Problems for the 39th IYPT 2026

1. Invent yourself
A self-starting siphon can be made using a piece of rigid tubing bent into a specific shape. When the siphon is partially immersed in water, it begins siphoning water without the need for initial suction. Investigate how the relevant parameters, such as the geometry, affect the siphoning process.

2. Electrical damping
A magnet suspended by a spring will display simple harmonic motion when displaced. If the magnet oscillates within a coil connected to a resistor, its motion will be damped. Investigate the factors that affect the damping.

3. Ring fountain
When a flat metal ring falls from a certain height into a water tank, it generates a fountain that can shoot water high into the air. How does the maximum height of the fountain depend on the ring's parameters?

4. Oil flow
A thin layer of cooking oil on a flat metal surface flows outwards when heated. Investigate the phenomenon and its dependence on relevant parameters.

5. Elastic wave dynamics
Suspend a metal ball from a fixed support using a rubber band and twist it many times around its vertical axis. When the ball is released, standing waves are formed on the rubber band. Investigate this phenomenon and study how the wave depends on relevant parameters.

6. Flipo Flip
A Flipo Flip toy can roll for multiple turns even though its shape is not circular. Investigate how its motion depends on parameters such as geometry and the initial release conditions.

7. Tennis racket theorem
When an object with different principal moments of inertia about each axis is thrown while it rotates, it can suddenly start rotating around an axis different from the one it was initially rotating about. Investigate how the rotational motion of such an object is affected by relevant parameters during its free fall.

8. Magnetic accelerator
Fix magnets in pairs onto a metal sheet as shown. If you attach two magnetic discs onto an axle this "vehicle" will accelerate over the rows of magnets under certain conditions. Investigate the phenomenon.
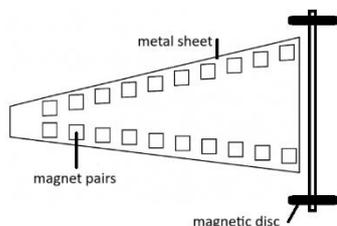
9. Levitation control
When arranged in a specific configuration, small graphite sheets can levitate on neodymium magnets. By shining light onto the surface of the graphite sheet, it is possible to control its movement. Explain and investigate the phenomenon.

10. Submerged crater
If you release sand or similar granular material in a container filled with water, the material will sink to the bottom and may form a crater-like structure. Explain and investigate the phenomenon.

11. Sweet monochromator
Pass linearly polarised white light through a column of sugar solution. When transmitted light is observed through a polariser it may appear coloured. Rotate the polariser, and the transmitted light colour may change. Construct such a sweet monochromator and optimise for the narrowest light wavelength bandwidth.

12. Autumn coin
The motion of a coin falling to the bottom of a tank filled with liquid can be remarkably similar to the fluttering and tumbling of a falling autumn leaf. Investigate how the motion of the coin depends on relevant parameters.

13. The singing ruler
When a ruler is clamped at one end and struck, it oscillates and emits a characteristic sound. Investigate how the sound depends on relevant parameters.

14. Crystal Critters
Observe the evaporation of a drop of table salt solution on a warm hydrophobic surface. After the water evaporates, a variety of characteristic crystal shapes remain. Research and explain this phenomenon.

15. Magnetic Newton's cradle
Repulsing, non-touching magnets are used instead of colliding balls to make a new type of Newton's cradle. The new cradle can act in a similar way to a regular cradle, but can also exhibit other interesting behaviour. Explain and study the movement of this magnetic cradle.

16. Twisted spaghetti
When a bundle of spaghetti is twisted, it might withstand higher transverse (side) forces than a straight, untwisted bundle. Investigate the response of a twisted bundle to transverse stress and identify the optimal twist that maximises tolerance to transverse stress.

17. Travelling flame
A flame can propagate continuously around a ring-shaped trough containing a thin layer of flammable liquid. Investigate how the characteristics of this travelling flame depend on relevant parameters.

IYPT2026 |
第 39 届国际青年物理学家竞赛赛题中文翻译及浅析

01、Invent Yourself / 自己发明

A self-starting siphon can be made using a piece of rigid tubing bent into a specific shape. When the siphon is partially immersed in water, it begins siphoning water without the need for initial suction. Investigate how the relevant parameters, such as the geometry, affect the siphoning process.

一种自启动虹吸管可通过将刚性管弯曲成特定形状制成。当此虹吸管局部浸入水中时，无需初始抽吸即可开始虹吸。研究相关参数（如几何形状）对虹吸过程的影响。

图片来源[2]

浅析：一般的虹吸现象需要管内预先充满液体。将虹吸管弯曲成特定形状后，此装置可能会主动排出气体，形成虹吸流动。这里，特定形状是建立理想模型的关键，实验围绕理论预言的定量检验和优化是容易想到的方式。
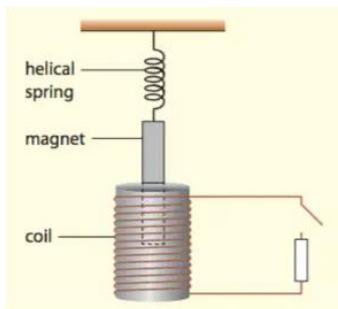
参考文献：

[1] De Cesare G, Essyad K, Furlan P, et al. Experimental study at prototype scale of a self-priming free-surface siphon[C]//Advances in Hydroinformatics: SimHydro 2017-Choosing The Right Model in Applied Hydraulics. Springer Singapore, 2018: 899-912.

[2] Aydin M C, Öztürk M, Yücel A. Experimental and numerical investigation of self-priming siphon side weir on a straight open channel[J]. Flow Measurement and Instrumentation, 2015, 45: 140-150.

02、Electrical damping / 电阻尼

A magnet suspended by a spring will display simple harmonic motion when displaced. If the magnet oscillates within a coil connected to a resistor, its motion will be damped. Investigate the factors that affect the damping.

一个悬挂在弹簧上的磁铁在发生位移时呈现简谐运动形式。若此磁铁在与电阻相连的线圈内振动，其运动会受到阻尼。探究影响阻尼效果的因素。

图片来源：https://physics.stackexchange.com/questions/280599/electromagnetism-dampening-of-magnet-in-coil

浅析：电磁阻尼是 IYPT 题目中的常客。本问题所设计到的楞次定律是中学物理就已经定性探究过的，本题着重关注在动力学过程中电磁阻尼导致的具体影响。本题的理论建模是容易的，考虑到理想情况下电磁阻尼关于相对运动的形式已有相当多的文献研究过，只需要在简谐运动的方程中增加阻尼项即可。关于阻力形式的检验和阻尼系数的测定，可以直接通过对磁铁运动的记录并和理论动力学方程的解来对比确定。需要注意，电阻的存在可以改变电路系统的发热功率，从而有效的改变阻尼系数。本问题跟高中求解的磁场中闭合电路中的动杆问题也有很密切的联系，若在杆上添加一个弹簧，两者应该是等价的。

03、Ring fountain / 环形喷泉

When a flat metal ring falls from a certain height into a water tank, it generates a fountain that can shoot water high into the air. How does the maximum height of the fountain depend on the ring's parameters?

当一扁平金属环从一定高度落入水箱时，会形成一道向空气中喷射水流的喷泉。此喷泉的最大高度如何取决于金属环的参数？

浅析：当扁平金属环从高处落入水中，会瞬间压缩环内空气形成气泡空腔，空腔坍塌时水体急速回填，挤压出向上喷射的水箭。喷泉的最大高度本质上由金属环的动能转化为水柱势能的效率决定，而这一效率受环的直径与厚度共同影响。

参考链接：

[1] https://www.youtube.com/shorts/dLk_VWHRrh0

04、**Oil flow/ 油流**

A thin layer of cooking oil on a flat metal surface flows outwards when heated. Investigate the phenomenon and its dependence on relevant parameters.

平坦金属表面的食用油薄层在受热时会向外流动。研究该现象及其与相关参数的依赖关系。

浅析：可能是 Marangoni 效应的影响：油层中心区域与边缘区域的温度不同，导致边缘的表面张力系数高，油层向表面张力更大的区域流动。（如果加热是均匀的或许就是另一种解释）

05、**Elastic wave dynamics / 弹性波动力学**

Suspend a metal ball from a fixed support using a rubber band and twist it many times around its vertical axis. When the ball is released, standing waves are formed on the rubber band. Investigate this phenomenon and study how the wave depends on relevant parameters.

用橡皮筋将一金属球悬挂在固定支架上，并绕其竖直轴多次扭转。当松开金属球时，橡皮筋上会形成驻波。研究这一现象并探究波的特性与相关参数的依赖关系。
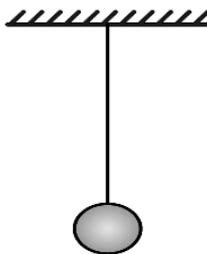
浅析：当橡皮筋被扭转并释放后，金属球将进行扭转振荡，该振荡可被视为一种受迫阻尼振动。金属球的扭转振荡会激发在橡皮筋中传播的扭转波，由于橡皮筋两端固定

在支架上，这些波在传播至固定端时会发生反射。当橡皮筋长度为半波长的整数倍时，入射波和反射波的叠加会形成驻波。金属球的质量 、初始扭转圈数，橡皮筋的材料属性等等都会影响实验现象。

06、Flipo Flip / 翻转玩具

A Flipo Flip toy can roll for multiple turns even though its shape is not circular. Investigate how its motion depends on parameters such as geometry and the initial release conditions.

Flipo Flip 玩具能滚动多圈，即使其形状并非圆形。研究其运动如何依赖于相关参数，例如几何参数及初始释放条件。

浅析：Flipo Flip 玩具能在平面上以翻转和滚动相结合的形式运动，其曲面特性是能发生翻转的重要条件。不同的几何结构可能影响其稳定性及翻转方式，中心突起程度是值得关注的参数之一。

参考现象：

https://www.youtube.com/watchv=kz7LHXG9oBI

07、Tennis racket theorem/ 网球拍定理

When an object with different principal moments of inertia about each axis is thrown while it rotates, it can suddenly start rotating around an axis different from the one it was initially rotating about. Investigate how the rotational motion of such an object is affected by relevant parameters during its free fall.

当一个物体各主轴的主转的物体在旋转的时候被抛出，它可能会突然开始绕一个与最初旋转不同的轴旋转。研究在自由下落过程中，这类物体的旋转运动如何受到相关参数的影响。

浅析：网球拍定理，正式名称为扎尼别科夫效应或中间轴定理，描述了刚体绕三个不同主轴旋转时，绕中间轴（转动惯量居中的轴）旋转会表现出不稳定性，而绕其他两轴则稳定。其发现历史可追溯至 19 世纪中期，当时现象已在经典力学中被初步认知，但未系统研究。1985 年，俄罗斯宇航员弗拉基米尔 扎尼别科夫在国际空间站进行微重力实验时，首次直观观察到这一效应：旋转物体如 T 型螺母或网球拍会在绕中间轴运动时发生翻转。这一发现被命名为扎尼别科夫效应，并因保密因素延迟了公开传播。1991 年，Ashbaugh 等人的论文正式解释并验证了该现象，利用网球拍实验证实了欧拉方程的应用。网球拍定律是一个教科书级别的经典刚体动力学案例，可以用身份证、网球拍等道具轻松复现现象，并通过无力矩的欧拉方程求解。但是，实际系统中的空气阻力也会引入力矩，从而使不同形状的物体产生不同的现象（本年的题目 12 就是一个例子）。

08、Magnetic accelerator / 磁铁加速器

Fix magnets in pairs onto a metal sheet as shown. If you attach two magnetic discs onto an axle this "vehicle" will accelerate over the rows of magnets under certain conditions. Investigate the phenomenon.

如图所示，成对的磁铁放置到金属板上。如果你将两个圆柱磁安装到一个轴上，这个"车辆"将会在特定条件下在这一排排磁铁上加速前进。探究这一现象。


浅析：当两个圆柱磁铁固定在轴上构成车辆，置于对称排列但带倾角的磁铁轨道时，车辆会从磁铁张开端向闭合端自发加速。其本质在于磁铁倾角与磁场梯度的协同作用：轨道磁铁统一内倾，在张开端形成斜向前的磁斥力分量驱动启动；车辆向闭合端运动时，磁场强度持续增强，磁斥力水平分量不断增大，同时金属底板切割磁感线产生的涡流在临界速度后由阻力转为推力，二者叠加形成持续加速度。

参考视频：https://www.youtube.com/watch?v=iyv9GhaITNE

09、Levitation control/ 控制悬浮

When arranged in a specific configuration, small graphite sheets can levitate on neodymium magnets. By shining light onto the surface of the graphite sheet, it is possible to control its movement. Explain and investigate the phenomenon.

当以特定方式排列时，小块的石墨片可以在钕磁铁上悬浮。通过将光照射到石墨片的表面，可以控制其运动。解释并研究这一现象。
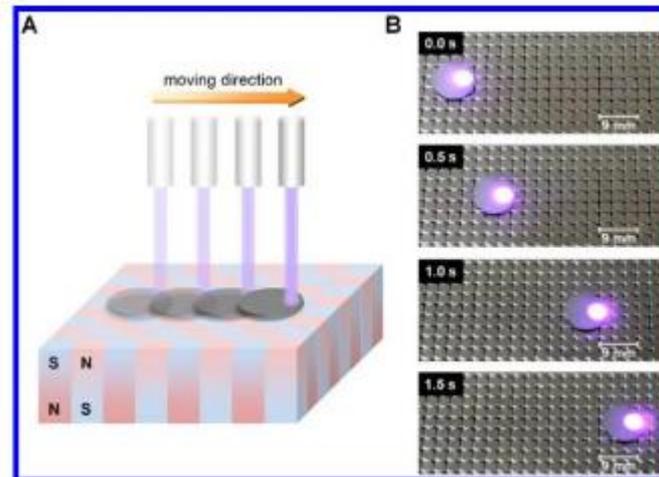
浅析：轻薄石墨片的抗磁性可以抵消重力，实现可见的悬浮。同时，石墨具有很强的光热效应，局部温度升高可能会使其抗磁性减弱（类似居里相变的消磁过程），从而使得原本稳定的磁悬浮状态发生改变，产生由于受力/力矩不平衡导致的运动。IYPT 近年钟爱磁悬浮问题，本题的趣味在于将一般动态磁悬浮中引入了热力学（相变），这一光热效应导致的力学非稳定现象很值得深入研究，有很多可以尝试的点。

参考视频与文献：

[1] https://www.youtube.com/watch?v=AJ7fMVp_O5s

[2] Kobayashi, M., & Abe, J. (2012). Optical motion control of maglev graphite. Journal of the American Chemical Society, 134(51), 20593-20596.

10、Submerged crater / 水下陨石坑

If you release sand or similar granular material in a container filled with water, the material will sink to the bottom and may form a crater-like structure. Explain and investigate the phenomenon.

若将沙粒或类似颗粒材料释放至盛满水的容器中，材料将沉至底部，并可能形成坑状结构。解释并研究该现象。

浅析：这个问题为颗粒在牛顿流体中的沉降问题。沙粒向下沉降的过程中同时收到水的浮力与阻力，其周围会形成一个薄的边界层并在沙粒后方产生尾流，使得多个沙粒

沉降时会互相影响，改变彼此的运动轨迹和沉降速度，当首批沙粒到达容器底部时会产生环形的向外水流，后续的沙粒受此影响更容易堆积在中心区域周围，形成坑状结构。可以研究沙坑的半径、沙丘的休止角等与颗粒种类、形状的关系。

参考文献：Lv K,Min F F,Zhu J B,et al.Experiments and CFD-DEM simulations of fine kaolinite particle sedimentation dynamic characteristics in a water environment [J].Powder Technology,2021,382:60-69.

11、Sweet monochromator / 甜蜜的单色仪

Pass linearly polarised white light through a column of sugar solution. When transmitted light is observed through a polariser it may appear coloured. Rotate the polariser, and the transmitted light colour may change. Construct such a sweet monochromator and optimise for the narrowest light wavelength bandwidth.

让线偏振的白光通过一根充满糖溶液的柱状容器。当透射光通过偏振片观察时，它可能呈现出彩色。旋转偏振片时，透射光的颜色也可能发生变化。搭建这样的一个单色仪并优化其最窄的光谱带宽。
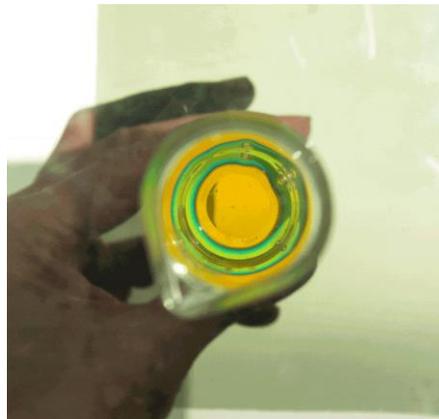
浅析：本题目主要涉及到旋光效应，即糖类等手性物质能够使线偏振光的偏振平面旋转的现象。偏振平面的旋转角度会依赖于入射光的波长，因此白色线偏振光入射后，使用检偏器就可以在不同的角度下看到各个彩色光，基于这个原理就可以制作出简单的单色仪。题目的重点是要将单色仪的带宽最小化（即增强色散的梯度），这可能可以通过改变糖溶液的类型（蔗糖、果糖等，具有不同的比旋光度）、糖溶液浓度和入射光在糖溶液中的光程等因素来实现。

参考链接：

[1]https://www.youtube.com/watch?app=desktop&v=975r9a7FMqc

[2]https://www.exploratorium.edu/snacks/rotating-light

12、Autumn coin / 如叶之坠

The motion of a coin falling to the bottom of a tank filled with liquid can be remarkably similar to the fluttering and tumbling of a falling autumn leaf. Investigate how the motion of the coin depends on relevant parameters.

一个硬币沉到充满液体的水缸里时，其运动与一片扑动(fluttering)飘落(tumbling)的树叶的颤动和翻滚的状态惊人地类似。解释硬币的这种运动如何依赖于相关参数。

浅析：该题目涉及刚体动力学和流体力学。值得注意的是，球形的物体并不会产生这样的特殊运动形式，因此物体的形状是一个重要的因素，它与物体的质量、运动速度以及流体特性一起共同影响流体对刚体产生的力和力矩。同时，题目中所说的"扑动"和"翻涌"其实是两种运动模式，这两种运动模式之间的转变也是一个值得探究的问题，由相关参数的特殊临界值决定。在很多的国内外景区，都有将硬币扔入一个"水下小容器"用于祈福的游戏，通常从容器正上方释放的硬币都无法到达容器中，本题的研究会回答这一问题。
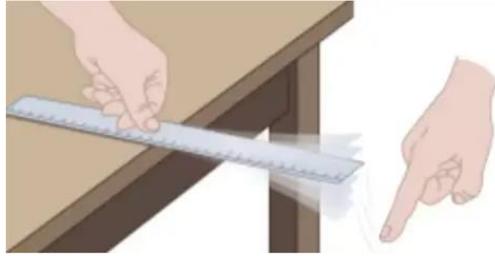
参考文献：

[1] Belmonte, A., & Moses, E. (1999). Flutter and tumble in fluids. Physics world, 12(4), 21.

[2] ANDERSEN, A., PESAVENTO, U., & WANG, Z. J. (2005). Unsteady aero-dynamics of fluttering and tumbling plates. Journal of Fluid Mechanics, 541, 65–90. doi:10.1017/S002211200500594X

[3] Field S B, Klaus M, Moore M G, et al. Chaotic dynamics of falling disks[J]. Nature, 1997, 388(6639): 252-254.

13、The singing ruler / 尺子之歌

When a ruler is clamped at one end and struck, it oscillates and emits a characteristic sound. Investigate how the sound depends on relevant parameters.

当尺子的一端被夹住固定并敲击时，它会振动并发出特有的声音。研究这种声音如何取决于相关参数。

浅析：当尺子被敲击时发生形变储存弹性势能，松手后开始往复振动，对周围空气产生声压激发声波。在本题中可将尺子视为 Euler-Bernoulli 梁，忽略剪切变形和旋转惯性的影响，计算尺子振动的基频，其基频取决于尺子自由端的长度，尺子材质和尺子厚度，另外当尺子振幅过大时需要考虑非线性效应。

振幅较大时的参考文献：

Fletcher N H, Rossing T D. The physics of musical instruments[M]. Springer Science & Business Media, 2012.
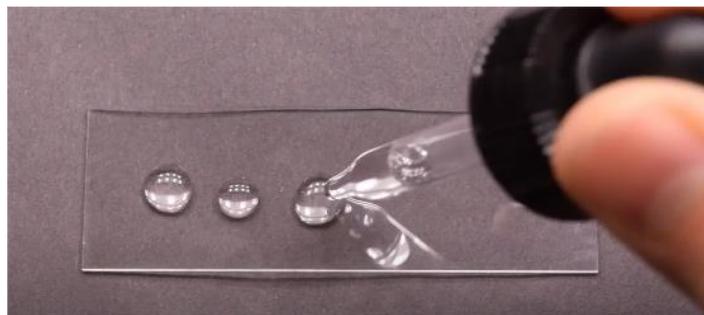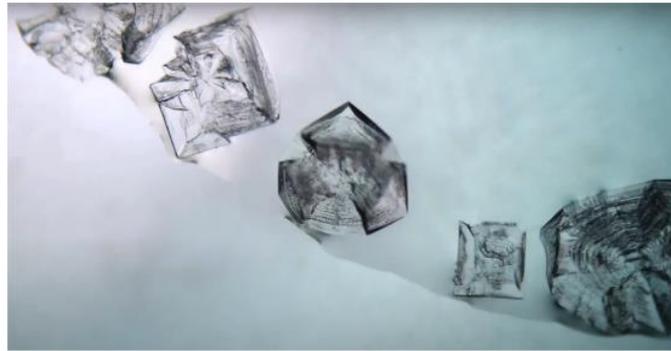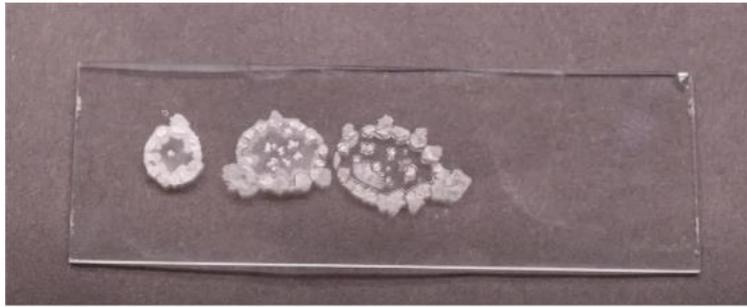
14、Crystal Critters / 晶体小精灵

Observe the evaporation of a drop of table salt solution on a warm hydrophobic surface. After the water evaporates, a variety of characteristic crystal shapes remain. Research and explain this phenomenon.

观察一滴食盐溶液在温暖的疏水表面上的蒸发过程。水蒸发后，会留下各种特征的晶体形状。研究并解释这一现象。
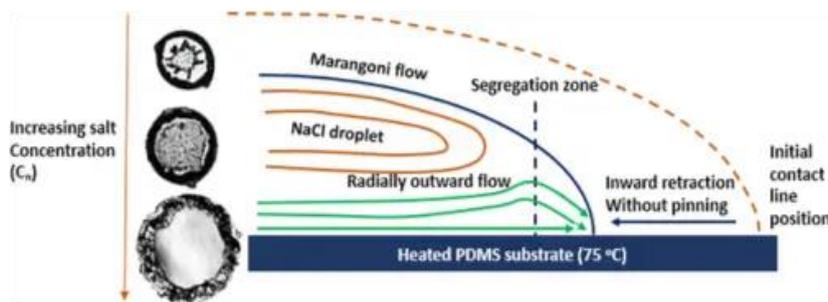
图片来源：[2]

图片来源：[4]

浅析：此现象源于食盐溶液在温暖疏水表面上的蒸发结晶过程，水分蒸发导致盐分过饱和，形成多种特征晶体形状（如立方或枝晶结构），这可能由表面张力梯度、局部蒸发速率不均或接触角效应引起。实验控制变量（如溶液浓度、表面温度和疏水涂层）是可以直接想到的方式，可以使用显微成像和图像分析量化晶体形态、尺寸分布及蒸发时间；结合蒸发模型（如扩散限制理论）和计算模拟分析影响因素，并可扩展至不同盐类或环境湿度条件，以揭示晶体生长动力学机制。这一现象涉及到化学和材料中很前沿的研究问题，如枝晶的结构和生长动力学。

参考文献：

[1] Zhang X. et al. (2023). Evaporation of saline droplets on a superhydrophobic substrate: Formation of crystal shell and "legs." Materials, 16(14), 5168.

[2] Basu N, Mukherjee R. Evaporative drying of sodium chloride solution droplet on a thermally controlled substrate[J]. The Journal of Physical Chemistry B, 2020, 124 (7): 1266-1274.

[3] Kumar V., Dash S. (2022). Patterns during Evaporative Crystallization of a Saline Droplet. Langmuir, 38(33), 10265-10273.

[4] https://www.youtube.com/watch?v=ZTG8FCJZL3M

15、Magnetic Newton's cradle /磁力牛顿摆

Repulsing, non-touching magnets are used instead of colliding balls to make a new type of Newton's cradle. The new cradle can act in a similar way to a regular cradle, but can also exhibit other interesting behaviour. Explain and study the movement of this magnetic cradle.

用相斥的非接触磁体替代碰撞的球体，制成新型牛顿摆。该装置既可模拟常规牛顿摆的运动，也能呈现其他有趣行为。解释并研究此磁力摆的运动规律。
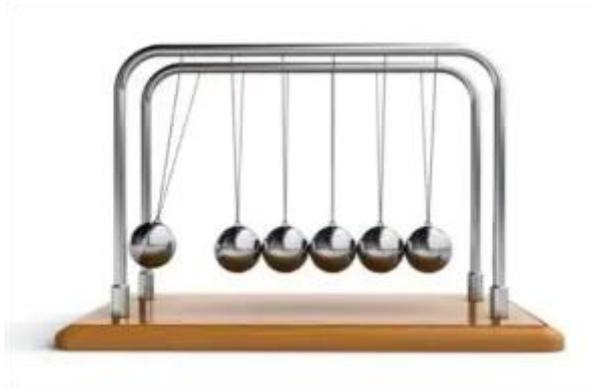
浅析："非接触磁体"意味着力是通过磁场传递而非直接碰撞，相比于无磁时的瞬时刚性碰撞，加入排斥磁体后，力变成随距离连续变化的磁场力，因为磁力随距离急剧变化，且作用有距离，力的传递不再是同步的。这可能导致能量传递出现延迟、错位，导致了可能出现的"有趣行为"。

参考文献：

[1] Chang, Jung-Joe, and Jung-Dean Chang. "Magnet Attenuation of Mechanical Collisions on Newton's Cradle." (2024).

[2] Kraftmakher, Yaakov. "Experiments with a magnetically controlled pendulum." European journal of physics 28.5 (2007): 1007.

[3] https://www.youtube.com/watch?v=-T00RDWg-6I

16、Twisted spaghetti / 扭转的意面

When a bundle of spaghetti is twisted, it might withstand higher transverse (side) forces than a straight, untwisted bundle. Investigate the response of a twisted bundle to transverse stress and identify the optimal twist that maximises tolerance to transverse stress.

当一束意面被扭转时，其承受横向（侧向）力的能力可能强于未扭转的直面条束。研究扭转面束对横向应力的响应，确定最大化横向应力耐受下的最佳扭转方式。

浅析：当一束意面被扭转时，其抵抗横向力的能力得到提升，这主要归因于摩擦力的增强和几何结构的改变。对于未扭转的意面束，在承受横向力时主要依赖单根面条的

抗弯强度，且面条之间容易发生相对滑移。施加扭转后，面条间的接触面积和摩擦力显著增加，使得横向力能够更有效地分布到整个面条束。这种扭转后的结构类似于绳索或缆线，每根面条都分担部分拉力，协同抵抗横向载荷。该结构特性与桁架结构相似，能够将横向作用力转化为面条的轴向拉力。要实现最佳的横向应力耐受效果，需要考虑多个影响因素，包括面条的数量、直径、材质特性以及扭转程度。

17、Travelling flame/ 行进之焰

A flame can propagate continuously around a ring-shaped trough containing a thin layer of flammable liquid. Investigate how the characteristics of this travelling flame depend on relevant parameters.

在装有薄层可燃液体的环形槽中，火焰可以在其上持续环绕传播。研究该行进火焰的特性如何依赖于相关参数。

浅析：在装有薄层可燃液体的环形槽中，火焰的持续环绕传播可以理解为一种由热膨胀和重力共同驱动的流动不稳定性与燃烧反应耦合的现象。火焰锋面附近的液体受热膨胀，密度降低，在重力作用下形成一个向上抬升的区域。由于环形槽的几何形状，这种抬升会引发液体沿槽表面流动，形成一个环形对流。这种对流将未燃烧的可燃液体输运到火焰锋面，同时将燃烧产物带离火焰锋面，维持了火焰的持续传播。火焰传播速度取决于多种因素，包括液体的种类、液层厚度、槽的宽度、环境温度以及重力加速度等。

参考现象：https://www.youtube.com/watch?v=SqhXQUzVMlQ