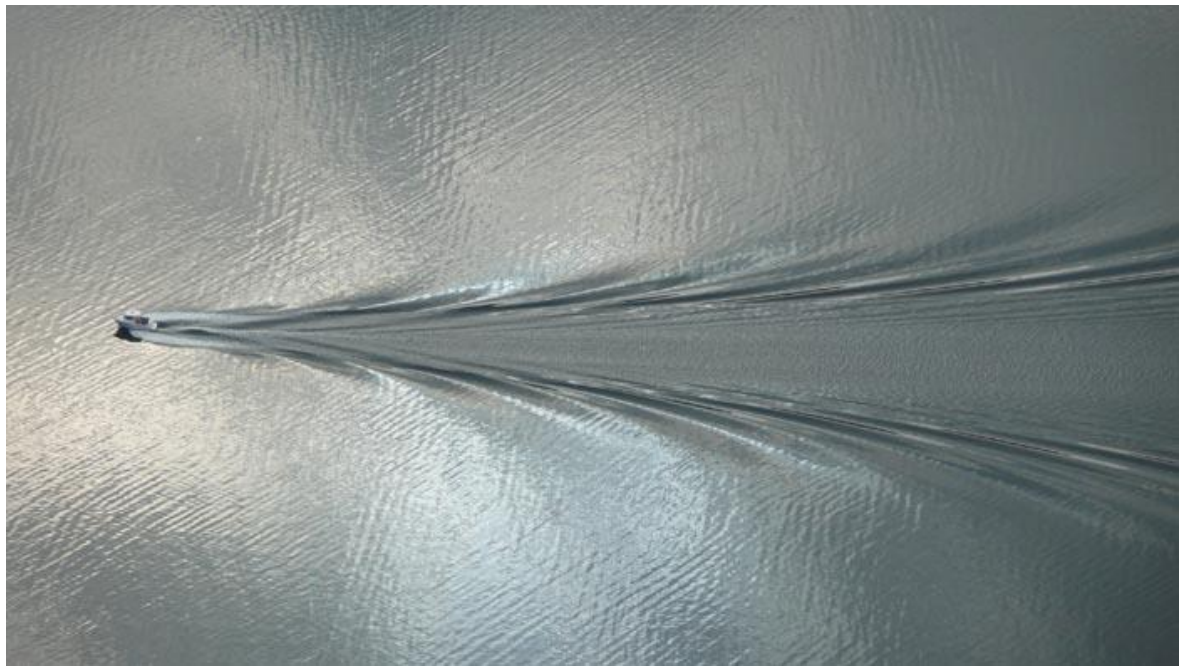


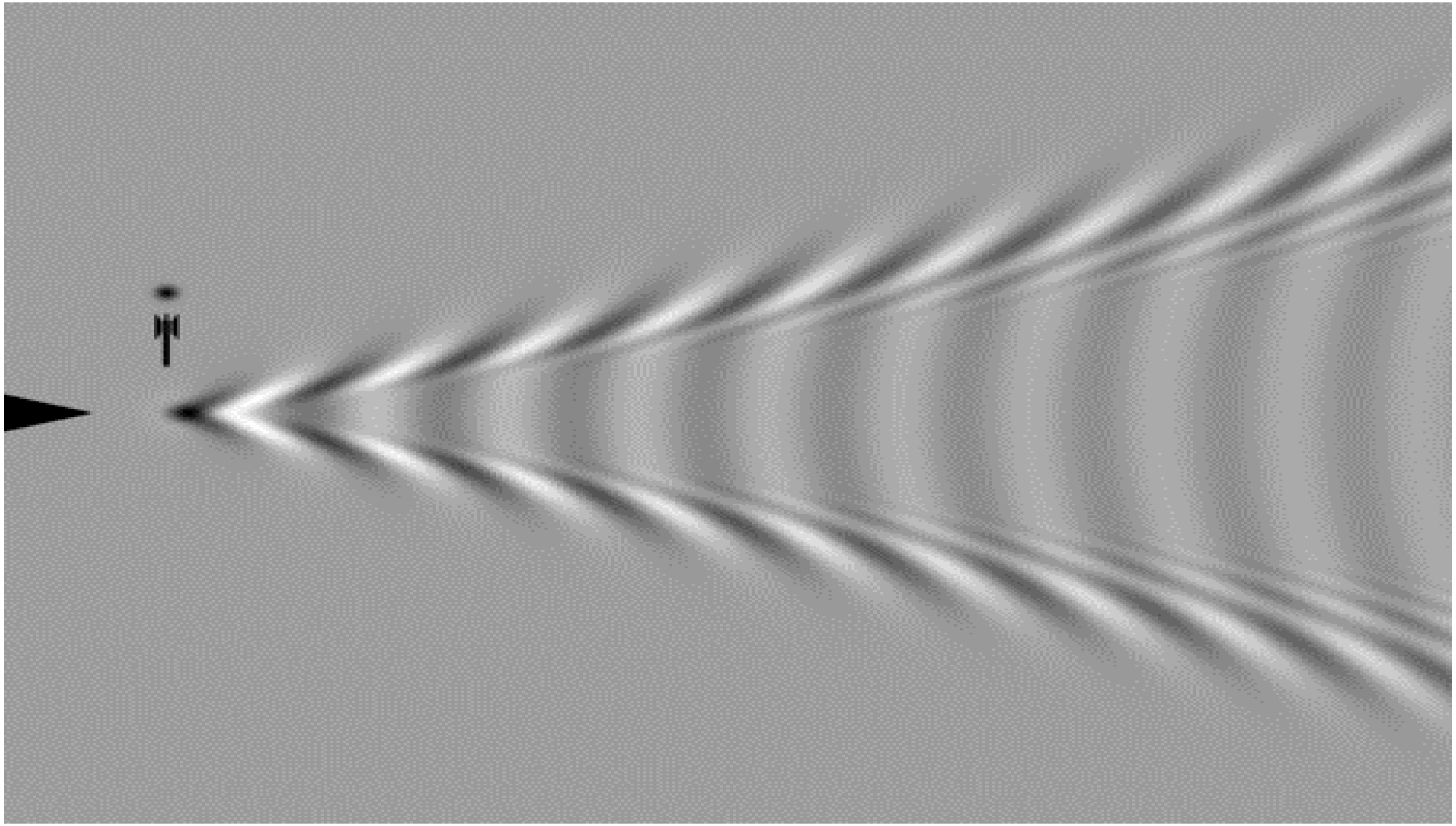


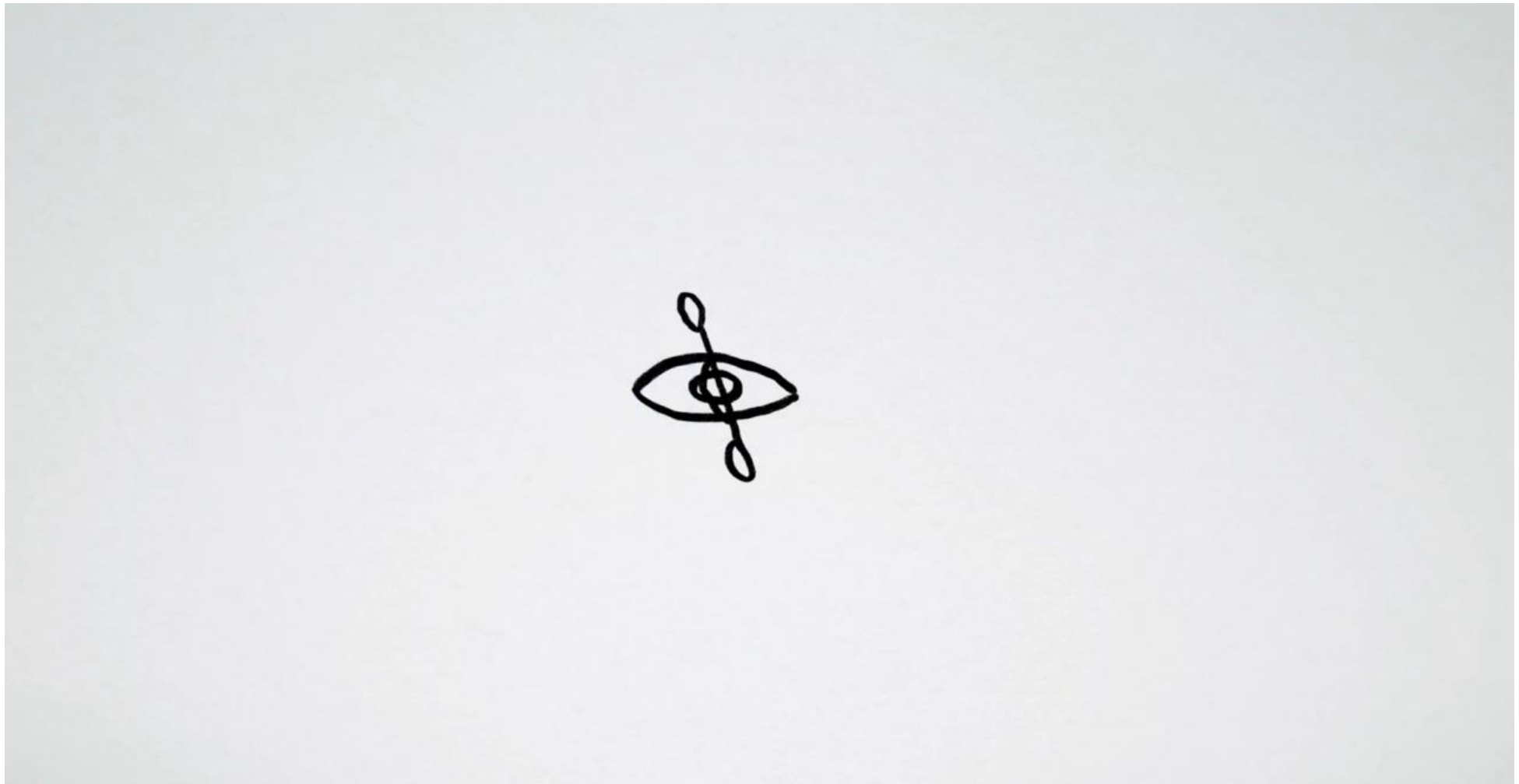


$Ma = u/c$

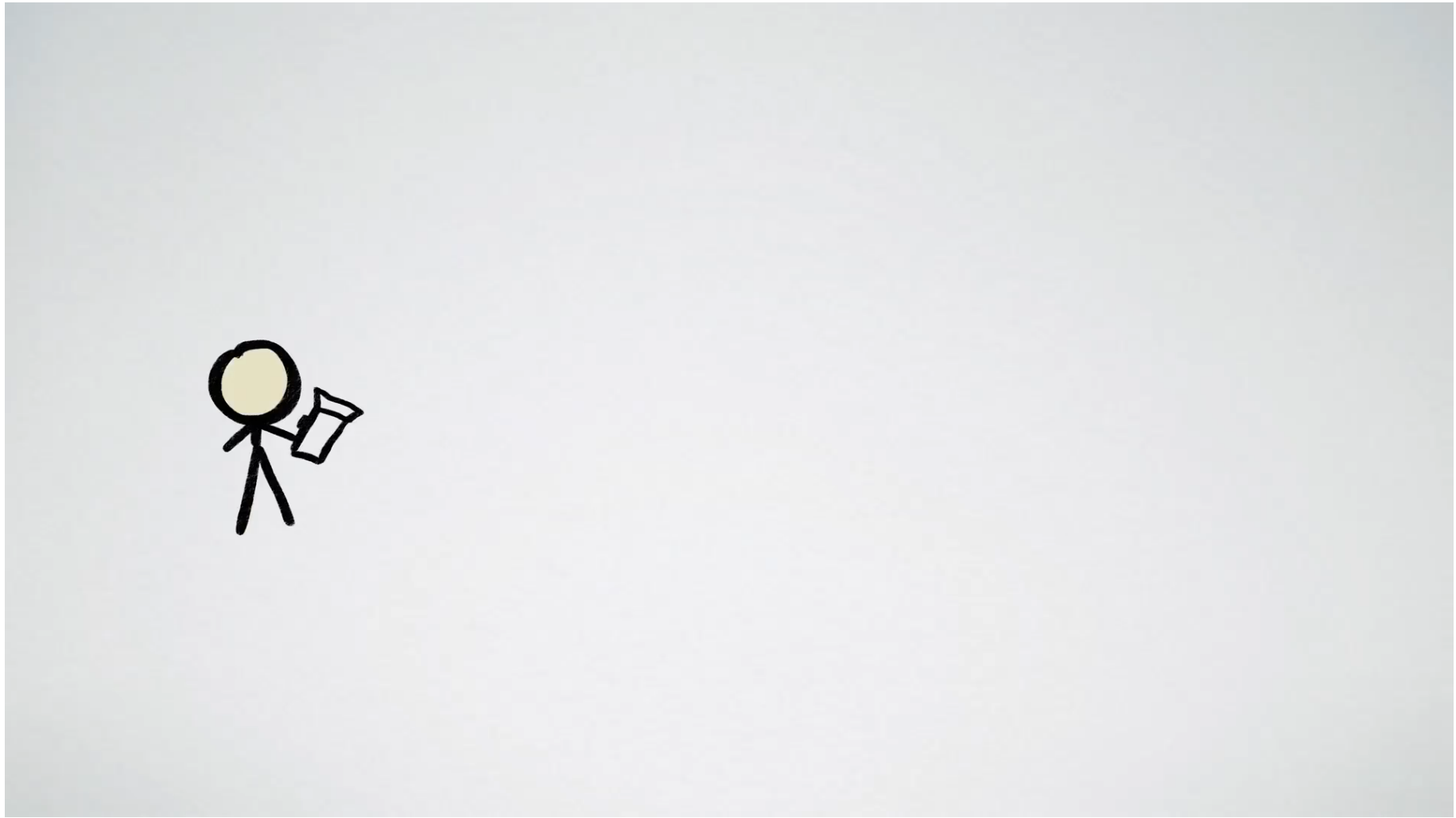




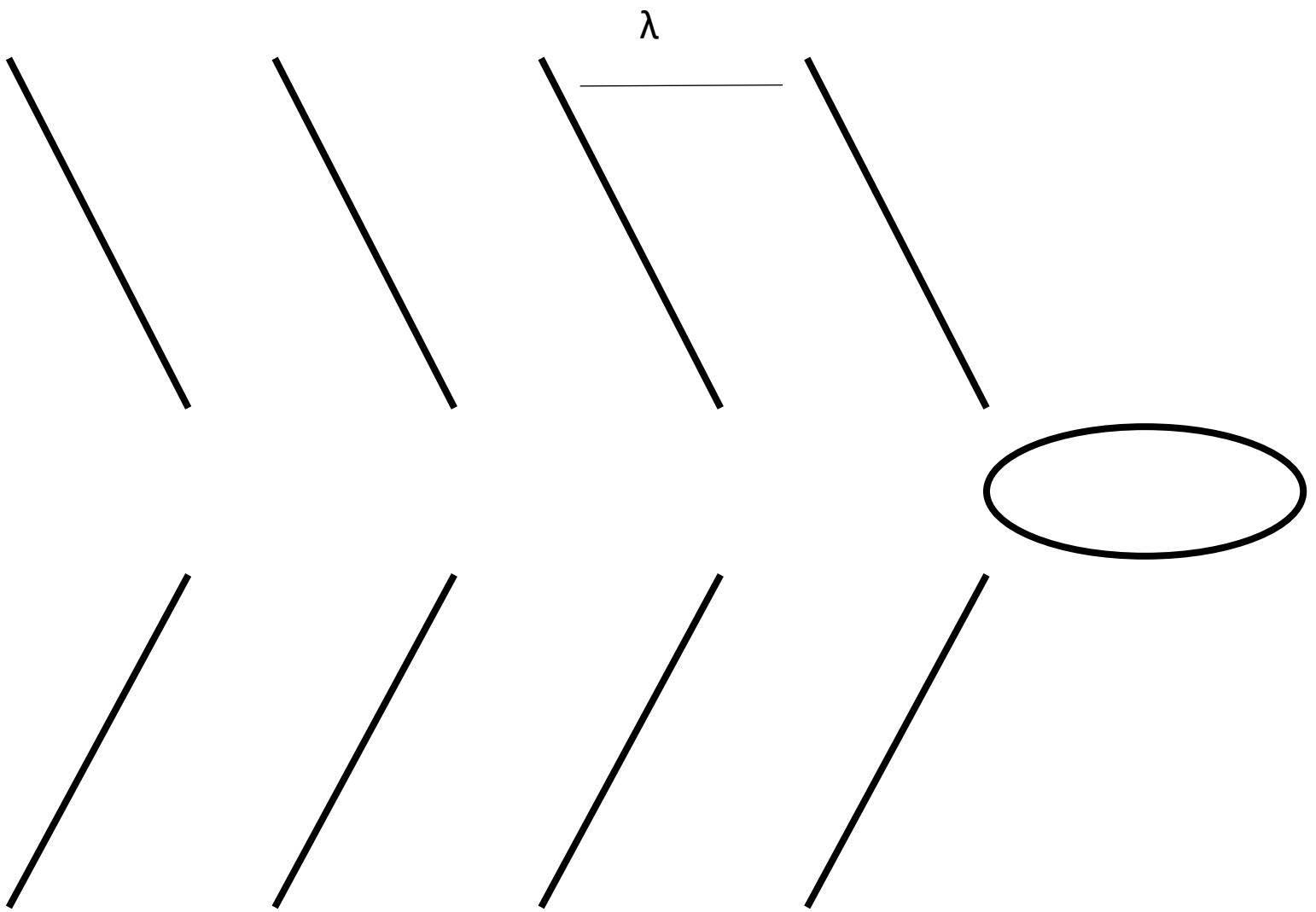


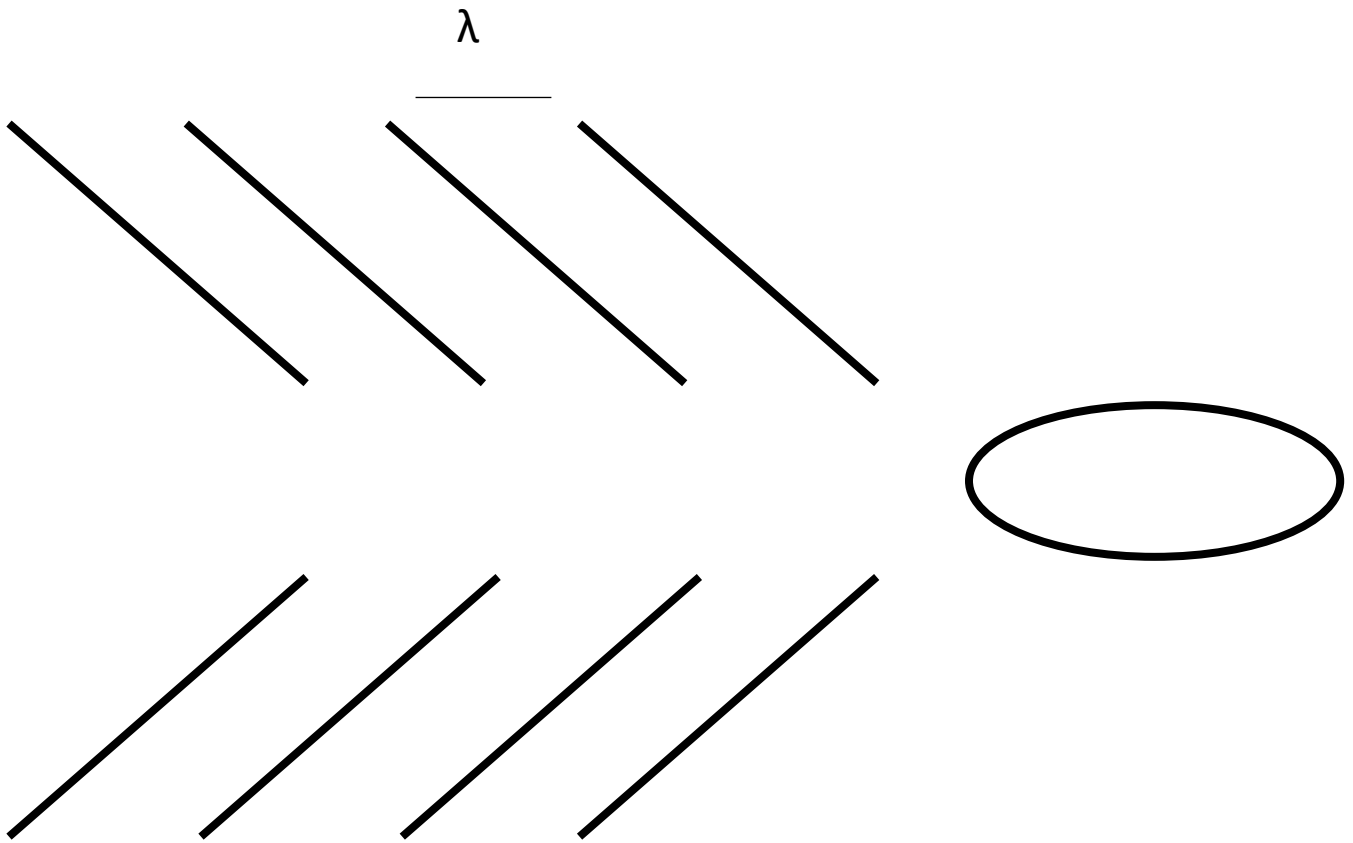


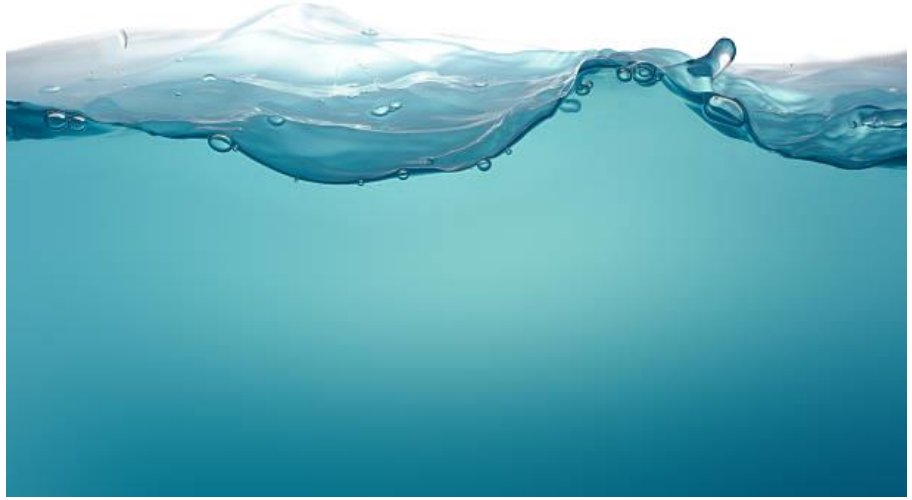
Phenomenon | Theoretical Model | Experiment | Conclusion



Phenomenon | Theoretical Model | Experiment | Conclusion


λ


λ

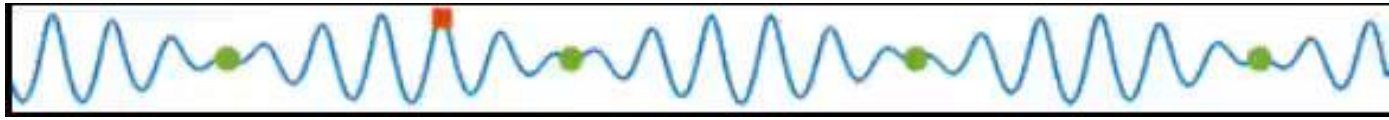


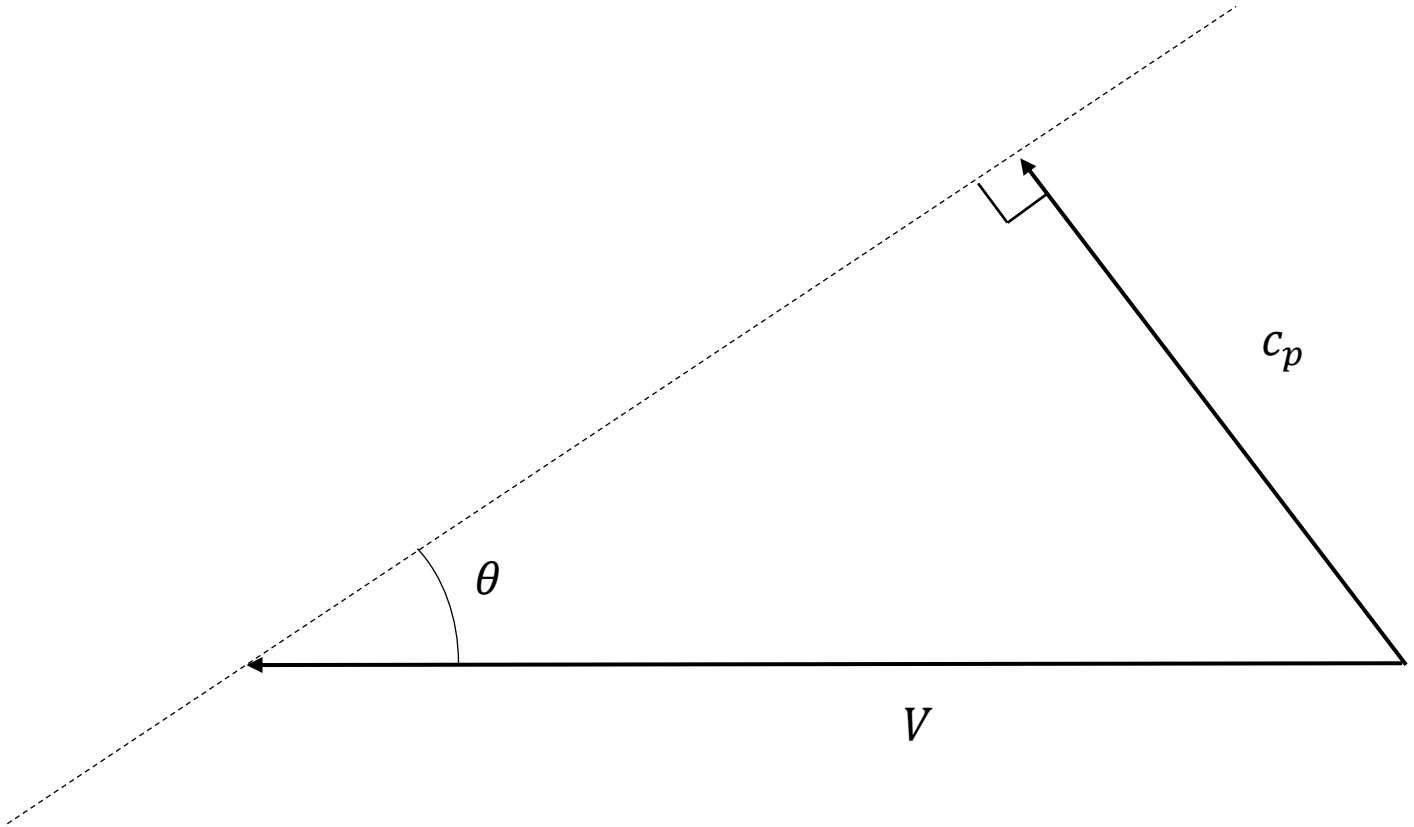
phase velocity:

$$c_p = \frac{\lambda}{T} = \frac{\omega}{\kappa} \qquad \sqrt{\frac{g}{k}\tanh(kh)}$$

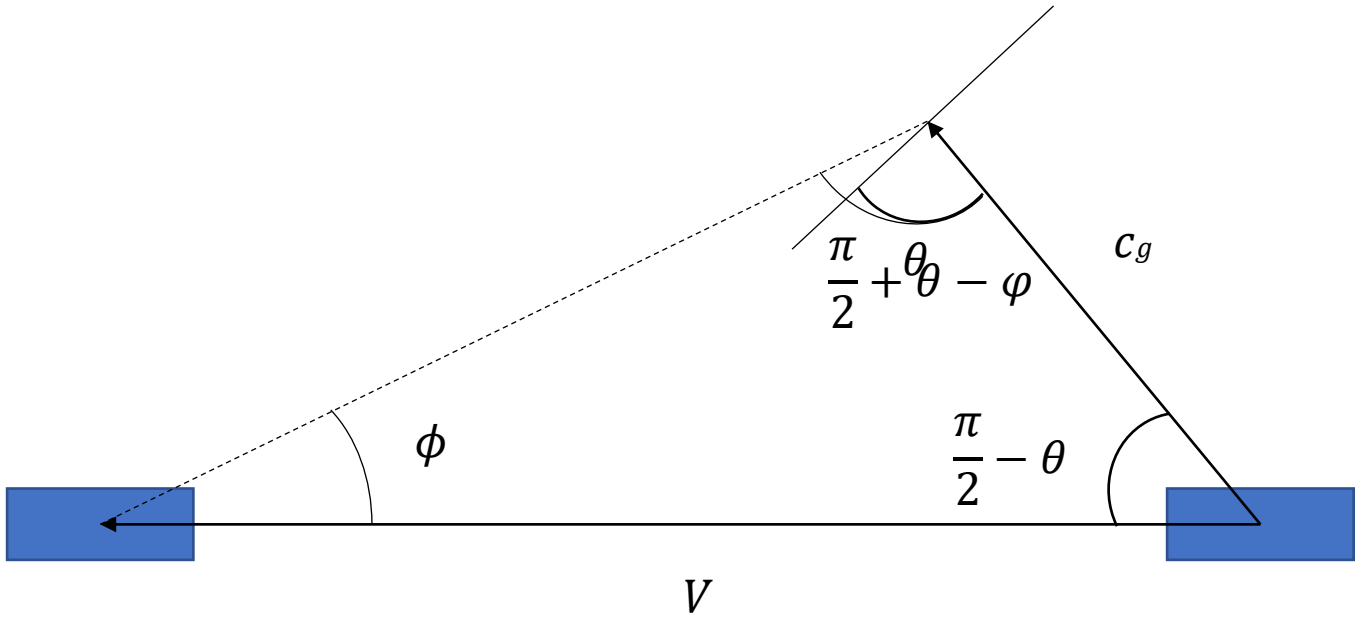
Group velocity:

$$c_g = \frac{d\lambda}{dT} \qquad \frac{1}{2}Cp\left(1 + \frac{2kh}{\sinh(2kh)}\right)$$

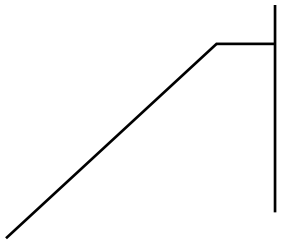




$$\frac{c_p}{V} = sin\theta$$



$$\frac{c_g}{sin\varphi} = \frac{vt}{\sin(\frac{\pi}{2}+\theta-\varphi)}$$



$$\frac{c_p}{V} = sin\theta$$

$$B \equiv \frac{c_p}{c_g} = \frac{1}{2}\left(1 + \frac{2kh}{\sinh(2kh)}\right)$$

$$\frac{c_g}{sin\varphi} = \frac{vt}{\sin\left(\frac{\pi}{2} + \theta - \varphi\right)} =$$

$$\frac{B c_p t}{sin\varphi} = \frac{\frac{c_p}{sin\theta}\, t}{\sin\left(\frac{\pi}{2} + \theta - \varphi\right)}$$

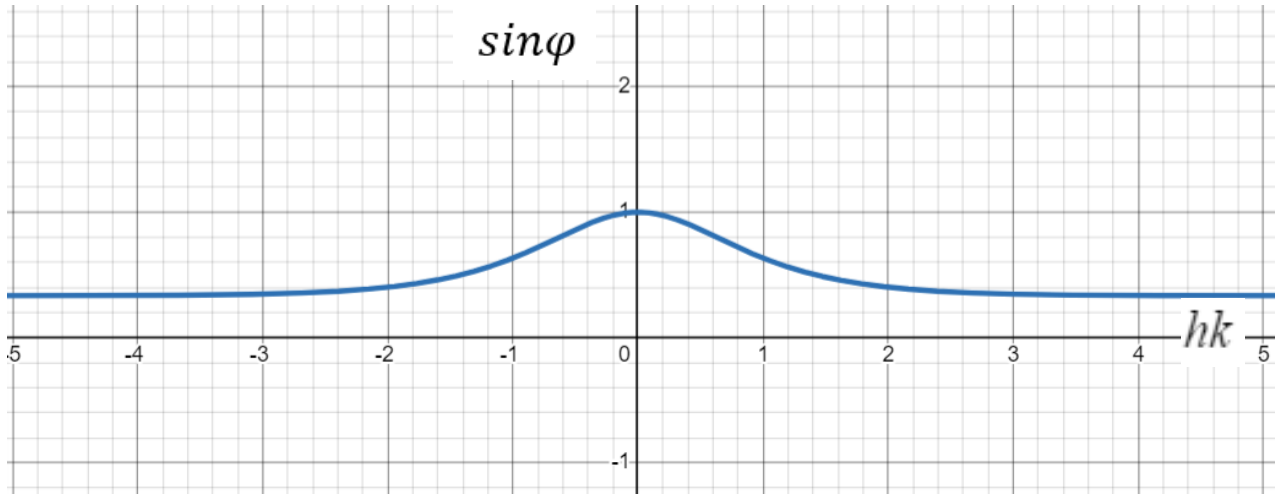
$$B c_p t \sin\left(\frac{\pi}{2} + \theta - \varphi\right) sin\theta = c_p t sin\varphi$$

$$B sin((2\theta - \varphi) = (2 - B) sin\varphi$$

$$sin\varphi < \frac{B}{2 - B}$$

$$B \equiv \frac{c_p}{c_v} = \frac{1}{2}\left(1 + \frac{2kh}{\sinh(2kh)}\right)$$

$$sin\varphi < \frac{B}{2 - B}$$



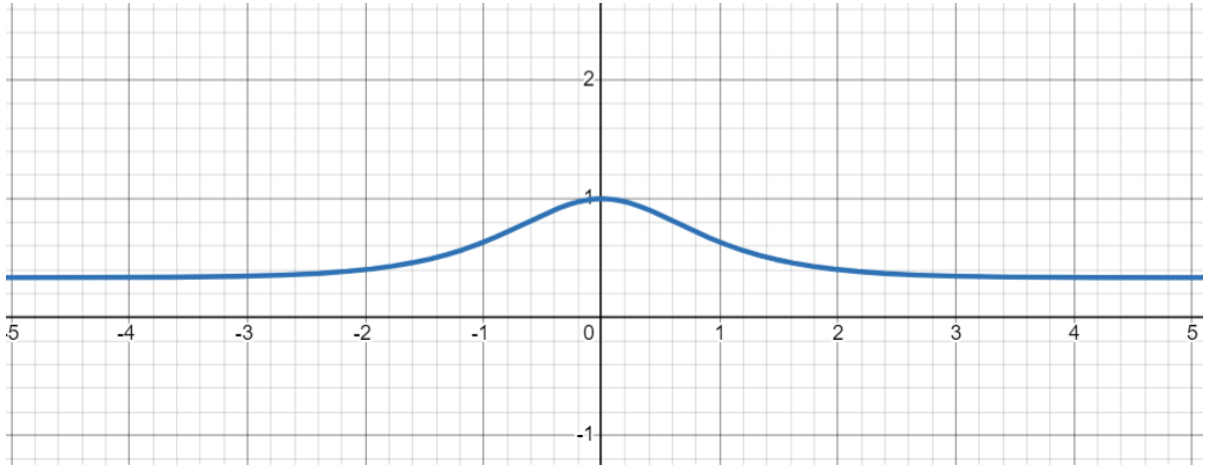
Gravity waves on water surface

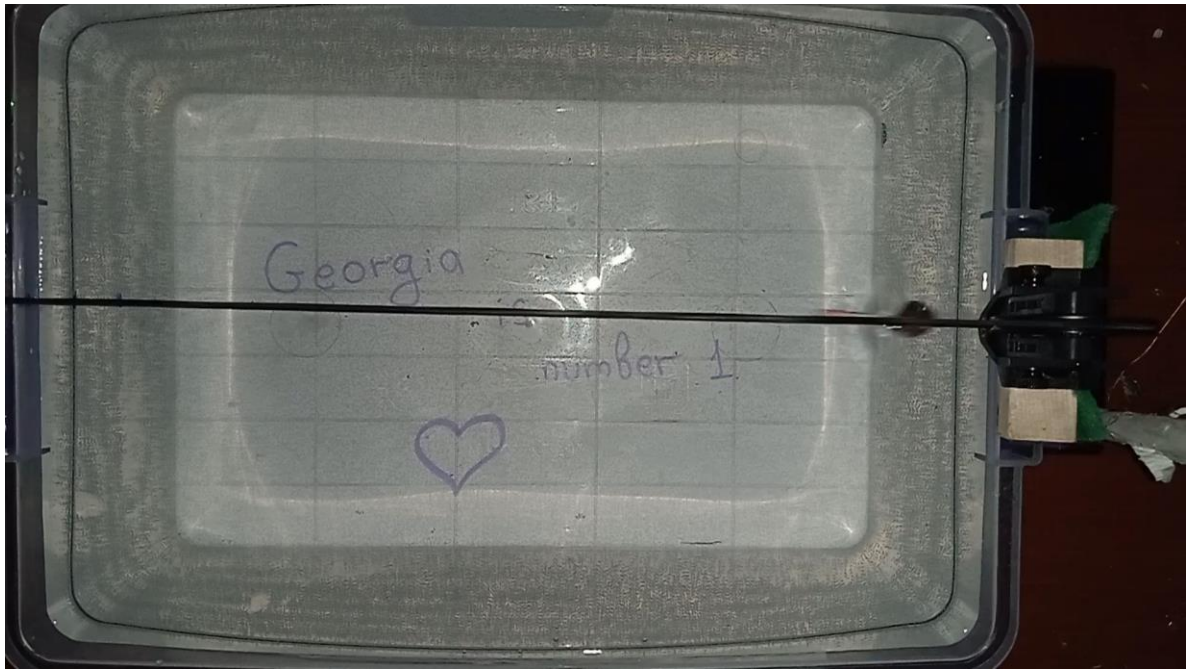
$$sin\varphi < \frac{(e^{4hk} - 1 + 4hke^{2hk}}{3e^{4hk} - 3 - 4hke^{2hk}}$$

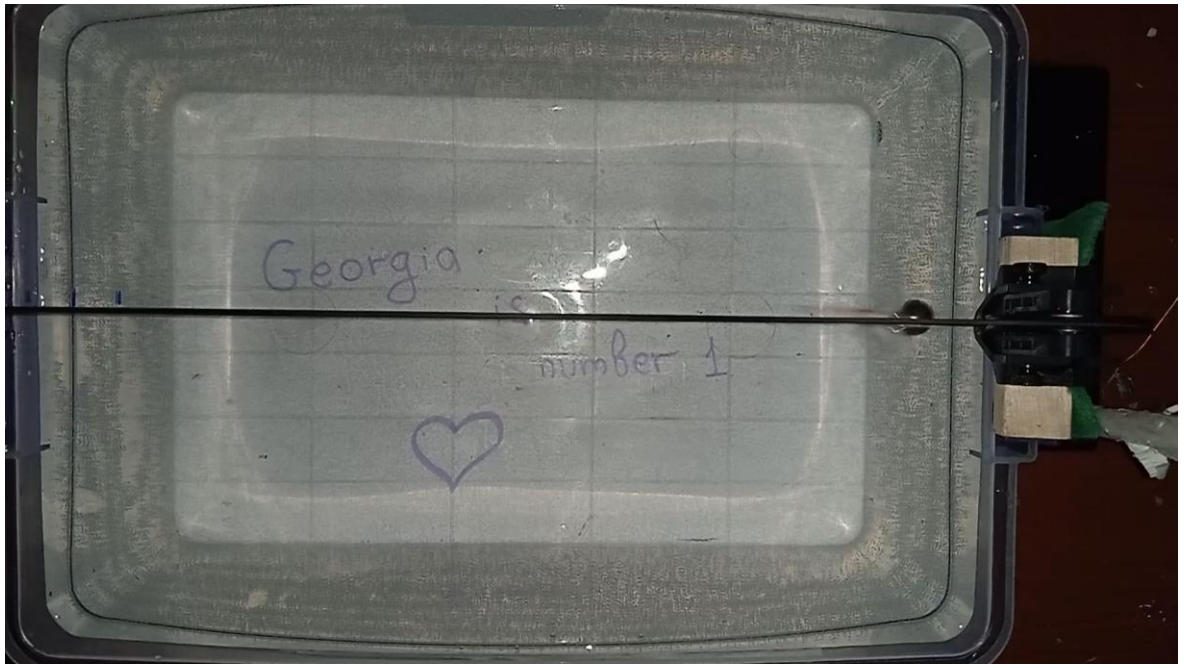
DEEP WATER

$$\frac{c_p}{c_v} = \frac{1}{2} \Rightarrow sin\varphi = 1/3$$

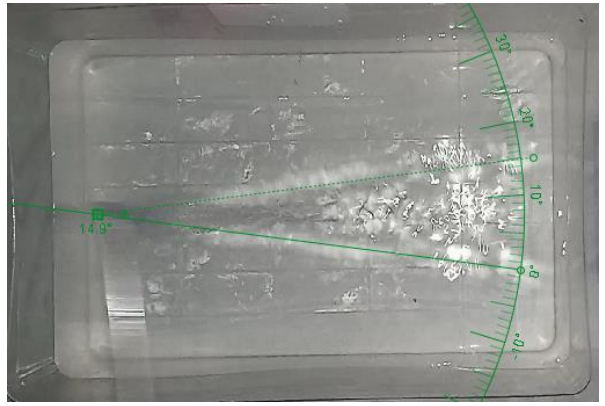
$$\varphi = 19.47^\circ$$

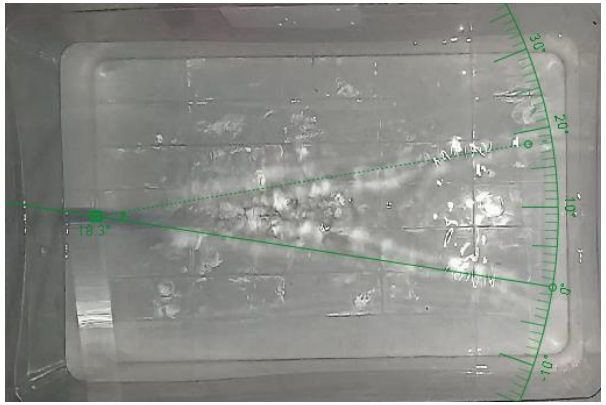


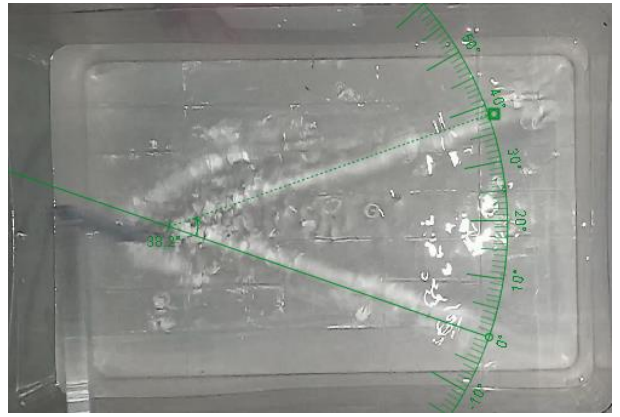


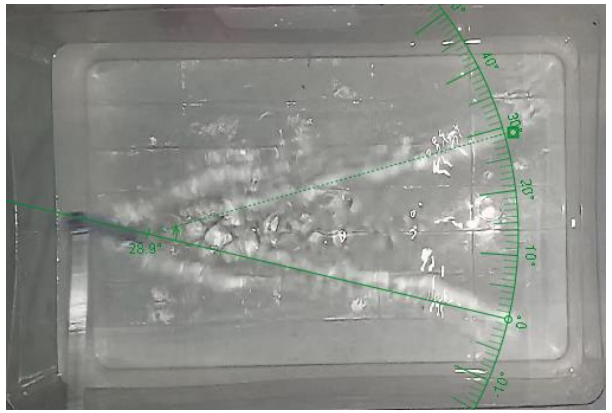


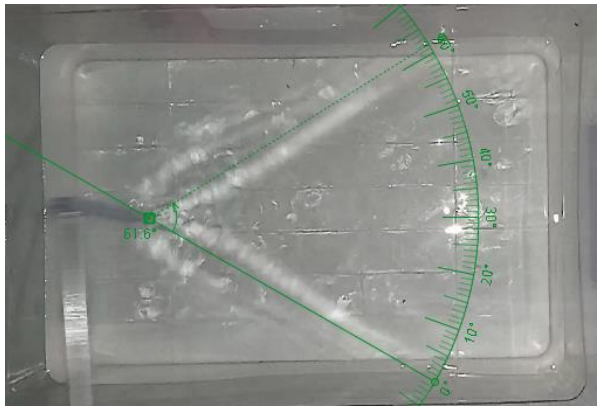
Phenomenon | Theoretical Model | Experiment | Conclusion

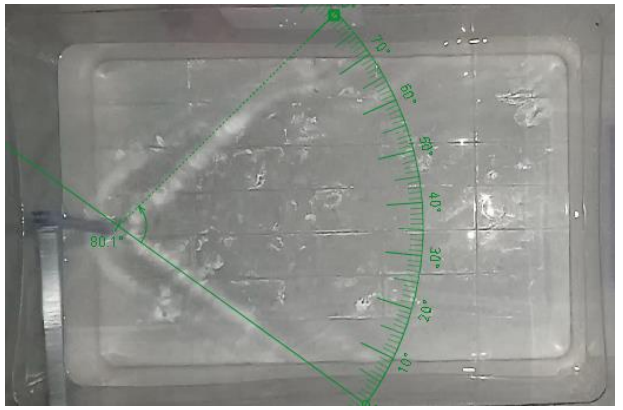

14.9°

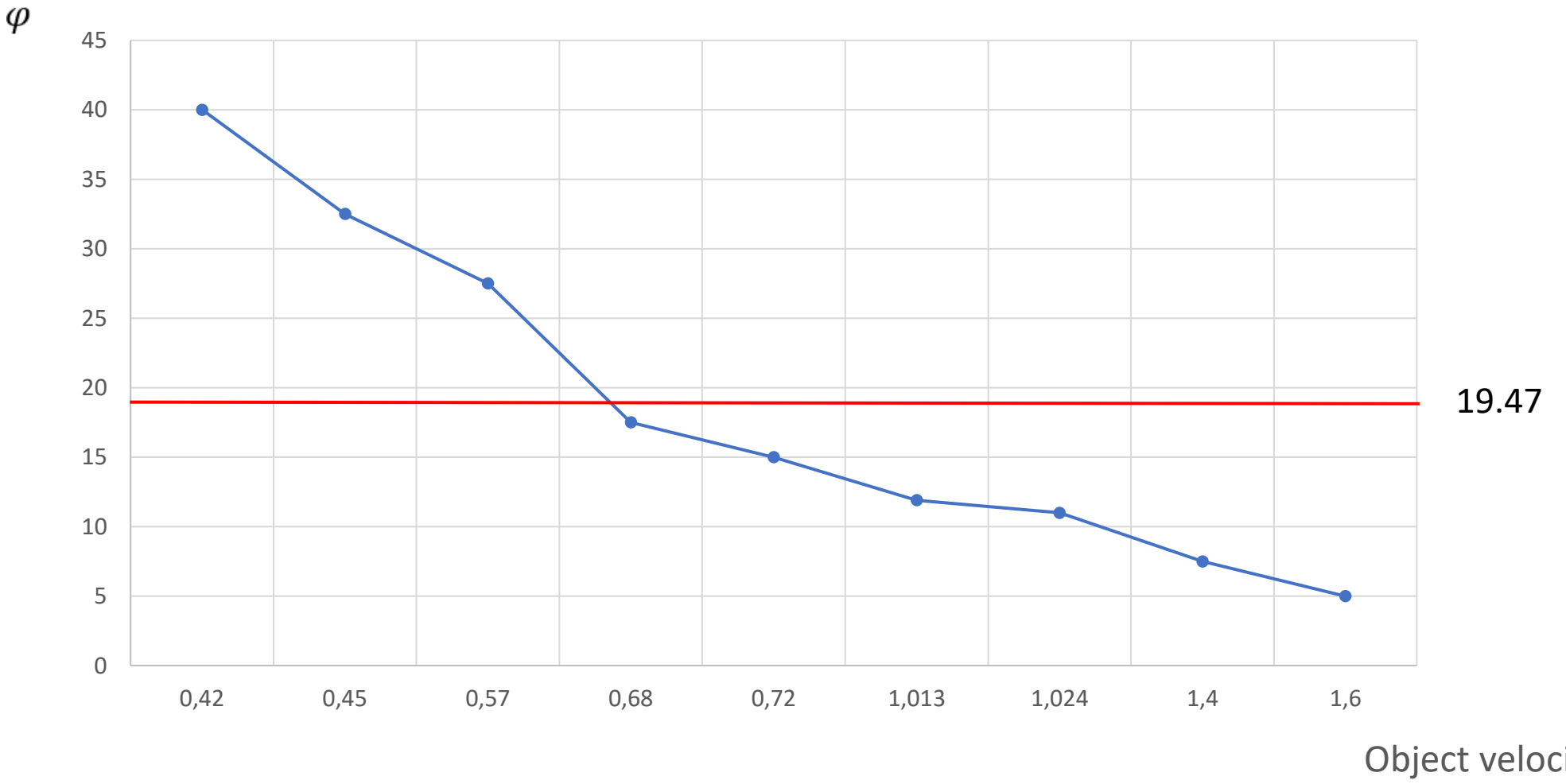

18.3°

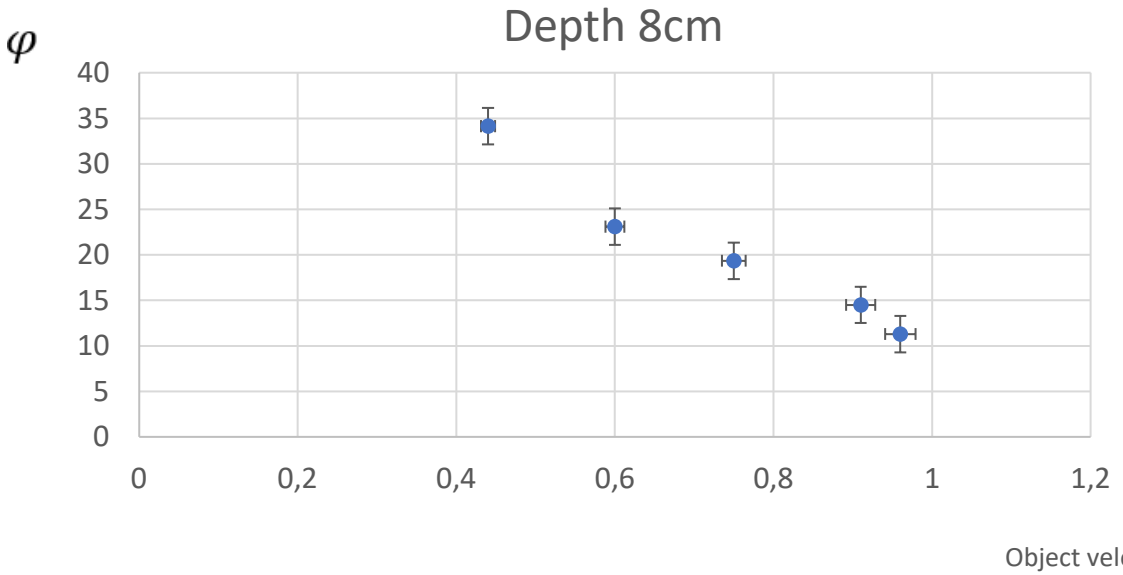

38.2°

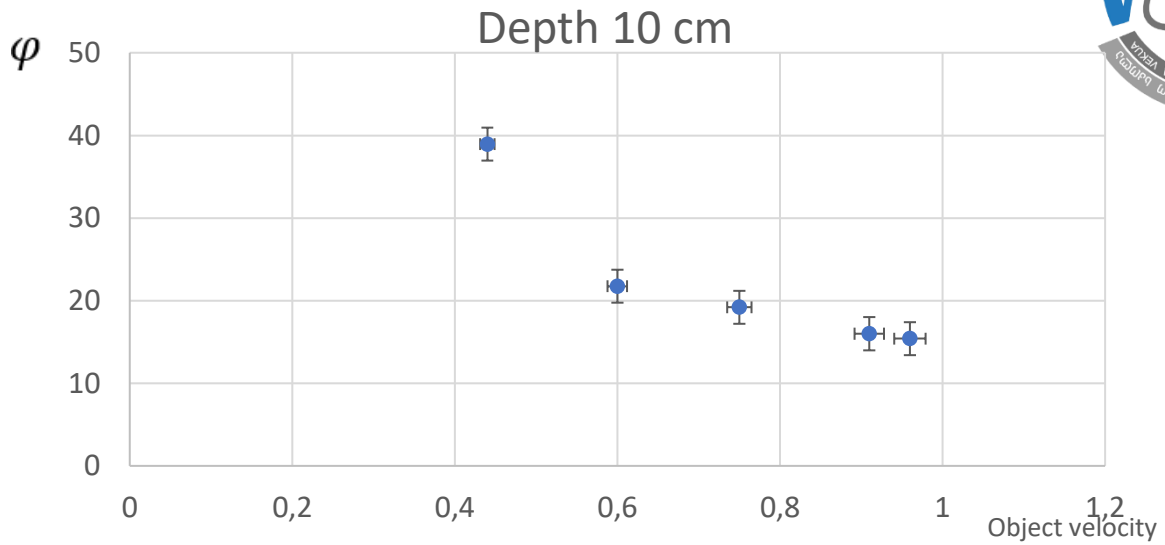

28.9°

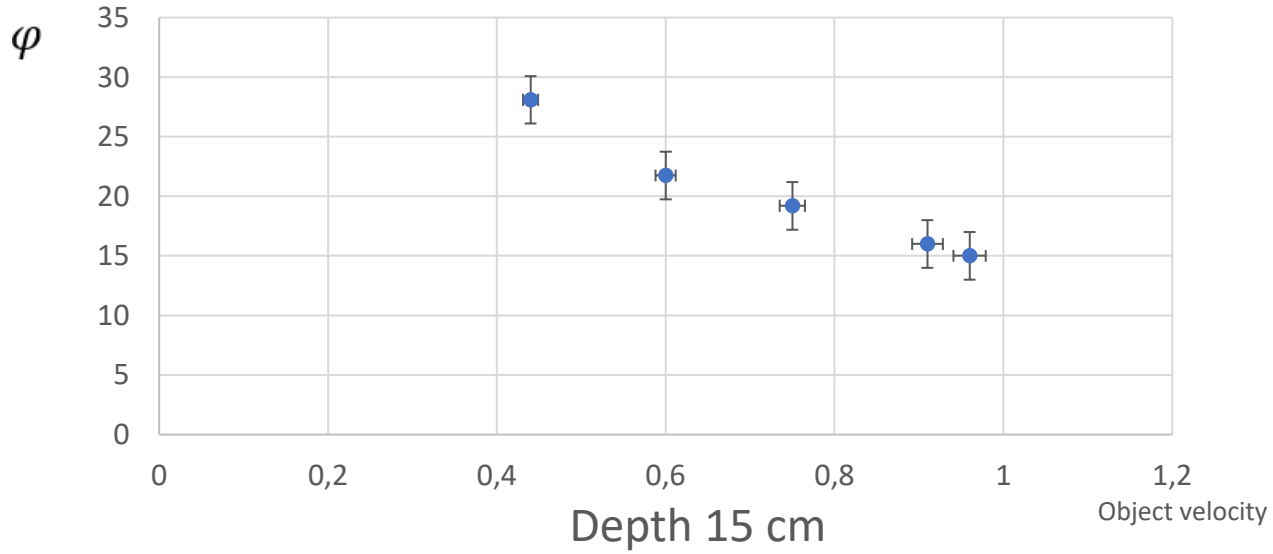

61.6°

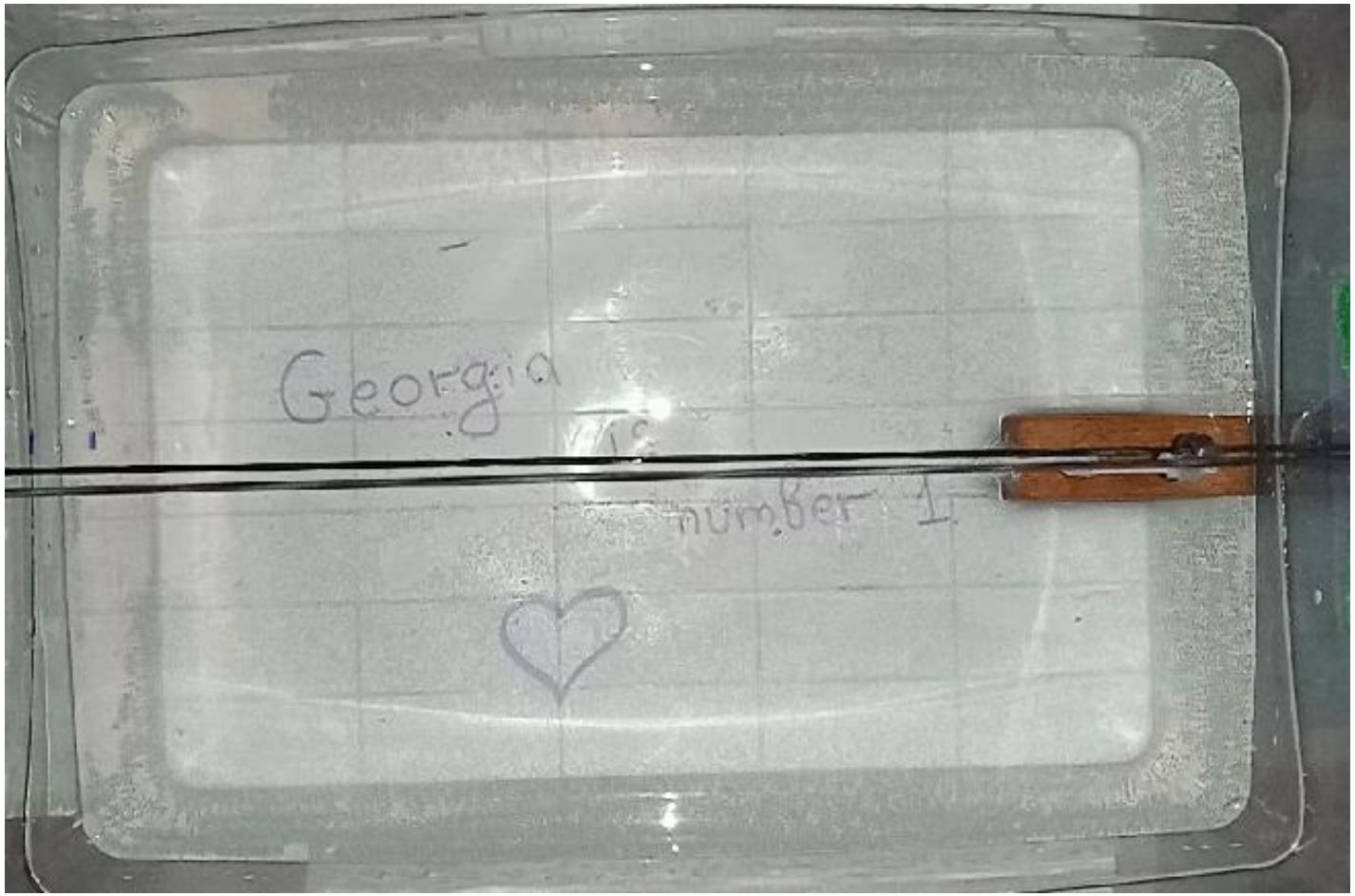

80.1°

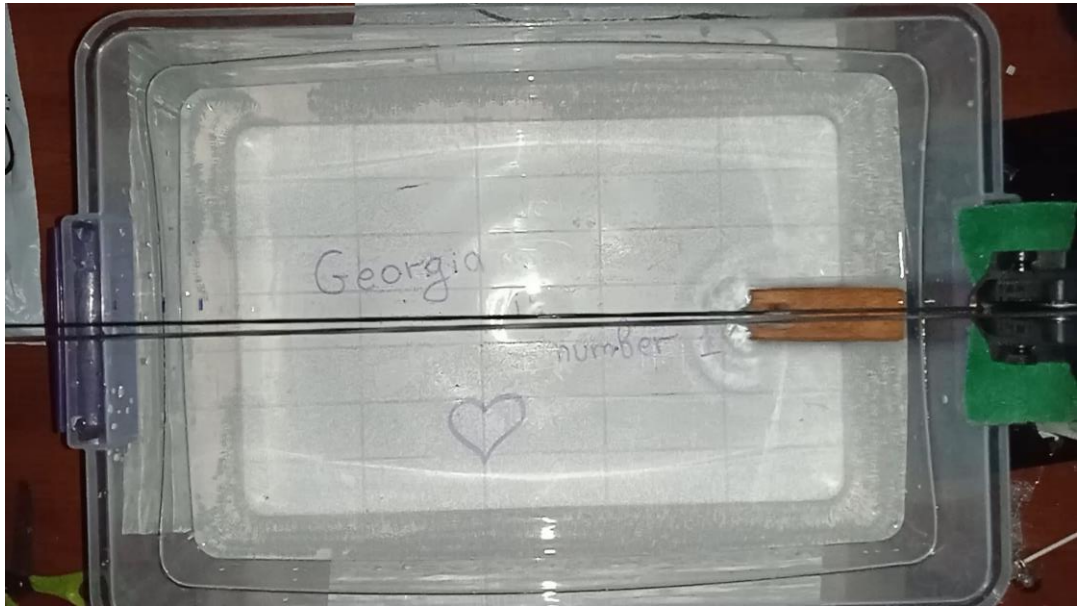

φ
45
40
35
30
25
20
15
10
5
0
0,42
0,45
0,57
0,68
0,72
1,013
1,024
1,4
1,6
19.47
Object velocity

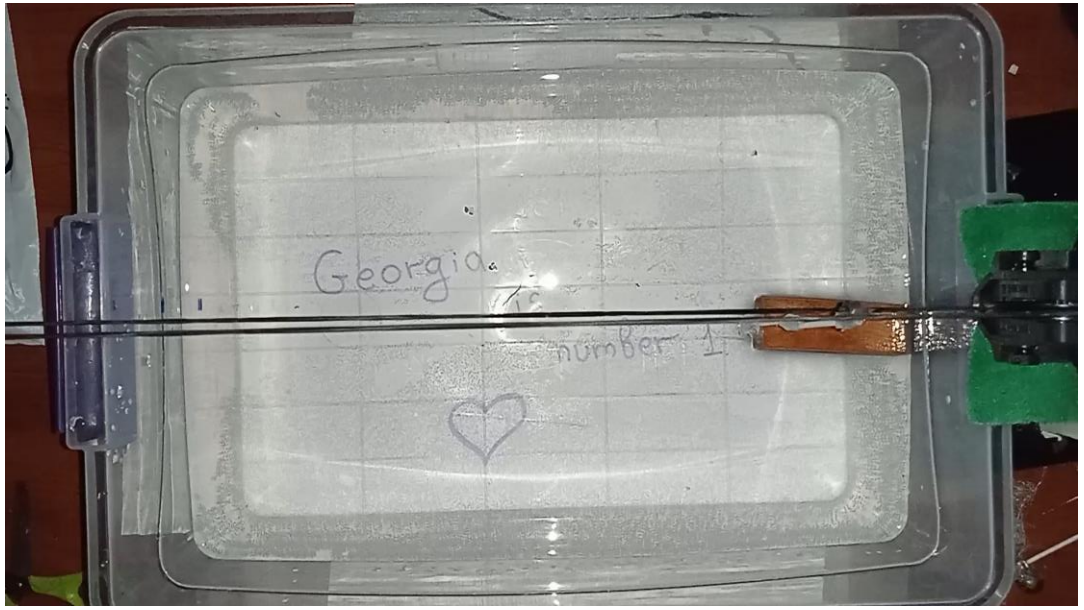

Depth 8cm
φ
40
35
30
25
20
15
10
5
0
0
0,2
0,4
0,6
0,8
1
1,2
Object velocity

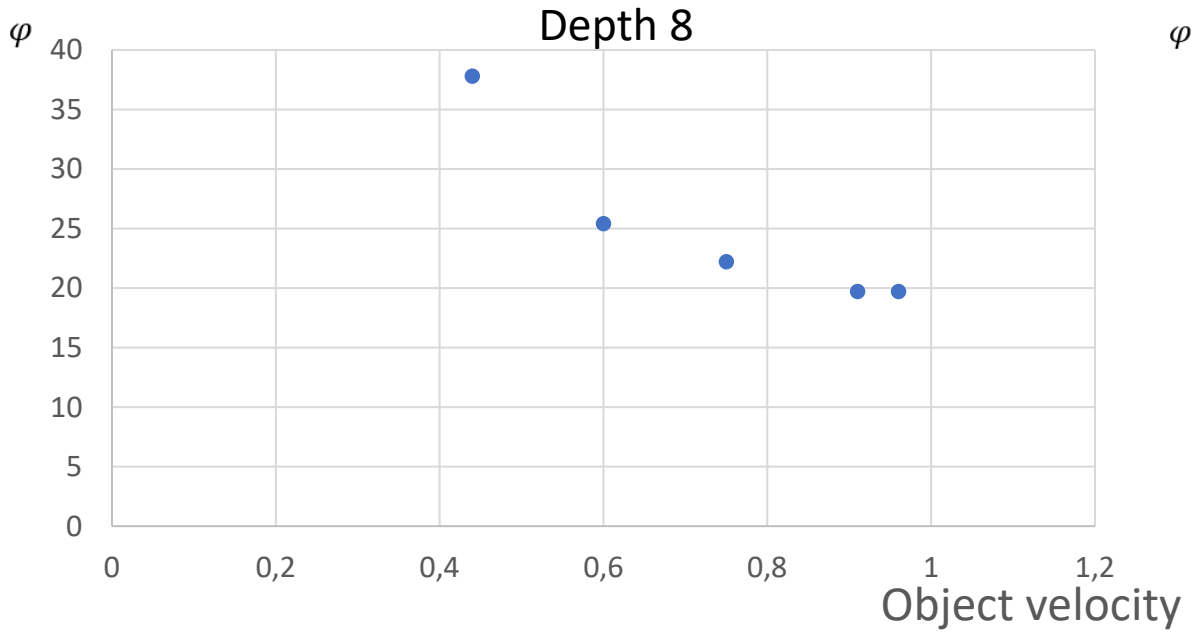

Depth 10 cm
φ
50
40
30
20
10
0
0
0,2
0,4
0,6
0,8
1
1,2
Object velocity

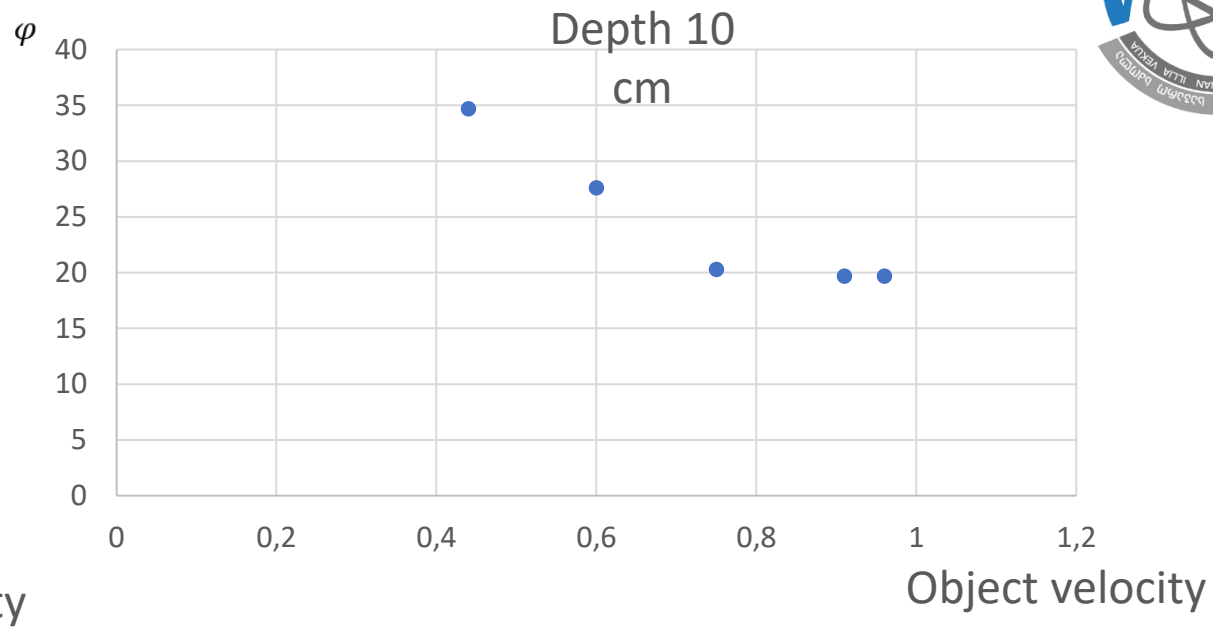

φ
35
30
25
20
15
10
5
0
0
0,2
0,4
0,6
0,8
1
1,2
Object velocity
Depth 15 cm

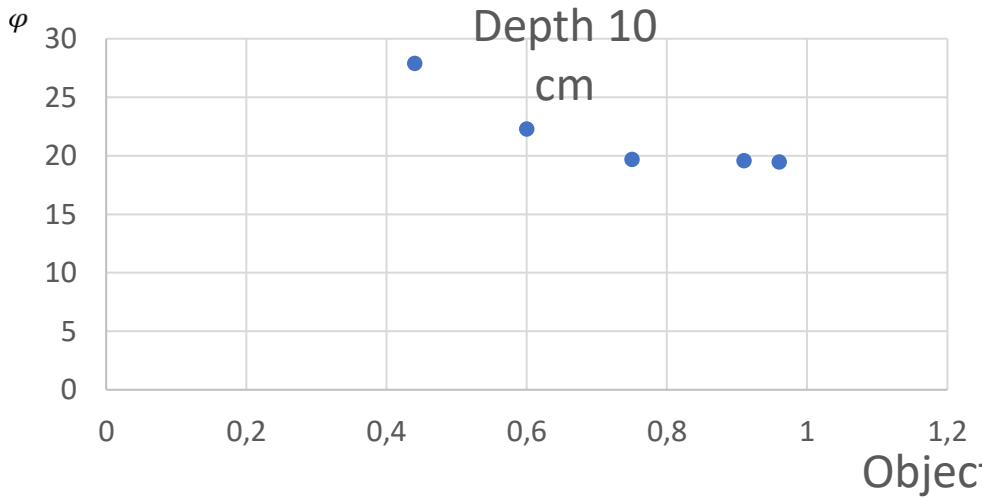

Georgia
number 1

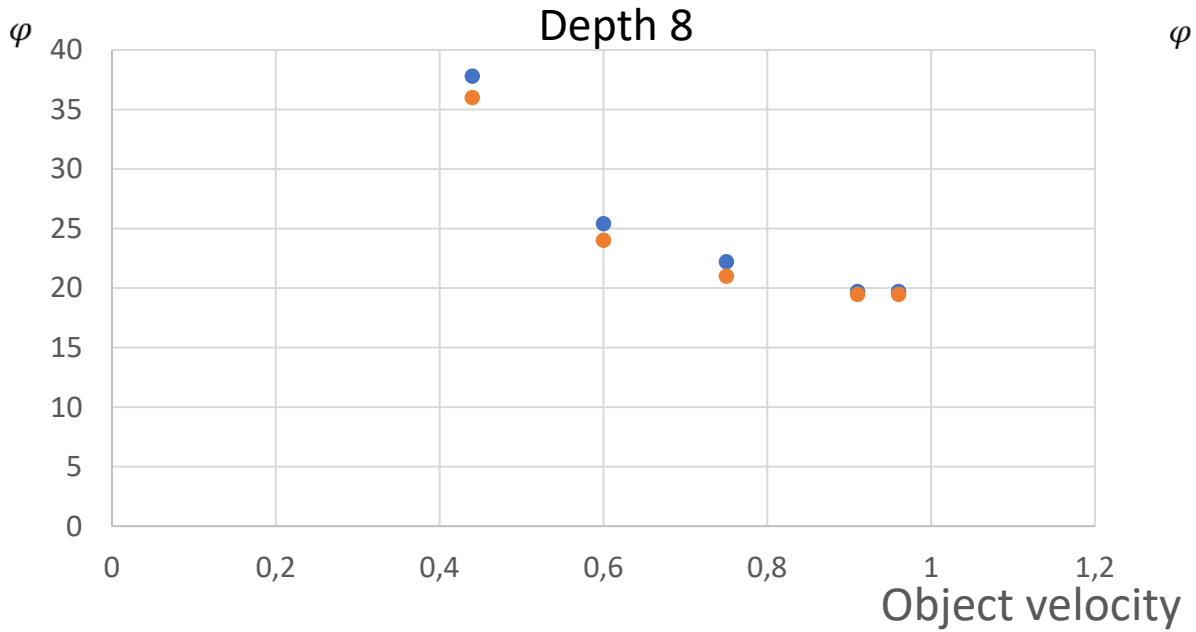

Georgia
number 1

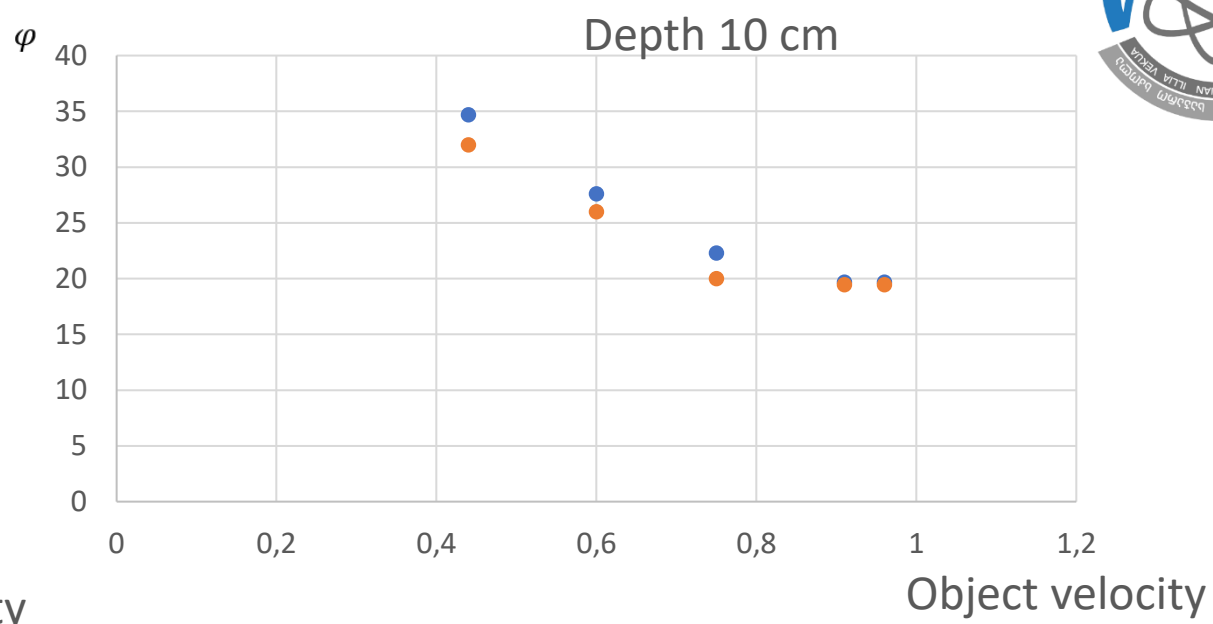

Georgia
number 1


Depth 8
φ
40
35
30
25
20
15
10
5
0
0
0,2
0,4
0,6
0,8
1
1,2
Object velocity

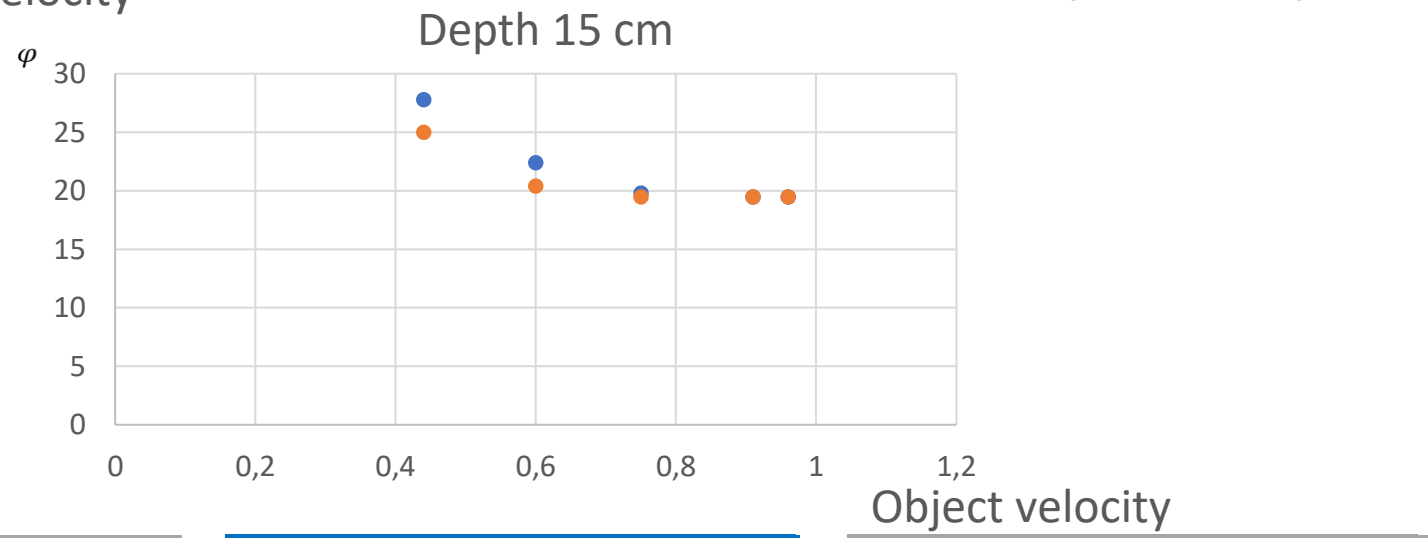

Depth 10
cm
φ
40
35
30
25
20
15
10
5
0
0
0,2
0,4
0,6
0,8
1
1,2
Object velocity


Depth 10
cm
φ
30
25
20
15
10
5
0
0
0,2
0,4
0,6
0,8
1
1,2
Object velocity



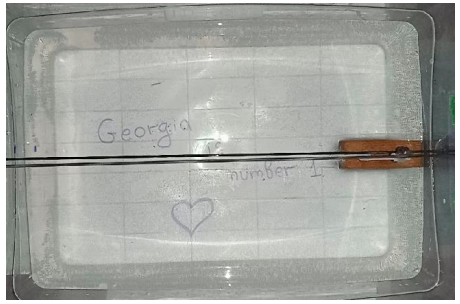


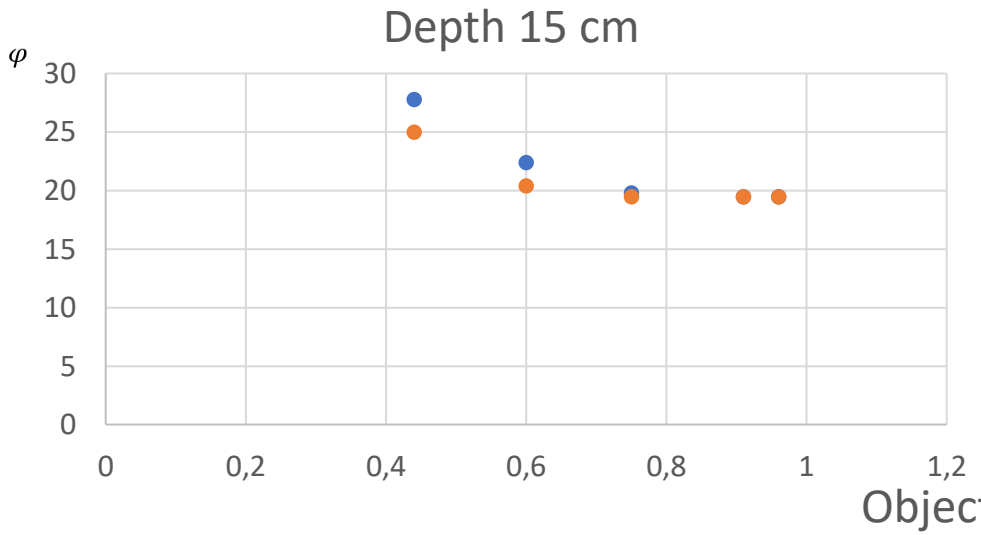
- Experimental result
- Theoretical result

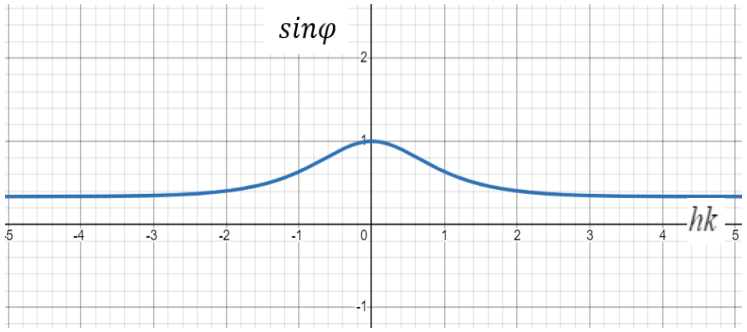


- Waves that are propagated by moving object on water surface are different
- As Kelvin predicted half angle for pure gravitational waves in deep water is 19.47 degree
- For shallow water Different circumstance will cause different half angles

$$sin\varphi < \frac{(e^{4hk} - 1 + 4hke^{2hk}}{3e^{4hk} - 3 - 4hke^{2hk}}$$

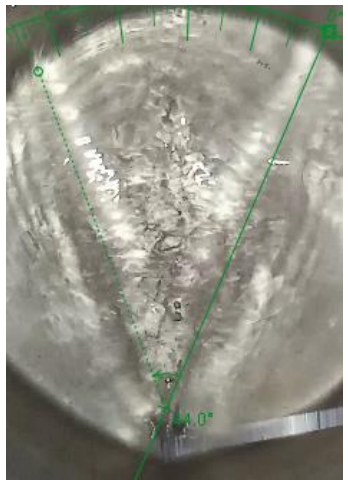


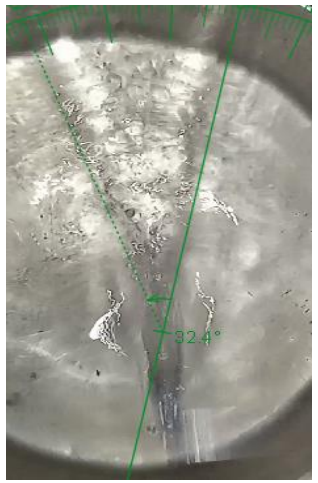


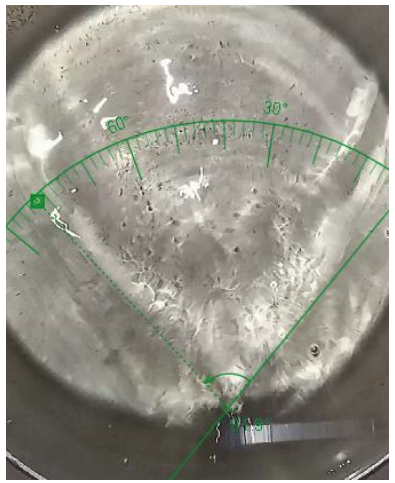


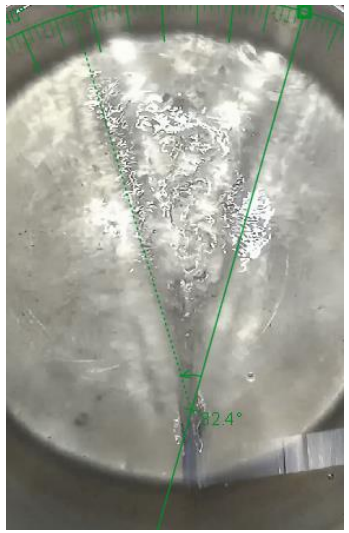
Phenomenon | Theoretical Model | Experiment | Conclusion

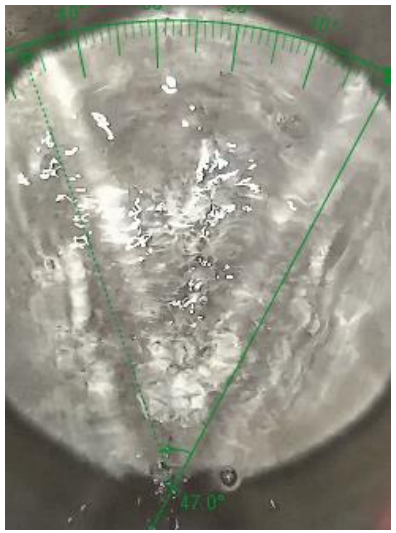
Thank you for your attention

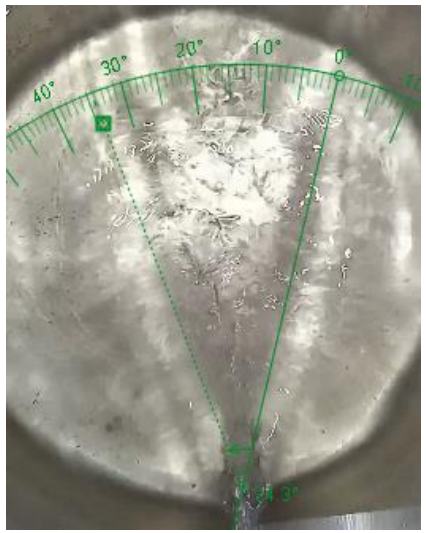












მოვლენის ახსნა | თეორიული მოდელი | ექსპერიმენტი | დასკვნა