PROBLEM 25: DAMPED PENDULUM

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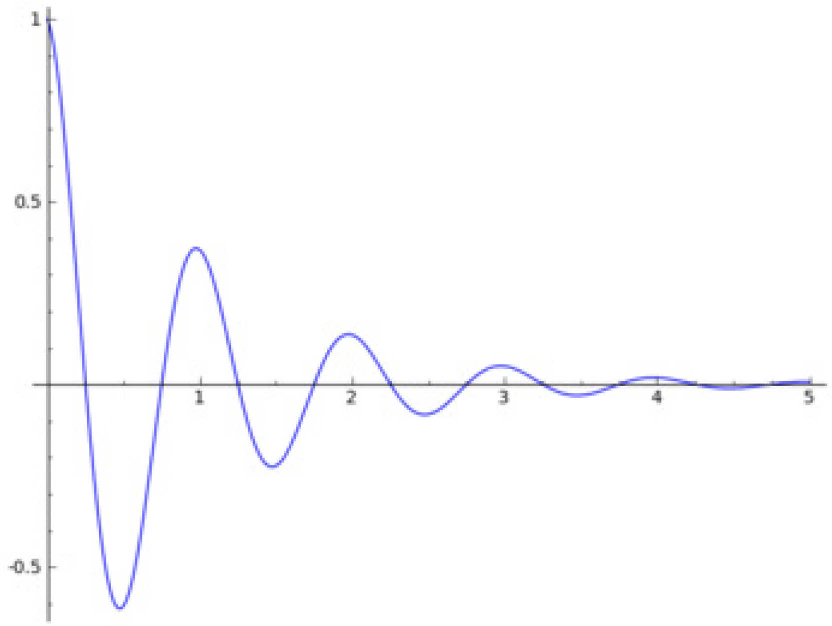
PROBLEM

Damped pendulum

- Determine the **decay time** of a **pendulum**

DEFINTIONS

- Decay time – amount of time it takes for the pendulum to be at rest at the equilibrium point
- Pendulum – a mass attached to a string and allowed to swing in simple harmonic motion



SIMPLE HARMONIC MOTION

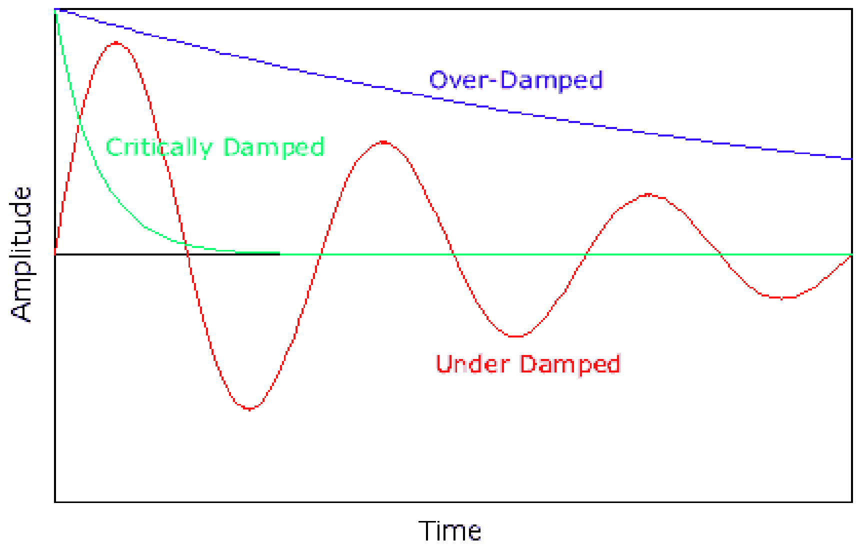
- Special type of motion
  - Restoring force is proportional to the displacement
  - Restoring force acts in the direction opposite of the displacement
- There is periodic motion or oscillation motion
- This means the object always repeatedly returns to a point in its motion
- In simple harmonic motion dampening forces are not considered

COMPLEX HARMONIC MOTION

- Does consider dampening forces
- Dampening forces slow the object down
- Far more real world applications then simple harmonic motion as some form of dampening forces almost always act on an object

DAMPENING FORCES

- Three different types of dampening forces:
  - Critically dampened – The system returns to equilibrium as quickly as possible
  - Overdampened – The system returns (exponentially decays) to equilibrium
  - Underdampened – The system oscillates with the amplitude decreasing too zero
- Real life application
  - Bungee
  - Swings



PENDULUM

- A mass attached to a string and allowed to swing in simple harmonic motion
- A pendulum is in complex harmonic motion
  - Returning to equilibrium point
  - There are dampening forces acting on the pendulum

$$T = 2\pi\sqrt{\frac{L}{g}}$$

T = Time period
L = Length
g = acceleration due to gravity

HYPOTHESIS

- The higher the friction the less time it will take too reach a point of rest at its equilibrium point
  - Friction will be increased if the object has larger surface area and thus there is more air resistance
  - The mass of the object will increase the tension in the string and thus the friction of the string

VARIABLES

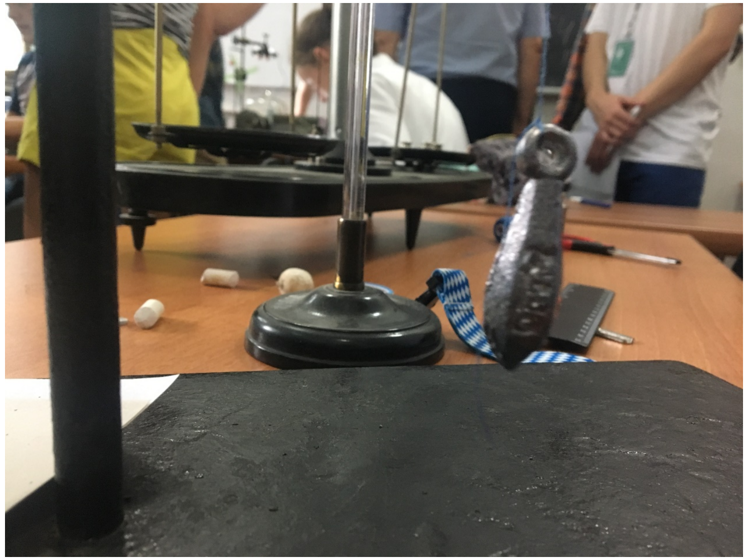
- Standardized
  - String length (40.4 cm)
  - Acceleration to due gravity (9.81 m/s^2)
  - Initial angle
- Independent:
  - Mass
  - Surface area
- Dependent:
  - Decay time

$$T = 2\pi\sqrt{\frac{L}{g}}$$

PENDULUM OBJECTS

Used three different objects as a pendulum

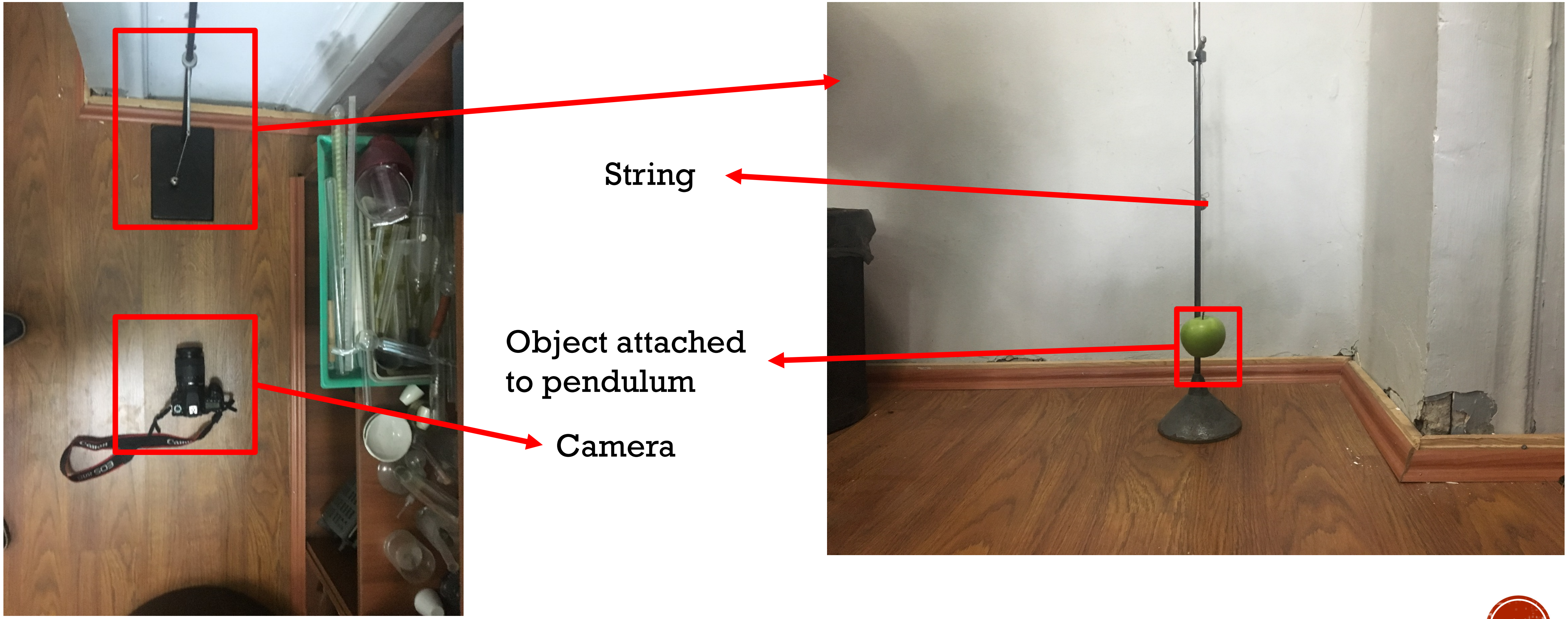
Metal Bob



Metal Ball

Apple

EXPERIMENTAL SET UP



EXPERIMENT

Time-lapse of experiment

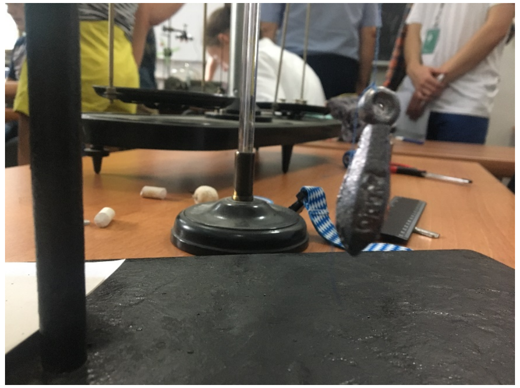
The distance the pendulum moves gets slightly shorter every period

Does not change:
Period
String length
Gravity

RESULTS

- Metal ball: 17 minutes
  - Metal ball had the lowest mass and the lowest air resistance
- Metal bob: 11 minutes
  - Metal bob had second highest mass and second highest air resistance
- Apple: 10 minutes
  - Apple had highest air resistance and highest mass

CONCLUSION



- Ranking of decay:
  - Apple
  - Metal Bob
  - Metal Ball
- Matched the hypothesis, air resistance and mass both had an effect

THANK YOU FOR LISTENING