Climate Change – Complexity

ID student: Activity 1

Weather in Barcelona

The 27th of June was the first day of the 2nd Summer School of Identities project, as well as the arrival day in Barcelona for many of us. Consider that you organize your trip in Barcelona for the summer school and you want to check the weather predictions. You are given the weather predictions (as seen in https://www.accuweather.com/) for the 27th of June, based on predictions made on the 20th , the 22nd , the 24th and the 26th of June.

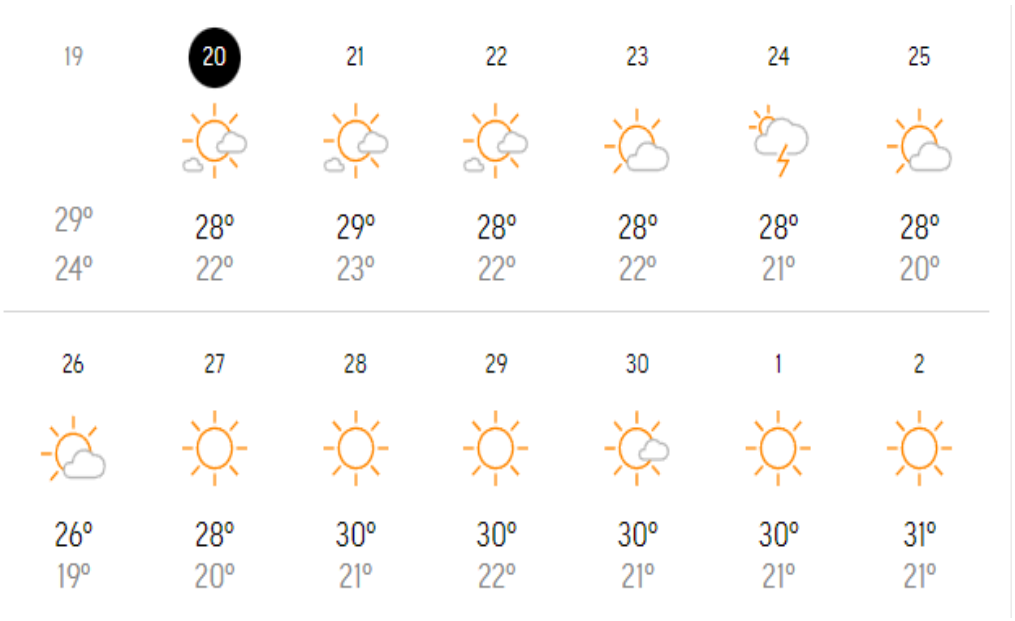

Figure 1: 20th of June

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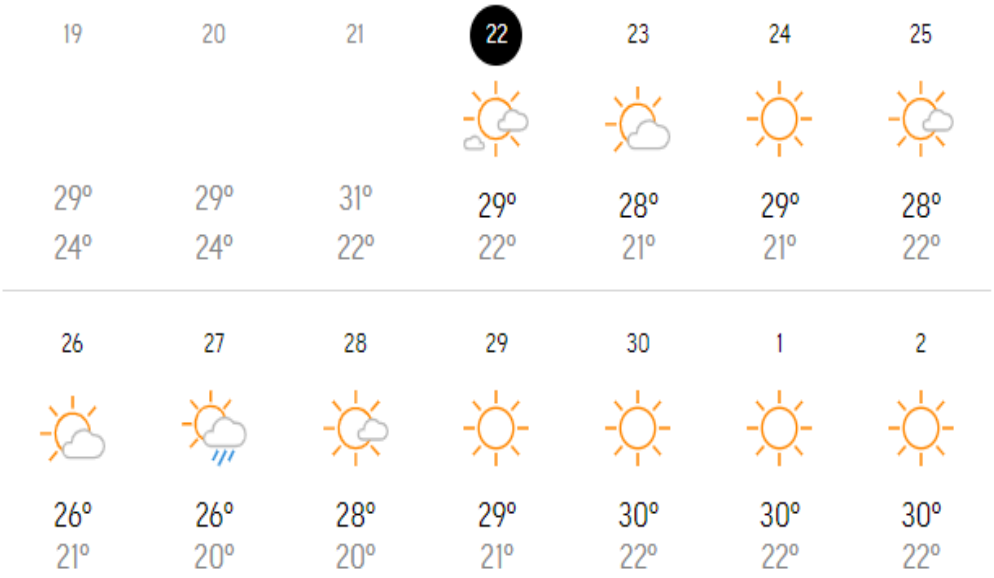

Figure 2: 22nd of June

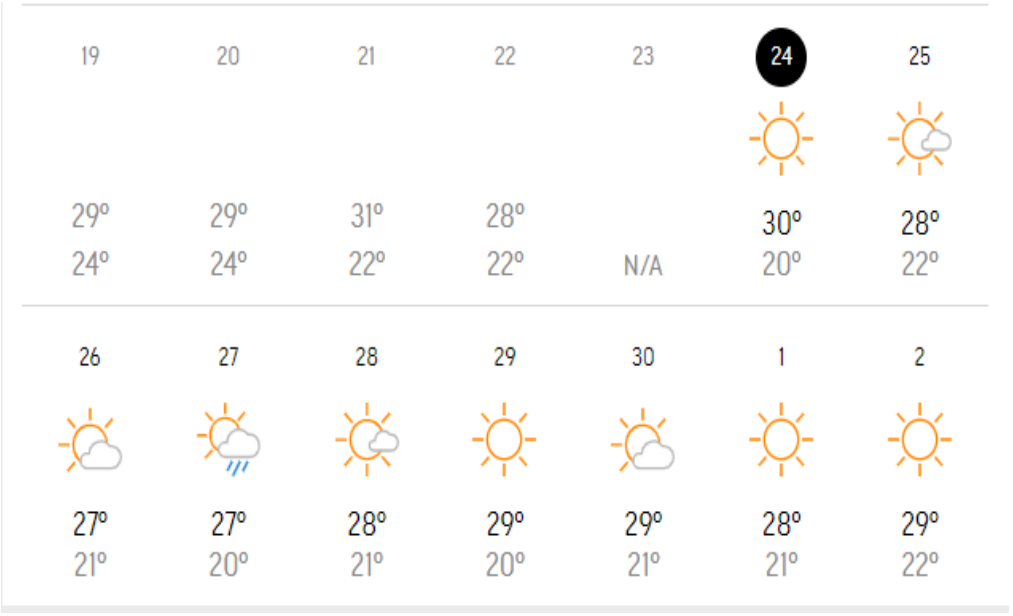

Figure 3: 24th of June

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Figure 4: 26th of June

1) Please observe the figures above. How accurate do you think these predictions are? Which one would you trust more in order to organize your trip?

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In Figure 5 you can see the actual weather of Barcelona the arrival day (27th of June), as it is presented by the same source.

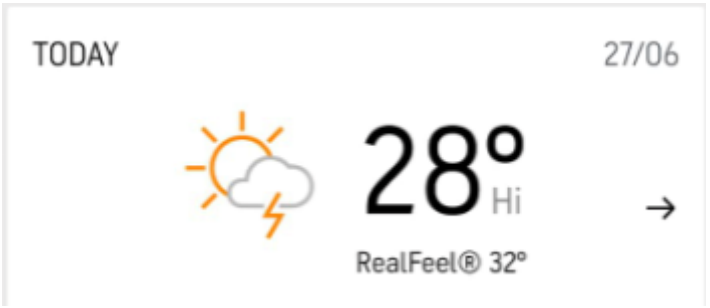

Figure 5: 27th of June

2) Discuss with your group why these divergences between the different weather predictions regarding June 27th occur.

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ID student: Activity 2

Chaotic Oscillator

The following images depict different representations developed by a chaotic oscillator consisting of an aluminum disc and a coaxial pulley mounted on the axis of a rotary motion sensor that freely rotates in a vertical plane. The rotary motion sensor transmits up to 1440 logical pulses per evolution to a digital interface connected to a personal computer. A small bronze cylinder is eccentrically attached to the disc. Two linear springs are counter-fixed to the pulley using a string. The end of one of the springs is fixed. A rotary motor connected to the end of the second spring by a mechanical arm moves the system harmonically *(Stavrou et al.,2013)*. The apparatus is presented in *Figure 1*.

Figure 1: The apparatus of the chaotic oscillator (Stavrou et al.,2013)

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1) Draw an estimation of the graphical representation that will be produced by the apparatus performing an harmonic oscillation.

The following pictures *(Figure 2 & 3)* represent harmonic oscillations developed by the particular apparatus both to an angular position over time graph and a phase space graph. Particularly, in *Figure 2* is presented a 1st chaotic motion developed by the system and in *Figure 3* is presented a comparison of the 1st and a 2nd chaotic motion developed by the system. Please observe the pictures and answer the following question.

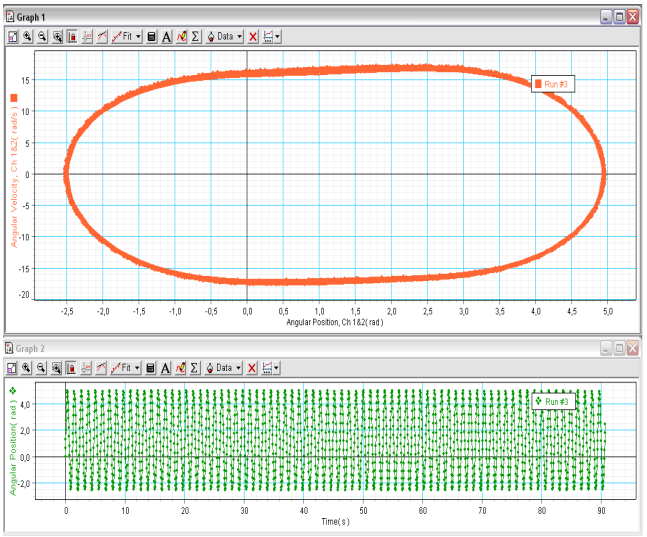

Figure 2: representation of harmonic oscillation (Stavrou et al.,2013)

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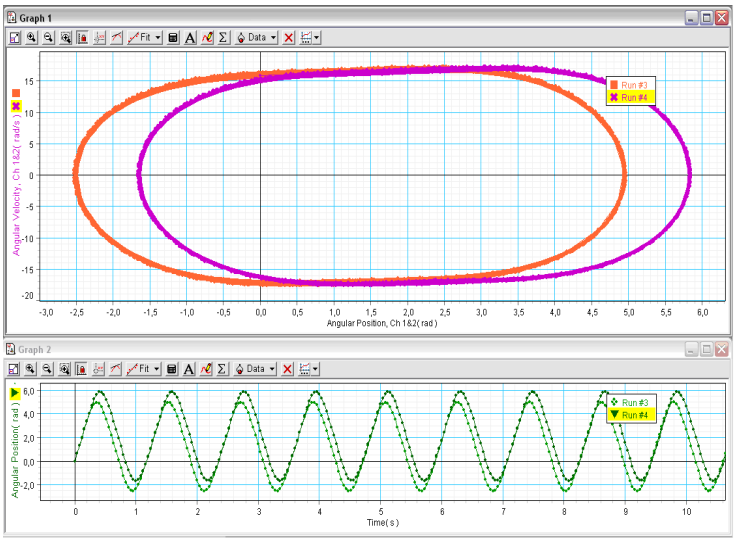

Figure 3: representation of the comparison of two harmonic oscillations (Stavrou et al., 2013)

2) What do you observe regarding the representations of the graph developed by the apparatus performing an harmonic oscillation? Is there any form of repetition to the system?

The following pictures *(Figure 4 & 5)* represent a chaotic motion developed by the particular apparatus both to an angular position over time graph and a phase space graph. Particularly, in *Figure 4* is presented a 1st chaotic motion developed by the system and in *Figure 5* is presented a comparison of the 1st and a 2nd chaotic motion developed by the system. Please observe the pictures and answer the following questions.

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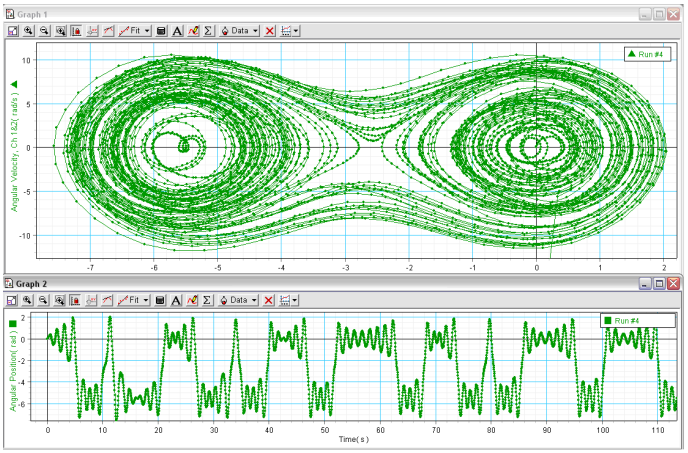

Figure 4: representation of chaotic motion (Stavrou et al., 2013)

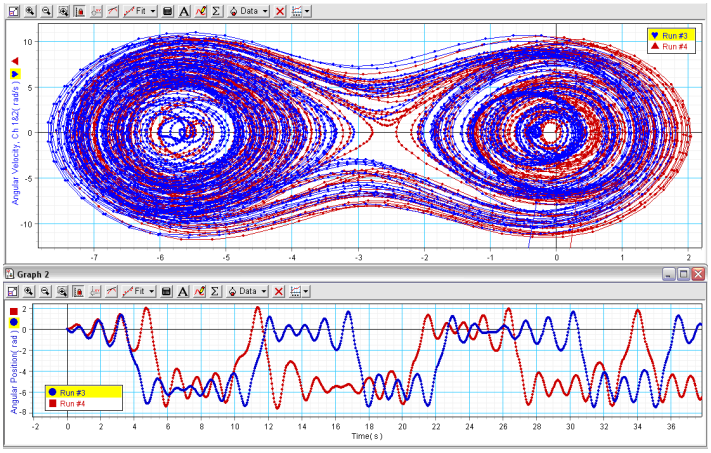

Figure 5: comparison of two representations of chaotic motion

3) What do you observe regarding the representations of the graphs developed by the apparatus performing chaotic motion both to an angular position over time graph and a phase space graph? Is there any form of order to the system?

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4) What are your conclusions about the forms of order that chaotic systems develop?

Magnetic Pendulum

Using the apparatus depicted below (*Figure 6)* we conduct several repetitions of the oscillation of the metallic ball.

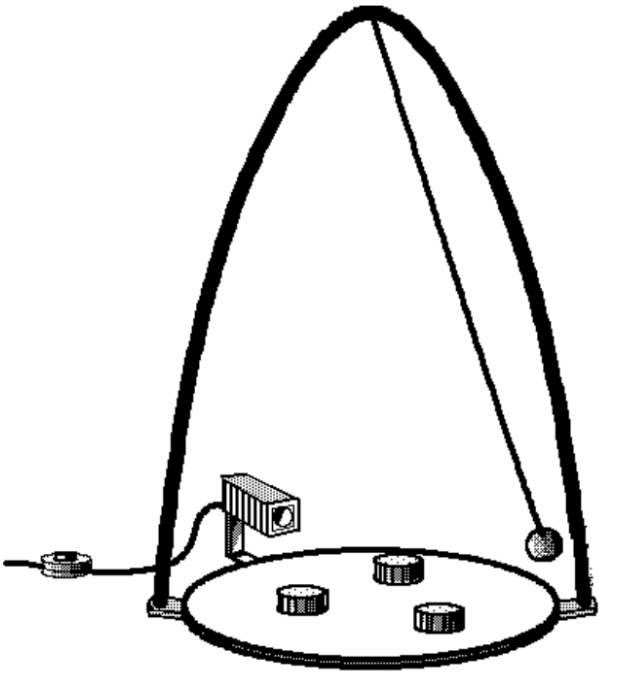

Figure 6: Representation of the apparatus of the magnetic pendulum

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5) If in every repetition the initial point for the metallic ball is the same, what will the trajectory of the metallic ball be among two consecutive repetitions?

Please watch the following video with the magnetic pendulum's movement.

http://h5p.edthe.edc.uoc.gr/magnetic-pendulum-experiment/

6) What do you observe about the trajectories of the metallic ball? Does your observation agree with your opinion before watching the video?

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The following image *(Figure 7)* represents the magnetic fields of the pendulum. Please watch the picture carefully and answer the question.

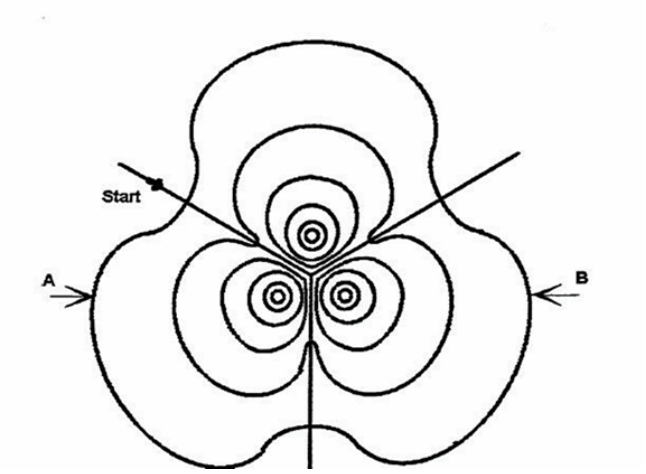

Figure 7: The three magnetic fields of the magnetic pendulum (Stavrou & Duit, 2014)

7) Can you explain the movement of the metallic ball when it moves across the cross section of two neighboring magnetic fields? Which factors influenced this trajectory?

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References

Stavrou, D., Assimopoulos, S., & Skordoulis, C. (2013). A unit on deterministic chaos for student teachers. *Physics Education*, 48(3), 355.

Stavrou, D. & Duit, R. (2014). Teaching and Learning the Interplay Between Chance and Determinism in Nonlinear Systems, *International Journal of Science Education*, 36 (3), 506-530

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