Co-funded by the
Erasmus+ Programme
of the European Union

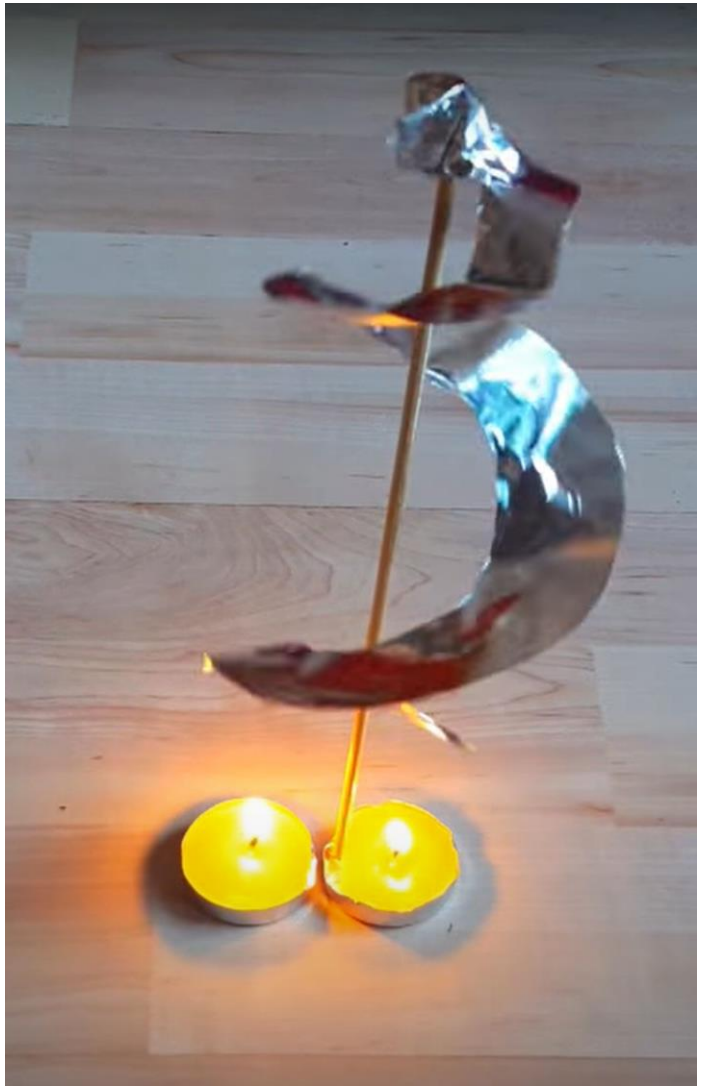
13. Candle Powered Turbine

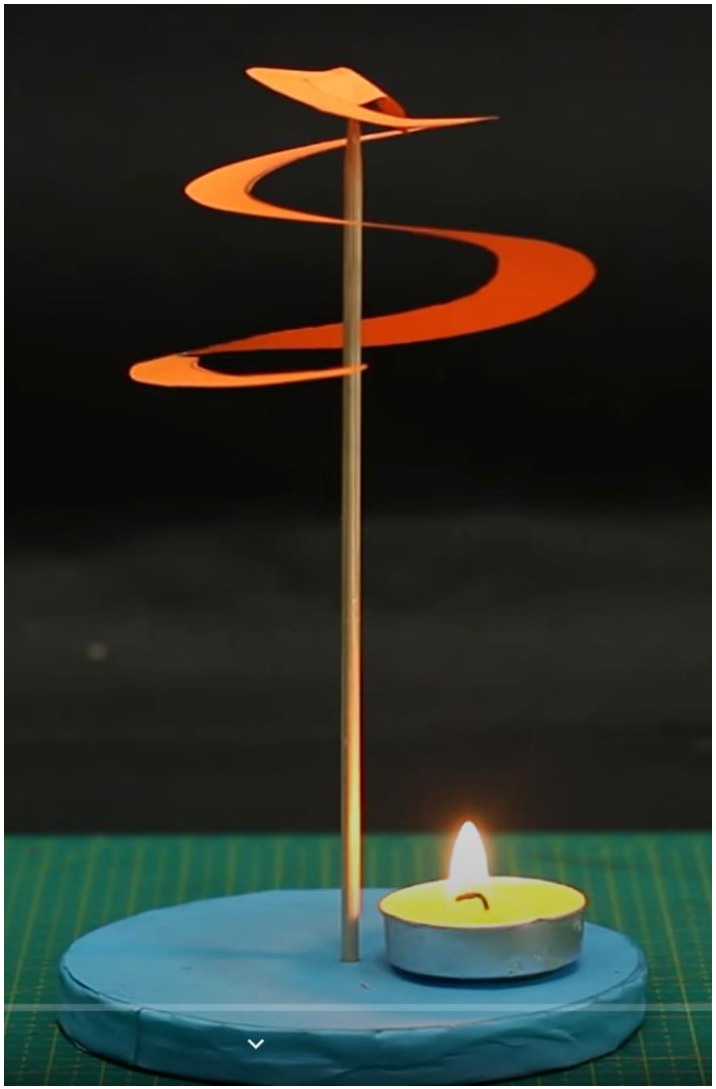
A paper spiral suspended above a candle starts to rotate. Optimise the setup for maximum torque.

13. Sviečková turbína

Papierová špirála zavesená nad sviečku sa začne otáčať. Optimalizujte zariadenie za účelom dosiahnutia maximálneho momentu sily.

13. Candle Powered Turbine





13. Candle Powered Turbine

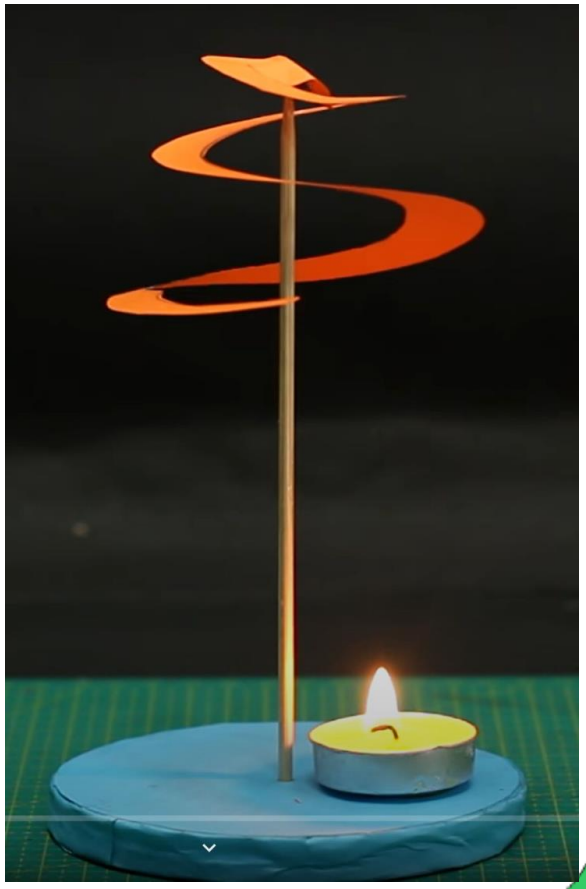
A paper spiral suspended above a candle starts to rotate. Optimise the setup for maximum torque.

paper

spiral

suspended above a candle

starts to rotate



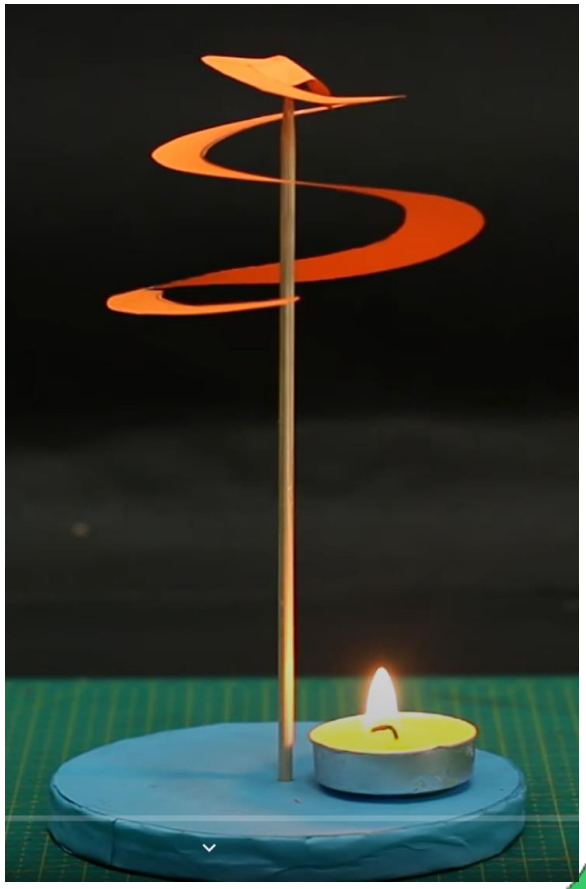
13. Candle Powered Turbine

A paper spiral suspended above a candle starts to rotate. Optimise the setup for maximum torque.

Optimise

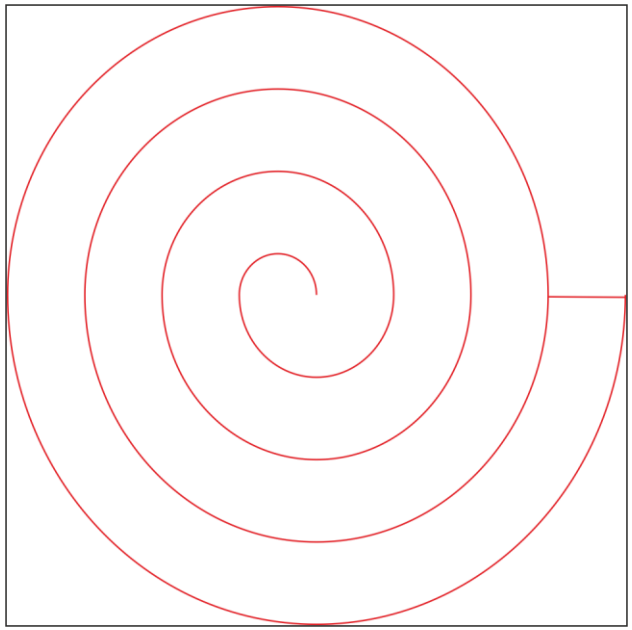
the setup

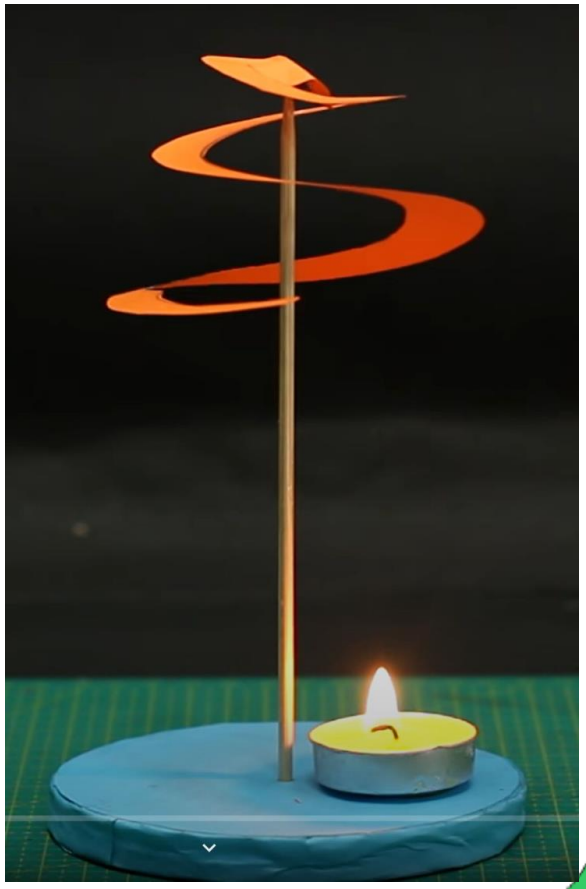
for **maximum torque**



13. Candle Powered Turbine

How to create a paper spiral, traditional one?



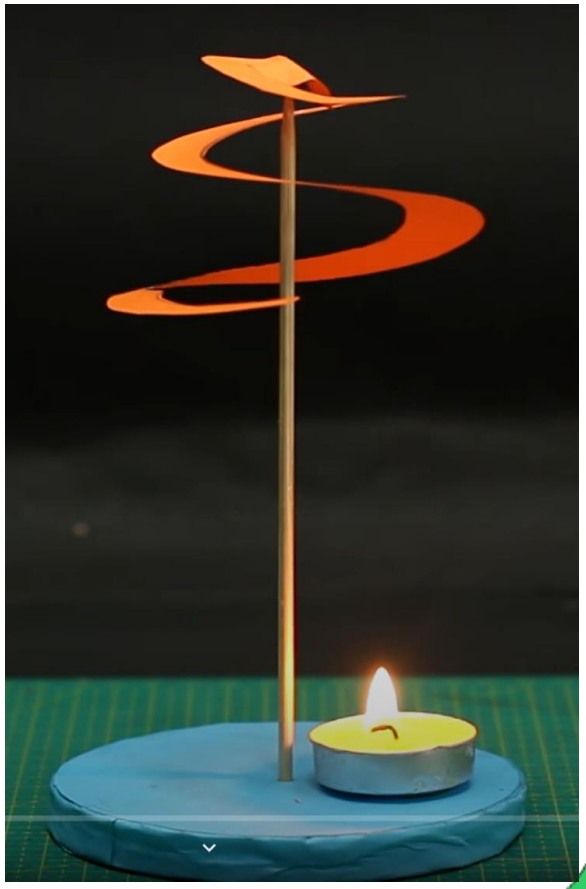


13. Candle Powered Turbine

How does it work?

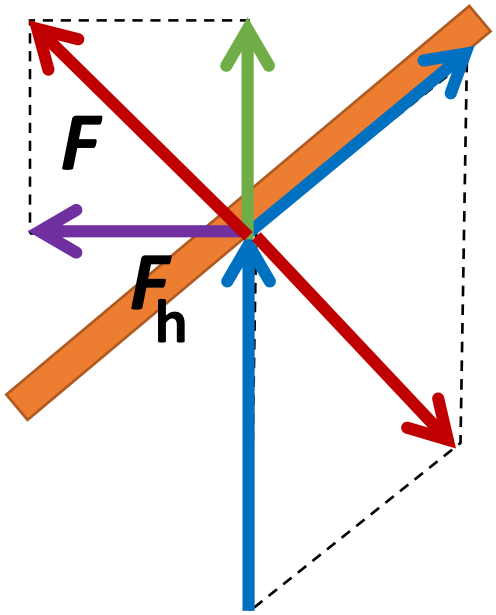
- burning candle
- rising hot air
- inclination of the spiral
- change of momentum of air flow
- torque acting on the turbine
- turbine rotation

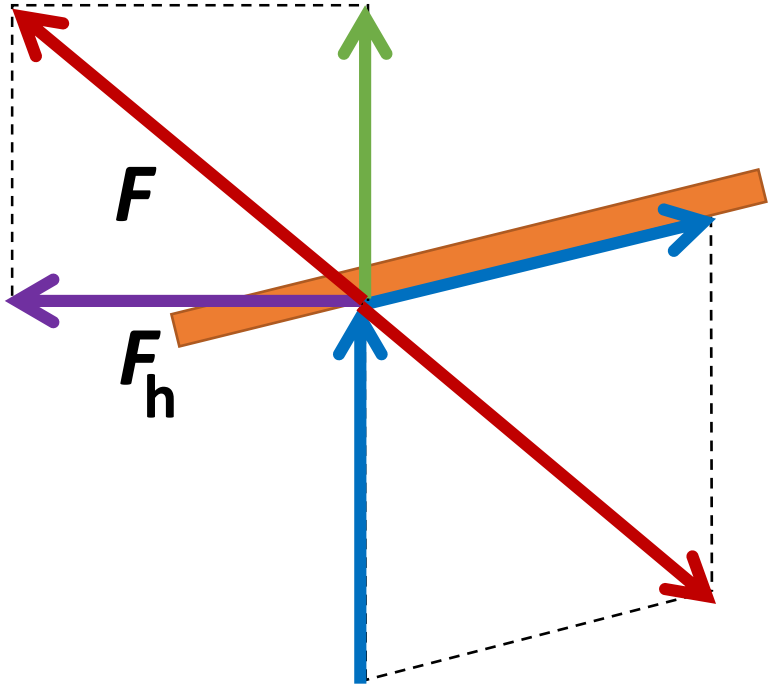
$$\boldsymbol{F} = \frac{d\boldsymbol{p}}{dt}$$



13. Candle Powered Turbine

Basic physics





$$F = m\frac{dv}{dt}$$

Side view

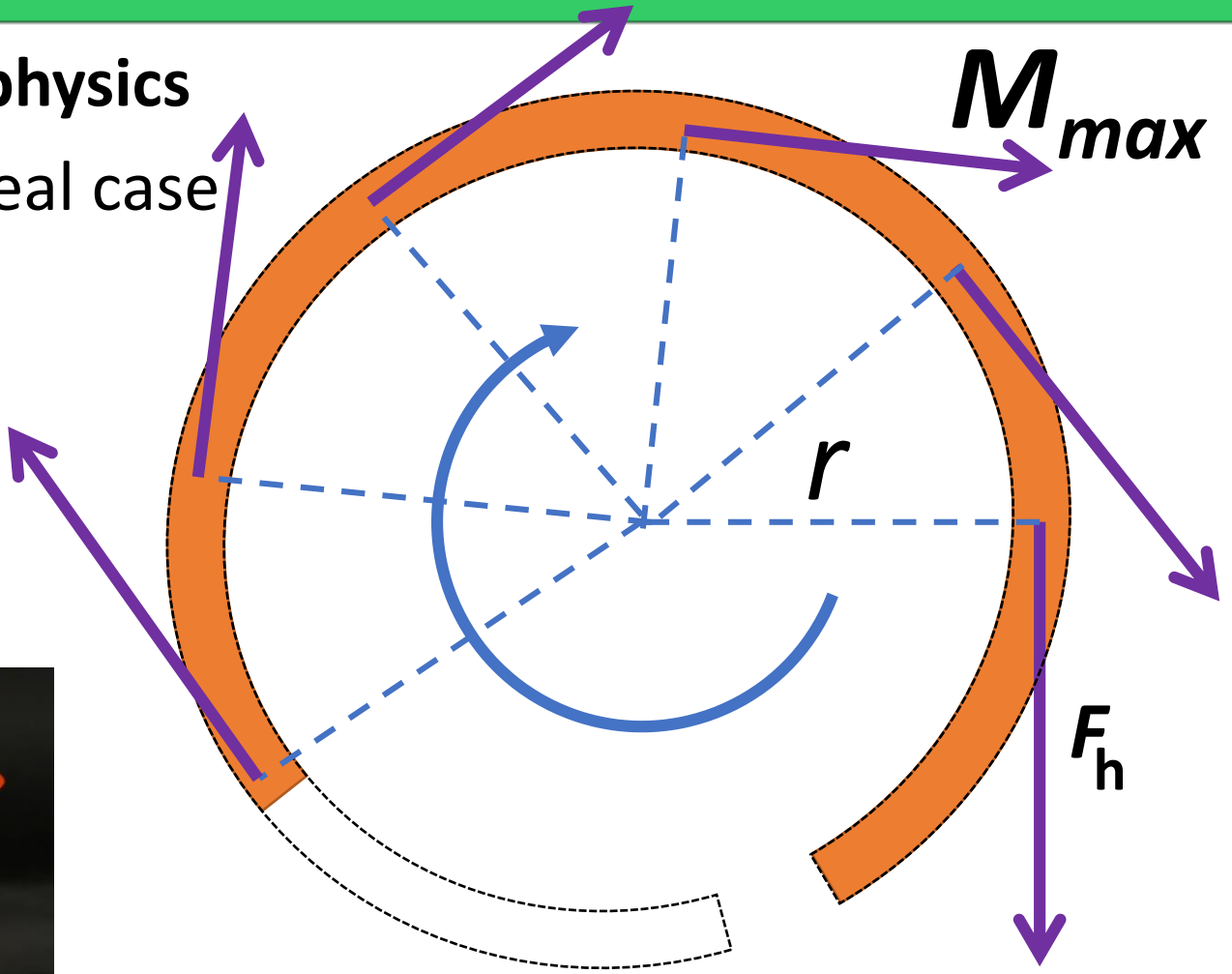
$$F = m\frac{dv}{dt}$$

13. Candle Powered Turbine

Basic physics

- an ideal case

$$M_{max} = r \times F_h$$



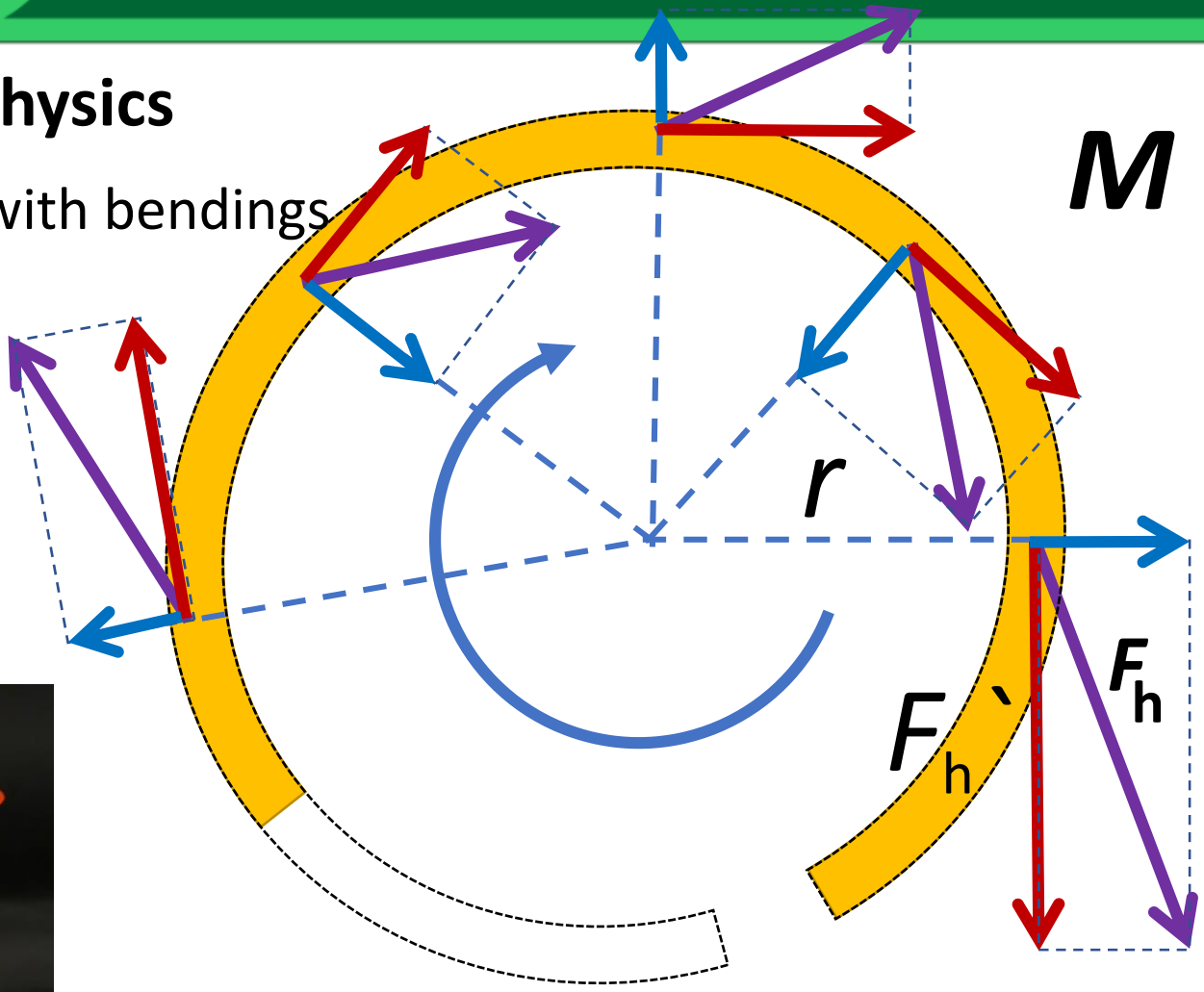
Top view

13. Candle Powered Turbine

Basic physics

- spiral with bendings

$$M = r \times F_h`$$



Top view

13. Candle Powered Turbine

Basic physics

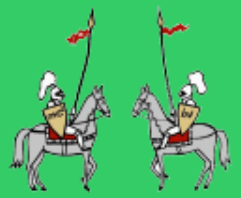
How can we observe the torque?

$$M = r \times F$$

Qualitatively, by observation of angular speed
(higher speed means more torque)

You can design an apparatus for measuring the torque

- by school dynamometer?



13. Candle Powered Turbine

Optimise the setup

- mass (volume) of the air in movement
- speed of air in contact with spiral
  - candle power
  - vertical spiral position
- spiral for better hot air movement
  - shape
  - radius (arm of the torque)
  - slope
  - number of coils
  - horizontal tilt
- paper density

13. Candle Powered Turbine

Optimise the setup

mass (volume) of the air in movement

- candle with more wicks
- wider wick (flames)
- position of wicks relative to spiral arm
- room temperature of air
- flammable substance (beeswax)

13. Candle Powered Turbine

Optimise the setup

speed of air in contact with spiral

- candle power
- vertical spiral position

How does the speed of air change in height?
How does the air flow inside the turbine?

Try to use anemometer...or air flow visualisation...

13. Candle Powered Turbine

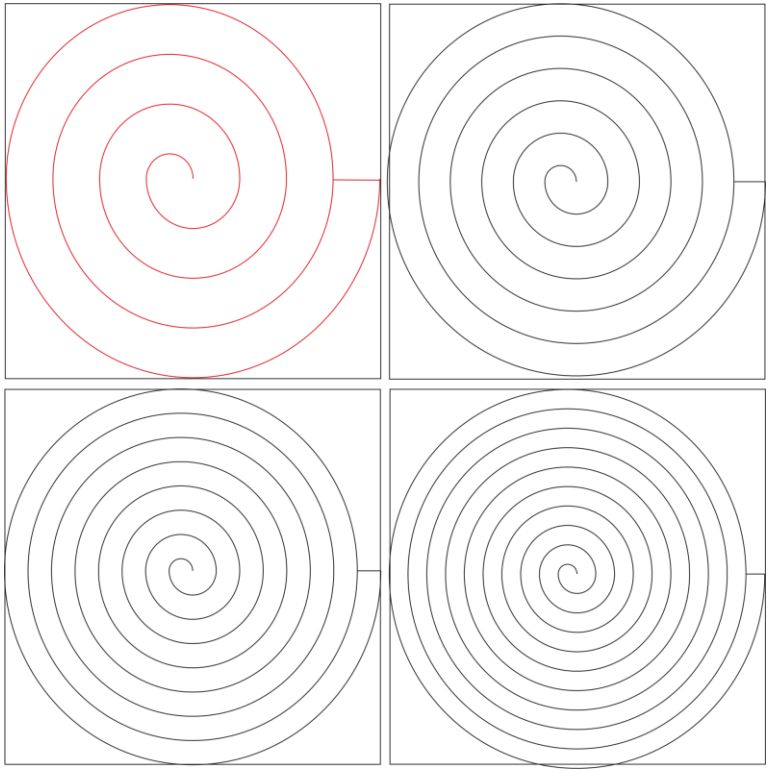
Optimise the setup

Spiral for better hot air movement

- shape and radius (arm of the torque)
- slope
- number of coils
- horizontal tilt

Paper density

- office paper 80 g/m^2
- cardstock paper 300 g/m^2



13. Candle Powered Turbine

Optimise the setup

Design a spiral with another shape